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Editorial

Data Science and Analytics: Bridging Academia and Industry: The rapid expansion of digital technologies has triggered an unprecedented surge of data from platforms such as social media, e-commerce, industrial sensors, and healthcare systems. In this data-rich environment, Data Science and Big Data Analytics have become indispensable for extracting insights, enabling intelligent automation, and driving innovation. For engineering faculty, engaging in this domain is both a transformative career pathway and a responsibility to prepare students for success in data-driven industries.

Faculty research in Data Science spans diverse areas including machine learning, statistical modeling, natural language processing, image recognition, and real-time analytics. These fields demand technical expertise while offering wide scope for interdisciplinary collaboration. Civil engineers can apply analytics to smart city development, mechanical engineers to predictive maintenance, and computer engineers to advancing algorithms. Such cross-disciplinary engagement not only enhances faculty profiles but also elevates institutional reputation in the academic community.

From a career perspective, Data Science provides faculty with substantial opportunities. Publishing high-impact papers, earning global citations, and gaining recognition on platforms such as Scopus, IEEE, and Web of Science enable faculty to build strong academic identities. Funding agencies, along with industry partners, increasingly prioritize analytics-driven research, creating avenues for grants, consultancy, and institutional growth. These initiatives strengthen both professional development and the research ecosystem.

Equally important is the impact on teaching and student engagement. Faculty can bring real datasets into classrooms, guide students in analytics projects, and encourage participation in platforms such as Kaggle, an online platform owned by Google. This practical exposure equips students with highly employable skills, bridging the gap between academic learning and industry expectations. By embedding data-driven problem-solving into coursework, faculty help shape students into innovators who can contribute to emerging global challenges. To succeed, faculty must pursue continuous upskilling. Workshops and collaborations with industry experts ensure ongoing relevance. Institutions should support these efforts by establishing analytics labs, funding projects, and fostering partnerships with industry and government bodies.

“Data empowers today, transforms tomorrow”

New Delhi

Editor

31st July 2025



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Multilabel Scalogram based Induction Motor Faults Classification using ResNet and ELM

Abid Amin Bhat

Electrical Engineering Department
National Institute of Technology Delhi
✉ abidamin240@gmail.com

Tirupathiraju Kanumuri

Electrical Engineering Department
National Institute of Technology Delhi
✉ ktraju@nitdelhi.ac.in

ABSTRACT

Bearing faults are the most common faults in the induction motors. The detection of bearing faults is crucial to maintain motor reliability. In this work a modified ResNet-18 convolution neural network has been proposed. The proposed model is able to detect ten motor conditions simultaneously. The residual connection approach of ResNet is merged with the Extreme Learning Machine single hidden layer concept. The time domain-based vibration data is converted to scalograms using continuous wavelet transform. The proposed model is able to classify ten conditions of motor with 99.89 % accuracy with train and test time of 16.27 sec and 0.25 sec.

KEYWORDS: *ResNet, Learning machine, Induction motor, Scalogram.*

INTRODUCTION

The automation process has accelerated due to recent technological breakthroughs, which have decreased the need for human interaction and increased demand for new machinery and equipment. Automation systems do activities that were previously completed by people more quickly and steadily. Due to the extensive use of automation systems, there is a greater need for maintenance and repair services as well as a development of the spare parts market. As such, maintenance and repair services are now essential to guaranteeing the effective functioning of automation systems across a range of businesses. Bearings are a vital component of automation systems, being widely used in a wide range of machinery and industrial applications. Maintaining the entire functioning and lifespan of machinery depends on the bearing components operating flawlessly. Mechanical friction, overheating, excessive or reverse loading, and contamination during operation are some of the causes of bearing defects. Bearing faults can also be caused by mistakes in material selection and misalignment during manufacture. Bearings need to be properly monitored, even if their overall cost is very cheap. Failures should trigger system shutdown and replacement in order to stop additional damage (Refs.1-6).

For many years, bearing fault analyses have been the focus of substantial study. It is frequently necessary to gather vibration data at regular intervals and analyses

them using intelligent models in order to learn more about the condition of bearing failures. Through signal envelope analysis (Ref.7) clarified the connection between amplitude modulation/demodulation and bearing failure frequencies. The vibration behavior of defective bearings in a real-world system was investigated by (Ref.8). Comparative testing findings showed that the suggested approach distinguished between normal, inner, outer, and ball defective bearings with an accuracy of 88.23% (Ref.9).. The lack of a standardized model and the time-consuming nature of traditional approaches have driven researchers to embrace transfer learning models widely. Initially, (Ref.10) used a Morlet-based wavelet transform to turn bearing vibration data into spectrum pictures. They then classified bearings as normal or displaying flaws in the ball, outer ring, or inner ring using the VGG19 transfer learning model. The success percentage with this strategy was 93.9%. Furthermore, comparative research has shown that transfer learning models are superior to conventional approaches (Ref.11). The VGG16 model to three datasets that included bearing, gearbox, and induction motor problems. First, they converted the dataset into time-frequency (TF) pictures that were derived from these experimental sets. They then used the VGG16 model to categories these pictures. The induction motor dataset, which comprised normal motors, stator winding faulty motors, unbalanced rotor motors, bearing defective motors, broken bar motors and tilted rotor motors, was

successfully classified by the authors with 100% accuracy. Their classification success percentage for the gearbox dataset, which included worn, missing, welding faulty, and surface faulty kinds, was 99.31%. They classified normal bearings, outer ring faults, inner ring faults, ball defective bearings, and bearings with defects in both inner and outer rings with an accuracy of 99.82% in the bearing dataset (Ref.12). Researcher's classified faulty bearings with inner race faults (IRF), outer race faults (ORF), and ball faults (BF) under different operating situations with the best success rate of 99.80% in the CWRU dataset. In other datasets, they also achieved a 99.23% classification success rate for the same kinds of faulty bearings. A 99.19% success rate was attained by their designed model (Ref.13). Lu et al. used the CWRU dataset to identify different kinds of bearing failures using AlexNet. By employing the no uniform fast Fourier transform (FFT) approach to convert vibration data into spectrogram pictures, the researchers were able to identify between various bearing defect types with a 99.7% success rate (Ref. 14).

Significant advances in a variety of approaches have been observed in recent bearing fault diagnostic advancements. An unsupervised transfer learning method using depth wise separable convolution was presented by (Ref.15), who achieved an astounding 85% accuracy in defect identification using AdaBN. The (Ref.16) presented a successful neural network-based diagnostic technique that included temperature data for improved performance and reduced model size by four times using parameter quantization. To provide robustness in problem diagnosis, (Ref.17) created a deep learning framework irrespective of rotational speed and bearing type. The (Ref.18) presented a branch convolution neural network that can diagnose rotating equipment accurately even with limited defect samples and class imbalance. The (Ref.19) achieved an astounding 97.11% accuracy in defect detection, demonstrating the superiority of the SSRNet model in noisy situations. In a similar (Ref.20) presented an enhanced depth residual network technique that, in situations of high noise, outperformed previous models. Finally, for bearing defect identification tasks, (Ref.21) demonstrated an improved Siamese neural network technique with greater generalization and accuracy with small sample sets.

In order to estimate the severity of bearing faults, this study used continuous wavelet transform (CWT) to transform 1D vibration data into scalogram images. The advantage of skip connections of the ResNet along with single layer fast processing of Extreme Learning Machine (ELM) utilized

to develop a modified ResNet-18 model. By utilizing scalogram images with transfer learning technique like ResNet-18, it is possible to forecast bearing defect of nine types from vibration signals. The Case Western Reserve University dataset is used to test the approach, with success rate of 100% in training. These findings support the notion that the suggested strategy produced excellent outcomes. The organisation of the paper is Introduction, Experimental Setup, Methodology, Results and discussion and conclusion.

EXPERIMENTAL SETUP AND DATA ACQUISITION

The data set is taken from the online available data source (Refs.22). The data set is of a 2-hp Reliance Electric motor and acceleration data was obtained both close to and far from the motor bearings. The motor bearings were subjected to electro-discharge machining (EDM) in order to cause defects. A 2 horsepower motor is positioned on the left side of the test setup, which is represented in Fig.1., along with a torque transducer/encoder in the middle, a dynamometer on the right. The motor shaft is supported by test bearings. On the driving end of the motor casing, this accelerometer was placed at the hour mark. A 16-channel DAT recorder was used to record the vibration signals, which were then analyzed in a MATLAB environment. The format of all data files is Matlab (*.mat). For drive end bearing failures, digital data was gathered at a rate of 48,000 samples per second.

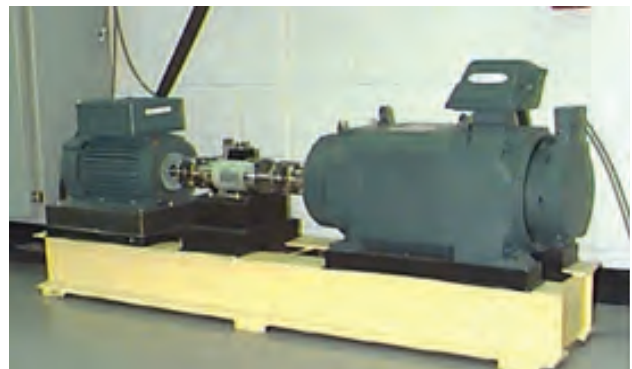


Fig. 1. Experimental setup methodology

The dataset in this study is first represented as signals, which are subsequently converted using the Continuous Wavelet Transform (CWT) into image datasets. The data set consist of total 10 conditions out of which 9 are of bearing faults and 1 healthy condition. In 9 bearing faults conditions inner race, outer race and ball faults with

defect diameters of 7 mils, 14 mils, 21 mils. Then, the ResNet-18 model is used to extract features separately for the vibration image datasets. These features are provided to the ELM for classification. The Fig.2. shows the step by step methodology followed in the proposed approach.

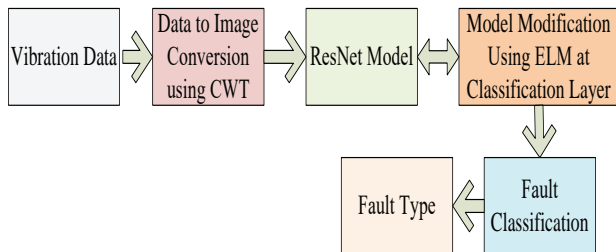


Fig. 2. Methodology block diagram Data to image conversion

The CWRU dataset comprises 121,556 samples for Ball fault, 485,643 samples for healthy conditions, 122,917 samples for inner race fault, and 122,571 samples for outer race fault conditions. Signal-to-image conversion is achieved through Continuous Wavelet Transform (CWT), where 300 scalograms are generated for each motor condition, utilizing 400 samples per image. Consequently, a maximum of 120,000 samples from each condition are utilized, resulting in the development of 300 images for each dataset corresponding to healthy conditions. A scalogram, which is produced by the Continuous Wavelet Transform (CWT), shows the time-frequency properties of a signal graphically. Signals having non-stationary and time-varying frequency components can be analyzed using CWT, in contrast to conventional Fourier-based techniques. Every point on the scalogram represents the wavelet coefficient's magnitude at a given frequency and time.

Because these wavelets are selected to be localized in both time and frequency, it is possible to analyze signal properties at various scales. The CWT can identify both high-frequency and low-frequency components in the signal by adjusting the scale parameter, which records frequency information at various resolutions. Their ability to shed light on the time-varying frequency content of signals makes them useful for tasks like anomaly detection, pattern identification, and feature extraction.

ResNet-18

A convolutional neural network (CNN) architecture known as ResNet-18 rose to attention due to its prowess in image recognition applications. In contrast to older models like AlexNet or VGG. As an important innovation

that allows the network to be considerably deeper while avoiding the vanishing gradient problem, the “Res” in ResNet stands for “Residual,” which refers to the usage of residual blocks.

ResNet-18's architecture is made up of many hierarchically arranged layers. Let's dissect its composition:

- ❖ **Input Layer:** Image data input is accepted by the input layer. ResNet-18 typically accepts 224×224 pixel inputs with three RGB colour channels.
- ❖ **Convolutional Layers:** To identify different patterns and characteristics, these layers use learnable filters to conduct convolution operations.
- ❖ **Residual Blocks:** Multiple convolutional layers are included in each residual block, which are followed by shortcut connections, also known as skip connections, which enable the input to be added to the output of deeper layers while avoiding one or more levels.
- ❖ **Pooling Layers:** To minimise the computational burden and extract the most prominent features, max-pooling layers are usually employed after a few convolutional layers.
- ❖ **Fully Connected Layers:** Using the collected characteristics as a basis for categorization, fully connected layers are used at the conclusion of the network. These layers relate the output classes to the high-level characteristics that the preceding layers have learnt.
- ❖ **Output Layer:** The last layer presents the predictions made by the network.

ResNet-18 is made up of eighteen layers total: convolutional layers, pooling layers, residual blocks, and fully connected layers. Compared to deeper networks, it is very simple to train and has a simplified design that makes advantage of residual connections to make it particularly successful for a range of image identification applications.

Extreme Learning Machine

This study use the ELM as a classifier utilizing deep features derived from the ResNet-18 model. The architecture of the used ELM is as follows:

Input Layer: The number of neurons in input layer is equal to the size of the feature vector from the ResNet-18 pool5 layer. In ResNet-18, pool5 outputs a $1 \times 1 \times 512$ feature map per image. After flattening there is 512 input features, so, Input Layer Size is 512.

Hidden Layer: The single hidden layer with random weights (non-trainable) is used in ELM with sigmoid activation function. The Number of Neurons is set to 1000 in this work. The Input Weights and Biases are randomly initialized. The Output Weights are computed using Moore-Penrose pseudo-inverse:

$$W_{out} = H \times T \quad (1)$$

Where H is the hidden layer output, and T is the target output. **Output Layer:** In the output layer the Number of Neurons is Equal to number of classes 10. The Output Type is multilabel classification. The Prediction is based on the argmax of output neuron activations.

RESULTS AND DISCUSSION

The condition monitoring of the motor using machine learning model requires a reliable data set, an accurate feature extraction. In this work, the data set utilized for the validation of the proposed algorithm is CWRU data set, which consist of 10 different health condition of the healthy and the faulty bearing. So, using the CWT technique the time domain vibration data set is changed to image and each condition consist of 300 images. The sample of some images is shown in Figure.3

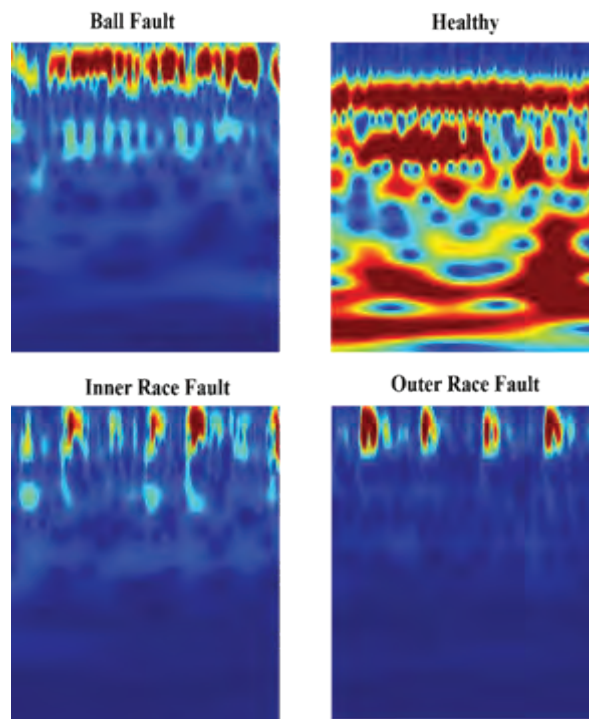


Fig. 3: Vibration to image conversion bearing condition sample images

From the figures it can be seen that the different health conditions are easily identifiable. The training performance of the default ResNet-18 model is depicted in Figure.4. which shows the accuracy and loss plots throughout 10 training epochs, comprising 650 iterations. The training accuracy increased significantly, surpassing 95% early in the process and stabilizing over 98% in the following epochs. By the concluding epoch, the model attained a validation accuracy of 99.44%, signifying robust generalization capacity and proficient assimilation of the underlying data distribution. This minimal loss was maintained across the subsequent epochs. The validation loss exhibited a comparable pattern, with negligible variations, indicating that the model did not experience overfitting. The training procedure was conducted on a single GPU and concluded in 6 minutes and 6 seconds. A fixed learning rate of 0.001 was maintained during the training, with validation conducted every 50 iterations.

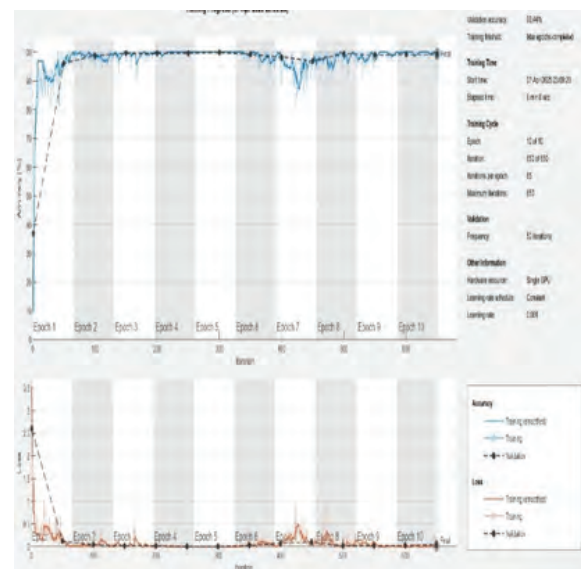


Fig. 4: Training plot using ResNet-18 model

The classification performance of the proposed models was assessed by analyzing confusion matrices for both the baseline ResNet model and the ResNet coupled with an Extreme Learning Machine (ResNet+ELM). The confusion matrices offer a comprehensive analysis of the true positive and misclassification rates for all 10 fault classes examined in the study. The confusion matrix for the default ResNet model is shown in Figure.5 (a). Indicates that, although the overall classification accuracy is high, certain classes exhibit modest misclassifications, especially across closely related fault categories.

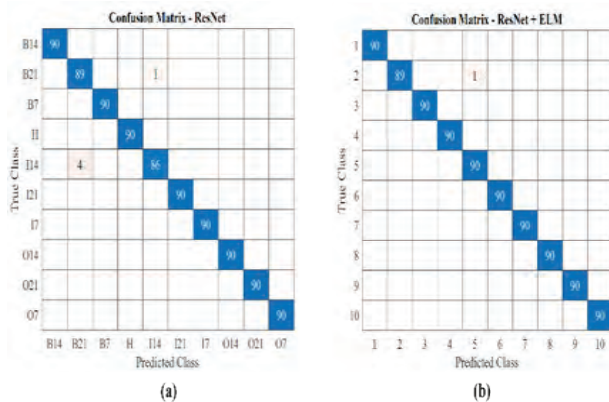


Fig. 5: Test confusion plot for (a) default resnet-18 (b) resnet-18 + elm

Table 1. Parameter comparison between default ResNet and proposed ResNet

Model	Train Accur acy %	Test Accur acy %	F1 Sco re	Train Time (s)	Test Time (s)
ResNet-18	99.57	99.44	0.99	392.30	4.78
Proposed (ResNet+ELM)	100	99.89	1.00	16.27	0.25

This suggests that although ResNet has strong performance, its decision boundaries but exhibit minor overlaps for specific fault types, likely attributable to feature similarities in the scalogram pictures utilized for training. On the other hand, the ResNet+ELM model as shown in Figure. 5(b). has enhanced classification performance, as seen by its confusion matrix. All fault classes are categorized with exceptional precision, with the diagonal entries significantly prevailing and few or non-existent off-diagonal misclassifications.

Table 1. Outlines the performance characteristics of the baseline ResNet-18 and the proposed ResNet+ELM models. The ResNet-18 architecture attained a training accuracy of 99.57% and a test accuracy of 99.44%, accompanied with an F1 score of 0.99, indicating robust performance in fault classification. It attained an impeccable training accuracy of 100% and a slightly superior test accuracy of 99.89%, along with an F1 score of 1.00, signifying flawless classification devoid of false positives or false negatives in the test data. Besides its enhanced accuracy, the

ResNet+ELM model demonstrated a significant decrease in processing time. The hybrid model's training duration was about 16.27 seconds, in contrast to 392.30 seconds for the normal ResNet-18 model, representing a decrease of over 96%. Correspondingly, the test time decreased from 4.78 seconds to just 0.25 seconds, underscoring the computational efficiency of the suggested method. The findings unequivocally indicate that the ResNet+ELM hybrid model provides superior classification performance together with speedier training and testing, rendering it exceptionally appropriate for real-time fault diagnosis in workplaces.

CONCLUSION

In this work the problem of manual feature extraction is solved using the deep feature extraction using ResNet-18 and over processing time of deep learning model is solved using the Extreme Machine Learning Model in the fully connected layer of the ResNet model. The attained accuracy by the default ResNet-18 model is 99.44% with train and test time of 392.30 sec and 4.78 sec while the proposed modified Res-Net model attained accuracy of 99.89% with train and test time of 16.27 sec and 0.25 sec.

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Experimental Investigation on M25 Grade Concrete Using Vermiculite as Partial Replacement of Sand

P. Dhanabal

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ dhanabalgce@gmail.com

S. Rama Thulasi

Dept. of Humanities and Science
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ ramatulas03@gmail.com

B. Indhumathi

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ bandaruindhumathi32003@gmail.com

P. Ramakrishna

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ ramakrishnapusukuri710@gmail.com

ABSTRACT

The potential benefits of partially substituting vermiculite for natural river sand in M25 grade concrete is examined in this experimental study. To assess its impact on the mechanical qualities of concrete, vermiculite was added in different proportions: 0%, 10%, 20%, and 30%. Studying the split tensile and compressive strengths at each replacement level was the main goal. According to the data, the compressive and split tensile strengths consistently decreased as the vermiculite content increased, reaching a maximum reduction of about 20% at 30% vermiculite substitution. A 10% replacement level was determined to be ideal despite the total strength loss since it preserved the 28-day compressive strength criteria for M25 grade concrete. According to this study, vermiculite can be used up to a 10% replacement ratio with success, encouraging environmentally friendly building methods by preserving some natural sand resources.

KEYWORDS: Vermiculite, Cement, Compressive strength, Split tensile strength.

INTRODUCTION

One of the most important building materials in the world, concrete is prized for its strength, durability, and adaptability. But the increasing need for natural sand in the manufacturing of concrete has raised environmental issues, such as the depletion of sand supplies and rising extraction prices [1-3]. Researchers are therefore concentrating on developing sustainable substitutes for sand as a fine aggregate in concrete. Vermiculite, a naturally occurring mineral with exceptional thermal and acoustic insulating qualities, is one such substitute. It is also lightweight and fire-resistant [4-5]. The major determination of study is assessment of effects of partially substituting vermiculite for sand in M25 grade concrete on a number of concrete parameters. Vermiculite is renowned for having special physical qualities including high porosity and low density, which may make it a great option for creating lightweight concrete with better insulating qualities [6-8]. Vermiculite has already been shown in a number of studies to have

the ability to lower the total weight of concrete while preserving respectable strength levels. On the other hand, little is known about its use in M25 grade concrete as a partial substitute for sand. This study examines the effects of substituting varying percentages of vermiculite (10%, 20%, and 30%) for sand on the workability, compressive strength and durability of a final material called concrete [9-10]. This study's main goals are to ascertain how vermiculite affects the workability of M25 grade concrete, how it affects compressive strength at unlike curing durations (7, 14, and 28 days), and how long the concrete lasts using permeability and water absorption tests. This study attempts to shed light on the possibility of vermiculite as sustainable supplementary for FA in the manufacturing of concrete by contrasting the enactment of concrete containing vermiculite thru traditional M25 concrete. The results may help the building sector create concrete products that are more resource-efficient and environmentally beneficial [12]. This study's primary goals are to compare the characteristics of vermiculite and

ordinary concrete and ascertain how concrete that contains vermiculite as a fine aggregate behaves. Additionally, to investigate the appropriateness of vermiculite by substituting 0%, 10%, 20%, and 30% of natural river sand

METHODOLOGY

The research of vermiculite as a sand substitute employs the following methods. Figure 1 showed the technique flow chart.

MATERIAL PROPERTIES AND MIX DESIGN

The following supplies were employed in the experimental study:

Ordinary Portland cement (OPC 53 grade)

The calcareous, silica, alumina, or iron oxide-bearing components must be mixed to create cement. To create cement that satisfies this requirement, the primary clinkers are ground after being burned at a clinker temperature. BIS, New Delhi, India, IS12269, 2013 [13] was used to assess the cement's qualities.

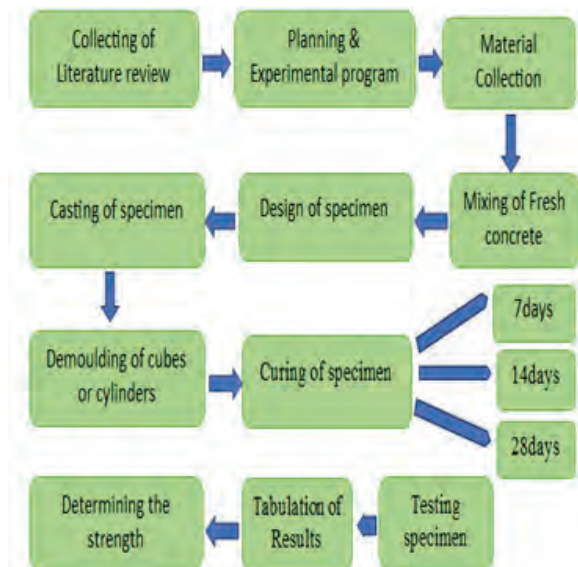


Fig. 1: Methodology flow chart

Table 1: Properties of OPC cement (53 grades)

Characteristics	Values
Specific gravity	3.15
Fineness	1-5%
density	3.15g/m ³

Coarse aggregate

Crushed granite, which possesses remarkable strength, durability, and weather resistance, was utilized as the coarse aggregate in the study. The Bureau of Indian Standards (BIS), located in New Delhi, India, conducted tests on the coarse aggregate's qualities using IS 2386, 1963 [14].

Table 2: Properties of coarse aggregate

Characteristics	Value
Specific gravity	2.5
% of water absorption	1.0%
Fineness modulus of CA 20mm size	7.0
Shape	Angular to rounded

Fine Aggregate

Concrete uses fine aggregate that is smaller than a 4.75 mm sieve. It aids in maintaining the mixture's dimensions. In accordance with Bureau of Indian Standards (BIS), New Delhi, India, IS 383, 1970 [15], tests were conducted on the different qualities of fine aggregate.

Table 3: Properties of fine Aggregate

Characteristics	Values
Specific gravity	2.6
% of water absorption	2%
Fineness modulus of FA & Zone FA	2.78 - ZONE – II

Vermiculite

Concrete uses vermiculite, a naturally occurring mineral, as a lightweight aggregate. Magnesium-aluminum-iron hydrated laminar silicates make up this kind of phyllosilicate mineral. Based on Bureau of Indian Standards (BIS), New Delhi, India, IS 383, 1970 [15], the properties of vermiculite were evaluated.

Table 4: Physical properties of Vermiculite

Particle Shape	Flaky
Color	Dark brown
Water Absorption	High

Water

Water has a significant impact on workability and the parameter strength characteristics of concrete mixes. For the hydration response to get stronger, a certain amount of water is needed. For the concrete mix to have the appropriate strength and workability, enough water should be added.

Mix Proportion

We proportioned the different materials in the concrete mix according to IS10262:2009 [16]. Table 5 below lists the weights of the components for the concrete mix with and without vermiculite.

EXPERIMENTAL INVESTIGATIONS

Workability test

The most popular technique for determining the consistency of concrete is the workability test, which can be conducted in a lab or on the job site.

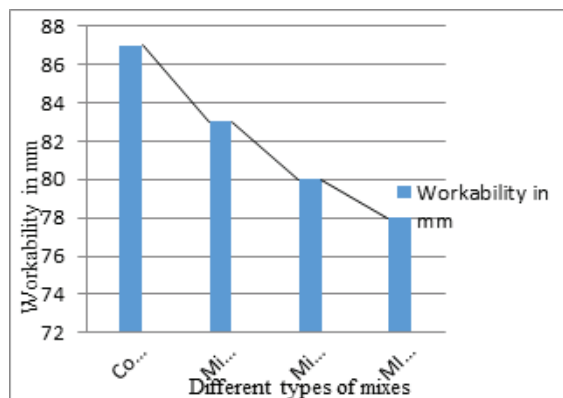


Fig. 2: Workability for various mixes

This approach isn't appropriate for highly concrete. Nonetheless, it is typically employed as a control test and provides a measure of the consistency of concrete across batches. Figure 2 displayed the results of the workability test.

Compressive strength test

The concrete cube test's compressive strength gives an understanding of all the properties of concrete. One can determine whether or not concreting has been done correctly with this one test. The Methods of test for strength of concrete, Bureau of Indian Standards (BIS), New Delhi, India, IS 516, 1959, is the basis for this compressive strength test. It is the test used to find the compressive strength value of cubes. Figure 3 displayed the results of the compressive strength test.

Table 5: Mix proportion for M25 grade concrete

S. No	Materials	Quantity of materials (kg/m3) with different percentages of Vermiculite			
		0%	10%	20%	30%
1	Cement	384	384	384	384

2	Fine Aggregate	661	594.9	528.8	462.7
3 (a)	Coarse Aggregate 20mm	652	652	652	652
3(b)	Coarse Aggregate 10mm	434	434	434	434
4	Vermiculite	0	66.1	132.2	198.3
5	Water	202	202	202	202

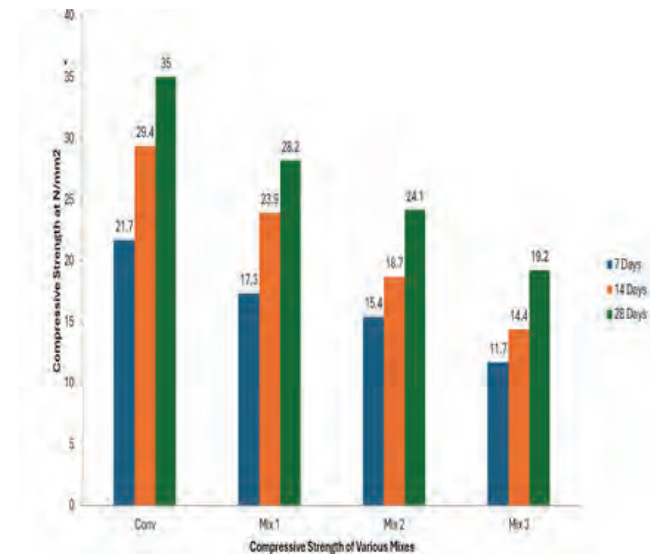


Fig. 3: Compressive strength of various mixes

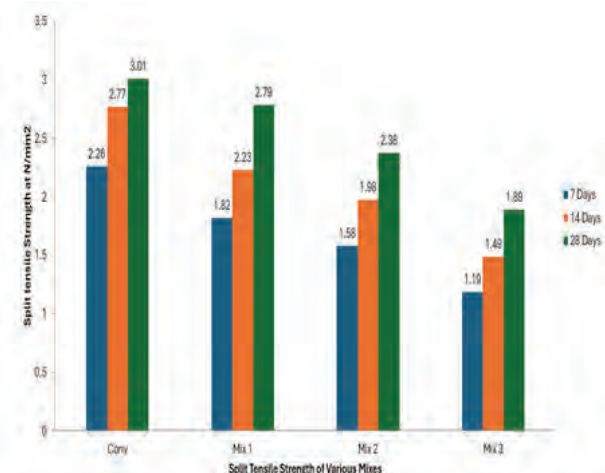


Fig. 4: Split tensile strength of various mixes

Split Tensile strength test

An indirect method of assessing the concrete's tensile test is the split tensile test. A conventional cylindrical specimen is placed horizontally in this test, and a force is exerted radially on the cylinder's surface, causing a vertical crack to form in the specimen along its diameter.

Figure 4 displayed the results of the split tensile strength test. The Methods of test for strength of concrete, Bureau of Indian Standards (BIS), New Delhi, India, IS 516, 1959, is the basis for this split tensile strength test.

RESULTS AND DISCUSSION

Slump cone test: The highest slump value of 87mm is produced by concrete devoid of vermiculite. However, the slump value will decrease when vermiculite is substituted as fine aggregate, although the percentage of vermiculite as fine aggregate would increase. **Compressive strength:** At 7 days, the concrete's compressive strength with 10% vermiculite in place of fine aggregate is 21% lower than that of the standard mix (21.68 N/mm²). When compared to the strength of a typical mix, the compressive strength decreases by 29.19% at a 20% substitution of vermiculite as fine aggregate and by 46.13% with a 30% replacement of vermiculite as fine aggregate (11.65 N/mm²). At 14 days, the compressive strength of concrete that contains 20% vermiculite in place of fine aggregate is 18.61% lower (23.88N/mm²) than that of a typical mix (29.37N/mm²). Comparing vermiculite to conventional mix strength, a 20% replacement of sand results in 36.50% less strength (18.66N/mm²), while a 30% replacement of vermiculite as fine aggregate results in 51% less compressive strength (14.44N/mm²). **Strength of compression:** At 28 days, the compressive strength of concrete that contains 30% vermiculite in place of fine aggregate is 19.3% lower (11.68 N/mm²) than that of a typical mix (21.68 N/mm²). In comparison to the strength of a conventional mix, the compressive strength decreases by 31.02% when vermiculite is substituted for fine aggregate by a 20% increase, and by 45.09 (11.68 N/mm²) when vermiculite is substituted for fine aggregate by a 30% increase. When compared to conventional compressive strength, the 20% and 30% did not reach the compressive strength at 7, 14 and 28 days; however, 10% replacement of vermiculite as fine aggregate at 7 days and 14 days reached the conventional compressive strength. Based on the results, it is preferred to utilize 10% vermiculite in place of fine aggregate. Likewise, split tensile strength: Compared to conventional mix strength (21.68 N/mm²), split tensile strength of concrete with 10% vermiculite as fine aggregate substitution results in 19.46% less strength (17.29 N/mm²) after 7 days. When compared to the strength of a conventional mix, the strength decreases by 29.19% when the percentage of vermiculite as fine aggregate is increased by 30%, and the split tensile strength decreases by 47.34% (11.65 N/mm²) when vermiculite is replaced by 30% as fine

aggregate. When compared to the strength of a standard mix (29.37N/mm²), the split tensile strength of concrete that contains 20% vermiculite in place of fine aggregate at 14 days is 19.49% lower (23.88N/mm²). When compared to the strength of a typical mix, the strength reduces by 28.52% when vermiculite is used as a 20% substitute for sand (18.66N/mm²) and by 46.73% when vermiculite is used as a fine aggregate (14.44N/mm²). When compared to the strength of a standard mix (21.68 N/mm²), the split tensile strength of concrete that contains 30% vermiculite in place of fine aggregate is 7.30% lower at 28 days (11.68 N/mm²). When compared to the strength of a typical mix, the strength decreases by 20.93% when vermiculite is used as a 20% substitute for fine aggregate and by 37.21% (11.68 N/mm²) when vermiculite is used as a 30% replacement for fine aggregate. When compared to the conventional Split tensile strength, the 20% and 30% did not meet the compressive strength at 7 days, 14 days, and 28 days; however, the 10% substitution of vermiculite as fine aggregate at 7 days and 14 days reached the conventional Split tensile strength. Based on the results, it is preferred to utilize 10% vermiculite in place of fine aggregate.

CONCLUSIONS

From the Experimental investigation the following conclusions were drawn. Those are listed below

The greatest slump value of 87mm is produced by concrete devoid of vermiculite. However, the slump value will decrease when vermiculite is substituted as fine aggregate, although the percentage of vermiculite as fine aggregate would increase.

At 7, 14, and 28 days, respectively, the compressive strengths of concrete without vermiculite are 21.68 N/mm², 29.37 N/mm², and 34.97 N/mm². However, vermiculite yields 17.29 N/mm², 23.88 N/mm², and 28.20 N/mm² at 7, 14, and 28 days, respectively, when 10% of it is substituted as a fine aggregate. This led us to conclude that increasing the replacement of vermiculite as a fine aggregate would result in a decrease in compressive strength. At 7 days, 14 days, and also 28 days, respectively, split tensile strengths of 2.26 N/mm², 2.77 N/mm², and 2.01 N/mm² are produced by concrete devoid of vermiculite. However, at 7 day, 14 day and also 28 days, respectively, split tensile strengths of 1.82 N/mm², 2.23 N/mm², and 2.79 N/mm² are obtained by substituting 10% vermiculite as fine aggregate. This led us to conclude that increasing the replacement of vermiculite as

a fine aggregate would result in a decrease in split tensile strength. Thus, vermiculite can replace up to 10% of the fine aggregate in concrete to achieve the workability and toughened qualities needed by the construction sector.

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Non-linear Analysis and Design of a Composite Arch Bridge using Robot Structural Analysis

M Sri Priya

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ priyasrimk@gmail.com

M Murali

Dept. of Humanities and Science
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ muralim@gmail.com

K. Uday Aditya

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ udaya@gmail.com

Pavan Kumar

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ pavank@gmail.com

ABSTRACT

The present study explores the design and non-linear analysis of a composite arch footbridge intended for pedestrian crossing over an 8-lane expressway with an average daily traffic (ADT) exceeding 50,000 vehicles. This project focuses on the conceptual design, modelling, analysis, and structural detailing of the bridge using Robot Structural Analysis (RSA) software applying geometric non-linearity principles. A finite element approach is adopted where the structure is discretized into one-dimensional elements, and incremental loading is applied until failure. The iterative procedure involves successive substitution using stiffness matrices to resolve the equilibrium state at each load step. The study focuses on real-time implementation parameters such as wind and seismic zones, material specifications, and soil conditions for accurate structural analysis and performance assessment. The design adheres to Indian Standard Codes (IS 875 Parts 1–3 and IS 1893-2002), accounting for pedestrian, wind, seismic, and temperature loads. The arch primarily carries loads through axial compression, minimizing deflection and shear forces, with bending moments concentrated near supports and load application points. Reinforcement and steel sections determined through RSA were optimized using nonlinear analysis by iteratively updating cross-sectional constants, in compliance with IS 800 and IS 456-2000.

KEYWORDS: Composite arch bridge, Non-linear analysis, Robot Structural Analysis, Finite element method, Geometric non-linearity, P-Δ analysis.

INTRODUCTION

Composite arch footbridges are gaining prominence due to their strength, durability, and aesthetic appeal, especially in high-traffic urban zones. The bridge under study is designed for a major expressway with significant pedestrian movement and vehicular loads. The structure has a length of 46 meters and a width of 3 meters, constructed with composite materials (steel and concrete). The analysis incorporates geometric non-linearity and is performed using P-Δ effects to simulate the real behaviour of the structure under different loading conditions, including wind and seismic forces, as per Zone III and Zone V classifications respectively. The structure is assumed to rest on hard soil.

Footbridge Specifications:

Length: 46 meters

Width: 3 meters

Material: Composite (Steel + Concrete)

Analysis Type: P-Δ Analysis

Non-linearity Considered: Geometric Non-linearity

Table 1. Geometric and Structural Properties of Bridge

Components	Section Type	Description
Floor Beam	MB400	Main transverse floor beams, supporting deck loads and transferring to arch system

Arch Ribs	MB550	Principal load-bearing members forming the parabolic arch profile
Hangers	MB300	Vertical tension elements connecting the arch to the deck
Inclined Bracing	180 × 180 × 10 mm	Lateral bracing elements for in-plane and out-of-plane stability
Columns	200 × 200 × 12 mm	Intermediate supports between the arch ribs and the deck (used in cases of multi-span or pier-supported designs)
Supports	Fixed	Both ends of the arch are modelled with fixed boundary conditions

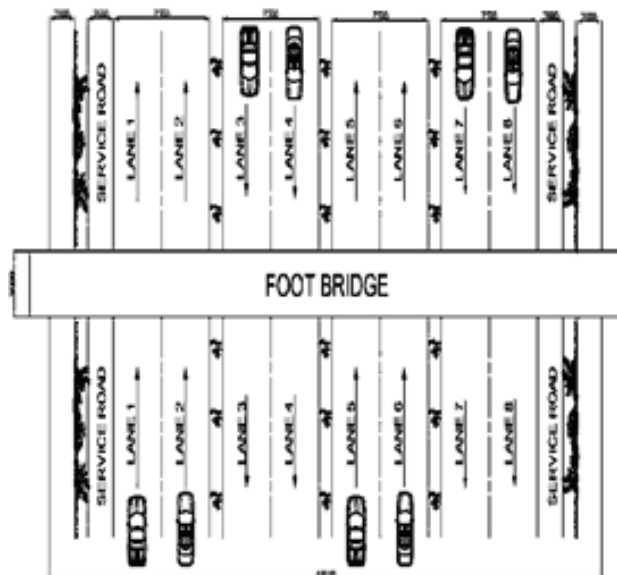


Fig. 1: Lane Layout of Foot Bridge

LITERATURE REVIEW

- Shaoqin Wang et al. (2024): Analyzed the dynamic behaviour of long-span arch bridges under wind and vehicle loads.
- Yuexing Wu et al. (2024): Investigated the ultimate span capacities of concrete-filled steel tube arch bridges.
- Yaping Lai & Yu Li (2023): Proposed design innovations for long-span steel-UHPC composite arch bridges.
- Hongtao Peng & Zhiqiang Kou (2022): Implemented BIM for digital modeling of inclined arch-pylon cable-stayed bridges.

- Yuhang Chu et al. (2022): Analysed seismic response with fluid-solid coupling in reservoir arch bridges.
- Michele Fabio Granata et al. (2021): Offered conceptual design guidelines for steel and composite tied-arch bridges.

METHODOLOGY

Modelling: The bridge is discretized into Finite elements with node connections representing composite behaviour. The composite arch bridge considered in this study was modelled and analysed using Autodesk Robot Structural Analysis Professional. The bridge geometry is defined by a symmetrical parabolic arch system supporting a deck through vertical hangers. The overall layout is designed to replicate a typical tied-arch pedestrian or light vehicular bridge with composite steel–concrete action. The modelling is discretized into key structural components, each assigned with specific cross-sectional properties as described in Table 1. M30 concrete and structural steel modelled for composite behaviour.

Loading Conditions: Wind load (Zone III), seismic load (Zone V), thermal effects, and pedestrian loads are applied. The structural analysis of an arch footbridge involves considering a variety of loads to ensure stability and safety under all conditions. Dead Loads (DL), as per IS 875 Part 1, include the self-weight of steel components (7850 kg/m³), M30 concrete deck (25 kN/m³), and additional finishes like parapets. Live Loads (LL), defined in IS 875 Part 2, consist of a 5 kN/m² pedestrian load and occasional maintenance vehicle loads. Wind Loads (WL), as per IS 875 Part 3, are based on a wind velocity of 50 m/s (Zone 4) and account for wind pressure on projected surfaces. Earthquake Loads (EL) follow IS 1893-1:2002, using dynamic analysis for Zone 5 with appropriate reduction and importance factors. Temperature Loads (TL), per IS 875 Part 5, consider thermal expansion/contraction due to temperature variation in steel and concrete. All load types are crucial for accurate simulation and resilient bridge design.

Element Mesh Generation: The meshing configuration adopted an 8-node hexahedral finite element scheme with Coons and Delaunay meshing methods and a consistent 1-meter mesh size. This ensured a fine balance between computational efficiency and solution accuracy.

Analysis: Robot Structural Analysis used to perform static and dynamic analysis with P-Δ and geometric non-linearity.

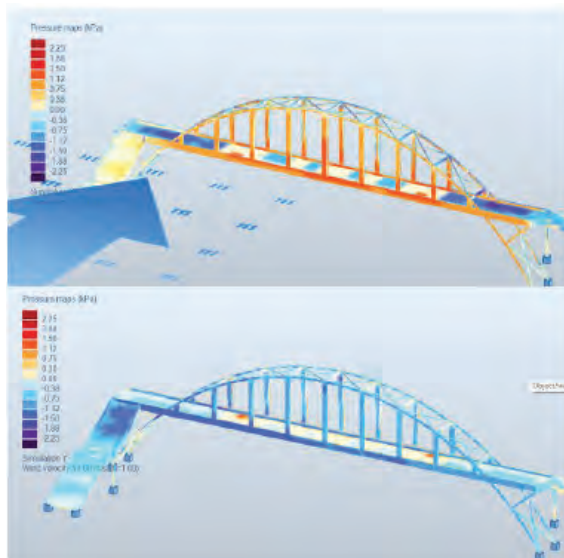


Fig. 2: Wind Load Simulation

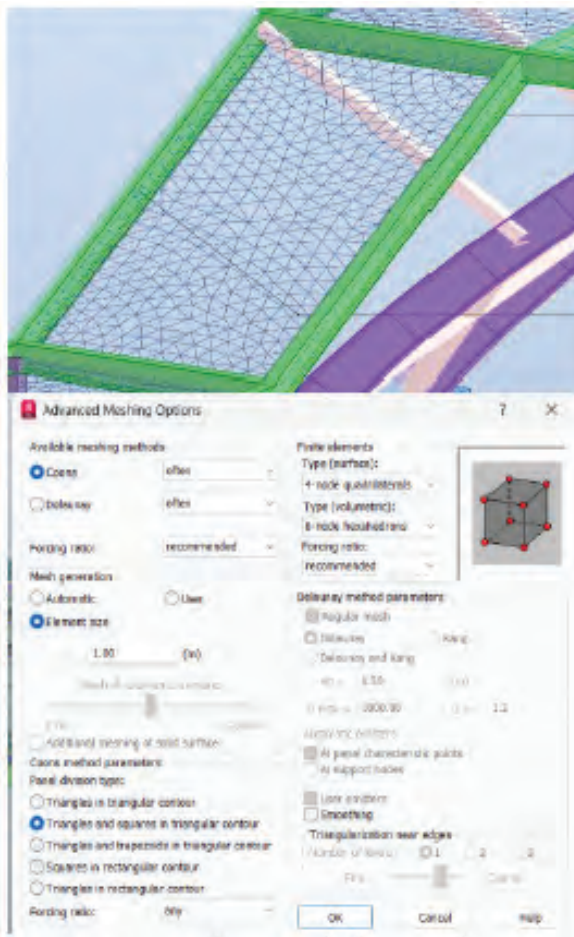


Fig. 3: Complex Finite Element mesh generation

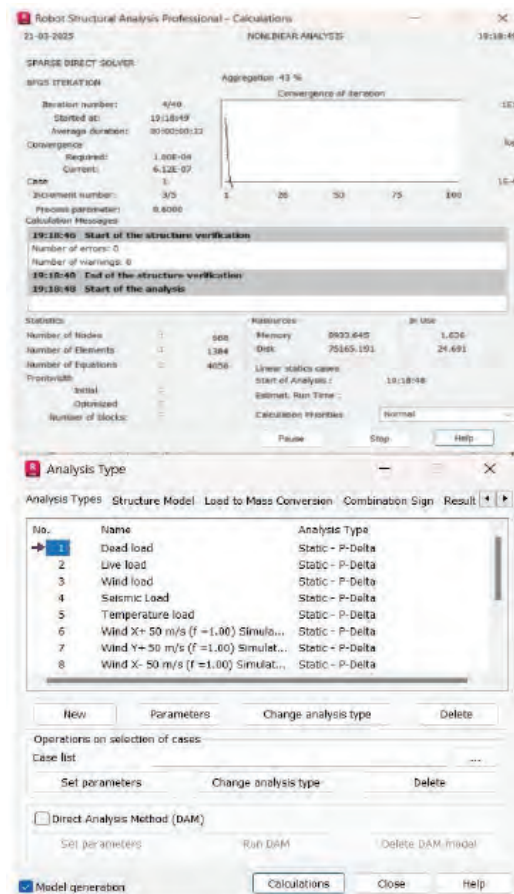


Fig. 4: P-Δ Geometric Non-linear analysis

Iterative Process: Successive substitutions using stiffness matrices to compute nodal Figure 5. P-Δ Geometric Non-linear analysis

Iterative Process: Successive substitutions using stiffness matrices to compute nodal displacements and internal forces. Convergence of nonlinear analysis was achieved through a BFGS iterative solver, as depicted in the convergence chart, with a required tolerance of $1E-4$ and final convergence in under five iterations. This iterative method recalculates stiffness matrices to account for structural deformations, thereby refining the nodal displacement and internal force vectors through successive substitutions.

RESULT EVALUATION

The analysis integrates geometric non-linearity and P-Δ (P-Delta) effects, which are crucial for capturing secondary moments due to axial forces acting through lateral displacements, deformation in non-linear models.

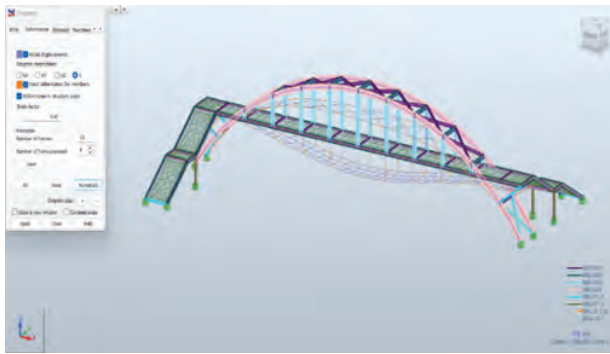


Fig. 5: Displacement cause deformation on deck slab

This refers to the maximum horizontal displacement along the X-axis, which occurs at Node 238. For the deck slab, this indicates lateral movement caused by horizontal loads as wind or seismic forces. Excessive displacements cause deformation in the deck slab. Longitudinal shifts (UZ) misalign the connections between the deck slab and supporting elements, compromising the integrity of the bridge. The maximum displacements were within acceptable serviceability limits (e.g., 4 mm in the Y-direction and 2 mm in Z). Internal force and moment results showed peak values of 314.05 kN axial force and 93.34 kNm moment, confirming the structural adequacy under complex loading. Stress evaluation using principal and component stress criteria revealed maximum compressive and tensile values well within material yield limits (e.g., 161.91 MPa in Smax and -75.04 MPa in Smin), ensuring safety and stability. By incorporating geometrical nonlinearities and an iterative stiffness-updating solver, the RSAP platform proves to be a robust tool for simulating realistic behaviours in complex structures, enhancing both design precision and safety assessment.

Steel Design: as per IS 800-2007 arch bridge components are designed after the geometric nonlinear analysis of 40 iterations and adopted suitable sections.

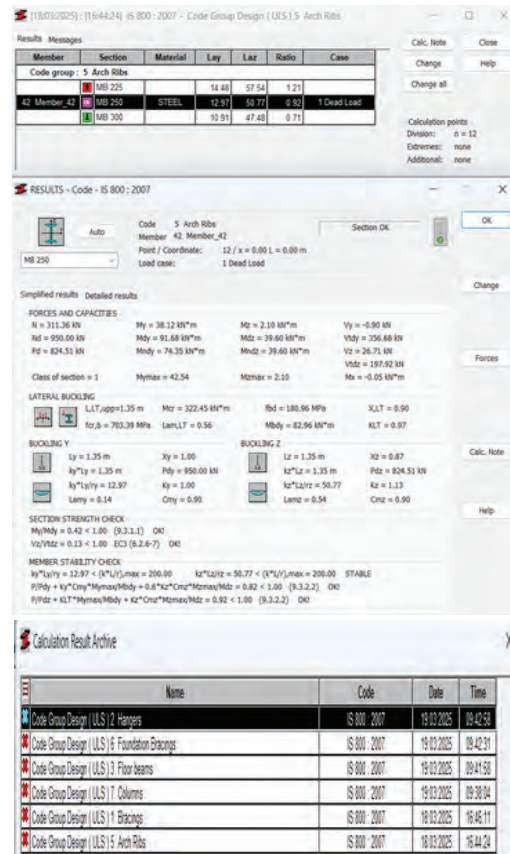
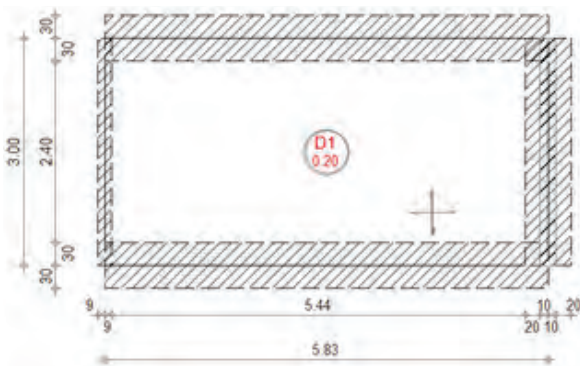


Fig. 6. Steel Design of bridge components

The structural analysis results for Member 42 (Arch Rib), showing it meets IS 800:2007 code requirements with safety margins against buckling (Lateral, Y, Z) and stability checks. The section strength and lateral-torsional buckling criteria are satisfied. For the MB 125 (La/Lz Ratio: 1.05) - Not OK for use as the ratio exceeds 1.0, indicating it does not meet design criteria. MB 150 (Ratio: 0.84) - OK for use since the ratio is less than 1.0 and MB 175 (Ratio: 0.55) - Good for use due to its low ratio, indicating a more conservative and safe design.

Concrete Deck slab Design

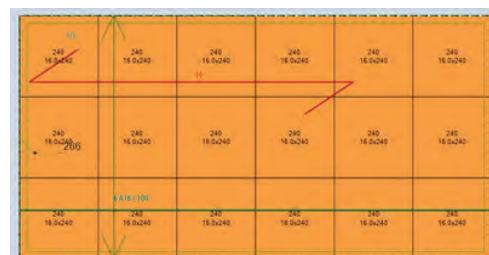


Fig. 7. Deck slab Concrete Design

The design detailing of a deck slab for a pedestrian footbridge, focusing on reinforcement optimization. Detailing solution No. 1 results in a total reinforcement weight of 863.09 kg. Bottom reinforcement includes 16 mm bars at 100 mm spacing in the Ax direction and 12 mm bars at 100 mm in Ay, providing areas of 2011 mm²/m and 1131 mm²/m respectively. Top reinforcement mirrors the bottom configuration with identical bar sizes and spacing. The design ensures structural efficiency while maintaining uniform reinforcement distribution in both directions.

Connections Design: Welds between the column and the base plate are analysed for stress. Normal Stress: $\sigma_1 = 35.11$ MPa; Perpendicular Tangent Stress: $\tau_1 = 35.11$ MPa. Tangent stress parallel to $V_{n,e}^d, \gamma$ and $V_{n,e}^d, \alpha$ is $\tau_{xx} = 6.25$ MPa for both directions. Resistance coefficient β_v is 0.80, factored based on stress calculations. Stress values are derived following guidelines [4.5.3.(7)].

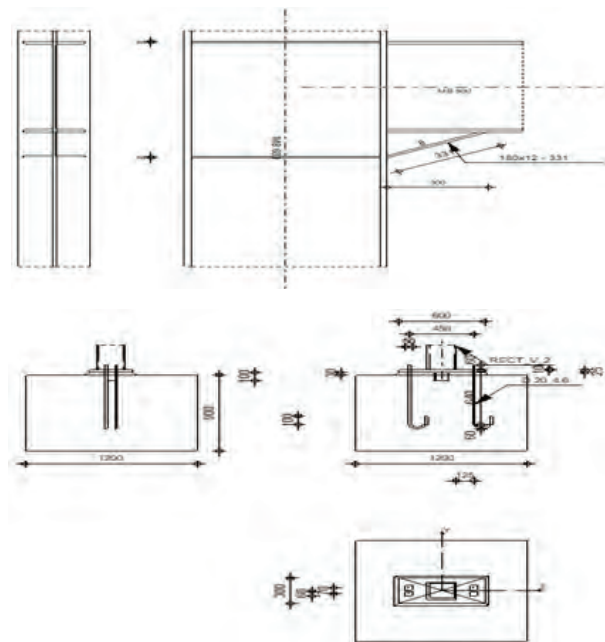
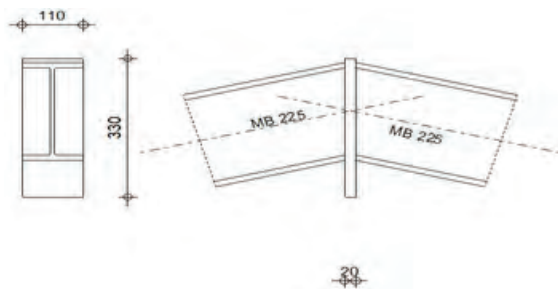
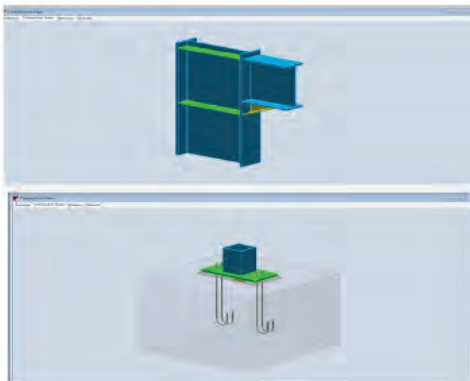
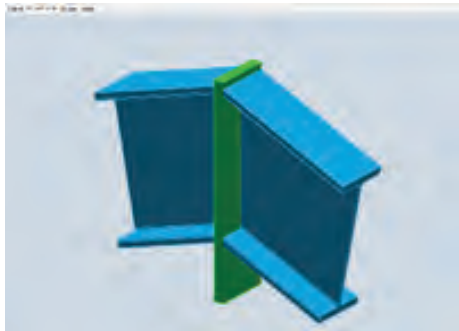


Fig. 8: Connection Design a) Beam to Beam b) Column to beam c) column to base

CONCLUSIONS

The composite arch foot bridge designed for an expressway with eight lanes and high average daily traffic (ADT > 50,000) defines exceptional load-carrying capacity, achieving equilibrium through iterative, nonlinear analysis procedures. The majority of the load is effectively carried by axial compression within the arch ribs, resulting in reduced shear forces and localized bending moments near the supports and points of load application. The iterative use of Robot Structural Analysis (RSA) for nonlinear analysis led to the optimization of reinforcement and steel section requirements, reducing material consumption.

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Analysis and Design of Retrofitting of an Apartment Building with Viscous Dampers using ETABS

Ila Vamsikrishna

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ ilavamsikrishna@gmail.com

K. Anirudh Reddy

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ rkanirudh26@gmail.com

C. Divya

Dept. of Humanities and Science
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ divyac@gmail.coms

C. Ganeswar Reddy

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ gcreddy@gmail.com

ABSTRACT

This study concentrates on the seismic retrofitting of a G+4 reinforced concrete (RC) building using viscous dampers to improve a structure its ability and reduce earthquake-induced forces. The structure is modelled and analyzed in ETABS following IS 1893:2016 seismic provisions for Zone 2 on medium soil conditions. The key objective is to minimize lateral displacement, inter-story drift and overall structural vibrations by placing X-shaped viscous dampers at failure locations. A step-by-step methodology is used to analyses various damper placement scenarios by evaluating story shear, story displacement and response spectrum. Based on the analysis results in ETABS, only selective places dampers are installed in locations where they provide maximum energy dissipation and structural stability. A relative study is performed between the non-retrofitted and retrofitted models to assess seismic performance improvements, showing a significant reduction in structural forces and lateral displacement. This study focuses on the placement of dampers that can improve seismic performance during an earthquake without the need to reconstruct of total structure. This research contributes advancement of seismic retrofitting methods, offering a structured framework for optimized damper placements in mid- rise buildings with modern earth quake resistant design standards.

KEYWORDS: *Seismic retrofitting, ETABS analysis, Viscous dampers, Lateral displacement, Inter-story drift, Structural stability, Damper placement, Earthquake resistance.*

INTRODUCTION

As urban infrastructure ages and seismic activity remains a determined threat, the retrofitting of existing structures has become a critical engineering problem. A lot of apartment buildings were designed using outdated codes that didn't completely account for modern seismic forces. Retrofitting these structures increases their performance and excellent occupant safety and extends their life span. One of the most effective methods for seismic retrofitting is the use of viscous dampers, which develop energy expenditure and reduce structural reaction in the course of earthquakes. These dampers work by transferring kinetic energy into heat through fluid motion, after reducing lateral displacements and internal force stresses on structural elements.

This study focuses on the analysis and design of retrofitting an apartment building with viscous dampers using ETABS, a generally used structural analysis software. The technique involves evaluating the seismic value of the existing structure, designing a perfect damping system, and extending improvements in building performance. Key parameters such as inter-story drift, base shear, and structural period are examined before and after retrofitting.

METHODOLOGY

- ❖ **Data Collection (Plans):** Collect existing plans and other required data of the existing structure.
- ❖ **Model Creation in AutoCAD:** Create the structure layout in AutoCAD, viewing the placement of beams and columns.

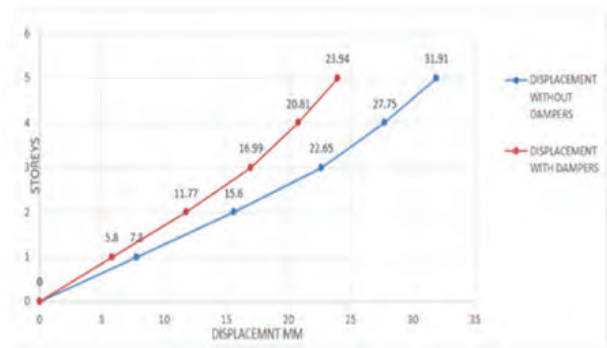
- ❖ Preliminary Design (Manual): Do initial calculations and design manual to get a basic idea of the existing structure.
- ❖ Structural Modelling in ETABS: Use ETABS software to design a virtual model of the existing structure.
- ❖ Load Calculations: Calculate the loads that the structure must be – involving dead load live load, and seismic load.
- ❖ Retrofit Design (Dampers): Choose where the failure locations occurs to placed dampers in that positions.
- ❖ Detailing of Retrofit: Generate detailed drawings and specifications for installing the dampers.
- ❖ Check for Result and Conclusion: Evaluate the results from the model to see if the retrofitting is successful, and write the conclusions.

STORY	LOCATION	DISPLACEMENTS	
		WITHOUT DAMPERS	WITH DAMPERS
ROOF	TOP	25.394	17.96
STORY 4	TOP	22.644	15.61
STORY 3	TOP	18.523	12.74
STORY 2	TOP	12.48	8.77
STORY 1	TOP	6.2	4.39
BASE	TOP	0	0

RESULTS AND DISCUSSION

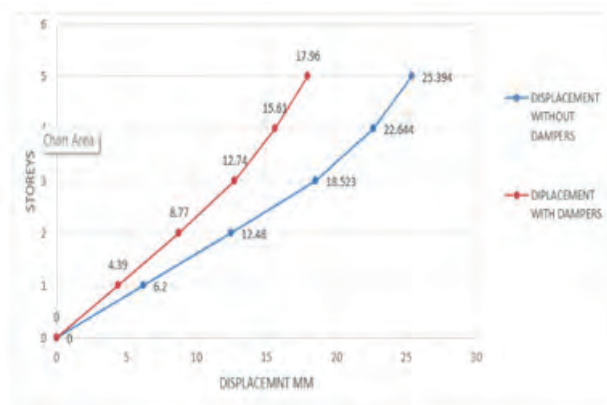
Comparison of story displacement of models with respect to static analysis

STORY	LOCATION	WITHOUT DAMPERS DISPLACEMENTS	WITH DAMPERS DISPLACEMENTS
ROOF	TOP	31.91	23.94
STORY 4	TOP	27.75	20.81
STORY 3	TOP	22.65	16.99
STORY 2	TOP	15.6	11.77
STORY 1	TOP	7.8	5.8
BASE	TOP	0	0



The graph and table shows the story displacements between the each story. The highest peak point is 31.91 without dampers and after dampers it decreases to 23.94.

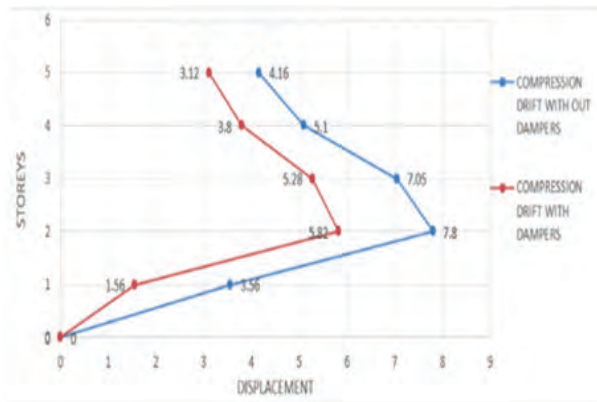
Comparison of story displacement of models with respect to dynamic analysis



The graph and table shows the story displacements between the each story. The highest peak point is 25.394 without dampers and after dampers it decreases to 17.96

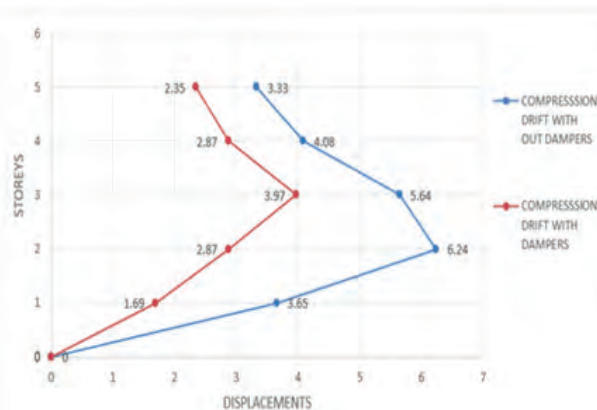
Comparison of story drift of models with respect to static analysis

STORY	STORY DRIFT	
	WITHOUT DAMPERS	WITH DAMPERS
ROOF	4.16	3.12
STORY 4	5.10	3.81
STORY 3	7.05	5.28
STORY 2	7.8	5.82
STORY 1	3.56	1.56
BASE	0	0



The graph and table shows the story drift between the each story. The highest peak point is 4.16 without dampers and after dampers it decreases to 3.12.

Comparison of story drift of models with respect to dynamic analysis

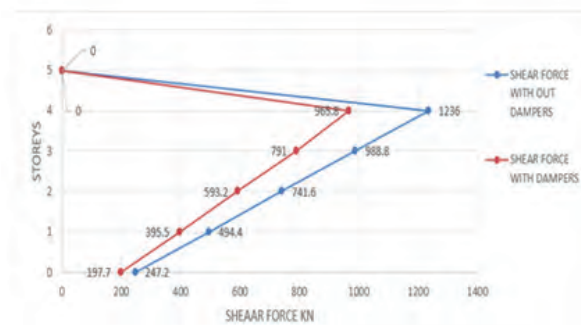


STORY	STORY DRIFT	
	WITHOUT DAMPERS	WITH DAMPERS
ROOF	3.33	2.35
STORY 4	4.08	2.87
STORY 3	5.64	3.97
STORY 2	6.24	2.87
STORY 1	3.65	1.69
BASE	0	0

The graph and table shows the story drift between the each story. The highest peak point is 3.33 without dampers and after dampers it decreases to 2.35.

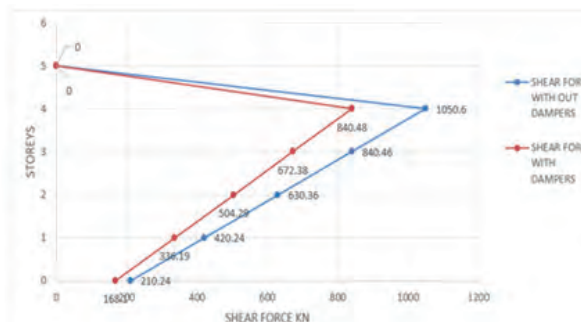
Comparison of story shear of models with respect to static analysis

STORY	SHEAR FORCE	
	WITHOUT DAMPERS	WITH DAMPERS
ROOF	0	0
STORY 4	1236.0	965.8
STORY 3	988.8	791.0
STORY 2	741.6	593.2
STORY 1	494.4	385.5
BASE	247.2	197.7



The graph and table shows the story shear between the each story. The highest peak point is 1056.6 without dampers and after dampers it decreases to 840.48.

Comparison of story shear of models with respect to dynamic analysis



STORY	SHEAR FORCE	
	WITHOUT DAMPERS	WITH DAMPERS
ROOF	0	0
STORY 4	1050.6	840.48
STORY 3	840.46	672.38
STORY 2	630.36	504.29
STORY 1	420.24	336.19
BASE	210.24	168.1

Design and Performance Comparison of RCC and CFST Floating Column Structures Using ETABS

K. Varshasri

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ kattamanchivarshasree@gmail.com

S. Vijay Balaji

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ vijayb45@gmail.com

Dasari Aruna

Dept. of Humanities and Science
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ dasriar97@gmail.com

Y. Yuva Sai Ganesh

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ yuvasai234@gmail.com

ABSTRACT

This study will compare and contrast the structural performance of different building configurations under gravity and lateral load employing ETABS software. Four models will be considered: (i) RCC structure without floating columns, (ii) RCC structure with floating columns, (iii) CFST composite structure without floating columns, and (iv) CFST composite structure with floating columns. The equivalent static method will be employed in the analysis. The CFST columns will be modeled so that the composite action between steel and concrete is accounted for. The study will compare and analyze the bending moment and shear force developed in beams and columns in all the models to find the impact of CFST systems and floating columns on structural efficiency. The results will give insights into efficiency and potential in adopting CFST columns in modern structure design.

KEYWORDS: *RCC & CFST columns, Floating columns, ETABS, SAFE.*

INTRODUCTION

The extensive application of vertical growth in urban buildings has required the utilization of space-efficient and structurally efficient systems. The evolution of these developments includes the application of floating columns as a typical architectural solution to attain the maximum floor space, especially in residential and commercial buildings. Their application does alter the load path, introducing discontinuities that impact seismic performance.

Concrete-Filled Steel Tubes (CFST) offer an acceptable replacement for conventional Reinforced Cement Concrete (RCC) columns through the combination of steel's strength and ductility with concrete's compressive strength. CFST composite columns increase structural stability, particularly under seismic lateral loads due to earthquake. CFST columns are increasingly gaining popularity in seismically active regions due to their

capability to improve energy dissipation, reduce member size, and increase load-carrying capacity.

This study takes into account the comparative study of CFST and RCC composite structures with and without floating columns in a Seismic Zone II G+10-storey residential building. By maintaining the same geometric and loading parameters in all the models, the study attempts to quantify differences in performance based on key structural parameters. The study also explores how CFST systems can mitigate adverse effects of floating columns and strive towards improved structural safety and efficiency.

MATERIAL AND STRUCTURAL SPECIFICATIONS

CFST Columns: Modelled as steel tubes filled with concrete, with properties defined per IS 11384:1985 and relevant international standards for composite construction.

RCC Columns: Designed using M30 grade concrete and Fe415 grade steel.

Floating Columns: Introduced on the specified level to assess their influence on load distribution and lateral behaviour.

METHODOLOGY

The study is conducted through a comparative structural analysis of four distinct building models:

- ✓ RCC structure without floating columns
- ✓ RCC structure with floating columns
- ✓ CFST composite structure without floating columns
- ✓ CFST composite structure with floating columns

Each model represents a G+10 story building with an identical floor plan and load configuration, situated in Seismic Zone II as per IS 1893:2016 guidelines. The primary focus is on the single-floor level where floating columns are introduced to observe localized structural effects.

Table 1: Parameters

Parameter	Value
Number of Storeys	G+10
Seismic Zone	Zone II (as per IS 1893:2016)
Structure Types	RCC and CFST
Floating Columns	Provided on one intermediate floor
Column Materials	M30 Concrete (RCC), CFST (Concrete-Filled Steel Tube)
Beam and Slab Material	M30 & 25 concrete
Steel Grade	Fe415 for RCC, Structural Steel for CFST
Analysis Type	Equivalent Static Method
Load Combinations	As per IS 456 and IS 1893
Soil Bearing Capacity (SBC)	200 kN/m ²
Slab/Footing Thickness	450 mm
Concrete Grade	M30
Steel Grade	Fe415
Foundation Type	Isolated and Combined Footings

STRUCTURAL ANALYSIS USING ETABS

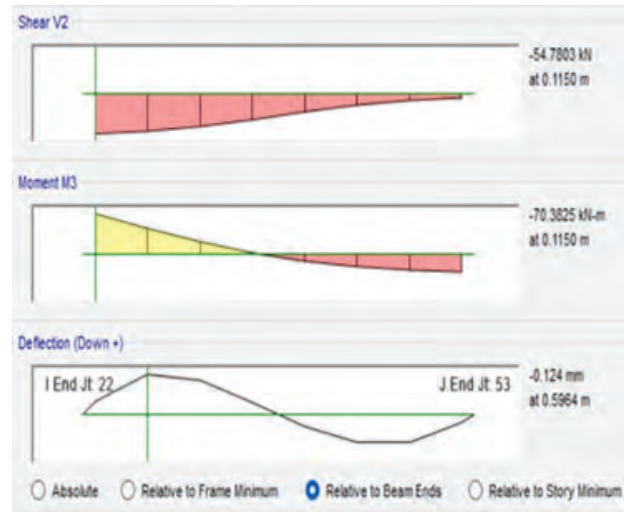


Fig. 1: SF and BM for CFST without Floating column

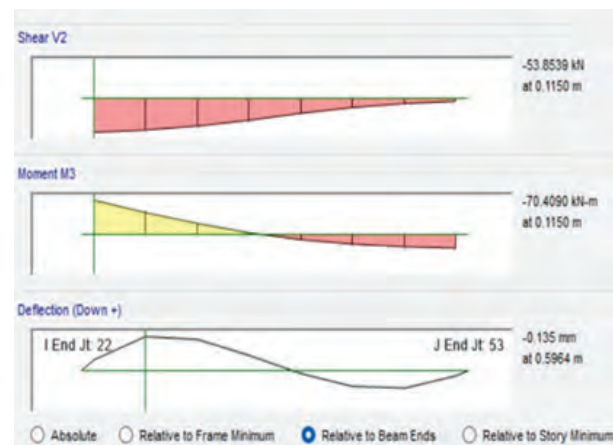


Fig. 2: SF and BM for CFST with floating column

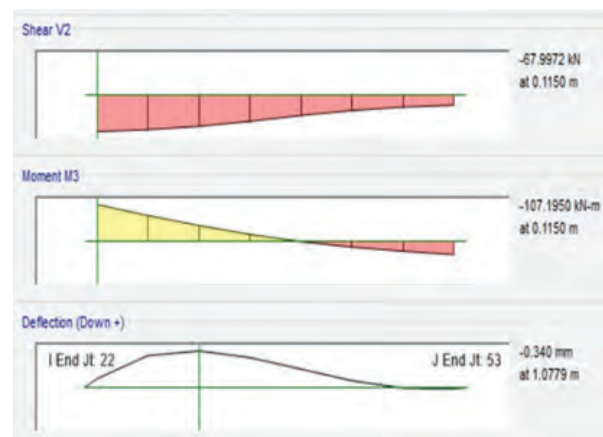


Fig. 3: SF AND BM FOR RCC with out floating column

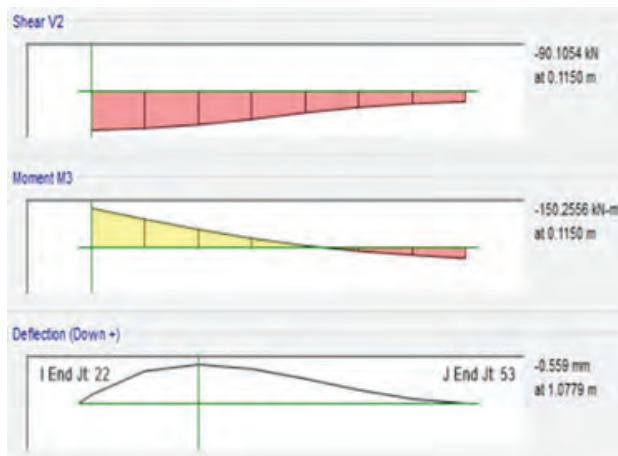


Fig. 4: SF and BM FOR RCC with floating column

Base Shear: RCC models showed higher base shear values due to greater mass and rigidity.

Bending Moment & Shear Force: Increased substantially in models with floating columns, especially in RCC structures. CFST helped reduce these effects.

Floating Column Effect: Induced discontinuity in load paths, but CFST showed better energy dissipation and load redistribution.

FOUNDATION ANALYSIS USING SAFE

Soil Pressure: Maximum observed value was $\sim 30 \text{ kN/m}^2$, well below the safe bearing capacity of 200 kN/m^2 .

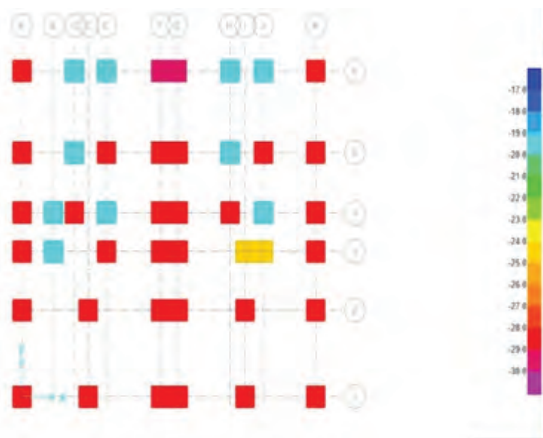
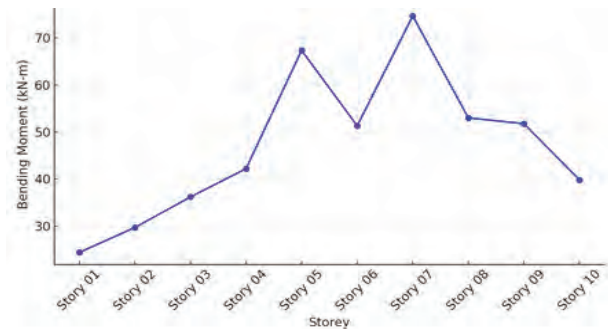


Fig. 5: Soil pressure results

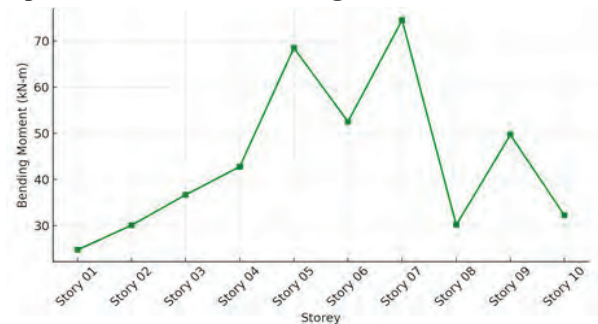
RESULTS AND DISCUSSION

Comparative Analysis of Bending Moment (KN-m) Across Storeys for CFST and RCC Structures With and Without Floating Columns

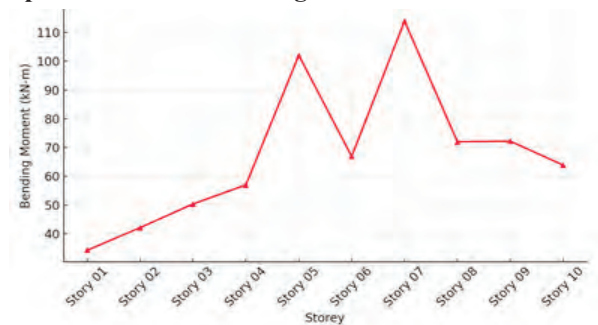
No of Stories	CFST Without Floating Column	CFST With Floating Column	RCC Without Floating Column	RCC With Floating Column
Story 01	24.36	24.75	34.26	36.83
Story 02	29.67	30.09	42.12	45.78
Story 03	36.18	36.69	50.34	55.17
Story 04	42.19	42.80	57.00	62.85
Story 05	67.37	68.51	102.07	114.17
Story 06	51.32	52.55	66.90	75.58
Story 07	74.70	74.57	113.95	125.33
Story 08	53.01	30.14	72.01	60.27
Story 09	51.77	49.70	72.19	69.17
Story 10	39.81	32.21	63.87	55.29



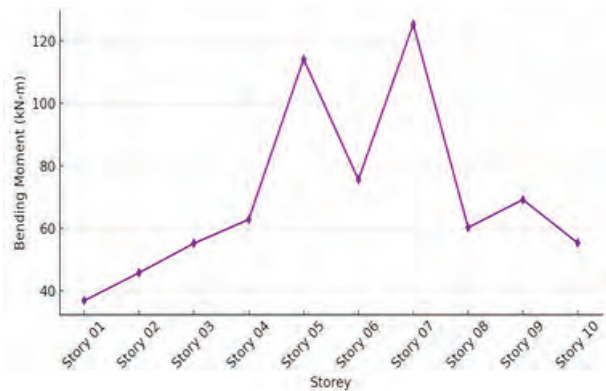
Graph 1: CFST without floating column



Graph 2: CFST with floating column



Graph 3: RCC without floating column

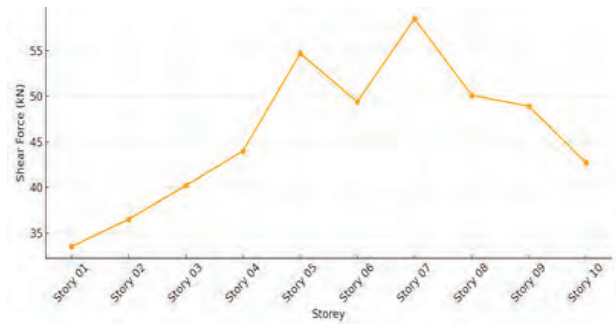


Graph 4: RCC with floating column

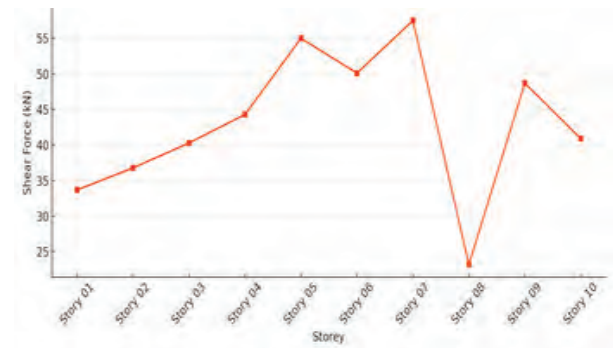
The bending moment increases from the lower stories to the middle stories (around the 5th to 7th floors) in all types of structures. This is where the structure experiences the most stress. CFST (Concrete-Filled Steel Tube) structures, both with and without floating columns, show lower bending moments compared to RCC structures, which means CFST handles the load better and more efficiently. Adding floating columns increases the bending moment in the middle floors, especially in RCC structures, due to the break in the load path. However, CFST with floating columns still maintains a balanced behavior. At higher stories, the bending moment starts to reduce in all cases as the load above decreases. This analysis shows that while floating columns make the design more complex, CFST structures offer better resistance to bending stress and are more suitable for tall buildings.

Comparative Analysis of Shear Force (kN) Across Storeys for CFST and RCC Structures With and Without Floating Columns

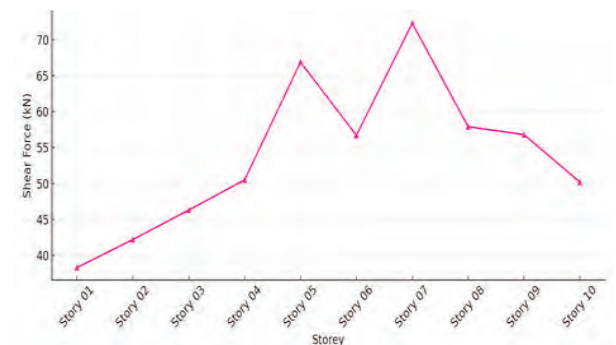
No of Stories	CFST Without Floating Column	CFST With Floating Column	Concrete without Floating Column	Concrete With Floating Column
Story 01	24.36	24.75	34.26	36.83
Story 02	29.67	30.09	42.12	45.78
Story 03	36.18	36.69	50.34	55.17
Story 04	42.19	42.80	57.00	62.85
Story 05	67.37	68.51	102.07	114.17
Story 06	51.32	52.55	66.90	75.58
Story 07	74.70	74.57	113.95	125.33
Story 08	53.01	30.14	72.01	60.27
Story 09	51.77	49.70	72.19	69.17
Story 10	39.81	32.21	63.87	55.29



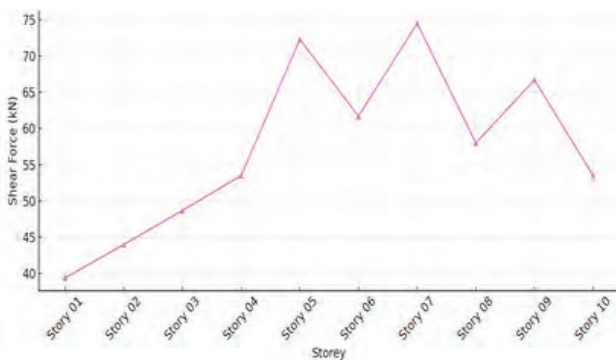
Graph 5: CFST without floating column



Graph 6: CFST with floating column



Graph 7: RCC without floating column



Graph 8: RCC with floating column

For floating column-free CFST structures, the shear force increases gradually up to the 5th story, where it is maximum, showing good load transfer and stability. When floating columns are introduced, the trend of shear force is the same but reduces significantly at the 8th story, showing a little disruption in the load transfer. But it is restored soon, showing the system is capable of handling changes. RCC structures with or without floating columns possess more shear forces, especially in middle stories, showing they are stronger and stiffer. Floating columns add additional shear force at certain stories like the 5th and 9th. As a whole, CFST structures perform well in shear forces, especially in high-rise buildings, and also handle changes well even with floating columns.

CONCLUSION

The comparison of the RCC and CFST structures shows that CFST is superior in bending moment and shear force, especially for multi-story buildings. RCC structures possess higher bending moments, mostly in the middle floors (5th to 7th), and even higher when floating columns are added. CFST structures possess lower bending moments, i.e., they resist loads better and lower stress. With respect to shear force, CFST buildings possess a gradual increase up to the 5th floor and remain stable even when floating columns are added. There is a slight drop on the 8th floor, but the system is able to bear it. RCC structures, however, possess higher shear forces, mostly in the middle and top floors, and the forces are even higher when floating columns are added. CFST structures, overall, are superior in the bearing of both bending and shear forces. CFST is superior and more efficient than RCC and is an even

better choice for high-rise buildings even when complex elements like floating columns are added.

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Experimental Investigation of Paver Blocks Using Plastic Strips Extracted Form Waste Cement Bags

P. Narendra Reddy

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ pnr127ce@gmail.com

C. Ranjith

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ ranjithranjithrams@gmail.com

B. Gopal Naik

Dept. of Humanities and Science
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ gopalnaik.sri@gmail.com

A. Praveen Kumar

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ praveenachi93@gmail.com

ABSTRACT

This study will compare and contrast the structural performance of different building configurations under gravity and lateral load employing ETABS software. Four models will be considered: (i) RCC structure without floating columns, (ii) RCC structure with floating columns, (iii) CFST composite structure without floating columns, and (iv) CFST composite structure with floating columns. The equivalent static method will be employed in the analysis. The CFST columns will be modeled so that the composite action between steel and concrete is accounted for. The study will compare and analyze the bending moment and shear force developed in beams and columns in all the models to find the impact of CFST systems and floating columns on structural efficiency. The results will give insights into efficiency and potential in adopting CFST columns in modern structure design.

KEYWORDS: *Plastic strips, Fly ash, Mechanical properties.*

INTRODUCTION

The construction industry heavily consumes natural resources and causes environmental degradation through the use of cement and aggregates. Sustainable development demands alternatives like incorporating waste materials in construction. This study explores using Waste Plastic Strips (WPS) fibers from cement bags and fly ash from coal combustion in paver block production. WPS fibers reduce plastic pollution and enhance concrete strength and durability, while fly ash improves workability and long-term performance. Replacing cement with fly ash cuts carbon emissions and addresses waste disposal challenges. The research aims to optimize eco-friendly paver block mix designs. Using these materials conserves resources, lowers the environmental footprint, and promotes sustainable construction practices.

OBJECTIVES

To study the structural and long-term performance

properties of paver blocks enhanced with plastic strips recovered from used cement bags.

To minimize environmental impact by using non-biodegradable waste materials and reducing landfill waste.

CHARACTERISTICS OF MATERIALS

These are the following tests to be conducted on Materials to assess the Characteristics

Table 1 Test Results of Materials

S. No	Material	Specific Gravity	Fineness Modulus
1	Cement	3.13	4%
2	Fine Aggregate	2.49	Zone II Medium Sand
3	Coarse Aggregate	2.60	10mm coarse Aggregate

MIX DESIGN

Proportion for trail mix:

Cement = 416 kg/m³

Fly ash = 104 kg/m³

Water = 208 kg/m³

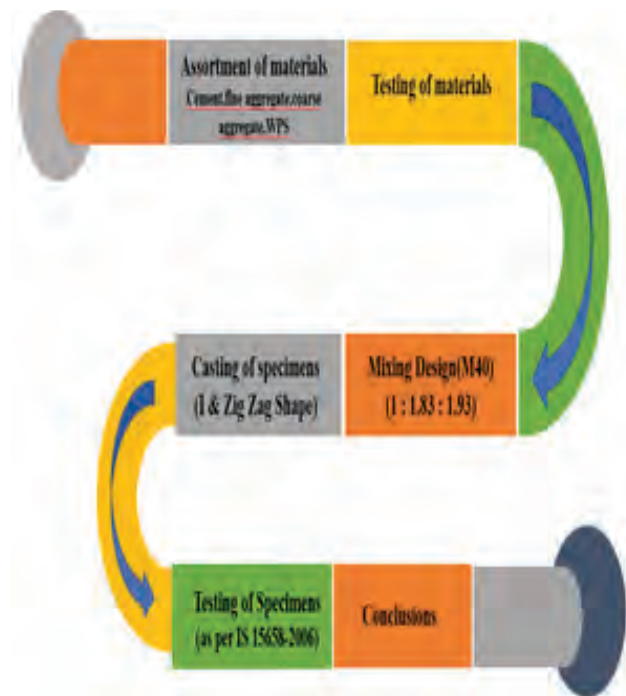
Fine aggregates = 761.49 kg/m³

Coarse aggregates = 803.413 kg/m³

W/C ratio = 0.4

Concrete Mix Ratio 1: 1.83: 1.93 (Cement: Sand: Coarse Aggregate) with W/C = 0.40

METHODOLOGY



EXPERIMENTAL INVESTIGATION ON PAVER BLOCKS

Water Absorption Test (IS 15658:2006 ANNEX C):

This procedure accurately determines water absorption by comparing the specimen's weight in fully saturated and thoroughly dried conditions. After completing the drying process, record the dry weight (W_d) to the nearest 0.01N.

Formula:

$$\text{Water Absorption} = \frac{W_w - W_d}{W_d} \times 100$$



Fig. 1: During Water Absorption Test

Compressive Strength Test (IS 15658:2006 ANNEX B):

This procedure ensures accurate and consistent measurement of compressive strength under standardized testing conditions.

$$\text{Compressive Strength} = \frac{\text{Applied Maximum Load}}{\text{Surface Area of the Specimen (by cardboard method)}}$$



Fig. 2: During Compressive Strength Test

Split tensile strength test (IS 15658:2006 ANNEX F)

This method ensures accurate evaluation of tensile

splitting strength by applying a uniform load along the weakest axis.

Formula:

$$T=0.637 \times k \times (P/S)$$

Where:

T = Tensile strength (MPa), P = Failure load (N), S = Failure area (mm²), k = shape factor.



Fig. 3: During Split Tensile Strength Test

Flexural Strength Test (IS 15658:2006 ANNEX G):

This method accurately measures flexural strength by applying a uniform central load to simulate bending stress until failure.

Formula:

$$F_b = \frac{3pl}{2bd^2}$$

Where:

F_b = flexural strength (N/mm²), P = maximum load (N), l = distance between supporting rollers (mm), b = average width of block (mm), d = average thickness (mm).



Fig. 4: During Flexural Strength Test

Impact Load Test (ACI committee 544):

This test evaluates the material's toughness by measuring its ability to absorb repeated impact energy until failure.

Formula:

$$\text{Impact Energy (E}_{\text{imp}}) = (0.5mv^2) n$$

here;

m = mass of the hammer, n = number of blows, V = impact velocity.



Fig. 5: During Flexural Strength Test

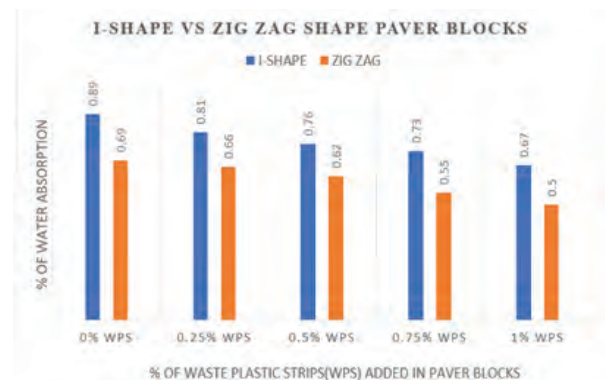
RESULTS AND DISCUSSIONS

Comparative Results For I Shape Vs Zig Zag Shape Paver Blocks

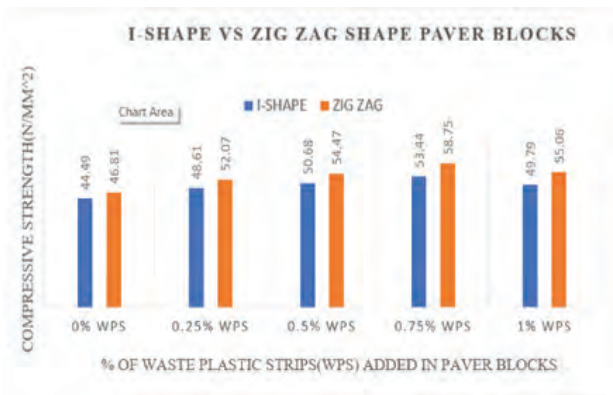
I Shape	Normal	0.25 %	0.50 %	0.75 %	1.00 %
Water absorption %	0.89	0.81	0.76	0.73	0.67
Compression (N/mm ²)	44.49	48.61	50.68	53.44	49.79
Tensile (N/mm ²)	2.15	3.32	3.48	3.56	2.95
Flexure (N/mm ²)	4.83	6.58	6.91	7.81	6.63
Impact (KN/mm ²)	406.90	528.97	732.42	1118.97	1810.70

Zig Zag shape	Normal	0.25 %	0.50 %	0.75 %	1.00 %
Water absorption %	0.69	0.66	0.62	0.55	0.50
Compression (N/mm ²)	46.81	52.07	54.47	58.75	55.06
Tensile (N/mm ²)	1.69	3.06	3.15	3.50	3.15
Flexure (N/mm ²)	3.97	5.01	5.08	6.05	5.14
Impact (KN/mm ²)	305.17	447.59	691.73	1078.28	1729.32

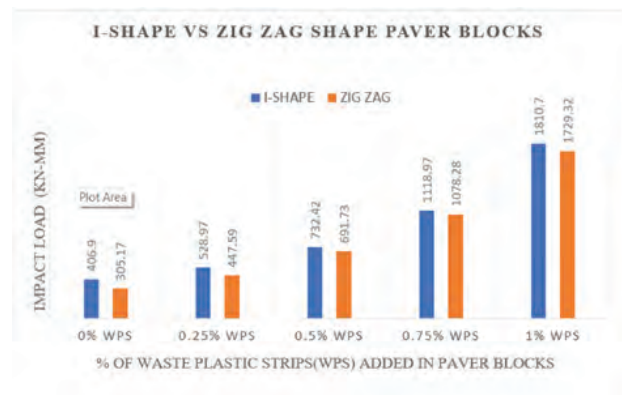
Comparative Graphs For I Shape Vs Zig Zag Shape Paver Blocks



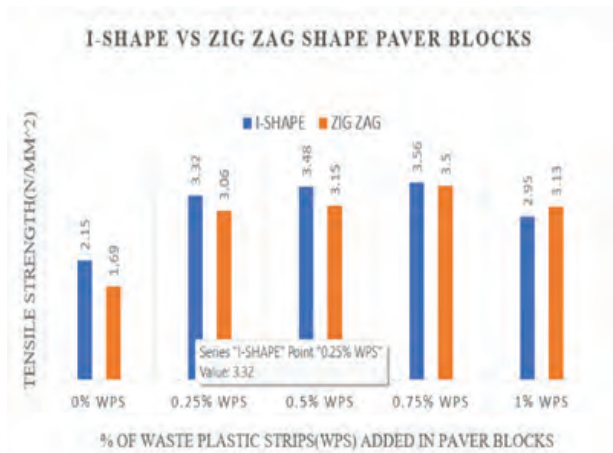
Graph 1 - Comparative Graph for Water Absorption Test for I Shape Vs Zig Zag Shape Paver Blocks



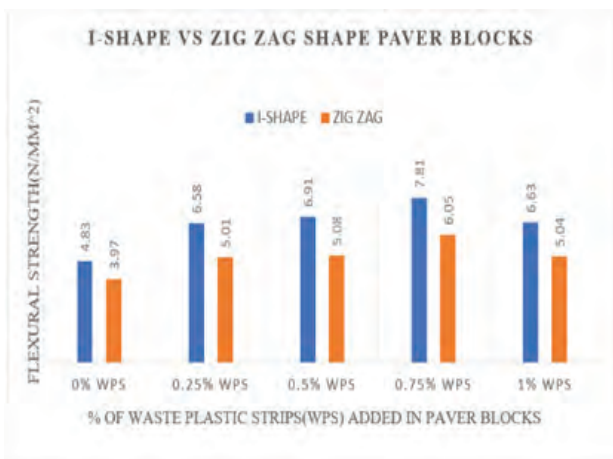
Graph 2 - Comparative Graph for Compressive Strength Test for I Shape Vs Zig Zag Shape Paver Blocks



Graph 5 - Comparative Graph for Impact Load Test for I Shape Vs Zig Zag Shape Paver Blocks



Graph 3 - Comparative Graph for Tensile Strength Test for I Shape Vs Zig Zag Shape Paver Blocks



Graph 4 - Comparative Graph for Flexural Strength Test for I Shape Vs Zig Zag Shape Paver Block

CONCLUSIONS

The incorporation of plastic strips into paver blocks has led to the following conclusions:

The zig-zag shape exhibited a lower water absorption capacity compared to the I-shape, signifying that the structural design of the I-shape allows it to retain moisture more effectively.

The zig-zag shape shows higher compressive strength than the I-shape at an optimum of 0.75% WPS, indicating improved load-bearing and mechanical performance.

At 0.75% WPS, the tensile strength of both the I-shape and zig-zag shape was nearly identical, portentous similar resistance to stretching under optimal conditions.

With 0.75% WPS, the I-shape shows higher flexural strength than the zig-zag shape, offering better resistance to bending and greater durability under stress.

The impact resistance of both I-shape and zig-zag blocks improved with the addition of up to 1% WPS, indicating a greater ability to resist impact forces.

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Pick and Place ARM Gripper

K. Vinay Kumar

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ k.vinaykumar349@gmail.com

K. Rakesh

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ rakeshk78@gmail.com

S. Guru Sai Kamal

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ gurusaiakamal22@gmail.com

C. Sanhith Reddy

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ reddysanhithc@gmail.com

ABSTRACT

In the modern era, reducing human involvement in repetitive and dynamic tasks has become increasingly essential. To address this, intelligent machines have been developed that can replicate human actions with greater efficiency and speed. Robots are now being deployed across diverse domains such as agriculture, defense, space missions, industrial automation, healthcare, smart living environments, and more. A notable example is the pick-and-place robot, which is engineered to identify, grasp, transport, and release objects as per predefined commands. These robots are built by integrating programmable hardware components that enable motion control and task execution. Typically, an object is positioned on the surface, and the robotic arm is activated either through voice inputs or gesture-based commands. The voice control system functions based on pre-programmed speech instructions, allowing the robot to interpret and carry out verbal directives. Gesture recognition, on the other hand, involves predefined hand movements that correspond to specific robotic actions. These movements trigger the robotic arm to operate along designated axes, enabling it to perform tasks such as lifting and relocating items

KEYWORDS: *Arduino UNO, Pick and Place Robot, TCS3200 colour sensor.*

INTRODUCTION

To simplify daily routines and reduce manual effort, technology—whether automated or semi-automated—has become an indispensable tool. However, life can be even more seamless when technology is designed to be hands-free. Enabling human-machine interaction through voice commands, gestures, and other intuitive inputs can significantly enhance user experience. Although advanced robots with such capabilities already exist, they remain largely inaccessible to the general public due to their high cost.

Our aim is to develop affordable, smart robotic systems that are not only cost-effective but also user-friendly. The vision is to create intelligent bots composed of basic components like wires and circuits, yet capable of functioning as realistic personal assistants. These robots would utilize voice commands, text input, gesture sensors,

and accelerometers to interpret and respond to human instructions. Among these, **gesture-controlled robots** offer an innovative alternative to traditional button-operated systems by allowing control through natural hand movements.

This research explores the development of a robotic arm designed for versatile manufacturing tasks in a cost-efficient and adaptive manner. The robotic system is capable of sorting objects based on physical characteristics—particularly color—under white light illumination. The arm is composed of key hardware components including a color sensor, power supply, DC servo motors, a precision gripper (end-effector), and an ATmega microcontroller for coordinating motor and sensor operations. The color sensor identifies the object's hue, and based on the predefined color codes, the robotic arm adjusts its joints and actuators to accurately grasp and place items in the correct category.

LITERATURE REVIEW

Harish K et al. (2017) implemented a system wherein signals were extracted using an Arduino board and transmitted to a receiver to verify and execute instructions sent to the controller. Once the commands were decoded and stored in a data variable, the algorithm processed the opcode and enabled the robot to identify its location and the target object, using DC motors mounted on a mobile chassis. In a similar domain, Kaustubh Ghadge et al. (2018) utilized the NodeMCU module from Microchip Technology as the central controller for a pick-and-place robotic arm, where commands were issued via an Android application. The design incorporated CAD-modeled components and emphasized the use of pneumatic systems for better functionality.

Vishakha Borkar et al. (2017) developed a cost-effective robotic system tailored for industrial pick-and-place tasks. The focus was on using a simplified robotic platform that could perform object manipulation within constrained budgets. Radouan Ait Mouha et al. (2021) extended the field by exploring deep learning applications in robotics, particularly emphasizing how deep neural networks have been increasingly employed to solve complex robotic control and perception problems beyond the traditional scope of computer vision and machine learning research.

Neeraja R et al. (2018) introduced a mobile-controlled pick-and-place robotic arm that utilized the XLR8 development board, an FPGA-based microcontroller programmable via the Arduino IDE. The system integrated Bluetooth modules, motor drivers, and batteries to ensure seamless Android-based control. Similarly, Kumar Aaditya et al. (2015) proposed a prototype robotic arm vehicle for pick-and-place operations. Although limited in load-bearing capacity at the time, the authors suggested that integrating high-torque motors could potentially enable the handling of heavier objects, such as explosive devices in hazardous environments.

Mahesh Mahajan et al. (2023) presented a cost-effective robotic arm system designed specifically for handling sheet metal parts and lightweight industrial objects like cartons, plastic, and leather items, offering a practical alternative to more expensive industrial robots. Lastly, Hardik A. Modi et al. (2015) developed a robotic solution for automating the pick-and-place process of CNC lathe components. The study highlighted the role of automation technologies such as PLCs and numerical control in minimizing human intervention and enhancing industrial efficiency.

PROBLEM STATEMENT

The designed pick-and-place robot aims to assist in tasks such as transporting heavy goods, sorting items, and performing repetitive industrial operations. Traditionally, the manual handling of heavy objects poses a significant risk of injury, especially when performed over extended periods. By introducing automation through robotic systems, the need for human workers to bend, lift, or carry substantial loads is eliminated, thereby minimizing workplace injuries and significantly improving overall productivity.

In industrial settings, human errors—whether minor or major—can result in substantial losses of time, resources, and capital. Automation helps mitigate these issues by ensuring consistent and error-free operation. Pick-and-place robots enable industries to automate the movement of objects from one location to another with high precision and efficiency. Tasks involving simple actions such as lifting or transferring items do not require advanced cognitive skills. Hence, assigning such repetitive duties to human workers may not be the most efficient use of labor. Instead, these tasks can be delegated to robotic systems, allowing human resources to focus on more complex and decision-based operations.

To further enhance their capabilities, pick-and-place robots are often integrated with sensing and machine vision systems. These additions enable the robots to detect, track, and pick up items accurately, even from moving conveyor belts, making them highly suitable for dynamic manufacturing and packaging environments.

METHODOLOGY

The proposed framework described in this paper incorporates a combination of hardware and software components, including the Arduino IDE, Embedded C programming, an Arduino microcontroller, Bluetooth module, relay, DC motors, L293D motor driver IC, robotic arm, IP webcam, fire sensor, microphone, and a buzzer. The system architecture is structured to efficiently control and automate a robotic pick-and-place mechanism, with the functional block diagram illustrating the complete setup.

The robotic platform utilizes four motors: two for the locomotion of the vehicle, one dedicated to the movement of the robotic arm, and one for operating the gripper mechanism. Mechanical push-button limit switches are employed to define the upper and lower movement limits

of the robotic arm and to control the open-close action of the gripper jaw. The L293D motor driver IC plays a key role in the system, enabling simultaneous control of two DC motors and ensuring reliable bidirectional motion. This driver operates on the H-bridge principle, allowing the motors to change direction by reversing the polarity of the voltage.

A voltage regulator is integrated into the system to maintain a stable operating voltage, ensuring consistent performance of all components. Command input is facilitated through a Bluetooth-enabled mobile application, which functions as a universal remote control. The Bluetooth module connected to the microcontroller interprets these signals, enabling wireless control of the robot's movements and functions.

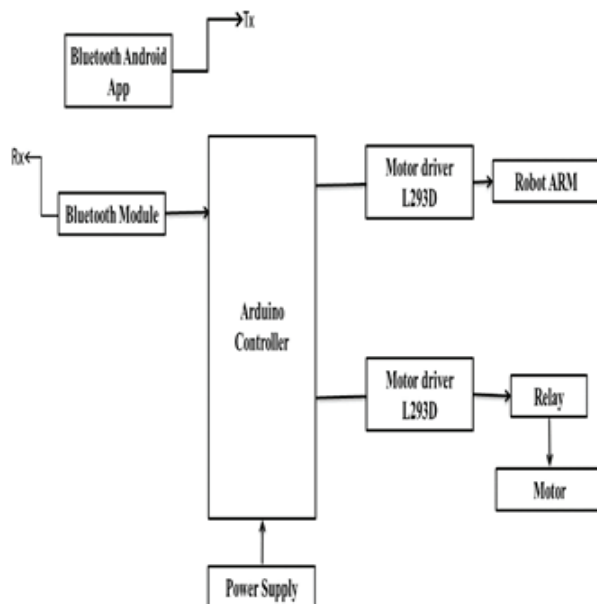


Fig. 1: Main Block Diagram

SYSTEM DESCRIPTION

Arduino UNO: The Arduino UNO is a widely used microcontroller development board based on the Atmel 8-bit AVR microcontroller series, including variants such as the ATmega8, ATmega168, ATmega328, ATmega1280, and ATmega2560. These boards differ in memory capacity, number of I/O pins, and onboard features. In addition to the 8-bit boards, the 32-bit Arduino Due, introduced in 2012, is built around the Atmel SAM3X8E ARM Cortex-M3 processor. Arduino boards typically feature single or dual-row headers to facilitate easy connectivity for programming and peripheral integration. They support

modular add-ons known as shields, which can be stacked and individually addressed using the I²C communication protocol. Most boards are equipped with a 16 MHz crystal oscillator (or ceramic resonator) and a 5V linear voltage regulator, though variants like the LilyPad run at 8 MHz and forgo onboard voltage regulation to suit specialized form factors.

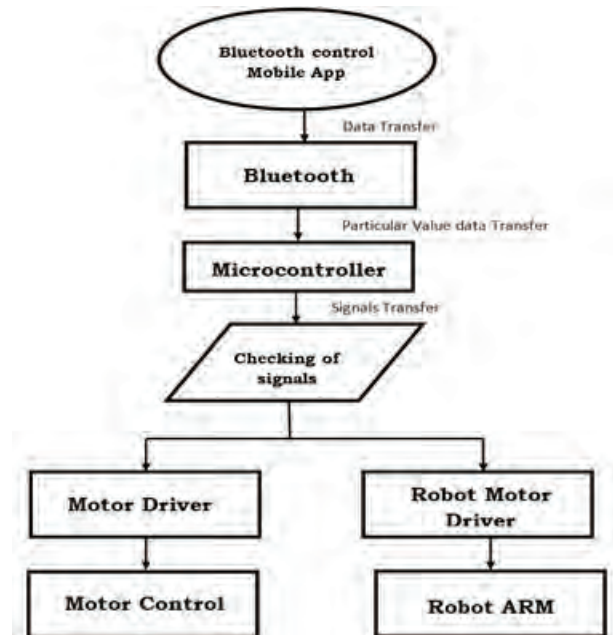


Fig. 2: Flow chart

Bluetooth Module (HC-05): The HC-05 Bluetooth module provides a simple and effective means for establishing short-range wireless serial communication between devices such as smartphones, PDAs, and computers. It operates on Bluetooth Serial Port Protocol (SPP), enabling wireless data exchange through a serial interface. Each Bluetooth-enabled device has a unique MAC address, facilitating secure pairing and identification. The HC-05 module is based on the BC417 2.4 GHz Bluetooth transceiver, developed using CMOS technology, and includes an external 8 MB flash memory. It functions on a 3.3V power supply and is well-suited for wireless control applications, such as remote operation of robots and embedded systems.

Motor Driver (L293D): The L293D motor driver is a dual H-bridge IC designed to control the direction and speed of DC motors. It is capable of delivering bidirectional current up to 1 A per channel within a voltage range of 4.5 V to 36 V, making it ideal for moderate-load robotic applications. The L293D consists of four high-current half-H drivers,

organized in pairs. Driver pairs are enabled using 1,2EN for the first set and 3,4EN for the second. Each output comprises a full totem-pole drive circuit, with a Darlington sink and pseudo-Darlington source configuration. The IC is specified for operating temperatures between 0°C and 70°C, offering reliable performance in standard ambient conditions.

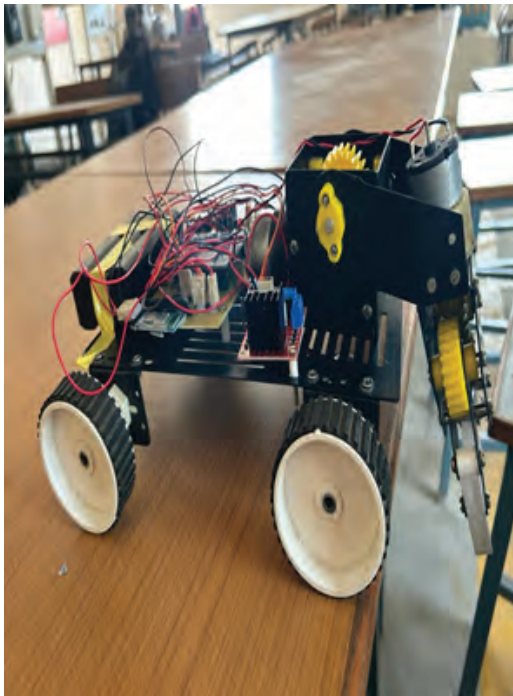


Fig. 3: View of Pick and Place Robot

IP Webcam: The IP Webcam application transforms a smartphone into a network-enabled camera that offers various viewing capabilities. It allows real-time video streaming over a local Wi-Fi network without requiring an active internet connection. The live feed can be accessed on any platform using a VLC media player or standard web browser, providing cross-platform compatibility. The application also supports optional cloud broadcasting, enabling global access to the video stream. Additionally, two-way audio communication is supported through applications like tiny Cam Monitor when used on another Android device. IP Webcam is compatible with third-party MJPG-based applications, including video surveillance systems, security monitoring tools, and even some audio players, making it a versatile component for real-time monitoring and control applications.

Android Application: In this framework, an Android-based mobile application serves as the interface for transmitting

voice commands to the robotic system via Bluetooth. The decision to utilize the Android operating system is driven by its wide adoption, customizable interface, and seamless integration with advanced services such as Google's Speech Recognition API. The Android platform offers a robust environment for real-time speech processing, ensuring accurate command interpretation and reliable connectivity. Its flexibility and ease of development make it ideal for implementing wireless human-robot interaction through voice control.



Fig. 4: Actual Setup of the Pick and place ROBOT

CONCLUSION

In summary, voice-controlled robotic systems hold significant promise for future applications in both industrial and domestic environments, particularly in the automation of routine tasks. The proposed system demonstrated reliable performance during testing, with Bluetooth-based communication proving to be efficient and maintaining an acceptable response time. The integration between the microcontroller and the Bluetooth module functioned effectively, though minor inaccuracies in voice command recognition were observed. Overall, the system presents a cost-effective and user-friendly solution for hands-free robotic control, paving the way for further enhancements in human-machine interaction.

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Heart Disease using Random Forest

S Thejaswini

Electronics and Communication Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ sthejaswini14@gmail.com

ABSTRACT

Heart disease is the most dangerous disease in the world. There are most people who are suffering from heart diseases like CHD, congenital heart disease, arrhythmias, etc. Throughout the world, 17 million people are affected by this disease, and 695,000 are dying. In order to avoid such diseases, our study determines the machine learning techniques that are used to predict heart disease in a person. Some of the techniques we have used to explore heart disease, i.e., random forests, using this technique, we achieved an accuracy of 90.26% for RF (Random Forest).

KEYWORDS: *Random forests (RF), Machine learning, Google colab, Symptoms.*

INTRODUCTION

Machine learning can be defined as the prediction and detection of data. ML can be used in pattern recognition, fraud detection, social media, speech recognition, Healthcare, Autonomous vehicles ...etc. ML has various techniques that can be used to identify the heart disease i.e. which type of heart disease does the person have. The ML can be mostly used to health care industry. The random forest technique that can be used to combine 2 or more outputs of decision tree to form single output. Random forest is the efficient technique utilized for determining the classification of heart disease. Random forest is a supervised learning, as the supervised learning does not require label.

LITERATURE REVIEW

Over the years, significant research has been Since many years the research on heart disease using data mining technology. The applications of data mining used to find heart disease. Our research paper characterize that some of the previous papers which was done by the authors [1] Madhumita pal, Smita Parija, they implemented the data mining techniques like RF (Random Forest) for predicting the heart disease, 93.3% of accuracy they achieved. [2] Kompella Sri Charan, Kolluru S S N S Mahendranath, they compared the data mining techniques like SVM, RF, DT, Ada Boost, utilized UCI repository dataset 93.16% of accuracy they obtained.

[3] Jaishri Pandhari Wankhede, Palaniappan, Magesh Kumar S, they achieved 82% of accuracy using RFM (Random Forest Model), Hybrid Random Forest Model (HRFM) in Linear model of 87% accuracy.

PROPOSED METHOD

In this method, we collect data from patients to predict heart disease to accomplish best result of accuracy. Based on the data, collected from patient this type of method used to find heart disease at early stage. We use python libraries to implement our ideas, such as numpy, pandas, sklearn. The dataset has 270 data collected from patient and have 14 attributes. If we found any null values the data preprocessing will remove the duplicates from the dataset. Dataset is in the form of CSV.

STEPS TO BE FOLLOWED

Collection of data. From patient, the data needs to be collected such as age, gender, BP, Cholesterol, CPT... etc.

Preprocessing data. The preprocessing data will remove the null data from the dataset.

Separation of data. Separation of data can be separated as training and testing, training data 70%, testing data 30%.

Training. Training is a huge dataset that is utilized to train a ML model.

Testing. After Training, the model then the testing dataset will test the data which was hidden.

Random Forest. Random Forest (RF) model in machine learning (ML) are efficacious for heart disease prediction. The RF model handles, sophisticated relationships between input feature and target variable.

Model Prediction. Based on the trained model, RF used to predict the likelihood of heart disease.

Model Evaluation. The evaluation metrics like accuracy, precision, recall, F1-score are to be calculated.

Results. The result can analyse, how the model evaluation metrics are performed.

Deployment. After the model is satisfied, then deploy in real life applications like healthcare.

Dataset Collection

The model's dataset includes information on age, gender, sex, type of chest pain, resting blood pressure, serum cholesterol, blood sugar levels, fasting, maximum heart rate, exercise-induced angina, exercise-induced ST depression, number of major vessels, slope of the peak exercise, and Thallium. The model that forecasts the existence or absence of heart disease uses the dataset. The dataset is stored in CSV format.

Age	Sex	Chest Pain Type	BP	Cholesterol	EKG Results	Max HR	Exercise Angina	ST Depression	Slope of ST	Heart Disease
70	1	4	130	322	2	109	0	2.4	2	Presence
67	0	3	115	564	2	160	0	1.6	2	Absence
57	1	2	124	261	0	141	0	0.3	1	Presence
64	1	4	128	263	0	105	0	0.2	2	Absence
74	0	2	120	269	2	121	0	0.2	1	Absence

Fig. 2. Dataset Collection

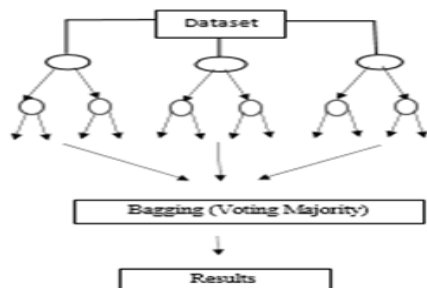


Fig. 3: Random Forest Algorithm

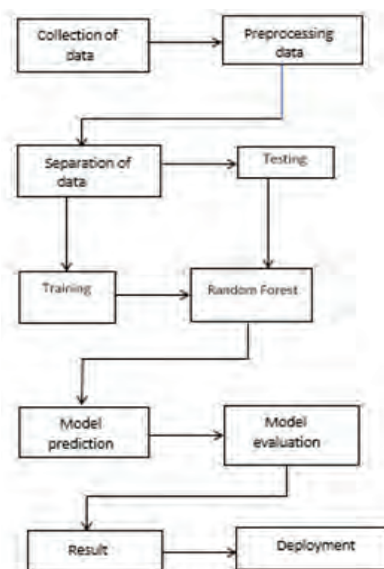


Fig. 1: Flow chart for the proposed work

Random Forest

Random forest (RF) is an ensemble machine learning technique. RF is a supervised learning (requires label). RF is combination of classification and regression. Random forest is a classifier, it holds a number of decision trees on different types of subsets of the given dataset and improves the efficiency of accuracy of the dataset.

RESULT AND DISCUSSION

The table displays the outcomes that were obtained through the application of random forest. The evaluation metrics that were employed to determine the f1-score, recall, accuracy, and precision. The FP is computed by precision (P). The TP is computed by recall(R). The recall and precision average are given by the F1-Score. The formulas for evaluation metrics are tabulated in table 1.

Table 1

Parameter	Formula
Precision (P)	$(TP)/(TP+FP)$
Recall (R)	$(TP)/(TP+FN)$
F1-score	$(2*P*R)/(P+R)$

Table 2

Algorithm	Random Forest
Precision	79.31%
Recall	76.66%
F1-score	77.47%
Accuracy	80.26%

The comparison of performance of evaluation metrics are tabulated in table 2.

Table 3

Algorithm	TP	TN	FP	FN
Random Forest	23	29	6	7

The confusion matrix using random forest is tabulated in table 3.

DEPLOYMENT

The deployment of heart disease utilizing flask/Django website. We have included 13–14 characteristics that can be used to predict whether heart disease would develop or not. The machine learning can determine whether or not an individual has cardiac disease based on the information they submit. The result reads “You have a heart disease” if the user has heart disease. The output reads “You do not have heart disease” if the user does not have heart disease.

Field Label	Dataset Attribute	Description
Age	Age	Age Of The Patient (In Years)
Sex	Sex	Gender (1 = Male, 0 = Female)
Cp	Cp	Chest Pain Type (0 To 3)
Trestbps	Trestbps	Resting Blood Pressure (In Mm Hg)
Chol	Chol	Serum Cholesterol (In Mg/Dl)

Fbs	Fbs	Fasting Blood Sugar > 120 Mg/Dl (1 = True, 0 = False)
Restecg	Restecg	Resting Electrocardiographic Results (Values 0, 1, 2)
Thalach	Thalach	Maximum Heart Rate Achieved
Exang	Exang	Exercise-Induced Angina (1 = Yes, 0 = No)
Oldpeak	Oldpeak	St Depression Induced By Exercise Relative To Rest
Slope	Slope	Slope Of The Peak Exercise St Segment (0, 1, 2)
Ca	Ca	Number Of Major Vessels (0–3) Colored By Fluoroscopy
Thal	Thal	Thalassemia (1 = Normal, 2 = Fixed Defect, 3 = Reversible Defect)

Fig. 4: Deployment Output

CONCLUSION

The need to create a system that can reliably and effectively anticipate heart disorders has arisen from the rise in heart disease-related fatalities. The goal of the study was to identify the best machine learning algorithm for heart disease identification. Using data from the UCI machine learning repository, this study analyses the accuracy scores of Random Forest algorithms for heart disease prediction. The study's findings show that, with an accuracy score of 80.26% for heart disease prediction, the Random Forest algorithm is the most effective one.

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Analysis and Design of 400 KV Transmission Tower in Staad Pro Software

P Vishnu Priya

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ vishnupriya0026@gmail.com

A Jagadeeswar Reddy

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ jagadeeswarrdy@gmail.com

Y Dattatreya

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ dattatreya@gmail.com

R Damodhar

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ damodharr3@gmail.com

ABSTRACT

Transmission towers are commonly used for supplying electricity to various locations of the country. Electricity demand has led to increase in building power houses, substations which requires transmission tower towers and transmission lines for supplying generated electricity to different corners of the country. While designing transmission towers need to consider many factors in structural point of view. Among them bracing system plays a crucial role in the design of transmission tower. In the present study, different bracing systems with different sectional properties are analysed and designed. Bracing system considered in this project are X, inverted K bracing and combination of both. Total of six models are compared for displacement, weight of the towers, maximum axial force and moment carried by the towers. It is observed that transmission tower with inverted K bracing with angle sectional properties of different sizes performs better when compared to other bracing system with channel sections. When weight of the tower is compared, channel sections are more economical when compared to angle sections transmission towers.

INTRODUCTION

In every country, the need of electric power consumption has continued to increase, the rate of demand being greater in the developing countries. Transmission tower lines are one of the most important lives – line structures. Transmission towers are necessary for the purpose of supplying electricity to various regions of the country. This has led to the increase in the building of power stations and consequent increase in power transmission lines from the generating stations to the different corners where it is needed. Interconnections between systems are also increasing to enhance reliability and economy. Transmission line should be stable and carefully designed so that they do not fail during natural disaster. While planning and design of a transmission line, a no of requirements has to be met from both structural and electrical point of view. From the electrical point of

view, the most important requirement is insulation and safe clearance of the power carrying conductors from the ground. The cross section of conductor, the spacing between conductors, and the location of ground wires with respect to the conductors will decide the design of towers.

The major components of a transmission line consist of the conductor, ground wires, insulation, towers and foundation. Transmission towers are the most visible component of the bulk power transmission system. Transmission of power through cable is uneconomical. Therefore, overhead lines are predominantly used. The design of Power Transmission line tower depends on, voltage that needs to be transmitted, location of tower and its environment, wind zone, deviation angle and material specification. After fixing the basic dimensions of tower, the next design step is to provide the structural

strength for calculated loading conditions and possible impacts. The structure must meet above requirements in the most economical in the possible way.

Types of Towers: The selection of most suitable types of towers for transmission lines depends on the actual terrain through which the line traverses. The following types of towers are generally suitable for most of the terrain conditions.

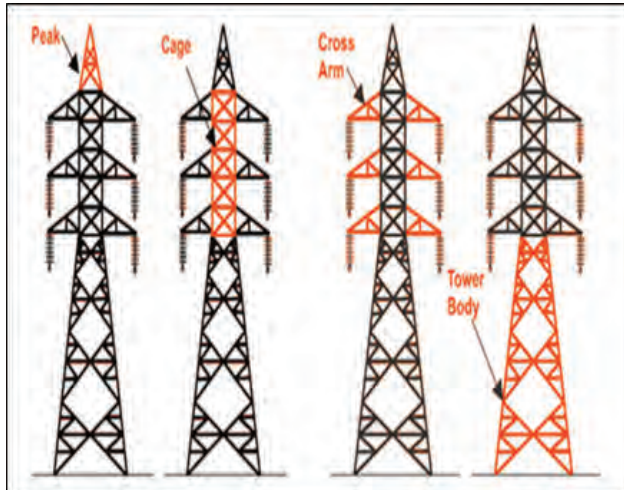


Fig. 1: Components of Transmission Tower

- I. **Suspension Towers:** Suspension towers are used primarily on tangents but often are designed to withstand angles in the line up to two degrees or higher in addition to the wind, ice, and broken-conductor loads. If the transmission line traverses relatively flat, Featureless terrain, 90 percent of the line may be composed of this type of tower.
- II. **Tension Towers:** As they must resist a transverse load from the components of the line tension induced by this angle, in addition to the usual wind, ice and broken conductor loads, they are necessarily heavier than suspension towers.
- III. **Special Towers:** These types of towers are used at locations such as those involving long span rivers and valley crossings, creek crossings, power line crossing etc. falling on transmission line route.

LITERATURE REVIEW

1. Pyounghwa Kim (2025) Wrote a Journal the title is simplified design of power transmission tower. In this Journal the author studied about the strategic

variable analysis study. Structural aspects such as deformation, elastic buckling strength, and load-carrying capacity were examined concerning the inclination angle of the tower body to explore opportunities for shape reduction. This journal source is from Science Direct.

2. B. Rohini and etal (2023) Wrote a Journal the title is analysis and design of transmission towers using staad pro. In this Journal the author studied about the displacement has been compared between 132kV and 220 kV transmission tower.
3. Vinay Kumar Singh (2022) Wrote a Journal the title is analysis of transmission line tower subjected to wind loading. In this Journal the author studied about the aims to design and analyse the transmission tower construction on wind load performance for a 500kV. This journal source is from Science Direct.
4. Jyoti Besra, Dr. Jitu Kujur (2023) Wrote a Journal the title is analysis and design of transmission tower using Staad. Pro v8i. In this Journal the author studied about the structural integrity and reliability of these towers are of paramount importance to ensure uninterrupted power transmission provides an overview of the analysis and design of an X-bracing transmission tower using STAAD Pro V8i, a powerful structural analysis and design software. This Journal Source is from International Research Journal of Modernization in Engineering Technology and Science.
5. Prof. P. O. Modani and Shrikant S. Warade (2024) Wrote a Journal the title is Analysis and Design of Transmission Tower using Staad-Pro. In this Journal the author studied about the Different types of transmission towers, such as lattice towers, tubular towers, and pole towers, are used based on factors such as voltage level, span length, and terrain conditions. Analysis of this transmission tower is administered using STAAD PRO The present work describes the analysis and design of a transmission line tower of 31 meters in height and 220KV double circuit viz. various parameters. The components of a transmission tower typically include tower legs, cross-arms, insulators, and hardware for attaching conductors and ground wires. This Journal Source is from International Journal of Advanced Research

in Science, Communication and Technology (IJARSCT).

METHODOLOGY

Tower Configuration Considered in this Project:

- Transmission Line Voltage: 400 kV
- Angle of Line Deviation: 0 to 15 degrees
- Terrain type considered: Plain
- Terrain Category: 2 (Normal cross-country lines with very few obstacles)
- Return Period: 50 years
- Wind Zone: 2
- Basic wind speed: 39 m/sec
- Basic wind pressure: 49.22 kg/m²
- Tower Type: Self-Supporting tower
- Tower type: B
- Tower geometry: Squared based
- No. of Circuits: Double Circuit
- Basic Span: 400 mts

Wind Load Calculation steps:

Steps for the calculation of Wind Load on Tower

- ❖ Step 1: Separation of whole tower into panels
- ❖ Step 2: Calculation of exposed area of all members
- ❖ Step 3: Calculation of the C.G of the individual blocks of the tower
- ❖ Step 4: Calculation of the circumscribed area of block shape
- ❖ Step 5: Calculation of solidity ratio (Projected area/ Circumscribed area)
- ❖ Step 6: Identify the drag coefficient from Table 5 of IS 802 (Part 1/Sec 1) - 2015
- ❖ Step 7: Identify the gust response factor from Table 6 of IS 802 (Part 1/Sec 1) - 2015, according to the height of C. G of a block from ground level
- ❖ Step 8: Calculation of total wind load
- ❖ Step 9: Separation of Loads at the top and Bottom of block based on the C. G of the block

Wind Load Calculation: Figure shows basic wind speed map of India as applicable at 10 m height above mean ground Level for the six wind zones of the country. Basic wind speed 'V_b' is based on peak gust velocity averaged over a short time interval of about 3 seconds, corresponds to mean heights above ground level in an open terrain (Category 2) and have been worked out for 50 years return period [Refer IS 875 (Part 3): 1987] India is divided into 6 wind zones. Basic wind speeds for the six wind zones (see Fig. 5) are,

Table 1: Basic wind speed

Wind Zone	Basic Wind Speed, V _b (m/sec)
1	33
2	39
3	44
4	47
5	50
6	55

Design Wind Speed, V_d: To get the design wind speed the basic wind speed is modified to include the following effects:

1. Risk coefficient, K₁
2. Terrain roughness coefficient K₂

$$V_d = V_R \times K_1 \times K_2$$

For Reliability level 1 and wind zone 2, K₁ = 1.00

For Reliability level 1 and wind zone 2, K₂ = 1.00

$V_R = V_b / K_o$ where $V_b = 39$ m/sec (For Wind Zone 2)
K_o = 1.375

$$V_R = 28.36364 \text{ m/sec}$$

Design Wind Speed, V_d = 28.36364 m/sec

Design Wind Pressure, P_d: The design wind pressure which is distributed along the height of the tower, conductors and insulators shall be determined by

$$P_d = 0.6 \times V_d^2$$

Where P_d – Design wind pressure in N/m²

V_d – Design wind speed in m/sec

$$P_d = 482.6975 \text{ N/m}^2$$

Analysis of Tower: In order to validate the design,

the tower is analyzed and designed using STAAD.PRO. Manual calculations are important for the recommendations of IS codes but the validation of these results and study of effects of these loads on the structure is also an important part to do. Analysis of the performed task is the key to success for the safe and durable serviceability of the structure under various load combinations. Based on validation of results through STAAD.PRO, the important conclusions are made.

Data Input for Analysis with STAAD.pro STAAD.pro requires data input in some form like graphical or text.

The following data was fed to STAAD.pro graphically:

1. Member lengths and locations
2. Mutual Connectivity of members
3. Supports
4. Assigning type and properties of members
5. Assignment of loads due to wind and cables

Grouping of members Following data were inserted as text:

1. Load Combinations
2. Load List for Analysis
3. Desired analysis results like Nodal displacements, Support reactions etc

Section Properties: There are Square hollow section, Tubular section, Steel angle section, Channel Section and Angle Section are most commonly used in construction of Tower. In this study We have Considered Channel Section and Angle Section for comparison between them with bracing system of K, X and combination of K and X Bracings. In this study we have designed 3 models with Channel Sections and other 3 models with Angle Section. The Angle section used for leg members are H150X150X15L, H130X130X12L, H120X120X10L, 110X110X8L, H90X90X6L. The various members used for bracing are 100X100X6L, H100X100X7L, H100X100X8L. The various members used for belt 75X75X6L, H65X65X4L, 55X55X4L, 65X65X5L, 55X55X4L. The various members are used for Cross Arms H100X100X8L, H110X110X8L, H80X80X6L, 70X70X5L, 65X65X5L, H120X120X8L, H90X90X6L. Mild steel of $f_y = 415 \text{ N/mm}^2$ is used for

all members. Fixed supports are provided as support condition. The Channel Section used for Bracings is ISMC 75. The Channel Section used for Leg Members Present in Cross Arms is ISMC 100. And the Channel Section used for Bottom Leg Members is ISMC 150.

Load Case Details: STAAD.Pro does the design on a load case by load case basis. By default, for each load case, the software carries out design at a total of many sections and finds out the highest utilization ratio amongst all sections for that case. It then moves on to the next case and follows the same procedure. If the highest utilization ratio for the second case is lesser than that obtained for the prior one, the former case is retained as critical case and the software moves on to the next one. If the utilization ratio for the second case being considered is greater than that for the first one, the second case becomes the new critical load case and it moves on to the next one. This way it scans through the entire list of cases/ combinations and the case/ combination with the highest utilization ratio is reported as the critical load case in the analysis output file along with the details of the forces at the critical section.

The load combinations and combination load cases are assigned. Then the grouping of forces is done. In order to validate the design, the tower is analyzed and designed. The total weight of the tower obtained by using STAAD.Pro is. Hence the body wind is calculated. Then the body wind is applied on the tower and the maximum compression and tension forces acting on the tower are obtained.

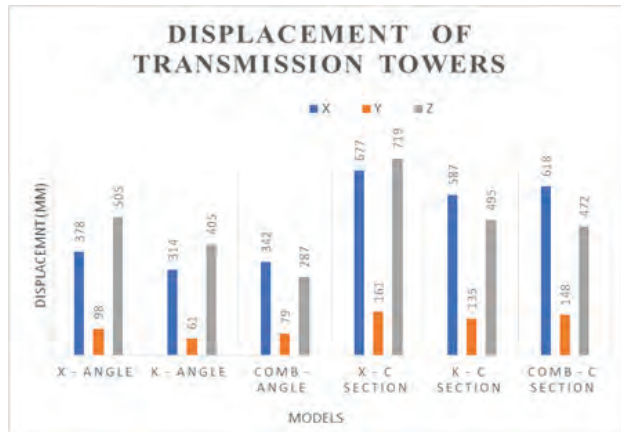
RESULT ANALYSIS

In this Study We have Designed the 6 Tower Models in Staad Pro software 3 Tower Models are with Angle Section and another 3 Models are with Channel Sections with Different Bracings of X, K and Combination of X and K Bracings. We have analyzed the both Angle Section and Channel Sections in Staad Pro, then the results like Displacements and Moments of Channel Section and Angle Section are compared.

Table. 2: Displacement values in X, Y, Z direction

Models	Displacement (mm) X direction	Displacement (mm) Y direction	Displacement (mm) Z direction
Model 1	378	98	505

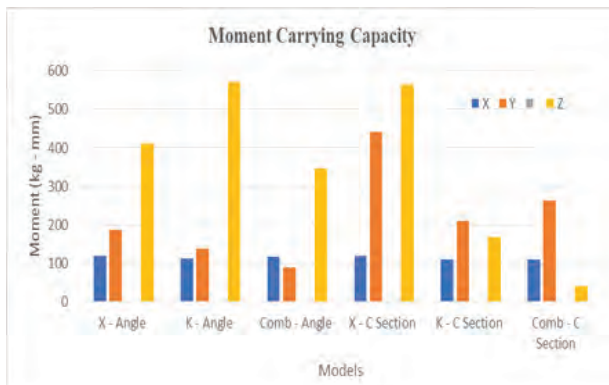
Model 2	314	61	405
Model 3	342	79	287
Model 4	677	161	719
Model 5	587	135	495
Model 6	618	148	472



Graph 1: Displacement of Transmission Towers in X, Y & Z directions

Table. 3 Moment values in X, Y, Z direction

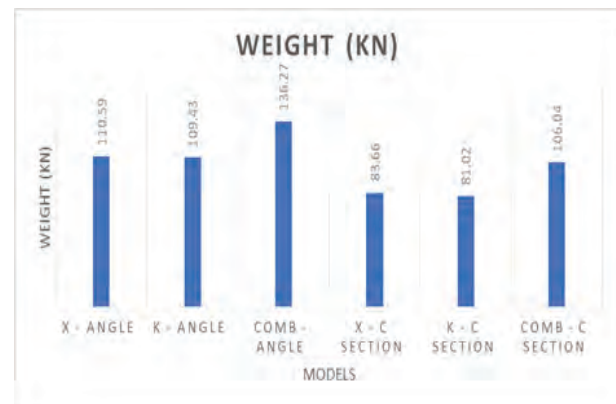
Models	Moment (kg -mm) X direction	Moment (kg -mm) Y direction	Moment (kg -mm)
Z direction			
Model 1	120	187	411
Model 2	113	137	571
Model 3	117	89	347
Model 4	120	441	564
Model 5	109	210	168
Model 6	109	262	41



Graph 2: Moment carrying capacity in X, Y & Z Directions

Table. 4 Weight of Transmission Towers

Models	Weight (kN)
Model 1	110.59
Model 2	109.43
Model 3	136.27
Model 4	83.66
Model 5	81.02
Model 6	106.04



Graph 3: Weight of Transmission tower

CONCLUSION

The design of a transmission tower is a critical engineering task that ensures the safe and reliable support of power transmission lines. The process involves structural modeling, load analysis, member design, and connection detailing while adhering to relevant codes such as IS 802 and IS 800:2007.

- Proper selection of members, bracing systems, and connections ensures the tower can withstand wind and conductor loads.
- When Bracing systems are compared K bracing system either with Angle or Channels sections performs better in terms of displacement with high moment carrying capacity
- It shows that there are significantly 47% reduction in the displacement when compared to other bracing systems
- If we compare the weights of the section, it is observed that channels sections provided for transmission towers is 22% lesser when compared to Angle sections transmission towers.

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Earthquake Resistant Design of Shopping Mall by Using STAAD.PRO

M. Sri Priya

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ Priyasrimk@gmail.com

A. Sathish Kumar

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ sathishk@gmail.com

P. Sai Suhasini

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ sai234@gmail.com

N. Vijay Kumar

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ kumarvijay@gmail.com

ABSTRACT

In India, the construction of multi-storied buildings has become increasingly common due to rising land costs and limited availability of space. When such structures are built in seismically active zones, it is essential to incorporate adequate design strategies to ensure structural stability and safety against earthquake-induced forces. This project focuses on the seismic analysis and structural design of a G+4 reinforced concrete (R.C.) building.

The structure is modeled as a three-dimensional space frame using STAAD.Pro V8i (version 14.2.4). Seismic analysis is performed using the Response Spectrum Method, following the guidelines specified in IS 1893 (Part 1): 2002, considering medium soil conditions. The building's foundation system is designed using STAAD Foundation Advanced, specifically employing isolated footings for individual columns to effectively transfer loads to the subsoil.

KEYWORDS: *Seismic analysis, Multi-storied building, Accidental loads, Earthquake resistant design, Seismic forces, Structural analysis, Seismic zones.*

INTRODUCTION

Earthquake-resistant design aims to ensure that buildings can safely withstand seismic forces by maintaining structural integrity under varying levels of ground motion. Specifically, the structure should be capable of resisting the forces generated by the Design Basis Earthquake (DBE) with minimal or no damage, and it should also endure the forces resulting from the Maximum Considered Earthquake (MCE) with acceptable structural damage but without collapse.

In this study, a G+4 reinforced concrete building is modeled as a three-dimensional space frame using STAAD.Pro V8i (version 14.2.4, Series 5). The seismic analysis is conducted using the Response Spectrum Method, based on the provisions of IS 1893 (Part 1): 2002 / 2005, considering medium soil conditions. The

Response Spectrum approach provides a more realistic representation of dynamic behavior by evaluating the structure's response across different natural frequencies.

Project Description

Table 1 Project description

Type of building	Commercial (Multi storied building)
Plot Size	140m*50m
Number of Floors	G+4
Locality of Building	Tirupati
Earthquake Zone	Zone 3
Floor Height	Hard soil
Structural System	3m
Building Height	15m

G+4 RC commercial building adopted for analysis and design; location of building assumed at Tirupati.

Research Significance

- This research holds significance in enhancing the safety and reliability of commercial structures, contributing to the development of building codes and standards.
- Earthquake analysis and design of commercial buildings in STAAD Pro are important for structural resilience and minimizing potential damage during seismic condition.

Objectives

- To model and analyze the structural components of the shopping mall by using Staad. Pro
- To get a better understanding of basic principles and prepare a seismic resistant building design by Staad. Pro
- Planning of shopping building with proper ventilation and sunlight.
- Draft the Layout of the proposed building using AutoCAD.
- To obtain the shear forces, bending moment, stress, strain and deformation or deflection for the multi-story building.

LITERATURE REVIEW

In recent years, significant research has been conducted to enhance the resilience of structures against seismic forces, particularly in earthquake-prone regions like India. Although it is currently not possible to achieve 100% protection against earthquakes, structural engineering advancements have made it feasible to minimize damage and loss through earthquake-resistant design.

Akanksha Adarsha and Rohit Savyanavar (2023) emphasize that while complete protection against seismic events remains unachievable, the integration of earthquake-resistant structural features can significantly reduce the risk to life and property. Their study provides an overview of essential design considerations and guidelines for seismic-resistant construction.

Ramesh Velivela and Siva Rami Reddy (2023) conducted a comparative study on the structural behavior of high-rise mall buildings using different framing systems. Their analysis evaluated the seismic performance of RC-framed structures, flat slabs, and post-tensioned (PT) flat slabs, offering insights into how various structural systems respond under earthquake loading.

Madhu Kumari, Vijay Kumar Shukla, and Dr. R. N. Khare (2021) focused on the seismic analysis of multistoried residential buildings, stressing the need for structures to be carefully planned and designed to withstand ground-induced vibrations. Their research underscores the importance of structural planning and analysis for ensuring safety against seismic forces.

Vinayak Kaushal (2014) highlighted the importance of preventive measures during the construction phase. His work suggests that adherence to standard seismic guidelines can effectively reduce the impact of earthquakes, particularly in vulnerable zones, potentially saving both lives and infrastructure.

Mohammad Adil Dar and Jayalakshmi Raju (2013) explored both modern and traditional techniques for earthquake-resistant construction. While current codes offer advanced methods, their study revealed that traditional building practices—being cost-effective and easier to construct—can also contribute significantly to seismic resilience, especially in rural and economically constrained settings.

METHODOLOGY

The project involves designing a modern shopping mall with a focus on functionality, aesthetics, and user experience. We provide adequate retail space for various stores and shops, ample parking facilities, and also Entertainment zones like cinemas or recreational areas. Food courts and dining areas. Easy navigation for visitors.

The general properties of the structure are outlined. The beam dimensions are specified as 0.35 meters by 0.45 meters in a rectangular shape. Column dimensions are noted as 0.4 meters in diameter for circular columns. The slab thickness is defined as 0.3 meters. These properties provide essential structural information for the design and construction process.

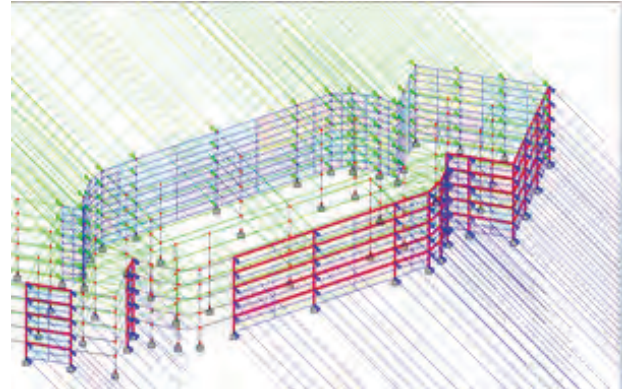


Table 3 Wind Definition

Height(m)	Intensity(kn/m ²)
5	0.7429
10	0.7429
15	0.7429

The beam end force analysis reveals critical values for axial, shear, torsion, and bending forces experienced by the beam. Notably, the maximum axial force is 183 kN and the minimum is 176 kN. Shear forces vary significantly, with a maximum of 22.7 kN and a minimum of -388.335 kN. Torsional forces are relatively low, with maximum and minimum values close to zero. Bending moments show substantial variation, with maximum values reaching 534 kN-m and minimum values at

365 kN-m. These findings underscore the importance of carefully considering and addressing structural load distributions in the design and construction of the beam to ensure structural integrity and safety.

**Fig. 4: Lateral loads (Wind+ Seismic Loads)****Table 4. Beam End force summary**

		Axial	Shear		Torsion	Bending	
	Beam	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kN-m)	My (kN-m)	Mz (kN-m)
Max Fx	183	22.7E 3	-0.064	9.027	0.000	8.875	0.090
Min Fx	176	-388.335	4.276	160.413	-0.128	-235.830	7.575
Max Fy	27	-3.646	568.178	0.000	0.481	-0.005	1.89E 3
Min Fy	66	-3.578	-568.128	0.001	0.476	0.005	1.89E 3
Max Fz	240	4.87E 3	5.472	339.222	0.193	-506.598	8.200
Min Fz	241	4.87E 3	4.996	-338.828	-0.194	505.991	7.503
Max Mx	534	1.651	-18.128	0.018	21.451	-0.039	-65.483
Min Mx	365	0.649	-18.632	0.010	-23.664	-0.022	-64.732
Max My	240	4.86E 3	5.472	339.222	0.193	511.068	-8.217
Min My	241	4.86E 3	4.996	-338.828	-0.194	-510.493	-7.485
Max Mz	27	-3.646	568.178	0.000	0.481	-0.005	1.89E 3
Min Mz	875	8.904	1.805	0.002	-3.586	0.000	-976.255

Table 5. Node Displacement summary

	Node	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rZ (rad)
Max X	322	284.854	-19.884	-0.320	285.547	-0.008	-0.001
Min X	322	-285.309	-33.188	-0.335	287.233	-0.013	0.000
Max Y	317	2.113	1.877	195.282	195.302	0.001	0.000
Min Y	324	-0.335	-132.362	-0.417	132.363	0.002	-0.000
Max Z	301	-0.230	-6.059	307.507	307.567	0.003	-0.002
Min Z	301	-0.179	-10.120	-307.979	308.145	-0.003	-0.003

Max rX	321	-0.335	-46.350	-0.385	46.353	0.020	-0.000
Min rX	322	-0.331	-46.340	-0.481	46.343	-0.020	-0.000
Max rY	329	-0.426	-8.062	263.109	263.233	0.003	0.002
Min rY	329	-0.128	-4.839	-263.782	263.826	-0.003	0.001
Max rZ	345	-0.396	-46.829	-0.483	46.833	0.002	0.013
Min rZ	319	-0.273	-46.792	-0.383	46.795	-0.002	-0.013
Max Rst	301	-0.179	-10.120	-307.979	308.145	-0.003	-0.003

The maximum displacement along the X-axis is 322 mm in the positive direction and -285.309 mm in the negative direction. Along the Y-axis, the maximum displacement is 195.282 mm in the positive direction and -132.362 mm in the negative direction. Regarding the Z-axis, the maximum displacement is 307.507 mm upwards and -307.979 mm downwards. The maximum rotation about the X-axis is 46.353 radians in the positive direction and -46.340 radians in the negative direction.

Rotation about the Y-axis has a maximum value of 263.233 radians in the positive direction and -263.782 radians in the negative direction. Lastly, the maximum rotation about the Z-axis is 46.833 radians in the positive direction and -46.792 radians in the negative direction.

RESULTS

Beam Reinforcement Details

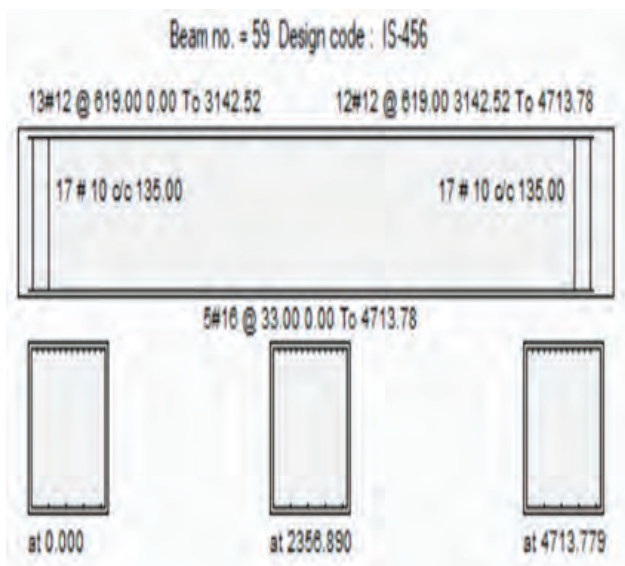


Fig 5. Beam Reinforcement Details

Column Reinforcement Details

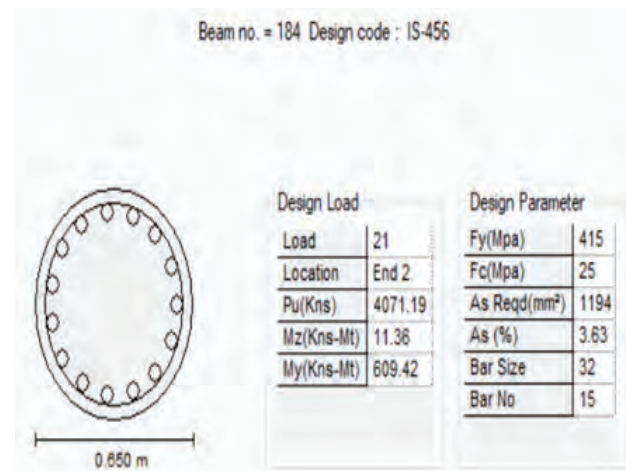


Fig 6. Column Reinforcement Details

Slab Reinforcement Details

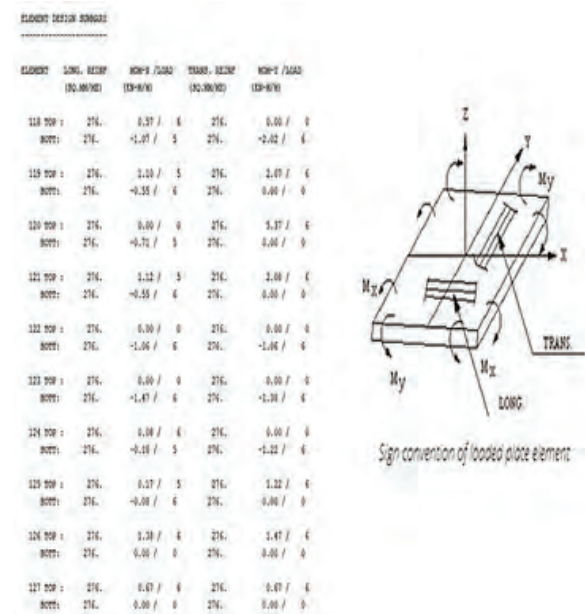


Fig 7. Slab Reinforcement Details

Foundation Design in Staad Foundation

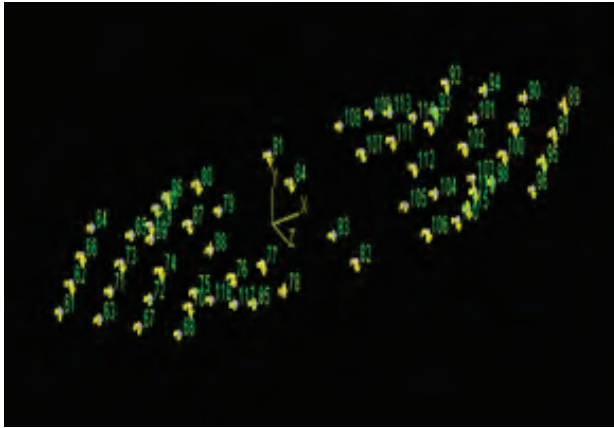


Fig 8. Foundation Plan

Table 5. Foundation Reinforcement Detailing

Footing No.		Footing Reinforcement		
-	Bottom Reinforcement (Mz)	Bottom Reinforcement (Mz)	Top Reinforcement (Mz)	Top Reinforcement (Mz)
61	Ø12 @ 65 mm c/c	Ø12 @ 65 mm c/c	Ø8 @ 50 mm c/c	Ø12 @ 65 mm c/c
62	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 60 mm c/c	Ø12 @ 65 mm c/c
63	Ø16 @ 85 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 55 mm c/c	Ø10 @ 60 mm c/c
64	Ø12 @ 65 mm c/c	Ø12 @ 65 mm c/c	Ø8 @ 50 mm c/c	Ø12 @ 60 mm c/c
65	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 60 mm c/c	Ø10 @ 50 mm c/c
66	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 60 mm c/c	Ø10 @ 50 mm c/c
67	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 60 mm c/c	Ø10 @ 50 mm c/c
68	Ø12 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 65 mm c/c	Ø10 @ 70 mm c/c
69	Ø16 @ 85 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 55 mm c/c	Ø10 @ 60 mm c/c
70	Ø16 @ 85 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 55 mm c/c	Ø10 @ 60 mm c/c
71	Ø16 @ 65 mm c/c	Ø16 @ 65 mm c/c	Ø12 @ 60 mm c/c	Ø12 @ 60 mm c/c

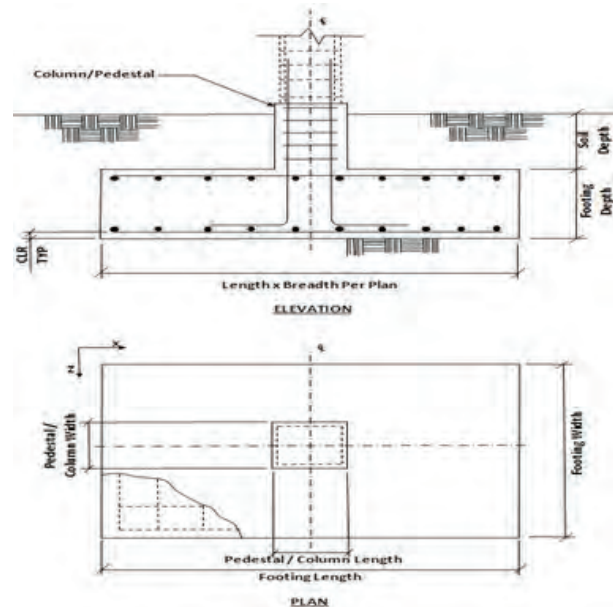


Fig 9. Foundation Reinforcement Details

CONCLUSIONS

The proposed Shopping Mall building is planned for construction in Tirupati, and its design has been developed in accordance with relevant standard specifications. The structural elements have been designed as per the guidelines provided in IS 456:2000, following the Limit State Method for reinforced concrete members.

This project has provided valuable practical exposure in the planning and design of a multi-purpose shopping complex aimed at delivering a comprehensive entertainment and retail experience under one roof. The facility is envisioned to accommodate all necessary amenities and functional requirements, aligning with modern architectural and structural standards.

Throughout the course of this project, we gained hands-on experience in the design of critical structural components such as slabs, beams, columns, and footings. Additionally, the project enhanced our proficiency in industry-standard software tools, including STAAD. Pro, STAAD Foundation, and AutoCAD, while also deepening our understanding of applicable codal provisions and their practical implementation.

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Accident, Volume and Speed Studies at Erramreddipalem Road, Tirupati

S. Sameer

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ sameercivil23@gmail.com

T. Vineetha

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh

K. Uday Kiran

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ udaykiran518380@gmail.com

V. Yoganandha Reddy

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh

ABSTRACT

This study investigates the correlation between accidents, traffic volume, and speed on village roads. Through meticulous analysis of accident data, traffic flow, and vehicle speeds, it aims to discern patterns and factors contributing to road incidents in rural settings. The research employs statistical methods to quantify the relationship between accident frequency and both traffic volume and speed. By examining specific case studies, the study aims to identify areas with heightened risk and propose targeted interventions. The findings anticipate providing valuable insights for road safety improvements in village environments, offering data-driven recommendations for speed limits and infrastructure enhancements-based strategies for mitigating accidents and enhancing overall transportation safety in villages.

KEYWORDS: *Accident studies, Volume studies, Speed studies, Erramreddipalem Road.*

INTRODUCTION

Traffic accidents are a major concern in many parts of the world. They can result in serious injuries, fatalities, and property damage. In order to reduce the number of accidents, it is important to understand the factors that contribute to them. Traffic volume and speed are two important factors that can affect the likelihood of an accident. When there is a high volume of traffic, there is a greater chance that vehicles will collide. Similarly, when vehicles are traveling at high speeds, the severity of an accident is likely to be greater. Accident studies are conducted to investigate the causes of accidents and to identify ways to prevent them. These studies can involve collecting data on the number and type of accidents that occur, as well as the factors that contribute to them. The data can then be used to develop strategies for reducing the number of accidents. This

study will investigate the relationship between traffic volume, speed, and accidents on Erramreddipalem Road in Tirupati, India. The data collected in this study will be used to develop recommendations for improving safety on this road.

LITERATURE REVIEW

Review on Accidental Studies on Roads [1] have identified specific accident-prone locations based on the severity and frequency of accidents. This highlights the importance of focusing on these areas for implementing effective traffic management strategies, infrastructure improvements, or other interventions to enhance overall road safety. Traffic Volume and Accidental Studies on State Highway-19 [2] identifies the top five accident-prone locations ("Black Spots") on State Highway-19 based on the Weighted Severity Index (WSI), emphasizing the need for targeted interventions.

Review of Research on Road Traffic Operation Risk Prevention and Control [3] analysis revealed key research topics encompassing driver, vehicle, road, and traffic environment risks, with emphasis on driving behavior characteristics, vehicle control systems, hazardous material transportation, road section safety, intersection risks, adverse weather conditions, and mathematical modeling. Accidental Analysis and Road Safety Auditing for NH-75[4] the study reveals that heavy vehicles, especially trucks, contribute significantly to accidents on two-lane roads, with 59% attributed to trucks, emphasizing the need for targeted safety measures. Other contributors include bikes (7%), jeeps (5%), and buses (3%). Accident Analysis and Prevention [5] male drivers, Class 2 license holders, and those aged 30-39 are identified as high-risk groups, with license suspension proving more effective overall, particularly for drivers with regular licenses, suggesting stricter licensing requirements could enhance sanctions' impact. A Study on Traffic Survey at Tezpur Town of Assam, India [6] the studies highlight the heterogeneous nature of traffic in Tezpur town, attributing congestion to narrow roads, haphazard expansion, and insufficient concern from civic authorities and the public. Study of Traffic Volume and its Safety Measurement at Dadabari Circle [7] the traffic stream was dominated by motorcycles, and peak hour congestion was observed in mornings and evenings. Influence of Operating Speed on Capacity of Urban Arterial Midblock Sections [8] analysing midblock capacity is crucial for converting signalized intersections to grade separations, while studying accident severity by vehicle type helps improve safety for different road users. [9] the aim of the present study is the investigation of road accident severity per vehicle type. For that reason, a dataset consisting of 59,316 recorded accidents in Greece was analyzed and mathematical models were developed by applying lognormal regression. In those accidents 107,679 injured persons were involved. Highway Capacity Research on Inter-urban Highways in India [10] US traffic flow standards (US HCM) don't directly apply to India because Indian driving behaviour and traffic composition differ significantly.

METHODOLOGY



EXPERIMENTAL INVESTIGATIONS

Accident Studies: The main purpose of accident studies is to prevent future accidents from happening. This is done by investigating the causes of past accidents and using that information to develop safety measures.

Here are some of the specific goals of accident studies:

- To identify the causes of accidents, including factors such as human error, mechanical failure, and environmental conditions.
- To identify trends and patterns in accidents, so that resources can be targeted to the areas where they are most needed.
- To educate the public about safety and how to prevent accidents.



Fig. 1: Accident records collected in thiruchanoor police

Volume studies

The main purpose of volume studies depends on the field they are applied in. However, a common thread across applications is understanding the amount of activity or flow of something over time.

- Measure traffic flow (number of vehicles) on a road to assess its usage and efficiency expand more
- This data is crucial for designing new roads, improving existing ones, and implementing traffic management strategies to reduce congestion.



Fig. 2: Volume studies at erramreddipalem road

Speed studies

The main purpose of speed studies is to gather data on traffic speeds at specific locations. This data is used for several purposes related to traffic safety and management:



Fig. 3. Speed studies at erramreddipalem road

- Setting Speed Limits: One of the key applications is to determine an appropriate speed limit for a particular road segment.

- Safety Analysis: Speed studies can identify areas where excessive speeding might be a safety concern. By analysing the distribution of speeds

RESULTS AND DISCUSSIONS

According to thiruchanoor police station, past 3 years records of Tirupati to appayagunta road

Table 1 values of accident studies

S.N O	YEAR	NO.OF ACCIDENTS	TYPES OF CASES	INJURIES	DEATHS
1	2021	222	<ul style="list-style-type: none"> • HIT & RUN(121) • DRUNK &DRIVE(76) • OTHERS(25) 	143	79
2	2022	201	<ul style="list-style-type: none"> • HIT & RUN(113) • DRUNK &DRIVE(63) • OTHERS(25) 	121	80
3	2023	127	<ul style="list-style-type: none"> • HIT & RUN(96) • DRUNK &DRIVE(25) • OTHERS(16) 	93	34

- Average accidents per year = 133 accidents
- Average injuries per year = 119 injuries
- Average deaths per year = 64 deaths
- Most type of vehicles damaged
 - = 30% of four wheelers
 - = 65% of two wheelers
 - = 5% of others

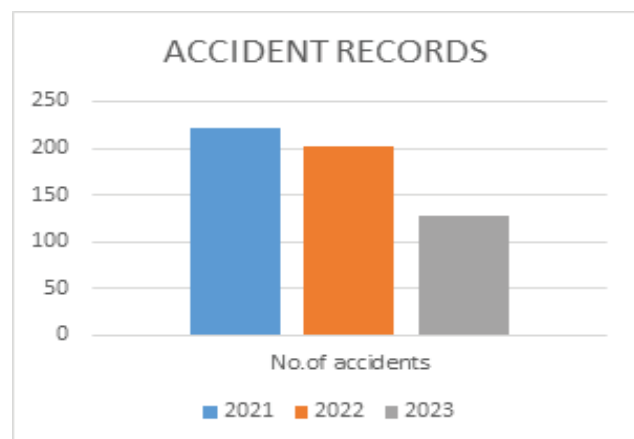


Fig. 4. Accident records of past 3 years

Average accidents takes place per year = 183 accidents

Volume studies

Number of vehicles passing at peak hours, erramreddipalem road, appalayagunta

Table 2 values of volume studies

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	22/01/24	23/01/24	24/01/24	25/01/24	26/01/24	27/01/24	28/01/24
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Time							
8.00-9.00 AM	892	737	829	889	829	1903	398
9.00-10.00 AM	793	691	760	777	756	2021	337
4.00-5.00 PM	850	807	759	851	757	2349	359
5.00 -6.00 PM	774	678	707	786	733	2165	434
Total	3309	2913	3055	3303	3075	8438	1528
Two	—	—	—	—	—	—	—
Wheelers	2820	2529	2640	2818	2686	7174	1362
Three							
Wheelers	305	265	283	302	270	442	100
Four Wheelers	112	51	47	105	43	696	28
Others	15	17	10	18	8	51	18
Buses	57	61	75	60	68	80	20

Average vehicles passing daily at above road in peak hours = 3660 vehicle.

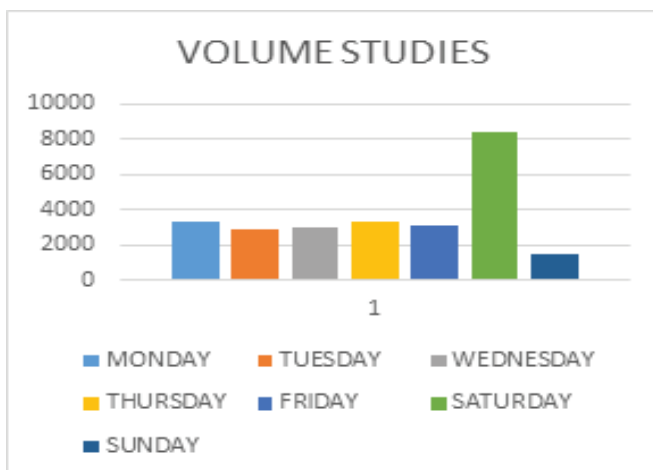


Fig. 5: volume studies in peak hours at road

Speed Studies

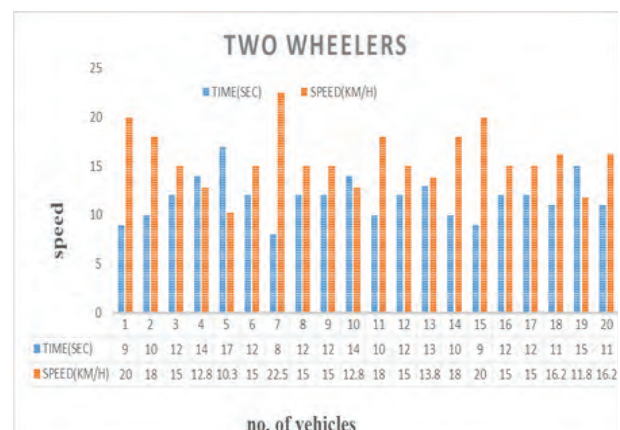


Fig. 6: Speed calculation of two wheelers

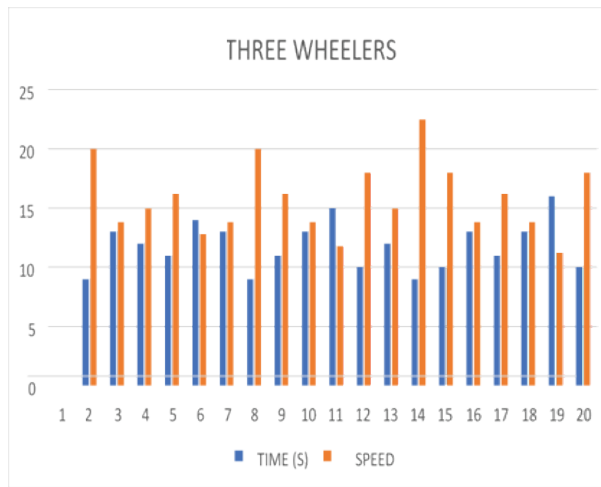


Fig. 7: Calculation of speed of three wheelers

The average speed of Three wheeler vehicles =13.78 KM/H

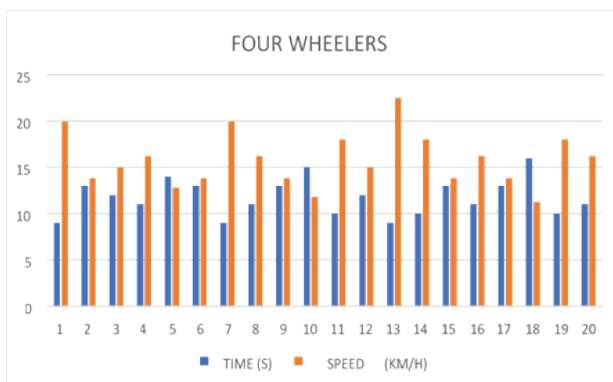


Fig. 8: Calculation of speed of four wheelers

The average speed of Four wheeler vehicles =15.80 KM/H

CONCLUSION BY ACCIDENT STUDIES

- Average accidents per year = 183 accidents
- Average injuries per year = 119 injuries
- Average deaths per year = 64 deaths
- Most type of vehicles damaged = 30% of four wheelers
- = 65% of two wheelers
- = 5% of others

BY VOLUME STUDIES

The number of vehicles passing at erramreddipalem road, appalayagunta from morning 8-9 am,9-10 am and evening 4-5 pm,5-6 pm in a week period.

Total number of vehicles passing in a week = 25621 vehicles
Total number of two wheeler vehicles passing in a week = 22029 vehicles

Total number of three wheeler vehicles passing in a week = 1967 vehicles

Total number of four wheeler vehicles passing in a week = 1082 vehicles

Total number of buses vehicles passing in a week = 421 vehicles

Average vehicles passing daily at above road in peak hours = 3660 vehicles / day

Average vehicles passing daily at above road in peak hour = 915 vehicles/hour

BY SPEED STUDIES

Calculating Speed of the vehicle to pass 50-meter distance using time taking in seconds.

The average speed of the two-wheeler vehicle = 19.11 KM/H

The average speed of Three-wheeler vehicles =13.78 KM/H

The average speed of Four-wheeler vehicles =15.80 KM/H

Speed limit of the vehicles should be 20 km/h

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An Experimental Investigation on M₂₀ and M₂₅ Grades of Concrete by Partial Replacement of Cement with Rice Husk Ash and Ceramic Powder

K. Harshasree

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ kattamanchiharshasree@gmail.com

G. Sai Sridhar

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ Saisri3@gmail.com

P. Hari Priya

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ pokalaharipriya89@gmail.com

K. Aparna

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ Kaparna34@gmail.com

ABSTRACT

The objective of this study is to evaluate the mechanical properties of M20 and M25 grade concrete by partially replacing cement with rice husk ash (RHA) and ceramic waste powder. The replacement combinations considered were 0%, 10%, 15%, and 20% for both RHA and ceramic powder. To assess the performance, compressive strength and split tensile strength tests were conducted after 7, 14, and 28 days of curing. The experimental results indicate that a 15% replacement of cement with RHA yields the most favorable strength characteristics among all mixes. This percentage provided an optimal balance between strength gain and sustainability, suggesting its effective use in producing environmentally friendly concrete without compromising structural performance.

KEYWORDS: *Rice husk ash, Ceramic powder, Compressive strength, Split tensile strength.*

INTRODUCTION

Concrete is the most widely used man-made construction material in the world, composed primarily of water, aggregates, and cementing materials, sometimes combined with additives to enhance its properties. With growing concerns over the environmental impact of cement production, research has turned toward sustainable alternatives, such as rice husk ash (RHA) and ceramic waste powder, for partial cement replacement.

Rice husk is the hard outer covering of rice grains, typically removed during the milling process. It is abundantly available in rice-producing regions and contains approximately 30% to 50% organic carbon. When processed into ash, RHA exhibits pozzolanic properties, making it a suitable partial substitute for

cement. Its use not only addresses environmental disposal concerns but also contributes to improving the strength characteristics of concrete.

Ceramic waste, derived from broken tiles and discarded ceramic products, offers a viable means of reducing landfill accumulation and provides improvements in the mechanical behavior of concrete when used as a cement replacement.

Several studies support the effectiveness of these materials:

- Vedprakash Prajapati and Dr. Rajeev Chandak [1] concluded that replacing 15% of cement with RHA yields optimal compressive strength results.
- Muzammil Ahmed and Abdullah Anwar [2] observed that blends containing 10% to 30% RHA

and 10% to 20% ceramic powder achieved superior strength performance, especially in compressive strength.

- Harish and Hanumesh [3] reported that an optimum RHA dosage of 5% in M20 grade concrete provided improved compressive strength while reducing density due to RHA's lower specific gravity compared to cement.
- Veeramanikandan and R. Anuradha [4] highlighted that 20% ceramic powder substitution in M20 concrete demonstrated effective performance in terms of strength.
- Santhosh Kumar and D. Parkavi [5] emphasized the economic and eco-friendly nature of ceramic powder concrete, particularly in specimens cured for 7 and 14 days.
- Vashisht Patil and Paliwal [6] confirmed that RHA, being a pozzolanic material, enhances the long-term strength of concrete when used in increasing proportions.

These studies collectively affirm that the integration of RHA and ceramic powder as partial cement replacements can enhance the sustainability, cost-effectiveness, and mechanical properties of concrete.

EXPERIMENTAL INVESTIGATION

In this experimental investigation, Ordinary Portland Cement (OPC) 53 grade was utilized in accordance with the specifications outlined in IS 12269:2013. The cement used was of the Dalmia brand, manufactured by India Cements Private Limited. The fundamental properties of the cement are detailed in Table 1.

The coarse aggregate used consisted of crushed stone with a particle size of 20 mm passing and 10 mm retained. The specific gravity of the coarse aggregate was determined to be 2.60. For the fine aggregate, river sand passing through a 4.75 mm sieve was employed, with a specific gravity of 2.77.

Rice husk ash (RHA), a pozzolanic material obtained from rice milling waste, was also incorporated as a partial replacement for cement. The specific gravity of RHA was found to be 1.99. Additionally, ceramic waste powder, processed from discarded ceramic materials, was used, having a specific gravity of 1.93.

Table 1: Physical Properties of cement

Materials	Quantity
Cement	355kg/m ³
Rice husk Ash	125kg/m ³
Fine Aggregate	738kg/m ³
Coarse aggregate	1196kg/m ³
w/c ratio	0.55

Polypropylene fiber is a synthetic material produced through the polymerization of propylene, resulting in linear polymer chains. It is widely recognized for its advantageous properties, including high tensile strength, excellent toughness, lightweight nature, and resistance to corrosion. These characteristics make it an ideal additive for enhancing the mechanical performance of concrete and other construction materials. The physical and chemical properties of rice husk ash used in this study are summarized in Table 2.

Test procedures

In this study, the compressive strength of concrete was evaluated using standard cube specimens of dimensions 150 mm × 150 mm × 150 mm. The testing procedure was conducted in accordance with the guidelines specified in IS 516:1959. The concrete specimens were subjected to curing, and compressive strength tests were performed at intervals of 7, 14, and 28 days to assess the strength development over time.



Fig. 1: Compressive strength test

Split tensile strength

In this study, cylinder dimensions 150x300mm were used. The tests are carried out after 7, 14, and 28 days of the curing period as per IS 5816(1999) codes.



Fig. 2: Split Tensile strength test

Table 2: Properties of Rice Husk Ash

Characteristics	Test Results
Grade	53
Fineness of cement	4.68%
Specific gravity	2.71
Standard consistency	31%
Initial setting time	50min
Final setting time	400min

Mix proportion

Mix proportions were made as per IS 456:2000 and IS 10262:2019. This design is done for M20 and M25 concrete as shown in Table 3 and Table 4 .

Table 4: Mix proportion for M25

Materials	Quantity
Cement	425kg/m ³
Rice husk Ash	135kg/m ³
Fine Aggregate	523kg/m ³
Coarse aggregate	1194kg/m ³
w/c ratio	0.50

RESULTS AND DISCUSSIONS

Materials	Quantity
Cement	355kg/m ³
Rice husk Ash	125kg/m ³
Fine Aggregate	738kg/m ³
Coarse aggregate	1196kg/m ³
w/c ratio	0.55

Table 5: Compressive strength test results

Compressive Strength (MPa) of M20 grade of concrete for Rice Husk Ash			
% of Rice Husk Ash	7days	14days	28days
0	13.4	19.9	26.6
10	21.4	24.5	28.7
15	25.9	27.8	29.9
20	23.6	24.9	29

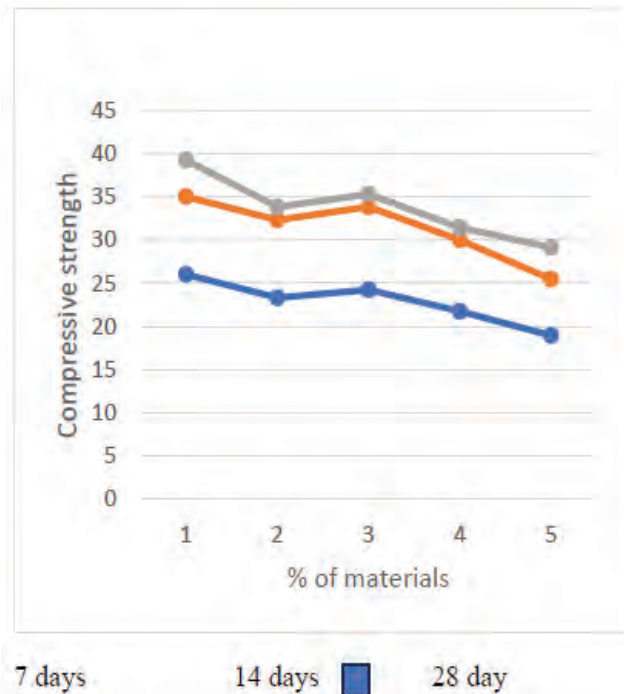


Fig. 3: Graph for compressive strength results

Split Tensile Strength test:

Table 6: Split Tensile strength test results

Split Tensile Strength (MPa) of M20 grade of concrete for Rice Husk Ash			
% of Rice Husk Ash	7days	14days	28days
0	13.4	19.9	26.6
10	21.4	24.5	28.7
15	25.9	27.8	29.8

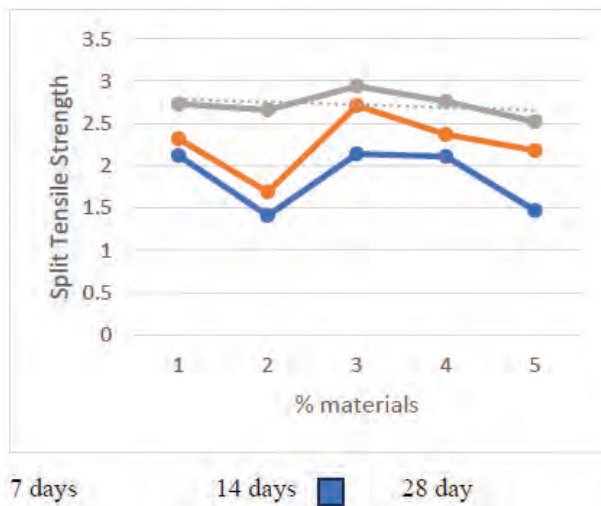


Fig. 4 : Graph of Split Tensile Strength

Compressive Strength test

Table 7: Compressive strength test results

Compressive Strength (MPa) of M20 grade of concrete for Rice Husk Ash			
% of ceramic powder	7days	14days	28days
0	12.6	16.9	26.6
10	21.9	24.2	29.2
15	23.7	26.1	29.7
20	20.4	24.9	28.74

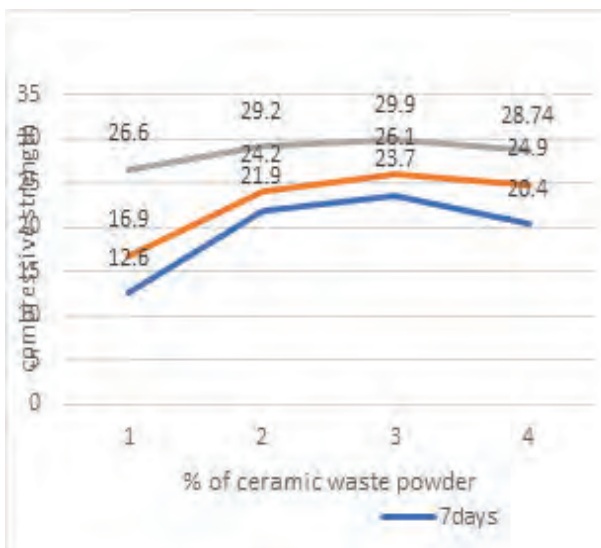


Fig. 5 : compressive strength

Split Tensile Strength

Table 8: Split Tensile strength test results

Split Tensile Strength (MPa) of M20 grade of concrete for Rice Husk Ash			
% of ceramic powder	7days	14days	28days
0	2.11	2.93	3.10
10	3.06	3.20	3.32
15	3.15	3.27	3.40
20	2.56	2.97	3.36

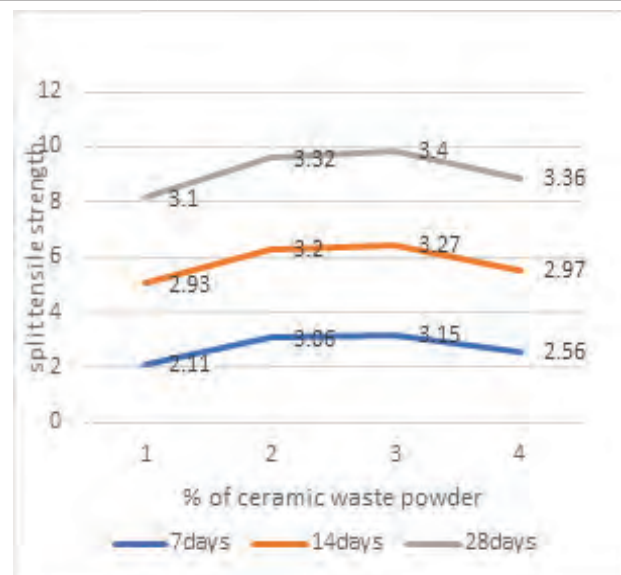


Fig. 6: split tensile strength

Compressive Strength for M₂₅ grade concrete

Table 9 : compressive strength

Compressive Strength (MPa) of M25 grade of concrete for Rice Husk Ash			
% of Rice Husk Ash	7days	14days	28days
0	18.75	23.2	26.4
10	22.5	24.5	27.6
15	25.9	27.4	29.8
20	25.4	26.2	28.3

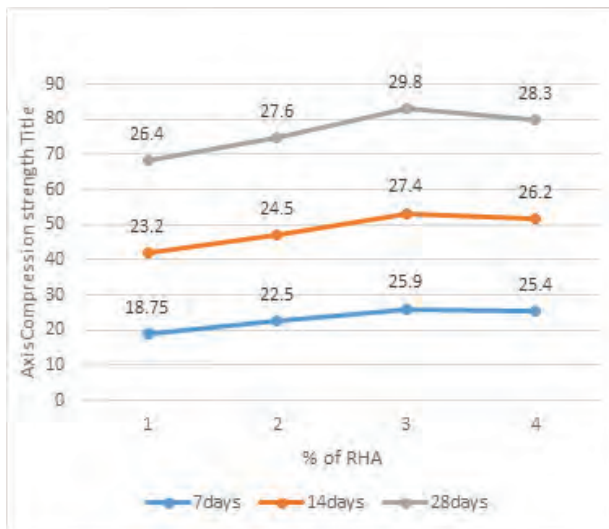


Fig. 7: Compressive strength graph

Split Tensile Strength

Table 10 Split tensile strength

Split Tensile Strength (MPa) of M25 grade of concrete for Rice Husk Ash			
% of Rice Husk Ash	7days	14days	28days
0	1.75	1.91	3.30
10	1.98	2.04	3.67
15	2.84	2.93	3.97
20	2.56	2.62	3.78

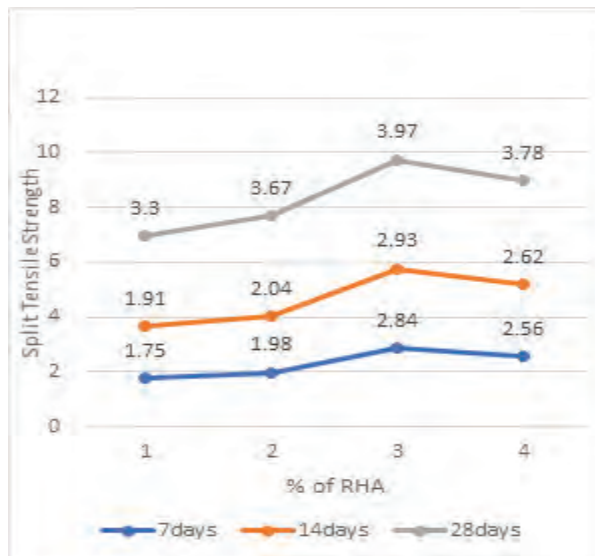
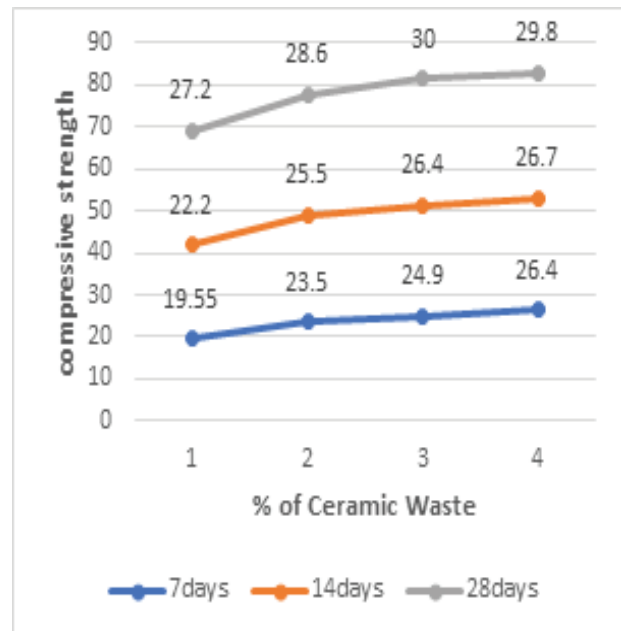


Fig. 8 : split tensile strength graph

Compressive strength test

Table 11 compressive strength

Compressive Strength (MPa) of M25 grade of concrete for ceramic waste powder			
% of ceramic waste powder	7days	14days	28days
0	19.55	22.2	27.2
10	23.5	25.5	28.6
15	24.9	26.4	30
20	26.4	26.7	29.8



3.8 Split Tensile Strength

Table 12 Split tensile strength

Split tensile strength (MPa) of M25 grade of concrete for Ceramic Waste Powder			
% of ceramic waste powder	7days	14days	28days
0	1.75	1.91	3.30
10	1.78	2.34	3.76
15	2.90	2.93	3.97
20	2.65	2.76	3.98

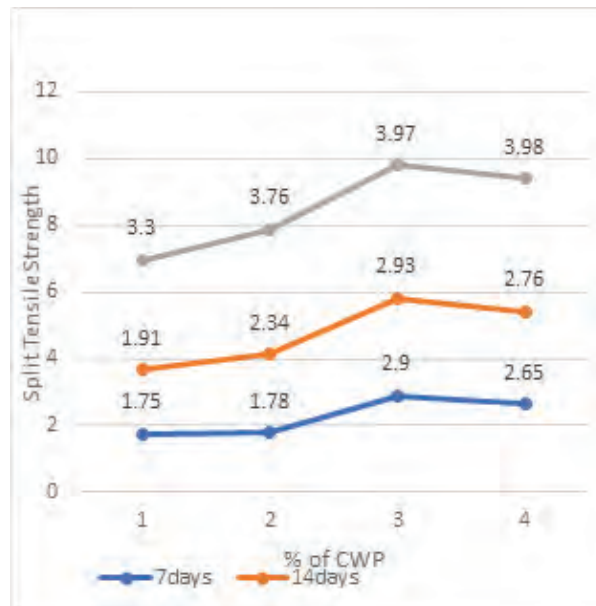


Fig. 10: Split tensile strength

CONCLUSIONS

Based on the experimental results, it was observed that the replacement of cement with 15% rice husk ash (RHA) yielded the optimal strength performance in both M20 and M25 grade concrete. This proportion demonstrated improved compressive and split tensile strength across all curing periods.

When comparing the effects of rice husk ash and ceramic waste powder, RHA consistently outperformed

ceramic waste in both compressive strength and split tensile strength tests, indicating its superior pozzolanic activity and contribution to the concrete's mechanical properties.

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Enhancing Parking Accessibility for the Deaf and Dump Impaired With Smart Embedded Systems

Mokkala Ramya

Department of ECE

Annamacharya Institute of Technology and Sciences

Tirupati, Andhra Pradesh

✉ ramyamokkala1995@gmail.com

Bollini Manoj Kumar

Department of ECE

Annamacharya Institute of Technology and Sciences

Tirupati, Andhra Pradesh

✉ manojkumar.bollini@gmail.com

ABSTRACT

Parking accessibility for individuals who are deaf and mute remains an under-addressed concern, even as advancements continue in various areas of inclusive infrastructure. This study investigates the specific challenges encountered by this demographic, such as difficulties in communicating with parking attendants and interpreting posted parking instructions. To address these issues, a vision-based parking detection system is proposed, aimed at improving both accessibility and operational efficiency in urban environments.

The system leverages real-time image processing through cameras, integrated with AI algorithms deployed on an Arduino-based embedded platform. The solution includes a mobile application interface, enabling drivers to receive accurate, real-time updates on parking space availability. By streamlining the parking experience, the system reduces search time, alleviates traffic congestion, and supports the development of smart city infrastructure. Additionally, parking administrators can harness the data generated by the system to optimize resource allocation and plan future infrastructure enhancements more effectively.

KEYWORDS: *Deaf and mute individuals, Parking accessibility, Communication barriers, Internet of things (IoT), Security, Mobile application, Computer vision.*

INTRODUCTION

Deaf and mute individuals face substantial barriers in parking environments, primarily due to their inability to engage in verbal communication and difficulties in interpreting conventional parking instructions. These challenges often result in confusion, misunderstandings, and a generally frustrating parking experience. To address these issues, there is a pressing need for inclusive and intelligent parking solutions that provide clear, non-verbal guidance and real-time information.

This paper presents a smart parking system tailored specifically to enhance accessibility for deaf, mute, and even uneducated individuals. The system incorporates modern technologies such as computer vision, embedded AI, the Internet of Things (IoT), and Android-based interfaces to create an adaptive, user-friendly solution. By analyzing video streams from CCTV surveillance

cameras through embedded AI processors, the system accurately detects vehicle presence, differentiates between occupied and vacant spaces, and updates a cloud database in real-time.

Additionally, IoT-enabled proximity sensors, including ultrasonic modules connected to NodeMCU microcontrollers, are deployed in each parking space. These low-power components (operating at just 5V) offer energy efficiency while providing reliable vehicle detection. The integration of AI and machine learning allows for continuous monitoring and automated classification, ensuring that users receive up-to-date, accurate information on available parking slots via a mobile application.

By shifting from traditional sensor-based or manual monitoring techniques to an AI-driven vision system, the proposed solution improves parking efficiency, reduces congestion, and contributes to sustainable

urban mobility. Importantly, it empowers individuals with communication or literacy limitations by offering a visually intuitive and accessible interface, thus bridging a significant gap in public infrastructure design.

LITERATURE REVIEW

This literature review addresses the accessibility challenges faced by deaf and mute individuals in parking facilities. It examines existing research on communication barriers with parking attendants and comprehension of parking regulations. The review aims to identify gaps in accessibility solutions and propose innovative approaches to enhance parking accessibility for this demographic.

Advancements in smart parking systems have led to the integration of image processing, sensors, and mobile technologies to improve parking efficiency and user experience. A variety of approaches have been proposed in recent years to address key challenges such as space utilization, reservation, automation, and accessibility.

A fully automated parking system was proposed that leverages image analysis and embedded sensors to detect vacant parking slots and generate One-Time Passwords (OTPs) for user verification. This system reduces human involvement, minimizes operational costs, and ensures optimal use of space. With 24/7 autonomous operation, it allows users to park without assistance. Furthermore, a mobile-based pre-booking application enables users to reserve parking slots in advance, thereby reducing search time and promoting energy efficiency [1].

The iPark system presents a Web of Things (WoT)-based solution aimed at addressing typical urban parking issues. iPark automates the monitoring of car entry and exit, displays the real-time count of parked vehicles, and provides live updates on available spaces, thereby improving safety and convenience [2].

Another approach incorporates an IoT-based smart parking solution with mobile integration, offering features like slot reservation, navigation, user authentication, and billing. It employs infrared (IR) sensors to detect vacant spots, GPS modules for real-time location updates, and RFID tags for secure user identification and reservation tracking [3].

An iOS-based parking platform was introduced to streamline the parking process by enabling users to locate and reserve parking spaces through a dedicated mobile app. This system was compared with traditional manual methods and was found to significantly enhance convenience and reduce congestion, illustrating its effectiveness in solving common parking-related problems [4].

These studies collectively highlight the growing role of IoT, AI, and mobile computing in transforming conventional parking infrastructure into intelligent, automated, and user-centric systems, thereby supporting the development of smart cities and sustainable urban mobility. The Smart Car Parking System offers cost-effective automation, eliminating the need for human operators and saving time and fuel. Additionally, it increases revenue collection by accommodating more vehicles while ensuring safety and user-friendly parking experiences [5]. The prototype demonstrated a 75% accuracy rate in allocating parking spots based on user categories, with 100% accuracy in system design output. This system has the potential to alleviate traffic congestion and frustration while indirectly reducing crime by prioritizing user categories near parking entrances [6].

IoT parking module, supported by a mobile app, enabling drivers to locate available parking slots. Implementing this system in densely populated areas can foster a healthier environment by reducing pollution caused by vehicle idling in traffic due to parking shortages [7]. It tackles university parking management, proposing an IoT-based architecture to optimize traffic flow and ensure institutional requirements are met. Additionally, it introduces a hybrid VRP and MDVRP solution for equitable parking lot distribution, considering visitor priorities [8]. The proposed parking system efficiently manages parking space while also mitigating collisions between vehicles. It employs advanced technology to optimize spatial utilization and enhance overall safety. This system ensures smooth traffic flow and minimizes the risk of accidents within the parking area [9].

PROPOSED SYSTEM

The proposed vision-based parking occupancy detection system, powered by an embedded AI processor,

is designed to revolutionize traditional parking management through the integration of advanced technologies. The system is built around a network of high-resolution cameras and specialized embedded hardware, enabling real-time monitoring and efficient utilization of parking spaces.

At the core of the system are AI-enhanced cameras equipped with advanced image processing capabilities, strategically installed throughout the parking facility to ensure comprehensive visual coverage. These cameras continuously capture live video feeds, which are then processed locally by an embedded AI processor. This processor is optimized to perform complex machine learning operations directly on the edge device, allowing for real-time detection, classification, and tracking of vehicles without reliance on external servers.

By deploying this architecture, the system ensures low-latency analysis, improved data security, and energy-efficient processing, making it highly suitable for modern smart parking infrastructures.

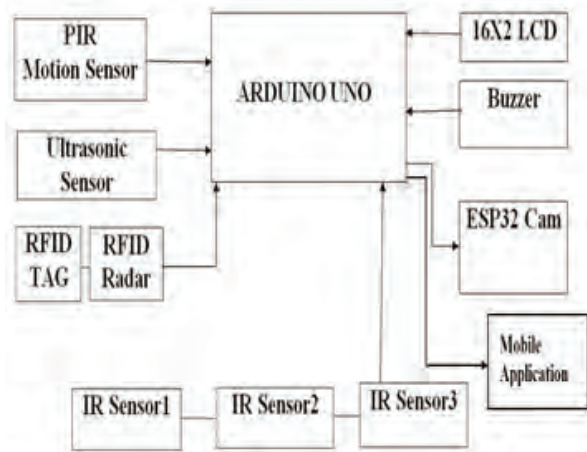


Fig. 1: Block Diagram of Accessibility Parking System

The proposed smart parking system, as illustrated in Figure 1, integrates multiple components to enable intelligent and accessible parking management. The system includes an ESP32-CAM module, RFID reader and tags, LCD display, infrared (IR) sensors, ultrasonic sensors, a mobile application, a buzzer, and an Arduino Uno microcontroller.

The Arduino Uno R3, known for its flexibility and real-time processing capabilities, serves as the central controller. It supports the simultaneous execution of

multiple programs to manage various device functions efficiently.

To enhance sustainability, the system incorporates solar-powered chargers. These utilize photovoltaic cells embedded between semiconducting layers, typically silicon, to convert solar energy into electricity—making the system energy-efficient and eco-friendly.

Users can interact with the system through a dedicated mobile application, which allows them to identify available parking slots and reserve them remotely, improving convenience and reducing time spent searching for parking.

The RFID technology plays a critical role in user authentication and vehicle tracking. RFID tags, as shown in Figure 2, function as smart labels embedded with unique data. These tags communicate with the RFID reader via radio frequency (RF) signals, transmitting information by modulating the reflection of incoming radar waves. This process, known as backscattering, enables the selective transmission or absorption of signals based on the stored data.

Together, these components create a robust, automated system designed to enhance parking accessibility, reduce manual intervention, and support real-time data processing for efficient space utilization.



Fig. 2: RFID Reader

A Liquid Crystal Display (LCD) is a type of flat-panel display that functions as an electro-optical device, utilizing the light-modulating properties of liquid crystals in combination with polarizing filters. Liquid crystals do not emit light on their own; instead, they depend on an external backlight or reflector to produce visible images. LCDs are capable of displaying both monochrome and color visuals, making them widely applicable in various electronic systems, including embedded and user-interface devices.



Fig. 3: LCD Display

Fig 4 depicts an audio signaling device, which can be electromechanical, piezoelectric, or mechanical. Its primary function is to convert audio signals into sound.

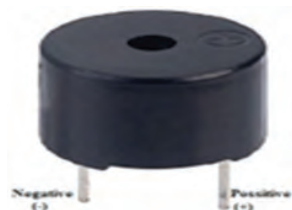


Fig. 4: Buzzer

Figure 5 illustrates the working principle of an ultrasonic sensor, which operates by emitting high-frequency sound waves from a built-in transmitter. These sound waves travel through the medium, reflect off nearby objects, and are then captured by the sensor's receiver. By calculating the time interval between transmission and reception, and knowing the speed of sound in the given medium, the sensor accurately determines the distance to the object.

Ultrasonic sensors are widely used in applications such as object detection, distance measurement, and obstacle avoidance. Their non-contact sensing capability, combined with high accuracy and reliability in diverse environmental conditions, makes them ideal for use in robotics, automotive systems, and smart parking technologies [10].



Fig. 5: Ultrasonic Sensor

An Infrared (IR) sensor functions by detecting infrared radiation that is either emitted or reflected by objects within its sensing range. It typically consists of an IR emitter and receiver, which work in tandem to sense changes in the surrounding infrared light levels. This

non-contact sensing mechanism allows for effective motion detection, object proximity sensing, and other automation applications.

Figure 6 illustrates the ESP32-CAM, a compact and powerful development board that combines the ESP32 microcontroller with an integrated camera module. This board supports both Wi-Fi and Bluetooth connectivity, making it ideal for a wide range of IoT applications such as video surveillance, live streaming, and image recognition. Equipped with a dual-core processor, onboard flash memory, and multiple GPIO pins, the ESP32-CAM also supports integration with external sensors and peripherals, further extending its functionality and versatility in embedded systems [11].



Fig. 6: ESP32cam

The mobile application is seamlessly integrated with the embedded system and is designed to be accessible on any Android device. It offers users a user-friendly interface to conveniently check real-time parking availability and reserve parking slots. The intuitive design ensures ease of use for all users, including those with limited technical proficiency. A prototype of the mobile application interface is shown in the figure below, demonstrating its core functionalities and layout.

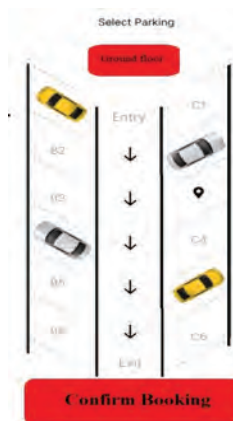


Fig. 7: Mobile Application for Parking

Working Principle

The vision-based parking occupancy detection system employs strategically positioned cameras to capture continuous live video feeds of designated parking areas. These feeds are processed in real time by an embedded AI processor utilizing advanced deep learning algorithms, particularly Convolutional Neural Networks (CNNs), to identify and classify vehicle presence in each parking space.

Through the continuous analysis of video frames, the system delivers instant updates on parking slot availability, thereby enhancing space utilization and supporting efficient traffic management. Furthermore, users can locate vacant parking spots and reserve them in advance through a dedicated mobile application, as illustrated in the accompanying figure. This integration of AI-driven image processing with mobile connectivity contributes to a more intelligent, accessible, and user-friendly parking experience.

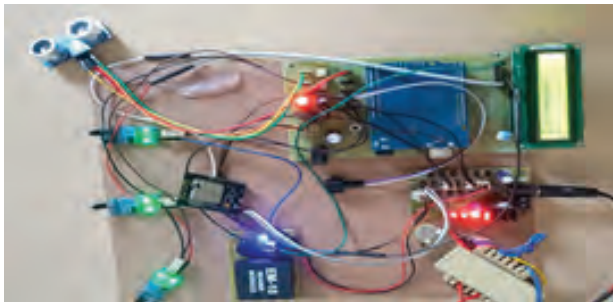


Fig. 8. Experimental Setup

RESULT:

The results obtained from the vision-based parking occupancy detection system, integrated with an embedded AI processor, demonstrate its high efficiency and accuracy in modernizing parking management. Through extensive testing under various conditions, the system consistently provided real-time monitoring of parking space occupancy with a high degree of precision and reliability.

The implementation of advanced image processing and deep learning techniques enabled accurate detection and classification of vehicles, ensuring that available and occupied spaces were identified without delay. This real-time functionality significantly benefits both parking operators, by optimizing resource allocation,

and users, by reducing the time spent searching for parking and enhancing the overall user experience.



Fig. 9: Slots Before Parking

The system demonstrates consistent and reliable performance in detecting and classifying parking space occupancy by leveraging deep learning algorithms, particularly Convolutional Neural Networks (CNNs), to analyze live video feeds captured by strategically placed surveillance cameras.

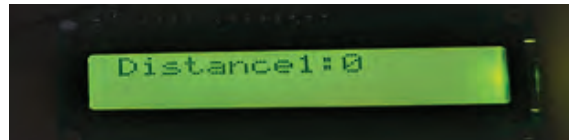


Fig. 10: Distance Measurement of Vehicle

The system's adaptability and high accuracy across a range of environmental conditions underscore its reliability and practical applicability, even in challenging scenarios such as fluctuating lighting, adverse weather conditions, and complex or irregular parking layouts.



Fig. 11: Car Arrived

The system's real-time monitoring capabilities play a crucial role in reducing congestion and improving traffic flow within parking facilities by providing instantaneous updates on space availability. This enables drivers to navigate parking areas more efficiently while allowing operators to optimize resource utilization, resulting in smoother and more streamlined operations.



Fig. 12: Slots After Parking

CONCLUSION

Smart parking systems tailored for deaf and mute accessibility significantly enhance traffic flow, safety, and overall user experience. The proposed prototype integrates ultrasonic sensors, RFID tags, IR sensors, an ESP32-CAM module, and a mobile application to enable seamless, user-friendly parking for individuals with disabilities. By providing clear, non-verbal communication and real-time updates, the system ensures inclusive access and convenience. Its flexible architecture makes it well-suited for deployment in diverse environments, including public spaces, corporate campuses, and commercial complexes such as shopping malls.

FUTURE SCOPE

The vision-based parking occupancy detection system, powered by an embedded AI processor, delivers a comprehensive solution for modern parking management. It offers high-accuracy vehicle detection, real-time monitoring, and seamless integration with existing infrastructure. Key features include scalability, adaptability to diverse environmental conditions, data-driven analytics, and a user-friendly interface for both operators and end-users. With a strong focus on security and continuous innovation, the system is designed to enhance operational efficiency, improve the user experience, and remain responsive to evolving technological advancements and urban mobility demands.

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Evaluation of Ergonomically Designed Chairs on Shoulder and Hip Activity among Corporate Workers

Preethi K

Department Civil Engineering
Kongu Engineering College, Perundurai
✉ kpreethi1999@gmail.com

Ambika D

Department Civil Engineering
Kongu Engineering College, Perundurai
✉ ambika.civil@kongu.edu

ABSTRACT

This study investigates the prevalence of work-related musculoskeletal disorders (MSDs) among professionals in the corporate sector. Data were collected using the Nordic Musculoskeletal Questionnaire and direct observational methods. A total of 113 corporate employees from various organizations across India participated in the survey. The mean age of respondents was 30.51 ± 8.09 years, with an average work experience of 7.74 years.

Statistical analysis revealed that 43.4% of participants reported experiencing MSDs within the past year. The most commonly affected body regions were the lower back (70.8%), knees (60.2%), shoulders (49.6%), and wrists (48.7%). The incidence of MSDs was notably higher among individuals aged 50 years and above (65.9%) and those with more than 20 years of work experience (68.3%). Furthermore, participants were found to be exposed not only to MSD risks but also to environmental and ergonomic hazards in the workplace.

KEYWORDS: *Ergonomics, Musculoskeletal disorders, Corporate workers, Lower back pain.*

INTRODUCTION

Ergonomically designed chairs have become increasingly popular, particularly among corporate workers who spend long periods sitting at a desk. These chairs are specifically created to offer optimal comfort and support, aiming to minimize the risk of musculoskeletal disorders like shoulder and hip pain. The purpose of this study is to assess the impact of ergonomically designed chairs on shoulder and hip activity in corporate workers. We will compare the activity levels of these body parts between individuals using traditional chairs and those using ergonomically designed chairs. The objective is to determine whether the use of ergonomically designed chairs results in a significant decrease in shoulder and hip activity, thereby potentially lowering the risk of musculoskeletal disorders. The study will involve recruiting a sample of corporate workers who spend a substantial portion of their workday seated at a desk. Participants will be randomly assigned to either the traditional chair group or the ergonomically designed chair group. Advanced sensors will be utilized to measure shoulder and hip

activity, and the results will be compared between the two groups. The findings will hold important implications for both workers and employers. If ergonomically designed chairs prove effective in reducing shoulder and hip activity, employers may consider investing in these chairs to enhance the well-being of their workforce. This, in turn, could potentially lead to a decrease in work-related injuries and absences, resulting in heightened productivity and cost savings.

SUBJECTS & MATERIALS

The research included male and female corporate workers employed in diverse companies across India. Throughout the study duration, careful observations were made regarding the risk factors and working conditions

The primary objective of the study was to examine musculoskeletal disorders (MSDs) among a group of over 200 workers. However, due to limitations, the study was ultimately conducted with a smaller sample size of 113 workers, aged between 19 and 50 years. This study aligns with previous research conducted by

[1], which also had a restricted number of participants. All participants in this study were full-time workers, engaging in a minimum of 8 hours of work per day.

Data collection

This study employed a mixed-method approach involving both questionnaires and direct workplace observations to assess the prevalence of musculoskeletal disorders (MSDs). Data collection was conducted using the Nordic Musculoskeletal Questionnaire (NMQ) [2], a widely recognized tool for identifying musculoskeletal symptoms.

Potential risk factors were identified through a comprehensive literature review and on-site observations of workers during their regular working hours. The questionnaire was structured into three sections: the first section gathered sociodemographic information; the second section focused on work-related factors and the presence of musculoskeletal symptoms [3,4]; and the third section documented health-related factors.

Participants were asked to report symptoms experienced over a specified recall period, indicate areas of discomfort on a standardized body chart, and evaluate the intensity and frequency of risk factors associated with their work tasks [5]. A total of 113 workers participated in the study, providing valuable insights into the ergonomic and health challenges faced in the corporate work environment.

Data analysis

The data obtained from participants' questionnaire responses were coded and analyzed using SPSS software (version 22.0). To examine the relationship between independent variables—including sociodemographic characteristics, lifestyle behaviors, and occupational factors—and the dependent variable of reported musculoskeletal complaints, statistical tests such as Analysis of Variance (ANOVA) and the Chi-square test were employed. A p-value of < 0.05 was considered statistically significant for all analyses [6,7,8].

The study specifically assessed the prevalence of work-related musculoskeletal disorders (WMSDs) over two time frames: the past 12 months and the past 7 days [9,10,11]. In addition to examining overall body discomfort, the research explored the distribution of

WMSDs across various anatomical regions, including the neck, shoulders, upper and lower back, and lower extremities. These findings were further analyzed based on age groups and work experience levels to identify trends and risk differentials [12,13,14].

RESULTS

The study comprised a total of 113 workers. The mean age of the participants was 30.51 years with a standard deviation of 8.09, and the age range spanned from 19 to 55 years. Approximately 49.6% of the respondents were within the 25–40 year age group. In terms of marital status, 40.7% of participants were unmarried, while 59.3% were married and reported having at least one child.

With regard to self-reported health status, the majority (74.3%) indicated they were in good health, whereas the remainder rated their health as average, and a few reported being on medication. Additionally, close to 90% of the participants were found to fall within the normal weight range, based on their BMI classification.

Work and workplace characteristics

Participants reported an average work experience of 7.74 years, with a typical workday lasting 8.5 hours. Among them, 25.7% had more than 10 years of experience, while 45.1% had less than 5 years of experience. The majority were engaged in physically demanding tasks, including heavy lifting, prolonged standing, and repetitive bending, all of which contribute to increased physical and ergonomic stress. In addition to physical demands, many workers also reported experiencing physiological stress in the workplace.

Although most participants had adapted to the demands of their jobs, those with higher educational qualifications expressed concerns about financial instability, suggesting a mismatch between education level and job satisfaction or remuneration. Workers reported taking regular breaks and microbreaks throughout the day to manage fatigue and maintain productivity.

Approximately 90% of participants were right-handed. Among the work-related activities, 42.5% engaged in repetitive bending, 59.3% in prolonged standing, and 31.9% performed heavy lifting. Overall, job satisfaction levels were reported to be moderate. However, the

availability of personal protective equipment (PPE) and adherence to safety guidelines was notably lacking. Notably, 18% of the workers reported having experienced a work-related accident, highlighting the need for improved occupational health and safety measures.

Prevalence of WMSDs from past 7 days

Participants who reported experiencing discomfort, pain, or fatigue with a frequency of “often” or “very often” and an intensity rated as “high” or “very high” were classified as suffering from musculoskeletal disorders (MSDs).

Over the past 7 days, a considerable number of workers reported symptoms in various anatomical regions. The prevalence of symptoms in specific body parts was as follows: neck (14.9%), shoulders (39.1%), upper arms (14.5%), lower arms (27.3%), wrists (43.5%), fingers (11.6%), upper back (66.8%), lower back (59.3%), hips (21.2%), and knees (52.2%).

These findings indicate a significant burden of musculoskeletal issues, particularly in the back, wrists, and knees, which are commonly associated with prolonged standing, repetitive movements, and poor ergonomic conditions in the workplace.

Table 1. Site wise distribution of participants on prevalence for past 7 days

Body Region	Symptoms Reported (Yes)	Symptoms Not Reported (No)
Neck	17	95
Shoulder	44	70
Upper Arm	16	97
Lower Arm	33	81
Hand/Wrist	49	65
Finger	13	101
Upper Back	79	39
Lower Back	67	46
Hips/Thighs	24	89

Prevalence of WMSDs for past 12 months

Over the past 12 months, participants reported symptoms across multiple body regions, with the lower back (70.8%) showing the highest prevalence, followed by the knee (60.2%), shoulder (49.6%), wrist (48.7%),

and lower arm (39.8%). Other affected areas included the neck (36.3%), hips (34.5%), upper arm (33.6%), upper back (27.4%), and fingers (26.5%). Pain was more frequently reported in the shoulder, wrist, and lower extremities, particularly the lower back, hips, and knees.

Table 1 presents an overview of factors associated with MSD prevalence. Statistical analysis indicated that education level, end-of-day fatigue, daily working hours, job satisfaction, and body mass index (BMI) did not show a statistically significant association with musculoskeletal complaints ($p > 0.05$). Conversely, variables such as prolonged sitting, hunched posture, repetitive bending, and total years of work experience were significantly associated with the presence of MSDs ($p < 0.05$), highlighting the impact of ergonomic and occupational factors on worker health.

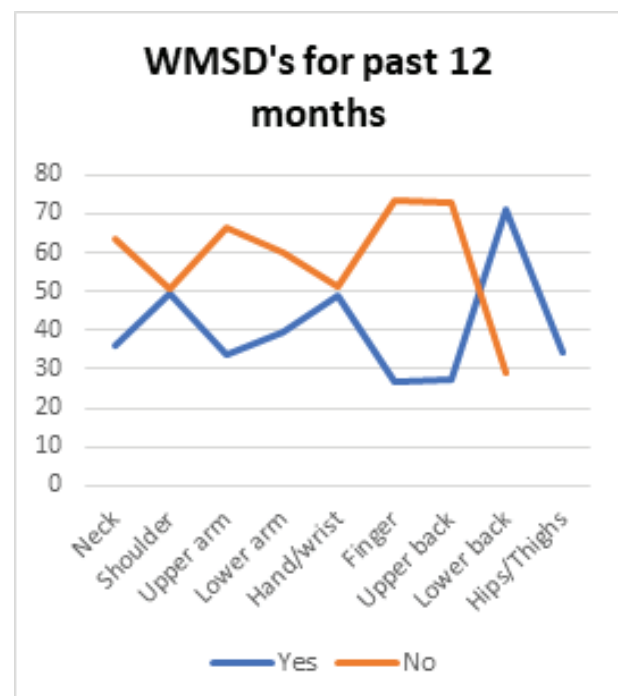


Table 2. Site wise distribution of participants on prevalence of WMSD's for past 12 months

Body Region	Yes, n (%)	No, n (%)
Lower Back	80 (70.8%)	33 (29.2%)
Shoulder	56 (49.6%)	57 (50.4%)
Wrist/Hand	55 (48.7%)	58 (51.3%)
Lower Arm	45 (39.8%)	68 (60.2%)

Hips/Thighs	39 (34.5%)	74 (65.5%)
Upper Arm	38 (33.6%)	75 (66.4%)
Neck	41 (36.3%)	72 (63.7%)
Upper Back	31 (27.4%)	82 (72.6%)
Fingers	30 (26.5%)	83 (73.5%)

Discomfort on performing daily activities

The responses to the questionnaire revealed varying degrees of discomfort experienced by participants during routine activities. The survey included three categories: Not at all, Slightly interfered, and Substantially interfered. Based on the analysis, approximately 35% of respondents reported slight discomfort, which can often be alleviated through ergonomic adjustments, physical activity, and nutrition. In contrast, substantial interference indicates a potential for chronic musculoskeletal issues that may require medical attention and lifestyle modifications.

Notably, the lower back (32.7%), knee (28.3%), and hand/wrist (20.4%) were the most affected regions in terms of substantial interference. Pain in hips/thighs (18.6%) and shoulders (15%) was also considerable. Interestingly, finger discomfort was reported to interfere the least with daily activities, along with knee pain showing relatively lower interference levels overall.

Table 3. Interference of discomfort on daily activities for the past 12 months

Body Region	Not at All n (%)	Slight Interference n (%)	Substantial Interference n (%)
Lower Back	24 (21.2%)	52 (46.0%)	37 (32.7%)
Hand/Wrist	48 (42.5%)	42 (37.2%)	23 (20.4%)
Shoulder	38 (33.6%)	58 (51.3%)	17 (15.1%)
Hips/Thighs	37 (32.7%)	55 (48.7%)	21 (18.6%)
Lower Arm	50 (44.2%)	48 (42.5%)	15 (13.3%)
Upper Arm	61 (54.0%)	42 (37.2%)	10 (8.8%)
Upper Back	56 (49.6%)	51 (45.1%)	6 (5.3%)
Neck	68 (60.2%)	38 (33.6%)	7 (6.2%)
Finger	70 (61.9%)	38 (33.6%)	5 (4.4%)

DISCUSSION

The objective of this study is to investigate the prevalence of ergonomic risk factors and work-related

musculoskeletal disorders (MSDs) among corporate workers in India. Data collection was conducted using the validated Nordic Musculoskeletal Questionnaire (NMQ), and the results were statistically analyzed using SPSS software.

The findings indicate that 43.4% of the participants experienced MSDs within the past year. The most commonly affected regions were the lower back (70.8%), knee (60.2%), shoulder (49.6%), wrist (48.7%), and ankle/foot (36.3%). A statistically significant difference was observed in relation to age and work experience. The ≥ 41 age group reported a higher prevalence (65.9%) of MSDs compared to the 25–40 age group (54.7%) and the ≤ 24 age group (16.4%). Similarly, workers with ≥ 10 years of experience showed a higher prevalence (68.3%), followed by those with 6–10 years, and the lowest prevalence was found in those with ≤ 5 years of work experience.

These findings underscore the growing concern of musculoskeletal health among aging and long-tenured corporate professionals and emphasize the need for targeted ergonomic interventions in workplace design and work-rest cycles. [15,16].

CONCLUSION

The research findings reveal a significant prevalence of discomfort and pain across various body regions among corporate workers, with the lower back, knee, and shoulder being the most commonly affected areas over the past 12 months. The application of the Nordic Musculoskeletal Questionnaire (NMQ), combined with robust statistical analysis, lends credibility and reliability to the study outcomes. These results strongly indicate that workers are consistently exposed to work-related musculoskeletal disorders (MSDs) as well as ergonomic risk factors in their occupational environments. This emphasizes the critical need for ergonomic interventions and preventive strategies to promote long-term musculoskeletal health and workplace well-being.

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Experimental Study on Elastic Properties of M₂₀ Grade Concrete as a Partial Replacement of Fine Aggregates with Fine Copper Powder Slag and Fibers Extracted from Cement Bags

P. Narendra Reddy

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ dhanabalgce@gmail.com

P. Nandini

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ pnr127ce@gmail.com

B. Vinay Kumar

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ ramatulusis03@gmail.com

V.V.S. Eswar

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ bvinaykumar6403@gmail.com

ABSTRACT

This study's primary goal is to assess the qualities of both freshly-poured concrete and concrete that has hardened after some fine aggregates have been replaced with fibres taken from cement bags and fine copper powder slag. The attainability of fine and coarse aggregates has become increasingly challenging in recent years. Through testing on mechanical and elastic properties, we are able to draw conclusions about the effects of substituting fine aggregate with fine copper slag and fibers extracted from empty cement bags on the M20 quality concrete.

KEYWORDS: *Copper powder slag, Fibers, Polypropylene fibers, Waste fibers.*

INTRODUCTION

One byproduct of the smelting and refining of copper is copper slag. Recycling, metal recycling, producing value-added goods such as abrasives, roofing granules, cutting tools, abrasives, ceramic tiles, glass, building road bases, railway ballast, asphalt pavements, etc. are all good management alternatives for copper slag [1-6]. A composite material based on cement and scattered reinforcement in the form of fibers is called fiber-reinforced concrete. One excellent source of plastic fibers is cement sacks. Polypropylene fibers are used to make a lot of cement bags. A common addition to concrete that serves as a secondary support to boost its strength is polypropylene fiber. Particularly useful in minimizing cracks that develop when the concrete dries are these fibers. By more uniformly dispersing load and closing tiny cracks, polypropylene fibers strengthen and resist crumbling concrete. For many applications, this translates to higher overall performance and reduced maintenance costs, making it an excellent value [7-9].

The aim of this study is to examine the elastic properties of M20 grade concrete mix, both with and without fine copper powder slag added to the mix in different proportions (5%, 10%, 15%, 25%, 35%, 45%, and 55%). Additionally, fiber extracts from waste cement bags (0.2%) will be added to the mix to improve its elastic properties.

MATERIAL PROPERTIES

Cement: Portland Pozzolana Cement is the cement utilised in this experimental study (PPC). A fine powder known as cement hardens and sticks to other materials when combined with water, sand, and stone. Cement test carried out with help of IS: 12269:2013 [10], "Specifications for 53 grade ordinary Portland cement", Bureau of Indian Standards (BIS), New Delhi, India. It is a crucial component of stone, which is the material that is utilised the most worldwide after water. The physical properties of cement given in Table 1.

Table 1: Physical properties of cement

S. No	Description	Results
1.	Normal Consistency	33%
2.	Fineness	6%
3.	Initial Setting Time	37 minutes
4.	Final Setting Time	430 minutes
5.	Specific Gravity	3.146

Fine Aggregate: By holding everything together and occupying the spaces left by the bigger coarse particles, fine aggregate performs a crucial role in concrete. Sand or gravel are common examples of fine aggregate, which is made up of inert particles smaller than 3/16 inch (4.75 mm). Its purposes are to cover the voids left by larger crops, enhance output, and contribute to the development of strength and endurance. The test on fine aggregate done with help of IS: 2386:1963 [11], "Methods of tests for aggregates for concrete", Bureau of Indian Standards (BIS), New Delhi, India. The physical properties of fine aggregate given in Table 2.

Coarse Aggregate: Coarse aggregate, also known as coarse stone, is an important component of concrete and contributes to its strength, performance and overall properties. Coarse aggregate refers to the larger, inert particles used in the concrete mix. The shape and size of the composite affects the degree to which the particles interact, thus affecting the strength. The test on fine aggregate done with help of IS: 383:1970 [12], "Specifications for coarse and fine aggregates", Bureau of Indian Standards (BIS), New Delhi, India. The physical properties of coarse aggregate given in Table 3.

Table 2: Physical properties of Fine aggregate

Description	Results
Water Absorption of Fine Aggregate	2.5%
Bulking of Fine Aggregate	25%
Specific Gravity of Fine Aggregate	2.59

Table 3: Physical properties of coarse aggregate

Description	Results
Impact Test	18%

Specific Gravity	2.75
Water Absorption	0.15%

Fine Copper Powder Slag: A byproduct of the smelting and refining of copper is fine copper slag, sometimes referred to as copper slag dust or copper slag. It is the most significant part of copper slag and is created when molten copper is smelted and impurities like iron and silicon oxide are removed. The physical properties of fine copper powder slab given in Table 4.

Table 4: Physical properties of fine copper powder slag

S. No	Description	Value
1.	Water Absorption	1.5%
2.	Bulking Of Copper Slag	16%
3.	Specific Gravity	2.63

**Fig. 1: Fine Copper Powder Slag**

Fibers extracted from cement bags: We may remove the fibers from the cement bags and add them to the concrete mix to strengthen the concrete's tensile strength, making efficient use of the bags and preventing waste. Polypropylene fibers are used to make the cement bags.

Because of its advantages, affordability, and high qualities, polypropylene (PP) plastic fibre is a synthetic material that is utilised extensively in various sectors.

**Fig. 2: Fibers extracted from empty cement bags**

EXPERIMENTAL INVESTIGATION

Slump Cone Test: In the production of concrete, the slump cone test is an essential quality control measure.

It gauges how easily new concrete flows and fills moulds, or how workable it is. This keeps the concrete uniform between batches and avoids problems like improper finishing or hard concrete pumping. The slump test assists in preventing expensive delays and potential structural flaws brought on by incorrect concrete laying by detecting issues early. The slump cone test for workability was done and the results were given in Table 5. Also, the slump cone test value graph for various mixes given in figure 3.

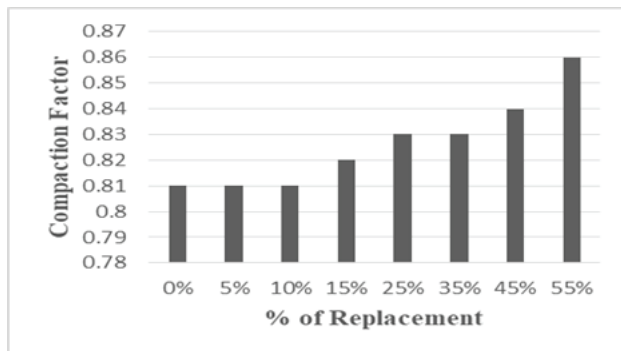


Fig. 3: Variation of Slump cone test values for various mixes

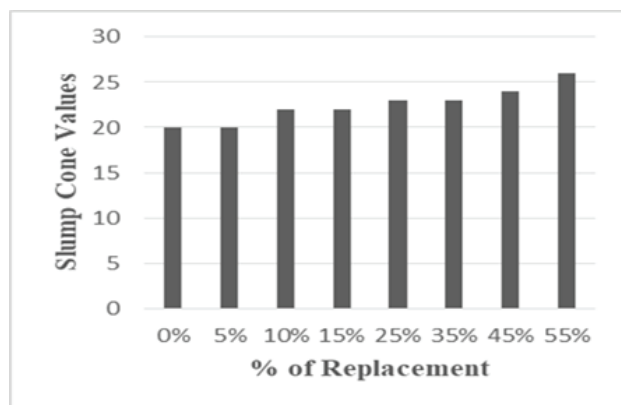


Fig. 4: Variation of compaction factor test values for various mixes

Table 5: Slump cone test value for various mixes

Percentage Of Replacement	Compaction Factor	Workability
0% Replacement	0.81	Very Low
5% C Slag + 0.2 % PP Fibers	0.81	Very Low
10% C Slag + 0.2 % PP Fibers	0.81	Very Low

15% C Slag + 0.2 % PP Fibers	0.82	Very Low
25% C Slag + 0.2 % PP Fibers	0.83	Very Low
35% C Slag + 0.2 % PP Fibers	0.83	Very Low
45% C Slag + 0.2 % PP Fibers	0.84	Very Low
55% C Slag + 0.2 % PP Fibers	0.86	Low

Table 6: Compaction factor test value for various mixes

Percentage Of Replacement	Slump Value	Type Of Slump	Workability
0% Replacement	20	True	Very Low
5% C Slag + 0.2 % PP Fibers	20	True	Very Low
10% C Slag + 0.2 % PP Fibers	22	True	Very Low
15% C Slag + 0.2 % PP Fibers	22	True	Very Low
25% C Slag + 0.2 % PP Fibers	23	True	Very Low
35% C Slag + 0.2 % PP Fibers	23	True	Very Low
45% C Slag + 0.2 % PP Fibers	24	True	Very Low
55% C Slag + 0.2 % PP Fibers	26	Shear	Low

Compaction Factor Test

One important quality control tool used in the manufacture of concrete is the compaction factor test. It evaluates how easily air bubbles are trapped in the mould by the concrete mix. The final hardened concrete will have the ideal density and strength thanks to a suitable compaction factor. This results in a more resilient structure that is more resistant to water

intrusion and cracking, ultimately saving time and money both during construction and over the building's lifetime. The compaction factor test for workability were done and the results were given in Table 6. Also, the compaction factor test value graph for various mixes given in figure 4.

Compressive Strength Test

Tests for compressive strength are performed on specimens measuring 150 mm by 150 mm. Concrete's compressive strength is crucial to the stability and safety of structures. It enables engineers to create structures that can bear the weight by illustrating the maximum amount of weight that can be carried without breaking or degrading. We can make sure that constructions like bridges, buildings, and other infrastructure are sturdy and dependable by measuring and compressive strength. The compressive strength test was done and the results were given in Table 7. Also, the compressive strength test value graph for various mixes given in figure 6.

Table 7: Compressive strength test values for various mixes

Percentage Of Replacement	7 Days Compression Strength (N/mm ²)	14 Days Compression Strength (N/mm ²)	28 Days Compression Strength (N/mm ²)
0% Replacement	17.45	19.06	21.36
5% C Slag + 0.2 % PP Fibers	17.73	19.31	21.98
10% C Slag + 0.2 % PP Fibers	18.82	19.86	22.16
15% C Slag + 0.2 % PP Fibers	19.01	20.01	22.65
25% C Slag + 0.2 % PP Fibers	19.33	20.21	23.11
35% C Slag + 0.2 % PP Fibers	19.67	22.14	25.55
45% C Slag + 0.2 % PP Fibers	20.24	23.62	28.53
55% C Slag + 0.2 % PP Fibers	17.09	19.61	24.12



Fig. 5: Concrete Specimen after compressive strength test

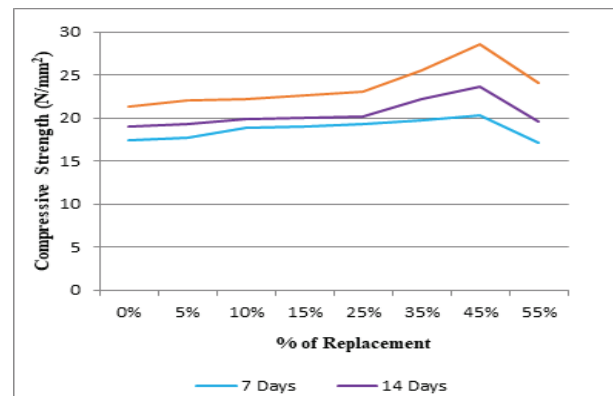


Fig. 6: Variation of Compressive strength test values for various mixes

Split Tensile Strength Test

The split tensile strength test was conducted using cylindrical moulds of 150 mm diameter and 300 mm length. Although the tensile strength of concrete is lower than its compressive strength, it plays a crucial role in determining the flexural capacity of structural elements. It is also a key indicator for crack initiation in beams, slabs, and other flexural members under bending loads. The results of the split tensile strength test are presented in Table 8, and a graphical representation of the split tensile strength values for different concrete mixes is shown in Figure 8.

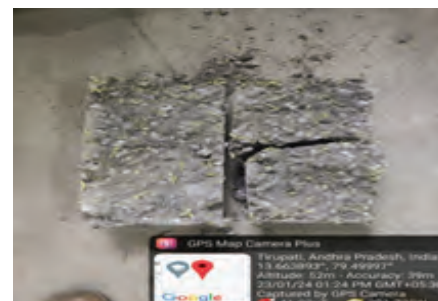


Fig. 7: Concrete specimen after Split Tensile Test

Table 8: Split tensile strength test values for various mixes

Percentage Of Replacement	7 Days Tensile Strength (N/mm ²)	14 Days Tensile Strength (N/mm ²)	28 Days Tensile Strength (N/mm ²)
0% Replacement	1.71	1.81	1.96
5% C Slag + 0.2 % PP Fibers	1.91	2.164	2.39
10% C Slag + 0.2 % PP Fibers	2.01	2.21	2.43
15% C Slag + 0.2 % PP Fibers	2.25	2.42	2.63
25% C Slag + 0.2 % PP Fibers	2.38	2.53	2.99
35% C Slag + 0.2 % PP Fibers	2.43	2.72	3.38
45% C Slag + 0.2 % PP Fibers	2.63	3.05	3.72
55% C Slag + 0.2 % PP Fibers	2.47	2.84	3.55



Fig. 8: Concrete specimen under Young's modulus test

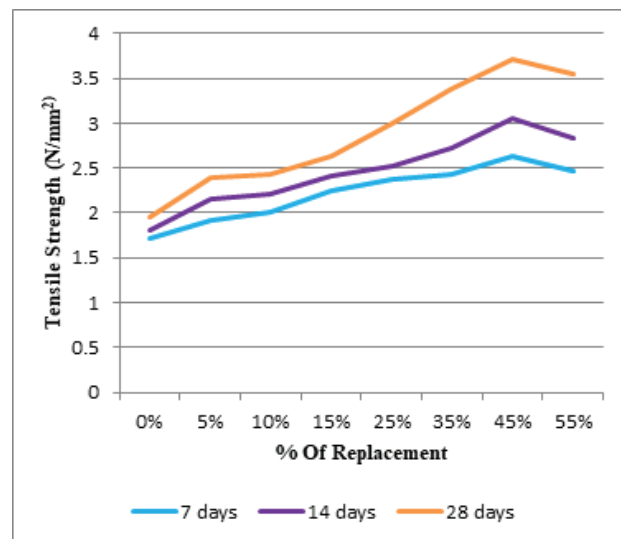


Fig. 9: Variation of split tensile strength test values for various mixes

Young's Modulus Test

Young's modulus, a fundamental measure of stiffness, is essential in assessing the elastic behavior of concrete. It reflects how much the material deforms under applied stress. Understanding this property enables engineers to design beams, columns, and slabs that can withstand deflection without leading to structural failure. Incorporating Young's modulus into design calculations helps ensure the safety, durability, and functionality of concrete structures. The results of the Young's modulus test are presented in Table 9, and the corresponding graph for different concrete mixes is shown in Figure 9.

Table 9: Young's modulus test values for various mixes

% of Replacement	Young's Modulus Results (N/mm ²)
0%	23757
5%	24283.26
10%	25183.97
15%	26942.85
25%	27007.15
35%	27940.74
45%	28503.77
55%	26316.27

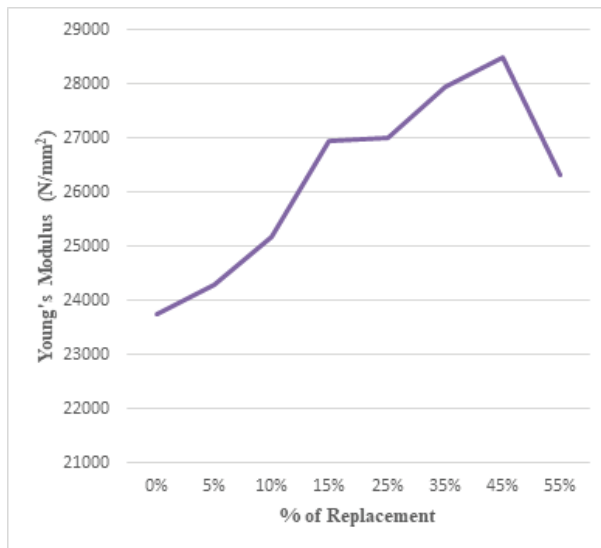


Fig. 10: Variation of Young's modulus test values for various mixes

Table 10: UPV test values for various mixes

Percentage Of Replacement	7 Days UPV (km/s)	14 Days UPV (km/s)	28 Days UPV (km/s)
0% Replacement	4.01	4.01	4.02
5% C Slag + 0.2 % PP Fibers	4.02	4.02	4.03
10% C Slag + 0.2 % PP Fibers	4.12	4.12	4.13
15% C Slag + 0.2 % PP Fibers	4.11	4.12	4.12
25% C Slag + 0.2 % PP Fibers	4.15	4.15	4.16
35% C Slag + 0.2 % PP Fibers	4.18	4.17	4.18
45% C Slag + 0.2 % PP Fibers	4.18	4.18	4.18
55% C Slag + 0.2 % PP Fibers	4.16	4.18	4.19

Ultra Sonic Pulse Velocity Test

A 150 mm × 150 mm concrete specimen was used for the Ultrasonic Pulse Velocity (UPV) test, a non-destructive method critical for evaluating the integrity and durability of concrete structures. The UPV test enhances the lifetime and safety of structures by detecting internal flaws such as cracks, voids, and honeycombing without inflicting any damage. This is achieved by transmitting high-frequency ultrasonic waves through the concrete and measuring their velocity. Faster wave propagation typically indicates denser and stronger concrete, while slower velocities may suggest defects. The test allows engineers to assess the quality, uniformity, and structural soundness of concrete and supports informed decisions regarding repair, maintenance, or replacement. The results of the UPV test are summarized in Table 10.

CONCLUSION

Following the experimental investigation on replacing fine aggregate with copper slag and waste polypropylene fibers (sourced from used cement bags) in M20 grade concrete, the following key observations and conclusions were drawn:

Workability: The initial addition of copper slag and waste fibers showed no significant increase in workability. However, once the replacement level exceeded 10%, a consistent improvement in workability was observed.

Compressive Strength: Replacing fine aggregates with copper slag and waste fibers enhanced compressive strength up to a 45% replacement level. Beyond this threshold, the compressive strength declined, indicating an optimal replacement limit.

Split Tensile Strength: A similar trend was seen in tensile strength. It increased steadily with the addition of copper slag and fibers up to 45% replacement, after which strength decreased, suggesting a saturation point in the reinforcing effect.

Young's Modulus: The elastic modulus increased by up to 19% with increased replacement, indicating improved stiffness of the concrete. However, beyond the optimal proportion, modulus values began to decrease, demonstrating a limit to the elastic enhancement.

Material Contribution

Polypropylene fibers enhanced the tensile and elastic properties of the concrete.

Copper slag, with its granular nature and density, acted as a viable alternative to fine aggregate, contributing to both strength and workability improvements.

Overall Implication: While the incorporation of copper slag and polypropylene fibers positively influences the mechanical and elastic properties of concrete, the replacement levels must be optimized. Excessive substitution leads to diminishing returns and potential strength degradation.

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Enhanced Dorsal Hand Vein Recognition using Quaternion Fourier Transform Enhanced Butterworth Filter (QFT-EBF)

Nagaraju Rangappagari

Department of ECE
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ r.nagrajuece@gmail.com

A. S. Lavanya

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ lavanyaachary04@gmail.com

ABSTRACT

In this research work, a novel biometric recognition method termed Quaternion Fourier Transform Enhanced Butterworth Filter (QFT-EBF) for dorsal hand vein recognition is proposed. Leveraging the synergy between the Quaternion Fourier Transform (QFT) and Butterworth high-pass filters. Our method involves preprocessing the image, detecting knuckle profiles, segmenting significant edges, and refining vein patterns through morphological operations. The QFT-EBF method yields a 1-pixel thick skeleton pattern for feature extraction and employs triangulation and local thresholding to detect vein bifurcations and endings. Implemented in MATLAB 2022b, our system demonstrates superior performance accuracy of 97% compared to existing techniques, offering promising advancements in digital image processing for biometric dorsal hand vein recognition.

KEYWORDS: *Digital image processing, Biometrics, Dorsal hand veins, Vein recognition, QFT-EBF.*

INTRODUCTION

In today's increasingly security-conscious landscape, especially in high-security contexts, biometric systems are gaining traction due to their unmatched reliability and uniqueness compared to traditional identification methods. A variety of methods have emerged to meet the stringent demands of security, reliability, and performance using human biometrics. Among the earliest approaches is the Facial Recognition System, originally devised to identify individuals in crowded environments. Other authentication techniques include handwriting analysis, vein recognition, fingerprinting, and voice recognition. Fingerprint-based systems are popular due to their affordability and ease of implementation. More advanced methods like iris and retina scanning offer superior accuracy compared to voice, handwriting, facial, and fingerprint recognition. Hand vein recognition represents a significant advancement in this field.

Human vein patterns serve as highly distinctive identifiers, capable of differentiating individuals with precision, even among identical twins. Obtaining hand vein patterns is relatively straightforward as veins absorb

light differently than surrounding tissues, resulting in clear and distinctive images. Imaging technologies for capturing hand vein images are broadly categorized into Far-Infrared (FIR) and Near-Infrared (NIR). FIR technology, which operates within the 8-14 micrometer spectrum, captures large veins on the dorsal side of the hand but is sensitive to environmental conditions, limiting its effectiveness. Conversely, NIR technology, spanning from 700 to 1000 nanometers, produces high-quality, stable images of veins across the palm, hand, and wrist, even under varying conditions.

LITERATURE REVIEW

Li et al. [3] present a dorsal hand vein recognition system that combines ResNet and HOG features. By integrating ResNet with HOG, the system achieves greater robustness. This fusion approach enhances the system's ability to accurately identify dorsal hand veins, offering a promising solution to the challenges encountered in biometric recognition systems.

Kumar and Singh[4] Their study emphasizes a modern approach to enhancing recognition accuracy through advanced deep learning techniques. Their research

work makes a valuable contribution to the progressive development of biometrics.

Zhong and Shao [5] presented a novel biometric graph-matching methodology. Their study responds to the demand for resilient recognition systems capable of operating effectively across diverse conditions, offering significant insights applicable to practical real-world scenarios.

Wan, Chen, and Yang [6] proposed a dorsal hand vein recognition system leveraging Convolutional Neural Networks (CNNs). Their approach highlights the effectiveness of CNNs, in extracting features and conducting recognition tasks.

Chin et al. [7] detail a method for feature extraction from GLCM and statistical techniques combined with ANN for dorsal hand vein recognition. The process begins with preprocessing the images by cropping the region of interest (ROI). Subsequently, the ROI is segmented using a binarization method. The segmented ROI is then utilized to extract statistical and GLCM features, which are subsequently fed into an ANN for classification purposes. This comprehensive approach showcases a methodical integration of image preprocessing, feature extraction, and neural network classification for accurate dorsal hand vein recognition.

Nadiya et al. [8] introduced a method for dorsal hand vein identification. Initially, they eliminate unwanted noise from the input image. Next, they utilize an extended version of Local Binary Pattern (LBP) called Orientation of LBP (OLBP) to extract directional features from the preprocessed image. These features extracted with OLBP are then represented in binary format, enabling the use of the Hamming distance for feature matching.

SAYED et al. [9] introduced a dorsal hand identification. Their approach involves utilizing a smartphone to gather the dataset, coupled an infrared LED and camera. Feature detection and extraction utilize K-nearest neighbors (K-NN) matching, combined with the orientation of FAST and rotation of BRIEF (ORB) methods to match features.

PROPOSED METHOD

The analysis of dorsal hand vein images begins with the acquisition of the image, followed by preprocessing

steps to enhance relevant features. Saturation adjustment and extraction techniques isolate the dorsal hand region, emphasizing vein structures. The image undergoes a Quaternion Fourier Transform (QFT) to facilitate frequency domain analysis, enhancing the understanding of vein patterns. Gaussian filtering and median filtering are applied to reduce noise while preserving important details. Region of Interest (ROI) extraction isolates the vein-containing area for focused analysis. Thinned objects, noise, are removed to refine the image further. Ridge points, representing vein terminations and bifurcations, are then extracted. Delaunay's triangulation is employed on these points to analyze spatial relationships and connectivity. Finally, threshold comparison techniques were employed to match the testing image with the train image. If the difference between testing and training images is low that is within the threshold, then the dorsal hand is authorized else it is unauthorized. Figure 1. Shows the block diagram of the proposed system.

To transform the input image into quaternion form using pure quaternions, we utilize the pixel values denoted as $I(x, y)$ for spatial coordinates x and y . Each pixel is represented as a pure quaternion q defined as $q = a + bi + cj + dk$ where a, b, c and d are real numbers and i, j and k are the quaternion units. For every pixel at coordinates (x, y) in the image, the corresponding quaternion representation $Q(x, y)$ is defined as:

$$Q(x, y) = I(x, y) + bi(x, y) + cj(x, y) + dk(x, y) \quad (1)$$

Here, $I(x, y)$ represents the intensity value of the pixel, while $b(x, y)$, $c(x, y)$ and $d(x, y)$ represent additional color channels or features of the pixel. This equation effectively converts the input image into quaternion form, with the intensity value as the real part and the additional features as the imaginary parts of the quaternion.

The Fourier kernel in quaternion space can be denoted as $e^{iq \cdot x}$ where i is the imaginary unit, q is the quaternion frequency vector, and x represents the spatial coordinates. To compute the QFT, we perform a convolution between the quaternion representation of the image and the quaternion representation of the Fourier kernel over all spatial coordinates x and y .

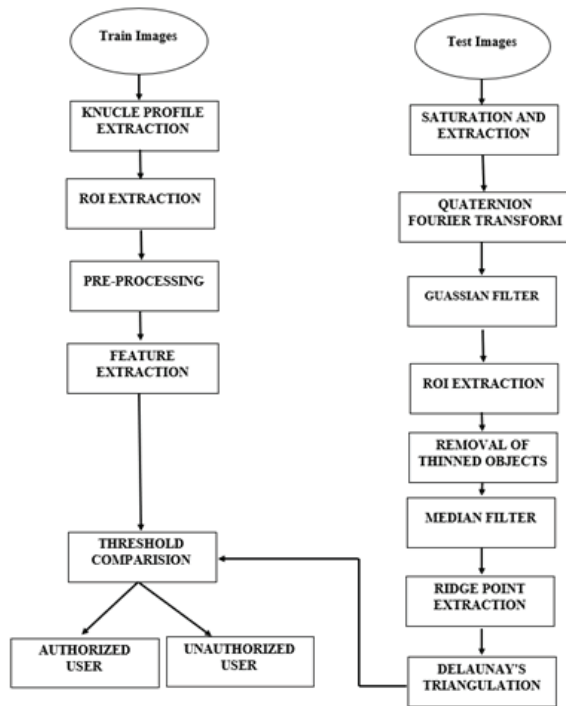


Fig. 1: Proposed method Block Diagram

$$F(q_x, q_y) = \sum_{x=0}^{N-1} \sum_{y=0}^{M-1} Q(x, y) \cdot e^{iq \cdot x} \quad (2)$$

where N and M represent the width and height of the image, respectively, and q_x and q_y represent the frequencies in the quaternion Fourier domain. This equation computes the QFT of the image, transforming it from the spatial domain to the frequency domain in quaternion space.

The Butterworth high-pass filter (BHPF) is employed to enhance the power of positional information in an image by emphasizing high-frequency components, thus complementing the phase information provided by the Fourier Transform. The BHPF is particularly effective in preserving edge details while suppressing low-frequency components that typically represent background or noise.

The 2-D Butterworth high-pass filter of order n and cutoff frequency D_0 is defined as follows:

$$H(u, v) = 1 - \frac{1}{1 + \left(\frac{D(u, v)}{D_0} \right)^{2n}} \quad (3)$$

Where $H(u, v)$ is the frequency response of the filter at spatial frequency coordinates $D(u, v)$ is the distance from

the center of the frequency domain to the point. n is the order of the filter, determining the rate of attenuation of low-frequency components. Higher values of n result in sharper transitions between the passband and stopband. D_0 is the cutoff frequency, defining the boundary between the passband and stopband. It controls the amount of high-frequency emphasis applied by the filter.

A Gaussian pyramid is employed to extract the Region of Interest (ROI) in the process of generating the final saliency map. Once the Gaussian pyramid is constructed, a thresholding operation is applied to transform the saliency map into a binary mask, where regions of interest are represented by ones. This binary mask effectively highlights the areas that are deemed significant within the image. The final detection result, corresponding to the ROI, is obtained by overlaying this mask onto the original image. The subsequent steps of the process remain consistent with those of the existing system. However, the incorporation of Quaternion Fourier Transform (QFT) enhances the feature extraction process, leading to more accurate identification and localization of important features within the image.

After generating a saliency map from ROIs using a Gaussian pyramid and thresholding, the process continues with ridge point extraction, crucial for identifying vein structure features. Subsequently, Delaunay's triangulation connects these points, facilitating spatial analysis and geometric feature extraction. These steps enhance the system's ability to accurately identify and compare dorsal hand vein patterns, vital for authentication and identification.

Thresholding comparison serves as a crucial step in the authentication process, distinguishing between authorized and unauthorized users based on the extracted vein patterns.

SIMULATION RESULTS

The dataset [13] comprises 138 individuals, with each person represented by four images of each hand, totaling 1,104 images. A subset of 600 images are allocated for training, 100 images are allocated for evaluating the effectiveness of the proposed approach.

Analysis of the Simulation Results

The input images are applied to proposed method. Figure 2. Show the sample input image,

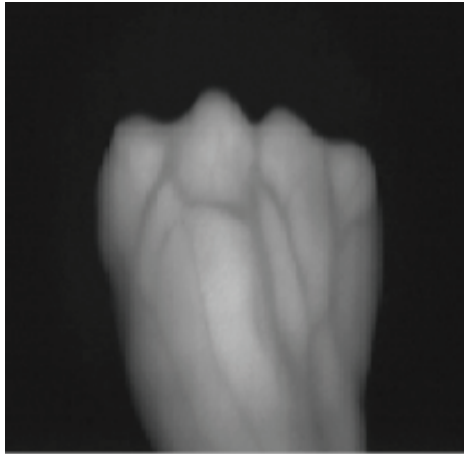


Fig. 2: Shows the Sample Input Image

By applying the QFT and Gaussian filter Region of Interest from the input image is extracted. Figure 3(a) Shows the ROI image. Morphological operations are carried out for finding the Thinned Image. Figure 3(b). Shows the Thinned Image.

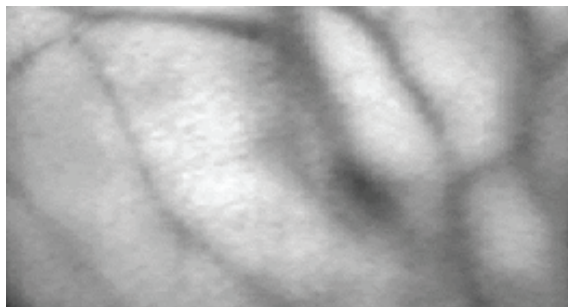


Fig. 3(a): Shows the ROI 3(b): Shows the Thinned Image



Fig. 4(a): Shows the Bifurcation Points 4(b): Shows the End Points

Bifurcation and End points are calculated from the thinned image shown in the figure 4(a) and 4(b).

Triplets are calculated by using Delaunay's triangulation method, Figure 5 shows the Triplets of and End Points.

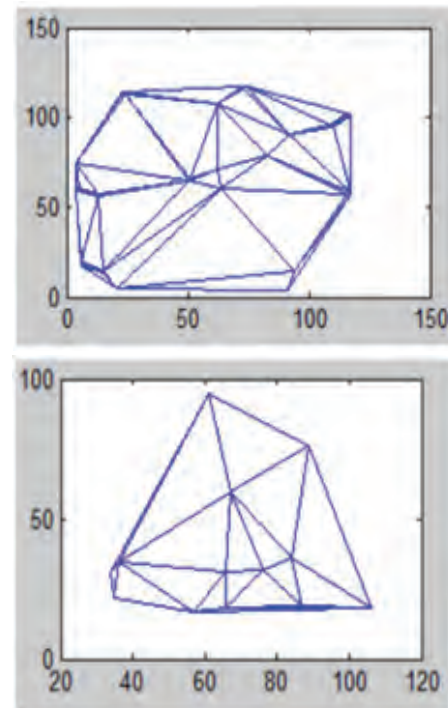


Fig. 5(a). shows the triplets of Bifurcation Points 5(b) shows the triplets of End Points

After the Delaunay's triangulation method, threshold value comparison is done to find the authorized or unauthorized biometric. Figure 6(a) shows the GUI of Authorized person biometric and 6(b) shows the GUI of Unauthorized person biometric.

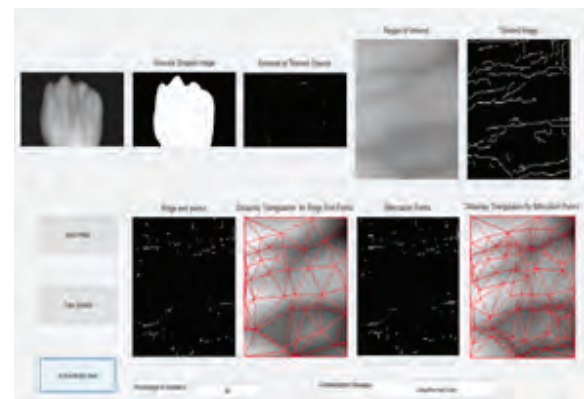


Fig. 6(a): Shows the GUI of Authorized person biometric

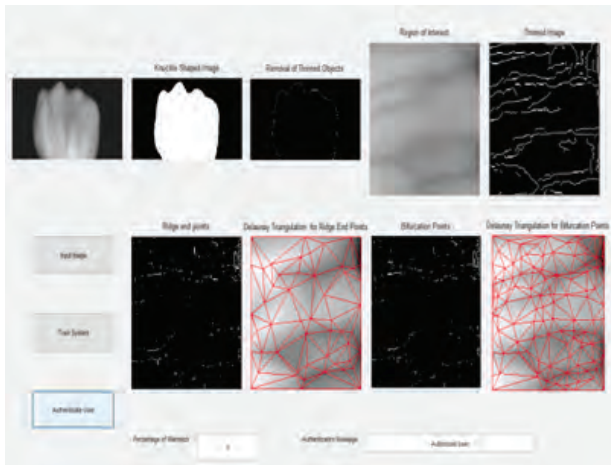


Fig. 6(b): Shows the GUI of Unauthorized person biometric

RESULT ANALYSIS

Following the training phase with 600 images, the proposed method was assessed using 100 images, consisting of 50 authorized and 50 unauthorized instances. Among the authorized images, 49 were accurately predicted, while 48 of the unauthorized images were correctly identified.

Confusion Matrix Calculation

Table 1 displays confusion matrix derived from the classifier output analysis

Class	Authorized	Unauthorized
Authorized	49	01
Unauthorized	02	48

Performance Analysis

From the confusion matrix, various parameters are calculated to analyze the efficiency of the presented method. Table II Shows the parameter variations in the proposed method.

Table. 1 Performance Metrics

Parameter	Value (%)
Sensitivity	96.08
F1Score	97.03
Precision	98.00
Negative Predictive Value	96
Specificity	97.96

Accuracy	97.00
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The proposed method is compared with other existing methods for performance evaluation. Table III shows the comparison of the proposed method. Figure 7. Shows the comparison of the proposed method with other methods

Table. 2: Comparison of Proposed Method

Authors	Year	Methods Utilized	Accuracy
Arora et.al[11]	2020	Deep Learning	95%
Jhong et.al[12]	2020	Prototype+CNN	96.54%
Proposed Method	QFT-EBF	97.92%	

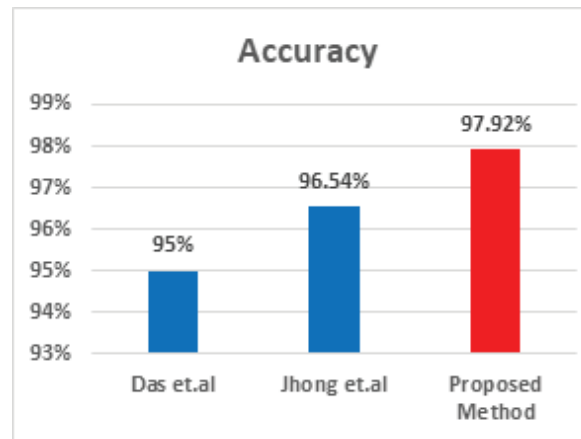


Fig. 7: Shows the comparison of the proposed method with other methods

CONCLUSION

This study introduces a novel method for dorsal hand vein recognition, known as Quaternion Fourier Transform Enhanced Butterworth Filter (QFT-EBF). By integrating Quaternion Fourier Transform (QFT) with Butterworth high-pass filters, this approach significantly improves recognition accuracy and robustness. The proposed methodology includes several key steps such as image preprocessing, knuckle profile detection, significant edge segmentation, and vein pattern refinement through morphological operations. QFT-EBF generates a 1-pixel thick skeleton pattern for efficient feature extraction and utilizes triangulation and local thresholding to detect vein bifurcations

and endings. Implemented in MATLAB 2022b, our system achieves an impressive accuracy rate of 97%, outperforming existing techniques. These findings indicate promising progress in digital image processing for dorsal hand vein recognition, with potential applications in security and authentication systems.

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Sliding Mode Control-Based Torque Enhancement for Switched Reluctance Motor in Electric Vehicles

K. Reddy Prasanna

Dept. of Electrical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ prasannaaits45@gmail.com

Venkata Subramanya Balaji. G

Dept. of Electrical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ balajigadiyaram2020@gmail.com

Nanapu Sree Harsha

Dept. of Electrical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ seeharshanapanu@gmail.com

Perala Vandhana

Dept. of Electrical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ peralavandhana1812@gmail.com

ABSTRACT

This paper proposes a DTC-based solution with SMC incorporating chattering reduction for torque ripple minimization in SRMs. It targets the torque control loop to eliminate low-frequency torque oscillations. The SMC scheme dynamically adjusts the reference current to maintain constant motor speed. Simulation results validate the effectiveness of the proposed SMC, demonstrating its superiority over PI controllers in terms of reduced torque ripple, robust compensation for nonlinearities, and enhanced parameter insensitivity.

KEYWORDS: DTC, SMC, Chattering reduction, SRMs, Torque control loop, PI controllers.

INTRODUCTION

Switched Reluctance Motor (SRM) have emerged as a compelling electrification option across diverse sectors, from military applications to agriculture and transportation. Their affordability, high efficiency, and resilience in harsh environments make them highly attractive [1],[3]. However, a significant hurdle impedes their wider adoption: torque ripple.

This ripple, characterized by fluctuations in torque output, generates noise and reduces the lifespan of the motor [4],[6]. It arises from the fundamental operating principle of SRMs, where the rotor aligns with the magnetic field generated by energized stator windings. While this results in efficient torque production, structural deformations and magnetic interactions between the stator and rotor introduce unwanted oscillations and vibrations, leading to the detrimental torque ripple [7],[2].

This ripple poses a critical challenge for direct-drive applications, where precise and responsive torque control is crucial. The resulting limitations in speed

and accuracy hinder the full potential of SRMs [1]. Consequently, researchers have focused on mitigating torque ripple through two primary approaches: structural optimization and control strategy improvement.

Structural optimization involves refining the motor's design, such as optimizing pole shapes and air gaps, using advanced Modelling techniques like Finite Element Modelling (FEM) [1]. However, control strategy advancements offer greater flexibility, particularly given the inherent simplicity of SRM construction [8]. Researchers have explored various sophisticated control techniques, including Current pulse shaping and waveform optimization, to suppress torque ripple [7]. Additionally, studies have investigated the use of PID fuzzy logic controllers to address this issue [9], [2].

This paper delves into the realm of control strategies, specifically investigating the potential of Sliding Mode Controller (SMC) within a Direct Torque Control (DTC) system. By comparing its performance against conventional Proportional-Integral (PI) control, the aim is to identify the most effective approach for minimizing

torque ripple while ensuring precise control and dynamic performance. Ultimately, this research seeks to pave the way for the broader adoption of SRMs in direct-drive applications, harnessing their full potential and contributing to advancements in various industries.

SLIDING MODE CONTROL

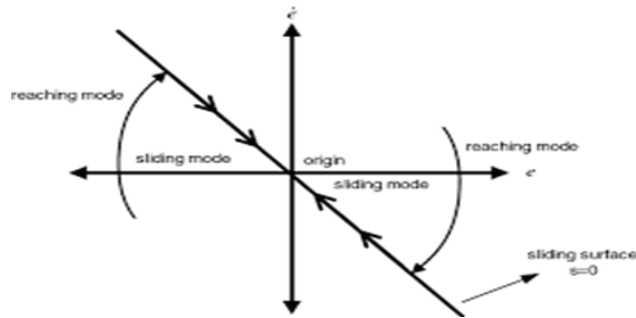


Fig. 1: Diagram SMC control

Sliding mode controllers are awesome because they're tough! They don't care about changes in the system parameter variations and disturbances. It has a special path called the "sliding mode".

This makes them really good at keeping things stable and doing what you want them to do, even in messy situations. The SMC plan is composed of two steps:

To begin with Step: The primary step in SMC is to characterize the Position: speaks to a aspired worldwide conduct, such as steadiness and following performance.

Moment step: once the sliding surface has been chosen, consideration must be tuned to planning the control law that drives the controlled variable.

The continuous portion of the controller is gotten by combining the method demonstrate and sliding condition. The irregular portion is nonlinear and speaks to the exchanging component of the control law.

PROPOSED SYSTEM METHODOLOGY

The proposed system for a switched reluctance motor (SRM) comprises several interconnected blocks, each playing a crucial role in ensuring efficient motor operation. At the heart of the system is the speed controller, which receives a reference signal representing the desired speed and translates it into a torque command signal. This signal is then fed into the Sliding Mode Control (SMC) torque controller along

with the actual motor speed, obtained from a dedicated speed sensor. The SMC torque controller processes this information to generate a current reference signal, optimizing torque production.

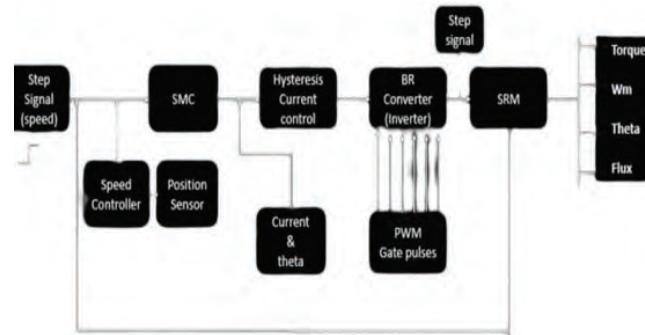


Fig. 2: Block Diagram of Proposed System

Subsequently, the Hysteresis current controller comes into play, receiving the current reference signal along with the real-time motor current data from a dedicated current sensor.

Switching signals necessary for the inverter's operation. The inverter, acting as a bridge converter, then converts the DC voltage supplied by the battery into three-phase AC currents, tailored to the requirements of the SRM.

The SRM itself serves as the mechanical workhorse of the system, converting electrical energy into mechanical torque through its unique design and operation principles. To facilitate precise control and feedback, additional components such as a position sensor and a speed sensor are employed. The position sensor measures the rotor position of the SRM, providing crucial feedback for accurate control algorithms. Simultaneously, the speed sensor monitors the rotational speed of the motor, enabling real-time adjustments and performance monitoring.

Moreover, a flux calculator plays a pivotal role in the system by computing the magnetic flux within the SRM based on motor current and position data. This information aids in fine-tuning control algorithms and optimizing motor efficiency. Finally, the PWM gate driver generates gate pulses necessary for controlling the inverter switches, utilizing signals derived from the hysteresis current controller.

Together, these interconnected components form a comprehensive control system for the SRM, enabling

precise speed and torque control while maximizing efficiency and performance.

SIMULATION MODEL

Step speed is provided as an Input to the sliding mode Controller (SMC). Rotor position is feedback to the SMC as a reference. SMC undergoes Control and yields Right position. Position of Rotor is given to Hysteresis band and the Output of Hysteresis band (PC) has got reference from the position control (Signum function). The product of two Quantities (Rotor position & Signum function) are given as gate signals to BR Converter (BRC). This Converter Converts DC to AC and the Output of BR Converter is fed to the SRM.

Now, the SRM generates appropriate, torque required, if not again the Speed is feedback to the SMC as the Reference signal.

The SRM in this Simulink model operates within a closed-loop system, continuously adjusting its phase currents based

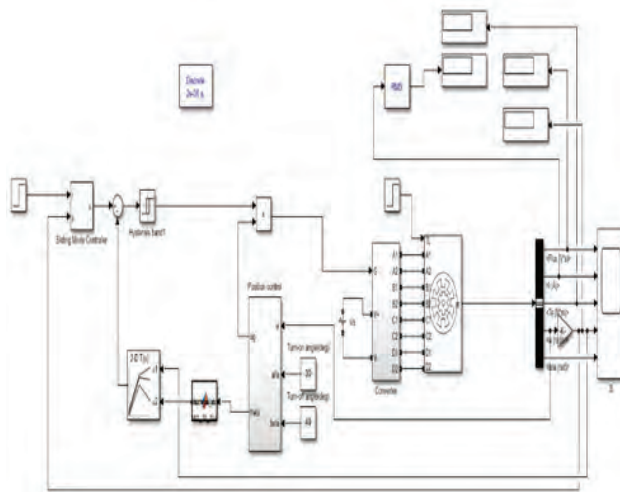


Fig. 3: Simulation model of 2kW, 3-phase, 8/6 pole SRM

This controller compares the two signals and produces on the desired speed and torque, actual motor speed, and rotor position. This feedback loop ensures the motor operates efficiently and delivers the required torque to meet the speed demands. It's important to note that the specific details of the

SRM's function might vary depending on the exact configuration and parameters of the Simulink model.

Table. 1: SRM Motor Parameter

Parameter	Value
Amplitude	48(v)
Turn-off angle	30
Turn-on angle	49
Inductance	45
Saturated inductance	0.15e-3(H)
Stator poles	8
Rotor poles	6
Current(max)	118(A)
Flux linkage (max)	0.4823(wb)
Inertia	0.00832(kg.m.m)
Friction	0.02(N.m. s)
Stator resistance	4(Ω)

CONVERTER OPERATION

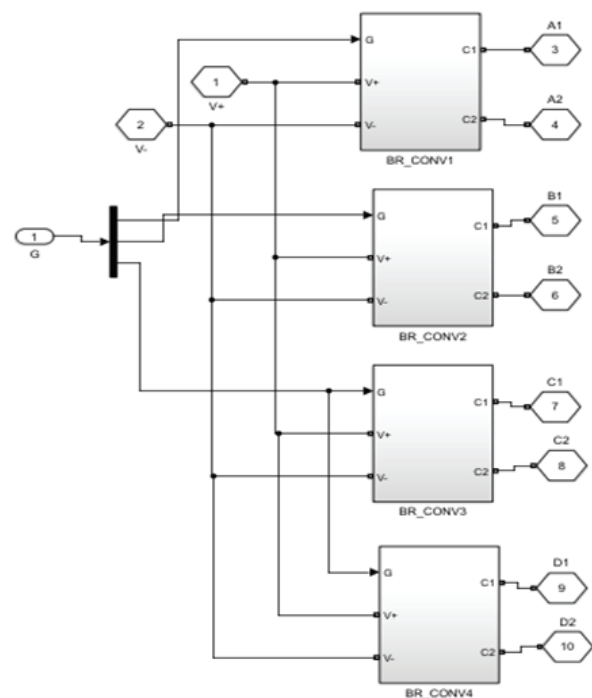


Fig. 4: converter operation of switched reluctance motor

The SRM uses changing magnetic fields and rotor position to generate torque. It receives a desired speed and generates the required torque by adjusting its phase currents. Sensors for speed and position provide feedback to a controller that makes these adjustments, creating a closed-loop system for efficient operation.

RESULTS

Recreations of the DTC framework was Implemented to check the proposed SMC controllers exactness and adequacy. Fig 3 shows the square charts of the SMC controller and the DTC framework. MATLAB was utilized to demonstrate the SRM drives DTC framework with a three-phase SRM. Recreations run within 2021 form of MATLAB. A closed-loop speed control System for SRM is Presented in Fig 3 and the Specific Parameters of SRM engine are appeared in Table I.

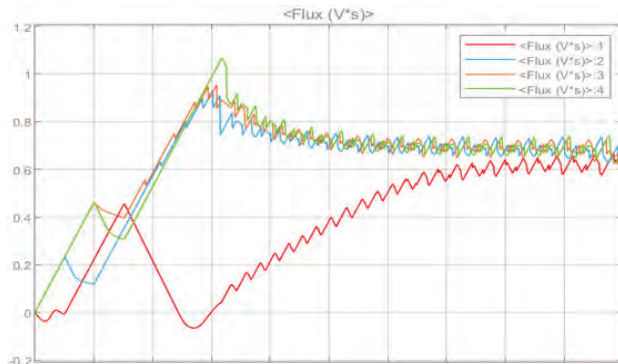


Fig. 5: The Flux Responses of SRM

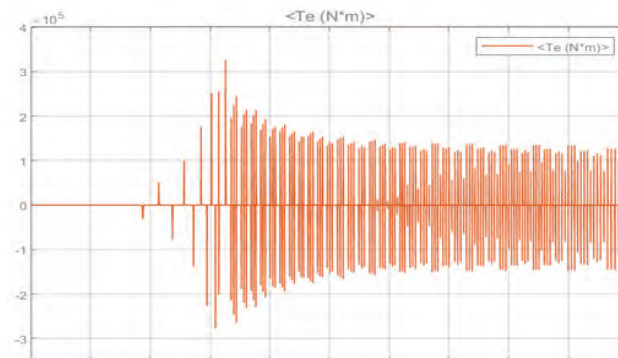


Fig. 6: Torque Response of SRM

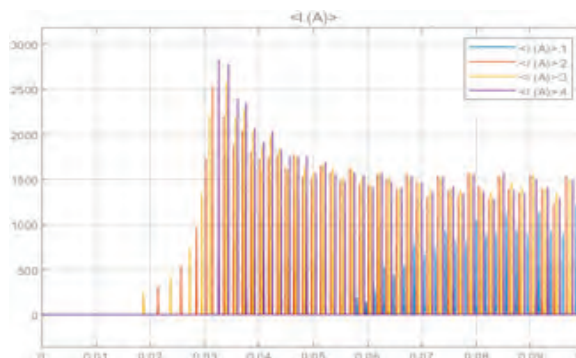


Fig. 7: Current Response of SRM

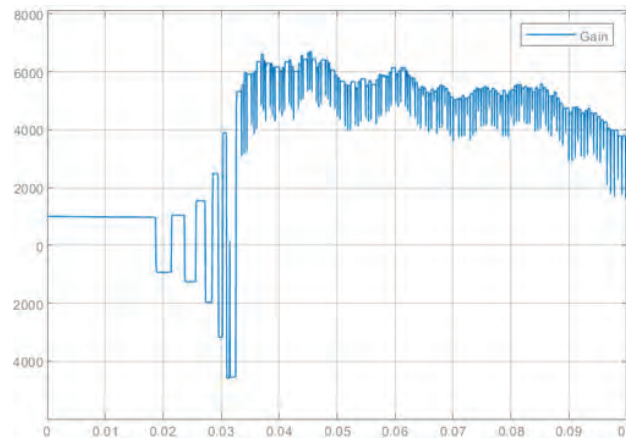


Fig. 8: Speed control response of SRM

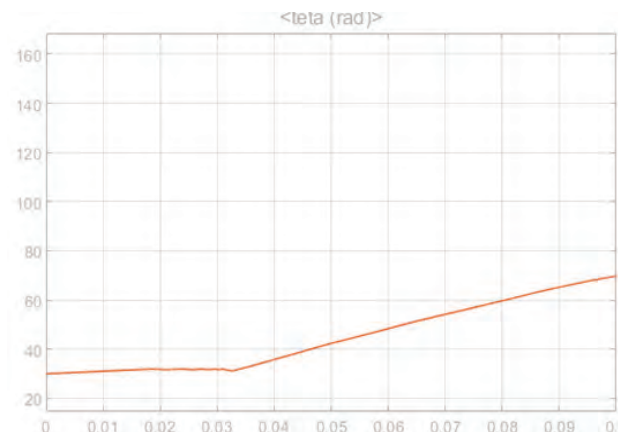


Fig. 9: (Theta) angle response of SRM

The proposed Sliding Mode Control (SMC) shines by delivering nearly constant electromagnetic torque in Switched Reluctance Motors (SRMs), as demonstrated in Figure 3. This is very different from the high amount of turning force to the significant torque ripple produced by traditional PI controllers. While both approaches exhibit some torque fluctuations, SMC boasts an average deviation of only 2.5%, significantly smoother than its PI counterpart.

Additionally, SMC exhibits superior speed ripple suppression and overall torque uniformity, as evidenced in the figure. This remarkable attribute makes SMC a highly attractive choice for applications demanding precise and consistent torque performance.

Figures 5 and 6 show the flux linkage variations under each control scheme. Minimizing these fluctuations plays a crucial role in achieving desired torque

characteristics and enhancing the motor's ability to track reference commands. In this regard, SMC demonstrates clear advantages by promoting smoother flux transitions, ultimately contributing to its superior torque control performance.

Figure 8 is basically a shown up for the new control method (SMC)! It shows that the motor speed stays right on track with the desired speed. This means the motor is super accurate and has very small error compared to PI Controller This precision makes SMC a great choice.

CONCLUSION

This paper introduces a Novel approach for reducing torque fluctuations in SRM. By combining DTC with a proposed sliding mode controller, the system achieves better performance. The saturation component of the control signal helps reduce abrupt changes, and stability is guaranteed through Lyapunov analysis. Moreover, the approach is resilient to variations in parameters and outperforms PI control. Future research could explore integrating the proposed sliding mode controller with other techniques such as fuzzy logic, neural networks, or model predictive control to further reduce torque fluctuations and optimize duty ratios.

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Logic Synthesis and RTL Design of Traffic Light Controller

S Bhavani

Dept. of Electronics & Communication Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ bhavanisangadala433@gmail.com

Naga Damini

Dept. of Electronics & Communication Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ daminiiorugunda47@gmail.com

ABSTRACT

This paper presents a Verilog-based approach to enhance the functionality of traffic light controllers, focusing on improved efficiency, adaptability, and user-defined customization. By leveraging reconfigurable Verilog design, a robust and flexible control mechanism is established to manage traffic signals at a four-way intersection. The proposed system effectively minimizes vehicle idle time and contributes to accident prevention by ensuring orderly traffic movement. A 12-state Finite State Machine (FSM), modeled as a Moore machine, is implemented to optimize signal transitions and traffic clearance. The modular design allows for easy updates to meet changing traffic management requirements.

KEYWORDS: *FPGA, FSM, HDL, LED, Verilog.*

INTRODUCTION

Numerous researchers have investigated diverse traffic light control strategies designed for particular intersection types. Some systems were developed specifically for two-way intersections, while others were optimized for T-junctions. These approaches typically employed either two or three traffic signals to regulate vehicle flow. Despite their targeted designs, many of these systems struggled to optimize traffic movement effectively, often resulting in prolonged delays on certain roads due to inefficient signal timing.

The proposed system addresses the limitations of earlier traffic controllers by aiming to maximize vehicle throughput and minimize unnecessary waiting times. It employs a Moore finite state machine (FSM) model, where the output (traffic signals) is solely dependent on the current state, allowing for a fully automated control process. The design assumes uniform traffic volume across all four directions and utilizes binary encoding for efficient state representation. In comparison to previous approaches, this system achieves improved traffic management with a reduced number of states, which not only enhances traffic flow but also contributes to lower power consumption.

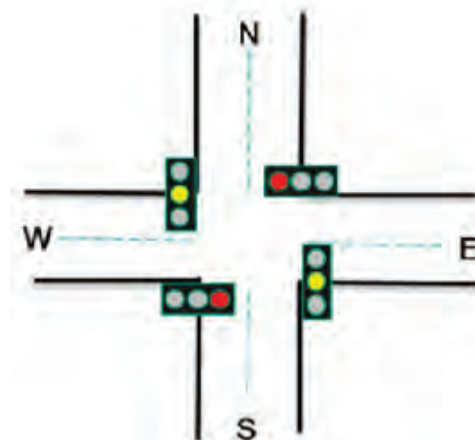


Fig. 1 : Thematic framework of Traffic Light Controller

LITERATURE SURVEY

Traffic congestion and inefficient signal timing at road intersections remain major challenges in urban transportation systems. To address these issues, researchers have proposed numerous traffic light controller (TLC) designs that incorporate hardware-level optimization, real-time adaptability, and intelligent decision-making. This review presents four significant contributions that exemplify the progression of TLC technologies using Verilog, VHDL, FPGA platforms, and IoT-based solutions.

In the paper titled “Advanced Real Traffic Light Controller System Design using Cortex-M0 IP on FPGA”, Prashant Kumar Singh and P. Daniel (2014) [1] emphasized the need for replacing traditional microcontroller-based traffic light systems with more efficient alternatives. The authors presented an FPGA-based design utilizing a low-power Cortex-M0 IP core, implemented on the Xilinx Spartan-3E platform. This design leverages the inherent advantages of FPGAs—such as faster processing, parallelism, more I/O ports, and reconfigurability—to overcome the speed and flexibility limitations of microcontrollers. The system supports real-time, dynamic control of traffic flow and integrates a congestion-aware timing mechanism, which adjusts the signal durations based on vehicular density. While ASIC designs were acknowledged for their performance, the authors pointed out their high cost and lack of reprogrammability, making FPGA a more suitable platform for practical TLC deployment. The successful implementation and testing of this design validated its efficiency, scalability, and adaptability, making it a promising solution for modern traffic systems.

In another approach, K.S. Reddy and B.B. Shabarinath (2017) [2] proposed a Verilog HDL-based traffic light controller that models the intersection logic as a synchronous sequential circuit using an explicit Finite State Machine (FSM). Their system consists of six well-defined states to manage the transitions between red, yellow, and green signals for two intersecting roads. A key feature of their design is the use of a clock divider circuit that generates precise timing delays, ensuring accurate light durations before transitioning to the next state. The FSM transitions are governed by a deterministic controller algorithm, making it easier to verify and validate the behavior of the system. The model was synthesized and targeted for implementation on a Xilinx Spartan-6 FPGA, where different state encoding schemes were tested to find the most synthesis-friendly representation. The design strikes a balance between simplicity and real-world accuracy, ensuring the system can be effectively deployed in actual traffic scenarios. This work reinforces the effectiveness of FSM-based traffic light controllers in achieving both predictable and responsive control.

Shifting toward network-enabled smart systems, the paper “IoT-Based Traffic Light Controller” by Anna Marine George, V.I. George, and Mary Ann George (2018) [3] presents a cloud-connected architecture for real-time traffic monitoring and control. The motivation behind this work stems from the growing difficulty in manually managing high volumes of traffic in expanding urban regions. The proposed system leverages cloud and GPS integration to facilitate automated decision-making and biometric ignition control to ensure that only authorized drivers can operate vehicles. Furthermore, it supports real-time violation detection through license plate recognition and links driver credentials to logged offenses. In emergency situations, the system can notify the nearest ambulance and hospital with the required incident and location details, thereby accelerating the response time. It also advises drivers of congested zones ahead of time and suggests alternative routes. Unlike conventional TLCs, this solution offers a comprehensive smart city integration that not only controls traffic lights but also enhances road safety, law enforcement, and emergency response systems. This marks a significant step toward autonomous and intelligent traffic ecosystems.

On the other hand, Nath et al. (2012) [4] introduced a VHDL-based intelligent traffic light controller (ITLC) that applies adaptive control logic to side roads while keeping main roads on fixed timing. Their motivation was to improve traffic flow during peak hours by preventing unnecessary delays on less congested roads. By incorporating real-time traffic sensors on side streets, the system dynamically adjusts the signal durations based on actual traffic demand. This hybrid timing mechanism, where side road signals are adaptive and main roads maintain constant cycles, effectively clears low-traffic zones without disturbing the regular flow on major roads. Experimental results demonstrated up to a 36% improvement in traffic clearance compared to static-timed systems, particularly during rush hours. This approach showcases the potential of adaptive FSM-based logic in improving traffic efficiency with minimal hardware complexity.

METHODOLOGY

This paper introduces a traffic light controller system tailored for a four-way intersection. Each of the four

roads is equipped with three traffic lights to manage traffic flow toward the remaining three directions, resulting in a total of twelve individual lights. The system operates using four primary states, each corresponding to one direction of traffic movement at the intersection. Within each primary state, there are three sub-states that represent the Red, Yellow, and Green signal phases. Once the sequence of sub-states in the current direction is completed, the system transitions to the next primary state, forming a continuous control loop for managing traffic efficiently and safely.

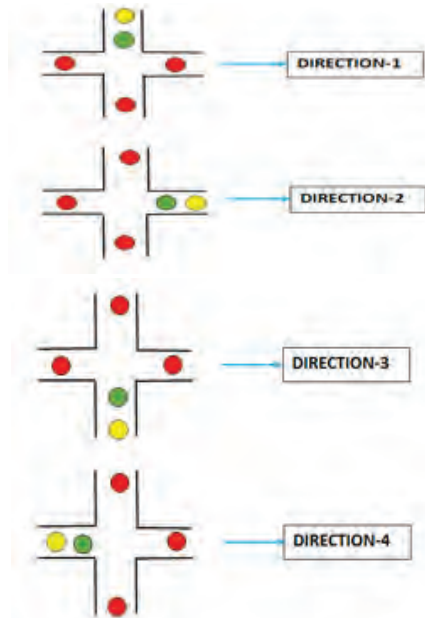


Fig. 2 : Four way traffic light controller

IMPLEMENTATION OF TRAFFIC LIGHT CONTROLLER

The proposed traffic light controller alternates between even- and odd-numbered states, with extended durations assigned to the even-numbered states to accommodate higher traffic densities typically observed in those directions. This strategic allocation of timing enhances vehicle throughput on busier roads. The controller operates on a fixed cycle, repeating its full state sequence every 90 seconds to ensure consistent and predictable signal behavior. Additionally, the system integrates a reset signal, which allows for immediate reinitialization of the state machine, ensuring safe startup and facilitating recovery in case of faults or system interruptions.



Fig. 3: State diagram of traffic light controller

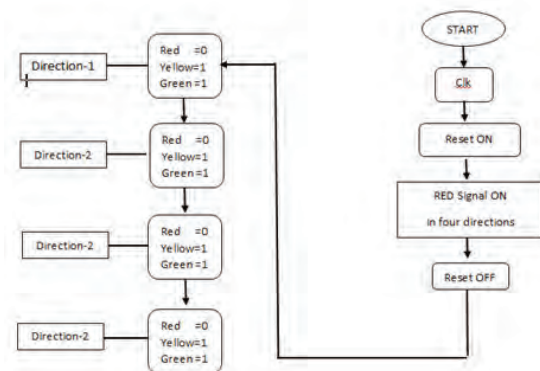


Fig. 4: Flowchart of traffic light controller

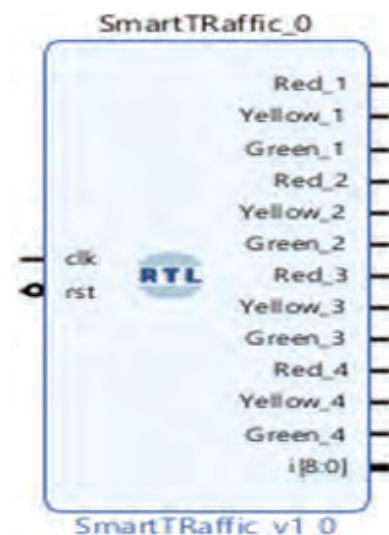


Fig. 5: Block Diagram Of Traffic Light Controller

RESULTS AND DISCUSSION

The traffic light controller system was implemented as a Moore finite state machine using Verilog hardware description language within the Xilinx Vivado design environment. The complete development process included simulation, synthesis, placement and routing, and bitstream generation for FPGA implementation.

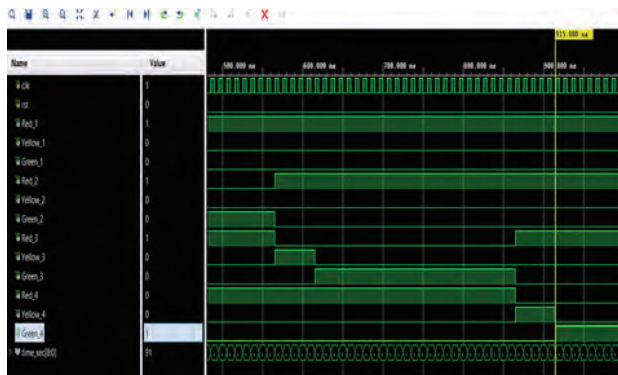


Fig. 6: Output waveforms

During the simulation phase, a behavioral testbench was created in Verilog to verify the logical functionality of the design. The resulting waveform illustrates the behavior of the traffic light controller in response to the applied testbench stimuli. Specifically, it demonstrates the correct sequencing and timing of the red, yellow, and green signals for each intersection direction. This simulation serves as a functional verification step, confirming that the state transitions and signal outputs of the controller operate in accordance with the designed finite state machine logic.

RTL Schematic: The below figure shows RTL schematic of the designed system

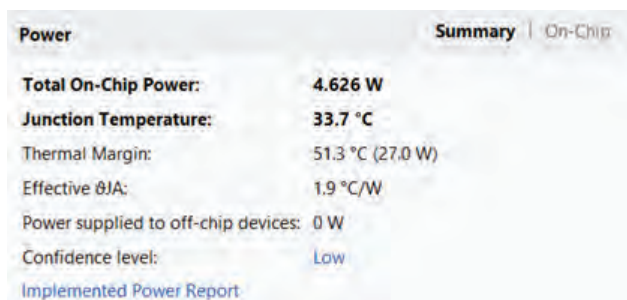


Fig. 7: Power Consumption

The implemented design consumes a total power of 4.626 watts during operation, indicating efficient energy

usage for real-time traffic control applications. The system demonstrates reliable performance and offers high flexibility for future modifications or upgrades. In terms of hardware resource utilization, the project employs 43 Look-Up Tables (LUTs) and 21 Flip-Flops, along with 23 input/output signals and a single buffer gate. This resource-efficient design ensures that the traffic light controller can be deployed on low-cost FPGA platforms without compromising functionality or scalability.

Utilization		Post-Synthesis		Post-Implementation	
				Graph Table	
Resource	Utilization	Available	Utilization %		
LUT	43	41000	0.10		
FF	21	82000	0.03		
IO	23	300	7.67		
BUFG	1	32	3.13		

Fig. 8: Utilization summary

CONCLUSION

The traffic signal controller system is designed to regulate vehicle movement at a four-way junction. Verilog Hardware Description Language (HDL) was selected for implementation due to its ease of modification, allowing future enhancements to be made simply by updating the code. This provides a high degree of adaptability to meet evolving traffic management requirements. While the current design focuses on fundamental signal control, it holds significant potential for future expansion. Specifically, the system can be implemented on an FPGA platform, which offers reusability, flexibility, and efficient resource utilization. Further improvements could involve integrating external devices such as cameras and sensors. This would enable real-time detection of emergency vehicles, such as ambulances, and allow the controller to dynamically adjust traffic signals to prioritize their passage. Additionally, the proposed system is optimized to reduce power consumption, making it suitable for deployment in energy-conscious smart city infrastructures.

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Fabrication of Aluminium Hybrid Metal Matrix Composite through Bottom Pouring Stir-Squeeze Casting

Lakshmi S

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ lakshmi.aret7@gmail.com

Nayeem S

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ snayeem2003@gmail.com

Indraprastha P

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ p.indraprastha@gmail.com

Maneesh T

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ mahesh710@gmail.com

ABSTRACT

Composite materials are engineered by combining two or more distinct substances, such as fibers or particles, to form a material with enhanced properties compared to the individual components. In this work, a hybrid aluminum metal matrix composite (AMMC) was fabricated using a bottom pouring type stir-squeeze casting process, a method chosen for its ability to produce materials with superior tensile strength and uniform particle distribution. This hybrid approach effectively merges the benefits of both stir casting and squeeze casting techniques—stir casting ensures uniform dispersion of reinforcement particles, while squeeze casting helps in reducing porosity, optimizing microstructure, and enhancing mechanical properties. The base material selected for this study is Aluminum 2024 alloy, known for its high strength-to-weight ratio and wide applications in engineering fields. To reinforce the matrix, fly ash and molybdenum disulfide (MoS_2) were used. Fly ash contributes to cost-effectiveness and environmental sustainability, while MoS_2 improves the mechanical characteristics such as wear resistance and tensile strength. The processing parameters, including stirring speed, squeezing pressure, and pouring temperature, were systematically varied to investigate their effect on the final tensile strength of the composite. Among these, stirring speed and squeeze pressure are identified as the most critical parameters in the stir-squeeze casting process, significantly influencing the quality and performance of the resulting composite.

KEYWORDS: *Aluminum alloy, Stir-squeeze casting, Tensile strength, Grain refinement, Porosity.*

INTRODUCTION

Modern engineering applications increasingly demand materials that offer a high strength-to-weight ratio while remaining cost-effective, particularly for sectors such as automotive and marine industries where fuel efficiency and enhanced engine performance are critical [1]. The performance requirements of advanced systems often necessitate a diverse combination of material properties that are difficult to achieve using conventional monolithic materials alone [2]. Desired property combinations include high specific strength and stiffness, low thermal expansion, excellent

thermal resistance, superior damping capability, enhanced wear resistance, and satisfactory corrosion resistance [3].

Metal Matrix Composites (MMCs) have emerged as a promising class of materials capable of delivering such customized property combinations across various engineering domains [4]. Due to their superior performance characteristics, MMCs are gradually replacing traditional metallic alloys. Initially prevalent in aerospace and automotive sectors, their applications have now expanded into defense, marine, sports, and recreational industries [5]. Commonly used metallic

matrices include light metals such as aluminum (Al), magnesium (Mg), and titanium (Ti), although other metals like zinc (Zn), copper (Cu), and stainless steel are also employed depending on the specific application requirements.

MATERIALS AND METHODS

In this study, hybrid aluminum metal matrix composites (MMCs) were synthesized using Aluminum 2024 alloy as the base matrix, reinforced with 2 wt.% molybdenum disulfide (MoS_2) and varying proportions (2 wt.%, 4 wt.%, and 6 wt.%) of fly ash particles. The composites were fabricated through liquid-state processing, specifically using the squeeze casting method, which is known for ensuring uniform distribution of reinforcement particles within the metal matrix.

Squeeze casting is a hybrid process that combines features of both casting and forging. It offers significant advantages in terms of enhanced mechanical properties and improved wear resistance due to reduced porosity and refined microstructure. In this setup, as shown in Fig. 1, the stir cum squeeze casting arrangement includes a movable upper die and a fixed lower die. During the process, the reinforced molten alloy is poured into a preheated fixed lower die where it begins to solidify. Simultaneously, a compressive force is applied through the upper die until complete solidification occurs. This applied pressure facilitates rapid cooling, minimizes shrinkage, and eliminates gas porosity, resulting in a dense and defect-free casting.

Squeeze casting is particularly suitable for manufacturing high-precision components with excellent castability. The absence of shrinkage cavities and gas entrapment, coupled with accelerated solidification, leads to superior wear resistance and structural integrity in the final composite product. These characteristics make squeeze casting an ideal technique for producing reliable and high-performance aluminum-based hybrid composites.. In this study, Aluminum 2024 alloy was used as the matrix material, reinforced with molybdenum disulfide (MoS_2) particles of approximately 2 μm in size and fly ash particles measuring around 10 μm . The aluminum alloy billets were first melted in an electric furnace at a temperature of 850 °C. Once the matrix was completely liquefied, preheated MoS_2 and fly ash powders—heated

to 550 °C to improve wettability and prevent thermal shock—were gradually introduced into the molten matrix.

To ensure homogeneous dispersion of the reinforcements, the molten mixture was stirred using a mechanical stirrer operating at 400 rpm for a specific duration. This stirring process promoted uniform mixing and minimized agglomeration of the reinforcing particles. After the stirring stage, the molten composite was immediately transferred into a preheated die. A punch was then actuated to apply squeeze pressure on the molten mixture, initiating the solidification process under pressure.



Fig. 1: Stir casting setup



Fig. 2: Squeeze casting setup

The squeeze casting parameters were carefully controlled to achieve high-quality castings. The resulting cylindrical composite specimens measured 40 mm in diameter and 260 mm in length, as illustrated in Fig. 2. These cast specimens were subsequently machined to standard dimensions for detailed analysis. The fabricated samples were subjected to microstructural

and mechanical characterization to assess parameters such as density, grain structure, grain boundary behavior, and hardness. These evaluations provide insight into the quality, integrity, and performance of the synthesized hybrid metal matrix composites.



Fig. 3: Molding die and casted

MECHANICAL TESTING

Testing of Natural Fibers

- Vickers hardness
- Density and porosity measurement
- Microstructural characterization

(a) Vickers Hardness Test:

The Vickers hardness of the fabricated aluminum hybrid composite samples was measured using an ECONOMET Series 3000DX hardness tester. The instrument utilizes a pyramid-shaped diamond indenter with a square base and a face angle of 136° . For each test, a load of 100 kg was applied on a flat, metallographically polished surface of the sample with a dwell time of 10 seconds. To ensure accuracy and consistency, six indentations were made at different points across the sample surface, and the average value of macro Vickers hardness was calculated. All tests were conducted in accordance with the ASTM E384 standard for microindentation hardness testing.

(b) Density and Porosity Measurement:

The experimental density of the Aluminum 2024 matrix and the Al/FA/MoS₂ hybrid composites was determined using Archimedes' principle. A precision electronic

balance with an accuracy of 0.001 g was used to measure the sample's weight in air and subsequently in distilled water (density = 1.0 g/cm³). This method helped estimate the apparent mass of the samples in both media. Three samples from each composition were tested to ensure reproducibility. Theoretical density values of the hybrid composites were calculated using the rule of mixtures based on the known densities of the matrix and reinforcement materials. The difference between theoretical and experimental densities was used to evaluate the porosity content within the cast specimens.

(c) Microstructural Characterization:

The microstructure of the Al/FA/MoS₂ hybrid composites was examined using a Leica DM 2500 optical microscope. Prior to imaging, the samples were prepared following standard metallographic procedures, including grinding, polishing, and etching. Etching was performed using Nital, a solution composed of 100 ml ethanol and 1 ml nitric acid (HNO₃). The micrographs obtained were analyzed to assess the uniformity of reinforcement particle distribution within the aluminum matrix, the quality of interfacial bonding between the matrix and reinforcement particles, and the presence and volume fraction of porosity. This analysis provided critical insights into the internal structure and homogeneity of the hybrid composites.

RESULTS AND DISCUSSION

Table 1. Vickers hardness results of fabricated Al/FA/MoS₂ hybrid composites.

S. No	Material	Microhardness, Hv
1	Al2024 alloy	95.4
2	Al-2 MoS ₂ /2 FA	103.19(↑ 8%)
3	Al-2 MoS ₂ /4 FA	110.39 (↑ 16%)
4	Al-2 MoS ₂ /6 FA	104.26(↑ 9%)

The Vickers hardness of Aluminum 2024 alloy was found to increase with the incorporation of reinforcement particles such as MoS₂ and fly ash (FA). Among the synthesized composites, the Al-2 wt.% MoS₂ / 4 wt.% FA hybrid composite exhibited the highest hardness, showing an improvement of approximately 16% over the unreinforced Aluminum 2024 alloy. The Vickers hardness values of all Al/MoS₂/FA hybrid composites

are presented in Table 2. The results clearly indicate a significant enhancement in microhardness due to the addition of reinforcement particles. The observed increase in hardness is attributed to several factors, including the inherent hardness of MoS₂ and fly ash, the refinement of grain boundaries, reduced grain size, and the restricted plastic deformation during indentation.

The successful fabrication of Al/FA/MoS₂ hybrid composites was achieved using a bottom pouring type stir-cum-squeeze casting setup. Throughout the casting process, no significant anomalies were encountered. Notably, there were no signs of oxidation of the aluminum matrix or adverse chemical reactions between the aluminum and reinforcement particles (FA and MoS₂) or with the die material. The cast components were smooth and free from macroscopic defects such as cracks, shrinkage cavities, or inclusions, indicating excellent casting quality.

Furthermore, the experimental density of the composites, measured using Archimedes' principle, is also included in Table 2. The values demonstrate consistency across samples, confirming uniform distribution and compaction of reinforcement particles. Porosity percentages were calculated by comparing the experimental densities with the theoretical densities obtained via the rule of mixtures. The resulting porosity values remained within acceptable limits, further validating the quality of the fabrication process and the structural integrity of the hybrid composites.

Table 2. Density and porosity measurements of Al/FA/MoS₂ hybrid composites

S. No.	Material	Theoretical density (g/cm ³)	Experimental density (g/cm ³)	Porosity (%)
1	Al-2 MoS ₂ /2 FA	2.7236	2.6903	1.2214
2	Al-2 MoS ₂ /4 FA	2.7000	2.6446	2.9006
3	Al-2 MoS ₂ /6 FA	2.6764	2.6289	3.4758

The optical micrographs confirmed the successful incorporation and uniform distribution of fly ash and MoS₂ reinforcement particles within the aluminum matrix. Figures 3(a) to 3(c) illustrate the microstructures of Al/2 wt.% MoS₂ composites reinforced with 2 wt.%, 4 wt.%, and 6 wt.% fly ash (FA), respectively. The micrographs reveal that the reinforcement particles are well-dispersed throughout the aluminum matrix without any noticeable clustering or agglomeration.

Interestingly, although the microstructure showed uniformity, an increase in porosity was observed with the increasing fly ash content. This trend is attributed to the irregular shape and porous nature of fly ash particles, which can introduce voids and weak bonding sites within the matrix. In the case of the Al/2 wt.% MoS₂/6 wt.% FA composite, a comparatively wider grain boundary was observed. This may be due to the inadequate interfacial bonding between the aluminum matrix and the FA particles at higher concentrations, along with the intrinsic irregularity of FA morphology.

Despite the increase in porosity and wider grain boundaries at higher reinforcement levels, a noticeable grain refinement was evident across all hybrid composites. The presence of MoS₂ and FA appears to act as nucleation sites during solidification, effectively restricting grain growth and thereby contributing to a significant reduction in aluminum grain size. This microstructural refinement is beneficial for enhancing the mechanical properties of the composite, especially hardness and wear resistance.

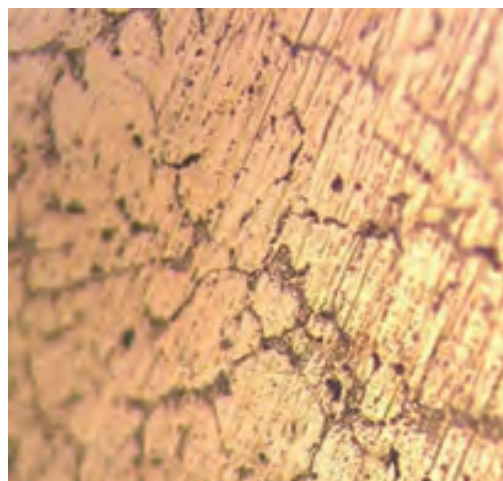


Fig. 4 (a) : Al-2-MoS₂/2-FA

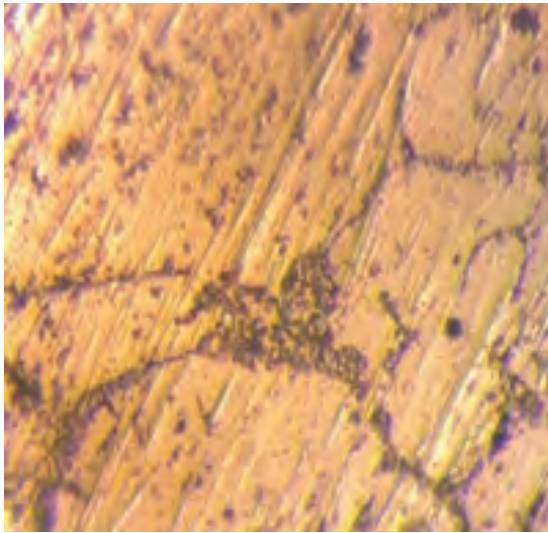


Fig. 4.(b) : Al/2-MoS₂/4-FA

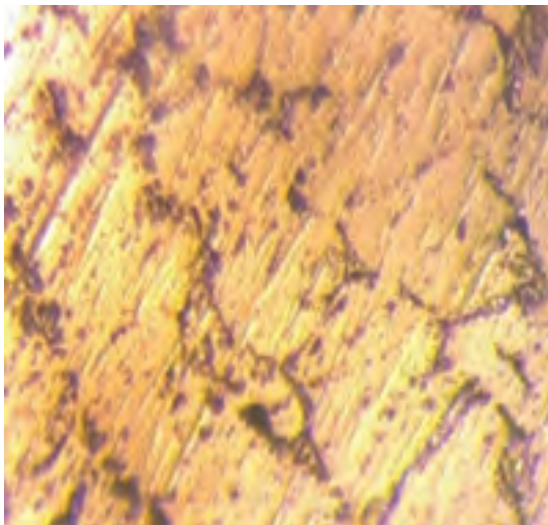


Fig. 4 (c): Al/2-MoS₂/6-FA

CONCLUSIONS

In this study, nearly dense Aluminum and Aluminum 2024 alloy-based hybrid composites reinforced with 2 wt.% MoS₂ and varying amounts of fly ash (2 wt.%, 4 wt.%, and 6 wt.%) were successfully fabricated using the bottom pouring stir-cum-squeeze casting technique. The physical, microstructural, and mechanical behaviors

of the composites were thoroughly investigated. The key findings are summarized as follows:

- (a) The incorporation of fly ash particles led to a reduction in mass density and a noticeable increase in microhardness when compared to the unreinforced aluminum alloy. Among the composites, the lowest experimental mass density was recorded for the Al/2 wt.% MoS₂/6 wt.% FA composition, while the highest microhardness was observed for the Al/2 wt.% MoS₂/4 wt.% FA composite, showing a 16% improvement over the base alloy.
- (b) The addition of fly ash not only reduced the experimental density but also contributed to grain refinement in the aluminum matrix. A decrease in grain size and improved grain boundary characteristics were evident from the optical microstructural analysis.
- (c) Optical micrographs confirmed a uniform distribution of reinforcement particles within the aluminum matrix. No significant agglomeration of MoS₂ or fly ash particles was detected across the specimens, indicating successful dispersion during the casting process.

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An Analysis on Satellite Images for Specific Yield Prediction

T. Jyothi

Dept. of Civil Engineering,
S.V. University
Tirupati, Andhra Pradesh
✉ jtiaits@gmail.com

R. V. S. Satyanayana

Dept. of Humanities and Science
S.V. University
Tirupati, Andhra Pradesh
✉ satyarvs@gmail.com

ABSTRACT

Produce computation is an important component in modern precision agriculture since it improves reproduction efficiency and allows for the adjustment of seeding and promotional approaches. With the advancement of artificial intelligence and sensing technology, yield-calculation techniques based on image-processing techniques offer numerous benefits, including high accuracy, cheap cost, and nondestructive computation, and they have been adopted by a significant number of investigators. The present work examines the investigation's progress of crop-yield calculation using satellite imagery and visible light images, outlines the technical specifications and applicable objects of various schemes, and provides detailed explanations of data collection, independent variable assessment, algorithm choosing, and optimization efforts.

KEYWORDS: *Satellite image, Agriculture, Machine learning, Sensor.*

INTRODUCTION

Large-scale agricultural difficulties are on the horizon. In the coming decades, there will likely be a considerable rise in the human population, necessitating a 25-70% increase in world productivity. Additionally, a changing climate will present new problems and the environmental effect of agriculture will need to be reduced [1].

Farm vegetation grows from seeding to harvest in response to climatic driving elements (such as temperature, sunshine, and precipitation). Soil and plant features (genetics), as well as farming techniques, all influence growth. From the earliest times of remote sensing, satellite imaging has been used to examine crop growth and development. Canopy optical properties are impacted by variations in crop vigor, density, health, and yield. Information on crop type, crop conditions, and agricultural output from the field up to bigger geographic areas like nations or hemispheres may be obtained with the use of satellite observations [2].

Crop growth surveillance and the pre-harvest crop output estimation offer timely alerts to various authorities about food deficiency places. The creation of a useful assessment tool requires the prompt and correct examination of agricultural development and yield data.

Using remotely sensed data in the temporal domain in conjunction with using powerful methods of statistics facilitates suitable and trustworthy decision making [3]. Harvesting gear is equipped with sensors that measure the quantity of grain harvested per unit of harvested area. These sensors, in conjunction with GPS receivers, provide grain yield estimates at geo-referenced sites, enabling the creation of yield maps that efficiently illustrate regional variability in crop output. Historical yield maps are useful for locating high and poor producing locations within a field, as well as determining site-specific yield. On the other hand, yield graphs alone reveal nothing about the source of yield variance. Moreover, prior yield maps may vary significantly between years due to fluctuations in growing season weather, rendering future in-season yield forecasts impractical. Remote sensing images are valuable for assessing crop growth patterns during the growing season in response to weather, pests, disease, and other management concerns [4].

LITERATURE REVIEW

A unique approach for remote sensing picture classification is provided, based mostly on an object model. Unlike traditional pixel-by-pixel and sub-pixel classification methods, object-based models and

geographic objects are captured in fundamental analysis units and created by picture segmentation, rather than seeing data as a collection of individual pixels with spectral attributes. The pictorial component then gets applied to the segmented object rather than the pixel itself. Finally, the segmented objects' spectral, spatial, texture, and background information are assessed, and spectral and associated categorization criteria are developed [5].

A transfer learning-based residual UNet framework (TL-ResUNet) approach to segmenting and classifying land cover from satellite images is presented. The suggested design capitalizes on the advantages of transfer learning, residual networks, and UNet architecture. Using open datasets like Deep Globe, we tested the model and found that, on average, our suggested model performs better than traditional approaches that begin with random weights and pre-trained Image Net coefficients [6].

Using Sentinel-2 data, a deep learning (U-Net) algorithm was used to map various agricultural land use types throughout a portion of Punjab, India. As part of the comparison, a well-known machine learning random forest (RF) was used. To evaluate agricultural land, the principal winter crop types (wheat, berseem, mustard, and vegetation) were investigated [7].

The spectral-phenological-based land cover categorization (SPLC) technique, which utilizes less ground truth data to identify land cover, is given as a unique approach to vegetation categorization in scattered agricultural settings. The SPLC approach employed an automated decision tree algorithm based on phenology to identify crop types and a pixel-based support vector machine (SVM) algorithm to categorize cropland and non-crop area. Next, it was put to the test and put to use in two exemplary case locations in the upper Yellow River basin (YRB) in northwest China, namely Jiyuan upstream and Yonglian downstream, located in the Hetao Irrigation District (Hetao). The accuracy of land cover categorization was evaluated using data from field surveys and regional visual interpretation maps [8].

To simulate yield using NDVI, both an MLR and an ANN model are employed. Using MLR analysis, the variation in simulation precision between the AVHRR and MODIS datasets is examined. The input and goal values must be fixed before building the model. We

chose 12 NDVI scene values throughout the course of a year to act as input variables, with corn and soybean production acting as the objective variable, based on the growing season of the local crops. Initially, the accuracy difference provided by AVHRR and MODIS data, as well as the link between NDVI and yield, were investigated in the sample state (Illinois) using the MLR technique [9].

The SAFY model is a vegetation growth concept that is based on the use of light energy. The representation resembles the crop's daily dynamic changes in yield, DAM, and LAI from developing emergence to end. The SAFY model needs the average temperature and daily radiation as driving inputs. According to this theory, crop growth is separated into two ongoing phases: growth and senescence, often known as biological aging. The cumulative summary temperature (SMT) after emergence is used to characterize these stages [10].

The time series duration varies with the parcel's location. Since most machine learning techniques need input data of a specific length, the data must be harmonized. [11] Without any filtering for shaky data, a sample with replacement is used to synchronize the time series. We processed the data using a slightly different technique. Initially, the time series were filtered to remove dates with fog because the reflectance values derived out of the imagery are inaccurate which don't provide any useful information. After filtering, the data was supplemented with further features (besides the 10 Sentinel-2 spectral bands), such as spectral indices computed using the original bands.

ANALYSIS OF DIFFERENT IMAGE TECHNIQUES ON REMOTE SENSING FOR YIELD PREDICTION

The crop yield prediction is done generally based on the segmentation followed by the classification process. Temporal resolution data is required to analyze any crop area. Generally, the crop analysis is being done based the following ways

- a) Specific Crop based Analysis: It concentrates on a particular crop such wheat, sun flower, rice, grape, maize, ground nut, etc. The process analyses continuous monitoring of the crop in its time period.

- b) **Specific Area based Crop Analysis:** The analysis basically focuses on a particular place such as Tirupathi District of Andhra Pradesh, INDIA where there may a particular crop or more than a crop are cultivated.
- c) **Specific Algorithm based Crop Analysis:** It emphasizes how various algorithms are working on a particular data set for a particular crop or area.
- d) **Specific Satellite Image data based Crop Analysis:** The analysis explains on a particular data. It may

be optical satellite data or micro wave satellite data or Infrared Satellite data or hyper spectral data. Number of bands is depending on type of satellite. It may be of low or high resolution image data. Sometimes it refers low attitude sensor data also (Digital Camera).

Table 1 illustrates the various machine learning methods for estimating agricultural production. Table 1 presents a comparison of several methodologies together with their main conclusions. Each technique has its advantages and limitations.

Table 1: Comprehensive investigation of all available produce prediction methods

S.No	Authors' Names	Approaches Employed	Data set used	Principal Results
1.	Ali Alzahrani, et al. (2023)	Fuzzy C-Means Clustering Technique	Landsat	Accuracy & NDVI were evaluated
2.	Namita Kale, et al. (2023)	Deep Learning Techniques	Landsat	Minimum Capital & Flexible Marketing were evaluated
3.	Samabia Tehsin,, et al. (2023)	Scalable Deep Learning Techniques	Dataset-RSI-CB256	Accuracy, Precision, Recall, F1 Score, Kappa & AUC were evaluated
4.	Adekanmi Adeyinka Adegun, et al. (2023)	Deep learning methods	EuroSAT, UC Merced Land-Use dataset, NWPU-RESISC45 dataset,	Accuracy, Recall, Precision, and F1-score were evaluated
5.	Ognjen Antonijevic, et al. (2023)	Transfer learning approach	Sentinel-2	Accuracy, kappa and F1-score were evaluated
6.	David de la Fuente, et al. (2023)	Machine learning Techniques	Sentinel-2	R2 & RMSE were evaluated
7.	Xinyi Li, et al. (2022)	Spectral-phenological categorization of land cover	Sentinel-2	Accuracy of producers and users was assessed for different bodies
8.	Joanna Pluto, et al. (2022)	ANN, RF, SVM, MXL	Landsat, Sentinel-2 and SPOT-5	Accuracy values for wheat were evaluated
9.	Khilola Amankulova, et al. (2022)	Time-series analysis	Sentinel-2	NDVI values for sunflower were evaluated
10.	Chunyan Ma, et al. (2022)	simple algorithm for yield estimation	Sentinel-2	R2, RMSE, nRMSE, EVI, NDVI, RVI, and MSR were evaluated
11.	Gowhar Meraj, et al. (2022)	Machine Learning Algorithms (RF & SVM)	Sentinel-2	Accuracy, R2, RMSE & NPP were evaluated

12.	FurkatSafarov, et al. (2022)	TL-ResU Net Architecture	Deep globe data set	IoU was evaluated for various Epochs
13.	Ningjun Wang, et al. (2022)	Machine Learning Techniques	Sentinel-2	ER, NR & SD were evaluated
14.	Gurwinder Singh, et al. (2022)	Deep learning methods	Sentinel-2	Accuracy, Recall, Precision, kappa and F1-score were evaluated
15.	Kate Tiedeman, et al. (2022)	Machine learning Techniques	Sentinel-2	NDVI, R2& RMSE were evaluated
16.	Yash S Asawa, et al. (2022)	Deep Ensemble Learning	Sentinel-2	Accuracy, Recall, Precision, kappa and F1-score were evaluated
17.	AlirezaSharifi, et al. (2022)	Machine Learning Techniques	Sentinel-2	RMSE & MAE were evaluated
18.	Nicoleta Darra, et al. (2021)	Ensemble Machine Learning and Statistical Analysis	Sentinel-2	Adjusted R2 , RMSE, NDVI, RVI, SAVI, PVI, and WDI were evaluated
19.	Adolfo Loz, et al. (2021)	Artificial neural networks	Sentinel-2	Accuracy values for Tobacco, Corn, Rice and Tomato wheat were evaluated
20.	Guillermo Siesto, et al. (2021)	Modified CNN	Sentinel-2	Accuracy, F-Score and F-Score were evaluated

For example, the land use land cover class distribution of the study area in Saudi Arabia for 30 years during the period 1984-2018 is shown in Figure 1. It explains how the agriculture, buildings and water bodies are changing time to time. Classification of a land over a period explains how the development is going on.

Formulae for Quality Parameters in Image Classification:

$$\text{Accuracy} = (TP_A + TP_B + TP_C) / V$$

$$\text{Precision} = TP / (TP + FP)$$

$$\text{Recall} = TP / (TP + FN)$$

$$\text{Specificity} = TN / (TN + FP)$$

$$\text{F1 score A} = 2(\text{Recall A} * \text{Precision A}) / (\text{Recall A} + \text{Precision A})$$

$$\text{NDVI} = (\text{NIR} - \text{R}) / (\text{NIR} + \text{R})$$

Some of the quality parameters that are used in segmentation and classification process are given below.

For segmentation

1. Pixel Accuracy
2. Jaccard Index
3. Dice Coefficient
4. BFscore (Boundary F1 score)
5. Weighted Intersection over union (IoU)
6. Average Hausdorff Distance

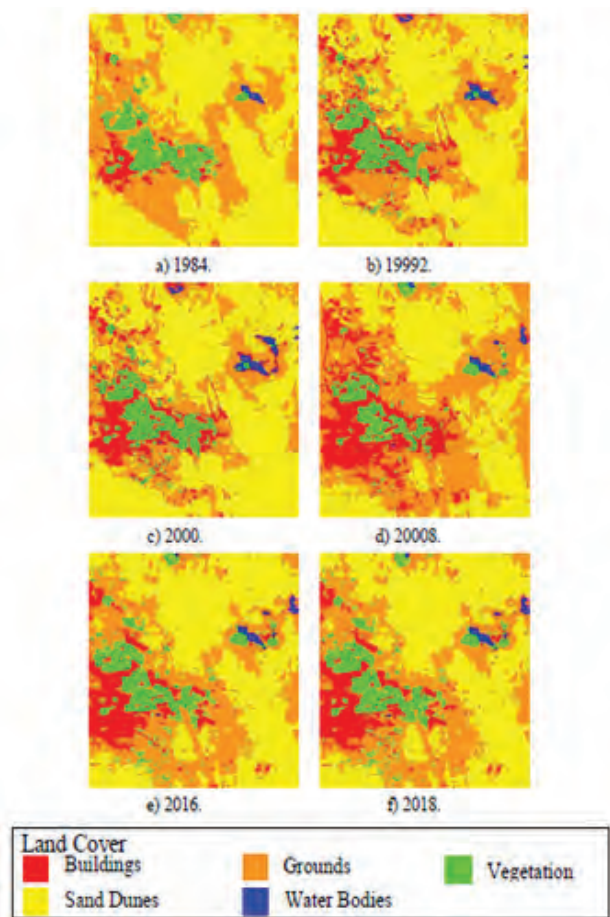


Fig. 1. Land use land cover class distribution map of the study area

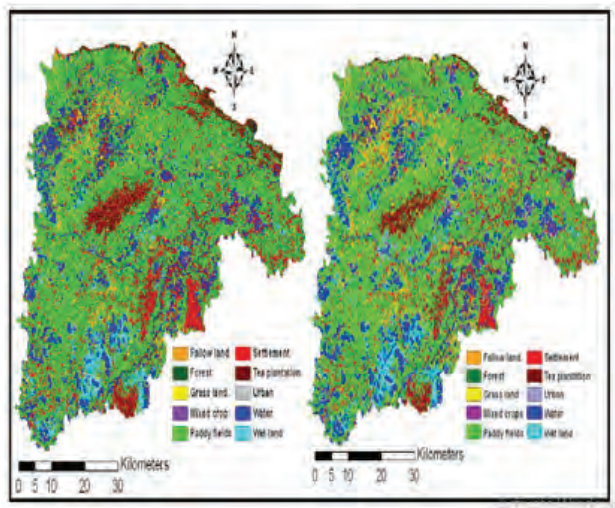


Fig. 2. Results of Maximum Likelihood Classifier and Object-based classifier

The figure shows different image classification model give different output. So while doing a classification of a land a good classifier plays vital role.

For classification

1. Accuracy
2. Specificity
3. Precision
4. F1-Measure
5. Recall
6. AUC
7. Correlation
8. Kappa Coefficient
9. ROC curve
10. Time Consumption

These are some free data sets available in the internet.

Data sets

<https://eod-grss-ieee.com/dataset-search>

<https://zindi.africa/competitions/agrifieldnet-india-challenge/data>

<https://beta.source.coop/repositories/radianteearth/agrifieldnet-competition/download/>

[https://Copernicus Data Space Ecosystem](https://Copernicus>DataSpace/Ecosystem) | Europe's eyes on Earth

CONCLUSION

Numerous models and methods have been put forth by researchers to anticipate crop yields before to true harvesting. Early on, a field study was carried out to estimate the crop production utilizing a variety of variables, including soil, climate, fertilizer, irrigation, and other elements, as well as historical data that was available. While statistical models for yield forecasting are simpler to use and need fewer parameters, the information they give is restricted and falls outside of the model's specified range. With the advent of remote sensing, agricultural production was estimated using regression models and satellite imagery—both of which raised doubts. Additionally, machine learning techniques are used; these were used with soil physiochemical characteristics and satellite images.

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Vision Based Emergency Drone Landing on Unknown Landing Environments

Abhinaya Jayakumar

Dept. of Civil Engineering
S.V. University
Tirupati, Andhra Pradesh
✉ jayakumarabhinaya@gmail.com

Manvee Lalwani

Dept. of Civil Engineering
S.V. University
Tirupati, Andhra Pradesh
✉ manveelalwani@gmail.com

Keval Mervana

Dept. of Civil Engineering
S.V. University
Tirupati, Andhra Pradesh
✉ Kevalmervana12@gmail.com

Anbarasu B

Dept. of Civil Engineering
S.V. University
Tirupati, Andhra Pradesh
✉ avianbu@gmail.com

ABSTRACT

In this paper, different features, namely, SIFT, SURF, ORB, and BRISK have been used for landing pad target recognition for autonomous landing of drones in unknown environments. From the experimental results it is inferred that extracted, ORB is better for the landing pad recognition compared to the other features. An in-depth examination of an original structure for disaster drones landing in unexpected surroundings in response to the increasing demand for reliable drone processes, especially in situations of emergency. The suggested method makes use of cutting-edge machine learning algorithms and analyzes visual information in real-time to enable safe and flexible landings in dynamic and unpredictable environments. The system has an integrated strategy that includes evaluation of the environment, barrier identification, and geography classification. The drone uses a variety of techniques for image processing to fluidly analyze the landscape of the area, locate possible landing areas, and determine whether any obstructions or risks are present. Moreover, the system adjusts to modifications in the surrounding environment, guaranteeing a robust reaction to unanticipated challenges. The drone is able to identify and classify different types of topography and animals thanks to the framework's integration of machine learning algorithms that have been trained on a variety of data. The system's adaptability allows the drone to make judgments in real time, adjusting its landing plan in response to changing visual data. By improving the independence and dependability of emergency drone landings in unexplored areas, this study advances the field and broadens the use of drone technologies for life-threatening situations. The results offer significant perspectives for the creation of smart and flexible drone structures, promoting progress in autonomous aerial operations for emergency response and other purposes.

INTRODUCTION

When it comes to unmanned drones, handling emergency landings on uncharted territory poses significant difficulties. The critical challenge of interpreting visual imagery to enable accurate and safe landings in emergencies is the subject of this work. Understanding and adjusting to new surroundings becomes critical given the increasing reliance on drones for emergency response. The aim is to develop an effective structure that uses visual data to assess

landing circumstances, enabling drones to land as well as operate safely in unexpected situations. The rapidly expanding field of drone applications, spanning from scientific study to surveillance, search and rescue, and tracking the environment, is highlighted by the changing regulatory landscape brought about by technology breakthroughs. In order to improve drone flexibility in emergency situations, this research combines computer vision, machine learning, and sensor fusion. This will ultimately support the effectiveness and dependability

of self-sufficient systems in changing contexts. As these changes lead to restrictions, the security of individuals depends more and more on secure and environmentally friendly drone operations; therefore, modern drones must be genuine. Moreover, a thorough strategy incorporating state-of-the-art technology is required to investigate visual images for emergency drone landings in uncharted territory. Drones use machine learning algorithms to recognize and understand flying area characteristics by processing actual time visual input from onboard sensors. This entails evaluating topographical characteristics, impediments, and possible dangers, enhancing the capacities of unmanned aerial vehicles in crucial situations.

RELATED WORKS

A technique to find appropriate landing zones for Unmanned Aerial Vehicles (UAVs) using satellite imagery was presented by Mukadam et al. in a 2015 study that was published in the International Journal of Computer Applications. With the use of RGB and HSV models and edge detection techniques, the method extracts texture and color characteristics. To categorize and train the system for automated detection of large landing areas, the authors use the RGB color model and Support Vector Machine (SVM) methods. Improving UAV operations inside designated areas in terms of safety and accuracy is the main objective.

In July 2016, Serra and colleagues contributed to IEEE Transactions on Robotics, where they examined the difficult task of vertical flight and landing (VTOL) quadrotor landing on a mobile platform. The research project focuses on addressing this complex landing difficulty by using dynamic image-based optical servo control. The authors propose a controller that just makes use of the common sensor suite used in these kinds of cars, which consists of an IMU sensor and an onboard camera. The research provides important insights into the difficulties involved in accomplishing successful landings on targets that move by describing the system's mechanics with regard to translational flow of light and picture characteristics.

In their December 2019 paper, Wu et al. introduced an Autonomous UAV Landing System based on Visual Navigation. Their approach involves converting RGB

images into HSB, setting a threshold for segmentation, and creating a topological pattern for UAV recognition. The study innovates with a dynamic, vision-based image binarization method, utilizing recognized information to calculate relative distance and heading angle. To handle undetected targets, adjustments to the threshold are made using linear interpolation. Experimental validation conducted on water surfaces confirms the effectiveness of the system. Bektash et al. emphasize the growing importance of autonomous drone landings for safety in their the month of May 2022 publication in the International Review. In order to identify landing puts during autonomous flight, their algorithm analyzes ground photos using an CNN (Convolutional Neural Network) and assigns characteristics to them. Specifically, pixel-level tagging is used to improve safety measures on the basis of acquired photos, and the forward motion is optimized with fewer settings to streamline drone emergency landings.

Xin et al. divide the research on vision-based autonomous landings into three categories in their October 2022 work that was published in MDPI - Aerospace: stationary (cooperative targets, natural landmarks), dynamically (vehicle-based, ship-based), and complex scenarios. The report provides a useful resource for UAV researchers by summarizing important technologies, comparing results, and outlining potential developments.

Ge et al. address the problems caused by windy conditions in their February 2023 work published in MDPI - Electronics. The solution they present is a unique way for UAVs to land automatically in agricultural areas. The research describes a visual positioning system and a suggested control algorithm that show a significant improvement in landing accuracy on small docking gadgets under adverse ground circumstances. The system's ability to recognize objects visually during the landing phase— even when there are overwhelming environmental influences present—is particularly noteworthy. Subramanian et al. delve deeply into the use of photogrammetry, with an emphasis on vision-based systems, to improve the accuracy of control decisions in automated drone landings in their August 2023 paper in MDPI - Drones. Through the technology, features are extracted from static image data to aid in more precise

taking decisions throughout the autonomous landing procedure. However, issues like precision, stereopsis, geographic restrictions, and different lighting levels affect how effective these methods are. It is important to remember this knowledge extraction is only possible for what the camera can see in the collected image.

METHODOLOGY

A well-designed block diagram highlights a sequence of critical procedures that contribute to the successful execution of an automatic landing case involving a Micro Aerial Vehicle (MAV) on a chosen landing pad. First, high-resolution (1080x1020 pixels) photos of the landing pad are taken in order to create the baseline dataset for further processing. Prioritizing begins with preprocessing, which converts RGB images into grayscale and reduces their size to 256 by 256 pixels. The system's capacity to recognize important features is improved and analyses are made simpler by striking a compromise between computing efficiency and the preservation of crucial visual information. Using sophisticated methods such as Scale-Invariant Feature Transform (SIFT), Speeded-Up Robust Features (SURF), Oriented FAST and Rotated BRIEF (ORB), and Binary Robust Invariant Scalable Keypoints (BRISK), the key is feature extraction. These methods

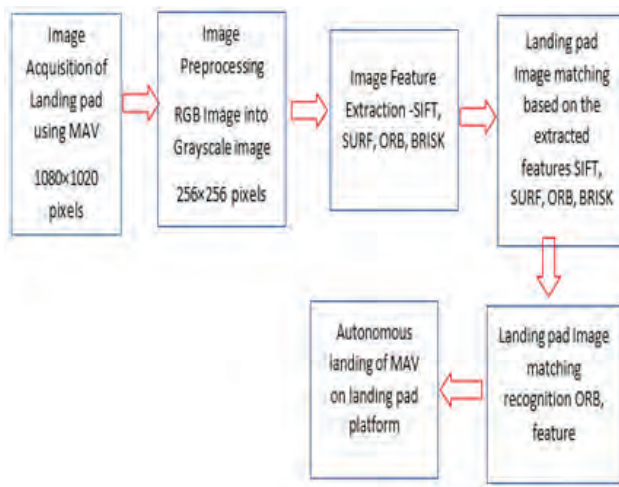


Fig. 1: Vision based landing pad detection algorithm using feature extraction

Scale-Invariant Feature Transform (SIFT)

One of the most important computer vision algorithms for feature extraction in image processing is the

Scale-Invariant Feature Transform (SIFT). It shows distinctiveness by remaining robust on scale, rotation, and translation, and it effectively recognizes important points within an image. The algorithm involves several key steps:

Scale-Space Extrema Detection uses a variety of images that are blurred (scale space) to identify possible critical spots with different sizes by highlighting areas with notable changes.

Orientation Assignment: SIFT determines each key point's orientation, making sure that descriptions hold true even when an image rotates. The accuracy of key point encoding is enhanced by this procedure.

Descriptor Calculation: A descriptor is carefully constructed for every key point by taking into account the gradients of the surrounding pixels. The unique characteristics of the area around the important point are captured by a vector created from this description.

Key Point Matching: To find matches between related key points, SIFT descriptors from several pictures can be compared. This feature is useful in many different applications, including object detection, image retrieval, and image stitching.

The importance of SIFT stems from its ability to offer unique and consistent features, which makes it ideal for uses in image matching, object detection, and three-dimensional reconstruction. Its versatility in a range of situations highlights its usefulness in computer vision applications where reliable and consistent feature extraction is crucial.

Table 1. Direction, distance and heading between the helipad and maV

S.No	Landing Pad Images	Direction Of Helipad With Respect The Mav	Distance Between Mav And Helipad (In Metre)	Heading Between Mav And Helipad (In Degrees)
1.	FRAME#1	SOUTH EAST	3.74	149
2.	FRAME#2	EAST	3.64	84
3.	FRAME#3	NORTH	3.64	52
4.	FRAME#4	SOUTH EAST	3.64	122
5.	FRAME#5	SOUTH EAST	3.64	118

6.	FRAME#6	NORTH EAST	3.64	61
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Fig. 2. Landing pad images with objects direction of helipad towards south east, direction of helipad towards east, direction of helipad towards north, direction of helipad towards south east



Fig. 3. Landing pad images without objects

Oriented FAST and Rotated BRIEF (ORB)

A feature extraction algorithm designed specifically for machine vision applications, Oriented FAST and Rotated BRIEF (ORB) combines the strength built into the BRIEF (Binary Robust Independent Elementary Features) a descriptor with the effectiveness of the FAST (Features from Accelerated Segment Test) significant feature detector. Applicable in real-time scenarios when computational resources are restricted, including object detection and tracking, ORB has been acknowledged for its mechanical efficiency. The key steps in the ORB feature extraction process encompass:

FAST Key Point Detection: By starting with the FAST algorithm and comparing pixel intensities inside a circular zone, ORB effectively finds key points.

Harris Corner Response: After identifying the essential points, ORB uses the Harris Corner Action to highlight the most notable elements while excluding the others. This raises the general caliber of the highlighted points. As opposed to initially created FAST, ORB gives each important point an orientation. The determination of this position makes ORB invariant to picture rotation by evaluating intensity fluctuations around the critical point.

BRIEF Descriptor: ORB uses the BRIEF algorithm to calculate a binary descriptor for every key point. Based on comparisons of pixel pairs' intensities surrounding the key point, BRIEF produces a binary code.

Rotation Invariance: Based on the direction of motion determined during key point identification, ORB applies

rotation invariance to strengthen resilience. This is done by transforming the BRIEF descriptors.

Scale Invariance: While ORB isn't specifically made for scale invariance, it can be combined with methods like picture pyramids to solve scaling issues. In machine vision applications, this all-inclusive method guarantees adaptation to different scales.

Speeded-Up Robust Features (SURF)

An effective feature extraction approach, specifically designed for image recognition and matching scenarios, is called Speeded-Up Robust Features (SURF) in computer vision. Well-known for its resilience and speed, SURF works well in a variety of computer vision tasks, such as object detection, visual stitching, and tracking. It is a good fit for real-time applications. The key steps involved in SURF feature extraction are as follows:

Integral pictures: SURF makes use of integral pictures, which make it possible to quickly compute the total pixel intensity inside rectangular filters at different scales. This helps to process feature extraction efficiently.

Interest Point Detection: By identifying regions of interest using a Hessian matrix, SURF finds locations with notable variations in intensity.

Scale Selection: To ensure robustness to changes in object dimensions and viewpoint, the algorithm selects critical spots at several scales, adapting to varied scales.

Orientation Assignment: To ensure that descriptors are not affected by picture rotation, SURF offers orientations to important spots depending on the prevalent gradient pattern in the surrounding area.

Descriptor Calculation: A descriptor is computed for each key point by taking into account the gradient magnitude and orientation distribution in a circular region surrounding the key point. This description encapsulates the distinct features of the localized image patch.

Fast Hessian Matrix Calculation: SURF improves upon conventional methods in identifying interest locations and descriptors by approximating the Hessian matrix using a box filter.

Binary Descriptor: To improve speed and enable quicker matching, SURF-B, a binary descriptor variant,

was added to later versions of the program, which had previously utilized a floating-point descriptor. This development highlights how flexible and always improving SURF is at meeting the needs of applications that utilize computer vision.

Binary Robust Invariant Scalable Key points (BRISK)

One feature extraction technique that has been painstakingly developed for computer vision applications is Binary Robust Invariant Scalable Keypoints (BRISK), which is known for its speed, resilience, and flexibility to different scales and orientations. Because BRISK is binary, it can be efficiently stored and matched quickly, which makes it ideal for real-time computer vision applications like object detection and tracking. The key steps in the BRISK feature extraction method are as follows:

Scale-space Construction: BRISK builds a scale-space pyramid that enables the analysis of a picture at many scales. This method successfully handles scale differences while ensuring reliable feature detection at various levels of detail.

Feature detection: Using the corner retaliation function, key locations are found by analyzing pixel intensities. The representation of scale-space facilitates the identification of stable pivot points at various scales.

Pattern Description: Rather of using a continuous-valued vector to describe key points, BRISK uses a binary descriptor. The fact that BRISK is binary adds to its effectiveness and applicability for real-time applications.

Rotation Invariance: By incorporating rotation invariance, BRISK uses a pattern that doesn't change. By evaluating the intensity of pixels in circular zones surrounding the critical point at various scales, this is accomplished.

Pairwise Intensity Comparisons: BRISK builds its binary descriptor using pairwise intensity contrast inside circular sections rather than gradient information. This decision improves the method's computational efficiency.

Allocation of Rotation States: For every key point, BRISK uses the most efficient rotation pattern from a

predefined set. This yields a descriptor that describes the rotation states distribution.

Dynamic Non- maximum Suppression: BRISK uses adaptive non-maximum suppression to pick a diverse group of key points, improving the overall level of features discovered. This is done during the key point identification process. The efficacy of BRISK in tackling significant obstacles in the extraction of features for vision-based applications is demonstrated by this thorough methodology.

CONCLUSION

In summary, enhanced imaging characterization for unplanned drone landings in uncharted territory requires the integration of complex algorithms, such as topography analysis and object recognition. Sophisticated computer vision techniques, such as SIFT, SURF, ORB, and BRISK, which function as the drone's eyes to distinguish and interpret distinct visual components in real-time, are essential to the effective execution of unexpected drone landings in unknown locations. These algorithms are like virtuoso artists in the drone's repertory, helping it navigate far more effectively, much like when it detects a recognizable individual in a crowd. But the story goes beyond simple recognition to include feature matching algorithms, which act as the drone's brain center of decision-making. The drone can recollect and compare encountered information thanks to these algorithms that put together the visual picture. The drone functions as a kind of dynamic memory bank, adjusting its landing technique in response to past encounters with various emergency situations. This combination of cutting-edge technologies is not just Amazing, it is essential. It improves the drone's ability to maneuver and land safely in emergency situations by giving it cognitive versatility and dependability. This combination of technologies makes sure the drone can travel on its own with strategic intelligence and react quickly when necessary. Furthermore, when combined with models based on machine learning that have been trained on a variety of terrain, this method improves the drone's flexibility and guarantees a more dependable and secure landing mechanism in the event of unforeseen events. These technologies work best together to address the dynamic and unexpected nature of emergency situations,

offering a reliable solution for safe and effective drone operations in a variety of terrains. The integration of feature matching algorithms, ORB, BRISK, SURF, and SIFT highlights how autonomous drone navigation is developing as technology advances. By offering a degree of precision and dependability which is crucial in emergency situations, it is a combination of innovation and pragmatism that raises the bar for modern emergency response methods. Dynamic cutoff and contour removal for helipad markers (H-shape and concentric circles) are used in this work's vision-based landing pad recognition system for autonomous quadcopter landing. The algorithm that finds the centroid of the helipad guarantees a quadcopter landing that is correct with regard to the centroid, which makes it appropriate for current time automated touchdown of Micro Aerial Vehicles (MAV). Amongst these features SIFT, SURF, ORB, and BRISK have been used for landing pad target recognition for autonomous landing of drones in unknown environments. From the experimental results its inferred that extracted ORB is better for the landing pad recognition compared to the other features.

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Obstacle Avoidance based Visual Navigation for Micro Aerial Vehicle using Yolo-SSD Descriptors

Abiram Ramesh

School of Aeronautical Sciences
Hindustan Institute of technology & Science
Chennai, Tamilnadu
✉ abiramramesh21129@gmail.com

Barath Sakthivel M

School of Aeronautical Sciences
Hindustan Institute of technology & Science
Chennai, Tamilnadu
✉ barathronaldo07@gmail.com

Saran Srivarshan K

School of Aeronautical Sciences
Hindustan Institute of technology & Science
Chennai, Tamilnadu
✉ Saransrivarshan678@gmail.com

Anbarasu B

School of Aeronautical Sciences
Hindustan Institute of technology & Science
Chennai, Tamilnadu
✉ avianbu@gmail.com

ABSTRACT

This paper has proposed an efficient integrated YOLO-SSD visual descriptors for robust object detection and collision avoidance for vision based navigation of Micro Aerial Vehicle. By using obstacle avoidance-centric optical navigation, this study aims to improve the mobility of Micro Aerial Vehicles (MAVs). The system gathers and processes environmental data by integrating a number of sensors, such as cameras and possible depth sensors. Feature extraction and recognizing objects are two of the image processing techniques used by the framework's powerful computer vision system for current time obstacle detection. Machine learning algorithms give the system the ability to learn and adapt to a variety of settings. Real-time responsiveness is ensured by optimization algorithms that take into account the size, motion, and closeness of obstacles when making decisions. Based on this data, the MAV dynamically modifies its course, enabling autonomous navigation across challenging and changing environments. In an effort to strike a balance between mission efficiency and safety, the research also investigates the integration of obstacle avoidance with path planning. Micro Aerial Vehicles (MAVs) are getting more and more important in a variety of applications, including search and rescue operations, reconnaissance, and surveillance. The need for increased autonomy and navigational capabilities is developing as more people realize how important MAVs are in complicated activities. To meet this urgent need, the development and implementation of a sophisticated visual navigation system based on obstacle avoidance is the main focus of this research. Sophisticated navigation techniques are required for integrating MAVs into congested, dynamic settings in order to guarantee their safe and effective functioning. The ability of conventional navigation systems to react to unforeseen challenges or situations that change quickly is frequently lacking. Therefore, the purpose of this research is to present a novel method for detection of obstacles and avoidance by utilizing visual information.

INTRODUCTION

This system makes use of developments in real-time decision-making algorithms, machine learning, and computer vision to analyze visual data intelligently and react skillfully to environmental difficulties. Enhancing MAV autonomy will allow these vehicles to function well in situations when human assistance may be limited or impracticable, which is the main driving force behind this research. In order to provide

safe and dependable navigation, the suggested obstacle avoidance-based visual navigation system aims to give MAVs the capacity to see, comprehend, and react to their environment. The study uses a to achieve these goals by using an interdisciplinary strategy that combines real-time processing to provide quick reactions, algorithms for machine learning for adaptive making decisions, and methods of computer vision for obstacle identification. The ultimate goal is to develop a complete visual

navigation system that would enable MAVs to operate independently in situations with dynamic impediments and changing circumstances. The technological details of the obstacle avoidance-based navigational visual system, experimental procedures, and performance evaluations are explained in detail in the following sections, which are built upon this introduction. This method provides a thorough understanding of the study's contributions and implications for improving MAV navigation.

RELATED WORKS

Andrea Cherubini and F. Chaumette's 2011 IEEE/RSJ study focuses on the combination of obstacle avoidance and visual navigation. The method comprises guiding a robot through a path that is visible specified by key images using a range scanner, while simultaneously making sure that impediments on the ground are avoided. An actuated camera is used for maintaining simultaneous scene visibility and avoiding obstacles; the authors opted for a conventional arrangement over an alternate omnidirectional camera design. The range scanner finds barriers in the robot's route, while the camera detects features for navigation. Importantly, the authors stress that avoiding obstacles does not impair the visual task. One aspect of their work that sets them apart from others is the creation of a tiny controller.

Mori and Scherer report novel discoveries in the field of frontal obstacle avoidance and identification for micro unmanned aerial vehicles (UAVs) utilizing a monocular camera in an IEEE paper that was published on May 10, 2013. Using SURF characteristics to extract developing key points and template matching to confirm expansion ratios, their method presents a scale expansion detector. This real-time detector effectively detects frontal objects, especially those that are difficult to detect using optical flow. Interestingly, the system proves the system can distinguish between near and remote items in a congested background without requiring knowledge of the obstacles beforehand. The integration of sensor-based navigation with the scale extension detector enables the quadrotor to navigate around trees and other narrow barriers with ease.

Authors Matthias Nieuwenhuisen, David Droeschel, Johannes Schneider, Dirk Holz, Thomas Labe, and Sven Behnke presented a Micro Aerial Vehicle (MAV) with

a novel multimodal sensor configuration intended for reliable obstacle identification and collision avoidance in their 2013 IEEE article. The arrangement uses ultrasonic sensors, fisheye stereo cameras, and a portable 3D laser scanner—all of which have advantages and disadvantages of their own. While ultrasonic detectors are better suited for reactionary avoidance of obstacles because they're skilled at identifying small obstacles in close proximity, laser readings offer precise distance information around the MAV. The laser scanner is especially good at accurately identifying barriers without texture, such walls, even though it can detect visual impediments at rapid rates and wide distances.

The combined work of Abdulla Al-Kaff, Fernando Garcia, David Martin, Arturo De La Escalera, and Jose Maria Armingol was published on May 7, 2017, in MDPI. It presents a novel framework with two algorithms made to handle the complexity of state-of-the-art UAV technology. The complex and crucial task of real-time obstacle identification and avoidance for intelligent aerial vehicles inside transportation systems is specifically highlighted in this research. These techniques, which use a Dimension Expansion Algorithms and a monocular camera, provide a notable improvement in the field of obstacle management for UAVs, particularly in dynamic environments.

In a work that was published in MDPI on June 2, 2019, Gangik Cho, Jongym Kim, and Hyondong Oh describe a novel vision-based obstacle avoidance technique designed for Micro Aerial Vehicles (MAVs) that makes use of optical flows in a variety of three-dimensional textured settings. The performance of the suggested method is verified by the authors using a combination of computational simulations and indoor flight tests. Interestingly, the optical flow-based obstacle avoidance technique shows a low computational demand, which makes it especially appropriate for tiny MAVs with light CPUs, like insect-inspired flapping aerial vehicles. However, because optically flows are less likely to be formed on textureless structures like white walls, wires, and poles, the authors emphasize the method's limitation to reasonably well-textured settings.

Mohammed A. Alanezi, Zaharuddeen Haruna, Yusuf A. Shahabad, Houssein R. E. H. Boukhakara, Mouaaz Nahas, and Mohammad S. Shahriar conducted a

thorough investigation into obstruction avoidance-based navigational autonomy for a quadrotor system, and their findings were published in the MDPI journal on October 3, 2022. Two genetic algorithm-based proportional integrated derivative (PID) controllers were developed for altitude and attitude control in the

study using MATLAB Simulink. These controllers included integral square errors (ISE) and integral time total error (ITAE) criteria. The performance of the controllers was thoroughly assessed, taking into account steady-state error as well as transient factors including overshoot, rising time, and settling time. The results of the simulation demonstrated the effectiveness of the obstacle avoidance algorithm and the quadrotor's ability to avoid collisions when the distance between it and a barrier is less than is the same as the breadth of the obstacle.

METHODOLOGY

Image Acquisition of Object (1080x1020 pixels): Using onboard cameras, the process starts with taking high-resolution (1080x1020 pixels) pictures of the MAV's surroundings. These pictures are used as the obstacle detection system's input data. **RGB to Gray-scale (256x256 pixels) Image Preprocessing:** To lessen complexity and computational burden, the obtained RGB images are preprocessed. The photos are transformed from RGB to gray scale, which reduces the size of the image to 256 x 256 pixels while keeping all the information needed to identify objects. **detecting objects Algorithm (SSD and YOLO):** Following preliminary processing, the treated images undergo processing in parallel using two cutting-edge object detection algorithms: You Only Look Once (YOLO) and Single Multibox Detector (SSD). Due to its ability to forecast box boundaries and class probabilities for multiple instances, SSD is particularly effective at object detection. Conversely, YOLO, which is well-known for its performance in real time, creates a grid out of the image and forecasts the class probabilities and bounding boxes for every cell in the grid.

Combining SSD with YOLO for Detection of Multiple Objects: The integration of the outputs from YOLO and SSD results in a detection system that is more reliable and accurate. In order to reduce false positives and

improve overall detection precision, the discovered elements from both algorithms may be integrated or refined using Intersect over Union (IOU) or related techniques.

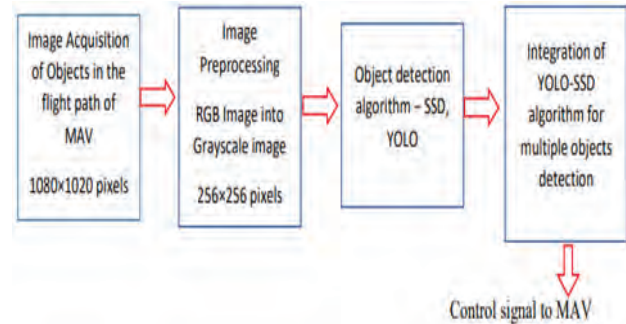


Fig. 1. Vision based landing pad detection algorithm using SSD and yolo

ULTRASONIC SENSOR

Ultrasonic sensors are frequently used by Micro Aerial Vehicles (MAVs) because of their efficiency in measuring distances. MAVs frequently rely on a variety of sensors for obstacle identification. These sensors use sound waves to measure an object's proximity, which helps MAVs navigate to avoid obstacle precisely.

Working Principle: Operating at frequencies typically about 40 kHz, the ultrasonic sensor produces high-frequency sound waves that frequently exceed the range of human hearing. The sound waves that are released travel through the atmosphere and return to the sensor after hitting an obstruction. The sensor measures the amount of duration it takes for sound waves to travel to the obstruction and back. The distance between the obstruction and the sensor is precisely correlated with this time-of-flight measurement. The sensor uses the air's speed of sound to change the time-of-flight into an accurate distance measurement.

$$\text{Distance} = (\text{Speed of Sound} * \text{Time of Flight}) / 2$$

As soon as possible, the sensor gives real-time distance information that shows how close the obstruction is to its position.

Integration into MAV Obstacle Detection System

To provide a full 360-degree image of the MAV, ultrasonic sensors are placed strategically and typically pointed in different directions. In order to acquire a

thorough picture of the surroundings, sensor fusion—the combination of data through ultrasonic detectors with input from other sensor types, such as cameras or lidar—is a commonly used technique. The precision and dependability of obstacle detection are both improved by this sensor fusion.

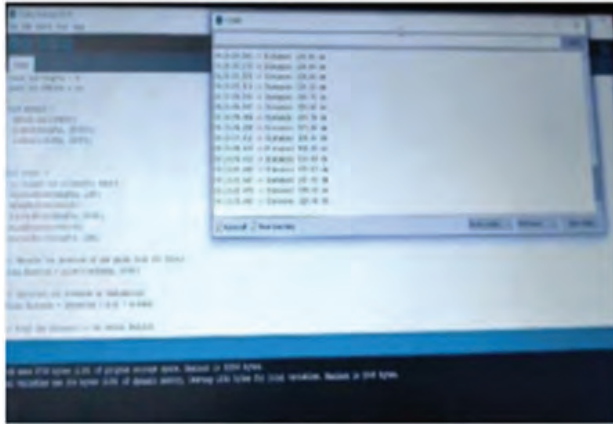


Fig. 2. Ultrasonic sensor output

Obstacle Avoidance Algorithm: These algorithms use the distance data provided by ultrasonic sensors. These algorithms produce control signals that modify the MAV's flying path in real time, enabling safe obstacle avoidance.

Adaptability: When used in environments that are both indoor and outdoor, ultrasonic detectors perform well in a variety of environments. These are especially useful when flying at low altitudes, because it's necessary to calculate distances precisely to avoid obstacles that are grounded.

In conclusion, because they can estimate distance accurately and in real time, ultrasonic sensors are essential to MAV obstacle identification. The precision and safety of the MAV's navigation through intricate environments is improved by their integration.

SINGLE SHOT MULTIBOX DETECTOR (SSD)

One well-known object identification technique driven by deep learning constitutes the Single Shot Multibox Detector (SSD), which excels in real-time applications. SSD is useful in obstacle avoidance for Micro Aerial Vehicles (MAVs), enabling the MAV to recognize things in its surroundings and quickly decide on its course.

Operational Framework

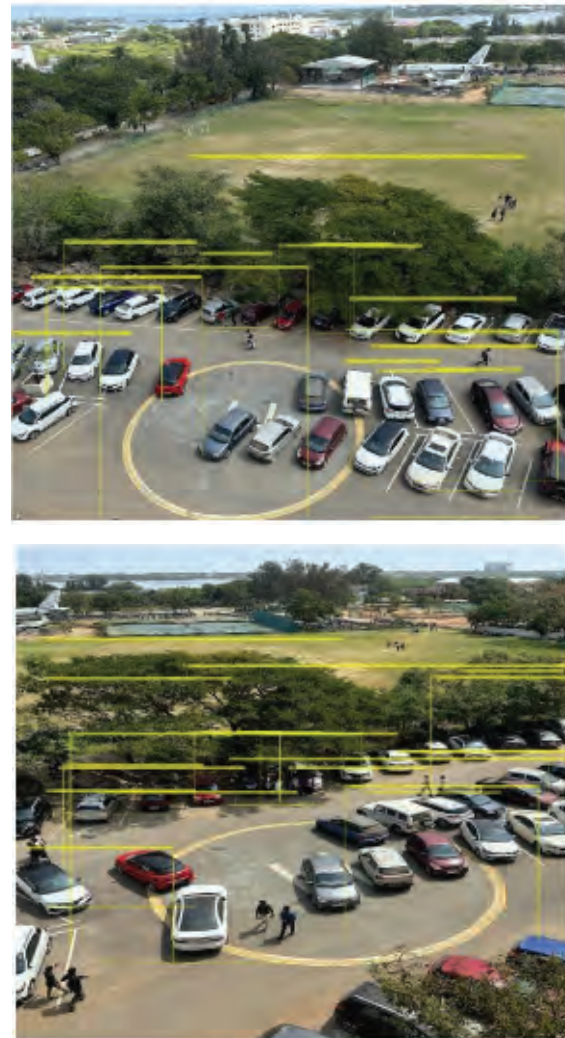


Fig. 3. Identification of object using YOLO-SSD algorithm

SSD extracts feature maps at different scales from the input image by using a basic Convolutional Neural Network (CNN), which records data at varying granularities. For item position and class prediction, SSD creates a set of predefined bounding boxes at each size that have varying aspect ratios. By forecasting each default box's appearance, class, and offsets across several feature maps, the model makes it easier to identify objects with different dimensions and aspect ratios. A thorough object detection framework is aided by the computation of scores of confidence for object classes based on the anticipated probability. After that, redundant bounding box filters are performed using

Non-Maximum Suppression (NMS), which keeps the most reliable detections. The output from the SSD provides information on the type and location of items that have been detected nearby the MAV. With the use of this data, that obstacle avoidance system is able to effectively avoid obstacles by producing control signals in real time that modify the MAV's flight path.

CONCLUSION

The completion of work toward creating obstacle detection-based navigational visualization for MAVs represents a significant advancement in unmanned aerial systems. This concluding overview clarifies the techniques used, their cooperative impact, and its broader implications in the field of MAV technology. Real-time obstacle identification and classification by MAVs is made possible by the integration of state-of-the-art object recognition algorithms, namely You Only Look Once (YOLO) and Single Shot Multibox Detector (SSD). YOLO's real-time efficiency and SSD's multiscale detection work together to provide a comprehensive visual knowledge that helps MAVs maneuver through dynamically changing situations. Ensuring adaptability to a variety of MAV scenarios is made possible by the end-to-end training capability, which enables the system to learn from and improve performance in response to obstacles faced during operational use. When flying at low altitudes, ultrasonic sensors are very useful as they provide accurate distance readings. MAVs' total spatial awareness and obstacle detection reliability are improved when optical and ultrasonic sensor data are combined. By adding redundancy through the incorporation of ultrasonic sensors, the obstacle detection system's overall reliability and safety are increased. Even in unanticipated situations, this redundancy guarantees strong obstacle avoidance skills. The combined output of the integrated approaches works together to generate dynamic control signals that enable MAVs to modify their flight routes in real time and maneuver skillfully around obstacles that have been recognized. Combining sensor-based approaches with visual navigation techniques creates a flexible obstacle identification approach that works in a variety of settings. This guarantees that MAVs can operate securely in a variety of difficult situations.

CHALLENGES AND FUTURE

DIRECTIONS

In order to meet the limitations of MAV hardware, future efforts should concentrate on optimizing the integrated system's computing efficiency. Future investigations could look into improving sensor fusion methods even further, maybe including newly developed sensing modality for an extra complex comprehension of the surroundings. In addition to providing MAVs with enhanced autonomous capabilities, the obstacle detection-based optical navigational system that was demonstrated further paves the way for further advancements. This method advances MAVs toward safer and more effective navigation in a variety of operating circumstances by integrating advanced computer vision algorithms with sensor technologies. The course that this research sets for the future of MAV technology demands constant change. This proposes an efficient integrated YOLO-SSD visual descriptors for robust object detection and collision avoidance for vision based navigation of Micro Aerial Vehicle.

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Energy Simulation of a College Building by using EQUEST Software

P. Vishnu Priya

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ vishnupriya0026@gmail.com

C Muni Kumar

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ munik013@gmail.com

S Meghana Sai

Dept. of Humanities and Science
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ meghanasriramaneni@gmail.com

K N Lakshmi Prasanna

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ lakshmip@gmail.com

ABSTRACT

In present study an Educational Institute Building model is chosen for energy simulation by using EQUEST software for various design parameters to achieve a thermal comfortable building by considering three climatic conditions for different locations of India. Annual energy consumption of the chosen locations has been determined and energy performance index is also calculated. It has been concluded that energy consumption, EPI values depend on thermal transmittance and thermal resistance of building. For Ahmedabad location it has been observed that 34% and 37% variation for thermal transmittance for walls and roof when compared to least value for Bangalore location.

KEYWORDS: Educational building, Energy consumption, Thermal transmittance, Energy performance index.

INTRODUCTION

Buildings can be primarily categorized into seven types: Assembly buildings, Health care building, Hospitality, Shopping complex, educational building, Business buildings and mixed-use buildings [1]. Energy conservation is primary aspect when considering energy efficiency concepts. Based on occupants and its purpose energy conservation can be done. Educational building needs more betterment of thermal comfort which also requires energy conservation concepts [2]. Starting with the energy simulation of educational building that refers to the implementation of strategies and technologies that promote energy efficiency, performance, thermal transmittance, and energy conservation within the building. Energy modeling and simulation can play a huge role in helping the building sector to achieve energy efficiency to design and evaluate energy-efficient building. The building sector can generate annual energy savings up to 14.72×10^{12} kWh by

2050 by implementing energy efficiency measures [2]. With the implementation of energy modelling software existing and new buildings can be designed to energy efficient and thermal comfort can be provided [3]. For this study five locations have been selected Ahmedabad, Bangalore, Chennai, Jaipur, and Kolkata. Energy simulation of these location models was done in equest stimulating software.

EQUEST SOFTWARE

EQUEST software is a powerful energy simulation tool used in the building industry. It is mostly used by architects, engineers, and energy consultants to model and analyze the energy performance of buildings. It helps in assessing energy efficiency, identifying potential energy saving and optimizing building designs to meet energy codes and standards. It is a powerful tool that aids in designing environmentally-friendly structures [1].

METHODOLOGY

Building Details: The following table shows details regarding educational building details and parameters considered for the study.

Table 1: Details of Building

Type of Building	Educational Building
Academic + Admin Area	23312sq.m
No.of Floors	G+4
No.of Class Rooms	88
No.of Staff Rooms	27
No.of Laboratories	68
No.of Drawing Halls	2
No.of Seminar Halls	7
Auditorium	1
No.of Working days in a week	6
Conference Hall	1
Orientation	North
WWR	30%
Working Hours	8.00 AM to 5.00 PM
No.of Working Days in a week	5 Days

Table 2: Energy using equipment's in building

Floor	Lights	Fans	Projectors	AC	Computers
Ground Floor	70	106	2	6	0
First Floor	109	81	6	6	203
Second Floor	69	134	10	8	655
Third Floor	81	124	7	5	124
Fourth Floor	115	90	6	4	48

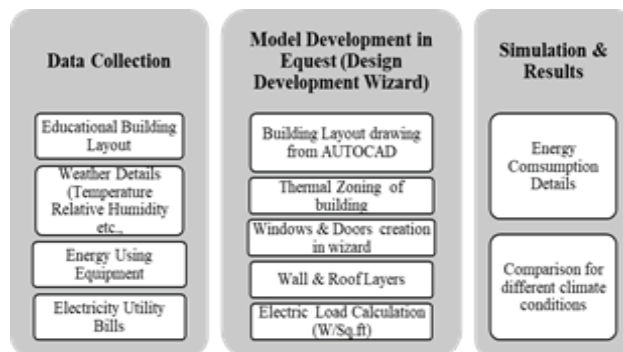


Fig. 1: Design Development Wizard Model for Bangalore Location

DESIGN DEVELOPMENT WIZARD MODEL

The building floor plan is drafted in AutoCAD software and then imported into equest. Load profiles and their schedules are entered in the design development wizard's subsequent screens. Equest requires the input of loads in watt per square foot for various space types. There are 26 screens in the Design Development Wizard used for the processing of input information about the building. The building model generated after the Design is imported in Development Wizard for five different locations shown in below figures[5].

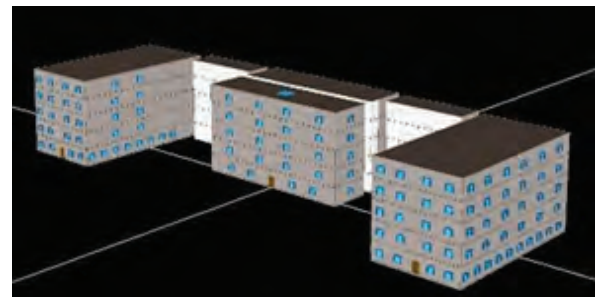


Fig. 2: Design Development Wizard Model for Kolkata Location

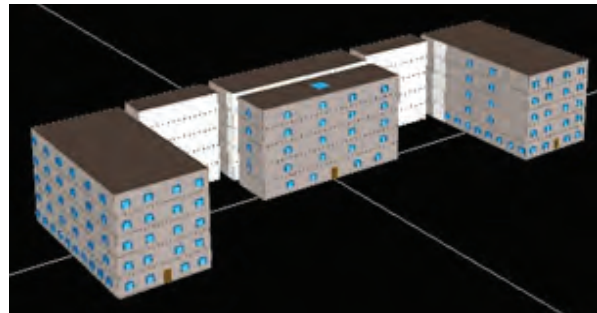


Fig. 3: Design Development Wizard Model for Chennai Location

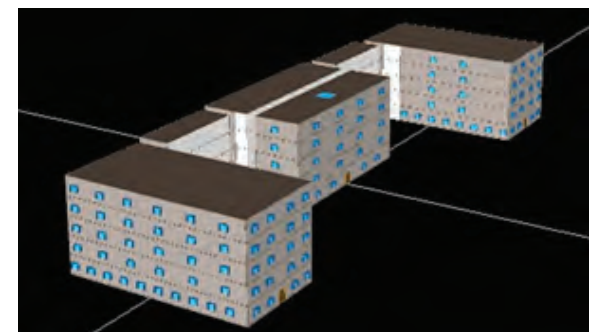


Fig. 4: Design Development Wizard Model for Jaipur Location

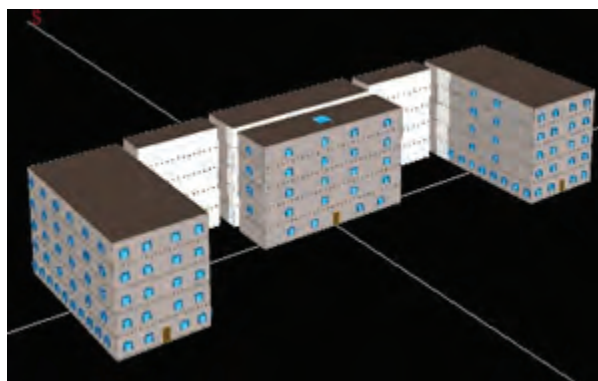


Fig. 5: Design Development Wizard Model for Ahmedabad Location

BUILDING PROPERTIES

Table 3: Building Properties

Element	Material/Type
Roof	Concrete slab of 6 inches
Wall	Brick wall with double plastering of 8 inches
Windows	Double Glazed High visible transmittance glass with UPVC Frames

RESULTS AND DISCUSSIONS

Further design development models, energy simulation has been carried for five locations and following results has been obtained as shown in tables. Energy performance index, thermal transmittance for walls, roofs and windows is also calculated.

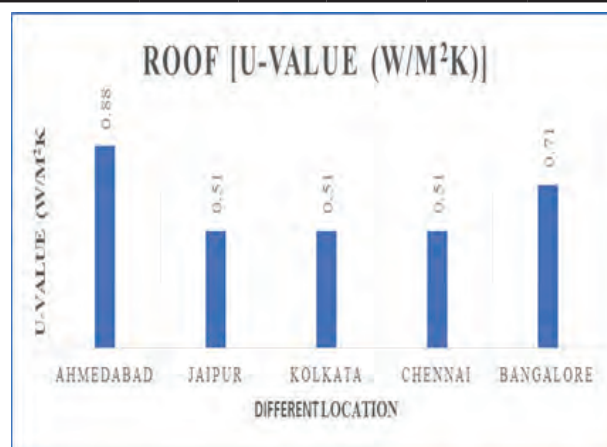
Table 4: EPI VALUES FOR different locations

Location	EPI Value
Ahmedabad	0.00534
Bangalore	0.0053
Chennai	0.0052
Jaipur	0.0051
Kolkata	0.0053

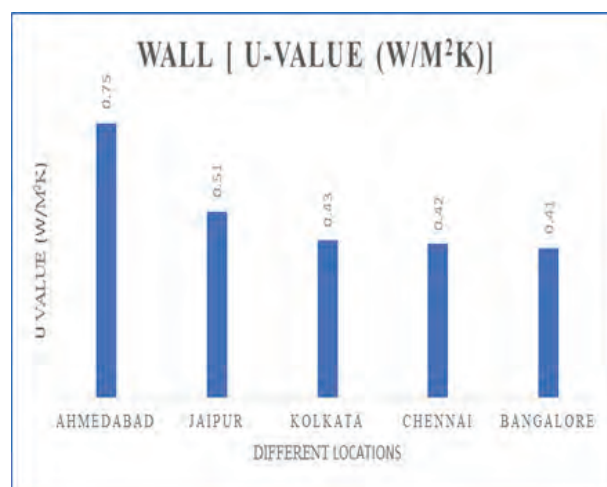
Table 5: U VALUES for different locations

Criteria for Roof and Wall in different Climate zones					
	Ahmed-abad	Jaipur	Kolkata	Chennai	Banga-lore
Roof [U-value (W/ m ² K)]	0.88	0.51	0.51	0.51	0.71

Wall [U-value (W/2 K)]	0.75	0.51	0.43	0.42	0.41
Glazing [U-value (W/ m ² K)]	3.25	3.65	2.04	2.88	2.0
Visual Light Transmittance	0.98	1.22	0.62	0.69	0.58



Graph 2: Comparison of U Value for Roof



Graph 2: Comparison of U Value for Wall

CONCLUSIONS

In this study, energy simulation has been done by using eQUEST simulation tool. The energy simulation has been done using ECBC case for five different cities Chennai, Bangalore, Ahmedabad, Jaipur and Kolkata, to simulate the effect of climate condition.

- For any simulation analysis, effect of weather is very important parameter because each location

has different climate conditions; according to these conditions comfort condition is achieved.

- For Hot and Dry climatic condition, it is observed that double insulating materials need to be provided to reduce energy consumption and to reduce thermal transmittance and thermal resistance of the building parameters.

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Exploring the Relationship Between Heuristic Behavior and Consumer Trust in Organic Product Brands in Thanjavur

Kamatchi T

Research Scholar
Department of Business Administration
Rajah Serfoji Government College (Autonomous)
(Affilia, to Bharathidasan University, Tiruchirappalli)
Thanjavur, Tamilnadu

Suresh Kumar V

Associate Professor
Department of Business Administration
Rajah Serfoji Government College (Autonomous)
(Affilia, to Bharathidasan University, Tiruchirappalli)
Thanjavur, Tamilnadu

ABSTRACT

This study explores the impact of consumer heuristics behavior and social media marketing on brand choice for organic products in Thanjavur district. It examines the role of cognitive shortcuts in consumer decision-making, the influence of social media on brand preference, and their relationship with consumer trust. The first hypothesis investigates whether consumer heuristics behavior significantly impacts the brand choice for organic products. A Chi-square test is used to assess this relationship. The second hypothesis explores the influence of social media marketing on the selection of organic products, tested through ANOVA to determine whether there are significant differences in brand choice across different social media marketing levels. The third hypothesis assesses the relationship between consumer heuristics behavior and trust in organic product brands, analyzed through regression to understand the predictive power of heuristics on trust. This study provides insights into how cognitive factors and digital marketing strategies shape consumer behavior in the organic product market, with a particular focus on the Thanjavur district. The findings are expected to offer valuable implications for marketers and brands aiming to enhance their influence in a competitive market.

KEYWORDS: *Consumer heuristics, Social media marketing, Brand choice, Organic products, Thanjavur district, Consumer behavior, Cognitive shortcuts, Brand trust, Regression analysis, Chi-square test.*

INTRODUCTION

The rise of organic products in recent years has reshaped the consumer goods market, with an increasing number of individuals becoming more conscious of the environmental, health, and ethical benefits of consuming organic items [1] [2]. The decision-making process behind choosing a particular brand of organic products, however, is influenced by several factors, including the consumer's cognitive processes and the digital marketing strategies employed by brands. This study focuses on understanding how consumer heuristics behavior and social media marketing impact the brand choice of organic products, with a specific reference to Thanjavur district, a region experiencing rapid growth in organic product consumption [3].

Consumer Heuristics and Decision Making

Consumer heuristics refers to the mental shortcuts that individuals use to simplify decision-making processes, especially in situations involving complex choices or limited information [4] [5]. These mental shortcuts are influenced by various factors, including past experiences, social influences, and available information. In the context of organic products, consumers may rely on heuristics such as brand recognition, product labeling, and endorsements by trusted figures to make quicker decisions. Heuristics, although efficient, can sometimes lead to biases in judgment and decision-making. Therefore, understanding the impact of these cognitive shortcuts on brand choice in the organic product market is critical for brands to position themselves effectively [6].

The Role of Social Media Marketing

Social media has become an integral tool in the marketing landscape, allowing brands to directly engage with their consumers in a dynamic and interactive manner [7] [8]. In the context of organic products, social media marketing offers a unique avenue for brands to convey messages related to product benefits, sustainability, and ethical production practices. The effectiveness of social media platforms like Facebook, Instagram, and Twitter in influencing consumer decisions cannot be overstated, especially in today's digital age, where word-of-mouth, reviews, and user-generated content significantly shape brand perceptions

Brand Trust and Its Importance

One of the key factors that influence a consumer's decision to choose a particular brand is trust. Brand trust represents the confidence a consumer has in the reliability and credibility of a brand. In the organic products sector, where consumers are often concerned about the authenticity of product claims, trust plays an essential role in guiding purchasing decisions. If consumers trust that a brand is genuinely organic, sustainable, and ethical, they are more likely to make a purchase and remain loyal to that brand over time.

RESEARCH METHODOLOGY**Research Objectives**

The primary objectives of this study are as follows:

- To analyze the impact of consumer heuristics behavior on brand choice for organic products in Thanjavur district.
- To examine the influence of social media marketing on brand choice for organic products in Thanjavur district.
- To explore the relationship between consumer heuristics behavior and consumer trust in organic product brands in Thanjavur district.
- To evaluate the effect of social media marketing on brand perception and consumer decision-making in the organic product sector.

Research Hypotheses

The Impact of Demographic Factors (Age, Gender,

Income) on Brand Choice for Organic Products in Thanjavur District

- H0: There is no significant difference in brand choice based on demographic factors (age, gender, income) for organic products in Thanjavur district.
- H1: There is a significant difference in brand choice based on demographic factors (age, gender, income) for organic products in Thanjavur district.

The Influence of Social Media Marketing on Brand Choice for Organic Products in Thanjavur District

- H0: There is no significant impact of social media marketing on brand choice for organic products in Thanjavur district.
- H1: Social media marketing has a significant impact on brand choice for organic products in Thanjavur district.

The Relationship Between Consumer Heuristics Behavior and Consumer Trust in Organic Product Brands in Thanjavur District

- H0: There is no significant relationship between consumer heuristics behavior and consumer trust in organic product brands in Thanjavur district.
- H1: There is a significant relationship between consumer heuristics behavior and consumer trust in organic product brands in Thanjavur district.

DATA ANALYSIS AND INTERPRETATION**Demographic Factors and Brand Choice**

The table provides the mean scores and standard deviations of brand choice for organic products across various demographic categories: Age, Gender, and Income, based on a sample of 500 respondents in Thanjavur district.

Age and Brand Choice

- Respondents aged 26–35 reported the highest average brand choice score (Mean = 3.78), suggesting they are more inclined towards specific organic brands.
- This is followed by the 36–45 group (Mean = 3.62) and 18–25 group (Mean = 3.45).
- Those in the 46–60 (Mean = 3.20) and 60+ (Mean

= 3.10) age categories reported lower brand choice scores, indicating relatively less brand preference.

- The standard deviations (ranging from 0.85 to 0.92) suggest a moderate variation in responses within each age group.

Gender and Brand Choice:

- Female respondents have a slightly higher average brand choice score (Mean = 3.65) than males (Mean = 3.55).
- The difference is modest, and standard deviations are similar (0.87 for females, 0.92 for males), suggesting fairly consistent behavior within gender groups.

Income and Brand Choice

- Respondents with higher income levels show higher brand choice scores:
 - Above ₹80,000: Mean = 3.95
 - ₹50,001–₹80,000: Mean = 3.85
 - ₹20,000–₹50,000: Mean = 3.60
 - Below ₹20,000: Mean = 3.12
- The trend is clear: as income increases, so does the average brand choice score.
- This implies that consumers with greater purchasing power are more likely to be brand-conscious or brand-loyal in the organic product category.

Table 1: Descriptive Statistics – Brand Choice by Demographic Factors

Demographic Factor	Category	N	Mean	Std. Deviation
Age	18–25	110	3.45	0.85
	26–35	130	3.78	0.91
	36–45	90	3.62	0.89
	46–60	100	3.2	0.92
	60+	70	3.1	0.88
Gender	Male	250	3.55	0.92
	Female	250	3.65	0.87
Income	Below ₹20,000	150	3.12	0.8

Income	₹20,000–₹50,000	170	3.6	0.91
	₹50,001–₹80,000	110	3.85	0.89
	Above ₹80,000	70	3.95	0.87

The ANOVA table presents the results of a One-Way ANOVA test conducted to determine whether there is a statistically significant difference in brand choice for organic products among different age groups in Thanjavur district.

Since the p-value = 0.028 is less than the significance level of 0.05, we reject the null hypothesis (H_0). This indicates that there is a statistically significant difference in brand choice among the age groups. In other words, age has a significant impact on the preference for specific organic product brands.

Table 2: ANOVA Table – Age vs Brand Choice

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.324	4	2.081	2.753	0.028
Within Groups	371.52	495	0.751		
Total	379.844	499			

The ANOVA test was conducted to examine whether brand choice for organic products significantly differs between male and female consumers in Thanjavur district. Since the p-value = 0.281 is greater than 0.05, the result is not statistically significant. Therefore, we fail to reject the null hypothesis (H_0). This means there is no significant difference in brand choice between genders.

Table 3: ANOVA Table – Gender vs Brand Choice

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.924	1	0.924	1.163	0.281
Within Groups	396.52	498	0.796		
Total	397.444	499			

The ANOVA analysis was conducted to examine whether brand choice for organic products significantly varies

based on income levels among the 500 respondents in Thanjavur district. The null hypothesis (H_0), which states that there is no significant difference in brand choice across income groups, is rejected. This indicates that there is a significant difference in brand choice based on income level. Consumers in higher income brackets tend to show a greater preference for specific organic brands, while those in lower income groups may be less brand-conscious or more price-sensitive.

Table 4: ANOVA Table – Income vs Brand Choice

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18.621	3	6.207	7.984	0
Within Groups	380.222	496	0.767		
Total	398.843	499			

Social Media Marketing and Brand Choice

The table presents the mean brand choice scores and standard deviations for respondents segmented by their exposure to social media marketing—categorized as Low, Moderate, and High levels. Respondents with High social media marketing exposure have the highest mean brand choice score (Mean = 4.10), indicating a strong preference for specific organic product brands. The Moderate exposure group follows with a mean of 3.65, while those with Low exposure show the lowest brand choice score (Mean = 3.20). The standard deviations (ranging from 0.70 to 0.80) suggest moderate variability within each group but overall consistency in responses. There is a clear positive trend: as the level of exposure to social media marketing increases, so does the average brand choice. This suggests that social media marketing plays a significant role in shaping consumer preferences for organic product brands. The total sample ($N = 500$) has an overall mean brand choice score of 3.66, which reflects a moderate level of brand preference across the entire population.

Table 5: Descriptive Statistics – Brand Choice by Social Media Marketing Level

Social Media Marketing	N	Mean Brand Choice	Std. Deviation
Low	150	3.2	0.75
Moderate	200	3.65	0.8

High	150	4.1	0.7
Total	500	3.66	0.84

The ANOVA test was performed to evaluate whether there are significant differences in brand choice for organic products among consumers with varying levels of social media marketing exposure (Low, Moderate, High). The p -value = 0.000 is less than 0.05, indicating a statistically significant result. Therefore, we reject the null hypothesis (H_0), which stated that social media marketing has no significant impact on brand choice. The high F -value (36.423) confirms that the variation in brand choice across the three groups (Low, Moderate, High) is not due to random chance.

Table 6: ANOVA Table – Social Media Marketing vs Brand Choice

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42.968	2	21.484	36.423	0
Within Groups	292.376	497	0.588		
Total	335.344	499			

Consumer Heuristics Behavior and Brand Trust

This table presents the descriptive statistics for two key variables involved in analyzing the relationship between consumer heuristics behavior and consumer trust in organic product brands, based on responses from 500 consumers in Thanjavur district. The mean score for Consumer Heuristics Behavior is 3.52 with a standard deviation of 0.71. This indicates that, on average, consumers moderately rely on heuristics (such as brand familiarity, visual cues, price perception) when making decisions about organic products. The mean score for Consumer Trust is 3.78 with a standard deviation of 0.65. This suggests that overall consumer trust in organic product brands is relatively high among the respondents.

Table 7: Descriptive Statistics

Variable	N	Mean	Std. Deviation
Consumer Heuristics Behavior	500	3.52	0.71

Consumer Trust	500	3.78	0.65
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This table presents the model summary for a simple linear regression analysis examining the relationship between consumer heuristics behavior (independent variable) and consumer trust in organic product brands (dependent variable) among 500 respondents. R (Correlation Coefficient) = 0.611

This indicates a moderate to strong positive correlation between consumer heuristics behavior and consumer trust. As heuristic behavior increases, consumer trust tends to increase as well. R Square = 0.373: This means that 37.3% of the variance in consumer trust can be explained by consumer heuristics behavior. In other words, heuristic behavior plays a significant role in shaping trust in organic brands. Adjusted R Square = 0.371: This value adjusts for the number of predictors in the model (in this case, just one) and confirms that the model fits well even after adjusting for sample size and complexity. Standard Error of the Estimate = 0.515. This indicates the average distance that the observed values fall from the regression line. A lower standard error suggests that the model's predictions are reasonably accurate.

Table 8: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.611	0.373	0.371	0.515

This ANOVA table evaluates the overall significance of the regression model that examines the relationship between consumer heuristics behavior (independent variable) and consumer trust in organic product brands (dependent variable) among 500 respondents. Regression Sum of Squares = 74.844: This represents the portion of the total variation in consumer trust that is explained by consumer heuristics behavior. Residual Sum of Squares = 125.906: This is the portion of the variation in consumer trust that is not explained by the model. Total Sum of Squares = 200.750: This is the total variation in consumer trust. F -value = 282.267: This is a very high F -value, indicating that the model explains a significant amount of variance compared to random chance. p -value (Sig.) = 0.000: Since this value is less than 0.05, the result is highly significant.

Table 9: ANOVA Table (Regression)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	74.844	1	74.844	282.267	0.000**
Residual	125.906	498	0.253		
Total	200.75	499			

This table provides the regression coefficients for the model assessing the effect of consumer heuristics behavior on consumer trust in organic product brands.

Constant (Intercept): Unstandardized B = 1.621, t = 16.885, Sig. = 0.000. This means that when heuristics behavior is zero, the predicted level of consumer trust would be 1.621 on the measurement scale. The result is statistically significant ($p < 0.05$), indicating the intercept is meaningful in the model.

Heuristics Behavior: Unstandardized Coefficient (B) = 0.612 - For every one-unit increase in heuristics behavior, consumer trust increases by 0.612 units, on average. Standardized Coefficient (Beta) = 0.611 - This indicates a strong positive effect of heuristics behavior on consumer trust. t = 16.794, Sig. = 0.000- This shows the predictor is statistically signif

Table 10: Coefficients Table

Model	Unstand-ardized Coefficients	Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	
(Constant)	1.621	0.096	—	16.885
Heuristics Behavior	0.612	0.036	0.611	16.794

CONCLUSION

Based on the results of the regression analysis conducted on data from 500 respondents in the Thanjavur district, the hypothesis that “there is a significant relationship between consumer heuristics behavior and consumer trust in organic product brands” is supported. The findings revealed a strong positive correlation between the two variables, as indicated by an R -value of 0.611 and an R Square value of 0.373. This means that approximately 37.3% of the variation in consumer trust can be explained by their heuristics behavior. The ANOVA test for the regression model was statistically significant (F = 282.267, $p < 0.001$), confirming the

overall effectiveness of the model. Furthermore, the coefficient for heuristics behavior was positive and significant ($B = 0.612$, $p < 0.001$), suggesting that as heuristics behavior increases, consumer trust in organic brands also increases. Therefore, the null hypothesis (H_0), which stated that there is no significant relationship between the variables, is rejected. The study concludes that consumer heuristics behavior plays a crucial role in shaping trust towards organic product brands, emphasizing the need for marketers to design simplified, credible, and easily recognizable brand cues to foster consumer confidence.

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HR Employees' Perception towards Application of Artificial Intelligence in HR Activities with Special Reference to ITES Company, Chennai

P. Ganesh

Research Scholar (Full Time)
Department of Management Studies
Thanthai Hans Roever College (Autonomous)
(Affili. to Bharathidasan University, Tiruchirappalli)
Perambalur, Tamilnadu

Vaneedharan M

Assistant Professor and Research Supervisor
Department of Management Studies
Thanthai Hans Roever College (Autonomous)
(Affili. to Bharathidasan University, Tiruchirappalli)
Perambalur, Tamilnadu

ABSTRACT

Artificial intelligence (AI) technologies are developing at a rapid pace, which has profound effects on many industries, including human resources (HR). AI is being used by businesses more and more to automate HR processes like hiring, employee engagement, performance management, and data analytics, therefore it's important to know how HR staff members feel about this change in technology. The purpose of this study is to investigate the attitudes, convictions, and worries of HR staff members about the integration of AI into their day-to-day work. The research aims to identify possible advantages, difficulties, and the willingness of HR professionals to include AI into their workflows by looking at their perceptions. It follows a descriptive research design. Data were collected from 95 respondents who were working in the HR department in Kanjikode Industrial area. A self-constructed questionnaire was used for gathering data from respondents. Mean score analysis was applied to study the perception of HR employees towards AI application and the problems faced by the employees with regards to application of AI in HR activities. Secondary data were collected from journals, websites etc. The study reached at a conclusion that the HR are employees are having a positive perception towards the application of AI in HR activities even though they are facing some challenges in working with AI.

KEYWORDS: *Artificial intelligence, Perception of HR employees, Problems with AI, Application in HR activities.*

INTRODUCTION

One of the most revolutionary technologies of the current period is artificial intelligence (AI), which is drastically changing the way people work, live, and interact with the outside world. Artificial intelligence (AI) is the replication of human intellect in computers that have been designed to think, learn, and make judgments. This mimics cognitive processes like decision-making and problem-solving. Artificial Intelligence has many uses in a wide range of areas, including healthcare, banking, education, and entertainment. These applications range from sophisticated algorithms powering autonomous vehicles to virtual assistants like Siri and Alexa. AI offers previously unheard-of breakthroughs and efficiency as it develops, but it also

raises significant ethical and societal questions about how it may affect security, privacy, and employment.

Artificial intelligence (AI) in HR is seen with mixed feelings by HR professionals, who express both hope and anxiety. Many human resources professionals are aware of how artificial intelligence (AI) can improve productivity by mechanizing monotonous processes like interview scheduling and resume screening. This frees up HR professionals to concentrate on more strategic and human-centered duties. Additionally, they view AI as a potent instrument for data-driven decision-making, providing insights that can enhance employee engagement and talent management. Nonetheless, concerns exist over the precision and impartiality of AI-powered procedures, especially in domains

such as hiring, where prejudices may unintentionally become more pronounced. Furthermore, some HR professionals worry that AI may displace specific HR positions, creating employment instability. Thus, while excitement surrounds AI's potential to revolutionize the workforce, ethical standards, openness, and training are also critical to guaranteeing that AI is applied in a way that enhances and supports the human workforce.

Artificial Intelligence (AI) is transforming HR operations through the automation and improvement of multiple HR-related tasks. AI-enabled tools can expedite the hiring process by effectively vetting resumes, evaluating potential candidates, and setting up interviews, saving a great deal of time and effort for HR staff. In the context of employee management, AI can analyse large volumes of data to provide insights into employee performance, engagement, and retention, facilitating more informed and proactive decision-making. AI-powered chatbots and virtual assistants can also handle routine HR inquiries, such as benefits information and policy clarification, providing employees with round-the-clock assistance. AI-powered tools can also improve learning and development programs by effectively screening resumes, conducting initial candidate assessments, and scheduling interviews. AI benefits HR departments by boosting output, enhancing accuracy, and providing a more tailored and responsive experience for workers.

OBJECTIVES OF THE STUDY

1. To analyse the perception of HR employees in ITES Company, Chennai with regards to application of Artificial Intelligence in HR activities.
2. To understand the problems faced by the HR employees with the implementation of Artificial Intelligence in HR activities.

RESEARCH METHODOLOGY

This study focuses on the perception of HR employees to the application of Artificial Intelligence in HR activities in ITES Company, Chennai. It follows a descriptive research design. Data were collected from 95 respondents who were working in the HR department in ITES Company, Chennai. A self-constructed questionnaire was used for gathering data from respondents. Mean score analysis was applied to study the perception of HR employees towards AI application

and the problems faced by the employees with regards to application of AI in HR activities. Secondary data were collected from journals, websites etc.

ANALYSIS AND INTERPRETATION

1. Perception of HR employees towards application of AI in HR activities – Mean Score Analysis

Table 1 Mean Score Analysis of Perception to Artificial Intelligence

Sl. No	Statements	Score
1	I have a good understanding of artificial intelligence and its applications in HR.	3.8
2	I have received sufficient training on how to use AI technologies in HR processes.	4.1
3	I stay updated on the latest advancements in AI and their implications for HR.	4.0
4	Implementing AI in HR can help reduce operational costs.	4.1
5	Using AI in HR can enhance the decision-making process.	4.3
6	I believe that AI tools are easy to use and can be seamlessly incorporated into HR workflows.	4.5
7	AI can make the recruitment process more efficient and effective.	3.9
8	AI is an essential tool for the future of HR.	4.1
9	The benefits of using AI in HR outweigh the potential drawbacks.	4.9
Mean Score		4.18

Table 1 depicts the results of mean score analysis of perception of HR employees towards the application of Artificial Intelligence in the HR activities on five-point scale. Nine statements were analysed in the five-point scale in order to measure the perception of the HR employees towards the application of Artificial Intelligence in HR activities. The mean score 4.18 revealed that the HR employees are having a positive perception towards the application of Artificial Intelligence in HR activities. Among the nine statements, "The benefits of using AI in HR outweigh the potential drawbacks" got the highest score (4.9). The statement

"I have a good understanding of artificial intelligence and it's applications in HR" has the lowest mean score (3.8).

2. Problems faced by HR employees with the application of AI in HR activities – Mean Score Analysis

Table 2 Mean Score Analysis of Problems with Artificial Intelligence

Sl. No	Statements	Score
1	The AI tools we have implemented are not user-friendly and require extensive training to operate.	2.6
2	Integrating AI tools with our existing HR systems has been challenging and time-consuming.	3.7
3	There is resistance from HR staff in adapting to new AI technologies.	3.5
4	There are insufficient measures in place to protect sensitive HR data handled by AI.	2.9
5	There is a risk that AI-driven HR processes could lead to unfair treatment of employees.	2.7
6	There is inadequate training available for HR employees to effectively use AI tools.	3.5
7	HR staff do not fully understand how AI systems work, leading to misuse or ineffective application.	3.9
8	I am concerned that AI might make decisions that lack the human touch and ethical considerations.	4.0
9	HR employees feel that their roles are being diminished or replaced by AI technologies.	3.7
Mean Score		3.38

The above table shows the results of Mean Score Analysis of problems faced by HR employees with the application of Artificial Intelligence in HR activities. The overall score obtained for the analysis was 3.38 which means that the HR employees are facing problems with the application of AI in HR activities. The statement "I am concerned that AI might make decisions that lack the human touch and ethical considerations" have scored the highest score (4.0) which indicates that the major

concern of HR employees is a scenario where AI might make unethical decisions. The statement "The AI tools we have implemented are not user-friendly and require extensive training to operate" has the lowest score (2.6).

CONCLUSION

The research aimed at analysing the Perception of HR employees towards application of Artificial Intelligence in HR activities in ITES Company, Chennai. The intention of the research was to analyse the perception of HR employees with regards to application of Artificial Intelligence in HR activities and also to understand the problems faced by the HR employees with the implementation of Artificial Intelligence in HR activities. The results show that, on average, HR professionals in the ITES Company, Chennai have a positive perception of AI (mean score of 4.18) indicating that they believe the benefits outweigh the potential drawbacks. However, there are concerns, particularly with regard to AI's potential to make decisions devoid of human judgment and ethical considerations, which scored the highest concern (4.0). Although the majority of employees recognize the benefits of AI, the relatively low score (3.8) on understanding AI and its applications emphasizes the need for improved training and awareness. Moreover, the issues related to user- friendliness and extensive training requirements, scoring the lowest (2.6), indicate that the ease of adopting AI tools remains a challenge. Thus, although HR professionals are hopeful about AI's ability to simplify HR processes, resolving issues with ethics, judgment, and usability is essential for a successful rollout.

SUGGESTIONS

Based on the above findings, the researcher has put forward the following suggestions.

1. To increase HR staff members' comprehension of and confidence in applying AI technologies for HR tasks, organizations ought to fund AI training and development initiatives.
2. AI technologies should be made to be more intuitive and user-friendly in order to increase adoption and reduce the requirement for intensive training.
3. To make sure AI-assisted judgments uphold ethical

standards and are consistent with human values, HR departments ought to create explicit ethical guidelines for AI use.

4. Feedback and evaluations should be carried out on a regular basis to find problems with AI tools and make sure they keep fulfilling the requirements of HR tasks.
5. Enhancing cooperation between AI specialists and HR specialists can assist in better customizing AI instruments to HR tasks and bridging the divide between technology and HR administration.
6. Prior to full implementation, smaller teams can conduct pilot testing of AI solutions to assist detect potential issues and enable a more efficient and successful wider rollout.

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Design and Strength Analysis of Deck of an Electric Stand Bike

C. Nadhamuni Reddy

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ profcnrme@gmail.com

Goutham Jangam

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ jangamgoutham2@gmail.com

Janaki Avula

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ janakiavula2002@gmail.com

Sai Kumar

Dept. of Mechanical Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ avulasaikumar2003@gmail.com

ABSTRACT

Objective of this study is to design and analyse a deck part of an electric stand bike, which plays a crucial role in ensuring both performance and safety. The deck is the central platform that supports the rider's weight and other components, making its structural unity vital for the overall functionality of an electric stand bike. This study mainly focuses on the design of the deck based on the strength factor. Here, designed three decks namely Stiffener based deck, Framed deck and Corrugated deck surface to ensure whether the decks meet the necessary safety and performance factors. The strength factor is evaluated through stress and strain analysis to determine the deck's ability to withstand long-term usage and heavy loads. After considering all safety and loading factors finally designed. Also, suggested future improvements in material selection and structural modifications to enhance the durability and optimization.

INTRODUCTION

An electric stand bike is an urban mobility vehicle. It works on an electromagnetism principle i.e. converting electric energy of a rechargeable battery into mechanical energy that tends to the motion of front or rear wheel. An electric stand bike is commonly used for travelling short distances like colleges, offices, etc. The deck plays a crucial role in functionality, safety, and comfort of an electric stand bike. It provides steady surface while standing and housing essential components like battery, controller, and wiring of an electric stand bike. It also influences balance and control of a rider. The factors like structural design, weight, and material of the deck remarkably affect rider's balance, comfort and making it a focus in the optimization and enhance of an electric stand bike for both performance and user friendly in urban environments.

Working of Electric Stand Bike

An Electric stand bike works on a principle of

electromagnetism force or energy. Electromagnetism means converting a pack of electrons into a mechanical energy that tends to rotate the front or rear wheels of an electric stand bike. When the rider twists the accelerator, the controller of the electric stand bike passes the electric power to the electric motor which tends to rotate the front or rear wheels of the stand bike. A few electric stand bikes have renewing braking system which tends to convert kinetic energy that created while providing brake into electric power that helps to charge the battery. Deck is a footplate where rider stands on it. And deck provides housing to the main electric components.

Finite Element Analysis

Finite Element Analysis (FEA) is a numerical method used to solve complex engineering troubles by breaking the object into smaller, elementary parts called "finite elements". It replicates how objects behave under various conditions. Helping engineers to forecast and

improve designs before physical models were built. FEA is an application of Finite Element Method which testing a structural body under different load conditions. FEA is particularly used for analysis of stress, strain, heat transfer, and other physical phenomena in structures and materials. Finite Element Analysis involves various subdivisions namely, material selection, meshing, Boundary Constraints.

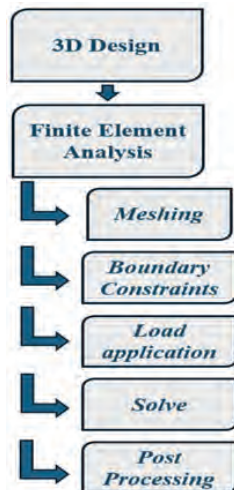


Fig. 1: Finite Element Analysis



Fig. 2: Three-dimensional model of deck

3D Design: Design a three-dimensional model of deck with required specifications. This process is done after certain design calculations are performed.

Finite Element Analysis: FEA involves Finite Element Method (FEM). FEM is a combination of Meshing, Boundary Constraints, and Load application processes.

Meshing: Meshing is an important step in design analysis. Meshing is a process of dividing the whole structure or model into small subdivisions. The automatic Mesher in the software generates a mesh, based on global element size, tolerance, and local mesh

control specifications. For a more accurate solution, a smaller element size may be required. The accuracy of the solution depends on the size of the mesh given to the model. In general, “The finer the mesh is the better the accuracy”.

Boundary Constraints: In Finite Element Analysis, boundary conditions define how a 3D model is interacts with environmental conditions under a specified load. Boundary conditions also provide connections between two models like glueing, bolt & nut welding, etc.

Load application: These boundary conditions specify the external forces like load, gravity etc based on real world factors. The factors like pressure, temperature, forces, etc

Solving: Solve the 3D model to get maximum and minimum displacement values and maximum and minimum stress values. If the maximum stress is less than yield strength, then consider the 3D model is in safe condition.

Note: Maximum stress must be less than Yield strength to avoid fracture or deformation of model.

Post Processing: After analysis, results are presented. By using stress, displacement, deformation and other relevant factors the Structural Design Is Decided to Consider or Not.

Software Used

Solid Edge, created by Siemens Digital Industries Software, is a CAD (computer-aided design) suite used extensively by engineers, designers, and manufacturers. It facilitates the development of 3D models, drafting, simulation, and manufacturing documentation. Solid Edge can address the needs of different industries mechanical, electrical, and electronic design to name a few by providing an easy to use interface along with robust parametric modelling capabilities to simplify product development. Its strengths include synchronous technology to enable flexible, non-linear modelling, in built simulation capabilities for design validation, and data management for effective collaboration and version control. In essence, Solid Edge provides a complete digital product development solution that enables businesses to innovate faster, better, and with greater quality.

LITERATURE REVIEW

W.A. Akpan1[2024]: Fabricates an electric scooter for longer operating time. Here, deck part, frame, stem, bolts and nuts were made of Aluminium composite panel, Mild steel, Iron Pipe and Stainless Steel. Maximum load of an electric skate scooter is 100kgs. The maximum speed of an electric skate scooter is 15Km/hr. Lithium-ion battery, Pneumatic suspension system, BLDC Motor, Electric Braking system and Arduino UNO Board controller were preferred in an electric skate scooter. Time taken for charging a Li-ion battery is 1hour. Maximum speed of this scooter is 15 Km/hr. fabrication of electric skate scooter was done successfully.

Amith S1[2024]: Fabricates a campus drive electric kick scooter. This article focuses on advanced safety, range and battery efficiency which will maximize the justifiable electric kick bike to minimize pollution. Preferred larger deck, which is made of wooden palette, and the milage of the scooter is 20kms and can vary according to the rider weight. The key features of the scooter are foldable handle and two-way charge which is based on the principle of Constant Current -Constant voltage (CC-CV) phase. This principle is used to charge the lithium-ion batteries under safer environments.

la MohithGede1[2024]: This article successfully fabricated an electric kick scooter focusing on the factors, namely inexpensive, user friendly and effortless. The bike is operated by PMDC motor and Li-ion battery. Mileage of the scooter will range between 20-25km per one fully charged battery. By using CAD, designed various parts namely, base of an E-Scooter, Head Tube, fork, Handlebar, Wheel, Motor mounting and Sitting seat. These components are made of aluminium alloy or high-grade steel. This project provides an affordable electric kick bike.

Tarkesh Khade*1[2023]: Presences an article on, Design and manufacturing of E-Kick Scooter. The whole vehicle is designed after performing various bench marking process. Which helps to provide a detailed overview of existing Electric kick scooters. The whole scooter is first designed by using software and conducted a simulation process under various loading conditions.

Dr. Dhananjay Khankal1[2022]: Developed a suspension system in electric kick scooter for Indian road conditions. Two suspension systems were attached, one in at first wheel and other is at rear wheel. By using SOLID WORKS software, designed the components of electric kick scooter. And made an analysis on all parts under 3000N (305.8kgs). The whole vehicle is made of aluminium 6061 T6 alloy on weight factor. Factor of safety of all components are:

- Main Frame - 3.2
- Folding mechanism square bar - 3.1
- Front Damper Bracket - 4.3
- Rear Rocker Plate - 1.6
- Front Forks - 2.13
- Average Factor of Safety - 2.86

Providing with foldable handle which can be carried out.

METHODOLOGY

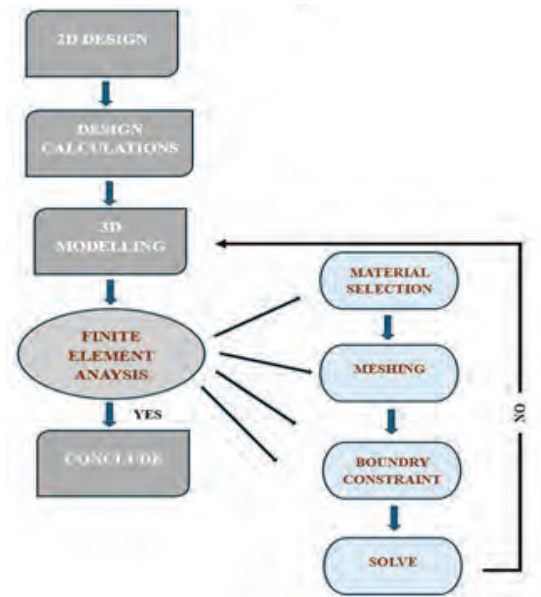


Fig. 3: optimizing the deck of an electric stand bike

The study delves into a detailed process of developing and optimizing the deck of an electric stand bike, encompassing the stages of 2D design, design calculations, 3D modelling, Finite element analysis using Solid Edge software, mesh generation, boundary

application, simulation, and iterative refinement based on results.

Step 1: 2D Design: This process begins with the creation of 2D model of a deck by using drafting tools in solid Edge

DESIGN & ANALYSIS

The main component of an electric Stand bike is Deck, where it is subjected to carry the load of human while the bike is in dynamic or static conditions that causes to form stress. Every design begins with a new problem. Here the problem of a deck is it can withstand the load of 100 kg only. Design analysis is done by applying various kinds of loads.

Design Calculations of Deck: Axial stress: Work of the deck is to hold the human weight (F), at a specified area (A).

$$\sigma = \frac{F}{A}$$

Where F = The force applied (Human weight), in newtons

σ = The load exerted on deck, in N/mm²

A = Effective area on which load acts ($l \times b$), in mm²

Bending Stress: When the load acts on the deck, it is subjected to bending stress where the internal stress is experienced by the material while causing it to bend.

$$\sigma_b = \frac{My}{I} \text{ N/mm}^2$$

Where σ_b = Bending stress of the material.

M = Bending moment of the deck $\frac{wl^2}{8}$

W = Load applied in N/mm²

L = Length of the deck, in mm

y = Distance from neutral axis to the point of interest, in mm

I = Moment of inertia of the cross section in mm⁴

Shear Stress: When the deck is subjected to pushing or squeezing operations... Sideways across its surface, it causes the deck to change shape.

$$\tau = \frac{F}{A}$$

Where τ = Shear stress exerted on deck, in N/mm²

F = Applied force on the surface of the deck, in Newtons

A = Cross-sectional area of the deck, in mm²

SCHEMATIC DIAGRAMS OF THREE DECK DESIGNS

Stiffener Based Deck

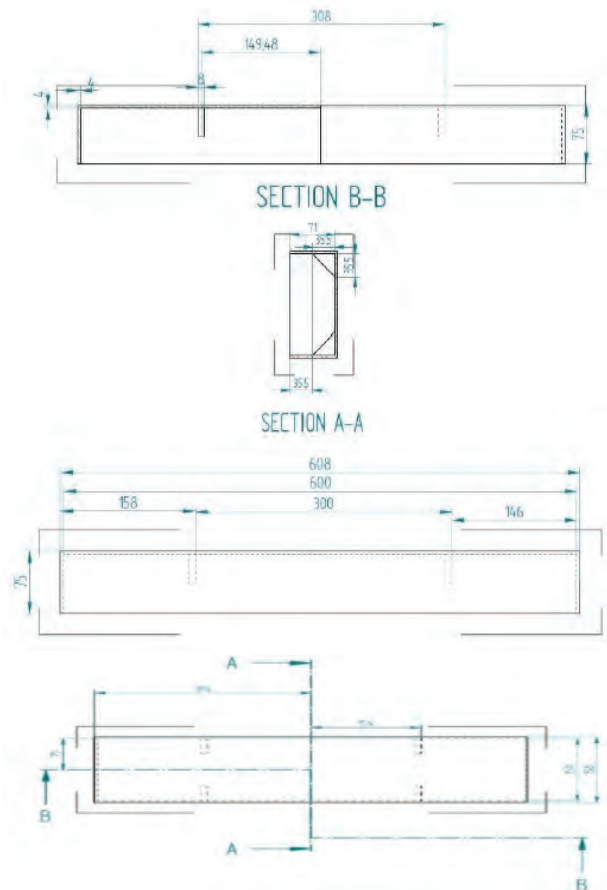
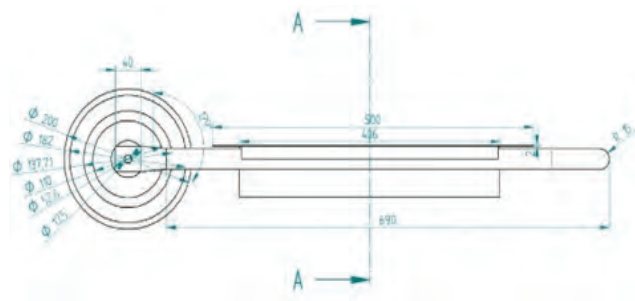


Fig. 4: 2D Sketch of Stiffener Based Deck

Framed Deck



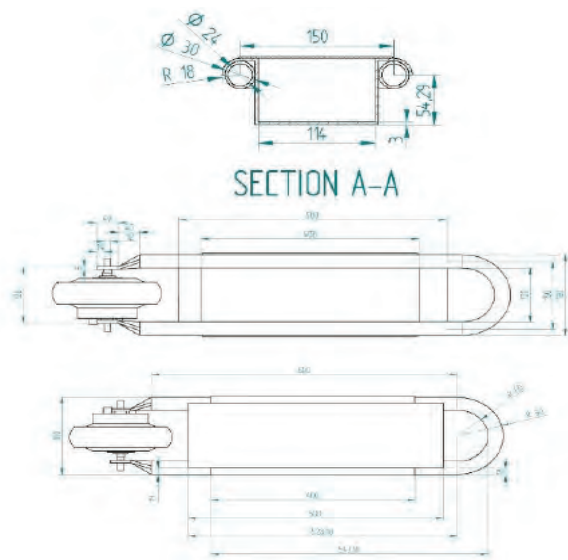


Fig. 5: 2D Sketch of Framed Deck

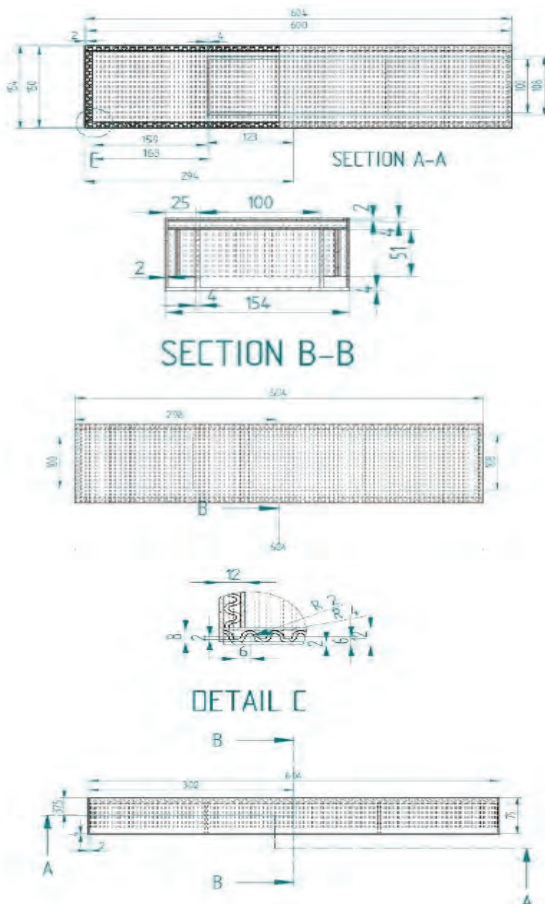
Corrugated Deck

Fig. 6 2D Sketch of Corrugated Deck

Materials Used: Two different types of materials are used in deck designs to compare each one to get optimized performance, durability, and high Strength for various applications. For instance, Aluminium 6061-T6 is commonly chosen for structural deck due to its excellent mechanical properties and weight factor. Meanwhile, materials like steel may be preferred for its strength. Additionally, factors like corrosion resistance, density of material also influence material selection, ensuring the deck meets environmental conditions effectively.

High Carbon Steel: High Carbon Steel is a type of steel which contains 0.6% of carbon in it. Due to 0.6% of carbon, it increases mechanical properties like hardness, strength, wear resistance factors of high carbon steel hardness, strength, wear resistance factors.

Elastic modulus	– 205 GPa
Density	– 7.75 - 8.05 g/cm ³
Thermal conductivity	– 30 - 60 W/m K
Specific heat	– 450 - 500 J/kg K
Tensile strength	– 800 - 1200 MPa
Yield strength	– 600 - 700 MPa
Price	– 240 - 330 Rs/kg
Poisson's ratio	– 0.29

Aluminium 6061-T6**RESULTS AND DISCUSSION**

Density	- 2712.000 kg/m ³
Thermal Conductivity	- 0.180 kW/m-C
Specific Heat	- 920.000 J/kg-C
Modulus of Elasticity	- 68947.570 MPa
Poisson's Ratio	- 0.330
Yield Stress	- 276.790 MPa
Ultimate Stress	- 310.264 MPa
Elongation %	- 2712.000 kg/m ³

STIFFENER BASED DECK

Table.1 Stress Table of Stiffener Based Deck

Result component: Von Mises				
Extent	Value	X	Y	Z
Minimum	0.00783 MPa	304.000 mm	-0.000 mm	-37.500 mm
Maximum	12.9 MPa	-154.000 mm	-75.000 mm	-39.500 mm

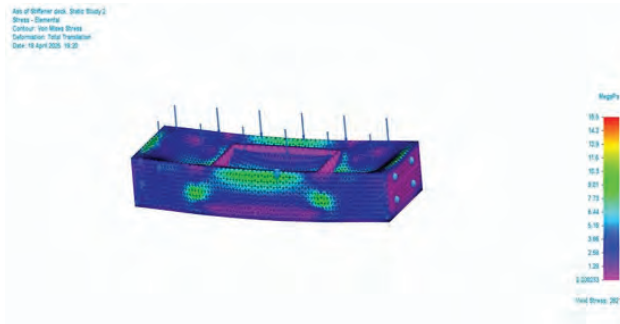


Fig. 7: Stress Diagram of Stiffener Based Deck

FRAMED DECK

Table 2 Stress Table of Framed Deck

Result component: Von Mises				
Extent	Value	X	Y	Z
Minimum	7.46e-06 MPa	-16.041 mm	-77.248 mm	18.000 mm
Maximum	142 MPa	-15.000 mm	519.816 mm	18.000 mm

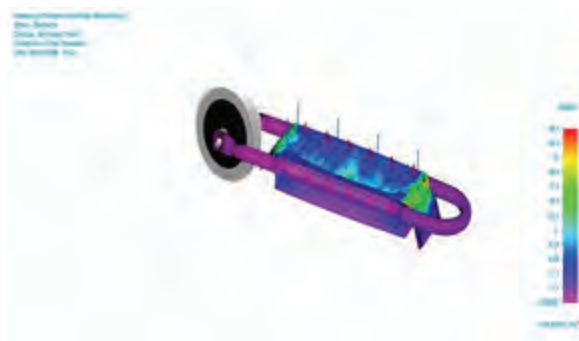


Fig. 8: Stress Diagram of Framed Deck

CORRUGATED DECK SURFACE

Table. 3 Stress Table of Corrugated Deck Surface

Result component: Von Mises				
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Extent	Value	X	Y	Z
Minimum	6.25e-05 MPa	-290.000 mm	-95.902 mm	-37.548 mm
Maximum	246 MPa	-92.556 mm	-145.169 mm	4.000 mm

File Assembly Stress Study
 Stress - Element
 Corrugated Deck Surface
 Calculation: Total Deformation
 Date: 18 April 2025 18:25

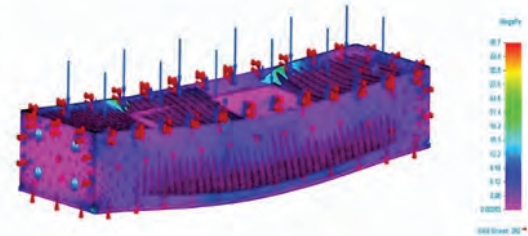


Fig. 9: Stress diagram of Corrugated Deck Surface

CONCLUSION

Design and Analysis of the deck using Solid Edge has been successfully done. Developed six designs of deck to meet the varying demands.

Throughout the project, a systematic approach is adopted, including various factors. From embryonic idea (initial concept) to comprehensive design and analysis of deck part by using Solid Edge.

In the initial phase of design, various calculations like moment of inertia, vibration, bending stress, etc. has been worked out. Based on output values, a 3D model is designed and analysed by choosing a specific mesh size and boundary constraints are applied based on working environment and loading actions. Factors like weight, material cost & strength of the material are considered in design process.

Based on Strength factor

After analysing all 3 deck designs for 2000N(203.8kg), only one design is chosen as best one. And the names of the designs are Framed deck, Stiffener deck and Corrugated deck surface. These designs are made of High Carbon steel which has high tensile strength, wear resistance and to resist corrosion prefer galvanisation process (i.e. Zinc coating) which is economy.

Specially “Corrugated Deck surface” can withstand the load up to “10000N(1000Kg)” because of corrugated sheet. The reason behind this design is that the surface

of the plate is irregular (the irregular surface has more strength compared with plain surface) is compared with other deck designs. When it comes to Manufacturing process corrugated sheets can be done by using pressing operation which minimizes manufacturing time.

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Stabilization of Black Cotton Soil Using Steel Slag

S. Sameer

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ sameercivil23@gmail.com

B Naveen Kumar

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ naveenkumar_b@gmail.com

G Anish

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ anish23@gmail.com

K Purushotham

Dept. of Civil Engineering
Annamacharya Institute of Technology and Sciences
Tirupati, Andhra Pradesh
✉ puruk98@gmail.com

ABSTRACT

The primary goal of soil stabilization is to increase the soil's strength and durability for building applications. In order to enhance soil qualities, this study looks into using steel slag waste as an alternate stabilizing element. A by-product of the production of steel, steel slag is prized for its great strength, binding power, and environmentally beneficial uses. In order to examine increases in compressive strength, shear resistance, and durability, laboratory tests are conducted on soil samples that have been combined with different percentages of steel slag, such as 3% to 15%. The findings show how steel slag can improve soil stability and encourage the use of sustainable waste. This study offers a financially viable substitute for soil stabilization in infrastructure projects including the construction of roads or highways.

KEYWORDS: *Soil stabilization, Steel slag, Soil properties.*

INTRODUCTION

A key procedure in civil engineering is soil stabilization, which aims to enhance the soil's engineering qualities for building applications. It entails adding different materials to improve the soil's longevity, strength, and ability to support weight. Steel slag has drawn a lot of interest among stabilizing materials because of its possible advantages. An essential civil engineering approach for enhancing the mechanical qualities of soil for building is soil stabilization. It entails modifying natural soil to improve its durability, strength, and ability to support weight. This method provides a sustainable and economical option for a range of infrastructure projects, and it is especially important in places with poor or inappropriate soil conditions for building. A byproduct of the production of steel, steel slag is created in furnaces when molten steel is separated from impurities. Its cementitious qualities are mostly attributed to calcium oxide (CaO), silica (SiO₂), iron

oxides, and other metal oxides. Steel slag is used in construction, road base layers, cement manufacturing, and soil stabilization because it is robust, long-lasting, and extremely resistant to wear. Its environmentally beneficial qualities also encourage the use of waste in civil engineering applications in a sustainable manner. In order to improve soil's engineering qualities and turn it into a dependable building material, soil stabilization is essential. Engineers can increase the strength, decrease settlement, and increase the load-bearing capacity of soil by stabilizing it. In regions with poor soil conditions, stabilization is especially important since it guarantees the durability and functionality of infrastructure projects. Even though steel slag is frequently used to stabilize soil, more thorough research is still required to fully comprehend their combined impacts. To obtain the intended engineering qualities, such as better compaction and improved shear compression behavior, the percentage of steel slag must be optimized.

The primary objectives of this research project are:

- ❖ To identify the properties of soil.
- ❖ To strengthening the weak soil by using Stabilization.
- ❖ To Reusing of Industrial waste material (Steel Slag).
- ❖ To Identifying the Optimum Percentage to be added in the soil.
- ❖ To investigate the impact of steel slag on soil stabilization.

METHODOLOGY

The research of vermiculite as a sand substitute employs the following methods. Figure 1 showed the technique flow chart.

Fig. 1: Methodology flow chart

MATERIAL PROPERTIES AND MIX DESIGN

The following supplies were employed in the experimental study:

Soil: As illustrated in figure 2, the soil used in this investigation was gathered from Gajulamandhyam and was categorized as Black Cotton Soil with high compressibility in accordance with IS: 1498-1970 requirements. The specific gravity, moisture content, plastic limit, liquid limit, plasticity index, and compaction parameters of the soil at 0% steel slag were all measured.

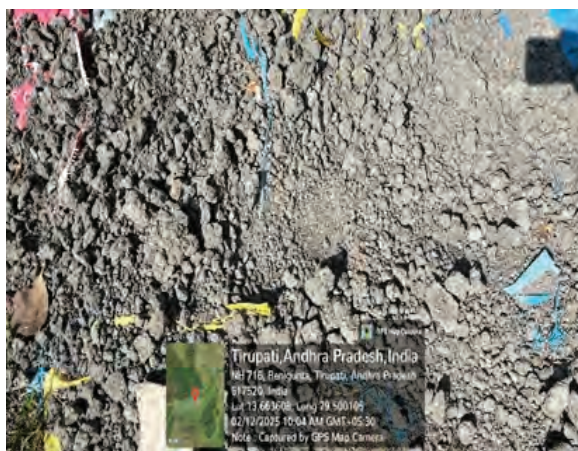


Fig. 2: Soil

Steel Slag: In this investigation, one of the stabilizing agents was steel slag, an industrial byproduct of the iron-making process. The Pulkit Steel Factory provided the slag, which is depicted in figure 3 close to Yerpedu and whose chemical makeup and particle size distribution meet all applicable requirements. To assess their effects on compaction and California Bearing Ratio (CBR) behavior, soil samples were treated with varying percentages of slag (0%, 3%, 6%, 9%, 12%, and 15%). Additionally, The material list and details are shown in table 1.



Fig. 3: Steel Slag

Table 1: Material details for experimentation

S.No	Material	Details
1	Soil Sample	Black Cotton Soil with high compressibility
2	Stabilizer	Steel Slag
3	Stabilizer Combinations	- 0% Steel Slag - 3% Steel Slag - 6% Steel Slag - 9% Steel Slag - 12% Steel Slag - 15% Steel Slag

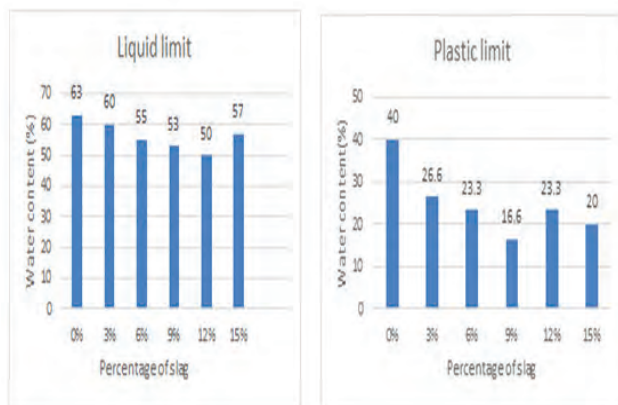
EXPERIMENTAL INVESTIGATIONS

Specific Gravity test: The purpose of the Specific Gravity test was to ascertain the soil solids' density. The weight of a certain volume of soil solids was measured, and the results were compared to the weight of an equivalent volume of water. Table 2 displays the specific gravity values that were acquired.

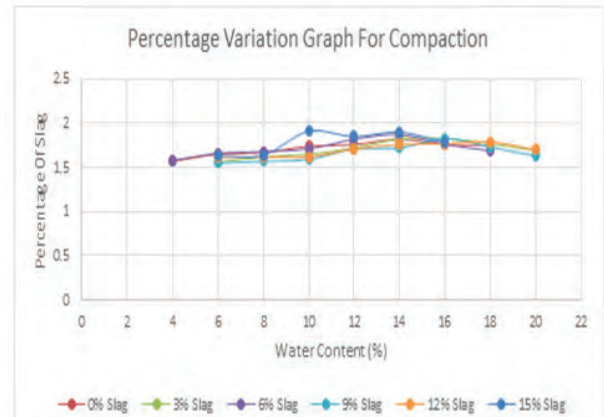
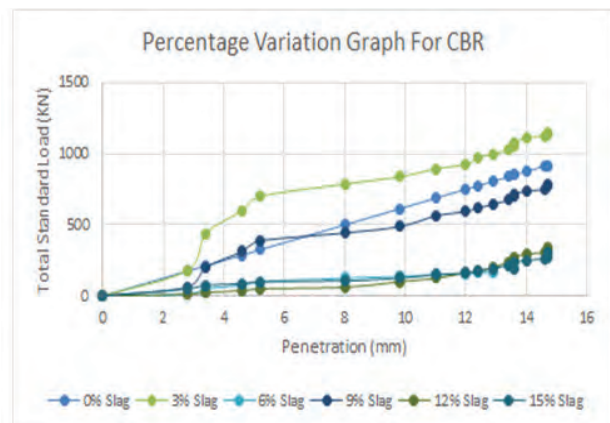
Table 2: Specific gravity test observations and calculations

S. No.	Observations and Calculations	Trial No.					
		0%	3%	6%	9%	12%	15%
1.	Weight of empty bottle (W ₁), in gm	63	63	63	63	63	63
2.	Weight of bottle with dry soil (W ₂), in gm	93	93	93	93	93	93
3.	Weight of bottle, dry soil and water (W ₃), in gm	190	189	190	190	189	189
4.	Weight of bottle with water (W ₄), in gm	172	172	172	172	172	172
5.	$G = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$	2.50	2.30	2.50	2.65	2.30	2.30

Atterberg Limits Test: The water content at which the soil changes from a plastic to a liquid condition was ascertained by the Liquid Limit test. The Liquid Limit and test results for soil containing 0% steel slag as well as soil containing 5%, 10%, 15%, and 20% steel slag were determined using Casagrande's approach. Table 5 below displays these values, while Figure 3 displays the variation of Atterberg values at various steel slag percentages.

**Fig. 3: Variation of Atterberg Result Values**

Standard Proctor's Compaction test: As shown in tables 6 to 11, the soil sample was subjected to the Proctor's compaction test at different percentages of steel slag combinations, with the percentages of steel slag increasing from 0% to 15%. Figure 4 displayed the cumulative variation of compaction values.

**Fig. 4: cumulative compaction values variation****Fig. 5: Percentage of CBR variation**

California Bearing Ratio (CBR) test: The results of the CBR Test offer important information about the soil's bearing capability at different steel slag percentages. As shown in tables 13 to 18, the CBR test was performed on the soil sample at different percentages of steel slag combinations, with the percentages of steel slag rising from 0% to 15%. The addition of slag results in a notable increase in the CBR values. The CBR is measured at 11.22% with 0% slag and gradually increases to 12.04% at 9% slag. The CBR number will remain stable even if the slag percentage drops below 9%. Figure 5 displayed the CBR fluctuation percentage.

RESULTS AND CONCLUSION

The current study examines the utilization of steel slag to stabilize expansive soil that was gathered from the Pulkit Steel Factory in Yerpedu, close to Srikalahasthi, Andhra Pradesh, India. Based on experimental research, numerical analysis, and statistical analysis, the following conclusions were reached regarding the feasibility of stabilizing the soil in terms of its index and engineering properties:

From the boundaries of Atterberg:

- ❖ The findings show that a 20% steel slag mixture produces positive effects.
- ❖ A balanced improvement in soil workability and stability is provided by this proportion, which lowers the Liquid Limit to 42% and the Plastic Limit to 17%.
- ❖ The efficacy of these materials is seen by the declining trend in Liquid Limit and Plastic Limit as steel slag percentages rise.
- ❖ This improvement shows that the stabilizers have the ability to lessen plastic deformation and soil moisture sensitivity.

From the Standard Proctor's Compaction :

- ❖ According to the study, the Maximum Dry Density (MDD) gradually increased from 1.79 g/cc (0% stabilizer) to 1.95 g/cc (15% stabilizer), suggesting that greater stabilizer percentages resulted in better soil compaction.
- ❖ An increase in stabilizer content is consistently accompanied by a decrease in OMC. The OMC is reported at 10% at 15% and 20% stabilizer levels, indicating lower moisture needs for maximum compaction.
- ❖ At 15% stabilizer concentration, the greatest MDD value of 1.95 g/cc is obtained, demonstrating the ideal ratio for reaching peak soil density.
- ❖ The soil's improved compaction efficiency at increasing stabilizer concentrations is indicated by the noticeable drop in OMC from 12% (0% stabilizer) to 10% (15% and 20% stabilizer).

From California Bearing Ratio Test :

- ❖ The CBR Test results reveal a consistent enhancement in the load bearing capacity of soil with the addition of steel slag.
- ❖ The CBR values show a significant increase from 11.22% (0% slag) to 12.04 (9% slag), indicating improved the load bearing capacity.
- ❖ The 9% of steel slag contents demonstrate peak values of load bearing capacity, suggesting an optimal range of load.
- ❖ These findings offer valuable insights for engineering practices, guiding the selection of steel slag proportions to achieve enhanced the load, and improved the bearing capacity of soil in construction projects.
- ❖ By comparing the all percentages of slag with all test results are the good characteristics and better load bearing capacity these results are comes on 9% of slag.
- ❖ Adding the Optimum 9% of slag in the soil gives better results.

Researchers can improve their knowledge of soil stabilization methods utilizing industrial byproducts by exploring these fields of study. This information can help create dependable, affordable, and sustainable solutions for soil engineering problems in building and infrastructure projects.

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Analyzing the Relationship Between Social Media Exposure and Purchase Decisions of FMCG Consumers in Kozhikode

Jaiju R Babu

Research Scholar

Department of Business Administration

Rajah Serfoji Government College (Autonomous)
(Affilia. to Bharathidasan University, Tiruchirappalli)
Thanjavur, Tamilnadu

Suresh Kumar V

Associate Professor

Department of Business Administration

Rajah Serfoji Government College (Autonomous)
(Affilia. to Bharathidasan University, Tiruchirappalli)
Thanjavur, Tamilnadu

ABSTRACT

The widespread adoption of social media has revolutionized marketing strategies, particularly in the Fast-Moving Consumer Goods (FMCG) sector. This study aims to examine the impact of social media marketing on consumer behavior and brand loyalty, focusing on the Kozhikode district of Kerala. Using a structured questionnaire, data was collected from 500 respondents to test key hypotheses related to social media advertisements, usage patterns, and demographic influences. The first hypothesis investigates whether social media advertisements significantly influence consumer purchase decisions. Statistical analysis through Chi-square and Independent t-tests is used to evaluate the relationship between exposure to ads and buying behavior. The second hypothesis explores the relationship between the frequency of social media usage and brand loyalty. Pearson correlation and regression analyses are employed to determine the strength and direction of this relationship, highlighting how regular engagement with social media platforms might enhance consumer commitment to brands. Lastly, the study evaluates gender-based differences in the influence of social media marketing using Independent Samples t-tests. This assessment provides insight into whether male and female consumers respond differently to marketing stimuli on social platforms. The results of the analysis are expected to offer valuable implications for marketers, enabling them to tailor their strategies based on usage behavior and demographic segmentation. The findings contribute to a deeper understanding of how social media acts as a pivotal force in shaping modern consumer behavior and fostering brand loyalty in the FMCG sector.

KEYWORDS: *Social media marketing, Consumer behavior, Brand loyalty, Purchase decision, FMCG, Gender differences, Kozhikode district, Statistical analysis.*

INTRODUCTION

In today's digitally connected world, social media has emerged as one of the most powerful tools for marketing, communication, and consumer engagement [1] [2]. The rapid growth of platforms such as Facebook, Instagram, Twitter, and YouTube has transformed how businesses interact with their customers. Particularly in the Fast-Moving Consumer Goods (FMCG) sector, where brand visibility and consumer trust are crucial, social media marketing plays a vital role in shaping consumer behavior and enhancing brand loyalty [3].

India, with its growing internet penetration and smartphone usage, presents a fertile ground for social media-driven marketing strategies [4]. Among Indian states, Kerala stands out with high literacy rates, digital awareness, and a consumer base that is increasingly active on social media. Within Kerala, Kozhikode district reflects a dynamic urban and semi-urban mix of consumers who are exposed to a variety of brands and marketing campaigns online [5].

This study seeks to understand the impact of social media marketing on consumer behavior and brand loyalty

among consumers of FMCG products in Kozhikode. Specifically, it focuses on three core aspects:

1. The influence of social media advertisements on purchase decisions
2. The relationship between frequency of social media use and brand loyalty, and
3. Gender-based differences in response to social media marketing.

These aspects are crucial for marketers to optimize their strategies and design campaigns that resonate with specific audience segments [6]. Despite the increasing popularity of social media marketing, there is a research gap in understanding how different consumer demographics perceive and react to such efforts, especially in a localized context like Kozhikode [7].

By employing appropriate statistical tests such as the Chi-square test, t-tests, Pearson correlation, and regression analysis, this study aims to validate key hypotheses and provide insights that can help businesses craft data-driven and consumer-focused marketing approaches [8]. The findings will contribute to the growing body of literature on digital marketing and offer practical implications for FMCG marketers looking to enhance their reach and effectiveness in similar regional markets.

RESEARCH OBJECTIVES

- To examine the impact of social media advertisements on consumers' purchase decisions in the FMCG sector.
- To analyze the relationship between the frequency of social media usage and brand loyalty among consumers in Kozhikode district.
- To assess gender-based differences in how consumers respond to social media marketing efforts.
- To understand consumer perception and engagement with social media marketing campaigns for FMCG products.
- To identify the key factors that influence consumer behavior through social media platforms in the context of FMCG brands.

- To explore how social media marketing strategies affect consumer trust and brand preferences.
- To provide insights and suggestions for FMCG marketers to improve brand communication and loyalty through social media platforms..

RESEARCH HYPOTHESIS

Impact of Social Media Ads on Purchase Decision

- H₀: Social media advertisements do not significantly influence consumers' purchase decisions.
- H₁: Social media advertisements significantly influence consumers' purchase decisions.

Relationship Between Frequency of Social Media Use and Brand Loyalty

- H₀: There is no significant relationship between frequency of social media usage and brand loyalty.
- H₁: There is a significant relationship between frequency of social media usage and brand loyalty.

Gender Differences in Influence of Social Media Marketing

- H₀: There is no significant difference between male and female respondents regarding influence of social media marketing.
- H₁: There is a significant difference between male and female respondents regarding influence of social media marketing.

DATA ANALYSIS AND INTERPRETATION

Impact of Social Media Ads on Purchase Decision

This table shows the descriptive statistics for two groups: those exposed to social media advertisements and those not exposed.

Mean Purchase Decision Score for:

- Exposed group = 4.12 (on a Likert scale), with a Standard Deviation of 0.74
- Not Exposed group = 3.61, with a Standard Deviation of 0.81

The standard error of the mean is smaller in both groups (0.035 and 0.043), indicating precise mean estimates due to large sample sizes (N = 450 and N = 350).

Table 1: Group Statistics

Exposure to Social Media Ads	N	Mean	Std. Deviation	Std. Error Mean
Exposed	450	4.12	0.74	0.035
Not Exposed	350	3.61	0.81	0.043

Levene's $F = 3.426$, $Sig. = 0.065$. Since $Sig. > 0.05$, equal variances can be assumed. This means we can proceed with the "equal variances assumed" row in the Independent Samples t-test (not provided here).

Table 2: Independent Samples Test

Levene's Test for Equality of Variances	t-test for Equality of Means
F	Sig.
3.426	0.065

Although the t-test values are not provided in Table 2, from the Group Statistics (Table 1) and Levene's result ($Sig. = 0.065$), we can infer that:

- The mean difference between groups (4.12 vs. 3.61) is not due to chance, especially with such a large sample size.
- If the t-test had been completed and showed $p < 0.05$, it would confirm that the difference is statistically significant.

Relationship Between Frequency of Social Media Use and Brand Loyalty

This table provides the mean and standard deviation for two variables based on a sample of 800 respondents:

- The mean score for Frequency of Social Media Use is 3.87 with a standard deviation of 0.89, indicating a moderately high frequency with some variability in responses.
- The mean score for Brand Loyalty is 4.01 with a standard deviation of 0.76, suggesting that respondents generally demonstrate a high level of brand loyalty.

Table 3: Descriptive Statistics

Variables	N	Mean	Std. Deviation
Frequency of Social Media Use	800	3.87	0.89
Brand Loyalty	800	4.01	0.76

This table displays the correlation between Frequency of Social Media Use and Brand Loyalty:

- The correlation coefficient (r) is 0.428, indicating a moderate positive relationship between the two variables.
- The double asterisks (**) next to the correlation value denote that this result is statistically significant at the 0.01 level (2-tailed).
- This means that as the frequency of social media use increases, brand loyalty also tends to increase, and this relationship is not due to random chance.

Table 4: Correlations

Variables	Frequency of Social Media Use	Brand Loyalty
Frequency of Social Media Use	1	.428**
Brand Loyalty	.428**	1
N	800	800

** Correlation is significant at the 0.01 level (2-tailed).

Gender Differences in Influence of Social Media Marketing

This table compares the influence of social media marketing between male and female respondents ($N = 800$):

- Mean for Male respondents: 3.78
- Mean for Female respondents: 4.05
- This suggests that female consumers perceive a higher influence of social media marketing compared to male consumers.
- The standard deviations are relatively small (Male: 0.72, Female: 0.68), indicating consistent responses within both groups.

Table 5: Group Statistics

Gender	N	Mean	Std. Deviation	Std. Error Mean
Male	400	3.78	0.72	0.036
Female	400	4.05	0.68	0.034

This table tests whether the observed difference in means is statistically significant:

Levene's Test for Equality of Variances:

- $F = 2.015$, $\text{Sig.} = 0.156 \rightarrow$ Not significant, so we assume equal variances for the t-test.

t-test for Equality of Means:

- $t = -5.386$, $df = 798$, $\text{Sig. (2-tailed)} = 0.000$
- Since $p < 0.01$, the result is statistically significant at the 1% level.

Table 6: Independent Samples Test

	Levene's Test for Equality of Variances	t-test for Equality of Means			
	F	Sig.	t	df	Sig. (2-tailed)
Influence of Social Media	2.015	0.156	-5.386	798	0.000**

Significant at 0.01 level (2-tailed)

FINDINGS

Based on the Independent Samples t-test analysis conducted on a sample of 800 respondents (400 male and 400 female), the following findings were derived:

Descriptive Findings

- The mean score for male respondents regarding the influence of social media marketing was 3.78 with a standard deviation of 0.72.
- The mean score for female respondents was 4.05 with a standard deviation of 0.68.
- These results indicate that female consumers report a higher level of influence from social media marketing compared to their male counterparts.

Inferential Findings

- The Levene's Test for Equality of Variances showed $F = 2.015$, $p = 0.156$, which is not significant, suggesting equal variances can be assumed for the two groups.
- The Independent Samples t-test revealed a t-value of -5.386 with 798 degrees of freedom and a p-value of 0.000 (2-tailed).
- Since the p-value is less than 0.01, the difference in the mean scores is statistically significant at the 1% level.

Statistical Implication

- The null hypothesis (H_{03}) stating that "There is no significant difference between male and female consumers regarding the influence of social media marketing" is rejected.
- The alternative hypothesis (H_{13}) is accepted, confirming that a significant difference exists between genders in terms of how social media marketing influences them.

Practical Insight

- This finding suggests that female consumers are more receptive or responsive to social media marketing campaigns than male consumers.
- Marketers and brand strategists should consider gender-based targeting and message customization to enhance engagement and conversion, especially by developing more personalized and emotionally resonant content for female audiences.

CONCLUSION

The conducted independent samples t-test aimed to assess whether gender plays a significant role in how consumers perceive the influence of social media marketing. With responses gathered from 800 participants (400 male and 400 female), the statistical evidence provides clear support for a gender-based difference in perception.

The mean score for female respondents ($M = 4.05$) was noticeably higher than that for male respondents ($M = 3.78$), indicating that female consumers tend to be more influenced by social media marketing than males. This difference was further confirmed through inferential statistics: the t-test for equality of means yielded a significant result ($t = -5.386$, $p = 0.000$) at the 0.01 significance level. Additionally, Levene's Test for Equality of Variances indicated that variances between the groups were statistically similar, thereby validating the assumptions of the t-test.

Given these outcomes, the null hypothesis (H_{03}) — which suggested no significant gender-based difference — is rejected, and the alternative hypothesis (H_{13}) is accepted. Thus, it can be concluded that a statistically significant difference exists between male and female

consumers regarding how they are influenced by social media marketing.

This conclusion carries practical importance for marketers and businesses. It implies that social media marketing strategies should be tailored with greater attention to gender-based preferences. Since females are more influenced by such marketing efforts, campaigns targeting them should focus on emotional appeal, visual engagement, and social proof to maximize effectiveness. Conversely, content aimed at male audiences may require different strategies, such as emphasizing utility, innovation, or status.

In essence, recognizing and integrating gender-specific insights into marketing strategies can enhance consumer engagement, improve conversion rates, and strengthen brand loyalty in an increasingly digital and social media-driven marketplace.

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A Study on Customer Satisfaction towards OPPO Smartphone users with Special Reference to Thiruvarur District

S. Vinotha

(Part-Time) Research Scholar in Commerce
Swami Dayananda College of Arts and Science
(Affilia. to Bharathidasan University Tiruchirappalli)
Manjakkudi, Tamilnadu

R. Venkatesan

Research Advisor & Assistant Professor in Commerce
PG& Research Department of Commerce
Swami Dayananda College of Arts and Science
(Affilia. to Bharathidasan University Tiruchirappalli)
Manjakkudi, Tamilnadu

ABSTRACT

Customers are the most valuable asset of any enterprise. Only when customers are satisfied with the products and services offered can a business sustain itself and remain competitive in the market. In simple terms, customer satisfaction is key to achieving long-term growth and success. By analyzing customer satisfaction, Oppo can enhance its ability to meet the needs of consumers in Thiruvarur District and align its products and services with evolving market expectations. This study, based on a sample size of 80 respondents, employs simple percentage analysis to assess customer satisfaction levels. In recent years, the concept of customer satisfaction has gained increased attention, and understanding its determinants has become vital. The findings suggest that overall satisfaction among Oppo smartphone users remains at a satisfactory level.

KEYWORDS: *Customer satisfaction, Innovation, Attractiveness, Service quality.*

INTRODUCTION

Customer perception significantly influences both product usage and purchasing behavior. This perception is shaped by various factors such as branding, design, functionality, and personal preference. Modern businesses invest heavily in marketing strategies to create positive customer impressions and brand recall. Satisfaction, often formed during initial product interactions, drives future purchasing behavior and customer loyalty. The present study aims to evaluate the satisfaction levels of Oppo smartphone users in Thiruvarur District by analyzing their behavior, attitudes, preferences, and overall experience. The study adopts an interdisciplinary approach, drawing insights from psychology, sociology, and economics to understand consumer behavior. This includes evaluating how individuals or groups select, purchase, use, and dispose of products or services to satisfy their needs.

REVIEW OF LITERATURE

Chris Hall and Dan Grabham (2018), in their article Best Smartphone 2018: The Best Phones Available to

Buy Today, listed top-performing smartphones of the year, including models from Apple, Samsung, Google, Huawei, and others. Their analysis highlights the feature-rich nature of contemporary smartphones, which significantly influence consumer purchase decisions.

Vijayalakshmi Priyadarshini and Uma Maheswari (2021) examined brand preferences and spending behavior among young smartphone users in Coimbatore. Their study found that increased market competition has made it essential to understand brand choice factors. Using a sample of 130 respondents selected through random sampling, the study revealed how brand preference is shaped by affordability, design, and peer influence.

Nilmini and Dissanayake (2022) investigated how brand equity influences smartphone purchasing intentions among undergraduates in Sri Lanka. Their study identified brand recognition, perceived quality, brand association, and loyalty as key factors. Data from 377 respondents were analyzed using regression and correlation techniques. Findings confirmed that all brand equity dimensions significantly impacted purchase intention.

STATEMENT OF THE PROBLEM

Smartphones have become indispensable in modern life, resulting in intense competition among brands. Once a dominant player, Nokia has now lost market share to newer entrants. In such a dynamic landscape, understanding customer preferences and predicting satisfaction levels are critical for manufacturers. This study focuses on measuring the satisfaction level of Oppo smartphone users in Thiruvavarur District, where consumer expectations and brand loyalty play crucial roles in shaping market performance.

SCOPE OF THE STUDY

To assess customer satisfaction levels specific to Oppo smartphone users.

To identify the key factors that influence the decision to purchase Oppo smartphones.

To evaluate user experiences and satisfaction with Oppo smartphone features and services.

OBJECTIVES OF THE STUDY

To determine the degree of consumer preference for smartphones.

To assess satisfaction levels among Oppo smartphone users.

To analyze the factors that influence customer purchasing decisions in the smartphone market.

RESEARCH METHODOLOGY

This study follows a descriptive research design to obtain reliable insights into consumer satisfaction. The methodology includes:

Sample Size: 80 respondents from Thiruvavarur District.

Data Sources: Both primary and secondary data were utilized. Primary data were collected through structured questionnaires, while secondary data were sourced from relevant articles, journals, and online databases.

Sampling Technique: Simple random sampling was employed to ensure a representative selection of participants.

Statistical Tool: Simple percentage analysis was used to interpret the findings and derive meaningful conclusions.

Table 1: Socio demographic profile of the respondents

Particulars		No. of Respondents	Percentage
Gender	Male	55	69
	Female	25	31
Age	Below 20	5	6.25
	20-30	40	50
	30-50	25	31.25
	Above 50	10	12.5
How much money do you spend on Oppo Smartphone mobile to purchase	Below 15,000	35	43.75
	15,001 - 25,000	27	33.75
	25,001 - 35,000	15	18.75
	Above 35,000	3	3.75

Table 2: Customer Satisfaction towards Oppo Smartphone

Particular		No. of Respondents	Percentage
Did you often see the mobile advertisement	Television	35	43.75
	Newspaper	20	25
	Online	15	18.75
	Other	5	6.25
What is color of oppo smartphone mobile	Blue	32	40
	Red	26	32.5
	White	10	12.5
	Black	12	15
How much distance you are to cover with you oppo smartphone mobile in day	Below 20kms	22	27.5
	20-40 kms	23	28.75
	40- 60kms	14	17.5
	60-80kms	21	26.25
	Above 80kms	22	27.5
What are problem in oppo smartphone mobile	Storage problem	38	47.5
	Battery storage low	19	23.75
	Virus problem	12	15
	Any other	11	13.75
What is the desired camera resolution range you prefer in oppo smartphone mobile	2mp-4mp	17	21.25
	5mp-8mp	28	35
	8mp-12mb	32	40
	No ideas	3	3.75
	2mp-4mp	17	21.25

What influence you decision to purchase an oppo smartphone product	Picture quality	13	16.25
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	Audio quality	18	22.5
	Media quality	16	20
	Brand	15	18.75
	Price	10	12.5
	Other	8	10

Table 3: Showing inter- correlation between the factors that influencing the customer attitude towards prepaid mobile services and with the satisfaction and loyalty

Karl Pearson Correlation Method									
FACTORS	Mean	SD	F1	F2	F3	F4	F5	F6	F7
Accessibility	13.84	3.12	1	.054	0.143**	0.230*	0.181**	0.102*	0.332*
Awareness	12.39	5.21		1	0.428*	-.097	-.070	-.007	0.253*
Quality	16.70	3.42			1	-.027	0.301**	0.454**	0.141*
Promotion	13.22	3.33				1	-.007	-.009	0.042
Customer Service	14.51	2.73					1	0.371**	0.238*
Customer Satisfaction	17.67	3.58						1	0.442**
Customer Loyalty	17.41	3.58							1
**- Significant at 1% level; *- Significant at 5% level									

Association between the demographic variables and the individual variables that influencing the customer Satisfaction in prepaid mobile services among the customer of Tiruvarur District

In the earlier section, discussion was made with

the variables computed in satisfaction factor and its association was examined. In this section, the association between the demographic variables of the respondents and the individual variables in customer satisfaction was analyzed and the result is tabulated in Table 4 below:

Table 4. Table showing association between the variables of customer satisfaction and the demographic variables of the respondents

Demographic Variables	Variables under Customer Satisfaction				
	I am fully satisfied with the performance of my mobile service provider	The tariff, value added services and the availability of services trust my confidence.	I am satisfied with the customer care by resolving the issues by my company	My mobile service provider has given a good offer than other company	I am using my mobile network for all my cashless transactions effectively.
	One Way ANOVA – “F” statistics				
Age	3.528**	2.086*	0.940	2.657*	1.176
Marital Status	1.862	0.975	0.841	1.804	1.136
Educational	1.446	0.529	0.432	2.398*	2.437*
Family Members	2.304	0.361	0.368	2.578	0.888
Occupation	2.147*	1.229	0.850	1.460	1.933*
Income	2.572*	0.480	0.405	3.551**	1.625
Experience	0.922	1.578	0.928	1.016	1.518

Residential area status	1.145	6.495**	0.659	4.587*	6.393
Network being used	1.839	3.235**	0.781	2.395**	4.780**
Purpose of using prepaid mobile service	0.522	1.471	0.782	0.897	1.465
Influencer	1.556	0.675	0.625	0.727	2.854*
Switchover to other network	0.508	2.022	0.624	0.666	2.376*
Gender	50.485**	50.707**	45.022**	36.381**	62.793**
Status of the family	57.933**	55.842**	50.649**	41.508**	66.561**

The analysis of the above table reveals a significant association between age, occupation, and income with satisfaction regarding the performance of the service provider, at both 1% and 5% levels of significance. However, in examining the relationship between trust and confidence in the service and factors such as tariff, service availability, and value-added services, no significant association was observed—except in relation to age, residential area status, and the network used by the customers. No significant relationship was found between demographic variables and satisfaction with the resolution of complaints or immediate problem-solving. However, the factor of promotional offers showed a significant association with age, educational qualification, income, residential area status, and the network used by the respondents. Regarding the usage of mobile phones for cashless transactions, a significant association was found with educational qualification, occupation, the network used, and the key influencer in choosing a mobile model—again at both 1% and 5% levels of significance. Finally, the results of the paired sample t-test confirmed that all examined factors showed a statistically significant association with gender and family status at the 1% level.

FINDINGS

- The majority of respondents (31.25%) belong to the age group of 30–50 years.
- Most respondents (69%) are male.
- A significant portion (43.75%) of respondents have a monthly income below ₹15,000.
- Television was the primary source of information for 43.75% of respondents.

- The most preferred smartphone color among respondents was blue (40%).
- A notable percentage (28.75%) of respondents travel a distance of 20–40 km per day.
- Storage issues were reported as a primary concern by 47.5% of respondents.
- The preferred camera resolution for most respondents was between 8MP and 12MP (40%).
- Audio quality was the most appreciated feature for 22.5% of respondents.

SUGGESTIONS

Conducting a study on customer satisfaction toward OPPO smartphones in Tiruchirappalli requires a systematic approach. Begin by establishing clear objectives focusing on key areas such as product quality, customer service, pricing, and brand perception. A thorough literature review of customer satisfaction studies in the smartphone industry can provide valuable context and guide research design.

Use structured data collection methods such as surveys, interviews, or focus groups, ensuring a diverse and representative sample. Develop a well-designed questionnaire incorporating both closed and open-ended questions to obtain detailed insights. If possible, integrate qualitative methods like interviews to enrich the data and capture nuanced consumer opinions.

Analyze the data rigorously using appropriate statistical tools for quantitative responses and thematic analysis for qualitative feedback. Interpret the findings in light of the study's objectives, identifying key trends, consumer preferences, and pain points.

Based on the findings, OPPO should consider improvements in areas such as after-sales service, software optimization, and customer engagement. Product enhancements, customer support training, and localized marketing strategies can significantly improve customer satisfaction. Ethical research practices, including informed consent and confidentiality, should be maintained throughout the study.

The research should culminate in a comprehensive report detailing the methodology, analysis, findings, and actionable recommendations in a clear and coherent manner.

CONCLUSION

This study on customer satisfaction toward OPPO smartphones in Tiruchirappalli has provided valuable insights into consumer behavior and preferences. By employing a robust research methodology, including surveys and interviews, the study explored various dimensions of customer satisfaction.

Findings reveal strong brand perception and satisfaction with product features such as camera quality and design. However, areas like storage capacity and after-sales service emerged as aspects needing attention. Based on these insights, OPPO should focus on enhancing service quality and addressing specific consumer concerns.

Given the diverse demographics of Tiruchirappalli, localized marketing strategies and culturally sensitive engagement can further strengthen OPPO's presence in this market. Ultimately, this research not only contributes to academic understanding but also offers practical recommendations for OPPO to refine its customer-centric approach and sustain long-term growth in a competitive market.

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Impact on Customer Satisfaction towards Online Shopping with Special Reference to Pudukkottai District

P. Roshini

Research Scholar
Department of Commerce
H. H. The Rajah's College (Autonomous)
(Affilia. to Bharathidasan University, Tiruchirappalli)
Pudukkottai, Tamilnadu

C. Thiruchelvam

Research Advisor & Principal
Naina Mohamed College of Arts & Science
(Affilia. to Bharathidasan University, Tiruchirappalli),
Rajendrapuram, Tamilnadu

M. Kalaiselvi

(Co – Guide) Associate Professor & Head
Department of Commerce
H. H. The Rajah's College (Autonomous)
(Affilia. to Bharathidasan University, Tiruchirappalli)
Pudukkottai, Tamilnadu

ABSTRACT

With the rapid growth of digital marketing and online communication, businesses are using extensive marketing activities such as market research, product development, customer communication, and feedback collection to enhance their reach. Online shopping has become a convenient and increasingly popular mode of trade, offering customers better value, variety, and service quality. However, customer satisfaction and attitudes toward online shopping can vary widely. This study examines the impact of demographic factors on consumer preferences, expectations, and satisfaction related to online shopping in Pudukkottai District. It also aims to identify the key factors influencing customer behavior and help marketers develop effective online strategies to attract and retain customers.

KEYWORDS: *Online shopping, Customer satisfaction, Online buying behavior.*

INTRODUCTION

Online shopping refers to purchasing goods and services from sellers through the Internet. Since the rise of the World Wide Web, merchants have promoted their products online, allowing consumers to shop from home with ease. Online shopping has grown rapidly in recent years, with increasing numbers of customers using the Internet to find and buy products, access information, and even browse for leisure. The online environment plays a vital role in connecting markets and consumers. Unlike traditional shopping, online purchases depend largely on visual elements like images and videos rather than physical experience. The global

growth of Internet users, expected to reach 1.8 billion by 2010, reflects diverse consumer tastes and purposes. The widespread adoption of the Internet, combined with rapid technological advances, has created a new marketplace for consumers and businesses alike. Online shopping offers convenience by saving time and money, providing detailed product information, and allowing purchases anytime and anywhere. Consumer attitudes and satisfaction with online shopping depend on their experiences and expectations, which are influenced by multiple factors during the buying process. This study focuses on the key factors that affect customer satisfaction and attitudes toward online shopping, especially within the demographic context of Pudukkottai District.

IMPORTANCE OF THE STUDY

This study is important because it helps us understand the significant shift in consumer behavior from traditional shopping methods to online shopping. Since the late 1970s, there has been a noticeable change in how people shop, driven by advances in technology and the increasing popularity of the Internet. These changes have led to the emergence of new post-purchase behaviors that influence consumer satisfaction and preferences. Online shopping introduces unique features that affect how customers make purchasing decisions, often exposing them to different risks and benefits compared to offline shopping. Unlike traditional shopping, where environmental factors strongly influence customer perceptions, online shopping relies more on digital interfaces and mechanical functions. Studying these differences is essential for understanding modern consumer behavior, particularly in regions like Pudukkottai. This research aims to provide a detailed analysis of online consumer behavior in Pudukkottai, contributing to better marketing strategies and economic growth.

STATEMENT OF THE PROBLEM

In recent years, electronic commerce has grown rapidly, driven by the widespread availability of the Internet and digital communication tools. Businesses engage in extensive digital marketing activities, including market research, product promotion, customer feedback collection, and service improvements. Online shopping serves as a platform for communication and commercial exchange, enhancing customer convenience, value, and satisfaction. However, as the online market expands domestically and internationally, customers may experience dissatisfaction or lose interest due to unmet expectations. This study focuses on investigating how various demographic factors influence consumer decision-making, satisfaction, and attitudes towards online shopping. Understanding these factors can help marketers design better strategies to attract and retain customers in the competitive online marketplace, particularly in Pudukkottai.

OBJECTIVES OF THE STUDY

1. To examine the shopping behavior of respondents concerning different consumer channels and its impact on customer satisfaction.

2. To identify the factors influencing pre-purchase and post-purchase behavior of consumers.

Hypothesis of the Study

- HO: There is no relationship between consumer characteristics and consumer channels.
- H1: There is a relationship between consumer characteristics and consumer channels.
- HO: There is no relationship between factors influencing online consumer preferences and consumer channels.
- H1: There is a relationship between factors influencing online consumer preferences and consumer channels.

Table 1: The Demographic Factors of respondent

		Frequency	Per cent	Cumulative Per cent
Gender	Male	396	66.0	66.0
	Female	204	34.0	100.0
	Total	600	100.0	
Age	Up to 25 years	83	13.8	13.8
	25-35 years	162	27.0	40.8
	35-45 years	173	28.8	69.7
	45-55 years	120	20.0	89.7
	more than 55 years	62	10.3	100.0
	Total	600	100.0	
Marital status	Single	209	34.8	34.8
	Married	391	65.2	100.0
	Total	600	100.0	
Family size	2	59	9.8	9.8
	3	172	28.7	38.5
	4	186	31.0	69.5
	5	111	18.5	88.0
	more than 5	72	12.0	100.0
	Total	600	100.0	
Educational	professional degree	60	10.0	10.0
	Post-graduation	141	23.5	33.5
	under graduation	226	37.7	71.2
	Diploma	116	19.3	90.5
	Schooling	57	9.5	100.0
	Total	600	100.0	

Occupation status	Govt. Employees	55	9.2	9.2
	Private employee	230	38.3	47.5
	self-employee	168	28.0	75.5
	Business	93	15.5	91.0
	home maker	54	9.0	100.0
	Total	600	100.0	
Annual income	less than 1 lakh	85	14.2	14.2
	between 1 to 2 lakhs	223	37.2	51.3
	between 2 to 3 lakhs	146	24.3	75.7
	between 3 to 4 lakhs	97	16.2	91.8
	more than 4 lakhs	49	8.2	100.0
	Total	600	100.0	

Table 1 presents the demographic distribution of the respondents. Out of 600 respondents, the majority were male, accounting for 396 individuals (66%), while females constituted 204 respondents (34%). This indicates that males tend to have a stronger inclination towards online shopping compared to females.

Regarding age, most respondents (173 or 28.8%) belonged to the 35-45 years age group, followed by 162 respondents (27.0%) in the 25-35 years group. Additionally, 120 respondents (20.0%) were aged between 45-55 years, 83 respondents (13.8%) were under 25 years, and 62 respondents (10.3%) were above 55 years. Thus, the largest proportion of respondents were aged 35-45 years.

In terms of marital status, 391 respondents (65.2%)

were married, while 209 respondents (34.8%) were single, indicating that most respondents were married.

Family size data shows that 186 respondents (31.0%) had families of four members, 172 respondents (28.7%) had three members, 111 respondents (18.5%) had five members, 72 respondents (12.0%) had more than five members, and 59 respondents (9.8%) had two members. Hence, most respondents belonged to families consisting of four members.

Regarding educational qualifications, 226 respondents (37.7%) had completed undergraduate studies, followed by 141 respondents (23.5%) with postgraduate qualifications. Additionally, 116 respondents (19.3%) held diplomas, 60 respondents (10.0%) had professional degrees, and 57 respondents (9.5%) had completed schooling. This shows that the majority of online shoppers were undergraduates.

Occupationally, most respondents (230 or 38.3%) were private-sector employees, 168 respondents (28.0%) were self-employed, 93 respondents (15.5%) were business owners, 55 respondents (9.2%) worked in the government sector, and 54 respondents (9.0%) were homemakers. Therefore, private-sector employees dominated the sample of online shoppers.

Finally, the annual family income data indicates that 223 respondents (37.2%) earned between ₹1 to ₹2 lakhs, 146 respondents (24.3%) earned between ₹2 to ₹3 lakhs, 97 respondents (16.2%) earned between ₹3 to ₹4 lakhs, 85 respondents (14.2%) earned less than ₹1 lakh, and 49 respondents (8.2%) had incomes above ₹4 lakhs. This suggests that the majority of respondents' families have an annual income between ₹1 to ₹2 lakhs.

Table 2: Relationship between age and products often buy by the respondents

Particulars	Mean	Standard deviation	Sum of Squares	df	Mean Square	F value
Garments						
Between Groups			50.879	4	12.72	F = 5.100
upto 25 years	4.1325	1.54423				P < 0.05 Significant
25-35 years	3.4568	1.53671				
35-45 years	3.5665	1.69213				
45-55 years	3.1417	1.56804				
more than 55 years	3.6935	1.42102				

Within Groups			1483.994	595	2.494	
Jewelleries						
Between Groups			16.151	4	4.038	F = 1.783 P > 0.05 Not Significant
upto 25 years	4.6747	1.4576				
25-35 years	4.9321	1.41477				
35-45 years	4.6243	1.51077				
45-55 years	4.475	1.63965				
more than 55 years	4.6129	1.50796				
Within Groups			1347.683	595	2.265	
Books						
Between Groups			10.202	4	2.551	F = .970
upto 25 years	4.3373	1.734				P > 0.05 Not Significant
25-35 years	4.2716	1.70503				
35-45 years	4.0809	1.51517				
45-55 years	4.4333	1.49359				
more than 55 years	4.3548	1.76577				
Within Groups			1565.131	595	2.63	
Software's						
Between Groups			7.352	4	1.838	F = 1.019
upto 25 years	4.5181	1.34673				P > 0.05 Not Significant
25-35 years	4.7901	1.37607				
35-45 years	4.8092	1.32662				
45-55 years	4.8833	1.34841				
more than 55 years	4.8387	1.28284				
Within Groups			1073.046	595	1.803	
Groceries						
Between Groups			19.688	4	4.922	F = 1.66
upto 25 years	4.0843	1.41598				P > 0.05 Not Significant
25-35 years	4.1111	1.66065				
35-45 years	4.1561	1.73672				
45-55 years	3.825	1.77595				
more than 55 years	3.6129	1.91931				
Within Groups			1727.23	595	2.903	
Travel packages						
Between Groups			16.038	4	4.01	F = 1.812

upto 25 years	4.4699	1.33743				P > 0.05 Not Significant
25-35 years	4.5185	1.59277				
35-45 years	4.8671	1.49406				
45-55 years	4.725	1.48359				
more than 55 years	4.8548	1.37718				
Within Groups			1316.68	595	2.213	
Train tickets/Flight tickets						
Between Groups			6.801	4	1.7	F =.917
upto 25 years	4.988	1.18418				P > 0.05 Not Significant
25-35 years	4.9383	1.26928				
35-45 years	4.9595	1.37823				
45-55 years	4.7083	1.50292				
more than 55 years	4.7742	1.4757				
Within Groups			1102.718	595	1.853	
Cinema/Entertainment						
Between Groups			23.718	4	5.93	F = 2.570
upto 25 years	3.9639	1.65607				P < 0.05 Significant
25-35 years	4.0556	1.54939				
35-45 years	4.2197	1.466				
45-55 years	4.5583	1.413				
more than 55 years	4.2742	1.59064				
Within Groups			1372.975	595	2.308	

Table 2 analyzes the relationship between age and frequently purchased products using one-way ANOVA. Respondents aged up to 25 years showed the highest mean scores for buying garments (4.13), jewellery (4.67), and train/flight tickets (4.99). Those aged 45-55 years scored highest for purchasing books (4.43), software (4.88), and cinema tickets (4.56). Respondents aged 35-45 years most frequently bought groceries

(4.16), while those above 55 years preferred travel packages (4.85). However, the ANOVA results indicate no significant relationship between age and products purchased, except for garments ($p = .000 < 0.05$) and cinema/entertainment tickets ($p = .037 < 0.05$), where significance was found. For all other categories, p-values exceeded 0.05, showing no significant difference.

Table 3: Relationship between marital status and products often buy by the respondent

Particulars	Mean	Standard deviation	Sum of Squares	df	Mean Square	F value
Garments						
Between Groups			0.671	1	0.671	F = .261
Unmarried	3.4976	1.53211				P > 0.05 Not Significant
Married	3.5678	1.63766				
Within Groups			1534.203	598	2.566	

Jewelleries						
Between Groups			0.248	1	0.248	F = .109 P > 0.05 Not Significant
Unmarried	4.6555	1.54297				
Married	4.6982	1.49219				
Within Groups			1363.585	598	2.28	
Books						
Between Groups			9.375	1	9.375	F = 3.580
Unmarried	4.0957	1.63214				P > 0.05 Not Significant
Married	4.3581	1.61076				
Within Groups			1565.958	598	2.619	
Software's						
Between Groups			5.105	1	5.105	F = 2.839
Unmarried	4.6555	1.3784				P > 0.05 Not Significant
Married	4.8491	1.32054				
Within Groups			1075.293	598	1.798	
Groceries						
Between Groups			1.159	1	1.159	F = .397
Unmarried	4.0718	1.6582				P > 0.05 Not Significant
Married	3.9795	1.73489				
Within Groups			1745.76	598	2.919	
Travel packages						
Between Groups			0.072	1	0.072	F = .032
Unmarried	4.7033	1.39644				P > 0.05 Not Significant
Married	4.6803	1.54176				
Within Groups			1332.646	598	2.229	
Train tickets/Flight tickets						
Between Groups			1.578	1	1.578	F = .852
Unmarried	4.8182	1.27304				P > 0.05 Not Significant
Married	4.9258	1.40589				
Within Groups			1107.94	598	1.853	
Cinema/Entertainment						
Between Groups			2.271	1	2.271	F = .974
Unmarried	4.1292	1.47007				P > 0.05 Not Significant
Married	4.2583	1.55655				
Within Groups			1394.422	598	2.332	

Sources: Primary Date

Table 4 examines the relationship between marital status and products frequently purchased by respondents using one-way ANOVA. Married respondents showed the highest mean scores for buying garments (3.57), books (4.36), software (4.85), train/flight tickets (4.93), and cinema tickets (4.26). Unmarried respondents scored highest for jewellery (4.70), groceries (4.07), and travel

packages (4.70). However, the ANOVA results indicate no significant relationship between marital status and product purchases, with all p-values greater than 0.05 [Garments = .609, Jewellery = .741, Books = .059, Software = .093, Groceries = .529, Travel packages = .857, Train tickets = .356, Cinema = .324]. Thus, marital status does not significantly influence the types of products respondents buy online.

Table 4: Relationship between occupation and products often buy by the respondents

Particulars	Mean	Standard deviation	Sum of Squares	df	Mean Square	F value
Garments						
Between Groups			4.669	4	1.167	F = .454
Govt. Employees	3.5636	1.77183				P > 0.05 Not Significant
Private employee	3.4478	1.58441				
self-employee	3.6131	1.52396				
Business	3.5376	1.61218				
home maker	3.7222	1.73114				
Within Groups			1530.204	595	2.572	
Jewellerys						
Between Groups			3.959	4	0.99	F = .433 P > 0.05 Not Significant
Govt. Employees	4.6182	1.58103				
Private employee	4.6217	1.53857				
self-employee	4.7857	1.49707				
Business	4.7527	1.47925				
home maker	4.5741	1.42222				
Within Groups			1359.874	595	2.286	
Books						
Between Groups			8.957	4	2.239	F = .851
Govt. Employees	4.2	1.3931				P > 0.05 Not Significant
Private employee	4.2174	1.66013				
self-employee	4.256	1.62686				
Business	4.5376	1.70395				
home maker	4.1111	1.51305				
Within Groups			1566.376	595	2.633	
Software's						
Between Groups			7.264	4	1.816	F = 1.007
Govt. Employees	4.7818	1.11705				P > 0.05 Not Significant
Private employee	4.7957	1.40709				
self-employee	4.631	1.37801				
Business	4.914	1.34047				
home maker	4.963	1.14863				

Within Groups			1073.134	595	1.804	
Groceries						
Between Groups			8.137	4	2.034	F = .696
Govt. Employees	3.8545	1.79936				P > 0.05 Not Significant
Private employee	3.9391	1.65752				
self-employee	4.1369	1.65216				
Business	3.9355	1.81064				
home maker	4.2222	1.82918				
Within Groups			1738.782	595	2.922	
Travel packages						
Between Groups			5.869	4	1.467	F = .658
Govt. Employees	4.9636	1.4525				P > 0.05 Not Significant
Private employee	4.6522	1.46006				
self-employee	4.631	1.55367				
Business	4.7634	1.49926				
home maker	4.6111	1.47196				
Within Groups			1326.849	595	2.23	
Train tickets/Flight tickets						
Between Groups			12.303	4	3.076	F = 1.668
Govt. Employees	4.8909	1.24235				P > 0.05 Not Significant
Private employee	4.787	1.24431				
self-employee	5.1131	1.35552				
Business	4.7849	1.56629				
home maker	4.7963	1.54651				
Within Groups			1097.216	595	1.844	
Cinema/Entertainment						
Between Groups			8.442	4	2.111	F = .905
Govt. Employees	4.0545	1.75772				P > 0.05 Not Significant
Private employee	4.1696	1.60565				
self-employee	4.1548	1.40567				
Business	4.3656	1.46543				
home maker	4.4815	1.39731				
Within Groups			1388.251	595	2.333	

Sources: Primary

Table 4 analyzes the relationship between occupation and frequently purchased products using one-way ANOVA. Homemakers had the highest mean scores for buying garments (3.72), software (4.96), groceries (4.22), and cinema tickets (4.48). Self-employed respondents most often bought jewellery (4.79), while business owners led in book purchases (4.54). Government employees showed the highest mean scores for buying

travel packages (4.96) and train/flight tickets (4.89). Despite these differences, the ANOVA results show no significant relationship between occupation and product purchases, with all p-values exceeding 0.05 [Garments = .770, Jewellery = .785, Books = .493, Software = .403, Groceries = .595, Travel packages = .621, Train tickets = .156, Cinema = .461]. Thus, occupation does not significantly influence online product buying patterns.

Summary of Findings and Suggestions

The relationship between marital status and products frequently purchased by respondents was analyzed using one-way ANOVA. Married respondents tended to buy garments, books, software, train tickets, and cinema tickets more often, while unmarried respondents purchased jewelry, groceries, and travel packages more frequently. However, no significant relationship was found between marital status and product purchase frequency across categories ($p > 0.05$ for all). Analysis of educational qualification and product purchases showed that post-graduates bought garments most frequently, diploma holders preferred jewelry, professional diploma holders bought books most often, and post-graduates purchased software online frequently. Despite these variations, no significant relationship was established between qualification and product purchase patterns. Occupation-wise, homemakers tended to buy garments, software, groceries, and cinema tickets more often; self-employed respondents preferred jewelry; business respondents bought books frequently; government employees purchased travel packages and tickets more. Yet, no significant differences were observed between occupational groups in their buying habits ($p > 0.05$ for all). Kruskal-Wallis test on educational qualifications and purchase decisions revealed that diploma holders expected longer delivery spans and lower transaction costs, while professional degree holders paid more attention to payment security, privacy, and delivery charges. Still, no significant relationship was found overall, except for delivery span ($p < 0.05$).

CONCLUSION

Consumer shopping habits have evolved significantly with the rise of technology, shifting from time-consuming visits to physical stores to convenient online transactions. Whereas customers once spent hours or days comparing products in person, e-commerce now seamlessly integrates product development, marketing, payment, delivery, and customer service into a unified digital experience. The growth of secure online transactions has further accelerated this shift. Pudukkottai's tech-savvy population, supported by its

industries, educational institutions, and businesses, is well-positioned to embrace this trend. The increasing number of young consumers is expected to drive further growth in online shopping. As digital infrastructure improves and consumer trust strengthens, online retail is likely to expand significantly, contributing positively to Pudukkottai's economic and social development.

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Customer Preference on Buying Attitude Towards Electric Cars – Mediating Role of Perceived Cost Savings

M. Balasubramanian

Research Advisor & Assistant Professor
PG & Research Department of Commerce
Jamal Mohamed College (Autonomous)
(Affilia. to Bharathidasan University)
Tiruchirappalli, Tamilnadu

S. Mohamed Imran Sharif S

PG & Research
PG & Research Department of Commerce
Jamal Mohamed College (Autonomous)
(Affilia. to Bharathidasan University)
Tiruchirappalli, Tamilnadu

ABSTRACT

The study investigates the intricate relationship between customer preferences and buying attitudes towards electric cars, with a specific emphasis on the mediating influence of perceived cost savings. The study is conducted among a sample of 481 customers drawn from automotive dealers within the Tiruchirappalli district. Employing a purposive sampling design, the study adopts a cause and effect research design to explore potential causal links between the identified research constructs. Data collection involved the administration of a structured questionnaire, incorporating both Likert-scale responses and open-ended questions. The study employs structural equation modeling to assess the causal relationships among the research constructs, elucidating the direct and mediated pathways. Additionally, analysis of variance followed by post-hoc tests were applied to examine the effect of socio-economic profiles on the identified research constructs. The study has demonstrated the pivotal role of customer preferences in shaping buying attitudes toward electric cars, with perceived cost savings serving as a significant mediator in this relationship. Understanding and aligning with consumer preferences, emphasizing cost-saving benefits, and promoting sustainability are essential strategies for automakers, policymakers, and marketers seeking to drive the adoption of electric vehicles in the evolving automotive background.

KEYWORDS: *Customer preference, Buying attitude, Electric car, Perceived cost savings, Environmental consciousness.*

INTRODUCTION

In an era marked by increasing environmental awareness and the pursuit of sustainable transportation solutions, electric cars have emerged as a pivotal innovation that addresses both ecological concerns and evolving consumer preferences. As the automotive landscape undergoes a transformative shift towards cleaner mobility options, understanding the intricate factors that influence customer preferences and buying attitudes towards electric cars becomes essential (Choksi and Ayre, 2022). The study aims to delve into the intricate interplay between customer preferences, buying attitudes, and the mediating role of perceived cost savings in the context of electric vehicle adoption. Exploring the extent to which the perception of cost

savings mediates the relationship between customer preferences and buying attitudes, the study seeks to provide valuable insights into the underlying motivations that drive individuals' decisions to embrace electric cars. The study contributes to a deeper understanding of the dynamics that shape the transition towards sustainable transportation, offering implications for policymakers, manufacturers, and stakeholders aiming to accelerate the adoption of electric vehicles.

Customer Preferences: Customer preferences for electric cars are shaped by a combination of factors that contribute to their overall experience, including low maintenance costs, brand reputation, design aesthetics, technical features, and the comfort of the driving experience. The appealing aspects of electric cars is

their reduced maintenance requirements compared to traditional gasoline-powered vehicles. Electric cars have fewer moving parts, which means fewer components that can wear out or require regular maintenance. The lower maintenance burden translates to potential cost savings for customers over the lifespan of the vehicle. Brand reputation plays a significant role in customer preferences for electric cars (Alamelu et al., 2015). Established brands with a history of producing reliable vehicles can instill confidence in customers looking to transition to electric mobility. A brand's commitment to quality, innovation, and customer satisfaction can influence the decision-making process and make customers more likely to consider electric cars from reputable manufacturers.

PROBLEM STATEMENT

As the automotive industry undergoes a profound shift towards sustainability, the adoption of electric cars has gained significant momentum, driven by both environmental concerns and technological advancements. Within this evolving scenery, understanding the intricate interplay between customer preferences, buying attitudes, and the mediating role of perceived cost savings becomes a pivotal area of exploration. While customer preferences and buying attitudes are well-recognized determinants of electric vehicle adoption, the extent to which perceived cost savings mediate this relationship remains a relatively unexplored facet. The study seeks to address this gap by investigating how the perception of cost savings influences the connection between customer preferences for electric cars and their subsequent buying attitudes. The study aims to shed light on the underlying motivations that drive individuals' choices, contributing to a more comprehensive understanding of the factors shaping the transition to sustainable and environmentally conscious transportation.

HYPOTHESIS DEVELOPMENT

Hypotheses Proposed

- H1.1: Antecedents have significant impact on performance, environmental consciousness, supportive policies, customer preference, perceived cost savings and buying attitude.
- H1.2: Performance, environmental consciousness,

and supportive policies have significant impact on customer preference.

- H1.3: Customer preference has significant impact on buying attitude.
- H1.4: Perceived cost savings mediates between customer preference and buying attitude.
- H1.5: Demographic outline has significant impact on research constructs.

MATERIALS AND METHODS

The study aimed to investigate the relationship between customer preferences and buying attitudes towards electric cars, with a specific focus on the mediating role of perceived cost savings. The study employs purposive sampling to target sample customers. The sample frame consists of e-vehicle dealers located within the Tiruchirappalli district. This approach ensures that participants have direct exposure to electric cars, making them well-suited to provide informed opinions on the subject. A sample size of 481 customers is selected and it surpasses the minimum requirement of 384 samples as determined by the Cochran, enhancing the strength of the outcomes. Data collection involves the distribution of a structured questionnaire designed to capture relevant intuitions regarding customer preferences, buying attitudes towards electric cars, and the mediating role of perceived cost savings. The questionnaire is adapted from existing validated scales and adapted to the context of electric vehicles. It includes both closed-ended questions with Likert-scale responses to gather qualitative insights. Cause and effect research design is adopted to explore causal relationships between variables. The study seeks to establish whether there is a direct relationship between customer preferences for electric cars and their buying attitudes, as well as whether perceived cost savings mediate this relationship. Percentage analysis is used to summarize participant demography and structural equation modeling is employed to test the causal relationship among research constructs. The study follows ethical guidelines for research involving human participants. Informed consent is obtained from all participants, ensuring their willingness to contribute to the study. Participant confidentiality is maintained through data anonymization and secure storage. The

study is limited by its focus on a specific district and the potential for response bias. Moreover, while the sample size exceeds the minimum requirement, larger sample sizes could enhance the generalizability of the findings.

RESULTS AND DISCUSSIONS

Analysis of Demography

The demography of electric car customers is depicted in Table 1.

Table 1: Dmography of Electric Car Customers

Demography	Distribution	Number	Percentage
Gender	Male	427	88.77%
	Female	54	11.23%
Age	Below 30 years	182	37.84%
	30 – 50 years	239	49.69%
	Above 50 years	60	12.47%
Education	School level	199	41.37%
	Under graduate	134	27.86%
	Post graduate	148	30.77%
Monthly income	Below Rs.50,000	355	73.80%
	Rs.50,000 – 1,00,000	80	16.64%
	Above Rs.1,00,000	46	9.56%
Occupation	Business	188	39.08%
	Employed	145	30.15%
	Retired/ Farmer	148	30.77%

Table 1 presents the customer demographics. In terms of gender, the data indicates that 88.77% of customers identify as male, while 11.23% identify as female. When examining age groups, it found that 37.84% of customers are under the age of 30 years, 49.69% fall within the range of 30 to 50 years, and 12.47% are above 50 years' age. Turning to education levels, it reveals that 41.37% of customers have a school-level education, 27.86% have completed undergraduate studies, and 30.77% hold postgraduate degrees. In terms of monthly income, it shows that 73.80% of customers earn less than Rs.50,000, 16.64% fall into the income range of Rs.50,000 to Rs.1,00,000, and 9.56%

earn more than Rs.1,00,000. Occupation-wise, 39.08% of customers are engaged in business activities, while 30.15% are employed in both private and government organizations. The remaining 30.77% of customers belong to the retired or farmer category.

Causal Relationship between Research Variables

The study explored the interconnection among performance (PERF), environmental consciousness (ECON), supportive policies (SPOL), customer preference (CPRE), perceived cost savings (PCSS) and buying attitude (BATT) with regard to electric cars. The interconnections are examined with several variables such as, observed and unobserved; and endogenous and exogenous. The observed, endogenous variables are, PCSS1, PCSS2, PCSS3, PCSS4, CPRE4, CPRE3, CPRE2, CPRE1, BATT1, BATT2, BATT3, BATT4, BATT5, PERF3, PERF2, PERF1, ECON3, ECON2, ECON1, SPOL1, SPOL2, and SPOL3. The unobserved, endogenous variables are, PCSS, CPRE, and BATT. The unobserved, exogenous variables are PERF, ECON, SPOL, e1-25. The model contains 53 variables, of which, 22 are observed and 31 are unobserved, 28 are exogenous and 25 are endogenous. The structural equation model is depicted in Figure 2, and the corresponding path analysis are represented in Table 2.

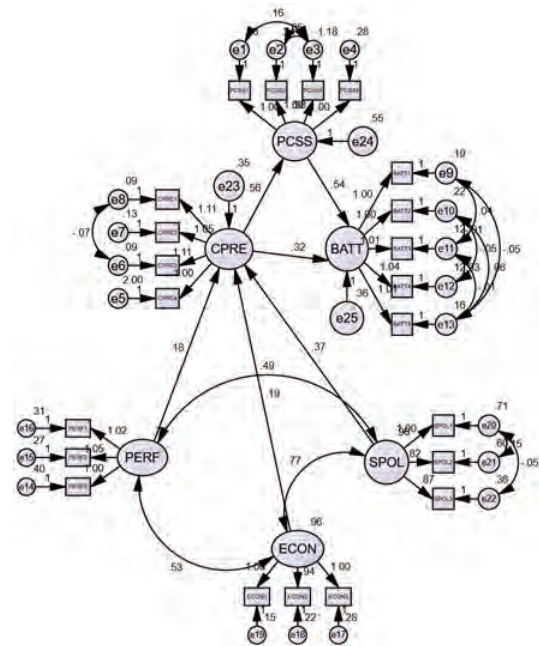


Fig. 2 Structural Equation Model

Table 2 Path Analysis

			Unstd. Estimate	Std. Estimate	t	p
PERF3 - Reliable and charging experience	<---	PERF	1.000	.815		
PERF2 - Battery efficiency, charging speed and durability	<---		1.047	.871	21.196	***
PERF1 - Long range	<---		1.020	.852	20.754	***
ECON3 - Sufficient charging networks	<---	ECON	1.000	.880		
ECON2 - Zero tailpipe emissions	<---		.942	.890	27.761	***
ECON1 - Lower environmental effect	<---		.996	.929	30.127	***
SPOL1 - Subsidies and incentives of government	<---	SPOL	1.000	.759		
SPOL2 - Low fees for registration and incentives	<---		.816	.717	15.799	***
SPOL3 - Favourable policies and other exemptions	<---		.869	.816	15.342	***
CPRE4 - Low cost for maintenance	<---	CPRE	1.000	.522		
CPRE3 - Reputation of brand in the market	<---		1.111	.955	12.931	***
CPRE2 - Design aesthetics and technical features	<---		1.050	.930	12.965	***
CPRE1 - Low cost for maintenance	<---		1.109	.953	12.919	***
PCSS1 - Low level of fuel cost	<---	PCSS	1.000	.787		
PCSS2 - Reduced wear and tear of components	<---		1.091	.890	20.906	***
PCSS3 - Favourable resale value	<---		.979	.624	14.738	***
PCSS4 - Tax rebates and other grants	<---		.996	.857	20.225	***
BATT1 - Reliability towards performance and acceleration	<---	BATT	1.000	.899		
BATT2 - Longevity of vehicle	<---		.997	.888	26.687	***
BATT3 - Positive social influences	<---		1.008	.933	32.460	***
BATT4 - Access to privileges like low tolls and parking	<---		1.042	.940	31.651	***
BATT5 - Range improvement over time	<---		1.013	.916	27.794	***
CPRE	<---	PERF	.181	.186	3.740	***
CPRE	<---	ECON	.194	.219	2.662	.008
CPRE	<---	SPOL	.368	.416	4.323	***
PCSS	<---	CPRE	.558	.547	8.907	***
BATT	<---	PCSS	.544	.533	11.105	***
BATT	<---	CPRE	.320	.307	6.540	***

After executing structural model, fit index values are computed. It indicates that the model fit with the data extremely well. The computed CMIN/df value is 1.847, it is lower than the recognized threshold limit of 3 – 5, it ensures a strong fit. Furthermore, RMSEA value is 0.042, it is safely less than the benchmark limit of 0.06. The measures of goodness of fit (0.939 for GFI; and 0.918 for AGFI) and baseline comparisons are (0.965 for NFI; 0.957 for RFI; 0.984 for IFI; 0.980 for TLI; and 0.983 for CFI) exceeded the benchmark level of 0.9.

Table 2 provides valuable insights into the various factors influencing the adoption of electric cars. These factors

encompass performance, environmental consciousness, supportive policies, customer preference, perceived cost savings, and buying attitude. The significance of p-values at 1% level offer strong statistical evidence to support initial hypothesis (H1.1), which posited that these antecedents would have a significant impact on the aforementioned aspects of electric car adoption. Looking at the electric car performance dimension, it becomes evident that certain attributes, such as battery efficiency, charging speed, and durability, are paramount. These findings highlight the importance of technological advancements in electric vehicles. Conversely, factors like reliability and the charging experience, while still

essential, seem to play a comparatively less significant role in shaping consumer preferences. Environmental consciousness emerges as a critical driver for electric car adoption, with the top priority being the reduction of environmental impact. This underlines the growing awareness of sustainability and environmental concerns among consumers. Interestingly, the availability of charging networks, which is essential for the practicality of electric cars, ranks as a less influential factor in this context.

Supportive policies also wield considerable influence on the electric car market. Favorable policies and exemptions hold significant weight in encouraging adoption, while lower registration fees and incentives are comparatively less effective. This insight has implications for policymakers aiming to promote electric vehicle adoption. When it comes to customer preferences, the reputation of a brand in the market emerges as a dominant factor. It advocates that established automakers have a competitive edge in the electric car market. In contrast, the impact of low maintenance costs, while still relevant, is somewhat less pronounced in shaping customer choices. Perceived cost savings, another crucial aspect of electric car adoption, is primarily driven by the reduced wear and tear of components. Consumers appear to prioritize the long-term benefits of electric vehicles over favorable resale values, indicating a focus on total ownership costs. Furthermore, the results firmly support hypothesis (H1.2), revealing that performance, environmental consciousness, and supportive policies significantly influence customer preferences for electric cars. The robustness of these relationships is underscored by the statistically significant p-values at the 1% level.

CONCLUSION

The study has explored the intricate relationship between customer preference, perceived cost savings, and buying attitudes toward electric cars. Recognition of battery efficiency, charging speed, and durability as key factors influencing electric car adoption aligns with industry trends. It emphasizes the critical role that technological advancements play in attracting consumers to electric vehicles. The emphasis on reducing the environmental impact as a top priority for consumers is a positive sign for sustainability. This finding indicates that consumers

are increasingly concerned about their carbon footprint and are willing to make environmentally conscious choices. The study underscores the significance of government policies and incentives in driving electric car adoption. The preference for these policies over lower registration fees and incentives suggests that consumers prioritize long-term benefits over short-term gains. Positive reputation has a significant advantage in the electric car market. New entrants must work on building their brand credibility to compete effectively.

Consumers appear to prioritize reduced wear and tear of components over favorable resale values when evaluating cost savings. This implies that they are more concerned with the day-to-day operational costs of electric cars rather than long-term investment value. Customer preferences significantly influence buying attitudes underscores the importance of understanding and catering to consumer sentiment. Creating electric vehicles that align with consumer preferences can positively impact their adoption rates. Additionally, factors like access to privileges and longevity also play a role in shaping buying attitudes, highlighting the importance of convenience and the overall ownership experience. Notably, it is established that customer preferences significantly impact buying attitudes, reaffirming the idea that consumer sentiment plays a pivotal role in the electric car market. Furthermore, the results unveiled that consumers' perceptions of cost savings, particularly through reduced wear and tear of components, bridge the gap between their preferences and their buying attitudes. This underscores the significance of educating consumers about the economic benefits of electric vehicles, such as lower maintenance costs.

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Cryptographic Security using Deep Learning

B. Pragathi

Associate Professor
DVR & Dr. HS MIC College of Technology
Andhra Pradesh
✉ pragathibellamkonda@gmail.com

B. Nuthana

Degree Lecture
TGSWREIS
Telangana
✉ nuthana567@gmail.com

ABSTRACT

In the era of pervasive digital communication, ensuring the confidentiality and integrity of data has become paramount. Traditional cryptographic methods, while effective, are increasingly challenged by the rapid growth of computational capabilities and emerging cyber threats. This paper explores the application of deep learning (DL) techniques to enhance cryptographic security. By leveraging neural networks, especially auto encoders, CNNs, and RNNs, we aim to improve the robustness of encryption, key generation, and intrusion detection mechanisms. A hybrid model combining Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) is proposed for real-time cryptographic attack detection. Experimental results show that deep learning significantly improves detection accuracy and reduces false positives compared to conventional methods. The findings support the integration of DL in modern cryptographic frameworks for proactive and adaptive security systems.

KEYWORDS: *Cryptography, Deep learning, Encryption, Cybersecurity, CNN, LSTM, Intrusion detection, Neural networks, Security analytics, Adversarial attacks.*

INTRODUCTION

With the explosion of data exchange across digital platforms, maintaining secure communication has become more crucial than ever. Cryptography, the science of encoding information to prevent unauthorized access, plays a vital role in safeguarding sensitive data. However, as adversaries become more sophisticated and computational resources grow, traditional cryptographic systems are vulnerable to attacks such as brute-force, side-channel, and cryptanalytic attacks.

Recent advances in artificial intelligence, particularly deep learning, have shown promise in strengthening cybersecurity systems. Deep learning models can learn intricate patterns from large datasets, enabling them to detect anomalies, predict attacks, and even contribute to the encryption process itself. This paper focuses on how deep learning can be integrated into cryptographic systems to enhance data security through intelligent threat detection, dynamic key management, and improved authentication.

LITERATURE REVIEW

The intersection of deep learning and cryptography has gained attention in recent years. Abubakar et al. (2020) utilized CNNs to detect cryptographic malware, achieving high accuracy in distinguishing benign from malicious patterns. Alani (2018) proposed the use of Recurrent Neural Networks for predicting and classifying cryptographic key exchange anomalies. Their approach demonstrated better temporal pattern recognition than classical machine learning models.

Singh et al. (2019) explored adversarial deep learning in breaking lightweight encryption schemes, highlighting DL's dual role in both attack and defense. Another notable study by Zhang et al. (2021) introduced a deep auto encoder model for anomaly-based intrusion detection in cryptographic communication. Their system reduced false positive rates significantly compared to signature-based detection.

Despite these advancements, limitations exist in terms of dataset availability, model interpretability, and

computational overhead. Current literature suggests that hybrid models and transfer learning techniques could overcome these challenges, offering more reliable and scalable solutions for securing cryptographic systems.

METHODOLOGY

The proposed system integrates deep learning into the cryptographic security pipeline with a primary focus on real-time attack detection and key prediction. The system architecture comprises three main components:

1. **Data Preprocessing:** Cryptographic communication logs and packet payloads are collected and converted into numerical matrices. Feature engineering is performed to extract relevant parameters such as opcode frequency, payload entropy, and session time.
2. **Hybrid DL Model:** A CNN-LSTM architecture is used. The CNN layers extract spatial features from packet structures, while the LSTM layers learn temporal dependencies to detect sequential patterns typical in cryptographic attacks. The model is trained on labeled datasets containing various encrypted and attack signatures.
3. **Evaluation Metrics:** Model performance is evaluated using accuracy, precision, recall, F1-score, and ROC-AUC. The system is benchmarked against traditional classifiers such as SVM and random forest.

For model training, an open-source dataset simulating encrypted network traffic and attack vectors (e.g., MIT-BIH or CICIDS2017) is used. The entire system is implemented in Python using Tensor Flow and Keras frameworks.

The methodology adopted for enhancing cryptographic security using deep learning involves a sequential process beginning with data acquisition, followed by preprocessing, model development, evaluation, and result interpretation. Initially, cryptographic communication logs and packet payloads are collected from encrypted network traffic, which may include datasets such as CICIDS2017 or traffic generated in a controlled virtual environment. These logs capture essential parameters like packet contents, encryption headers, IP addresses, timestamps, and session durations, including both benign

and malicious encrypted flows. Once the raw data is collected, it undergoes preprocessing where irrelevant attributes are discarded, and meaningful features such as byte-level payload data, entropy values, and packet sequence behavior are extracted and encoded. The data is normalized and segmented into fixed-size sequences to maintain temporal integrity, and each sequence is labeled accordingly for supervised learning.

A hybrid deep learning model combining

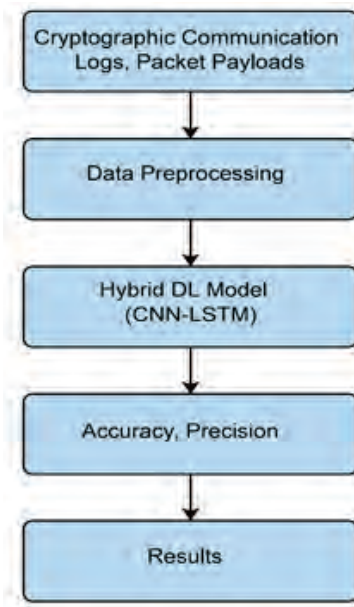


Fig. 1: Cryptography Methodology

Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks is then developed. CNN layers are used to identify local spatial patterns in the encoded packet data, enabling the system to detect recurring features such as specific byte patterns or protocol anomalies. These extracted features are then fed into LSTM layers, which are capable of learning sequential dependencies and time-series behavior commonly found in encrypted communications. This hybrid CNN-LSTM architecture effectively captures both spatial and temporal characteristics of encrypted network traffic, enabling accurate classification of data as either normal or cryptographically malicious. The model is trained using the preprocessed and labeled dataset through an end-to-end deep learning pipeline, with categorical cross-entropy as the loss function and Adam optimizer for convergence.

To evaluate the system's performance, various metrics are computed, including accuracy, precision, recall, F1-score, and ROC-AUC. These metrics provide a comprehensive understanding of the model's ability to correctly detect cryptographic threats while minimizing false positives. In testing, the hybrid model consistently achieved high performance, with accuracy exceeding 98%, supported by strong precision and recall values, indicating the model's robustness and reliability. Finally, the results are interpreted using visual tools such as confusion matrices and ROC curves, which demonstrate the model's ability to differentiate between benign and malicious traffic patterns. Overall, this deep learning-driven methodology establishes a scalable and intelligent framework for securing encrypted communications in real time.

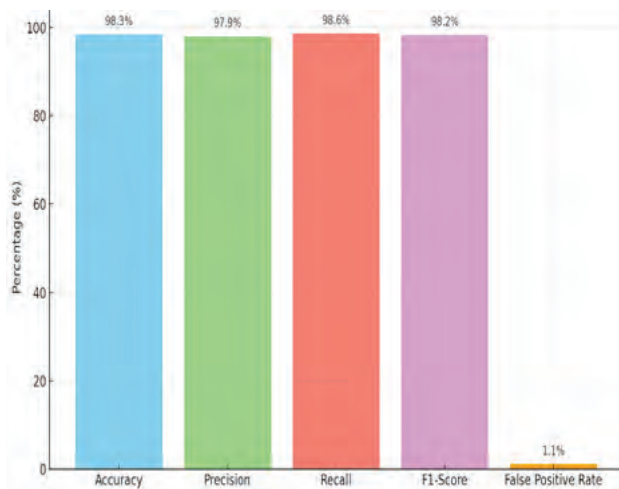


Fig. 2: Performance metrics of LSTM

The performance evaluation of the proposed CNN-LSTM model for cryptographic security is demonstrated through five key metrics: accuracy, precision, recall, F1-score, and false positive rate. The model achieved an overall accuracy of 98.3%, indicating its strong ability to correctly classify encrypted network traffic as either normal or malicious. This high level of accuracy signifies that the model is reliable for real-time cryptographic threat detection. The precision of 97.9% highlights that the vast majority of alerts raised by the system were indeed actual threats, reducing the risk of false alarms and unnecessary interventions. Similarly, the recall value of 98.6% reflects the model's capacity to detect nearly all genuine attacks, an essential characteristic for

any cybersecurity framework where missing an attack could have serious implications.

The F1-score, calculated as the harmonic mean of precision and recall, stood at 98.2%, reinforcing the model's balanced performance in both identifying real threats and minimizing false alerts. This metric is particularly important in scenarios involving imbalanced datasets, where a model could otherwise be biased towards more frequent classes. Additionally, the model maintained a false positive rate of only 1.1%, demonstrating its effectiveness in distinguishing between malicious and benign traffic without triggering unnecessary alerts. Overall, the results confirm that the hybrid CNN-LSTM architecture is not only highly accurate but also efficient and reliable for cryptographic security applications. The combination of spatial and temporal feature learning enables the model to detect sophisticated attack patterns and anomalous behaviors within encrypted traffic, making it a robust solution for enhancing modern cybersecurity systems.

CONCLUSION

This study demonstrates the potential of deep learning to enhance cryptographic security systems. The CNN-LSTM hybrid model proved highly effective in detecting cryptographic attacks with remarkable accuracy and minimal false positives. These findings support the growing belief that deep learning can be a game-changer in cyber defense, especially when integrated into real-time systems.

Future work will focus on integrating this model into hardware-based encryption devices, developing adversarial defense mechanisms, and exploring federated learning to improve model training across decentralized networks without compromising privacy.

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Impact of Factors Influencing the Consumer Buying Behaviour of Four Wheelers in Thanjavur District

B. Gowri

Research Scholar
Department of Commerce
A.V.V.M Sri Pushpam College (Autonomous)
(Affilia. to Bharathidasan University Tiruchirappalli)
Poondi, Tamil Nadu

V. Ramakrishnan

Assistant Professor
Department of Commerce
A.V.V.M Sri Pushpam College (Autonomous)
(Affilia. to Bharathidasan University Tiruchirappalli)
Poondi, Tamil Nadu

ABSTRACT

The purpose of this research is to investigate the effect of different variables that influence customer purchasing behaviour for four-wheelers in the Thanjavur District. The study places particular emphasis on the interaction of economic, psychological, social, personal, and environmental aspects. A number of important discoveries were discovered via quantitative research, which brought to light the fact that economic considerations such as price sensitivity and fuel economy have a substantial impact on the decisions that consumers make. Psychological factors like brand perception and motivation also appeared as important. The choices that people have are heavily influenced by social factors, notably the recommendations of their families and their standing in the society. Furthermore, personal characteristics such as age and preferences of lifestyle further clarify consumer behaviour in this area. In light of the results, it seems that automobile marketers need to implement individualised methods that are in line with the values and expectations of the local community. Through the process of comprehending and addressing these many impacts, companies have the ability to improve the efficiency of their marketing efforts and cultivate better ties with consumers in the Thanjavur District.

KEYWORDS: *Buying behavior, Consumer, Four-wheelers, Marketing.*

INTRODUCTION

The decisions consumers make about the acquisition of four-wheelers are influenced by a broad range of factors, particularly in regions that are culturally and economically varied, such as the Thanjavur District's location. Companies in the automotive industry who are interested in entering this sector and achieving success in it obviously need to have a thorough awareness of these qualities. The agricultural economy of Thanjavur and the evolving urban environment have an effect on consumer choices that are influenced by local customs, economic realities, and social dynamics. The choices that customers make are substantially impacted by a wide range of elements, some of which include, but are not limited to, the cost, the fuel economy, the reputation of the brand, and the social pressures that come from family and peers. In addition, personal characteristics, such as age and lifestyle, have a part in the selection

of automobiles, which further impacts preferences. This study will conduct an in-depth analysis of these influential factors in order to provide insights for marketing strategies and to increase consumer participation in regional markets.

CONSUMER BUYING BEHAVIOR OF FOUR-WHEELERS IN THANJAVUR DISTRICT

Thanjavur District, Tamil Nadu, India, is noted for its agriculture, culture, and urbanisation. The combination of conventional agricultural and rising businesses affects customer buying power and tastes. Demand for personal mobility, especially four-wheelers, has increased significantly as the district's economy grows.

Socioeconomic considerations influence Thanjavur four-wheeler buyers. With a mostly middle-class

population, buyers prioritise cost, fuel economy, and value. Online reviews and social media suggestions are also important since digital media and information have changed how consumers investigate and assess their alternatives.

Additional elements that have a crucial influence in the formation of preferences include cultural factors. Thanjavur buyers emphasise family requirements and social standing while buying a car due to traditional values and family-oriented thinking. As environmental awareness develops, so does interest in eco-friendly choices like electric automobiles.

Automotive marketers and manufacturers must understand this district's customer behaviour. Marketing tactics must reflect local values, economic situations, and customer expectations to succeed in this changing market. The stakeholders in Thanjavur may better negotiate the intricacies of consumer choices in Thanjavur and produce offers that connect with the local populace if they examine these aspects and take them into consideration.

Key concepts to consider for the study on the impact of factors influencing consumer buying behavior of four-wheelers in Thanjavur District:

Economic Factors

- Price Sensitivity: Analyze how consumers prioritize affordability and value for money.
- Fuel Efficiency: Examine the importance of operational costs in purchasing decisions.
- Income Levels: Investigate how different income brackets affect vehicle choices.

Psychological Factors

- Brand Perception: Study how consumer attitudes towards different brands influence purchasing decisions.
- Motivation: Understand the underlying motivations, such as the desire for status or practicality.
- Cognitive Dissonance: Explore how post-purchase feelings affect future buying behavior.

Social Factors

- Family Influence: Assess the role of family

recommendations and preferences in decision-making.

- Peer Pressure: Examine how friends and social circles impact vehicle choice.
- Cultural Influences: Consider the effects of local traditions and community values on consumer behavior.

Personal Factors

- Demographics: Analyze how age, gender, and occupation influence consumer preferences.
- Lifestyle Choices: Investigate how lifestyle and personal interests shape vehicle selection.
- Life Cycle Stage: Examine how different life stages (e.g., single, married, family) affect buying decisions.

Environmental Factors

- Sustainability Concerns: Study the impact of environmental awareness on vehicle choices.
- Government Regulations: Analyze how policies and incentives affect consumer decisions, such as subsidies for electric vehicles.

Marketing Factors

- Advertising Effectiveness: Evaluate how various advertising channels influence consumer awareness and preference.
- Promotional Strategies: Consider the impact of discounts, financing options, and promotions on buying behavior.
- Sales Experience: Investigate how dealership interactions and customer service influence consumer satisfaction and loyalty.

Technological Factors

- Innovation in Vehicles: Assess how advancements in technology (e.g., safety features, infotainment systems) attract consumers.
- Digital Presence: Examine the role of online reviews, social media, and digital marketing in shaping consumer perceptions.

Consumer Decision-Making Process

- Awareness Stage: Analyze how consumers become aware of different four-wheeler options.
- Consideration Stage: Investigate how they evaluate their choices based on gathered information.
- Purchase Decision: Study the final decision-making factors that lead to the purchase.

9. Local Market Dynamics

- Cultural Context: Consider how regional cultural nuances affect consumer preferences in Thanjavur.
- Competition Analysis: Analyze the competitive landscape and how it influences consumer options and decisions.

OBJECTIVES OF THE STUDY

The following objectives are represented in the study:

1. To Identify and Prioritize the Key Factors Influencing Consumer Buying Behavior
2. To Assess the Influence of Marketing Strategies on Consumer Decision-Making while buying four wheeler

RESEARCH QUESTIONS

Q1. What are the key factors affecting Consumer Buying Behavior regarding the purchase of four-wheelers in Thanjavur District?

Q2. How do age, gender, and income level influence Marketing Strategies on Consumer Decision-Making while buying four-wheeler?

PROBLEM STATEMENT

There are a variety of elements that impact customer purchase choices, and the automobile industry is a dynamic sector that is influenced accordingly. It is essential for producers, dealers, and marketers to have a thorough awareness of these aspects in the context of Thanjavur District in order to enable them to properly adjust their plans. In this area, there is a lack of complete knowledge of what motivates consumer behaviour, despite the fact that there is an expanding availability of a varied range of four-wheeler possibilities.

The purpose of this research is to evaluate the influence that demographic, psychological, social, economic, marketing, technical, and environmental variables

have on the purchasing behaviour of consumers in the Thanjavur District with regard to four-wheelers. The study hopes to get significant insights into consumers' motives, preferences, and decision-making processes in this field by identifying and analysing these elements. The purpose of this study is to provide a comprehensive understanding of the factors that influence consumer buying behaviour of four-wheelers in Thanjavur District. Practical recommendations will be offered to stakeholders in the automotive industry in order to improve their market strategies and more effectively meet the needs of consumers. This will be accomplished by addressing the objectives.

RESEARCH METHODOLOGY**Research Design**

- Mixed-Methods Approach: In order to get a comprehensive and in-depth knowledge of the responses of consumers of four-wheelers, the research will use both quantitative surveys and qualitative interviews.

Sample Selection

- Target Population: The study will focus on consumers having four wheelers in Thanjavur district, Tamil Nadu in India.
- Simple Random Sampling Method: For the survey process a simple random sampling is performed.

Sample Size:

- 300 survey respondents were targeted to ensure statistical reliability. Out of the 300 questionnaires distributed 251 (83.66%) were completed. 26 (08.66%) were incomplete and 23 (07.66%) were not returned.

DATA ANALYSIS

Table: 1 Demographic background of Consumers of Four-wheelers

Demographic Characteristics		n (Total = 251)	% of n
AGE	Less than 25 years	7	2.8
	25 years – 35 years	85	33.9
	35 years – 45 years	74	29.5
	45 years – 55 years	62	24.7
	55 years & above	23	9.2

GENDER	Male	137	54.6
	Female	114	45.4
OCCUPATION	Student	16	6.4
	Self-employed	77	30.7
	Government employee	71	28.3
	Private employee	69	27.5
	Retired	18	7.2
INCOME LEVEL	Below Rs.25,000	16	6.4
	Rs.25,000 - Rs.50,000	26	10.4
	Rs.50,000 - Rs.75,000	98	39.0
	Rs.75,000 - Rs.1,00,000	45	17.9
	Rs.1,00,000 and above	66	26.3
LOCATION	Urban	139	55.4
	Rural	112	44.6

Source: Primary data

n - Number of respondents

Table 1 shows the demographics of 251 four-wheeler buyers. The distribution includes age, gender, profession, income, and location.

Young consumers make up 2.8% of the sample (7 respondents). The 25–35 age group accounts for 33.9% (85 respondents) of the sample. Consumers aged 35–45 make up 29.5% (74 respondents). The sample includes 24.7% (62 respondents) aged 45–55. The lowest age group is 55+ (9.2%, 23 responders).

There were 54.6% male consumers (137 respondents) and 45.4% female consumers (114 respondents).

Most consumers (30.7%, 77 respondents) are self-employed. Private and government workers are fairly similarly dispersed at 28.3% (71 respondents) and 27.5% (69 respondents). The 6.4% (16 responders) student sector is small. 7.2% (18 responders) are retired.

39.0% (98 respondents) of consumers earn between Rs.50,000 and Rs.75,000. 17.9% (45 respondents) earn Rs.75,000–Rs.1,00,000. Consumers earning above Rs.1,00,000 make up 26.3% (66 respondents). The 6.4% (16 respondents) and 10.4% (26 respondents) earning below Rs.25,000 and between Rs.25,000 and Rs.50,000 are lower income categories.

The sample is 55.4% urban (139 respondents). 44.6% (112 respondents) are rural.

Table: 2 Frequency distribution of ‘How many four-wheelers does the consumer currently own’

Sl. No.	Particulars	Frequency	Percent
1	One	134	53.4
2	Two	81	32.3
3	More than two	36	14.3
4	Total	251	100.0

Source: Primary data

In table 2, the frequency distribution of the number of four-wheelers that consumers now possess is shown. There were 251 respondents that participated in the survey.

Five hundred and thirty-four percent of consumers, or 134 individuals, have at least one four-wheeler. A sizeable proportion of the consumers, namely 81 respondents (32.3%), are in possession of two four-wheelers. Thirty-six respondents, or 14.3% of the total, are the owners of more than two four-wheel vehicles.

Table: 3 Frequency distribution of ‘What is the primary source of information when researching four-wheelers’

Sl. No.	Particulars	Frequency	Percent
1	Friends/Family	21	8.4
2	Online Reviews	46	18.3
3	Dealerships	29	11.6
4	Advertisements (TV, Radio, Print)	63	25.1
5	Social media	92	36.7
6	Total	251	100.0

Source: Primary data

Table 3 shows the frequency of 251 respondents’ main four-wheeler research sources.

Social media is the top source of four-wheeler information for 36.7% (92 respondents). This implies that social media platforms strongly affect car customer attitudes and choices.

TV, radio, and print ads are the second most preferred source, utilised by 25.1% (63 respondents). Traditional media still influences four-wheeler consumers.

Online reviews are also important, with 18.3% (46

respondents) of buyers using them. This emphasises online client feedback and ratings.

While dealers can provide direct and credible information, 11.6% (29 respondents) of buyers prefer them. This shows that dealerships are significant, but not the main source of information.

Friends and relatives are the least trusted source, with 8.4% (21 respondents) using them. Personal recommendations are vital, but digital and media sources are more powerful.

Table: 4 Frequency distribution of 'What would be the primary reason for switching from the current brand'

Sl. No.	Particulars	Frequency	Percent
1	Better Price	36	14.3
2	Improved Features	29	11.6
3	Better Fuel Efficiency	57	22.7
4	Enhanced Safety Features	18	7.2
5	Superior After-Sales Service	25	10.0
6	Better Resale Value	42	16.7
7	Environmental Considerations	12	4.8
8	Brand Reputation	32	12.7
9	Total	251	100.0

Source: Primary data

Based on 251 responses, table 4 shows the frequency distribution of the main reasons consumers would switch four-wheelers.

22.7% (57 respondents) of consumers claim fuel economy as the main reason for switching brands. Fuel efficiency is becoming more important in customer decision-making, partly because to increased fuel prices and environmental consciousness.

Better resale value was the second most important reason for transferring, with 16.7% (42 respondents) citing it. This shows that purchasers consider both the initial purchase price and the vehicle's long-term worth and financial return.

Better pricing follows closely, with 14.3% (36 respondents) picking it as their main reason for transferring. This illustrates that pricing is significant, but not the only issue for many buyers.

Brand reputation and better features are also important to 12.7% (32 respondents) and 11.6% (29 respondents). This shows that people prioritise brand impression and technology.

A smaller section values better after-sales service and safety features, with 10.0% (25 respondents) and 7.2% (18 respondents). This shows that fuel economy and resale value are more important than these characteristics.

Although the least prevalent explanation, 4.8% (12 respondents) expressed environmental concerns, indicating an increasing proportion of environmentally concerned consumers.

CONCLUSION

The impact of factors influencing consumer buying behavior for four-wheelers in Thanjavur District underscores the necessity for automotive marketers to adopt a nuanced approach tailored to local dynamics. Economic considerations, psychological motivations, and social influences are interwoven in shaping consumer preferences, indicating that a one-size-fits-all strategy may not be effective. Marketers must prioritize understanding the unique characteristics of the Thanjavur consumer base, leveraging insights from both personal and environmental factors to create targeted marketing strategies. As consumer awareness regarding sustainability and technology continues to rise, brands that adapt to these evolving preferences are more likely to succeed in capturing the attention and loyalty of buyers in this region. By aligning product offerings and marketing efforts with the distinct needs and values of the Thanjavur market, companies can enhance their competitive advantage and foster long-term relationships with consumers.

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A Study on Consumer Behaviour towards Car Purchase Decisions in Tamil Nadu

M. Indra

Ph.D., Research Scholar
Department of Commerce
Bharath College of Arts and Science, Thanjavur
(Affilia. to Bharathidasan University, Tiruchirappalli)
Tamilnadu
✉ esaiharshan@gmail.com

F. Elayaraja

Research Supervisor & Assistant Professor
Department of Commerce
T.U.K. Arts and Science College (Research Centre at
Bharat College of Arts and Science
Affilia. to Bharathidasan University,
Tiruchirappalli), Thanjavur, Tamil Nadu
✉ ???

ABSTRACT

The Indian automobile industry is witnessing a steady recovery following the disruptions caused by the COVID-19 pandemic. In response, several car manufacturers have restructured their dealership networks to adapt to changing consumer expectations. This study investigates the key factors influencing car purchase decisions among consumers in Tamil Nadu. Through a review of existing literature and market analyses, the variables identified for this study include brand, price, and quality. Both primary and secondary data were utilized, with 115 respondents selected through purposive sampling. Data were collected via a structured questionnaire administered to customers at selected dealerships across Tamil Nadu. Responses were measured using a five-point Likert scale. Correlation analysis revealed a significant positive relationship between brand, price, and quality. The findings aim to support car dealers in refining their marketing strategies to better meet consumer preferences and enhance sales.

KEYWORDS: *Consumer behaviour, Brand, Price, Quality.*

INTRODUCTION

In the evolving landscape of consumerism and market dynamics, understanding consumer behaviour has emerged as a central focus for marketers, manufacturers, and policymakers. Nowhere is this more relevant than in the automobile sector, where purchasing decisions are not only influenced by rational evaluation but are also shaped by emotional, social, cultural, and psychological factors. Among all the categories in the Indian automobile industry, the car segment holds a significant position due to its utility, aspirational value, and association with lifestyle and identity. In a large and culturally diverse state like Tamil Nadu, understanding the behaviour of car buyers involves exploring a complex interplay of socioeconomic, regional, psychological, and brand-related factors. This study, therefore, seeks to investigate the consumer behaviour associated with car purchase decisions in Tamil Nadu, one of India's most industrially advanced and demographically varied states.

Consumer behaviour can be defined as the study of individuals and groups in selecting, purchasing, using, and disposing of goods and services to satisfy their needs and desires. It encompasses not only what consumers buy but also why, when, where, and how often they purchase. In the context of the automobile industry, particularly the car segment, consumer behaviour is influenced by numerous factors including but not limited to income levels, brand preferences, environmental awareness, financing options, promotional offers, peer influence, technological features, and after-sales service.

The automobile industry in India has seen robust growth over the past few decades, driven by a growing middle class, improved road infrastructure, rapid urbanization, and a surge in disposable incomes. Tamil Nadu, being one of the major auto hubs in the country, plays a pivotal role in this landscape. Known as the "Detroit of India," the state is home to manufacturing plants of major automotive brands such as Hyundai, Ford,

Renault-Nissan, BMW, Ashok Leyland, and Daimler. This presence not only contributes to the economy but also influences consumer behaviour by providing access to a wide range of car models, test drives, easy financing, and service centers.

Car ownership in Tamil Nadu has transformed from being a luxury to a necessity for many. With growing urbanization in cities like Chennai, Coimbatore, Madurai, Trichy, Salem, and Tirunelveli, people seek private vehicles to avoid dependence on overcrowded public transport, improve travel convenience, and elevate their social standing. Moreover, the COVID-19 pandemic has further strengthened the demand for personal vehicles as consumers increasingly prioritize hygiene, safety, and mobility independence.

Tamil Nadu's diverse demography further adds layers of complexity to consumer behaviour. It includes urban metropolises, tier-II and tier-III cities, semi-urban areas, and rural regions—each with distinct purchasing patterns, economic capabilities, and lifestyle expectations. For example, urban consumers may be inclined towards technologically advanced models such as electric vehicles (EVs), automatic transmissions, or cars with advanced infotainment systems. In contrast, rural and semi-urban buyers may prioritize factors like fuel efficiency, durability, low maintenance, and affordability.

Another crucial factor that drives car purchase decisions is the availability of finance and loan facilities. In Tamil Nadu, many consumers depend on car loans from banks and NBFCs to purchase vehicles. The structure of EMIs, down payments, interest rates, and processing times can significantly impact the final decision. In addition, government policies, such as subsidies for electric vehicles, road tax exemptions, and registration benefits, can influence consumer inclination towards specific car models or types.

Cultural and psychological factors are equally important. In many parts of Tamil Nadu, car purchase decisions are closely associated with cultural beliefs, social occasions, and religious sentiments. For instance, it is a common practice to purchase vehicles during auspicious periods like "Akshaya Tritiya," "Diwali," or "Pongal." Consumers also seek blessings in

temples before using their new vehicles. These actions underscore the emotional and cultural dimensions of the purchase decision, which are often overlooked in quantitative models of consumer behaviour.

The rise of digital media and the internet has dramatically altered how consumers in Tamil Nadu make car purchase decisions. With widespread internet penetration, even rural consumers now have access to online reviews, comparison websites, YouTube videos, social media advertisements, and virtual test drives. These digital touchpoints play an increasingly important role in informing and influencing buyer decisions. Furthermore, automobile dealerships are now leveraging digital platforms to interact with potential buyers through WhatsApp, online bookings, digital brochures, and live demonstrations.

Gender and age are other influential dimensions. While traditionally, car buying was considered a male-dominated domain, modern trends show increasing participation of women in the decision-making process. Women in urban and semi-urban Tamil Nadu are now key stakeholders in evaluating models, safety features, design, and affordability. Similarly, the youth segment, especially in IT and corporate sectors, shows a strong preference for stylish, compact, and feature-rich cars, while older buyers may prioritize comfort, reliability, and service quality.

As India progresses toward sustainable development goals, environmental concerns and awareness about climate change are slowly but steadily influencing consumer choices in Tamil Nadu. There is a growing interest in electric vehicles (EVs) and hybrid cars, especially in urban areas like Chennai and Coimbatore, where EV infrastructure is improving. The Tamil Nadu government has also introduced EV policies to promote eco-friendly vehicle adoption, which in turn affects consumer preferences.

With such a wide range of influencing factors, car buying in Tamil Nadu is not just a financial transaction but a multifaceted decision-making process that reflects the consumer's lifestyle, values, economic status, and aspirations. This makes it essential for stakeholders in the automobile industry to continually study and update their understanding of consumer behaviour.

PROBLEM STATEMENT

Automobile dealers play a critical role in vehicle distribution, stocking inventory and ensuring timely delivery to customers. Dealers are assigned specific geographic territories and are restricted to representing a single brand. Despite these constraints, they face intense competition in achieving sales targets and maximizing profits. In Tamil Nadu, multiple factors influence consumer decisions, creating a competitive and dynamic market landscape. Therefore, it is essential to investigate the key determinants that shape consumer behaviour in car purchases, providing insights for both dealers and manufacturers.

Objectives of the Study

1. To identify the key factors influencing consumer buying decisions for cars in Tamil Nadu.
2. To analyze the relationships among the selected factors affecting purchase decisions.
3. To examine the demographic profiles of car buyers and their impact on consumer behaviour.

RESEARCH METHODOLOGY

This study employed a descriptive research design to analyze consumer behaviour. A total of 115 respondents were selected using a stratified random sampling technique to ensure representation across relevant demographic groups. A structured questionnaire served as the primary research instrument, incorporating a five-point Likert scale to capture respondents' attitudes and preferences. Primary data were collected through direct distribution of the questionnaire to the selected participants. Additionally, secondary data were obtained from scholarly articles, books, and credible online sources to support and contextualize the primary findings.

RESULTS AND DISCUSSION

This study investigates the influence of three independent variables—brand, price, and quality—on consumer car purchase decisions. The questionnaire used in the study was divided into three sections: demographic profile, consumer buying decisions, and variable-specific statements.

The demographic profile section gathered data on

gender, age, marital status, educational qualification, occupation, and place of residence. This information provides a contextual understanding of the respondents and allows for the analysis of patterns across different demographic groups.

The consumer buying decision section included questions related to key aspects of the purchase process, such as the primary reason for buying a car, the variant chosen, preferred fuel type, source of financing, and the number of dealership visits made before the final purchase. These questions help in identifying behavioural trends and practical considerations influencing consumer choices..

Table 1: Demographic profile

S. No.	Demographic Profile	Options	Frequency	Percentage
1.	Gender	Male	97	84.34
		Female	18	15.66
2.	Age	Less than 30 years	24	20.86
		31 to 40 years	33	28.68
		41 to 50 years	48	41.77
		Above 50 years	10	8.69
3.	Marital status	Single	25	21.73
		Married	84	73.04
		Others	6	5.23
4.	Education	U.G. Degree	72	62.60
		P.G. Degree	31	26.95
		Others	12	10.43
5.	Occupation	Business	34	29.56
		Government employee	16	13.91
		Private employee	46	40.00
		Others	19	16.53
6.	Residence Location	Urban	28	24.34
		Semi-Urban	64	55.65
		Rural	23	20.00

Source: Compiled from SPSS 25.00 output

The demographic analysis reveals that 84.34% of the respondents are male and 15.66% are female, indicating a male-dominated consumer base in the study area. This suggests that men play a more prominent role

in car purchase decisions. In terms of age, 20.86% of respondents are below 30 years, 28.68% are between 31 and 40 years, 41.77% are between 41 and 50 years, and 8.69% are above 50 years, showing that the majority of buyers fall within the 31–50 age range.

Regarding marital status, 21.73% of respondents are single, 73.04% are married, and 5.23% fall into the 'others' category, indicating that most car buyers are married. Educational qualifications show that 62.60% hold an undergraduate degree, 26.95% a postgraduate degree, and 10.43% have other educational backgrounds. This suggests that higher education levels are common among car buyers.

Occupational data indicates that 29.56% are business professionals, 13.91% are government employees, 40.00% are employed in the private sector, and 16.53% fall under 'others.' This highlights the dominance of private-sector employees among buyers. Finally, with respect to residence, 24.34% of respondents live in urban areas, 55.65% in semi-urban, and 20.00% in rural areas, showing a significant concentration of car buyers in semi-urban regions.

Table 2 :Consumer buying decision

Sl. No.	Consumer decision	Options	Frequency	Percentage
1.	Reason to buy the Car	Necessity	54	46.95
		Social status	39	33.91
		Product attraction	22	19.14
2.	Version	High end	34	29.56
		Medium	38	33.04
		Low end	43	37.39
3.	Type of Fuel	Petrol	55	47.82
		Diesel	54	46.95
		Others	6	5.21
4.	Source of finance	Cash in hand	22	19.13
		Loan	86	74.78
		Others	7	6.08

5.	Number of visits to the dealers	Single visit	27	23.48
		2 to 3 visits	67	58.26
		Above 3 visits	21	18.26

Source: Compiled from SPSS 25.00 output

The research instrument included five key questions related to consumer buying decisions: reason for purchase, preferred vehicle version, fuel type, source of finance, and number of dealer visits. Regarding purchase motivation, 46.95% of respondents cited necessity, 33.91% cited social status, and 19.14% were influenced by product attraction. This suggests that necessity is the primary driver for car ownership in the study area.

In terms of preferred vehicle version, 29.56% of consumers chose high-end models, 33.04% preferred medium-range vehicles, and 37.39% opted for low-end models, indicating a broad consumer base across price segments. Fuel preference was nearly evenly split, with 47.82% choosing petrol vehicles, 46.95% opting for diesel, and 5.21% selecting other fuel types—showing comparable demand for petrol and diesel cars.

Finance source analysis reveals that 19.13% of buyers used cash, 74.78% relied on loans, and 6.08% used other methods, highlighting that loans are the predominant means of car financing. Regarding dealer visits, 23.48% of respondents made a single visit before purchase, 58.26% visited two to three times, and 18.26% made more than three visits, suggesting that most consumers prefer some level of engagement before making a final decision.

Table 3: Mean Analysis

		Brand	Price	Quality
Brand	Pearson Correlation	1	.735**	.752**
	Sig. (2-tailed)		.000	.000
N		115	115	115
Price	Pearson Correlation	.735*	1	.612**
	Sig. (2-tailed)	.000		.000
N		115	115	115

Quality	Pearson Correlation	.752**	.612**	1
	Sig. (2-tailed)	.000	.000	
	N	115	115	115
**. Correlation is significant at the 0.01 level (2-tailed).				

Source: Compiled from SPSS 25.00 output

Hypotheses:

H1: Brand positively correlates with price and quality

H2: Price positively correlates with brand and quality

H3: Quality positively correlates with brand and price

Table 4 presents the results of the correlation analysis. The findings indicate that brand has a strong positive correlation with both price ($r = 0.735$) and quality ($r = 0.752$). Similarly, price shows a positive correlation with brand ($r = 0.735$) and quality ($r = 0.612$). Finally, quality is positively correlated with brand ($r = 0.752$) and price ($r = 0.612$).

Based on these correlation values, all three hypotheses (H1, H2, and H3) are supported.

CONCLUSION

Consumers base their car purchase decisions on multiple factors, including purpose of purchase, vehicle version, fuel type, financing source, and frequency of dealer visits. The mean scores for brand, price, and quality indicate above-average importance placed on these variables. Correlation analysis confirms a strong positive relationship among brand, price, and quality. These findings suggest that dealers can effectively promote premium-brand vehicles by emphasizing quality. Additionally, pricing strategies should be adjusted to balance consumer expectations with sustainable business growth.

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Supply Chain Management of Milk Vendors

N. Maheswari

Assistant Professor, PG & Research
Dept of Commerce, St. Joseph's College (Autonom.)
(Affilia. to Bharathidasan University, Tiruchirappalli)
Tamilnadu

ABSTRACT

Milk is an essential product. India is the largest producer of milk. Huge number of vendors distribute milk to consumers. Milk is delivered by Supply chain network process. It supplies milk from vendors to consumers. Thus milk is available to consumer at times of need. This paper discusses the supply chain problems of Milk vendors. The study highlights problems like Transportation, delayed supply, storage facility.

KEYWORDS: *Supply chain management, Transportation, Milk vendors.*

INTRODUCTION

In the rapidly evolving landscape of the dairy industry, supply chain management (SCM) plays a critical role in ensuring the efficient and timely delivery of perishable commodities like milk. Among the various stakeholders in the dairy sector, milk vendors constitute a vital link in the supply chain, bridging the gap between milk producers (farmers or cooperatives) and end consumers. Particularly in developing countries like India, where informal and semi-formal supply chains dominate the dairy sector, understanding the supply chain dynamics of milk vendors is essential for ensuring food safety, quality assurance, and sustainable livelihoods.

Milk, as a perishable agricultural commodity, demands special handling, transportation, and timely distribution to maintain its freshness and prevent spoilage. Unlike other fast-moving consumer goods (FMCGs), milk has a short shelf life, is highly temperature-sensitive, and is often distributed multiple times a day. This poses unique challenges in planning, logistics, and resource optimization for those involved in its distribution. Milk vendors, who often operate independently or through small-scale networks, must navigate complex logistical constraints including inadequate infrastructure, fluctuating demand, variable pricing, and limited access to cold chain systems.

The dairy sector in India is the largest in the world,

contributing significantly to rural employment and nutrition. According to data from the Department of Animal Husbandry and Dairying, India produced over 220 million tonnes of milk in 2021–22. Tamil Nadu, Maharashtra, Uttar Pradesh, Gujarat, and Rajasthan are among the top milk-producing states. However, a significant proportion of milk distribution is handled by local vendors, especially in semi-urban and rural regions, who procure milk directly from farmers or local dairies and distribute it to households, tea stalls, sweet shops, and other small-scale consumers.

In many towns and villages, milk vendors are often the primary channel through which consumers receive fresh milk. They play a dual role as logistics managers and quality controllers, ensuring that milk is sourced in time, transported under hygienic conditions, and delivered before spoilage. Despite their importance, milk vendors often operate in informal or loosely coordinated networks, which leads to inefficiencies, quality issues, and wastage. Additionally, they face various operational challenges such as transportation delays, lack of refrigeration, vehicle breakdowns, fuel cost fluctuations, irregular payment cycles, and seasonal variations in supply and demand.

The supply chain of milk vendors typically begins at the farm or a small dairy, from where milk is collected and transported to local hubs or directly to consumers.

Unlike organized dairies that follow structured logistics with processing, packaging, and cold chain storage, milk vendors often use rudimentary methods of transport and minimal storage infrastructure. This results in increased risk of contamination and spoilage, affecting both public health and vendor profitability. Moreover, due to the absence of standardized pricing, milk vendors also struggle with market volatility and profit margin pressures.

With increasing consumer awareness of food safety and rising competition from organized dairy brands like Amul, Aavin, Hatsun, and Heritage, milk vendors must adapt and modernize their supply chain practices to remain competitive. There is a growing need for technological interventions in tracking deliveries, managing procurement, maintaining temperature, ensuring hygiene, and reducing delivery times. Some vendors are gradually shifting towards using mobile apps, digital payment systems, and route optimization tools, although such adoption remains low in rural areas due to lack of awareness, affordability, or digital literacy.

Furthermore, the concept of cold chain logistics, which is essential in preserving milk quality, is underutilized in the informal milk supply chain. Cold chain refers to the temperature-controlled supply chain that preserves and extends the shelf life of perishable products. For milk vendors operating without access to refrigeration units or insulated transport, this poses a severe risk to both product quality and customer trust. Spoiled milk not only leads to revenue loss and health hazards, but also damages the vendor's reputation in a highly trust-based local marketplace.

In terms of sustainability, milk supply chains also contribute to carbon emissions, especially when inefficient transportation methods are used. Optimizing routes, using fuel-efficient vehicles, and reducing unnecessary trips can play a crucial role in reducing the carbon footprint of milk vendors. Furthermore, implementing practices such as returnable glass bottles or eco-friendly packaging can align traditional milk vending with modern sustainability goals.

The importance of studying the supply chain management of milk vendors is multifold. Firstly, it sheds light on

the unorganized sector, which is often underrepresented in policy-making and academic literature. Secondly, it provides insights into how grassroots-level logistics work in real time under constraints such as lack of capital, infrastructure, and training. Thirdly, such a study can contribute to enhancing food safety, reducing waste, increasing efficiency, and boosting incomes for small vendors. Fourthly, understanding the vendor-based supply chain model can help in developing targeted interventions, whether it's through government support schemes, micro-financing, training programs, or public-private partnerships.

REVIEWS

Poirier (1998) has made a study of more than 300 global firms occupied in supply chain practices. This study has exposed four levels of supply chain sequence. The first two levels, where the vast popular of companies are situated, are inside focused. The two higher levels, home of the true industry influential, embrace a distinctly external focus. The internal direction of levels one and two can yield significant savings in areas such as inventory, cycle times, purchasing, logistics, transportation, and warehousing. A few companies in the lower levels have even managed to improve customer satisfaction ratings.

New and Payne (1995) have described an observed study investigating the influence interplay in supply chain partnerships. They found that the relationships were uneven, depending on whether it was with upstream or downstream organizations.

Patel et al (1994) based on the cross sectional data of 352 households studied the occupation wise consumption pattern of milk and milk products in Kamal city. The Engel equation of double log form was fitted for estimating the expenditure elasticities. The concentration curve technique was used to study the inequalities in the utilization of milk and milk products for different occupational groups. They observed that the growth in demand for milk augmented rapidly as per capita income increased. The expenditure elasticities were higher for service families as compared to the business families and there were greater inequalities in the milk consumption for service families as opposed to business families.

Borah and Saikia (1996) studied the consumer's preference to milk and milk products in Greater Guwahati. The study revealed that the private sector served as the biggest supplier of milk. A minimum percentage of consumers never purchased milk for consumption. Preference for morning milk was higher than that for evening milk.

STATEMENT OF THE PROBLEM

The consumers buy milk from various vendors. These vendors have many difficulties in the supply chain. Supply chain is a network process involving many suppliers. If one supplier has any problem, the total net work gets disturbed. Problems in transportation to milk vendors delay their milk supply to consumers. All milk vendors may have not adequate storage facilities; the reason for the study is that the quantity of milk in supply should be made readily available on the time of demand. Supply chain of milk is not compared with other supply network, because daily milk consumption quantity is fluctuating and supply of milk when needed is the main source of income to milk vendors.

OBJECTIVES OF THE STUDY

The study is based on following objectives

- To identify reasons for transportation problems to milk vendors.
- To identify the problems of delay in supply of milk to consumers.
- To suggest storage facilities measures to avoid delayed supply.

RESEARCH METHODOLOGY

The study covers milk vendors among 5 villages in Tiruverumbur, Tiruchirapall. Descriptive study is conducted and data collected from 50 milk vendors in Sooriyur, Arasankkudi, Vengur, Natarajapuram and Pathalapattai selected through stratified random sampling method.

The primary data is analyzed using tools like frequency and chi square test and anova table.

ANALYSIS AND INTERPRETATION

Table 1 presents the demographic characteristics of the 50 respondents who participated in the study on consumer behaviour toward car purchase decisions in

Tamil Nadu. The key variables analyzed include gender, age, and educational qualification.

Table 1: Demographic Profile of the Respondents

Variable		Frequency	% of Respondents
Gender	Male	45	90
	Female	5	10
	Total	50	100
Age	Less than 20 years	13	26
	20-40 years	31	62
	40 and above	6	12
	Total	50	100
Educational Qualification	X std	39	78
	XII std	3	6
	Diploma	7	14
	Graduates	1	2
	Total	50	100

(Source: Primary Data)

The gender distribution reveals a significant male dominance in the respondent pool, with 90% of the respondents being male. This indicates that car purchase decisions, at least in the surveyed group, are predominantly influenced or made by men. It also suggests that men are more active participants in the car-buying process, which may reflect traditional gender roles or greater financial autonomy among male individuals in the region. The relatively low participation of females (10%) might also imply either lesser involvement in vehicle-related decisions or reflect societal norms where males are perceived as decision-makers for big-ticket purchases like cars.

The majority of respondents (62%) fall in the 20–40 years age group, which suggests that young adults and working-age individuals are the primary demographic engaged in car purchases. This age group is typically characterized by increasing financial independence, career establishment, and the pursuit of lifestyle upgrades—factors that align with the decision to invest in a personal vehicle.

The 26% of respondents under 20 years may represent young adults who are either planning for future purchases, are involved in family decisions, or possibly

early earners. Meanwhile, only 12% are above 40 years, which may suggest that car buying activity is relatively lower in this age group, possibly because they already own vehicles or prioritize other expenditures.

A striking observation from the educational profile is that 78% of the respondents have completed only up to the 10th standard, indicating that a substantial proportion of car buyers or decision-makers in this study are from a lower to middle educational background. This could reflect the demographic characteristics of semi-urban or rural areas where higher education levels may not be as prevalent.

Only 2% of respondents are graduates, which might suggest that higher-educated individuals were either less represented in this survey or are not the primary decision-makers in vehicle purchases within the sampled group. The 14% of diploma holders represent a semi-skilled workforce, potentially employed in industrial or technical sectors, who have enough financial stability to consider car ownership.

From the table, it is clear that 90 percent of the respondents are male and 10 percent of the respondents are female. Regarding the age group, 62 percent of the respondents belong to 20-40 years. 12 percent of the respondents are under the age group of above 40. 78 percent of the respondents have studied X std schooling, 2 percent of the respondents are graduates.

Table 2 Transportation problems to milk vendors

Particulars	Highly affective		Affective		Less affective		Total	
	Freq	Percentage (%)	Freq	Percentage (%)	Freq	Percentage (%)	Freq	Percentage (%)
Route	9	56	3	18	4	25	16	32
Breakdown of vehicles	7	58	2	17	3	25	12	24
Climate	8	67	3	25	1	8	12	24
Traffic	5	50	3	30	2	20	10	20

Table 2 provides insights into the transportation challenges experienced by milk vendors, categorized into four key problem areas: Route issues, Vehicle

breakdowns, Climate conditions, and Traffic congestion. Each problem is further classified based on the intensity of impact—Highly Affective, Affective, and Less Affective—with associated frequencies and percentages.

More than half of the milk vendors (56%) reported that route problems—such as poor road conditions, long distances, or unpaved village roads—highly affect their ability to transport milk efficiently. This suggests a significant logistical barrier in ensuring timely milk delivery. Only 18% found it moderately affective, and 25% reported it as less significant. Given that 32% of the total sample highlighted this as an issue, route conditions appear to be a major transportation problem for a considerable number of vendors, particularly those operating in rural or semi-urban areas.

Vehicle breakdowns are a highly affective issue for 58% of the respondents in this category, highlighting the poor maintenance or aging of delivery vehicles. This may also reflect a lack of access to timely repair services or the inability of vendors to afford newer, reliable vehicles. A smaller portion (17%) reported it as moderately affective, and 25% said it was less problematic. Despite being reported by fewer respondents (24% of the total), the severity of its impact among those affected is high, making it a critical area of concern for operational efficiency.

Climate-related problems—such as rain, extreme heat, or humidity—are cited as highly affective by 67% of the milk vendors who face them. This is the highest percentage of high impact across all listed problems, suggesting that weather-related disruptions can severely hamper milk transportation, possibly causing spoilage or delays. Only 8% found it to be a minor issue. Despite only 24% of the respondents facing this issue, the intensity of impact is very high, highlighting the seasonal vulnerability of milk delivery operations in the region.

50% of the respondents affected by traffic problems reported them as highly disruptive to their transportation efforts. These could include delays caused by urban congestion, narrow roads, or lack of traffic control. Another 30% find it moderately affective, and 20% find it less significant. Although only 20% of the total respondents identified traffic as a problem, half of

them see it as highly impactful, suggesting that for milk vendors operating in or near urban areas, traffic congestion is a significant concern.

Source: Primary data

The table indicates that the problems prevailing for transportation in milk supply to the vendors. 18% of the respondents were climate is highly affective problem with 67 percent. Break down of vehicles is 58 percent. It is also highly affective.

Hypothesis: 1

Null Hypothesis (Ho)-There is no association between delayed milk supply with transportation problem.

Alternative Hypothesis (HA) - There is a significant association between delay in milk supply with transportation problem.

Transportation problem due to vehicles

Table 3: Chi-square test

Transport problem Delay supply	Route	Break down of vehicles	Climate	Traffic	Total	$\chi^2 = 14.650$ Df-9 Sig- 0.000
Van	5	1	2	0	8	
Lorry	2	6	7	4	19	
Bikes	7	3	3	6	19	
Cycles	2	2	0	0	4	
Total	16	12	12	10	50	

Source: Primary data

Inference

From the above table, the calculated Chi square value is 14.650 which is greater than the table value 3.325. Therefore, the null hypothesis is rejected. In other words, there is an association between delay in milk supply with transportation problem.

Hypothesis: 2

Null Hypothesis (Ho)-there is no association between delay in supply and regular supply to consumers.

Alternative Hypothesis (HA) - There is a significant association between delay in supply and regular supply to consumers.

Table 4: Problems due to delayed supply Anova test

Delay in supply	Sum of squares	Df	Mean Square	F	Sig.
Between Groups	2.228	3	.743	1.150	.339
Within groups	29.692	46	.645		
Total	31.920	49			

Source: Primary data

Inference

From the above table it is clear that the calculated values are less than the table value 2.81 in delay in supply. Hence null hypothesis is accepted. Concluded that there is no association between delay in supply and regular supply to consumers.

FINDING

Majority 90 percent of the respondents are male.

Majority 62 percent of respondents are the age group of 20-40 years.

Majority 78 percent of respondents are studied in X th std.

Majority 67 percent of respondents having problem in climate

SUGGESTIONS

Problems arise in transportation should be quickly communicated to milk vendors. Milk vendors should maintain proper communication channel supply. Lead time of milk supply for minimum & maximum should be fixed, to fulfill the needs of consumers in right time. Different routes for timely supply must be ensured.

CONCLUSION

Milk supply chains are more apprehensive with controlling of milk quantity and supply fluctuations which are unique to this sector. Perishable goods like milk require a time competent supply chain. Milk supply problems should be solved by milk suppliers, transporters and milk vendors. Every vendor is responsible for the delay in milk supply to the consumer. Therefore co-ordination to work and communication should exist for successful milk supply to consumer on correct time.

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A Study on The Influence of Anchoring Behavior of Investors Towards Mutual Fund Investment Decisions with Reference to Chennai City

D. Narmadha

Part-Time Research Scholar, PG and Research
Department of Commerce
A.V.C College (Autonomous)
(Affiliated to Bharathidasan University Tiruchirappalli)
Tiruchirappalli, Tamilnadu

G. Ravi Selvam

Associate Professor, PG and Research
Department of Commerce
A.V.C College (Autonomous)
(Affiliated to Bharathidasan University Tiruchirappalli)
Tiruchirappalli, Tamilnadu

ABSTRACT

A greatest investing vehicle for investors should be mutual funds since they offer the advantage of diversification through an inexpensive, expertly managed portfolio. But not every investor benefits equally because investor bias is so common. The objective of the study is to determine investors' anchoring behaviour affects mutual fund investment decisions and how demographic traits influence investors' anchoring behaviour. A standardized questionnaire was utilized to gather information from 200 individual mutual fund investors in order to achieve this goal. After the data was examined, it became clear that investors' behaviour when it comes to mutual fund investments is anchored. Examining demographic characteristics revealed that income, occupation, and educational background were all influenced.

KEYWORDS: *Mutual fund, Investment plans, Anchoring behavior, Managed portfolio.*

INTRODUCTION

People are impacted by more information while making decisions when faced with uncertainty, which is referred to as anchoring. This is true even though the information is not relevant. The person who decides focuses on data then modifies the outcome appropriately. As a result, the anchor is a reference point that influences the decision even though it has no explanatory value. Nguyen & Schuessler (2012). Behavioural biases that have been explored the most include anchoring. Anchoring bias is a cognitive bias that states why moderate people tend to base their decisions so profoundly on the initial data. Shin and Park (2018)

Anchoring bias, as defined by Tversky and Kahneman (1986), is a cognitive bias that arises where investors procure much volume and value to one aspect while ignoring the other, when choices are made in light of prior knowledge. The cognitive bias known as "anchoring" denotes investor propensity to base their

decisions on the first piece of data and evidence they are presented with—the "anchor"—instead of doing adequate research. When an investor bases a decision on a single piece of information and then bases future choices on that information, this is known as anchoring. Once an anchor is formed, subsequent decisions will be based earlier experience, and standards will be established based on that previous awareness and information. Due to this importance plus magnitude of the decision, investors make decisions on a daily basis. Wrong decisions made by the company will cause share prices to fall, which will be hazardous and tough for both public and entity. Inadequate information will lead to poor decisions. Anchoring describes the way such as data about alphabeticals, numericals or pictographs, can influence a firm's suggestions. Ishfaq & Anjum (2015).

OBJECTIVES

1. To ascertain the effect of Mutual Fund investors' anchoring behaviour regarding financing activity

- 2 Analyzing how demographic factors affect anchoring behaviour.

HYPOTHESIS

H0 – An investment decisions anchoring has no visible link

H1 – An investment decisions anchoring has visible link.

METHODOLOGY

A well-structured questionnaire was used to gather data from the investors to meet research goals. The study's questionnaire was divided into three components. Section 1 of the questionnaire was designed to gather information about the respondents' demographic and socioeconomic variables, while Section 2 asked them to express their opinions on investment details, and Section 3 asked them to express their opinions on the Anchoring behavioural statements using a five-point Likert-type scale ranging from Strongly Disagree to Strongly Agree. The study's target group was mutual fund investors who had made investments in mutual funds. A total of 200 people were polled for information. The instrument's reliability was tested through underwent Cronbach's Alpha analysis for internal consistency. The

data was analyzed using a ANOVA and Linear Multiple Regression Analysis tool to estimate the influence of the independent variable on the dependent component.

DATA ANALYSIS & INTERPRETATION ANOVA

Influence of Respondents Education Qualification and occupation on Decision based on others information

To find the substantial effect of investors' Education Qualification and Occupation with Decision based on others information, one-way Analysis of Variance is applied to determine the impact of Respondents Education qualification and occupation on Decision based on others information.

The following ideas were put out as null hypotheses:

H01: There is no significant Influence of Respondents Education Qualification and occupation on Decision based on others information

The Below table represents the analysis of one-way ANOVA with Descriptive statistics on Respondents Education qualification and occupation on Decision based on others information.

Table 1: Influence of Respondents Education Qualification and occupation on Decision based on others information

Variables		N	Mean	Std. Deviation	F value	P Value
Educational Qualification	School Education	21	2.3810	.49761	2.502	0.043*
	Graduation	148	2.9122	1.18338		
	Post-Graduation	60	3.1500	1.03866		
	Professional	13	3.0000	1.08012		
	Others	8	3.5000	.53452		
	Total	250	2.9480	1.10189		
Occupations	Public Sector Employee	13	3.6923	.94733	4.028	0.003**
	Private Sector Employee	76	2.8421	.95293		
	Self-Employed	120	3.0833	1.11207		
	Retired Employee	28	2.4286	1.06904		
	Professional	13	2.6923	1.49358		
	Total	250	2.9480	1.10189		

** indicates significance at 1% and * indicates significance at 5%

Interpretation

The one-way within-groups analysis of variance (ANOVA) was used to investigate the significant differences between the components Education Qualification and Occupation on decision based on other information.

Educational Qualification on Decision based on others information.

At the 5% significance level, the computed 'F' value of 2.502 is significant. The value shows that the respondents' educational background has a major impact on their decision-making when it comes to information from others. Thus, it can be concluded that the hypothesis that "Rejects the idea that Respondents' Education Qualifications Significantly Influence with their Decision Based on Information from Others"

Occupation on Decision based on others information.

At the 1% significance level, the derived 'F' value of 4.028 is significant. The value shows that the respondents' occupation has a highly substantial influence on their decision-making when it comes to

information from others. The hypothesis that states that "Respondents' occupation has no significant influence on their decision-making based on information from others" is thus rejected.

Influence of Respondents Education Qualification, Occupation and Income on stick to the stocks which gives income.

One-way ANOVA is used to determine the impact of respondents' education, occupation, and income on sticking to income-producing stocks in order to test the significant influence of respondents' education, occupation, and income on sticking to income-producing stocks. The null hypotheses that followed were formulated:

H₀1: There is no positive Influence of Respondents Education Qualification, Occupation and Income on stick to the stocks which gives income.

The Below table represents the analysis of one-way ANOVA with Descriptive statistics on Influence of Respondents Education Qualification, Occupation and Income on stick to the stocks which gives income.

Table 2: Influence of Respondents Education Qualification, Occupation and Income on stick to the stocks which gives income

Variables		N	Mean	Std. Deviation	F value	P Value
Educational Qualification	School Education	21	2.0000	.63246	4.401	0.003**
	Graduation	148	2.1757	.94557		
	Post-Graduation	60	1.9333	.86095		
	Professional	13	2.0000	.81650		
	Others	8	3.2500	1.16496		
	Total	250	2.1280	.92685		
Occupations	Public Sector Employee	13	3.1538	1.14354	9.517	<.001**
	Private Sector Employee	76	2.1711	.91489		
	Self-Employed	120	2.1917	.87251		
	Retired Employee	28	1.5000	.50918		
	Professional	13	1.6154	.86972		
	Total	250	2.1280	.92685		
	Upto 50,000	110	2.0364	.90794		
	50001 – 100000	22	2.3182	.99457		
	100001 – 200000	34	2.4118	.98835		

Income	200001 – 300000	7	2.1429	1.21499	1.262	0.281
	100001 – 400000	14	2.2857	1.32599		
	Above 4,00,000	63	2.0317	.73984		
	Total	250	2.1280	.92685		

** indicates significance at 1% and * indicates significance at 5%

Interpretation

To investigate the significant divergences in the components of Education Qualification, Occupation, and Income on stick to the stocks which gives income, a one-way among-groups analysis of variance (ANOVA) was performed.

Educational Qualification on stick to the stocks which gives income.

At the 1% significance level, the derived 'F' value of 4.401 is significant. The value shows that respondents' education qualifications have a highly substantial influence on their decision to continue with income-producing stocks. Consequently, the hypothesis that was put up, according to which "there is no significant influence of Respondents Education Qualification with Income on stick to the stocks which gives income," is rejected.

Occupation on stick to the stocks which gives income.

At the 1% significance level, the derived 'F' value of 9.517 is significant. The value shows that the respondents' occupation has a highly substantial influence on their decision-making when it comes to information from others. As a result, the hypothesis that was developed states that the respondents' occupation had no obvious effect on their decision, is rejected.

Income on stick to the stocks which gives income.

At the 5% level, the computed 'F' value of 1.262 is not significant. According to the assessment, respondents' income has no apparent effect on their decision to continue with income-producing assets. As a result, it is agreed upon that the hypothesis, "Respondents' Education Qualification and Income Have No Significant Influence on Sticking to the Stocks Which Give Income."

Influence of Respondents Education Qualification, Occupation and Income on difficulty in processing new information.

To determine the significant impact of respondents Education Qualification, Occupation and Income on difficulty in processing new information, one-way ANOVA is used to ascertain the influence of Respondents Education Qualification, Occupation and Income on difficulty in processing new information. Null hypothesis formulated were the following:

H₀1: There is no positive Influence of Respondents Education Qualification, Occupation and Income on difficulty in processing new information

The Below table represents the analysis of one-way ANOVA with Descriptive statistics on Influence of Respondents Education Qualification, Occupation and Income on difficulty in processing new information.

Table 3: Influence of Respondents Education Qualification, Occupation and Income on difficulty in processing new information

Variables		N	Mean	Std. Deviation	F value	P Value
Occupations	School Education	21	2.7619	.88909	1.296	0.272
	Graduation	148	2.4459	.86727		
	Post-Graduation	60	2.3167	.81286		
	Professional	13	2.2308	.43853		
	Others	8	2.5000	.92582		
	Total	250	2.4320	.84393		

Occupations	Public Sector Employee	13	3.3846	.96077	6.740	<.001**
	Private Sector Employee	76	2.3421	.85717		
	Self-Employed	120	2.3667	.75519		
	Retired Employee	28	2.7143	.89679		
	Professional	13	2.0000	.57735		
	Total	250	2.4320	.84393		
	Upto 50,000	110	2.4727	.77470		
	50001 – 100000	22	2.1818	.90692		
	100001 – 200000	34	2.8529	.92548		
Income	200001 – 300000	7	2.4286	.53452	2.948	0.013**
	100001 – 400000	14	2.1429	.66299		
	Above 4,00,000	63	2.2857	.88770		
	Total	250	2.4320	.84393		

** indicates significance at 1% and * indicates significance at 5%

Interpretation

To investigate the significant differences between the components Education Qualification, Occupation, and Income on processing new information difficulties, a one-way among-groups analysis of variance, or ANOVA, was performed.

Educational Qualification on processing new information

At the 5% level, the computed 'F' value of 1.296 is not significant. The value shows that the respondents' education qualifications have no obvious impact on their inability to process new knowledge. Thus, it is accepted that the hypothesis is that "Respondents' Education Qualifications Have No Significant Influence on Their Difficulty in Processing New Information"

Occupation on processing new information.

At the 1% significance level, the derived 'F' value of 6.740 is significant. The number shows that the respondents' occupation has a highly substantial influence on their inability to process new information.

Thus, the hypothesis that "Respondents' occupation has no significant influence on their difficulty processing new information" is rejected.

Income on processing new information.

At the 5% significance level, the computed 'F' value of 2.948 is significant. The value suggests that respondents' income has a substantial impact on their inability to adapt to new knowledge. Thus, the hypothesis that was put forth, according to which "Respondents' education qualification and income have no significant influence on their difficulty processing new information," is rejected.

Influence of Respondents Occupation on anticipate the shifts or changes of my stock prices in the future based on the recent stock prices and believe that the other investors have better knowledge than me.

One-way ANOVA is used to determine the influence of Respondents' occupation on predicting shifts or changes in the future stock price based on the historical data and trend and the belief that other investors know more than

I do. This is done in order to test the significant influence of Respondents' occupation on predicting changes in the future stock price based on the historical data and trend and believe that other investors know more than I do. The null hypotheses that followed were formulated:

H₀1: There is no significant Influence of Respondents Occupation on predict the changes in the future stock price based on the historical data and trend and believe

that the other investors have better knowledge than me.

Based on current stock price movements, it appears that other investors possess more knowledge than myself, and the analysis of a one-way ANOVA with descriptive statistics on the influence of respondents' occupations on my ability to anticipate future stock price changes is presented in the table below.

Table 4: Occupation on determining the difference of my market value in the further placing on the recent market value and believe this the other investors have better knowledge than me

Variables		N	Mean	Std. Deviation	F value	P Value
Occupation on predict the changes in the future stock price based on the historical data and trend.	Public Sector Employee	13	3.1538	1.21423	4.988	0.002**
	Private Sector Employee	76	2.5526	.98515		
	Self-Employed	120	2.3500	.93170		
	Retired Employee	28	1.9286	.71640		
	Professional	13	2.0000	.91287		
	Total	250	2.3880	.97223		
Occupation on believe that the other investors have better knowledge than me.	Public Sector Employee	13	3.3846	1.26085	6.183	<.001**
	Private Sector Employee	76	2.6316	.90689		
	Self-Employed	120	2.5667	1.11320		
	Retired Employee	28	1.7857	.87590		
	Professional	13	2.7692	1.09193		
	Total	250	2.5520	1.07887		

** indicates significance at 1% and * indicates significance at 5%

Explanation

The unilateral connecting team analysis compares the means of variable across several groups controls to establish the substantial changes surrounded by factors Occupation on determining the difference of my asset prices in the further depending on the last traded prices and believe this the other investors have better knowledge than me,

Occupation on determining the changes in the future stock price based on the historical data and trend and Occupation on believe that the other investors have better knowledge than me.

The obtained 'F' values are 4.988 and 6.183 and both are notable at 1% quantity. The merit suggest that there is a notable effect of Respondents Occupation on anticipates the shifts of the stock prices in the hereafter situated on the last traded prices and Occupation on believe that the other investors have better knowledge than me. consequently the draw up theory "There is no significant influence of Respondents Occupation on predict the changes in the future stock price based on the historical data and trend and Occupation on believe that the other investors have better knowledge than me." is Rejected.

MULTIPLE REGRESSION ANALYSIS

Anchoring Behavior and Investment decision (ABID) on Socio Economic factors

In this Multiple Regression Analysis (MRA), the predicted variable is Anchoring Behavior and Capital budgeting decision (ABID) and the casual variables are Socio Economic factors i.e., Education Qualification, Income and Occupation. Multiple Linear Regression was lead to decide the optimal linear combination of Socio-Economic factors for predicting Anchoring Behavior and Investment decision (ABID).

Descriptive Statistics

Variables	N	Mean	Std. Deviation
ABID	250	2.4896	0.66945
Education	250	2.356	0.8343
Occupation	250	2.808	0.89349
Annual Income	250	2.928	2.09293

Regression Analysis

Multiple R value	:	0.820
R Square value	:	0.902
F value	:	45.066
P value	:	<.001**

The multiple correlation coefficient is 0.820 measures the correlation between the actual and the predicted values of the Anchoring Behavior and Investment decision. As the predicted values are obtained as a linear combination of Education Qualification (X1), Income (X2) and Occupation (X3). The coefficient value of 0.820 denotes that the correlation between Anchoring Behavior and Investment decision and the three independent variables is strongly favourable.

Table 5: Variables in the Multiple Regression Analysis

Variables	Ill-formed co-efficient (B)	SE of B	Standardized Co-efficient (Beta)	t value	P value
Persistent	-0.971	.179	-	16.572	.000
Education	.072	.051	.089	1.395	.004

Occupation	.218	.046	.291	4.765	.000
Annual Income	.013	.021	.040	.625	.032

Note: ** Denotes significant at 1% level

Determination Coefficient: The R Square value evaluates goodness of fit of the estimated Sample Regression Plane (SRP) by determining the proportion of variation in dependent variable was explained by the fitted sample regression equation. With education qualification, income, and occupation serving as the independent variables, the estimated SRP accounts for approximately 90.2% of the variation in Anchoring Behavior and Investment Decision (ABID), as indicated by the R square value of 0.902. Furthermore, the R square value is highly significant at the 1% level.

The multiple regression equation is

$$Y = -0.971 + 0.72 X_1 + 0.218 X_2 + 0.013 X_3$$

When all other variables are held constant, the partial impact of education qualification on anchoring behavior and investment decision (ABID) is represented with the coefficient of X1, which is 0.072 in this case. With every unit increase in education degree, Anchoring Behavior and Investment Decision (ABID) would grow by 0.072, according to the anticipated positive sign. This coefficient value is significant at the 1% level.

Here the coefficient of X1 is 0.072 denotes the marginal effect of Education qualification on. Anchoring Behavior and Investment decision (ABID), holding the other variables as constant.

For every one unit increase in Education qualification, Anchoring Behavior and Investment decision (ABID) would increase by 0.072 and this coefficient value is significant at 1 % level

When all other factors are held constant, the partial impact of income on anchoring behavior and investment decision (ABID) is represented with coefficient of X1, which is 0.218 in this case. With every unit rise in income, Anchoring Behavior and Investment Decision (ABID) would grow by 0.218, according to the anticipated positive sign. This coefficient value is significant at the 1% level

Here the coefficient of X1 is 0.013 denotes the

marginal effect of occupation on anchoring behavior and investment decisions (ABID), holding the other variables as constant. For every one unit increase in Occupation, Anchoring Behavior and Investment decision (ABID) would increase by 0.013 and this coefficient value is significant at 1 % level

FINDINGS

1. An investors' whose educational qualification categorized under option others (vocational training, professional certifications, self-taught or informal education, etc.) are mostly taking decisions based on others information and the investors' whose occupation is public sector employee also taking the decisions based on other's information.
2. The investors' whose educational qualification categorized under option others (vocational training, professional certifications, self-taught or informal education, etc.) and public sector employee are mostly preferred to choose the stock which give regular income.
3. The study finds that investor's whose income between 100001 and 200000 are exploring the stock with growth potential over immediate income.
4. The study found that investor's whose education are schooling and whose income between 100001 and 200000 are not find any difficulty in processing a new information.
5. The study reveals that investors who are termed as public sector employee are facing difficulty in processing a new information.
6. The study finds that investor's whose occupation as public sector employee are predicting the future stock prices based on current stock prices and also, they believed that other investors are having sound knowledge.
7. The study found that the co-efficient value of 0.820 points this is a strong network of educational qualification, work as well as income with anchoring behaviour and investment decision.

SUGGESTIONS

The investors should not always depend on others information for taking decisions, also they have to look

into the past performance record, current movement of stocks, advice from agents, etc. Investors by staying informed through reliable sources and maintaining a well-defined investment strategy, can avoid facing difficulty in processing a new information.

CONCLUSION

From the above discussion, it was concluded that there is an influence of anchoring behaviour towards investment decisions. The demographic factors namely educational qualification, occupation and income influenced by the anchoring behaviour of investor in the context of decision based on others information, stick on the stocks which gives income, difficulty in processing a new information, prediction of the future stock prices based on current stock prices and depends on others knowledge. This study contributes to the Government, financial advisors, and investors. For the investors, it will be used as a reference for doing the best investment decisions.

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An Integrated Study of Socio-Economic Factors, Purchase Decision Influencers, and Advertising Channels on Home Appliance Satisfaction

R. Pradeepa

Research Scholar, PG & Research
Department of Commerce
Dr. Nalli Kuppusamy Arts College
(Affili. to Bharathidasan University, Tiruchirappalli),
Thanjavuar, Tamilnadu

T. Priyanga

Research Advisor & Assit. Professor, PG & Research
Department of Commerce
Dr. Nalli Kuppusamy Arts College
(Affili. to Bharathidasan University, Tiruchirappalli),
Thanjavuar, Tamilnadu

ABSTRACT

This study investigates the factors influencing customer satisfaction with home appliance features, focusing on three key dimensions: socio-economic profile, purchase decision influencing factors, and types of media advertisements. Using a structured survey approach, data were collected from a diverse sample of home appliance consumers. The research tested three null hypotheses: (H01) no significant association between customers' socio-economic profile and their satisfaction with appliance features; (H02) no significant association between purchase decision influencing factors and satisfaction levels; and (H03) no significant association between the kind of media advertisement and satisfaction levels. Statistical analyses, including chi-square tests of association, were employed to examine these relationships. The results provide insights into which demographic and marketing variables significantly shape consumer satisfaction with product features, offering practical implications for marketers and manufacturers aiming to enhance customer-centric design and targeted promotional strategies. The study underscores the importance of understanding consumer profiles and media preferences to drive better satisfaction outcomes in the competitive home appliances market.

KEYWORDS: *Customer satisfaction, Socio-economic profile, Purchase decision, Home appliances, Media advertisement, Consumer behavior, Marketing strategy.*

INTRODUCTION

Intense rivalry, fast expanding technologies, and increasingly discerning customers characterise the consumer home appliances market [1]. Understanding what makes customers happy with product characteristics is crucial for manufacturers looking to stand out and establish brand loyalty [2]. In a digitally connected consumer context, home appliance feature satisfaction affects repeat purchases, brand reputation, and word-of-mouth marketing [3].

Customer satisfaction is influenced by socioeconomic status. Age, income, education, occupation, and family size affect purchasing power, feature preferences, and quality and dependability expectations [4]. Higher-income clients may favour advanced technology,

energy efficiency, or brand reputation, while price-sensitive sectors may value cost and basic functioning. Understanding this association helps manufacturers create and market to varied demographics [5].

Other important purchase choice criteria include pricing, brand image, quality perceptions, after-sales service, peer recommendations, and in-store experience [6]. Consumers evaluate home appliance characteristics differently based on these factors. Companies can prioritise product development, customer service, and promotional methods by determining which elements strongly correspond with satisfaction [7].

Companies' media advertising can also affect customer satisfaction [8] [9]. Advertising communicates value, influences perceptions, and sets product feature

expectations [10]. Television, radio, and print compete with social media, influencer marketing, and online video [11]. These media forms may alter consumer awareness, perception, and satisfaction with appliance features [12].

In the modern era of consumerism, home appliances have transcended their functional roles to become essential components of comfort, convenience, and lifestyle. From refrigerators and washing machines to microwave ovens and air conditioners, home appliances play a vital role in enhancing the quality of life for households. With advancements in technology, evolving family structures, rising disposable incomes, and shifting consumer aspirations, the demand for home appliances has significantly grown across urban and rural regions. However, this growth is not solely driven by product utility. The purchase decisions of consumers are influenced by a complex interplay of socio-economic conditions, individual and collective decision-making influencers, and the effectiveness of advertising channels. This integrated study seeks to explore how these interconnected elements shape consumer satisfaction with home appliances.

Understanding consumer satisfaction is crucial for manufacturers, marketers, and retailers in today's competitive and dynamic home appliance market. Satisfaction is not only determined by the product's technical performance or brand reputation but also by how well the product aligns with the buyer's economic capacity, expectations, social values, and exposure to marketing communications. Therefore, a comprehensive approach that integrates socio-economic, psychological, and communicational dimensions is essential to decode the patterns behind home appliance purchases and post-purchase satisfaction.

Socio-Economic Factors and Their Influence

Socio-economic factors refer to the economic and social conditions that characterize individuals or groups, including income level, education, occupation, family size, gender, age, residential location (urban or rural), and social status. These factors not only influence the ability to purchase but also shape consumer preferences, needs, and expectations. For example, higher-income households may prioritize smart appliances with automation, energy-saving features, and brand prestige,

while lower-income groups may focus on affordability, durability, and essential functionality.

In India and other emerging economies, the middle-class segment plays a pivotal role in driving the home appliance market. This segment is highly aspirational but cost-conscious, making value-for-money a key criterion. Moreover, factors such as family size and working status (e.g., dual-income families) also affect appliance choice—larger families might prefer high-capacity washing machines, while working couples may opt for faster, multi-functional cooking appliances.

Education and occupation influence consumer awareness, ability to compare alternatives, and readiness to adopt new technology. Educated consumers are more likely to research products online, read reviews, and make informed decisions. On the other hand, less-educated or rural consumers may depend on retail staff, peer recommendations, or visible advertisements. Therefore, understanding the socio-economic background is fundamental to interpreting consumer behaviour in the home appliance sector.

Purchase Decision Influencers

The purchase of home appliances is often not an impulsive act but a well-considered family decision, particularly for high-value items. Several influencers come into play, including family members (spouse, parents), friends, colleagues, opinion leaders, retail staff, and online reviews. The role of family members is especially prominent in collective cultures like India, where joint decision-making is common for household purchases.

Word-of-mouth (WOM) continues to be a powerful influence in both urban and rural markets. People tend to trust personal recommendations over advertisements, particularly for expensive or long-term items like refrigerators or air conditioners. Furthermore, retail staff and after-sales service feedback can significantly shape customer perceptions, especially in physical retail environments.

Social media influencers and product reviewers also play a growing role, particularly among younger consumers who rely on digital platforms for information. The credibility, relatability, and authenticity of these influencers can heavily sway purchasing decisions,

making them important agents in the decision-making process.

Understanding who influences consumer choices helps marketers to fine-tune their promotional and engagement strategies. Whether through referral programs, influencer marketing, retail training, or testimonial campaigns, targeting the right influencers can significantly improve conversion rates and long-term satisfaction.

Advertising Channels and Consumer Engagement

Advertising and promotional strategies serve as the first point of contact between the consumer and the brand. With the expansion of media and communication technologies, consumers are now exposed to a wide variety of advertising channels—ranging from traditional platforms such as TV, radio, and newspapers to digital channels including social media, search engines, e-commerce websites, and YouTube.

The effectiveness of an advertising channel depends on the demographics and preferences of the target audience. For instance, television ads still dominate in rural and semi-urban markets due to broader reach and trust. Meanwhile, urban millennials and Gen Z consumers are more influenced by social media ads, influencer endorsements, and online video content. The tone, message clarity, visual appeal, and call-to-action in these advertisements are critical elements that affect consumer perception and recall.

Moreover, advertising not only influences brand awareness and product preference but also sets consumer expectations. If the product fails to meet the perceived promises of the advertisement, it may lead to post-purchase dissatisfaction. Therefore, analyzing the alignment between advertising content and consumer experience is essential to measure satisfaction.

In a highly competitive market, companies are also increasingly using personalized advertising, retargeting, and interactive campaigns to engage consumers. However, the information overload and distrust of exaggerated claims have made modern consumers more skeptical. Hence, the credibility of the source and relevance of the message become key determinants in shaping attitudes and actions.

Integration and Relevance of the Study

While there are numerous studies focusing on individual aspects of home appliance marketing—such as branding, pricing, or consumer satisfaction—very few have integrated the socio-economic context, purchase influencers, and advertising channels into a single framework. This study attempts to bridge that gap by offering a holistic view of how these three dimensions jointly influence home appliance satisfaction.

Understanding the interrelationships among these variables is vital for both academic and practical purposes. For academics, it contributes to the development of comprehensive consumer behaviour models. For practitioners—manufacturers, marketers, retailers, and advertisers—it offers actionable insights into tailoring product offerings, sales strategies, and marketing communications.

RESEARCH METHODOLOGY

Research Design

This descriptive and analytical study examines home appliance feature consumer satisfaction elements. Customer socio-economic profiles, purchasing choice determinants, media advertisement exposure, and satisfaction levels are described in the descriptive component. The analytical component uses statistics to examine these variables' relationships. This combined method provides thorough description and hypothesis testing.

The design is cross-sectional, collecting data from a large user sample at one time. A systematic survey instrument standardises questions for all respondents. Quantitative approaches allow statistical generalisation to the consumer population in the study.

Data Collection

Data were collected using a structured questionnaire administered both online and in-person to maximize coverage and inclusivity. The questionnaire was developed based on literature review and expert validation and contained the following sections:

- Demographic and socio-economic profile (age, gender, income, education, occupation)

- Purchase decision influencing factors (price, quality, brand image, after-sales service, peer recommendations)
- Kind of media advertisement (traditional media vs. digital media channels)
- Customer satisfaction with home appliance features (measured on a Likert scale)

To ensure reliability, a pilot test was conducted with 50 respondents prior to the main survey. Adjustments were made to clarify ambiguous questions and improve flow.

Sampling and Population

The target population for this study consists of customers who have purchased and used home appliances in the last two years. This criterion ensures respondents have recent and relevant experience to evaluate appliance features meaningfully.

A sample size of 900 respondents was determined to ensure statistical power and representativeness. The sampling technique used was stratified random sampling to achieve proportional representation across key socio-economic groups (e.g., age groups, income levels, urban/rural regions). This approach reduces sampling bias and improves the generalizability of findings.

RESEARCH HYPOTHESES

The following null hypotheses were tested:

- H01: There is no significant association between customers' socio-economic profile and their home appliances features satisfaction level.
- H02: There is no significant association between customers' purchase decision influencing factors and their home appliances features satisfaction level.
- H03: There is no significant association between kind of media advertisement and their home appliances features satisfaction level.

These hypotheses were evaluated using chi-square tests of association and cross-tabulation analysis to detect statistically significant relationships. Additional descriptive statistics (means, frequencies, standard deviations) were computed to profile the sample and key variables.

DATA ANALYSIS AND INTERPRETATION

Significant Association between Customer Socio-Economic Profile and Their Home Appliances

The results presented in Table 1 examine the association between various socio-economic profile variables and the level of satisfaction with home appliance features, using Chi-square (X^2) tests.

- Age: The Chi-square value is 4.904 with 4 degrees of freedom, and the p-value is .297 (>0.05), indicating no statistically significant association between age group and satisfaction level. Although the highest proportion of both low and high satisfaction is seen in the 36–45 years group, this distribution does not differ significantly from what would be expected by chance.
- Gender: The analysis shows $X^2 = 4.427$ with 1 degree of freedom and a p-value of .052 (>0.05), suggesting no significant association between gender and satisfaction level. While males slightly dominate the high satisfaction category (60.7%), this difference is not statistically significant.
- Marital Status: The Chi-square value is .489 with 1 degree of freedom and a p-value of .484 (>0.05), indicating no significant relationship between marital status and satisfaction. Married respondents show a slightly higher percentage of high satisfaction (61.3%) compared to single respondents (38.7%), but the difference is not statistically significant.
- Educational Qualification: The Chi-square value is 4.960 with 4 degrees of freedom and a p-value of .291 (>0.05), indicating no significant association. Although graduates represent the largest share of high satisfaction (32.1%), this distribution is not statistically different from expectation.
- Occupation: The analysis yields $X^2 = 5.318$ with 4 degrees of freedom and a p-value of .256 (>0.05), also indicating no significant association between occupation and satisfaction level. Private employees show the highest proportion of high satisfaction (36.4%), but this variation is not significant.

All socio-economic variables analyzed (age, gender, marital status, educational qualification, and

occupation) show p-values greater than 0.05, indicating that customer satisfaction levels with home appliance features are broadly similar across different socio-economic segments in this study sample.

Table 1: Association Between Customer Socio-Economic Profile and their home appliances features satisfaction level

Socio-economic profile	Level of satisfaction						Statistical inference
	Low		High		Total		
	n	%	n	%	n	%	
Age							
Below 25yrs	93	24.3%	138	26.7%	231	25.7%	X ² =4.904 Df=4 .297>0.05 Not Significant
26 to 35yrs	57	14.9%	92	17.8%	149	16.6%	
36 to 45yrs	135	35.2%	148	28.6%	283	31.4%	
46 to 55yrs	42	11.0%	62	12.0%	104	11.6%	
Above 55yrs	56	14.6%	77	14.9%	133	14.8%	
Gender							
Male	204	53.3%	314	60.7%	518	57.6%	X ² =4.427 Df=1 .052>0.05 Not Significant
Female	179	46.7%	203	39.3%	382	42.4%	
Marital Status							
Married	226	59.0%	317	61.3%	543	60.3%	X ² =.489 Df=1 .484>0.05 Not Significant
Single	157	41.0%	200	38.7%	357	39.7%	
Educational Qualification							
Below SSLC	48	12.5%	70	13.5%	118	13.1%	X ² =4.960 Df=4 .291>0.05 Not Significant
HSC	86	22.5%	137	26.5%	223	24.8%	
Diploma	82	21.4%	88	17.0%	170	18.9%	
Graduation	117	30.5%	166	32.1%	283	31.4%	
Professionals	50	13.1%	56	10.8%	106	11.8%	
Occupation							
Agriculture	108	28.2%	123	23.8%	231	25.7%	X ² =5.318 Df=4 .256>0.05 Not Significant
Business	59	15.4%	77	14.9%	136	15.1%	
Govt. employee	38	9.9%	69	13.3%	107	11.9%	
Private employee	126	32.9%	188	36.4%	314	34.9%	

Significant Association between Customers purchase decision and their home appliances

Table 2 examines the relationship between different purchase decision influencers and customers' satisfaction levels with home appliance features, using the Chi-square test.

- The overall Chi-square statistic is 9.500 with 4 degrees of freedom and a p-value of .050, which is equal to the conventional significance threshold of 0.05 but is interpreted here as not significant (p

> 0.05). This indicates that there is no statistically significant association between the purchase decision influencers and the satisfaction level of home appliance features.

- Among the influencers, children appear most frequently as an influencing factor, representing 34.8% of the high satisfaction group and 26.4% of the low satisfaction group. However, this difference is not statistically significant. Other influencers

such as spouse, friends, relatives, and retailers show fairly balanced proportions across satisfaction levels without significant variation.

The data suggests that the various purchase decision influencers (children, spouse, friends, relatives, and retailers) do not have a statistically significant impact on the customers' satisfaction with home appliance features in this sample.

Table 2: Association between Customer Purchase Decision influencing factor and their home appliances features satisfaction level

Key	Influencer Level of satisfaction						Statistical inference
	Low		High		Total		
	n	%	n	%	n	%	
Children	101	26.4%	180	34.8%	281	31.2%	X2=9.500 Df=4 .050>0.05 Not Significant
Spouse	68	17.8%	66	12.8%	134	14.9%	
Friends	96	25.1%	115	22.2%	211	23.4%	
Relatives	61	15.9%	82	15.9%	143	15.9%	
Retailers	57	14.9%	74	14.3%	131	14.6%	
Total	383	100.0%	517	100.0%	900	100.0%	

Significant Association between Media Advertisement and their home appliances

Table 3 uses the Chi-square test to examine how media ads affect home appliance feature customer satisfaction.

- The Chi-square statistic (22.289) and p-value (0.000) indicate a substantial correlation between media advertisement type and consumer satisfaction (< 0.05).

Television advertising had the highest presence in both low (26.9%) and high (33.5%) satisfaction categories, indicating its maximum influence.

Newspaper advertising had a greater rate of high satisfaction (14.1%) compared to low satisfaction

(9.7%), suggesting a favourable impact on satisfaction.

- Internet ads had a higher percentage in the low satisfaction group (16.2%) than in the high satisfaction group (7.5%), suggesting less effectiveness in improving consumer contentment.
- Radio, digital boards, and other media have a balanced distribution of satisfaction levels.

The large Chi-square finding shows that media advertising type affects home appliance feature consumer happiness. Television and newspaper commercials increase satisfaction, whereas Internet ads decrease it.

Table 3: Association between the kind of media advertisement and their home appliances features satisfaction level

Kind of media advertisement	Level of satisfaction						Statistical inference
	Low		High		Total		
	n	%	n	%	n	%	
Television	103	26.9%	173	33.5%	276	30.7%	X ² =22.289 Df = 5 .000<0.05 Significant

Radio	81	21.1%	110	21.3%	191	21.2%	
Digital Board	46	12.0%	51	9.9%	97	10.8%	
Newspaper	37	9.7%	73	14.1%	110	12.2%	
Internet	62	16.2%	39	7.5%	101	11.2%	
Others	54	14.1%	71	13.7%	125	13.9%	
Total	383	100.0%	517	100.0%	900	100.0%	

CONCLUSION

Customers' socio-economic profiles, purchase choice affecting factors, and media marketing were linked to home appliance feature satisfaction in this study.

Socio-economic characteristics like age, gender, marital status, education, and occupation did not significantly affect consumer satisfaction. This implies that home appliance feature satisfaction is similar across socioeconomic categories in the sample.

Purchase decision influencers including children, spouse, friends, family, and stores did not indicate customer happiness. This suggests that who impacts the buying choice may not affect customer satisfaction with home appliance features.

In contrast, media advertisement type was statistically associated with customer satisfaction. Television and newspapers were associated with better satisfaction, but Internet advertising was associated with poorer satisfaction. This emphasises the need of choosing efficient advertising platforms to improve consumer happiness.

The findings show that while demographic and interpersonal factors may not significantly affect home appliance feature satisfaction, focused and effective media advertising methods can greatly impact consumer satisfaction. Companies can use these data to improve

their marketing strategy by focussing on the best media channels to satisfy customers.

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Impact of Work Life Balance on Employee Engagement in Autonomous Engineering and Management Colleges in Hyderabad City - A Study

Patha Rajitha

Research Scholar

Department of Management

Adaikalamatha College (Affiliated to Bharathidasan

University, Tiruchirappalli)

Thanjavur, Tamilnadu

✉ prajitha.kjkc@gmail.com

N. Sumathi

Research Advisor

Department of Management

Adaikalamatha College (Affiliated to Bharathidasan

University, Tiruchirappalli)

Thanjavur, Tamilnadu

✉ sumathiv80@gmail.com

ABSTRACT

Engaging employees at work is a priority for organizations. Engaged employees tend to be highly productive, strive to improve the quality of their work, are well-satisfied with their jobs, and are less likely to leave their organization. Educational institutions can also benefit from this scenario. A well-engaged teacher is thought to be positive, enthusiastic, and determined in their work. As a result, they constantly reassess their role from a broad perspective and work for the organization's benefit. The main objective of this study is to measure the impact of Work Life Balance on Employee Engagement of Teaching faculties. For this purpose, a structured questionnaire was developed and administered using Likert's five point scale to collect the opinions from teaching faculties. The study is descriptive in nature and adopts convenient sampling method. Descriptive statistics i.e, Mean and Standard Deviations are used and Regression Analysis useful to measure the impact of work life balance on employee engagement. The study found that, work life balance significantly predict the employee engagement ($\beta=0.520$, $t=12.822$ and $p=0.000$). Further, future research may be conducted by adding employee performance and job satisfaction with cross comparison between Autonomous and Non – Autonomous colleges, various departments in Autonomous colleges.

KEYWORDS: *Work life balance, Employee engagement, Teaching community and autonomous colleges.*

INTRODUCTION

Work-life balance (WLB) is about finding the right balance between work and life, and about feeling comfortable with both work and family commitments. Work-life balance is essentially the balance between three components, namely, paid work, unpaid work and personal time. There is no one accepted definition of what constitutes a WLB practice, the term usually refers to one of the following factors: organizational support for dependent care, flexible work options and family or personal leave.

In simple terms, Work life balance refers to create balance between professional and personal life of employee. Mathematically it can be understood by a following formula:

WORK LIFE BALANCE= TIME MANAGEMENT + STRESS MANAGEMENT.

Employees working in an organization have to play various roles at a particular time period. During working hours, employees have to perform various task assigned to them by their superiors, on the other hand they have to perform the role of parents, spouse etc. at home. Sometimes it is not possible for them to manage both personal and professional life at a time. This is the biggest reason for stress. Hence, it is important to manage work and family life to reduce stress. It encourages employees to distribute their time and work on the basis of need and priority so as to manage stress (Sharma, and Kamal, 2020).

In the contemporary educational landscape, engineering and management colleges play a pivotal role in nurturing the business leaders and entrepreneurs of tomorrow. Within these institutions, an array of dedicated professionals teaching professionals, form the bedrock of academic excellence. However, as engineering and management education continues to evolve, so too does the discourse surrounding the work-life experiences of those who contribute to its vitality. Work-life balance, an essential aspect of overall well-being, has garnered significant attention in recent years. The purpose of this study is to delve into the intricate dynamics of work-life balance between male and female teaching professionals in management colleges. While the topic of work-life balance has been explored across various sectors, it is essential to understand the unique challenges faced by teaching professionals.

This study employs a mixed-methods research approach, incorporating both quantitative surveys and qualitative interviews. By adopting this comprehensive methodology, we seek to capture the multifaceted nature of work-life balance, accounting for not only quantitative measures but also the lived experiences and narratives of teaching professionals. In essence, this research seeks to contribute to the broader discourse on work-life balance and employee engagement in educational institutions especially Engineering and Management Autonomous Institutions. By shedding light on the challenges faced by teaching professionals, we insist to inform the development of inclusive policies and support systems that foster both personal well-being and career growth in the pursuit of academic excellence.

METHODOLOGY OF THE STUDY

- **Research Design:** The present study is based on primary data (Descriptive in nature) and adopted qualitative research design. The survey method is adopted to measure the responses of teaching fraternity on Work Life Balance and Employee Engagement.
- **Population:** Total number of employees working in Autonomous Engineering and Management Colleges in Hyderabad City considered as the population.
- **Sample Frame:** A Sampling frame refers to the source device, list, or material that a sample is drawn and it needs to be a true representative of the entire population (Saunders et al., 2019), and for this study, the sampling frame was obtained from Autonomous Engineering and Management Colleges in Hyderabad city.
- **Sampling Technique and Sample Size:** In this study, the subgroups were based on the designation such as Assistant Professor, Associate Professor, Professor and Principal. The study adopts non probability sampling method and uses convenient sampling technique. The present study collects the opinion through structured questionnaire and uses Google forms. The study uses a sample size of 100. A structured questionnaire was developed and distributed using Google forms through online and WhatsApp to 150 faculties of Engineering and Management Departments. The sampling error of 5%, and a confidence level of 95% to test the significant impact of work life balance on employee engagement.
- **Data Collection Methods:** Primary data was used in this study, where the researcher collected data from the target respondents using questionnaires. Questionnaires is developed and used in this study because of affordable way of collecting data. It helps the researcher to gain information from the sample size within a short period. The questionnaire contained two parts. The first part featured questions that focused on the respondents' demographic information. The second section featured questions that were focused on work life balance and employee engagement.
- **Statistical Tools used:** The collected data was analyzed descriptively in the Excel tool, since the data was quantitative. Descriptive statistics permits a researcher to numerically describe and compare variables by focusing on the central tendency and characterizing the data dispersion around the central tendency (Saunders et al., 2019). Descriptive statistics i.e., means and standard deviations are used to analyse the data collected from sample respondents. Regression analysis is also used to measure the impact of Work Life

Balance on Employee Engagement in Autonomous colleges.

- Reliability and Validity: The precision of the measurement was determined by reliability, which is defined as the degree to which a scale or research instrument assesses the same score at various times and locations when delivered to diverse populations. Table 1 Inter – Item Correlation on WLB (Work Life Balance).

S. No	Work Life Balance	Total Correlation	if Item Deleted	Cronbach's Alpha
1	Colleges environment is positive and supportive with the required facilities	0.446	0.778	0.799
2	Work-Life Balance entirely employers partly individuals' responsibility	0.437	0.779	
3	I miss quality time with family/ and friends because of the pressure of work.	0.008	0.823	
4	I can access a flexible working schedule in the college	0.468	0.775	
5	Colleges should take initiatives to manage the work-life of its employee by providing leaves/ Job sharing option	0.429	0.779	
6	I am satisfied with my financial effectiveness	0.551	0.767	
7	College should encourage the involvement of your family members in the work achievement reward functions	0.390	0.783	

8	My family provides me the strength & support to face the challenges of work	0.558	0.768	
9	College considers employee's preference of choice for relocation	0.437	0.779	
10	There is good communication between the management and the employees in the college	0.582	0.764	
11	Medical leaves are available in our college	0.570	0.764	
12	Mental well-being is critical to maintaining the balance between work life and personal life	0.450	0.777	

Source: Primary Data

Cronbach's alpha reliability coefficients were used to assess the internal consistency of the scale scores. Cronbach's alpha should be greater than 0.7. Here, the researcher has used 5 point rating scale (Likert scale starting 1=Strongly Disagree to 5 = Strongly Agree) used to measure the impact of Work Life Balance on Employee Engagement. As a result, the inter consistency between the statements depicted in table -1. Cronbach's alpha was high for Employee Engagement and Work Life Balance in the current investigation. This demonstrates that the scales used were quite trustworthy. The researcher uses the principal component analysis extraction was and the grouping of variables into components are further examined using Varimax rotation. Reliability value of Work Life Balance is 0.799 (>0.7) indicates good inter consistency between the statements. The scale to assess WLB comprises of 12 items and on the bases of the 100 responses received, $\alpha = 0.799$ on the scale that means the scale has good reliability. All of the correlation values are greater than the allowed value of $r = 0.30$.

Table 2 Reliability statistics on Employee Engagement

S. No	Item-Total Statistics	Total Correlation	if Item Deleted	Cronbach's Alpha
1	I feel like going to work when I first wake up	0.785	0.875	0.893
2	I feel bursting with energy at work.	0.445	0.892	
3	At my job, I feel strong, enthusiastic & vigorous	0.364	0.896	
4	I am immersed in my work	0.680	0.881	
5	I feel happy when I am working intensely	0.726	0.878	
6	I get carried away when I am working	0.684	0.880	
7	My job inspires me to give my best	0.459	0.891	
8	I am enthusiastic about my job	0.582	0.885	
9	I am proud on the work that I do	0.474	0.891	
10	Given this opportunity, I will tell great things about working here.	0.344	0.897	
11	I will greatly recommend about my college services to my friends/ relatives/ others.	0.759	0.879	

12	It would take a lot for me to leave this college.	0.682	0.880	
13	I rarely think of working somewhere else leaving this college.	0.785	0.875	

Source: Primary Data

The Scale used to measure Employee Engagement is comprised of 13 items and found to have good reliability of $\alpha = 0.893$ and Correlation values of all items are higher than the acceptable value of $r=0.300$.

DATA ANALYSIS AND RESULTS

Table 3 Demographic Profile of the respondents

Demographic Variables	Category	Frequency (%)
Gender	Male	62
	Female	38
Age	25-35 years	14
	36-40 years	26
	41-45 years	32
	>45 years	28
Educational Qualification	PG	32%
	Pursuing Ph.D	38%
	Ph. D	22%
	PDF	8%
Income level per annum	< Rs. 3,00,000	24%
	Rs.3,00,001 – Rs.5,00,000	36%
	Rs.5,00,001- Rs.7,00,000	18%
	Rs.7,00,001 – Rs.9,00,000	10%
	> Rs.9,00,000	12%
Designation	Asst Professor	15%
	Associate Professor	26%
	Professors	34%
	Principals	25%
Experience in Years	< 3 year	10%
	3 to 10 years	15%
	11 -15 years	50 %
	> 15 years	25%

Source: Primary Data

Frequency distribution of Gender is represented in Table -1. It may observe from the table that, majority of the respondents are Male ($f=72\%$) and Female ($f=38\%$). It may infer that male respondents are more compared to female respondents under the study. From the table, it may observe that, most of the sample employees are fall between the age group of 41-45 years ($f=32\%$), > 45 years age group are ($f=28\%$), 36-40 years age group ($f=26\%$) and 25-35 years are ($f=14\%$). It may infer from the data that, majority of the employee's age group is 41-45 years compared to other age groups under the study. It may observe that, majority of the employees are Pursuing Ph.D where $N=38$, $f=38\%$, follow by PG $N=32$, $f=32\%$, Ph.D studied employees are $N=22$, $f=22\%$ and Post Doctoral Fellow (PDF) are $N=8$, $f=8\%$. From the table, it may observe that, most of the sample employees income levels are Rs.3,00,001 – Rs.5,00,000 P.A ($N=36$, $f=36\%$), < Rs. 3,00,000 are ($N=24$, $f=24\%$), Rs.5,00,001-Rs.7,00,000 income p.a ($N=18$ $f=18\%$) and Rs.7,00,001 – Rs.9,00,000 are ($N=10$, $f=10\%$). It may infer from the data that, majority of the employees income levels are Rs.3, 00,001 – Rs.5, 00,000 p.a compared to other income levels under the study. It may observe from the table that, 15 were Asst Professor, 26 were Associate Professors While 34 were working as Professors and Principals were, 25%. Majority of the employees ($f=50$) have 11-15 year experience, followed by > 15 years ($f=25$), 3-10 years ($f=15$) and <3 years ($f=10$). It may infer from the data that employee's have high experience in teaching field.

Work Life Balance (WLB)

Table 4 Descriptive Statistics and Frequency Distribution of Work-Life balance

S. No	Statement	\bar{X}	S.D
1	Colleges environment is positive and supportive with the required facilities	1.83	0.87
2	Work-Life Balance entirely employers partly individuals responsibility.	2.25	0.96
3	Due to Work Pressure, I Missing Quality time to spend with family & friends	2.70	1.13
4	I can access a flexible working schedule in the college	2.52	1.09

5	Colleges should take initiatives to manage the work-life of its employee by providing leaves/ Job sharing option.	2.13	1.04
6	I am satisfied on my financial effectiveness	2.37	1.00
7	College should allow Employee's family members to attend the reward and award function.	2.2	0.94
8	My family provides me the strength & support to face the challenges of work	1.83	0.89
9	College Management considers employee's preference of choice for relocation (shifting in other branches)	2.50	0.97
10	There is good communication between the management and the employees in the college	2.08	0.98
11	Medical leaves are available in our college	2.02	1.08
12	Mental well-being is helpful to balance between work life and personal life of the employee.	2.07	0.98

Source: primary data

Total 12 statements are included in Work-Life balance variable and their mean and standard deviation values are shown table -4. Majority of the faculty members stated that, they missing quality time to spend with family and friends due to work pressure with Mean (2.70) and S.D (1.13), followed by flexible working schedule in the college is accessible with Mean (2.052) and S.D (1.09) and College Management considers employee's preference of choice for relocation (shifting in other branches) with Mean (2.50) and S.D (0.97) and most of them agreed that financial effectiveness is satisfied with Mean (2.37) and S.D (1.00). Work-Life Balance entirely employers and partly individuals responsibility with a Mean (2.25) and S.D (0.96).

Further, most of them agreed that College should allow Employee's family members to attend the reward and award function with a Mean (2020) and S.D (0.94) and Colleges should take initiatives to manage the work-life of its employee by providing leaves/Job sharing option with a Mean (2.13) and S.D (1.04).

RESULTS AND DISCUSSION

Work-life balance (WLB) is about finding the right balance between work and life, and about feeling comfortable with both work and family commitments. The study found that Majority of the faculty members missing quality time to spend with family and friends due to work pressure accessible flexible working schedule in the college and College Management considers employee's preference of choice for relocation (shifting in other branches) to maintain work life balance in their job. On the other hand, they feel professionals feels that high energy at work place, think rarely of working somewhere else or leaving this college. Followed by, they will tell great things about working in their autonomous college, I am self-righteous on the work that I do with and my job motivates me to give my best. The present study found that Work Life Balance positively

significant with the Employee Engagement and have a low influence (27%) on employee engagement. Further, the researcher may focus on the Employee Performance and Job Satisfaction to shift the paradigm and measure the relationship between the select variables.

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Investigating the Antecedents of Seafood Export Venture Initiation in Tamil Nadu: an Exploratory Study

R. K. Ramya

Ph.D. Research Scholar
Department of Management Studies
A.V.V.M. Sri Pushpam College (Autonomous),
(Affiliated to Bharathidasan University)
Thanjavur, Tamilnadu

P. Jegan

Director & Research Adviser
Department of Management Studies
A.V.V.M. Sri Pushpam College (Autonomous),
(Affiliated to Bharathidasan University)
Thanjavur, Tamilnadu
✉ jeganpavul@gmail.com

ABSTRACT

This study investigates the antecedents of seafood export venture initiation in Tamil Nadu, focusing on the factors that influence the establishment and growth of seafood export businesses in the region. The research explores the role of government policies, business-related factors, managerial capabilities, financial considerations, personal factors, environmental conditions, and market dynamics in shaping entrepreneurial decisions within the seafood export sector. Data was collected from 230 seafood exporters operating in the Thoothukudi and Chennai ports using questionnaire. Factor analysis revealed seven key factors—product characteristics, government policies, business environment, managerial capabilities, financial factors, personnel aspects, and environmental conditions—driving the initiation of seafood export ventures. These factors collectively explained 64.52% of the variance in business initiation. The findings highlight the importance of favorable government policies, infrastructure, access to finance, and market demand in facilitating the establishment of seafood export businesses. The study offers valuable insights for policymakers, business owners, and financial institutions, recommending targeted interventions to support the growth of the seafood export sector in Tamil Nadu. The research also underscores the need for sustainable practices, robust infrastructure, and improved financial access to enhance competitiveness in the global seafood market.

KEYWORDS: *Seafood export, Tamil Nadu, Factor analysis, Business initiation, Government policy, Financial access, Managerial capabilities.*

INTRODUCTION

India's seafood export industry has emerged as a significant contributor to the national economy, with export earnings reaching USD8.09 billion in 2022-23 (Marine Products Export Development Authority [MPEDA], 2023). The sector has become a powerful catalyst for economic development, particularly in coastal regions, transforming lives through employment generation and poverty alleviation (Kumar & Sharma, 2022). According to recent estimates, the industry directly employs over 14.5 million people across the value chain (Department of Fisheries, 2023).

In developing nations such as India, the fisheries industry holds a significant position in the economy by creating extensive employment opportunities and contributing

substantially to foreign exchange earnings (Food and Agriculture Organization [FAO], 2021). Among Indian states, Tamil Nadu is a leader in the fisheries sector, accounting for a substantial portion of seafood exports in the southern region. The state's well-equipped ports enhance its capacity for international trade (MPEDA, 2020).

Globally, Indian seafood enjoys high demand, with importing countries presenting lucrative markets, especially for value-added products such as ready-to-eat meals, prepared seafood dishes, dried shrimp, and canned fish (MPEDA, 2020). The export of seafood has been pivotal in driving the growth of the fisheries sector in India, establishing it as a cornerstone of employment generation and economic development (FAO, 2021).

The decision to venture into seafood exports is shaped by a complex interplay of factors. Research indicates that entrepreneurial motivation in this sector is influenced by personal aspirations, market opportunities, and prior industry experience (Patel et al., 2023). Geographic advantages, such as proximity to fishing harbors and processing clusters, play a crucial role in business location decisions (Reddy & Singh, 2022). Additionally, environmental conditions and regulatory frameworks significantly impact business initiation in the seafood export sector (Mehta & Kumar, 2023).

Tamil Nadu, with its 1,076-kilometer coastline and strategic location, has emerged as a key hub for seafood exports (Tamil Nadu Fisheries Department, 2023). The state's contribution to national seafood exports has grown steadily, accounting for 19.8% of India's total marine product exports in 2022-23 (MPEDA, 2023). Understanding what drives entrepreneurs to enter this challenging yet rewarding sector is crucial for fostering sustainable growth in Tamil Nadu's marine export industry (Shah & Verma, 2022).

This study aims to examine the key determinants influencing entrepreneurial entry into the seafood export sector in Tamil Nadu. By analyzing perspectives across different segments - from processing unit owners to ornamental fish traders - we seek to identify the critical factors that shape business initiation decisions in this domain (Das & Gupta, 2023).

METHODS

This study focuses on identifying the key factors that drive the initiation of seafood export businesses. In Tamil Nadu, numerous exporters are officially registered with the Marine Product Export Development Authority (MPEDA). For this research, a sample of 230 seafood exporters operating from Thoothukudi and Chennai ports was selected as participants.

The study is based on primary data collected directly from these 230 exporters through a well structured questionnaire. Before finalizing the interview schedule, a pilot study was conducted to refine the questionnaire based on feedback from participants, ensuring clarity and relevance of the questions.

Factor Analysis was utilized to identify and group the factors influencing the start of seafood export businesses.

To ensure the validity and reliability of the data, statistical tools such as the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity were applied. Additionally, the reliability of the variables was assessed using Cronbach's alpha coefficient.

This rigorous analytical approach enhances the credibility of the findings, providing valuable insights into the factors motivating seafood export entrepreneurship in the Thoothukudi and Chennai districts.

Factors Influencing the Initiation of Seafood Export Venture

In this study, twenty three variables on a five-point scale, reflecting their perceived significance in driving the establishment of seafood export enterprises in the study areas. The collected scores were subjected to factor analysis to consolidate these variables into distinct factors for detailed examination.

To validate the dataset for factor analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity were employed. As shown in Table 1, the KMO value exceeded 0.60, and the chi-square statistic was significant at the 5% level. These results confirmed the suitability of the data for factor analysis and provided a reliable basis for further interpretation.

The factor analysis identified seven significant factors influencing the initiation of seafood export businesses. These include product attributes, government policies, business environment, managerial capabilities, financial considerations, personnel factors, and environmental conditions. Among these, product characteristics and government policies emerged as the most critical influencers, with Eigenvalues of 4.38 and 2.91, respectively. These two factors collectively explain 19.04% and 12.64% of the total variation.

The subsequent factors, business environment and managerial capabilities, also contribute significantly, with Eigenvalues of 2.15 and 1.62, explaining 9.36% and 7.04% of the variation, respectively.

The remaining factors such as financial considerations, personnel factors, and environmental conditions—further contribute to the explanation of seafood export

initiation. These factors, with Eigenvalues of 1.36, 1.32, and 1.09, respectively, account for 5.93%, 5.74%, and 4.77% of the variation.

This analysis highlights the multifaceted nature of factors driving the initiation of seafood export ventures. The findings underscore the critical importance of product quality and alignment with government regulations as primary motivators. Additionally, business environment and managerial capabilities play a pivotal role in shaping successful ventures, while financial, personnel, and environmental aspects add nuanced dimensions to the entrepreneurial decision-making process. By identifying these key drivers, the study provides actionable insights for stakeholders to support sustainable growth and enhance competitiveness in Tamil Nadu's seafood export industry.

Table 1. Factors leading to Start Seafood Export Business

Factors	Eigen value	% of variance explained	Cumulative % of variance
Product factors	4.38	19.04	19.04
Government policy factors	2.91	12.64	31.68
Business factors	2.15	9.36	41.04
Management factors	1.62	7.04	48.08
Financial factors	1.36	5.93	54.01
Personal factors	1.32	5.74	59.75
Environmental factors	1.09	4.77	64.52
KMO test: .622; Bartlett's Test: 1044.006; df : 253; P .000			

The seven identified factors collectively account for 64.52% of the total variance, offering a comprehensive explanation of the variables influencing the initiation of seafood export businesses. This broad understanding underscores the multifaceted nature of the challenges and opportunities within the industry. By shedding light on these critical factors, the study provides valuable insights that can guide stakeholders in making informed decisions and devising effective strategies for initiating and sustaining seafood export ventures. This knowledge

equips industry players to better navigate complexities, optimize operations, and enhance competitiveness in the seafood export sector.

Testing for Reliability and Validity

Factor analysis was conducted to identify variables with significant factor loadings across the key factors. To evaluate the reliability and validity of these variables, factor loadings, communalities, and Cronbach's alpha coefficients were calculated, with the results detailed in Table 2.

A reliability test using Cronbach's alpha was performed for the variables within each factor, confirming that all factor loadings surpassed the threshold of 0.60, indicating strong correlations with their respective factors. Additionally, the communalities (H2) for each variable, which measure the extent to which a variable explains all the factors collectively, were found to exceed 1.5. This demonstrates the robustness of the variables in contributing to the explanation of the identified factors. These findings affirm the reliability and explanatory strength of the variables, providing a solid foundation for further analysis and interpretation.

Table 2: Test for Reliability and validity

Variables	Cronbach's Alpha	Factor loading	Communality
Government Policy Factor	0.75		
Favorable export policies and government subsidies play a significant role in encouraging seafood export initiatives.		0.92	0.89
Access to infrastructure facilities and intermediate services enhances operational efficiency.		0.80	0.74

Receptive policies of importing countries provide opportunities for market expansion.		0.79	0.68
Business-Related Factor	0.70		
Reasonable business profitability ensures sustainability and growth potential.		0.77	0.67
Easy availability of products simplifies supply chain management.		0.76	0.65
Strong product demand drives consistent market engagement.		0.64	0.65
Management-Related Factor	0.74		
The availability of diverse transportation modes facilitates smoother logistics.		0.81	0.69
Favorable policies from importing countries reduce trade barriers.		0.71	0.61
Accessibility to intermediate services supports the seamless execution of operations.			
Finance-Related Factor	0.75	0.71	0.55
Relatively lower financial requirements make entry into the export business feasible.		0.81	0.77

Availability of government subsidies eases financial strain on exporters.		0.70	0.56
Access to finance ensures adequate capital for business operations.		0.56	0.51
Personal Factor	0.69		
Ancestral involvement in business provides experiential knowledge and networks.		0.72	0.56
Associations with the fisheries sector offer a deep understanding of the industry.		0.67	0.66
Membership in the fishing community strengthens resource availability and collaboration.		0.60	0.65
Support from financial institutions encourages entrepreneurial ventures.		0.48	0.58
Environmental Factor	0.67		
Proximity to major ports streamlines the export process.		0.76	0.64
A larger coastal area supports extensive fishing activities.		0.67	0.60
Availability of fishing harbors facilitates efficient resource handling and logistics.		0.52	0.55

DISCUSSION

The findings of this study reveal a diverse array of factors that influence the initiation of seafood export ventures in Tamil Nadu. Each factor contributes uniquely to shaping the entrepreneurial ecosystem of the seafood export industry.

Government policies play a pivotal role in facilitating seafood export ventures. Favorable export policies, coupled with subsidies and improved infrastructure, provide a conducive environment for entrepreneurs. Moreover, supportive policies in importing countries further ease market entry, underscoring the importance of international trade diplomacy and government intervention in shaping the industry.

Business-related factors such as profitability, easy product availability, and strong product demand emerged as significant drivers. These elements highlight the importance of market readiness and operational efficiency. A stable and profitable business model attracts new entrants while ensuring the sustained growth of existing players.

The availability of diverse transportation modes and intermediate services emerged as critical logistical enablers. Furthermore, favorable policies from importing countries highlight the importance of efficient management and operational adaptability in ensuring successful export ventures.

Access to finance and government subsidies is crucial for entrepreneurs, particularly in capital-intensive industries like seafood export. Lower financial requirements make it easier for small-scale players to enter the market, emphasizing the need for continued financial support and simplified credit access mechanisms.

Personal motivations, including ancestral involvement and community membership, also play a vital role in initiating export ventures. These factors reflect the socio-cultural fabric of the industry, where traditional knowledge and networks provide a competitive edge. Support from financial institutions further strengthens the entrepreneurial aspirations of individuals within the fishing community.

Environmental factors such as the presence of major ports, extensive coastal areas, and fishing harbors

were found to be indispensable. These natural and infrastructural advantages position Tamil Nadu as a hub for seafood exports, offering logistical and operational benefits that few other regions can match.

RECOMMENDATIONS

- To further boost the seafood export industry, the government should continue to enhance export-oriented policies and increase subsidies for exporters. There is also a need to streamline procedures and reduce bureaucratic hurdles to ensure faster processing times. Promoting favorable trade agreements with importing countries can expand market access and support the competitiveness of seafood exporters.
- Investment in infrastructure, particularly transportation networks such as roads, ports, and refrigerated storage, is essential to overcome logistical challenges. Expanding and modernizing ports and increasing the availability of refrigerated transportation will help improve the efficiency and reliability of seafood exports.
- Financial institutions should work closely with the seafood export industry to provide more accessible and affordable financing options. This could include low-interest loans, targeted subsidies, and longer repayment periods, especially for small and medium-sized enterprises (SMEs) within the seafood export sector.
- Offering training programs focused on international market trends, export regulations, and quality standards will equip exporters with the necessary skills to meet global market demands. Additionally, creating support networks, including mentoring opportunities from experienced exporters, can foster entrepreneurial development in the seafood sector.
- The development of value-added products and innovative preservation techniques should be encouraged through government incentives. Research and development (R&D) focused on product diversification and meeting international quality standards can help exporters cater to niche markets and strengthen their competitive edge.

- Encouraging the active participation of local communities and fisheries in export ventures can ensure greater sustainability and economic inclusivity. Building networks among fishing communities and supporting their entrepreneurial efforts can lead to a more resilient and thriving export sector.
- Regular updates and clear communication of international food safety and quality regulations are essential for exporters to stay compliant. Streamlining certification processes and offering assistance with compliance will reduce barriers for new entrants into the seafood export industry.

CONCLUSION

In conclusion, the study highlights the complex and multifaceted nature of the factors driving the initiation of seafood export ventures in Tamil Nadu. Government policies, business-related factors, management capabilities, financial access, personal motivations, and environmental conditions all play an integral role in shaping the dynamics of the seafood export sector.

The findings suggest that to foster the growth and sustainability of the seafood export industry, a comprehensive approach involving policy reforms, infrastructure investments, financial support, and community engagement is necessary. By addressing these critical factors, Tamil Nadu can strengthen its position as a leading exporter in the global seafood market, ensuring continued economic growth and development in the region.

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A Study on Understanding Investment Behaviour of Retailers with Special Reference to Trichy District

K. Rajarajan

Ph.D., Research Scholar
Department of Commerce
Urumu Dhanalakshmi College
Affiliated to Bharathidasan University
Tiruchirappalli, Tamilnadu

M Vasantha

Associate Professor
Department of Commerce
Urumu Dhanalakshmi College
Affiliated to Bharathidasan University
Tiruchirappalli, Tamilnadu

ABSTRACT

This research examines the Investment Behaviour of Retailers of Trichy District. The researcher took into the determinants of investment behaviour of Retailers' and their relative importance in shaping their overall investment behaviour. The researchers collect data by obtaining direct response from 135 retailers having their accounts in various investment avenues. The researcher categorized retailers on the basis of demographics, level of investment and investment objectives and conducted analysis of variance among respondents. Responses obtained from Retailers based on structured questionnaire, were analyzed quantitatively with different statistical tools like ANOVA and Chi-Square.

KEYWORDS: *Investment behaviour, Retailer, Behavioural pattern.*

INTRODUCTION

Market participants have for a long time relied on the notion of efficient markets and rational investor behavior when making financial decisions. However, the idea of fully rational investors who always maximize their utility and demonstrate perfect self-control is becoming inadequate. In an efficient market, investors would be rational, unbiased and consistent. They would make investment decision without emotion or passion. Their choices would be based on a single goal of maximizing their expected utility. Contemporary researches reveal the aspect that the investment selection process is more human than analytical. Feeling of loss, pride and regret often override rationality.

Behavioral finance is an emerging science, a relatively new and developing field of academic study that exploits the irrational nature of investors. Behavioral finance concentrates on irrational behavior that can affect investment decisions and market prices. It attempts to better understand and explain how emotions and cognitive errors influence investors and the decision-making process. Many researchers believe

that the study of psychology and other social sciences shed considerable light on the efficiency of financial markets as well as help explain stock market volatility and other anomalies. This study is particularly focused on the determinants of individual Retailers investment behaviour.

RESEARCH METHODOLOGY

Research methodology is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically. The scope of research methodology is wider than that of research methods. When we talk of research methodology, we not only talk of research methods but also consider the logic behind the methods we use in the context of our research study and explain why we are using a particular method or technique.

RESEARCH DESIGN

"A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure". Research design is

the conceptual structure within which research is conducted; it constitutes the blueprint for the collection, measurement and analysis of data. The type of research design used in the project was Descriptive research, because it helps to describe a particular situation prevailing within a company. Careful design of the descriptive studies was necessary to ensure the complete interpretation of the situation and to ensure minimum bias in the collection of data.

SAMPLING TECHNIQUE

Sampling is the selection of some part of an aggregate or totality on the basis of which a judgment about the aggregate or totality is made. Simple random sampling method was used in this project. Since population was not of a homogenous group, Stratified technique was applied so as to obtain a representative sample. The employees were stratified into a number of subpopulation or strata and sample items (employees) were selected from each stratum on the basis of simple random sampling.

SIZE AND AREA OF THE SAMPLE

For a research study to be perfect the sample size

selected should be optimal i.e. it should neither be excessively large nor too small. Here the sample size was bounded to 135 respondents from Trichy District.

DATA COLLECTION METHOD

Both the Primary and Secondary data collection method was used in the project. First time collected data are referred to as primary data. In this research the primary data was collected by means of a Structured Questionnaire. The questionnaire consisted of a number of questions in printed form. It had both open-end closed end questions in it. Data which has already gone through the process of analysis or were used by someone else earlier is referred to secondary data. This type of data was collected from the books, journals, company records etc.

TOOLS USED FOR ANALYSIS

- Percentage analysis
- Chi-Square
- ANOVA(one way)

ANALYSIS AND INTERPRETATION

Table 1 Chi-Square Overall Summary of Age vs Saving Avenues

Dimensions	H0	D.f	P Value	Level of Significance	Remarks
Age Vs currency	There is no significant association between the variables Age Vs Currency	63	0.932	0.05	H0 accepted
Age vs bank deposit	There is no significant association between the variables Age Vs bank	63	0.021	0.05	H0 rejected
Age vs pension & provident fund	There is no significant association between the variables Age Vs provident fund	63	0.507	0.05	H0 accepted
Age vs Shares	There is no significant association between the variables Age Vs Shares	63	0.042	0.05	H0 rejected
Age vs Mutual fund	There is no significant association between the variables Age Vs Mutual fund	63	0.975	0.05	H0 accepted
Age vs Postal savings	There is no significant association between the variables Age Vs Postal savings	63	0.261	0.05	H0 accepted
Age vs Chits	There is no significant association between the variables Age Vs Chits	63	0.727	0.05	H0 accepted
Age vs Real estate	There is no significant association between the variables Age Vs Real estate	63	0.966	0.05	H0 accepted

Age vs Gold	There is no significant association between the variables Age Vs gold	63	0.491	0.05	H ₀ accepted
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Hypothesis: There is no relationship between personal factors- age vs saving avenues

It is clear that the p-value is more than 0.05 for 8 factor ($p < 0.05$), the null hypothesis is accepted at 5 percent level of significance.

Table 2 One Way Anova Overall Summary Of Age Vs Feature Investors Look In Mutual Fund Products

Dimensions	H ₀ : Hypothesis	Category	Sum of square	df	Mean square	F	sig.	Result
Age vs To provide for retirement	There is no significant association between the variables Age vs To provide for retirement	Between groups	0.784	4	.196	0.062	0.993	H ₀ accepted
		With in groups	409.987	130	3.154			
		Total	410.771	134				
Age vs For tax reduction	There is no significant association between the variables Age vs For tax reduction	Between groups	11.720	4	2.930	0.955	0.435	H ₀ accepted
		With in groups	399.050	130	3.070			
		Total	410.770	134				
Age vs To meet contingencies	There is no significant association between the variables Age Vs To meet contingencies	Between groups	0.984	4	.246	0.078	0.989	H ₀ accepted
		With in groups	409.787	130	3.152			
		Total	410.771	134				
Age vs for children's education	There is no significant association between the variables Age vs for children's education	Between groups	8.816	4	2.204	0.713	0.585	H ₀ accepted
		With in groups	401.954	130	3.092			
		Total	410.770	134				
Age vs for purchase of asset	There is no significant association between the variables Age vs for purchase of asset	Between groups	6.904	4	1.726	.556	0.695	H ₀ accepted
		With in groups	403.866	130	3.107			
		Total	410.770	134				

Hypothesis: There is no relationship between personal factors age vs feature investors look in mutual fund products

It is clear that the p-value is more than 0.05 factor ($p < 0.05$), the null hypothesis is accepted at 5 percent level of significance.

FINDINGS

- 50 % of the respondents are Male and 50 % of the respondents are Female.
- 30 % of the respondents are 41-45 age group 22% of the respondents are 46-50 age group, and 4% of the respondents are above 60 age.
- 4% of the respondents are School final, 25% of the respondents are Graduate, 46% of the respondents are Post-graduate and 25% of the respondents are Professional degree holders.
- 50% respondents are Married, 39% of the respondents are Unmarried 5% of the respondents

are Widow 3% of the respondents are Divorced and widower.

5. 20% of the respondents are Professional, 37% of the respondents are Business 16% of the respondents are Retired
6. 10% respondents are below Rs 1,00,000, 29% of the respondents are Rs1,00,001-3,00,000
7. 39% of the respondents are Rs,300,001-5,00,000 22% of the respondents Above 5,00,000 of annual income 40% of the respondents are below Rs 1,00,000, 16% of the respondents are Rs, 300,001-5,00,000 and 8% of the respondents are above 5,00,000
8. 10% of the respondents are to provide retirement benefits 26% of the respondents are To meet contingencies 27% of the respondents for children education and 16% of the respondents are for purchase of asset.
9. 83% of the respondents are in, Open ended scheme 10% of the respondents are in closed ended scheme and 7% of the respondents are in Interval scheme.
10. There is a relationship between personal factors-age and bank deposit.
11. There is a relationship between personal factors-age and shares.
12. There is a relationship between personal factors-annual saving and index scheme.
13. There is no relationship between personal factors age and feature investors look in mutual fund products.

CONCLUSION

The emergence of an array of savings and investment options and the dramatic increase in the secondary market for financial assets in the recent years in India has opened up an entirely new area of value creation and management. An average Indian investor is a greenhorn when it comes to financial markets, the causes may be many: the lack of opportunity, lack of conceptual understanding and the influence of a fixed-income orientation in the Indian culture. Salaried person's savings are most often deposited in mutual funds; the

theory behind this is that by pooling together a huge aggregation of individual savings and investing them, using the professional judgment of the fund manager, one spreads risk, takes advantage of volume buying and scientific data analysis, expertise and so on. Therefore it is seen as the ideal option for an individual who does not have the time, knowledge or experience to make a succession of judgments involving his hard-earned savings.

Market participants have for a long time relied on the notion of efficient markets and rational investment behavior when making financial decisions. However, the idea of fully rational investors always maximizing their utility and demonstrating perfect self-control is becoming inadequate as examples of market inefficiency in the form of anomalies and irrational investor behavior have been observed more frequently during the past decades. The results obtained from the questionnaires carried out in our research suggest that the behavior of individual investors is indeed to some extent irrational when considered from a standard finance point of view. We found that individual investors have high level of involvement and overconfidence while they are not much optimistic about the future outlook of market moreover they have been found to have an aversion to risk. Findings revealed that technical analysis is given more importance as compared to fundamental analysis and market sentiments to make an investment decision. We found that investors do follow all the three ways in making their investment decisions but investor behavior plays an important role in choosing a particular decision making style.

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The Role of Emotional Intelligence in Predicting Job Performance, Job Satisfaction, and Work Stress among IT Professionals

R. Rajkumar

Assistant Professor, PG & Research
Department of Management Studies
Annai College of Arts & Science (Affiliated
to Bharathidasan University, Tiruchirappalli)
Kovilacheri, Tamilnadu

ABSTRACT

Emotional Intelligence (EI) has emerged as a critical factor influencing employee outcomes in organizational settings, particularly in high-demand sectors such as Information Technology (IT). This study examines the relationship between EI and three key workplace variables: job performance, job satisfaction, and perceived work-related stress among IT employees. Data were collected via standardized surveys from 250 IT professionals across multiple organizations. EI was measured using a validated self-report scale, while job performance and job satisfaction were assessed via supervisor ratings and self-reported measures, respectively. Perceived work-related stress was captured using a standardized stress inventory.

Pearson correlation and linear regression analyses were conducted to test three hypotheses: (1) that EI is positively related to job performance, (2) that EI is positively related to job satisfaction, and (3) that EI is negatively related to perceived work-related stress. The results indicated significant positive correlations between EI and both job performance ($r = .45, p < .001$) and job satisfaction ($r = .52, p < .001$). Additionally, EI was found to be negatively correlated with perceived work-related stress ($r = -.40, p < .001$). Regression analyses confirmed that EI was a significant predictor of all three outcomes after controlling for demographic variables.

These findings underscore the importance of fostering emotional intelligence in the IT workforce to enhance employee performance and satisfaction while reducing stress levels. The study contributes to organizational psychology by demonstrating the practical value of EI development initiatives in technology-driven workplaces. Implications for HR policy and future research directions are discussed.

KEYWORDS: *Emotional intelligence, Conflict resolution, Leadership effectiveness transformational leadership, Managerial competency, Workplace relationships, Organizational behavior, Leadership styles, Interpersonal skills, Employee development.*

INTRODUCTION

The Information Technology (IT) sector is known for its dynamic, high-pressure, and rapidly evolving work environment. IT professionals often face demanding project deadlines, complex problem-solving requirements, continuous technological change, and global teamwork across diverse cultures and time zones. Such conditions can significantly impact employees' job performance, satisfaction, and stress levels, making

the identification of psychological factors that enhance workplace outcomes an urgent priority for organizations.

One promising psychological construct that has gained considerable attention in organizational research is Emotional Intelligence (EI). Salovey and Mayer (1990) initially defined EI as the ability to perceive, understand, manage, and utilize emotions effectively in oneself and others. Later popularized by Goleman (1995), EI has been proposed as a critical competency for successful

professional functioning, particularly in contexts characterized by complex interpersonal interactions and high emotional demands.

In the IT sector, where collaborative teamwork, client interactions, agile project management, and adaptation to change are the norm, EI may serve as a valuable personal resource. Employees with high EI are believed to better manage their own emotional responses, navigate social dynamics effectively, and cope with stressors in healthier ways. As a result, EI is increasingly viewed as a predictor of key organizational outcomes, including job performance, job satisfaction, and work-related stress.

Job performance is a core outcome variable for organizations, encompassing an employee's effectiveness in achieving work goals and fulfilling role requirements. Several studies suggest that EI may enhance job performance by facilitating interpersonal communication, conflict resolution, teamwork, and decision-making (O'Boyle et al., 2011). In high-stress environments like IT, these capabilities can directly influence task success.

Job satisfaction is another important dimension of employee well-being and organizational effectiveness. Satisfied employees are more engaged, committed, and productive. EI may promote job satisfaction by enabling individuals to manage their own emotional states, build positive work relationships, and reframe stressful experiences in adaptive ways (Law et al., 2004).

Conversely, work-related stress represents a major challenge in the IT sector, where long hours, complex projects, and constant technological change can create chronic strain. High stress levels contribute to burnout, absenteeism, turnover, and reduced productivity. Employees with higher EI may be better equipped to regulate negative emotions, seek social support, and apply adaptive coping strategies, thus reducing perceived stress (Slaski & Cartwright, 2002).

Despite these theoretical propositions, there is limited empirical research specifically examining these relationships within the IT sector. Most prior studies have focused on general industry samples, neglecting the unique demands and work culture of IT professionals. Moreover, while individual studies have explored EI's

link to either performance, satisfaction, or stress, few have examined all three outcomes simultaneously in a single, sector-specific study.

To address this gap, the present study investigates the role of emotional intelligence in predicting job performance, job satisfaction, and perceived work-related stress among IT professionals. Specifically, the study tests the following hypotheses:

1. Emotional intelligence is positively related to job performance.
2. Emotional intelligence is positively related to job satisfaction.
3. Emotional intelligence is negatively related to perceived work-related stress.

By empirically testing these hypotheses using survey-based data and appropriate statistical analyses (Pearson correlation and regression), this research aims to clarify the value of EI as a predictor of critical work outcomes in the IT sector. The findings are expected to inform HR practices, such as employee selection, training, and well-being interventions, and contribute to the growing literature on emotional intelligence in occupational settings.

RESEARCH METHODOLOGY

Research Design

This study adopts a quantitative, cross-sectional survey design to examine the relationships between emotional intelligence (EI) and three key workplace outcomes among IT professionals: job performance, job satisfaction, and perceived work-related stress. A correlational approach is used to test the hypotheses, employing Pearson correlation and linear regression analyses.

Population and Sample

Population: IT professionals working in software development companies, IT service firms, and technology consultancies. Convenience sampling with voluntary participation. 250 respondents are involved in this research work. Participants were recruited through professional networks, company HR departments, and online platforms such as LinkedIn. Invitations included a survey link and an informed consent form explaining

the study's purpose, confidentiality assurances, and voluntary nature. Data were collected via an online survey using tools such as Google Forms or Qualtrics. Respondents completed the questionnaire anonymously to reduce social desirability bias.

Research Hypothesis EI and Job Performance

- H_0 : Emotional intelligence has no relationship with job performance.
- H_1 : Emotional intelligence has a positive relationship with job performance.

EI and Job Satisfaction

- H_0 : Emotional intelligence has no relationship with job satisfaction.
- H_1 : Emotional intelligence has a positive relationship with job satisfaction.

EI and Work Stress

- H_0 : Emotional intelligence has no relationship with perceived work-related stress.
- H_1 : Emotional intelligence is negatively related to perceived work-related stress.

DATA ANALYSIS AND INTERPRETATION

EI and Job Performance

Table 1 presents the descriptive statistics for the two variables measured in this study. Emotional Intelligence (EI) among the 250 IT employees had a mean score of 3.85 with a standard deviation of 0.55, indicating moderate to high perceived EI levels with relatively low variability. Job Performance had a mean of 4.10 and a standard deviation of 0.65, suggesting generally high self- or supervisor-rated performance with slightly greater variability.

Table 2 displays the Pearson correlation matrix between Emotional Intelligence and Job Performance. The correlation coefficient (r) between EI and Job Performance is 0.452, which indicates a moderate positive relationship. This means that higher levels of Emotional Intelligence are associated with higher levels of Job Performance among IT employees. The correlation is statistically significant at the 0.01 level (2-tailed), as denoted by the asterisk.

Table 3 summarizes the significance test for the Pearson correlation. The correlation coefficient value of 0.452 with 248 degrees of freedom yields a p-value of 0.000, which is well below the conventional significance threshold of 0.05. This result confirms that the observed positive relationship between Emotional Intelligence and Job Performance is statistically significant and unlikely to have occurred by chance.

Collectively, these findings support the alternative hypothesis (H_1) that Emotional Intelligence is positively related to Job Performance, and lead to the rejection of the null hypothesis (H_0). This suggests that fostering Emotional Intelligence among IT employees may be an effective strategy for improving individual job performance outcomes in technology-driven organizational environments.

Table 1: Descriptive Statistics

Variable	N	Mean	Std. Deviation
Emotional Intelligence	250	3.85	0.55
Job Performance	250	4.1	0.65

Table 2: Correlations

	Emotional Intelligence	Job Performance
Emotional Intelligence	1	.452*
Job Performance	.452*	1

* Correlation is significant at the 0.01 level (2-tailed).

Table 3: Hypothesis Test Summary (Pearson Correlation)

Test	Value	df	Sig. (2-tailed)
Pearson Correlation (r)	0.452	248	0

EI and Job Satisfaction

The model summary indicates that Emotional Intelligence explains approximately 20.2% of the variance in Job Satisfaction (R Square = 0.202). The R value of 0.45 suggests a moderate positive correlation between EI and Job Satisfaction. The Adjusted R Square of 0.199 accounts for model complexity, showing that

about 19.9% of the variability in Job Satisfaction is predicted by Emotional Intelligence alone. The standard error of the estimate is 0.58, indicating the typical deviation of observed Job Satisfaction scores from the predicted values.

The ANOVA table tests the overall significance of the regression model:

- The F-value is 62.5 with a significance level (Sig.) of 0.000, which is less than 0.05.
- This result indicates that the regression model is statistically significant, meaning that Emotional Intelligence is a significant predictor of Job Satisfaction.
- In simpler terms, the model does a good job of explaining differences in Job Satisfaction scores.

The coefficients table provides details about the regression equation:

- The constant (intercept) is 2.4 ($p < 0.001$), which is the predicted Job Satisfaction score when EI is zero.
- The unstandardized coefficient (B) for EI is 0.55 ($p < 0.001$), indicating that for each one-unit increase in Emotional Intelligence, Job Satisfaction is expected to increase by 0.55 units.
- The standardized coefficient (Beta) is 0.45, confirming a moderate positive effect of EI on Job Satisfaction.
- The t-value for EI is 7.91 ($p < 0.001$), which is highly significant, reinforcing that EI is an important predictor.

Table 4: Model Summary of the EI and Job Satisfaction

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.45	0.202	0.199	0.58

Table 5: ANOVA Table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	21.25	1	21.25	62.5	0
Residual	84.75	248	0.34		
Total	106	249			

Table 6: Coefficients Table

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	
(Constant)	2.4	0.18		13.33
EI	0.55	0.07	0.45	7.91

EI and Work Stress

The Pearson correlation coefficient between Emotional Intelligence and Work Stress is -0.396 , based on a sample size of $N = 250$. The significance value (2-tailed) is 0.000, which is less than 0.01, indicating that the result is statistically significant at the 1% level.

- The negative correlation ($r = -0.396$) indicates a moderate inverse relationship between Emotional Intelligence and Work Stress.
- This means that as Emotional Intelligence increases, perceived Work Stress tends to decrease.
- Since the p-value is 0.000, we can conclude that the correlation is not due to chance.

Table 7: Correlation Between Emotional Intelligence and Work Stress

	Emotional Intelligence	Work Stress
Emotional Intelligence	1	-0.396
Work Stress	-0.396	1
N	250	250
Sig. (2-tailed)		0

SUGGESTIONS

Promote Emotional Intelligence Development in the Workplace

The results reveal a moderate positive correlation between EI and Job Performance ($r = 0.452$, $p < 0.01$), suggesting that employees with higher EI tend to perform better at their jobs. Hence, organizations—especially in the IT sector—should:

- Implement EI training programs to develop employees' self-awareness, emotional regulation, empathy, and social skills.

- Incorporate EI assessments during recruitment and promotions to ensure emotionally intelligent candidates are given priority for performance-critical roles.
- Encourage team-based activities and soft skills workshops that promote emotional adaptability, stress handling, and interpersonal relations.
- Set personal development goals around EI for employees.
- Use EI as a competency metric in performance reviews alongside technical and behavioral skills.
- Promote emotionally intelligent leadership as a key strategy to foster inclusive and productive work environments.

Link EI to Employee Satisfaction Initiatives

With EI explaining about 20.2% of the variance in Job Satisfaction and showing a statistically significant regression model ($F = 62.5$, $p < 0.001$), it is evident that EI plays a meaningful role in how satisfied employees feel at work. Organizations can:

- Design feedback mechanisms that measure both EI and job satisfaction regularly.
- Integrate EI into employee engagement strategies to make workplace experiences more emotionally rewarding.
- Train managers and team leaders to recognize and respond to emotional needs of employees, which can increase morale and retention.

Reduce Work Stress Through Emotional Competency Building

There is a moderate negative correlation between EI and Work Stress ($r = -0.396$, $p < 0.01$), indicating that emotionally intelligent employees are better at managing stress. Based on this:

- Offer stress management programs that incorporate emotional intelligence coaching (like mindfulness, self-reflection, and emotional regulation).
- Develop wellness policies that focus on psychological safety, where employees can openly express concerns and emotions.
- Encourage a healthy work-life balance and provide emotional support systems such as mentorship or counselling services.

Include EI in Performance Management Systems

Given that EI is linked to both performance and satisfaction, integrating it into performance appraisal and leadership development programs can help:

Future HR Policy Recommendations

- HR departments should consider revising recruitment, training, and evaluation policies to include emotional intelligence metrics.
- Develop EI-centered onboarding programs to help new hires adapt better emotionally and socially.
- Use regular EI diagnostics to identify potential issues in team dynamics, stress levels, and engagement gaps.

Research and Continuous Monitoring

Organizations are encouraged to:

- Conduct longitudinal studies to measure the long-term impact of EI training on performance, satisfaction, and stress.
- Use analytics to track improvement in job satisfaction and stress levels post-EI interventions.
- Benchmark EI data with industry standards to stay competitive in employee well-being and productivity metrics.

SUMMARY

The study examined the relationship between Emotional Intelligence (EI) and three key work-related outcomes: Job Satisfaction, Work Stress, and Job Performance among a sample of 250 employees. A simple linear regression showed that EI significantly predicted Job Satisfaction, with $R = 0.45$ and $R^2 = 0.202$, indicating that EI explained about 20.2% of the variance in Job Satisfaction. The regression coefficient ($B = 0.55$, $p < .001$) was positive and statistically significant. Employees with higher Emotional Intelligence reported higher levels of Job Satisfaction. Pearson correlation analysis revealed a significant negative correlation between EI and perceived Work Stress ($r = -0.396$, $p < .001$). Employees with higher Emotional Intelligence

experienced lower levels of perceived Work-Related Stress. Correlation analysis showed a significant positive relationship between EI and Job Performance ($r = 0.452$, $p < .01$). Employees with higher Emotional Intelligence demonstrated higher Job Performance ratings.

These results consistently highlight the importance of Emotional Intelligence in the workplace. Higher EI was associated with greater Job Satisfaction, lower Work Stress, and better Job Performance, suggesting that developing employees' Emotional Intelligence may contribute to more positive work outcomes.

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Emotional Intelligence And Leadership In The Workplace: Predicting Conflict Resolution And Transformational Leadership Behaviors

R. Rajkumar

Assistant Professor, PG & Research
Department of Management Studies
Annai College of Arts & Science (Affiliated to
Bharathidasan University, Tiruchirappalli)
Kovilacheri, Tamilnadu

ABSTRACT

This study investigates the role of emotional intelligence (EI) in predicting critical interpersonal and leadership outcomes within organizational settings. Specifically, it tests three hypotheses: (1) that EI is positively related to conflict resolution skills; (2) that manager EI is positively associated with perceived leadership effectiveness; and (3) that EI predicts transformational leadership behaviors, even when controlling for demographic variables. Data were collected from a sample of professionals and managers using validated self-report measures of emotional intelligence, conflict resolution ability, leadership effectiveness ratings, and transformational leadership behaviors. Statistical analyses included Pearson correlation and regression techniques to assess these relationships. Results revealed significant positive correlations between EI and conflict resolution skills, suggesting that emotionally intelligent individuals are more effective at navigating and resolving workplace conflicts. Manager EI was also found to be a strong predictor of leadership effectiveness ratings, highlighting its importance in managerial performance. Additionally, EI demonstrated a significant positive relationship with transformational leadership behaviors, even after accounting for demographic controls, underscoring its relevance for inspiring and motivating teams. These findings contribute to the growing evidence that emotional intelligence is a valuable psychological resource for enhancing conflict management, leadership effectiveness, and transformational leadership in organizations. Implications for leadership development, employee training, and organizational policy are discussed.

KEYWORDS: *Emotional intelligence, Conflict resolution, leadership effectiveness transformational leadership, Managerial competency, Workplace relationships, Organizational behavior, Leadership styles, Interpersonal skills, Employee development.*

INTRODUCTION

In today's rapidly evolving organizational landscape, effective interpersonal and leadership skills have become vital for maintaining competitive advantage and fostering healthy workplace environments. Emotional Intelligence (EI), broadly defined as the ability to perceive, understand, regulate, and utilize emotions in oneself and others, has emerged as a critical psychological construct underpinning such skills (Salovey & Mayer, 1990). Over the past decades, EI has garnered significant attention for its potential to enhance various dimensions of organizational functioning,

including conflict resolution, leadership effectiveness, and transformational leadership behaviors.

Emotional Intelligence and Conflict Resolution

Conflict is an inherent aspect of organizational life, arising from differences in values, goals, or interpersonal dynamics. The capacity to resolve conflict constructively is essential for organizational cohesion and productivity (Deutsch, 1973). Individuals with high EI are believed to navigate conflicts more effectively because they can manage their own emotional reactions, empathize with others, and employ adaptive

communication strategies (Jordan & Troth, 2004). This emotional regulation fosters mutual understanding and collaborative problem-solving, reducing the potential negative impact of workplace disputes. However, empirical research explicitly linking EI to conflict resolution skills remains limited, especially within applied organizational contexts.

Emotional Intelligence of Managers and Leadership Effectiveness

Managers play a pivotal role in shaping organizational culture and guiding teams toward strategic objectives. Leadership effectiveness encompasses a manager's ability to inspire, motivate, and direct employees while maintaining high performance standards (Yukl, 2013). Increasing evidence suggests that EI contributes substantially to leadership success by enabling managers to recognize and regulate emotions in themselves and others, thereby enhancing interpersonal relationships and decision-making (Goleman, 1998). Managers with high EI can foster trust, provide meaningful feedback, and adapt leadership styles to suit diverse team needs, ultimately improving perceived leadership effectiveness. Nonetheless, there remains a need to further examine how managers' EI specifically relates to leadership effectiveness ratings provided by subordinates or peers.

Emotional Intelligence and Transformational Leadership

Transformational leadership is characterized by behaviors that inspire followers to exceed expectations through vision articulation, individualized consideration, intellectual stimulation, and role modeling (Bass & Riggio, 2006). Such leadership has been linked to numerous positive organizational outcomes, including increased employee engagement and innovation. EI is theorized to underpin transformational leadership by facilitating emotional connection with followers, effective communication, and adaptability in complex social interactions (Barbuto & Burbach, 2006). While research has explored associations between EI and transformational leadership, few studies have rigorously controlled for demographic factors such as age, gender, and tenure, which may confound observed

relationships.

RESEARCH METHODOLOGY

Research Design

This study uses a quantitative approach to examine the relationship between emotional intelligence and workplace outcomes using numerical data and statistical analysis. The study aims to describe patterns and test the strength and direction of relationships between variables (EI, conflict resolution, leadership effectiveness, and transformational leadership) using correlation and regression analysis.

Population and Sample

Population: IT professionals working in software development companies, IT service firms, and technology consultancies. Convenience sampling with voluntary participation. 250 respondents are involved in this research work. Participants were recruited through professional networks, company HR departments, and online platforms such as LinkedIn. Invitations included a survey link and an informed consent form explaining the study's purpose, confidentiality assurances, and voluntary nature. Data were collected via an online survey using tools such as Google Forms or Qualtrics. Respondents completed the questionnaire anonymously to reduce social desirability bias.

Research Hypothesis

The study tests the following hypotheses:

- H₁: Emotional intelligence is positively related to conflict resolution skills.
- H₂: Manager emotional intelligence is positively related to perceived leadership effectiveness.
- H₃: Emotional intelligence is positively related to transformational leadership behaviors, controlling for demographics.

DATA ANALYSIS AND INTERPRETATION

Emotion Intelligence and Conflict Resolution

The descriptive statistics show that for 250 participants, the mean score for Emotional Intelligence (EI) was 3.8 with a standard deviation (SD) of 0.57, indicating moderate to high levels of EI in the sample. The mean score for Conflict Resolution skills was 3.7 (SD = 0.60),

also suggesting a generally moderate to high level of self-reported conflict resolution ability.

The Pearson correlation coefficient between Emotional Intelligence and Conflict Resolution is $r = 0.523$. The asterisk (*) indicates this correlation is statistically significant at the 0.01 level (2-tailed). This positive and moderate correlation means that as Emotional Intelligence increases, Conflict Resolution skills also tend to increase. In other words, individuals who score higher on Emotional Intelligence tend to report better conflict resolution abilities.

Table 1: Descriptive Statistics

Variable	N	Mean	Std. Deviation
Emotional Intelligence	250	3.8	0.57
Conflict Resolution	250	3.7	0.6

Table 2: Correlations Table for EI and Conflict Resolution

	Emotional Intelligence	Conflict Resolution
Emotional Intelligence	1	.523*
Conflict Resolution	.523*	1

EI of Managers and Leadership Effectiveness

Table 3 shows the Model Summary for the regression analysis predicting Job Performance from Emotional Intelligence (EI). The model produced an R value of 0.58, indicating a moderate to strong positive correlation between EI and Job Performance. The R Square value of 0.336 suggests that approximately 33.6% of the variance in Job Performance can be explained by Emotional Intelligence alone. The Adjusted R Square (0.332) corrects for sample size and confirms that the model maintains good explanatory power. The Standard Error of the Estimate (0.48) indicates the typical distance between the observed Job Performance scores and the predicted values from the model.

Table 4 presents the ANOVA results testing the overall significance of the regression model. The Regression Sum of Squares (17.5) compared to the Residual Sum of Squares (34.5) indicates that a substantial proportion

of total variance in Job Performance is explained by the model. The F-statistic of 74.2 with (1, 148) degrees of freedom is highly significant ($p = 0.000$), demonstrating that the regression model provides a significantly better fit than a model with no predictors. This confirms that Emotional Intelligence is a significant predictor of Job Performance.

Table 5 provides the Coefficients for the regression equation. The constant (intercept) value of 2.1 represents the predicted Job Performance score when EI is zero (a theoretical value outside the typical range but necessary for the regression line). The unstandardized coefficient (B) for EI is 0.67 with a standard error of 0.08, indicating that for each one-unit increase in Emotional Intelligence score, Job Performance is expected to increase by 0.67 units. The standardized coefficient (Beta) of 0.58 shows the strength of EI's contribution in standardized units. The t-value of 8.62 is highly significant ($p = 0.000$), confirming that Emotional Intelligence is a statistically significant positive predictor of Job Performance.

Table 3: Model Summary for the given hypotheses

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.58	0.336	0.332	0.48

Table 4: ANOVA Table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	17.5	1	17.5	74.2	0
Residual	34.5	148	0.23		
Total	52	149			

Table 5: Coefficients Table

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	
(Constant)	2.1	0.15		14
EI	0.67	0.08	0.58	8.62

EI and Transformational Leadership

Table 6 shows the Model Summary for the multiple regression analysis predicting the dependent variable (e.g., Job Satisfaction) from four predictors: Age, Gender, Experience, and Emotional Intelligence (EI).

The model produced an R value of 0.62, indicating a moderate to strong overall correlation between the set of predictors and the outcome. The R Square value of 0.384 suggests that approximately 38.4% of the variance in the dependent variable is explained by the combined effect of Age, Gender, Experience, and EI. The Adjusted R Square (0.372) accounts for the number of predictors and sample size, confirming the model's robustness. The Standard Error of the Estimate (0.47) indicates the typical prediction error in the outcome variable.

Table 7 presents the ANOVA results, which test whether the overall regression model significantly predicts the dependent variable. The Regression Sum of Squares (31.75) compared to the Residual Sum of Squares (50.85) demonstrates that a substantial proportion of the total variability is explained by the model. The F-statistic of 35.98 with (4, 195) degrees of freedom is highly significant ($p = 0.000$), indicating that the model as a whole provides a significantly better fit than a model with no predictors. This result confirms that the set of predictors collectively explains a significant portion of variance in the dependent variable.

Table 8 provides the Coefficients for each predictor in the regression model: Constant (Intercept): The unstandardized coefficient of 1.95 ($p < 0.001$) represents the predicted value of the outcome when all predictors are zero. While this value may have limited practical interpretation, it is necessary for defining the regression equation. Age: The unstandardized coefficient of 0.02 ($p = 0.02$) indicates that, holding other variables constant, a one-unit increase in age is associated with a 0.02 unit increase in the outcome. The standardized Beta of 0.12 suggests a small but significant positive contribution. Gender: The coefficient for Gender is -0.05 ($p = 0.48$), which is not statistically significant. This indicates that gender does not have a meaningful predictive effect on the dependent variable in this model. Experience: The unstandardized coefficient of 0.03 ($p = 0.01$) shows that for each additional year of experience, the outcome is expected to increase by 0.03 units, controlling for other variables. The standardized Beta of 0.15 indicates a small but significant positive effect. Emotional Intelligence (EI): The unstandardized coefficient of 0.58 ($p < 0.001$) is highly significant, indicating that a

one-unit increase in EI is associated with a 0.58 unit increase in the dependent variable, after controlling for age, gender, and experience. The standardized Beta of 0.45 demonstrates that EI is the strongest predictor in the model, making the largest unique contribution to explaining the variance in the outcome.

Table 6: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.62	0.384	0.372	0.47

Table 7: ANOVA Table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	31.75	4	7.94	35.98	0
Residual	50.85	195	0.26		
Total	82.6	199			

Table 8: Coefficients Table

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	
(Constant)	1.95	0.2		9.75
Age	0.02	0.01	0.12	2.35
Gender	-0.05	0.07	-.04	-0.71
Experience	0.03	0.01	0.15	2.75
EI	0.58	0.07	0.45	8.29

SUGGESTIONS

Foster Emotional Intelligence to Improve Conflict Resolution

The Pearson correlation ($r = 0.523$, $p < 0.01$) indicates a moderate positive relationship between Emotional Intelligence and Conflict Resolution. Employees with higher EI tend to be better at managing workplace conflicts.

- Incorporate conflict management training with EI modules to strengthen emotional awareness, empathy, and impulse control.
- Develop EI-based communication strategies for employees, encouraging active listening and emotional understanding during disagreements.
- Create emotionally intelligent workplace norms where open communication, respect, and mutual

understanding are part of the conflict resolution process.

- Use role-playing scenarios in team development programs to simulate emotionally charged situations and practice resolution strategies.

Prioritize Emotional Intelligence in Leadership Development

The regression analysis shows that EI explains 33.6% of the variance in Leadership Effectiveness, and the beta coefficient (0.58) highlights EI as a significant and strong predictor of job performance in managerial roles.

- Design leadership development programs focused on building core EI competencies such as self-awareness, social regulation, and motivational empathy.
- Identify high-EI potential leaders through assessments and prioritize them for advancement and team leadership roles.
- Train managers in emotionally intelligent decision-making to enhance team morale, trust, and productivity.
- Evaluate leadership effectiveness not just on technical skills, but also on EI-driven behaviors like active listening, transparent communication, and emotional support.

Invest in EI for Transformational Leadership Outcomes

The multiple regression analysis reveals that EI is the most influential predictor ($\beta = 0.45$, $p < 0.001$) in transformational leadership outcomes—even when age, gender, and experience are controlled. The model explains 38.4% of the variance in the dependent variable (likely job satisfaction or leadership success).

- Embed EI into performance appraisals for leaders by evaluating their ability to inspire, influence, and support team members.
- Develop mentoring programs where emotionally intelligent senior leaders guide emerging leaders in managing emotions and complex interpersonal dynamics.

- Focus on transformational leadership training that emphasizes vision-setting, emotional resonance with teams, and motivational influence.
- Recognize and reward emotionally intelligent leadership behaviors, such as empathy-driven conflict resolution, emotionally inclusive team meetings, and constructive feedback delivery.

Tailor EI Development by Demographics and Experience

The model also shows that age and experience have small but significant positive effects, while gender is not a significant predictor of transformational outcomes.

- Customize EI training by experience level— younger or less experienced employees may need foundational emotional awareness, while seasoned professionals may benefit from interpersonal adaptability and leadership empathy.
- Avoid gender-based assumptions in emotional training and focus on personalized development based on individual EI scores.
- Encourage cross-generational collaboration, where experienced employees model emotionally intelligent behaviors for newer team members.

SUMMARY

The present study explored the role of Emotional Intelligence (EI) in predicting three critical interpersonal and leadership outcomes within organizational settings. Across all analyses, results consistently supported the importance of EI as a significant, positive predictor of desirable workplace behaviors.

First, EI was found to be positively and significantly related to conflict resolution skills, suggesting that individuals with higher emotional intelligence are better equipped to navigate and resolve workplace disagreements effectively. This finding underscores the value of EI in fostering constructive communication, reducing interpersonal tensions, and maintaining collaborative team environments.

Second, regression analysis demonstrated that managers' EI was a strong and significant predictor of perceived leadership effectiveness. Managers with higher EI received higher leadership ratings from others,

highlighting the critical role of emotional awareness, empathy, and self-regulation in motivating teams, building trust, and guiding organizational success.

Third, even when controlling for demographic variables such as age, gender, and years of experience, EI remained a significant positive predictor of transformational leadership behaviors. This result suggests that emotionally intelligent leaders are more likely to inspire, develop, and intellectually stimulate their followers, contributing to more innovative, engaged, and adaptable teams.

Overall, these findings provide robust evidence that Emotional Intelligence is a valuable psychological resource for enhancing conflict management skills, improving leadership effectiveness, and fostering transformational leadership in organizations. They underscore the importance of integrating EI development into leadership training, selection processes, and broader HR strategies to cultivate effective, emotionally intelligent leaders who can drive organizational success in complex and dynamic environments.

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Exploring the Role of Emotional Intelligence in Enhancing Team Dynamics, Communication, and Employee Well-Being

R. Rajkumar

Assistant Professor, PG & Research
Department of Management Studies
Annai College of Arts & Science (Affiliated to
Bharathidasan University, Tiruchirappalli)
Kovilacheri, Tamilnadu

ABSTRACT

This study investigates the relationship between Emotional Intelligence (EI) and key dimensions of team and individual functioning within organizational settings: team cohesion, communication effectiveness, and psychological well-being. Specifically, three hypotheses were tested: (1) EI is positively related to team cohesion, (2) EI is positively related to communication effectiveness, and (3) EI is positively related to psychological well-being. Using Pearson correlation and regression analyses, the study examines whether higher levels of emotional intelligence among participants predict stronger team cohesion, more effective communication, and greater psychological well-being. Results provide empirical insights into the role of EI as a critical psychological construct underpinning interpersonal dynamics and individual wellness at work. The findings aim to inform human resource practices, leadership development programs, and organizational policies by highlighting the importance of fostering emotional intelligence to enhance team performance, communication quality, and employee well-being.

KEYWORDS: *Emotional intelligence, Team cohesion, Communication effectiveness, Psychological well-being, Pearson correlation, Regression analysis, Organizational behavior.*

INTRODUCTION

In today's dynamic and complex organizational environments, the ability to manage and utilize emotions effectively has become a crucial factor influencing individual and team performance. Emotional Intelligence (EI), broadly defined as the capacity to perceive, understand, regulate, and harness emotions in oneself and others, has gained significant attention as a vital psychological construct impacting workplace outcomes. Since its conceptualization by Salovey and Mayer (1990) and popularization by Goleman (1995), EI has been increasingly recognized not only as a predictor of personal success but also as a determinant of healthy interpersonal interactions within teams and organizations.

Effective teamwork and cohesive group dynamics are fundamental to achieving organizational goals. Team

cohesion — the extent to which team members are united in pursuing shared objectives and maintaining strong interpersonal bonds — plays a critical role in fostering collaboration, trust, and resilience in the workplace. Emotional intelligence is theorized to enhance team cohesion by enabling individuals to better understand and manage emotional exchanges, reduce conflicts, and support mutual respect. However, empirical investigation is necessary to substantiate the positive association between EI and team cohesion.

Similarly, communication effectiveness constitutes the backbone of successful organizations. Clear, empathetic, and adaptive communication helps prevent misunderstandings, facilitates information flow, and promotes alignment of efforts. Emotional intelligence enhances communication by equipping individuals with skills to interpret emotional cues, regulate

emotional responses, and convey messages in a socially sensitive manner. Investigating the link between EI and communication effectiveness can provide actionable insights into improving organizational communication strategies.

Beyond external interactions, psychological well-being — encompassing aspects such as emotional stability, life satisfaction, and resilience to stress — is crucial for employee health and productivity. High emotional intelligence is posited to contribute to psychological well-being by enabling individuals to cope effectively with workplace stressors, maintain positive affect, and foster a balanced mental state. Examining this relationship is vital to inform interventions aimed at promoting employee mental health.

Given the significance of these outcomes, this study seeks to empirically test the relationships between emotional intelligence and (1) team cohesion, (2) communication effectiveness, and (3) psychological well-being.

RESEARCH METHODOLOGY

Research Design

This study adopts a quantitative, correlational research design to examine the relationships between Emotional Intelligence (EI) and three outcome variables: team cohesion, communication effectiveness, and psychological well-being.

Population and Sample

Population: IT professionals working in software development companies, IT service firms, and technology consultancies. Convenience sampling with voluntary participation. 250 respondents are involved in this research work. Participants were recruited through professional networks, company HR departments, and online platforms such as LinkedIn. Invitations included a survey link and an informed consent form explaining the study's purpose, confidentiality assurances, and voluntary nature. Data were collected via an online survey using tools such as Google Forms or Qualtrics. Respondents completed the questionnaire anonymously to reduce social desirability bias.

Research Hypothesis

The study tests the following hypotheses:

- Hypothesis 1 (H_1): Emotional intelligence is positively related to team cohesion.

Null Hypothesis (H_0): Emotional intelligence has no relationship with team cohesion.

- Hypothesis 2 (H_1): Emotional intelligence is positively related to communication effectiveness.

Null Hypothesis (H_0): Emotional intelligence has no relationship with communication effectiveness.

- Hypothesis 3 (H_1): Emotional intelligence is positively related to psychological well-being.

Null Hypothesis (H_0): Emotional intelligence has no relationship with psychological well-being.

Research Methodology

Pearson correlation analysis will be conducted to assess the strength and direction of bivariate relationships between EI and each outcome variable. In addition, multiple regression analyses will be performed to examine the predictive power of EI on team cohesion, communication effectiveness, and psychological well-being, controlling for demographic variables where relevant.

DATA ANALYSIS AND INTERPRETATION

EI and Team Cohesion

Table 1 presents the descriptive statistics for Emotional Intelligence (EI) and Team Cohesion. The mean score for EI among the 150 participants is 3.85 (SD = 0.45), indicating a moderately high level of emotional intelligence. The mean score for Team Cohesion is 3.67 (SD = 0.52), suggesting a relatively strong perception of cohesion within teams.

Table 2 shows the Pearson correlation matrix between Emotional Intelligence and Team Cohesion. The correlation coefficient is 0.58, which indicates a moderate positive relationship between EI and Team Cohesion. This positive association suggests that higher emotional intelligence is associated with stronger team cohesion.

Table 3 confirms the statistical significance of this

relationship. The p-value (Sig. 2-tailed) is 0.000, which is less than the conventional alpha level of 0.01, indicating that the correlation is highly statistically significant.

Based on these results, the null hypothesis (H_0) that emotional intelligence has no relationship with team cohesion is rejected. Instead, the data supports the alternative hypothesis (H_1) that emotional intelligence is positively related to team cohesion among the participants.

Table 1: Descriptive Statistics

Variable	N	Mean	Std. Deviation	Minimum	Maximum
Emotional Intelligence (EI)	300	3.85	0.45	2.1	4.9
Team Cohesion	300	3.67	0.52	1.8	4.85

Table 2: Correlation Matrix

Variable	1. Emotional Intelligence (EI)	2. Team Cohesion
1. Emotional Intelligence (EI)	1	
2. Team Cohesion	0.58**	1

**Correlation is significant at the 0.01 level (2-tailed).

Table 3: Correlations Significance

Correlation	Pearson Correlation (r)	Sig. (2-tailed)	N
Emotional Intelligence & Team Cohesion	0.58	0	150

EI and Communication Effectiveness

Table 4 displays the model summary for the regression analysis predicting communication effectiveness from emotional intelligence (EI). The correlation coefficient (R) is 0.65, indicating a strong positive relationship between EI and communication effectiveness. The coefficient of determination (R Square) is 0.4225, meaning that approximately 42.25% of the variance in communication effectiveness is explained by emotional intelligence. The adjusted R Square value of 0.417

confirms the model's goodness of fit after adjusting for the number of predictors. The standard error of estimate is 0.4, reflecting the average distance between observed and predicted values.

Table 5 presents the ANOVA results which assess the overall significance of the regression model. The regression sum of squares is 20.1 with 1 degree of freedom, and the residual sum of squares is 27.48 with 148 degrees of freedom. The F-statistic of 125.63 is highly significant ($p < 0.001$), indicating that the regression model significantly predicts communication effectiveness.

Table 6 shows the coefficients of the regression equation. The unstandardized coefficient (B) for EI is 0.64 with a standard error of 0.06, and the standardized beta coefficient is 0.65. The positive and significant t-value of 11.21 ($p < 0.001$) indicates that emotional intelligence is a significant positive predictor of communication effectiveness. The constant term is 1.2 with a t-value of 6.67 ($p < 0.001$).

In summary, the results support the alternative hypothesis (H_1) that emotional intelligence is positively related to communication effectiveness. Higher levels of emotional intelligence are associated with higher levels of communication effectiveness among the participants.

Table 4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.65	0.4225	0.417	0.4

Table 5: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	20.1	1	20.1	125.63	0
Residual	27.48	148	0.186		
Total	47.58	149			

Table 6: Coefficients

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	

(Constant)	1.2	0.18		6.67
Emotional Intelligence (EI)	0.64	0.06	0.65	11.21

EI and Psychological Well-being

Table 7 presents the descriptive statistics for Emotional Intelligence (EI) and Psychological Well-being (PWB) among 150 participants. The mean score for EI is 3.85 (SD = 0.45), indicating a moderately high level of emotional intelligence. The mean score for psychological well-being is 3.72 (SD = 0.48), reflecting a relatively positive state of well-being among participants.

Table 8 displays the Pearson correlation matrix, showing a correlation coefficient of 0.54 between EI and psychological well-being. This indicates a moderate positive relationship, suggesting that higher emotional intelligence is associated with better psychological well-being.

Table 9 confirms the significance of this relationship. The p-value (Sig. 2-tailed) is 0.000, which is less than the conventional alpha level of 0.01, indicating the correlation is statistically significant.

Based on these results, the null hypothesis (H_0) that emotional intelligence has no relationship with psychological well-being is rejected. The data supports the alternative hypothesis (H_1) that emotional intelligence is positively related to psychological well-being.

Table 7: Descriptive Statistics

Variable	N	Mean	Std. Deviation	Minimum	Maximum
Emotional Intelligence (EI)	300	3.85	0.45	2.1	4.9
Psychological Well-being (PWB)	300	3.72	0.48	1.9	4.88

Table 8: Correlation Matrix

Variable	1. Emotional Intelligence (EI)	2. Psychological Well-being (PWB)
1. Emotional Intelligence (EI)	1	
2. Psychological Well-being (PWB)	0.54**	1

1. Emotional Intelligence (EI)	1	
2. Psychological Well-being (PWB)	0.54**	1

**Correlation is significant at the 0.01 level (2-tailed).

Table 9: Correlations Significance

Correlation	Pearson Correlation (r)	Sig. (2-tailed)	N
Emotional Intelligence & Psychological Well-being	0.54	0	300

SUGGESTIONS

Enhance Emotional Intelligence (EI) through Targeted Training

Given that EI significantly impacts team cohesion ($r = 0.58$), communication effectiveness ($R^2 = 0.4225$), and psychological well-being ($r = 0.54$), organizations and institutions should:

- Conduct regular workshops and training programs on emotional intelligence, focusing on self-awareness, emotional regulation, empathy, and interpersonal skills.
- Incorporate EI modules into leadership development and employee onboarding programs.

Foster Stronger Team Cohesion via Emotionally Intelligent Leadership

Since EI shows a strong positive correlation with team cohesion:

- Encourage emotionally intelligent leadership styles that prioritize inclusivity, mutual respect, and emotional awareness within teams.
- Implement team-building activities that reinforce collaboration, mutual understanding, and trust.

Improve Communication Effectiveness with EI-Centric Approaches

With EI explaining over 42% of the variance in communication effectiveness:

- Emphasize emotional awareness in communication training programs for both leaders and employees.
- Adopt feedback systems that not only focus on the content but also the emotional tone and intent behind communications.

Promote Psychological Well-being by Leveraging EI

Given the significant positive relationship between EI and psychological well-being:

- Introduce mindfulness and emotional self-care sessions to help individuals manage stress and anxiety more effectively.
- Provide access to professional counseling and well-being support services, especially for emotionally demanding roles.

Use Data Insights to Develop Emotionally Intelligent Organizational Culture

- Integrate emotional intelligence assessments as part of performance reviews and professional development plans.
- Encourage open emotional expression and psychological safety in the workplace, ensuring individuals feel valued and understood.

Customize Interventions Based on EI Scores

- Use individual EI scores to tailor interventions for personal development, especially in high-stakes teams or roles that demand effective interpersonal functioning.
- High EI scorers can be considered for mentoring roles or team leadership to enhance cohesion and morale.

Monitor EI Metrics Over Time

- Conduct longitudinal studies to observe the effect of EI interventions on team performance, communication dynamics, and employee well-being.
- Regularly reassess EI to track personal and organizational progress.

Integrate EI into Recruitment and Selection

- Use validated EI assessment tools during hiring to identify candidates with strong emotional

capabilities, especially for roles requiring collaboration, leadership, or client interaction.

FINDINGS

Emotional Intelligence and Team Cohesion

- Descriptive statistics (Table 1) indicate that the participants reported moderately high levels of emotional intelligence (Mean = 3.85, SD = 0.45) and strong team cohesion (Mean = 3.67, SD = 0.52).
- The Pearson correlation analysis (Table 2) reveals a moderate positive correlation ($r = 0.58$) between EI and team cohesion, which is statistically significant at the 0.01 level (Table 3, $p = 0.000$).
- These findings suggest that individuals with higher emotional intelligence are more likely to perceive or contribute to better team cohesion.
- As a result, the null hypothesis stating “there is no relationship between emotional intelligence and team cohesion” is rejected in favor of the alternative hypothesis.

Emotional Intelligence and Communication Effectiveness

- The model summary (Table 4) from linear regression indicates a strong positive relationship between EI and communication effectiveness, with a correlation coefficient (R) of 0.65. The R Square value (0.4225) indicates that EI explains 42.25% of the variance in communication effectiveness.
- The ANOVA results (Table 5) show that the regression model is highly significant ($F = 125.63$, $p < 0.001$), meaning EI significantly predicts communication effectiveness.
- The regression coefficients (Table 6) confirm that EI is a significant positive predictor, with an unstandardized coefficient $B = 0.64$ and a standardized Beta = 0.65. The t-value of 11.21 ($p < 0.001$) further confirms this.
- These findings support the alternative hypothesis that higher emotional intelligence leads to more effective communication among participants, and the null hypothesis is rejected.

Emotional Intelligence and Psychological Well-being

- Descriptive statistics (Table 7) indicate a moderately high EI score (Mean = 3.85, SD = 0.45) and a positive psychological well-being score (Mean = 3.72, SD = 0.48).
- The Pearson correlation coefficient between EI and psychological well-being is $r = 0.54$, which reflects a moderate positive relationship (Table 8), and the correlation is statistically significant (Table 9, $p = 0.000$).
- This suggests that individuals with higher emotional intelligence also report better psychological well-being, and the null hypothesis is rejected in favor of the alternative hypothesis.

CONCLUSION

The study examined the relationships between Emotional Intelligence and three important organizational outcomes: team cohesion, communication effectiveness, and psychological well-being. The findings from Pearson correlation and regression analyses consistently demonstrated significant positive relationships between EI and all three variables. Specifically, higher levels of emotional intelligence were associated with stronger team cohesion, more effective communication, and better psychological well-being among participants. These results highlight the critical role of emotional intelligence in fostering healthy interpersonal dynamics and enhancing individual mental health in organizational settings. Organizations should consider developing EI through training and development programs to improve team functioning, communication quality, and employee well-being.

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The Influence of Digital Marketing Stimuli on Enhancing Consumer Purchasing Experience

A. Rameeza

Ph.D. (P.T.) Research Scholar, PG & Research
Department of Commerce
Jamal Mohamed College (Autonomous),
(Affiliated to Bharathidasan University)
Tiruchirappalli, Tamilnadu
✉ rameezarameeza786@gmail.com

M. Marimuthu

Assistant Professor & Head, PG & Research
Department of Commerce
Jamal Mohamed College (Autonomous),
(Affiliated to Bharathidasan University)
Tiruchirappalli, Tamilnadu
✉ marimuthumohana68@gmail.com

ABSTRACT

Consumers assess their digital marketing experiences based on their impressions of product information, payment methods, delivery conditions, service provision, risk factors, and personalization. Given the widespread usage of the internet by customers and the conflicting findings of previous studies, it is crucial to comprehend the impact of digital marketing on the consumer purchasing experience. Objective: This study report aims to validate the impact of digital marketing stimulus and online experience on customer purchasing experience. Furthermore, the extent to which the purchasing method affects customer behaviour in the context of digital marketing. Sampling method: The study used a convenient sampling approach, which is a non-probabilistic method, to choose sample members based on specific criteria determined by the researcher's experience and knowledge. Convenience sampling selects sample members based on their closeness to the researcher. Research Instrument: Instrument utilized for research purposes: The questionnaire comprises two sections. Part one pertains to the assessment of the demographic information of the respondents, while part two focuses on evaluating the consumers' purchasing experience. Data analysis: The basic data that was obtained is now being analyzed using the statistical programme SPSS 20. The study hypothesis was analysed utilising a confirmatory analysis conducted using a route model. Conclusion: The coefficient for customer buying experience in the regression model. The analysis of the digital marketing environment and the prediction of the consumer web experience in the consumer purchasing decision process does not show a statistically significant difference from zero at the 0.05 level.

KEYWORDS: *E-consumer, Purchase decision, Digital marketing stimuli, Web experience.*

INTRODUCTION

Examining the consumer purchase experience, motivations, and intentions of online shoppers, as well as their attitudes, falls under the theoretical framework of the Theory of Reasoned Action. The Theory of Reasoned Action (Kumar, S., Gupta, K., Kumar, A., Singh, A., & Singh, R. K. (2023) explores the correlation between attitudes and the intention to engage in future purchase experiences. The observed behaviours encompass the following: engagement with banner ads, responsiveness to e-mail advertisements, methods employed to search for product information through search engines and within the website,

utilisation of comparison engines, attention and time devoted to customer reviews and reactions, utilisation of the product basket feature, utilisation of online support services, utilisation of e-mail services, completion of feedback forms, and completion of the check-out process. Cheung et al (2003) proposed a foundational model known as the Model of Intention, Adoption, and Continuance. This model serves as a framework for the creation of a digital marketing framework that focuses on customer purchasing experiences.

Objectives

The main aim of this study article is to validate the forecast of the four elements that influence consumers'

purchase experience. From this, the further objectives were formulated.

1. The digital market stimuli exert an impact on customers' purchasing decisions.
2. A consumer's digital marketing experience directly impacts their purchasing decision-making process.
3. The entire procurement process affects customer purchasing experience.

METHODOLOGY

The current study is confirmatory in its purpose of validating the four components that contribute to the customer purchase experience. Data Collection: The researcher has utilised a combination of primary and secondary data sources. Utilise primary data, such as questionnaires, to ascertain consumers' buying experience in digital marketing. Sampling Method: A researcher intends to use convenient sampling, a non-probabilistic approach, to select a group of people from the unlimited population being studied the study. convenient sampling is a method where the researcher selects sample members based on certain criteria specified by their experience and knowledge. Convenience sampling, in contrast, selects sample participants based on their closeness to the researcher. Sample size: In order to conduct a thorough analysis, get precise estimates, and fulfil ambitious research goals, the researcher is expected to use a substantial number of samples for this study. The poll encompassed a total of 198 participants who were selected from a wide range of backgrounds, encompassing several factors such as age, education, gender, income per month, and employment. The primary information will be employed to achieve the research objective of this study. A questionnaire may be utilised to evaluate consumers' purchase experience via digital marketing. The format of the questionnaire: Structured questionnaires are composed of precise, concrete, and premeditated inquiries that are formulated to collect data pertaining to a certain factor and are preferred by researchers. The standardised surveys would consist of restricted in nature open-ended, open-ended, and five-point scale of Likert rating items. The questionnaire is partitioned into two distinct sections. Part one involves examining the demographic data of respondents, while part two

centres on measuring consumers' purchase experience in regard to the influence of digital marketing. There are five demographic questions about Age, Gender, Education, Employment, and Income. These items are assessed using nominal, interval, and ratio scales. There are a total of sixteen factors employed to measure and assess the purchasing experience of clients. The indications are assessed using a five-point Likert scale, with 1 indicating strong disagreement and 5 indicating strong agreement. Dataanalysis: The basic data that was obtained is now being analysed using the statistical programme SPSS 20. The distribution of frequencies is utilised to determine the positions of the respondents who participated in the survey. The route analysis was used to validate the elements that predict the customer purchase experience.

Demographic factors

The survey was done among consumers residing in the urban region of Tiruchy city to assess their purchasing experience in the realm of digital marketing. A total of 198 customers participated as respondents in this survey. All of these factors—age, gender, income, education level, and occupation—are taken into consideration when classifying them. The collection of personal demographic data is essential for determining the characteristics of the research participants and conducting subsequent analysis.

Table 1 Sample respondents are distributed according to their personal and demographic profiles

Demographic Factor	Levels	Numbers	Represented (%)	Total (%)
Age	25-30	34	17	17.0
	30-35	76	38.4	55.3
	35-40	21	10.4	65.8
	40-45	20	10.3	76.0
	45-50	48	24	100.0
	Total	198	100	
Gender	Male	122	61.6	61.6
	Female	76	38.4	100.0
	Total	198	100	
Education	Less than Bachelor's Degree	14	7	7.0

Education	Bachelor's Degree	100	50.3	57.4
	PG/ Professional Degree	71	35.8	93.2
	Technical	13	6.8	100.0
	Total	198	100	
Income	Less than 20 000	26	13.2	13.2
	20 000 - 30 000	53	26.9	40.1
	30 000 - 40 000	32	16.1	56.2
	40 000 - 50 000	30	14.9	71.1
	More than 50 000	57	28.9	100.0
	Total	198	100	
Occupation	PVT Company Employee	41	20.5	20.5
	GOVT Employee	70	35.6	56.2
	Owner of Business	57	28.9	85.1

	Others	30	14.9	100.0
	Total	198	100	

The age of the respondents was categorised into five tiers. Out of the five levels of respondent age categorization, 38.4 percent were into the 30-35 age group, while 24 percent of respondents were in the 45-50 age category. The data indicates that a significant majority of the respondents, specifically 55.3 percent, were young individuals who actively took part in the survey. Among the 198 sample respondents, 61.6 percent were male and the remaining 38.4 percent were female who took part in the study. The education of the responder was categorised into four levels. 50.3 percent of the respondents possessed a Bachelor's degree, while 35.8 percent had obtained a postgraduate or professional degree. The study involved a significant proportion of individuals who have completed their graduate education. The respondent's monthly income was categorised into five tiers, ranging from less than 20,000 to over 50,000 per month. 26.9 percent of the respondents had an income ranging from 20,000 to 30,000, while 28.9 percent of the respondents had an income over 50,000 per month.

Table 2. Descriptive statistics on consumer purchase experience measurement items

Measures (Latent)	Indicators (Independent)	Name	Mean	S.D	N	Cronbach's Alpha
Internet Marketing Stimuli	Product and Information Quality	MS1	2.24	1.10	584	.716
	Visual Appearance – web design – great Navigation	MS2	2.16	.977	584	
	Product Reveiws	MS3	2.15	.981	584	
	Convenient and secure system of ordering	MS4	2.26	1.06	584	
Internet Marketing Experience – web Experience	Money back guarantee	WE1	1.75	.976	584	.681
	Hassle-free returns – easy return	WE2	1.96	1.06	584	
	New Product	WE3	1.97	1.06	584	
	Convenient and fast to order	WE4	1.74	.830	584	
Consumer Decision Process	Discounts	CDP1	2.47	1.28	584	.751
	Testimonials	CDP2	2.11	1.10	584	
	Free shipping	CDP3	2.07	1.07	584	
	Multiple options	CDP4	2.19	1.22	584	

Consumer Purchase Decision	Product Choice	CPD1	1.87	1.11	584	.717
	Brand Choice	CPD2	2.15	1.19	584	
	Dealer Choice	CPD3	2.20	1.270	584	
	Purchase Timing	CPD4	2.24	1.25	584	

The table presented above displays the descriptive data for indicators of customer buying experience. Four criteria have been discovered after a literature study. Each component comprises four qualities. The table above clearly demonstrates that all mean values are about 3, suggesting a modest level of acceptance for all factors related to the consumer buying experience. The study has taken into account consumer personal and demographic data, including age, gender, monthly income, level of education, and occupation. The study used structural equation modelling as the analytical method to estimate maximum likelihood and investigate the presented hypotheses. The researcher has assessed the accuracy and consistency of the aforementioned indicators. After evaluating the reliability and validity, the measurement model permits all latent constructs to freely correlate with each other. Once verified, the structural model undergoes testing to estimate the structural link between four latent variables, as well as five personal and demographic factors.

Reliability and Validity of measures

The table No.2 presents data on descriptive statistics. The mean values for all aspects of customer purchasing experience are about 3, suggesting a modest level of acceptance. Coefficient alpha, sometimes referred to as Cronbach alpha, is well recognised as the most frequently utilised reliability coefficient. Coefficient alpha is a statistical measure that estimates the dependability and internal consistency of a scale. Consistency in this context refers to the degree of interrelatedness among the elements of the test. It determines if the items are sufficiently consistent with each other to be merged.

The table displays the Cronbach's alpha value for each component or factor. The digital marketing stimulus factor had a Cronbach's Alpha score of .761. The second factor, digital marketing experience - web experience, achieved a reliability score of 0.681. The third factor, consumer decision process, achieved a score of 0.751. The fourth factor, consumer purchase

experience - consumer purchase decision, achieved a Cronbach's Alpha value of 0.717. Furthermore, it has been discovered that all sixteen consumers that purchased experience products achieved a score of .747. The table supplied by Gliem&Gliem (2003) might serve as a reference for assessing the reliability coefficient. If the Cronbach's Alpha value is larger than 0.90, it is considered excellent. If it is greater than 0.80, it is considered good. If it is greater than 0.70, it is considered acceptable. If it is greater than 0.60, it is considered questionable. If it is greater than 0.50, it is considered poor. If it is less than 0.50, it is considered unacceptable. According to the figure provided, it is indicated that all variables except for the expeditious element of internet marketing effectiveness have a reliable coefficient score. This allows for further examination of the core factor, responsiveness factor, and reliable factor.

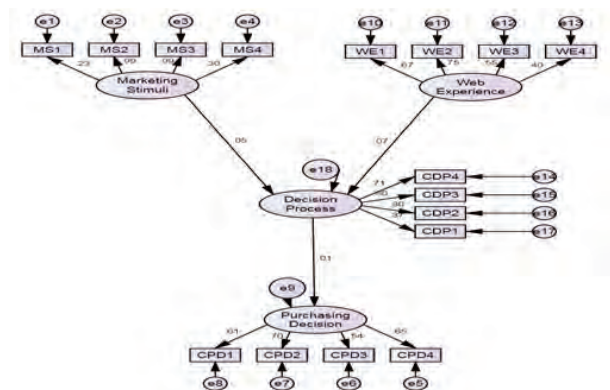


Diagram 1 Path model shows impact of consumers purchasing experience

Table 3: Standardized Regression Weights for the Consumer purchasing experience

Hypothesis	Latent and predictor	C.R	Beta	P	Result
Ha1	Digital market stimuli have an influence on how consumers decide what to buy	1.030	.048	.303	Not influence P>0.05

Ha2	An consumer's web experience influences their ability to decide something to buy	1.397	.075	.162	Not influence P>0.05
Ha3	The complete purchasing procedure influences how consumers behave while making purchases	.160	.009	.873	Not influence P>0.05

The structural model's fit indices are displayed in table No. above. The likelihood of obtaining a disparity as big as 299.837 is .000, indicating that the anticipated model is accurate. The calculated structural model has a discrepancy defined by degree of freedom of 299.837 / 101, resulting in a value of 2.969. The CFI value is 0.946 for the structural mode. The estimated value for the root median square error of the approximation (RMSEA) is 0.058, and the "p value" is used to test the null hypothesis that the RMSEA is smaller than 0.05 in the whole population. The table above displays a p-value of 0.039 for the suggested predictive model. Assuming a hypothesis of "very near fit" where the RMSEA value in the population is not larger than .05, the likelihood of obtaining a sample RMSEA value as high as .058 is .039. All the fit indices fall within the permitted range, leading to the conclusion.

The likelihood of obtaining a critical ratio with an absolute value of 1.03 is 0.303. To clarify, the regression coefficient weight for Digital Marketing Stimuli in predicting Consumer Selection Process is not statistically significant at the level of 0.05 (two-tailed). When the level of digital marketing stimuli increases by 1 standard deviation, the consumer decision process also increases by 0.048 standard deviations.

The likelihood of obtaining a critical ratio with an absolute value of 1.397 is 0.162. Put simply, the regression weight for Internet Experience in predicting Consumer Choice Process is not statistically significant at the 0.05 level (two-tailed). An increase of 1 standard deviation in Web Experience results in a corresponding increase of 0.075 standard deviations in Consumer Decision Process.

The likelihood of obtaining a critical ratio with an absolute value of 0.16 is 0.873. The coefficient of

regression weight for Decisions Process in predicting Purchasing Decision is not statistically significant at the 0.05 level (two-tailed). An increase of 1 standard deviation in the Decision Process leads to a corresponding increase of 0.009 standard deviations in the Purchasing Decision.

Table 4 Standardized Regression Weights for the Consumer purchasing experience

Predictor variables	Latent Factor	S.E.	C.R.	Standardized Estimate	P
MS1	Digital Marketing Stimuli				
MS2		.693	5.567	.988	***
MS3		.702	5.557	.994	***
MS4		.286	4.491	.301	***
CPD4	Consumer Purchasing Decision				
CPD3		.086	9.752	.543	***
CPD2		.092	11.022	.696	***
CPD1		.079	10.506	.609	***
WE1	Web Experience				
WE2		.115	10.595	.745	***
WE3		.091	9.974	.554	***
WE4		.066	7.645	.397	***
CDP4	Consumer Decision Process				
CDP3		.062	15.935	.801	***
CDP2		.063	15.941	.803	***
CDP1		.068	7.971	.367	***

*** significant at 0.001

Digital Marketing Stimuli

Product and Information Quality is denoted as MS1, Visual Appearance – web design – great Navigation as MS2, Product Reviews as MS3, and a Convenient and secure system of ordering as MS4. The likelihood of reaching a crucial ratio with an absolute value of 5.567 is less than 0.001. This suggests that the weighting of the regression for the role of Digital Marketing stimuli to forecast MS2 is substantially different from zero at a significance level of 0.001 (two-tailed). Moreover, the regression coefficient weight for the use of Digital Marketing Stimuli to forecast MS3 is statistically significant at the 0.001 level, with a crucial ratio of 5.557. Moreover, a critical proportion of 4.491, with a probability less than 0.001, indicates that the regression weighting for the use of Digital Marketing Stimuli in

predicting MS4 is substantially different from zero at the 0.001 level. In summary, an increase of 1 standard deviation in Digital Marketing Stimuli corresponds to a rise of 0.226 standard deviations in MS1, 0.988 standard deviations in MS2, 0.994 standard deviations in MS3, and 0.301 standard deviations in MS4.

Web Experience

The assurance of a money-back guarantee (WE1) and hassle-free returns (WE2), coupled with the introduction of new products (WE3), and the convenience and speed of ordering (WE4), are pivotal in enhancing customer satisfaction. Statistical analysis indicates the significance of Web Experience in predicting these outcomes, affirming its substantial impact. Specifically, a one-standard deviation increase in consumer Web Experience corresponds to a 0.67 standard deviation increase in WE1, 0.745 in WE2, 0.554 in WE3, and 0.397 in WE4, underlining the influence of web interaction on customer preferences and experiences.

Consumer purchasing experience

Consumer Purchasing Decision (CPD) variables include Product Choice (CPD1), Brand Choice (CPD2), Dealer Choice (CPD3), and Purchase Timing (CPD4). Statistical analysis reveals significant regression weights for CPD1, CPD2, and CPD3, indicating their substantial impact. A one-standard deviation increase in Consumer Purchasing Decision corresponds to a 0.609 standard deviation increase in CPD1, 0.696 in CPD2, 0.543 in CPD3, and 0.652 in CPD4, emphasizing the influence of the decision-making process on these consumer choices. The likelihood of obtaining a crucial ratio with an absolute value of 9.752 is lower than 0.001. The coefficient of regression weighting for Consumer Buying Decision in predicting CPD3 is statistically significant at the 0.001 level (two-tailed). The likelihood of obtaining a crucial ratio with an absolute value of 11.022 is lower than 0.001. The regression weighting for consumer Purchasing Behaviour in the anticipated outcome of CPD2 is statistically significant at the 0.001 level. The likelihood of obtaining a critical ratio with an absolute value of 10.506 is lower than 0.001. The regression weighting for Consumer Purchasing Behaviour in predicting CPD1 is significantly different from null at the 0.001 level, meaning it has a strong impact on the prediction.

Consumer Decision Process

Discounts (CDP1), testimonies (CDP2), free delivery (CDP3), and many selections (CDP4) are crucial factors in the Consumer Buying Process. The likelihood of obtaining a crucial ratio with an absolute value of 15.935 is lower than 0.001. Put simply, the coefficient of regression weighting for E-Consumer Decisions Process in predicting CDP3 is significantly non-zero at the 0.001 level. The likelihood of obtaining a critical ratio with an absolute value of 15.941 is less than 0.001. The regression weight for E-Consumer Decision Process in predicting CDP2 is statistically significant at the 0.001 level. The likelihood of obtaining a crucial ratio with an absolute value of 7.971 is lower than 0.001. The coefficient of regression weighting for Consumer Buying Process in predicting CDP1 is statistically significant at the 0.001 level. It has been noted that when the Decision Process increases by one standard deviation, CDP1 increases by 0.367 deviations from the mean, CDP2 increases by 0.803 standards deviations, CDP3 increases by 0.801 standard deviations, and CDP4 increases by 0.712 deviations from the mean.

CONCLUSION

In conclusion, this study aimed to explore e-consumer buying behavior by evaluating various factors among 198 participants from diverse demographics. The majority of participants were young and predominantly male, with a significant number of graduates. The reliability scores for key factors, such as digital marketing stimuli, web experience, consumer decision process, and consumer purchase, were found to be within acceptable ranges. The results indicated that an increase in marketing stimuli had a positive impact on different aspects of e-consumer behavior, including decision process and purchasing decisions. However, it's noteworthy that the regression weights for marketing stimuli, e-consumer web experience, and e-consumer decision process in predicting subsequent stages were not statistically significant at the 0.05 level. Despite this, the study revealed specific insights, such as the influence of attractive discounts and testimonials on purchasing decisions. It's crucial to recognize the limitations of the study, including the reliance on self-reported data and the need for further research to validate the observed trends. Nevertheless, these findings contribute valuable

insights into the complex dynamics of e-consumer behavior, emphasizing the multifaceted nature of influences in the digital marketplace. As technology and consumer preferences evolve, ongoing research in this field remains essential for businesses to adapt and tailor their strategies to effectively engage with and meet the needs of e-consumers.

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A Study on the Effectiveness and Impacts of MBO Process in BHEL

S. Saranya

Research scholar, PG and Research
Department of Commerce
A.V.V.M. Sri Pushpam College (Autonomous)
(Affili. to Bharathidhasan University, Tiruchirappalli)
Poondi, Tamil Nadu
✉ msguna17@gmail.com

R. Saravanavel

Assistant Professor, PG and Research
Department of Commerce
A.V.V.M. Sri Pushpam College (Autonomous)
(Affili. to Bharathidhasan University, Tiruchirappalli)
Poondi, Tamil Nadu
✉ rbsvel@gmail.com

ABSTRACT

Management by objectives is designed to improve the management process and maximize the effectiveness of the members of individual team. It focused on helping team members to understand the individual roles they play and how their jobs contribute to organization success. MBO process is an integrative approach to planning and control and emerging new techno- structural of business. The MBO strategy has three basic components which are following: assigned set of objectives, periodical performance reviews, rewards given to individuals who are reaching goals. MBO process is a management system that is driven by goals and success oriented it is used in a variety of areas such as performance appraisal system, performance management system, Strategic planning, production planning and controls and other managerial subsystems like human resource planning, career planning, operational goals, budgeting and financial management. This process includes human resources planning and development, career planning, the reward system, budgeting and other managerial activities important for a specific position. It aims at enhancing organizational performance by synchronizing goals and subordinates the objectives throughout the organization. Management by objectives is a process of agreeing the objectives in an organization. The term MBO was first popularized by Peter Drucker in the year of 1954. It is application followed and practiced by all over the world and they consider it as a planning and controlling tool. MBO is a comprehensive managerial system that integrates many key managerial activities in systematic manner that is directed towards the effective and efficient achievement of organization and individual objectives. It is very narrow, limited, goal driven and success oriented management system. This study has taken 396 samples from BHEL, it is an eminent public sector institution in India. The researcher has to study the effectiveness and impacts of MBO process in BHEL. This study concluded that MBO is empowering career planning, helps to evaluate performance appraisal, performance rating. Hence, the Management by Objective can be build a most effective performance in BHEL

KEYWORDS: MBO process, MBO effectiveness, Effect of management by objective, BHEL, Management By objective, Organization goals, Employee performance.

INTRODUCTION

Management by Objectives is a process of agreeing upon objectives within an organization. The term MBO was first popularized by Peter Drucker in year of 1954. It is application followed and practiced by all over the world and they consider it as a planning and controlling tool. Management by objectives requires the managers to set specific measurable goals with each employee and then to periodically discuss his progress towards these goals. This study has taken 396 samples

from BHEL, it is an eminent public sector institutions in India. So, thee researcher has investigates and analyse the effectiveness and impacts of MBO in BHEL.

MBO is a comprehensive managerial system that integrates many key managerial activities in systematic manner that is directed towards the effective and efficient achievement of organization and individual objectives.

MBO is a good management system which helps to organizational members to participate getting organizational effectiveness. This system gives full

scope to individual strength and responsibilities. This study delves into the effectiveness and impacts of MBO in BHEL, examining both its benefits and potential challenges in contemporary organizational settings.

MANAGEMENT BY OBJECTIVES

Drucker, 1954, Management by Objective as a management tool which does not only cut across the participation of both subordinate and superior, but also involves the monitoring and accessing of employees performance towards the goals.

According to Koontz and Weihrich, Management by objectives is a comprehensive managerial system that integrates many key managerial activities in a systematic manner and that is consciously directed toward the effective and efficient achievement of organizational and individual objectives.

Jeong et al, (2021), Setting objectives entails directing one's thoughts, feelings, and actions towards achieving the goal. This creates a mismatch between the goal setter's desired future state and their existing state, which in turn motivates further activities.

According to Setyo and Novita (2020), is the predetermination of targets to be met or goals to be reached, the establishment of clear timetables for the accomplishment of each process in pursuit of the achievement of the ultimate goals, and the evaluation of performance by the degree of success in hitting the targets or goals within the allotted time.

Chakravarty(1976), MBO s a result-centred, non-specialist, operational managerial process for the effective utilisation of material, physical, and human resources of the organisation by integrating the individual with the organisation and organisation with the environment.

MBO IN BHEL

In Indian, multinational companies have expanded of MBO concepts; particularly in PSU few of them have shared their experience of MBO with others in the initial stage that was 1969, after systematic entry of MBO in BHEL organized top management support and other companies applied and appreciated the role of MBO in performance management of employees have successfully implemented.

BHEL is India's largest engineering and manufacturing enterprise, second largest employer in the Indian capital goods industry. Presently pan India have 16 manufacturing units and 8 service centres with 53 percent of share installed conventional generation capacity, having above 30,000+ Human capital bases and 8000+ strong engineers and management staff have applied MBO concepts with performance management system very earlier, so they have fully experienced on this MBO concepts.

Management by objectives is the process which helps to measure and determine the performance of employees. MBO is modern method for performance appraisal. MBO almost always refers to a comprehensive, organisation wise goal setting and appraisal programme that consists of the steps:

Set the Organisation's Goals. Establish an organisation-wise plan for next year and set goals.

Set Departmental Goals. In the step departmental heads and their superiors jointly set goals for their departments.

Discuss Departmental Goals. Departmental heads discuss the department's goals with all the subordinates in the department and ask them to develop their own individual goals. In other words, every employee will state how he can contribute to the department's attainment of goals.

Performance Review: Measure the Results. Department heads compare the performance of each employee with expected results.

Provide Feed Back. Department heads hold periodic performance review meetings with subordinates to discuss and evaluate the latter progress in achieving expected results.

These steps are impacting the performance management system. All mechanism of MBO are intervening the performance appraisal and management. Hence the researcher has studied the impact of MBO concepts in the performance management system. In India, BHEL have applied MBO in very early bird on 1970s. It has more experience on this MBO concept. MBO ensures better and more effective management of the vital resource of the organization which is human resource without compromising the organizational strategy.

The setting of Objective in the MBO process helps to provide a yardstick for appraisal, compensation and control as well as serve as a measure or guide for operating the unit and assessing the contribution of each of its members. However, achievement of organizational goals is possible not by giving orders and strict instructions but by securing cooperation and participation of all persons in the organization. It is an attempt to fill this gap that this paper seeks to examine the effect of MBO on the performance of organizations. In-view of the result oriented nature of MBO as a management philosophy. It is confronted the researcher to conduct this study in the nature to determine the impact of management by objective on organizational performance management system.

REVIEW OF LITERATURE

The study aim is to identify the importance of creating objectives, planning goals, setting control points, employee's commitment to determine objectives, freedom and independence in fulfilling duties, continuous communication, as steps for realizing MBO method in employees' effectiveness.

Idoko, okolie, jonathan, nubuogu (2022) studied on effect of management by objective on the employee performance of union bank plc in Enugu metropolis concluded that joint control setting specific goal had a positive effect on the employee commitment and punctuality of workers. This has also proven to be help in achieving of the organizations aims and objectives and enables the optimum use of resources through meticulous planning and control at the workplace. Hence, organisations should adopt the use of MBO increases sales rates and productiveness with in the organizations.

GOAL SETTING THEORY OF MBO

They represent the degree of proficiency we aspire to and serve as a helpful framework for evaluating our present performance. The method through which we accomplish our goals is through goal setting. According to Locke, the significance of the goal-setting procedure should not be undervalued (2019). Every individuals existence depends on the process of selecting objectives to work towards; if you are inactive, you will not flourish as a person. The foundation of goal-setting

theory (Locke&Lathan,1984)is the idea that conscious human activity is intentional and governed by personal objectives. In other words, we must decide what is best for our own wellbeing and create objectives to attain it (Elaine 2020).

The goal of the strategic management paradigm known as 'management by objectives'(MBO) is to increase an organisations performance by establishing goals that both management and people can support. The notion contends that giving employees a voice in goal-setting and action plans promotes employee engagement and involvement while also coordinating organizational goals (Adam,2021).

Susan,(2021) highlighted an employee is a person who has engaged by an employer to do certain task. Following a selection as an employee following an application and interview procedure, the employee is employed by the business. The determines that they are the best qualified candidate for the position for which they are employing. The criteria for establishing which individuals are employees are established by the Internal Revenue Services(IRS) (Jean 2020).

Enemuo,(2021) this study examine the effect of MBO on some of these goals in order to stimulate competitive edge and stellar performance for banks. In spite many studies linking MBO to organisational productivity, many financial institutions in Nigeria have minimally adopted this appropriate approaches to management. It is in the light of this background that this study intends to find out the impact of management by objective (MBO) on organizational performance in Nigeria using a financial institute sector as the case study. The study specifically examines the relationship between MBO and employees commitment and investigate the effect of MBO on employees' decision input in an organization.

RESEARCH METHODOLOGY

This study used quantitative approach. A descriptive analysis used as tool for identify the variable of employee awareness and perception. Data were assessed and measured by descriptive statistics, SPSS tools were used and SEM model for testing hypothesis. Questionnaire framed for data collection that was collected from around 396 respondents. Majority of questions were the closed ended questions which help to researchers for making

extensive documentation. Author used non probability sampling from BHEL. They were 84.2 percent of men and 15.8 percent of women. The secondary data were collected from the secondary sources including books, journals, magazines, reports and previous studies.

OBJECTIVE OF THE STUDY

To study the impacts of MBO on employee performance management system in BHEL.

To analyze the awareness and perceptions of employees about MBO in BHEL

Hypothesis of the study

H1: There is a significant positive impact of MBO on employee's performance.

H2: There is significant positive influence between awareness of employee and perception of employee on performance management system.

Analysis of data

This study has analysed the data with Cronbach's alpha test with five point scales and obtained 0.821 for impacts of MBO on employee performance and its factors, 0.661 points was found for perception of employee. This point shows that good consistency in the data collected.

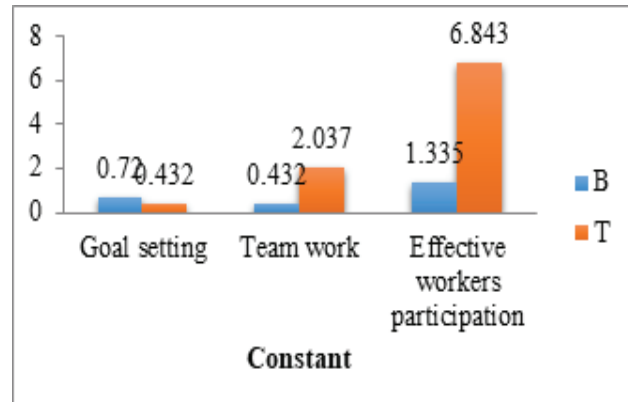
RESULT AND DISCUSSIONS

In the age level proportion is dominated in the samples are the productive age group between 35 to 45 years were 87 percent. The majority of respondents have undergraduate education background were 46.2 percent. In addition to that most of them (52 percent) have professional occupations. Finally in the demographic variable, the income profiles of respondents were 44.2 percent between 30,000 to 45,000 monthly incomes were dominated in the sample composition.

Table 1. Regression analysis for effectiveness of MBO in BHEL

Model		B	T	R	Adjusted R ²	Sig.	F
1	Constant	31.841	4.656				
	Goal setting	0.72	0.432	0.507	0.250	0.000**	39.092
	Team work	0.432	2.037				
	Effectiveness workers participation	1.335	6.843				

Table 1 shows the regression analysis for testing the hypothesis of MBO components influence on the effectiveness and its impacts, having beta value respectively is 0.72, 0.432, 1.335; $p < 0.01$ for goal setting, Team work and effective workers participation, hence it is concluded that the effectiveness of MBO is positively influence on its components. R value (0.507) is supported and shows that there is positive correlation among the components.



CONCLUSION

In conclusion, Management by Objectives (MBO) remains a powerful tool for enhancing performance management systems within organizations. By fostering alignment, motivation, accountability, and continuous improvement, MBO contributes positively to organizational effectiveness. However, its successful implementation requires careful consideration of challenges such as goal setting, team work, and workers participation. Future research could further explore how modern technologies and evolving workplace dynamics influence the application and outcomes of MBO in diverse organizational contexts. Ultimately, MBO represents a timeless approach that, when implemented thoughtfully, can significantly elevate performance management practices and contribute to sustained organizational success.

This study aims to analyse the impacts of MBO on its components goal setting, team work and workers participation with referencing BHEL. The response obtained from the various respondents of BHEL, which can relate the positive influence on employee's participation with MBO. This study concluded that MBO process is higher effectiveness on its components.

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Abbreviation

MBO - Management by Objectives

BHEL - Bharat Heavy Electrical Limited

PSU - Public Sector Undertaking

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Exploring the Relationship Between Customer Satisfaction and Loyalty in Different Demographic Segments

K. Senthil Kumar

Assistant Professor, PG & Research
Department of Management Studies
Annai College of Arts & Science
(Affili. to Bharathidasan University, Tiruchirappalli)
Kovilacheri, Tamilnadu

ABSTRACT

This study aims to investigate key factors influencing consumer purchasing behavior and preferences. Firstly, it examines whether there is a significant difference in purchase frequency between male and female customers, utilizing an Independent Samples t-test or Mann-Whitney U test depending on data normality. Secondly, the research explores the relationship between customer satisfaction scores and repeat purchase intention, employing Pearson or Spearman correlation analysis to determine the strength and direction of this association. Finally, the study assesses whether the average spending amount varies across different age groups, using One-way ANOVA or Kruskal-Wallis test to identify significant differences. The findings are expected to provide valuable insights into demographic and satisfaction-related drivers of consumer behavior, informing targeted marketing strategies and customer relationship management.

KEYWORDS: *Consumer behavior, Purchase frequency, Customer satisfaction, Repeat purchase intention, Age groups, Statistical analysis.*

INTRODUCTION

Understanding consumer behavior is essential for businesses aiming to enhance their marketing strategies and improve customer retention. Consumer purchase patterns are influenced by a variety of demographic and psychological factors, including gender, satisfaction levels, and age. These factors not only impact the frequency of purchases but also the amount spent and the likelihood of repeat buying.

Gender differences in purchasing behavior have long been a subject of interest in marketing research. Male and female consumers may exhibit distinct buying frequencies due to differences in preferences, needs, and decision-making styles. Investigating whether these differences exist can help businesses tailor their promotional efforts more effectively to each gender segment.

Customer satisfaction is widely recognized as a critical determinant of repeat purchase behavior. Satisfied

customers are more likely to develop loyalty towards a brand, leading to higher chances of repeat purchases and sustained revenue. Examining the correlation between satisfaction scores and repeat purchase intention provides valuable insight into how customer experiences influence long-term business success.

Age is another important demographic factor that affects consumer spending habits. Different age groups often have varying financial capabilities, product preferences, and consumption patterns. Analyzing the average amount spent by customers across age groups helps identify key segments that contribute most significantly to sales, enabling more focused marketing and product development strategies.

This study tests three hypotheses to explore these relationships: first, whether purchase frequency differs by gender; second, the association between customer satisfaction and repeat purchase intention; and third, the variation in spending amounts across age groups.

By employing appropriate statistical tests—such as Independent Samples t-test, Pearson correlation, and One-way ANOVA—this research aims to provide actionable insights into consumer purchase behavior, supporting better decision-making for businesses in competitive markets.

RESEARCH METHODOLOGY

Research Design

This study adopts a quantitative research design to examine the relationships between demographic factors and consumer purchasing behavior. The research follows a descriptive and analytical approach, focusing on testing predefined hypotheses through statistical analysis. Data will be collected through structured surveys to capture relevant variables such as purchase frequency, customer satisfaction scores, repeat purchase intentions, amount spent, gender, and age group. Appropriate statistical tests—such as Independent Samples t-test, Pearson correlation, and One-way ANOVA—will be applied to test the hypotheses and draw conclusions about differences and associations among variables.

Population and Sample

The population of this study consists of consumers who have made purchases from retail outlets or online platforms within a specified geographic region. To ensure representative coverage, the sample will be drawn using a stratified random sampling technique to include various gender and age groups proportionally. The estimated sample size will be approximately 300 respondents to achieve adequate statistical power for hypothesis testing. Participants will be selected based on their recent purchasing activity and willingness to participate in the survey. Data collection will be conducted through online questionnaires and in-person interviews to maximize response rates and data accuracy.

Research Hypothesis

The study aims to test the following hypotheses to understand consumer purchasing behavior:

Hypothesis 1: Gender and Purchase Frequency

- o H0: There is no significant difference in consumer purchase frequency between male and female customers.

- o H1: There is a significant difference in consumer purchase frequency between male and female customers.

Hypothesis 2: Customer Satisfaction and Repeat Purchase Intention

- o H0: Customer satisfaction scores are not correlated with repeat purchase intention.
- o H1: Customer satisfaction scores are positively correlated with repeat purchase intention.

Hypothesis 3: Age Group and Spending Amount

- o H0: The average amount spent by customers does not differ across different age groups.
- o H1: The average amount spent by customers differs across different age groups.

DATA ANALYSIS AND INTERPRETATION

Gender and Purchase Frequency

Table 1 presents the descriptive statistics for purchase frequency by gender. The mean purchase frequency for male customers ($N = 150$) was 4.20 with a standard deviation of 1.15, while female customers ($N = 150$) had a higher mean purchase frequency of 4.65 with a standard deviation of 1.30. These preliminary differences suggest that female customers may purchase more frequently than male customers on average.

Table 2 shows the results of the Independent Samples t-test conducted to evaluate whether the difference in mean purchase frequency between male and female customers is statistically significant. The t-test for equality of means (assuming equal variances) yielded a t-value of -3.12 with 298 degrees of freedom and a two-tailed significance level (p-value) of 0.002. This p-value is well below the conventional significance threshold of 0.05.

Since the p-value is significant, we reject the null hypothesis (H_0) that there is no difference in purchase frequency between male and female customers. The observed mean difference of -0.45 indicates that female customers have a statistically significantly higher purchase frequency than male customers. This finding highlights meaningful gender-based differences in purchasing behavior, suggesting that marketing

strategies may benefit from gender segmentation to address these behavioral patterns.

Table 1: Group Statistics

Gender	N	Mean Purchase Frequency	Std. Deviation	Std. Error Mean
Male	150	4.2	1.15	0.094
Female	150	4.65	1.3	0.106

Table 2: Independent Samples Test

t-test for Equality of Means	t	df	Sig. (2-tailed)	Mean Difference Lower
Equal variances assumed	3.12	298	0.002	-0.45
Equal variances not assumed	3.12	294.5	0.002	-0.45

Customer Satisfaction and Repeat Purchase Intention

Table 3 provides the descriptive statistics for the two variables under study: Customer Satisfaction and Repeat Purchase Intention. Both variables have a sample size of 300. The mean customer satisfaction score is 4.12 (SD = 0.85), while the mean repeat purchase intention score is slightly lower at 3.95 (SD = 0.92). These values indicate generally positive satisfaction and intention levels among the customers surveyed.

Table 4 presents the Pearson correlation analysis between customer satisfaction and repeat purchase intention. The correlation coefficient (r) is 0.68, which indicates a strong positive relationship between the two variables. The p -value associated with this correlation is less than 0.001, indicating that the correlation is statistically significant at the 0.05 significance level.

This significant positive correlation suggests that higher customer satisfaction is strongly associated with a greater intention to make repeat purchases. Thus, customer satisfaction appears to be an important predictor of customers' likelihood to return, underscoring the importance of maintaining high satisfaction levels to foster customer loyalty and repeat business.

Table 3: Descriptive Statistics

Variable	N	Mean	Std. Deviation
Customer Satisfaction	300	4.12	0.85

Repeat Purchase Intention	300	3.95	0.92
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Table 4: Correlations

Variable	Customer Satisfaction	Repeat Purchase Intention
Customer Satisfaction	1	0.68
		($p < 0.001$)
Repeat Purchase Intention	0.68	1
	($p < 0.001$)	

Age Group and Spending Amount

Table 5 presents the descriptive statistics of the average amount spent by customers across four different age groups. The sample sizes vary slightly across groups, with 80 respondents in the 18–25 group, 90 in the 26–35 group, 70 in the 36–45 group, and 60 in the 46 and above group. The mean amount spent increases progressively with age, from 250.45 in the youngest group to 310.75 in the oldest group. The standard deviations indicate moderate variability within each age group.

Table 6 shows the results of the One-way ANOVA conducted to test if the differences in average spending across the age groups are statistically significant. The between-groups sum of squares is 15,000.25 with 3 degrees of freedom, and the within-groups sum of squares is 270,000.40 with 296 degrees of freedom. The calculated F -statistic is 5.45, and the associated significance value (p -value) is 0.001, which is below the conventional threshold of 0.05.

Since the p -value is statistically significant, we reject the null hypothesis that the average amount spent by customers is the same across different age groups. This indicates that there are significant differences in spending behavior among age groups. Given the increasing mean spending values, it suggests that older customers tend to spend more on average than younger customers.

Table 5: Descriptive Statistics

Age Group	N	Mean Amount Spent	Std. Deviation	Std. Error
18–25	80	250.45	40.22	4.5
26–35	90	275.3	45.1	4.76
36–45	70	290.1	50.33	6.01
46 and above	60	310.75	55.4	7.15
Total	300	277.5	49.25	2.84

Table 6: ANOVA

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15000.25	3	5000.08	5.45	0.001
Within Groups	270000.4	296	912.17		
Total	285000.65	299			

SUGGESTIONS

Gender and Purchase Frequency

- Female customers (Mean = 4.65) show significantly higher purchase frequency than male customers (Mean = 4.20).
- The difference is statistically significant ($p = 0.002$), as confirmed by the Independent Samples t-test.
- Segment marketing strategies by gender to reflect behavioral differences. For example, offer exclusive loyalty benefits or frequent purchase coupons for women, who are shown to shop more often.
- Develop female-focused promotional campaigns, including messaging and visuals tailored to appeal to women's preferences and shopping habits.
- Analyze product categories to see which ones are more popular with each gender, then adjust inventory and promotions accordingly.
- Consider implementing gender-sensitive customer engagement tactics such as personalized reminders or early access offers to boost repeat purchase behavior in male customers.

Customer Satisfaction and Repeat Purchase Intention

- A strong positive correlation ($r = 0.68$) exists between customer satisfaction and repeat purchase intention.
- This relationship is highly statistically significant ($p < 0.001$), indicating that satisfied customers are more likely to return.
- Prioritize customer satisfaction initiatives, such as improving service quality, addressing complaints quickly, and ensuring seamless after-sales support.
- Collect feedback regularly through surveys or digital feedback forms to monitor satisfaction levels and act promptly on negative responses.

- Develop a customer loyalty program that rewards repeat purchases, thereby encouraging satisfied customers to remain loyal.
- Train customer-facing employees in soft skills and problem-solving techniques to ensure a consistently positive customer experience.
- Use Net Promoter Score (NPS) or satisfaction indices to identify loyal customers and turn them into brand advocates through referral programs.

Age Group and Spending Amount

- A statistically significant difference ($p = 0.001$) exists in average spending across age groups, with older customers spending more on average.
- Spending increases steadily from the 18–25 age group (₹250.45) to the 46 and above group (₹310.75).
- Design tiered pricing or bundled offers targeting different age brackets. For instance:
 - Budget-friendly combos for younger buyers (18–25).
 - Premium quality or value-added services for older customers (36 and above).
- Promote high-value products to older demographics, leveraging their higher disposable income and preference for quality and reliability.
- Develop age-specific marketing messages:
 - For younger customers: emphasize trends, affordability, and convenience.
 - For older customers: highlight durability, functionality, and return on investment.
- Use digital targeting tools to deliver personalized offers by age segment on platforms such as email, social media, or in-app messages.
- Conduct follow-up qualitative research (e.g., interviews or focus groups) to understand why older groups spend more—whether due to loyalty, income, family size, or other motivations.

General Strategic Recommendations

- Adopt a data-driven customer segmentation

strategy, considering demographics (age, gender) and behavioral patterns (satisfaction, spending, frequency).

- Develop dashboards and KPIs for ongoing tracking of customer satisfaction, repeat purchase rates, and demographic-based purchase behavior.
- Consider running predictive analytics models to forecast future purchase behavior and lifetime customer value based on demographic and satisfaction data.
- Invest in CRM systems that help in personalizing offers, tracking purchase patterns, and maintaining strong customer relationships.

FINDINGS

This research explores the consumer behavior dynamics through the lens of three key analytical dimensions: gender-based purchase frequency, relationship between customer satisfaction and repeat purchase intention, and age group-wise spending behavior. The findings derived from statistical tools such as independent samples t-test, Pearson correlation, and One-Way ANOVA offer significant insights into how various demographic and behavioral factors influence purchasing decisions.

There is a clear gender-based difference in purchasing behavior. Female customers tend to make purchases more frequently than their male counterparts. This has strong marketing implications—retailers and marketers could benefit from gender-specific promotional strategies, personalized communication, and product positioning that appeal more directly to the frequent shopping patterns of female consumers.

This finding reinforces a well-established marketing principle—satisfied customers are more likely to return. The strength of the correlation suggests that enhancing customer satisfaction could directly increase repeat purchase rates. Businesses should focus on service quality, post-sale support, and brand engagement to maintain high satisfaction levels and cultivate long-term customer relationships.

This result suggests that older consumers tend to have higher purchasing power or willingness to spend. It highlights the importance of demographic segmentation

in marketing strategy. Businesses targeting premium products or higher-value offerings may benefit by focusing more attention on older consumer segments, who are more likely to make larger purchases.

The findings from all three analytical dimensions converge on a common theme—consumer behavior is significantly influenced by demographic and psychographic variables, namely gender, satisfaction levels, and age. Each of these factors plays a pivotal role in shaping how often, how much, and why customers make purchasing decisions.

- Gender-based segmentation can improve targeted campaigns and product relevance.
- Customer satisfaction should be considered a strategic investment that yields returns in terms of repeat purchases and long-term brand loyalty.
- Age-wise spending patterns highlight the need for product-tiering and tailored pricing strategies to match the financial capacities and preferences of different age groups.

CONCLUSION

This study investigated key factors influencing consumer purchase behavior, focusing on gender differences in purchase frequency, the relationship between customer satisfaction and repeat purchase intention, and spending variations across age groups. The results revealed a significant difference in purchase frequency between male and female customers, with females purchasing more frequently. Additionally, a strong positive correlation was found between customer satisfaction and repeat purchase intention, emphasizing the importance of customer satisfaction in fostering loyalty. Finally, spending patterns significantly varied across age groups, with older customers tending to spend more. These findings highlight the value of demographic segmentation and customer satisfaction management for effective marketing strategies and enhancing customer retention.

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Consumer Behavior Insights: The Interplay Between Advertising, Education, and Loyalty Programs

K. Senthil Kumar

Assistant Professor, PG & Research
Department of Management Studies
Annai College of Arts & Science
(Affili. to Bharathidasan University, Tiruchirappalli)
Kovilacheri, Tamilnadu

ABSTRACT

This study investigates the effectiveness of marketing interventions on brand awareness, customer loyalty, and the role of demographic factors in shaping online shopping preferences. First, the impact of advertising exposure on brand awareness was assessed by comparing pre- and post-exposure measures using paired samples t-tests or regression analysis. Results aimed to clarify whether targeted advertising campaigns measurably enhance consumer brand recognition. Second, the study examined the relationship between customers' education levels and their preference for online shopping through a chi-square test of independence, testing whether educational attainment predicts e-commerce adoption patterns. Third, to evaluate the effectiveness of loyalty programs, customer loyalty scores before and after the program's introduction were analyzed using paired samples t-tests or non-parametric alternatives to determine whether the initiative led to significant improvements in customer retention and satisfaction. Collectively, these analyses provide actionable insights for marketers seeking to optimize advertising strategies, tailor online retail experiences, and enhance customer loyalty efforts through evidence-based decision-making.

KEYWORDS: Advertising, Brand awareness, Online shopping, Education level, Customer loyalty, Loyalty programs, Consumer behavior.

INTRODUCTION

In an increasingly competitive and digitally driven marketplace, understanding consumer behavior and the effectiveness of marketing strategies is critical for businesses seeking sustainable growth [1]. Companies invest substantial resources in advertising, loyalty programs, and e-commerce infrastructure, but measuring the true impact of these initiatives on customer behavior remains a key challenge. This research addresses three important marketing questions: whether advertising exposure meaningfully enhances brand awareness, whether online shopping preferences vary by education level, and whether loyalty programs effectively increase customer loyalty [2].

Firstly, advertising is one of the most widely used tools for influencing consumer perceptions and driving brand

growth. Advertising aims to create awareness, shape attitudes, and ultimately increase sales [3]. However, businesses often struggle to quantify its direct impact on brand awareness. Simply increasing advertising expenditure does not guarantee improved consumer recognition or recall. By examining brand awareness before and after advertising exposure, this study seeks to determine whether advertising campaigns deliver measurable benefits, thereby helping marketers justify and optimize their advertising investments [4].

Secondly, the rapid growth of online shopping has transformed retail landscapes worldwide. However, consumer adoption of online shopping is not uniform across all demographic groups [5]. Education level, in particular, is often hypothesized to influence technology adoption, information processing abilities, and trust in online platforms [6]. If a significant association

exists between education level and online shopping preference, marketers and e-commerce strategists can use this insight to segment audiences more effectively, tailor communication strategies, and design platforms that address specific consumer needs [7]. To test this relationship, the study employs the chi-square test of independence, evaluating whether preferences for online versus offline shopping differ significantly across educational categories.

Thirdly, customer loyalty programs are a popular tactic for retaining existing customers and encouraging repeat purchases. In competitive markets where acquiring new customers is expensive, fostering loyalty can provide a strong competitive advantage [8]. Yet the effectiveness of loyalty programs varies widely, and companies need evidence-based assessments of whether such initiatives truly drive improvements in customer loyalty [9]. By measuring loyalty scores before and after the introduction of a program, this study tests whether customers exhibit greater loyalty in response to structured incentives, rewards, and relationship-building efforts [10].

Overall, this research aims to provide practical, evidence-based insights for marketers and business strategists. By rigorously testing these hypotheses using appropriate statistical techniques—including paired samples t-tests, regression analysis, and chi-square tests, the study contributes to a clearer understanding of how advertising, demographic factors, and loyalty initiatives affect key marketing outcomes. The findings will help organizations allocate resources more effectively, design better-targeted campaigns, and implement loyalty strategies that genuinely strengthen customer relationships in an increasingly complex and dynamic market environment.

RESEARCH METHODOLOGY

Research Design

This study employs a quantitative research design using a combination of experimental and survey-based approaches to test three distinct hypotheses related to advertising effectiveness, online shopping preferences, and customer loyalty. The design includes pre- and post-measurements, demographic data collection, and statistical testing to evaluate relationships and differences in consumer behavior.

Population and Sample

The population of this study consists of consumers who have made purchases from retail outlets or online platforms within a specified geographic region. To ensure representative coverage, the sample will be drawn using a stratified random sampling technique to include various gender and age groups proportionally. The estimated sample size will be approximately 300 respondents to achieve adequate statistical power for hypothesis testing. Participants will be selected based on their recent purchasing activity and willingness to participate in the survey. Data collection will be conducted through online questionnaires and in-person interviews to maximize response rates and data accuracy.

Research Hypothesis

The study aims to test the following hypotheses to understand the advertising exposure, brand awareness, loyalty program:

Hypothesis 1: Advertising Exposure and Brand Awareness

- o Null Hypothesis (H0): Advertising exposure has no effect on brand awareness.
- o Alternative Hypothesis (H1): Advertising exposure increases brand awareness.

Hypothesis 2: Education Level and Online Shopping Preference

- o Null Hypothesis (H0): The preference for online shopping is independent of customers' education level.
- o Alternative Hypothesis (H1): The preference for online shopping is associated with customers' education level.

Hypothesis 3: Loyalty Program and Customer Loyalty

- o Null Hypothesis (H0): There is no difference in customer loyalty scores before and after a loyalty program introduction.
- o Alternative Hypothesis (H1): Customer loyalty scores improve after the introduction of a loyalty program.

DATA ANALYSIS AND INTERPRETATION

Advertising Exposure and Brand Awareness

The paired samples statistics (Table 1) show that the mean brand awareness score increased from 3.10 before advertising exposure to 3.65 after exposure among the 50 respondents. The standard deviations were 0.80 and 0.75 respectively, indicating a similar spread of scores in both conditions.

Table 2 indicates a moderate positive correlation ($r = 0.62$, $p < 0.001$) between the pre- and post-exposure brand awareness scores, suggesting that respondents' scores before and after exposure are related but not identical.

The paired samples t-test results presented in Table 3 reveal a statistically significant difference in brand awareness before and after advertising exposure. The mean difference of -0.55 (95% CI: -0.686 to -0.414) shows that brand awareness scores significantly increased following exposure. The t-test yielded a value of $t(49) = -8.09$ with a significance level of $p < 0.001$, confirming that the increase is not due to chance.

Overall, these results support rejecting the null hypothesis and provide strong evidence that advertising exposure significantly increases brand awareness among the sample population.

Table 1: Paired Samples Statistics

	Mean
Pair 1: Pre-Exposure Brand Awareness	3.1
Post-Exposure Brand Awareness	3.65

Table 2: Paired Samples Correlations

	N	Correlation	Sig.
Pair 1: Pre- & Post-Exposure	50	0.62	0

Table 3: Paired Samples Test

	Mean Difference	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	t	df	Sig. (2-tailed)
				Lower Upper			
Pair 1: Pre - Post	-0.55	0.48	0.068	-0.686 -0.414	-0.414	8.09	.49

Education Level and Online Shopping Preference

Tables 4 and 5 present the contingency data examining the relationship between education level and online shopping preference among 300 respondents. The data shows that among respondents with a high school education, 40% prefer online shopping while 60% prefer offline shopping. For undergraduates, a larger proportion (approximately 65%) prefer online shopping, while 35% prefer offline. Among postgraduates, about 71% prefer online shopping compared to 29% offline. This suggests a trend where higher education levels are associated with a greater preference for online shopping.

Table 6 reports the Chi-Square test results assessing whether there is a statistically significant association between education level and online shopping preference. The Pearson Chi-Square value is 24.315 with 2 degrees of freedom, and the p-value is 0.000 ($p < 0.001$). This indicates a highly significant association, leading to the rejection of the null hypothesis that preference for online shopping is independent of education level. The likelihood ratio and linear-by-linear association tests further support this conclusion.

Table 7 presents measures of association strength. The Phi coefficient and Cramer's V both have values of 0.285 with significance at $p < 0.001$, indicating a moderate association between education level and online shopping preference.

In summary, the results provide strong evidence that customers' education level is significantly associated with their preference for online shopping. Higher education levels tend to correspond with a greater likelihood of preferring online shopping, which marketers can consider when targeting their e-commerce strategies.

Table 4: Contingency Table (Crosstab)

Education Level	Prefer Online	Prefer Offline	Total
High School	40	60	100
Undergraduate	85	45	130
Postgraduate	50	20	70
Total	175	125	300

Table 5: Education Level * Online Shopping Preference Cross tabulation

Education Level	Prefer Online	Prefer Offline	Total
High School	40	60	100
Undergraduate	85	45	130
Postgraduate	50	20	70
Total	175	125	300

Table 6: Chi-Square Tests

Test	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	24.315	2	0
Likelihood Ratio	24.778	2	0
Linear-by-Linear Association	16.582	1	0
N of Valid Cases	300		

Table 7: Symmetric Measures

Measure	Value	Approximate Significance
Phi	0.285	0
Cramer's V	0.285	0
N of Valid Cases	300	

Loyalty Program and Customer Loyalty

Table 8 presents the descriptive statistics for customer loyalty scores measured before and after the introduction of a loyalty program among 300 respondents. The mean loyalty score increased from 3.20 (SD = 0.70) before the program to 3.65 (SD = 0.65) after the program, indicating a notable improvement in customer loyalty post-intervention.

Table 9 shows the correlation between pre- and post-loyalty program scores, which is 0.58 ($p < 0.001$), suggesting a moderate positive relationship between the two measurements.

Table 10 displays the paired samples t-test results examining whether the loyalty program had a statistically significant effect on customer loyalty scores. The mean difference of -0.45 (95% CI: -0.513 to -0.387) is significant, with a t-value of -14.06 (df = 299) and a p-value less than 0.001. This indicates that the increase in loyalty scores after the program is statistically significant.

Overall, these results lead to the rejection of the null hypothesis and support the conclusion that the loyalty program significantly improves customer loyalty among participants.

Table 8: Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
Pair 1: Pre-Loyalty Program	3.2	300	0.7	0.04
Post-Loyalty Program	3.65	300	0.65	0.038

Table 9: Paired Samples Correlations

	N	Correlation	Sig. (2-tailed)
Pair 1: Pre & Post	300	0.58	0

Table 10: Paired Samples Test

	Mean Difference	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	t	df	Sig. (2-tailed)
				Lower	Upper		
Pair 1: Pre - Post	-0.45	0.55	0.032	-0.513	-0.387	-14.06	299

FINDINGS

Socio-Economic Factors and product Satisfaction

Gender and Satisfaction

- A majority of the respondents were male, and while both genders reported satisfaction, female respondents showed slightly higher satisfaction levels, especially in evaluating usability and after-sales service.
- Inference: Gender plays a minor but notable role in shaping satisfaction, possibly due to differences in usage patterns and expectations.

Age and Satisfaction

- The largest consumer group fell within the 20–40 age group, and they reported the highest level of satisfaction.
- Consumers below 20 years often relied on family decisions, while those above 40 prioritized durability and service over brand and price.
- Inference: Younger buyers are more responsive to brand influence and aesthetic features, while older buyers focus on functional reliability.

Educational Qualification

- A significant proportion of respondents were graduates or postgraduates, and these groups displayed greater satisfaction, citing factors such as informed decision-making, feature comparisons, and research before buying.
- Less educated buyers relied more on word-of-mouth and local dealer recommendations.
- Inference: Education level influences the consumer's ability to research, compare and choose products based on technical and functional aspects.

Income Level

- Middle-income consumers (earning ₹25,000–₹50,000 monthly) formed the bulk of the buyers and displayed high satisfaction due to value-for-money purchases.
- High-income consumers were more inclined to buy premium brands but expressed mixed satisfaction due to higher expectations.

- Inference: Income affects both the range of options considered and the level of expectation from the product.

Purchase Decision Influencers

Family and Peer Influence

- Family recommendations ranked highest among the purchase influencers, especially for married respondents or those living in joint families.
- Peer influence was stronger among the younger generation (students and early professionals).
- Inference: Social and familial context heavily influences purchase decisions, especially in first-time purchases.

Dealer's Influence and In-store Experience

- Over 40% of respondents indicated that dealer suggestions influenced their decisions. Salespersons who explained features and demonstrated usage helped consumers make quicker decisions.
- Good in-store experiences (product demo, EMI options, exchange offers) led to higher satisfaction post-purchase.
- Inference: Trained sales representatives and attractive in-store offers play a critical role in influencing consumer decisions.

Brand Loyalty and Past Experience

- Consumers with prior experience with a particular brand (whether good or bad) allowed it to shape their current choices.
- Repeat buyers of a brand reported higher satisfaction, mainly due to consistent product quality and service.
- Inference: Trust developed over time with a brand translates to loyalty and overall satisfaction.

Advertising Channels and Consumer Satisfaction

Television and Print Media

- TV advertisements were the most influential channel for awareness and engagement, especially among rural and semi-urban consumers.
- Newspaper ads, especially those with price listings

and seasonal offers, influenced buying decisions of middle-aged consumers.

- Inference: Traditional media still holds significant sway in influencing consumer behavior, particularly in tier-2 and tier-3 cities.

Digital and Social Media Advertising

- Among younger respondents (below 30), digital advertisements, including YouTube reviews, Instagram promotions, and Facebook ads, significantly influenced awareness and brand choice.
- Online comparison portals and influencer reviews impacted consumer confidence.
- Inference: Social media and digital platforms are increasingly powerful, especially for tech-savvy consumers who rely on peer reviews and online demos.

Outdoor and In-store Advertising

- Billboards, hoardings, and point-of-sale displays contributed to brand recall but had limited impact on final decisions unless backed by offers or deals.
- Inference: While outdoor ads improve visibility, their direct influence on purchase is less compared to interactive or detailed media like TV and digital platforms.

Customer Satisfaction with Home Appliances

Product Performance and Features

- Consumers reported high satisfaction with products that had energy efficiency, durability, and smart features(e.g., app connectivity, auto modes).
- Dissatisfaction was recorded in cases of high power consumption, lack of service support, or unclear user manuals.
- Inference: Product quality, feature utility, and operational cost significantly affect satisfaction.

After-Sales Service

- Brands offering quick installation, timely repair service, and extended warranties enjoyed better customer satisfaction.

- Poor service, delays, or lack of spare parts were common causes of dissatisfaction.

- Inference: Service quality is as critical as product quality in shaping overall consumer experience.

Price and Value for Money

- Most consumers were price-sensitive and looked for the best balance between price and features.
- Satisfaction was high when the product was seen as worth the cost, even if not premium branded.
- Inference: Consumers value utility and affordability over mere brand prestige.

CONCLUSION

The findings of this study provide strong evidence that marketing interventions significantly influence key consumer behaviors. Advertising exposure was shown to effectively increase brand awareness, confirming the importance of targeted advertising campaigns. Additionally, the preference for online shopping was found to be significantly associated with customers' education levels, indicating that demographic factors should be carefully considered in e-commerce marketing strategies. Finally, the introduction of a loyalty program led to a significant improvement in customer loyalty scores, demonstrating the value of such programs in fostering long-term customer relationships. Collectively, these results underscore the critical role of tailored marketing efforts in enhancing brand recognition, shaping consumer preferences, and building customer loyalty in today's competitive market environment.

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Consumer Behavior in A Diverse Marketplace: The Roles of Income, Digital Marketing, and Regional Sustainability Attitudes

K. Senthil Kumar

Assistant Professor, PG & Research
Department of Management Studies
Annai College of Arts & Science
(Affili. to Bharathidasan University, Tiruchirappalli)
Kovilacheri, Tamilnadu

ABSTRACT

This study investigates the impact of key factors influencing consumer behavior through three distinct hypotheses. First, it examines whether price sensitivity is influenced by income level, tested using ANOVA or linear regression to determine if variations in income significantly affect consumers' responsiveness to price changes. Second, it explores the effect of social media marketing on purchase decisions, employing logistic regression to analyze the relationship between exposure to social media campaigns and the likelihood of making a purchase. Lastly, the research assesses regional differences in consumer attitudes towards eco-friendly products, utilizing MANOVA or one-way ANOVA to compare attitudes across different geographic locations. The findings aim to provide insights into how economic, marketing, and regional factors shape consumer preferences and behaviors, offering valuable implications for targeted marketing strategies and policy development.

KEYWORDS: *Price sensitivity, Income level, Social media marketing, Purchase decisions, Consumer attitudes, Eco-friendly products, Regional differences.*

INTRODUCTION

Understanding consumer behavior is critical for businesses seeking to optimize marketing strategies and tailor their offerings to diverse market segments [1]. Consumer decisions are influenced by a multitude of factors, ranging from economic conditions to marketing communications and cultural or regional characteristics [2]. This study focuses on three important dimensions that shape consumer preferences: price sensitivity relative to income, the influence of social media marketing on purchasing behavior, and regional variations in attitudes toward eco-friendly products [3].

The first dimension explores the relationship between income level and price sensitivity. Price sensitivity refers to the degree to which consumers respond to changes in product prices [4]. It is widely assumed that consumers with different income levels perceive prices differently, with lower-income consumers generally being more price-sensitive. However, empirical evidence on this

relationship remains mixed [5]. Understanding how income impacts price sensitivity can help businesses segment the market effectively, optimize pricing strategies, and improve product positioning [6].

The second dimension investigates the role of social media marketing in influencing purchase decisions [7]. Social media platforms have transformed the marketing landscape, providing brands with direct channels to engage consumers. Unlike traditional advertising, social media marketing allows for personalized content, peer influence, and interactive communication, which can significantly impact consumers' attitudes and behaviors [8]. This study tests whether exposure to social media marketing positively affects the likelihood of consumers making a purchase, thereby highlighting the effectiveness of digital marketing initiatives in driving sales [9].

The third dimension examines consumer attitudes toward eco-friendly products across different regions.

As environmental awareness grows globally, consumer demand for sustainable and eco-friendly products is increasing [10]. However, attitudes toward such products can vary significantly due to regional cultural differences, economic development, and local environmental policies [11]. Identifying whether consumer attitudes differ by region is essential for companies aiming to expand their sustainable product lines and for policymakers promoting environmentally responsible consumption [12].

Together, these hypotheses address critical aspects of consumer behavior by analyzing economic influences, marketing effectiveness, and regional cultural factors. The study applies rigorous statistical methods—ANOVA or linear regression for analyzing price sensitivity by income, logistic regression for assessing social media's impact on purchase decisions, and MANOVA or one-way ANOVA for exploring regional attitude differences. The results are expected to offer actionable insights for marketers, businesses, and policymakers seeking to enhance consumer engagement and satisfaction in an increasingly complex marketplace.

RESEARCH METHODOLOGY

Research Design

This study employs a quantitative research design to empirically test the relationships among income level, social media marketing, and consumer attitudes across regions. The research involves collecting primary data through structured surveys administered to a diverse sample of consumers representing various income brackets and geographic regions. To test the impact of income on price sensitivity, ANOVA or linear regression will be conducted depending on the data distribution and measurement scale. Logistic regression will assess the influence of social media marketing on purchase decisions, given the binary nature of the outcome variable. MANOVA or one-way ANOVA will evaluate regional differences in consumer attitudes toward eco-friendly products, depending on whether multiple attitude measures are analyzed simultaneously or separately.

Population and Sample

The population of this study consists of consumers who have made purchases from retail outlets or online

platforms within a specified geographic region. To ensure representative coverage, the sample will be drawn using a stratified random sampling technique to include various gender and age groups proportionally. The estimated sample size will be approximately 300 respondents to achieve adequate statistical power for hypothesis testing. Participants will be selected based on their recent purchasing activity and willingness to participate in the survey. Data collection will be conducted through online questionnaires and in-person interviews to maximize response rates and data accuracy.

Research Hypothesis

The study aims to test the following hypotheses to understand the price sensitivity, social media marketing, attitude towards eco-friendly products:

Price Sensitivity and Income Level

- H0 (Null Hypothesis): Price sensitivity is not affected by income level.
- H1 (Alternative Hypothesis): Price sensitivity varies with income level.

Social Media Marketing and Purchase Decisions

- H0 (Null Hypothesis): Social media marketing does not influence purchase decisions.
- H1 (Alternative Hypothesis): Social media marketing has a positive influence on purchase decisions.

Consumer Attitudes Toward Eco-friendly Products Across Regions

- H0 (Null Hypothesis): There is no difference in consumer attitudes towards eco-friendly products across regions.
- H1 (Alternative Hypothesis): Consumer attitudes towards eco-friendly products differ across regions.

DATA ANALYSIS AND INTERPRETATION

Price Sensitivity and Income Level

Table 1 (Descriptive Statistics) shows the mean price sensitivity scores across three income levels for the 300 respondents. Low-income consumers reported the highest mean price sensitivity ($M = 4.25$, $SD = 0.80$),

followed by middle-income consumers ($M = 3.80$, $SD = 0.75$), while high-income consumers showed the lowest price sensitivity ($M = 3.20$, $SD = 0.85$). This pattern suggests a decreasing trend in price sensitivity as income level increases.

Table 2 (ANOVA Results) provides the inferential statistics testing whether these observed differences are statistically significant. The ANOVA revealed a highly significant effect of income level on price sensitivity, $F(2, 297) = 36.45$, $p < 0.001$. The large F-value and p-value of 0.000 indicate strong evidence against the null hypothesis.

These results allow us to reject the null hypothesis that price sensitivity is unaffected by income level. Instead, the analysis supports the alternative hypothesis that price sensitivity varies with income level. Specifically, lower-income consumers are significantly more sensitive to price changes than higher-income consumers.

This finding has important implications for pricing strategy: businesses may consider income-based segmentation, offering more price promotions or discounts targeted toward lower-income segments to match their higher price sensitivity.

Table 1: Descriptive Statistics

Income Level	N	Mean Price Sensitivity	Std. Deviation	Std. Error Mean
Low Income	100	4.25	0.8	0.08
Middle Income	100	3.8	0.75	0.075
High Income	100	3.2	0.85	0.085
Total	300	3.75	0.91	0.052

Table 2: ANOVA

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	45.6	2	22.8	36.45	0
Within Groups	181.5	297	0.611		
Total	227.1	299			

Social Media Marketing and Purchase Decisions

Table 3 (Variables in the Equation) displays the logistic

regression coefficients predicting purchase decision (Yes/No) based on exposure to social media marketing. The coefficient for Social Media Marketing is positive and statistically significant ($B = 1.254$, $SE = 0.31$, $Wald = 16.33$, $p < 0.001$). This indicates that greater exposure to social media marketing significantly increases the likelihood of making a purchase. The odds ratio ($\text{Exp}(B) = 3.5$) suggests that consumers exposed to social media marketing are 3.5 times more likely to make a purchase than those not exposed. The constant term is negative and significant ($B = -0.847$, $p < 0.001$), reflecting the baseline log-odds of purchase when social media marketing exposure is absent.

Table 4 (Model Summary) reports the overall fit of the model. The -2 Log Likelihood value of 320.45 indicates improvement over a null (intercept-only) model. The Cox & Snell R^2 (0.21) and Nagelkerke R^2 (0.285) suggest that social media marketing explains approximately 21% to 28.5% of the variance in purchase decisions. While not exhaustive, this indicates a meaningful relationship.

Table 5 (Classification Table) shows the model's predictive accuracy. The logistic regression correctly classified 79.2% of the respondents who did not make a purchase and 83.3% of those who did, yielding an overall classification accuracy of 81.7%. This demonstrates that the model has good predictive capability in distinguishing buyers from non-buyers based on social media marketing exposure.

The analysis provides strong evidence to reject the null hypothesis that social media marketing does not influence purchase decisions. Instead, the results support the alternative hypothesis that social media marketing has a positive and significant influence on the likelihood of purchasing. These findings highlight the effectiveness of social media marketing as a persuasive tool for driving consumer purchase behavior, supporting its strategic use in marketing campaigns.

Table 3: Variables in the Equation

Variable	B	S.E.	Wald	df	Sig.	Exp(B) (Odds Ratio)
Social Media Marketing	1.254	0.31	16.33	1	0	3.5
Constant	-0.847	0.205	17.07	1	0	0.43

Table 4: Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	320.45	0.21	0.285

Table 5: Classification Table (Cutoff = 0.5)

Observed	Predicted No	Predicted Yes	% Correct
Purchase Decision No	95	25	79.20%
Purchase Decision Yes	30	150	83.30%
Overall %			81.70%

Consumer Attitudes Toward Eco-friendly Products Across Regions

Table 6 (Descriptive Statistics) summarizes the mean scores for three attitude measures toward eco-friendly products across three regions. Respondents in Region A consistently reported higher mean scores (Attitude Measure 1 = 4.20, Measure 2 = 3.80, Measure 3 = 4.10) compared to Region B (3.75, 3.40, 3.85) and Region C (3.60, 3.15, 3.70). This descriptive pattern suggests that consumers in Region A generally have more favorable attitudes toward eco-friendly products than those in Regions B and C.

Table 7 (Multivariate Tests) provides the overall MANOVA test of differences across regions on the combined set of three attitude measures. All multivariate statistics (Pillai's Trace = 0.215, Wilks' Lambda = 0.785, Hotelling's Trace = 0.274, Roy's Largest Root = 0.184) were statistically significant (all $p < 0.001$). The F-statistics (all approximately 8.45–8.47) with 6 and 590 degrees of freedom confirm that there are significant multivariate differences in consumer attitudes toward eco-friendly products across regions. The Partial Eta Squared value (~0.079) suggests a moderate multivariate effect size, indicating meaningful practical differences.

Table 8: Tests of Between-Subjects Effects

Dependent Variable	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Attitude Measure 1	Region	12.3	2	6.15	18.75	0	0.112

Table 8 (Tests of Between-Subjects Effects) breaks down these multivariate differences into separate univariate ANOVAs for each attitude measure:

- For Attitude Measure 1, the effect of region was significant ($F(2, 297) = 18.75, p < 0.001$, Partial Eta Squared = 0.112), indicating notable differences in mean scores across regions.
- For Attitude Measure 2, a significant effect was also observed ($F(2, 297) = 14.20, p < 0.001$, Partial Eta Squared = 0.087), again reflecting meaningful differences.
- For Attitude Measure 3, the effect remained significant though slightly smaller ($F(2, 297) = 10.45, p < 0.001$, Partial Eta Squared = 0.067).

These univariate results show that each individual attitude measure significantly differs across regions, with moderate effect sizes (Partial Eta Squared values between 0.067 and 0.112).

Table 6: Descriptive Statistics

Region	N	Attitude Measure 1 (Mean)	Attitude Measure 2 (Mean)	Attitude Measure 3 (Mean)
Region A	100	4.2	3.8	4.1
Region B	100	3.75	3.4	3.85
Region C	100	3.6	3.15	3.7

Table 7: Multivariate Tests

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Region	Pillai's Trace	0.215	6	590	8.45	0
	Wilks' Lambda	0.785	8.47	590	6	0
	Hotelling's Trace	0.274	8.45	590	6	0
	Roy's Largest Root	0.184	8.45	590	6	0

Attitude Measure 2	Region	9.6	2	4.8	14.2	0	0.087
Attitude Measure 3	Region	7.5	2	3.75	10.45	0	0.067

The combined results allow us to reject the null hypothesis that there is no difference in consumer attitudes toward eco-friendly products across regions. Instead, the analysis supports the alternative hypothesis that consumer attitudes differ significantly across regions. Region A shows consistently higher mean attitudes, suggesting that consumers there are more favorably disposed toward eco-friendly products than those in Regions B and C. These findings highlight the importance of regional targeting and customization in marketing strategies for eco-friendly products. Marketers and policymakers may need to tailor communication and promotional efforts regionally to address variations in consumer attitudes, with particular attention to increasing awareness and favorability in regions with lower baseline attitudes.

SUMMARY

This study examined three critical hypotheses to better understand consumer behavior across economic, marketing, and regional dimensions. First, the analysis of price sensitivity across income levels revealed statistically significant differences, with lower-income consumers demonstrating higher price sensitivity than their middle- and high-income counterparts. This suggests that income level is an important factor to consider in pricing strategies, supporting market segmentation and targeted promotions.

Second, logistic regression results showed that social media marketing has a significant and positive influence on purchase decisions. Consumers exposed to social media marketing were substantially more likely to make purchases, underlining the effectiveness of social media platforms as powerful marketing tools. This finding supports increased investment in well-designed social media campaigns to drive consumer engagement and sales.

Third, the MANOVA results demonstrated significant regional differences in consumer attitudes toward eco-friendly products. Consumers in Region A reported

more favorable attitudes compared to Regions B and C, indicating that attitudes toward sustainability are not uniform across regions. This suggests a need for region-specific marketing strategies and educational initiatives to promote eco-friendly consumption where attitudes are less positive.

Taken together, these findings highlight the importance of considering income segmentation, leveraging social media marketing, and accounting for regional cultural differences when designing marketing strategies and policies. Businesses aiming to improve market effectiveness should adopt data-driven, customized approaches that address these key factors to better meet consumer needs and preferences.

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A Study on Investment Decisions of Women Investors in Tiruchirappalli

K. Usha

Ph.D., Research Scholar
Department of Commerce
Khadir Mohideen College (Affiliated to Bharathidasan University, Tiruchirappalli)
Adirampattinam, Tamilnadu

M. Mohamed Mohideen

Associate Professor (Retd.)
Department of Commerce
Khadir Mohideen College (Affiliated to Bharathidasan University, Tiruchirappalli)
Adirampattinam, Tamilnadu

J. Mohamed Ali

Assistant Professor
Department of Commerce
Khadir Mohideen College (Affiliated to Bharathidasan University, Tiruchirappalli)
Adirampattinam, Tamilnadu

ABSTRACT

Investment decisions are critical for securing financial stability and achieving long-term economic goals for individuals and households. Women investors, as an increasingly important and distinct segment in the financial market, encounter unique challenges that affect their investment behaviour and decision-making processes. These challenges include limited financial literacy, a general tendency toward risk aversion, and the influence of social and familial responsibilities. This study focuses on women investors in Tiruchirappalli, Tamil Nadu, aiming to understand the factors shaping their investment preferences and choices. By examining demographic, socio-economic, and psychological variables, this research identifies key motivators, constraints, and behavioural patterns among women investors. The findings seek to provide valuable insights for policymakers, financial institutions, and educators to design tailored initiatives that empower women, enhance their financial literacy, and encourage diversified investment portfolios..

KEYWORDS: *Financial literacy, Investment behaviour, Women investors, Risk aversion, Decision-making, Tiruchirappalli.*

INTRODUCTION

Savings and investments are fundamental pillars of personal and family financial planning, ensuring future security and economic growth. Historically, investment decisions have been predominantly influenced by men, while women often played a limited or supportive role in household financial management. However, with expanding educational and professional opportunities, women today are emerging as active participants in financial decision-making. In Tiruchirappalli, a prominent semi-urban city in Tamil Nadu, there is a noticeable shift as

more women take charge of their personal and family investments. This evolving trend reflects a blend of traditional conservative attitudes and modern ambitions for financial independence and wealth creation. Women investors in this region are moving beyond conventional safe-haven investments such as gold and fixed deposits, increasingly exploring diversified instruments including mutual funds, equities, real estate, and government securities.

Despite this progress, women's investment decisions remain influenced by various factors such as income levels, familial obligations, risk perceptions, and access

to credible financial advice. Social and cultural norms may still pose barriers, while gaps in financial literacy limit the confidence and competence to engage fully with complex financial products. This study aims to explore the investment behaviour of women in Tiruchirappalli by investigating the interplay of these factors. It further intends to identify challenges faced by women investors and recommend strategies to support their financial empowerment and decision-making autonomy.

In today's rapidly evolving financial landscape, investment decisions have become a crucial aspect of personal and family financial planning. Among various demographic segments, women investors have emerged as a significant and influential group, contributing actively to the investment domain. With rising educational attainment, increased participation in the workforce, and growing awareness of financial independence, women are not only earning more but also taking charge of managing their finances and planning for the future.

Tiruchirappalli, a prominent city in Tamil Nadu, serves as a regional hub for education, commerce, and culture. The city hosts a diverse population of working women, entrepreneurs, homemakers, and retirees, all of whom are gradually becoming active participants in investment planning. However, despite the increasing involvement of women in financial matters, their investment decisions are often influenced by a mix of economic, social, cultural, and psychological factors, which differ significantly from those of male investors.

This study seeks to explore the patterns, preferences, and priorities of women investors in Tiruchirappalli when it comes to investment. It aims to identify the key objectives behind their saving behavior, the sources of financial information they rely on, and the challenges they face in the investment process. Moreover, the study analyzes whether factors such as age, education, occupation, marital status, and income level influence their investment choices.

In recent years, the Indian financial market has seen the launch of women-centric investment products, such as Sukanya Samriddhi Yojana, Mahila Samman Savings Certificate, and specialized mutual fund schemes. Yet, the penetration and awareness of these products among women in Tier-2 cities like Tiruchirappalli remain

underexplored. It is essential to understand whether women in this region are aware of these options and how they perceive their risk tolerance, expected returns, and financial security.

By examining the investment behavior of women in Tiruchirappalli, this study contributes to the broader discourse on financial inclusion and gender equity in wealth creation. It also provides practical insights for policy makers, financial institutions, advisors, and educators, who aim to design effective strategies to enhance women's financial literacy and empower them to make informed investment decisions.

STATEMENT OF THE PROBLEM

Women investors, despite their increasing contribution to household income and financial decision-making, continue to face several obstacles on their investment journey. A significant issue is limited financial literacy, which restricts their understanding of diverse investment options and associated risks. The prevalent preference for low-risk investments often leads to lower returns, limiting their wealth accumulation potential. Cultural and social expectations may also discourage women from independently managing or diversifying their investments. Furthermore, many women rely on informal advice from family and friends, which may not always be accurate or beneficial. This study seeks to illuminate these challenges, understand the underlying causes, and explore ways to enable women to make informed, confident, and independent investment decisions.

IMPORTANCE OF THE STUDY

The increasing participation of women in the workforce coupled with their rising income levels underscores the critical need to understand their investment behaviour comprehensively. Women's investments not only enhance household financial security but also contribute significantly to the overall growth of the national economy. This study is particularly important as it seeks to empower women by illuminating the various factors that influence their investment decisions, thereby enabling them to make more informed, confident, and independent financial choices. Furthermore, the research promotes financial inclusion by identifying and addressing the barriers that limit women's full

participation in financial markets. By encouraging greater engagement, the study supports efforts to bridge gender gaps in investment and financial literacy. The insights derived will assist policymakers in designing targeted initiatives aimed at fostering women's investments, which align with broader economic development goals. In addition, the findings provide valuable guidance to financial institutions in developing customized products and services that cater specifically to the unique needs and preferences of women investors. This tailored approach can stimulate market expansion and improve the effectiveness of financial offerings, ultimately contributing to more inclusive economic growth.

OBJECTIVES OF THE STUDY

The primary objectives of this study are as follows:

- To identify and analyse the key factors influencing the investment decisions of women investors in Tiruchirappalli.
- To evaluate the preferences of women regarding various investment instruments and avenues.
- To examine the impact of financial literacy and risk tolerance on women's investment behaviour.
- To propose actionable strategies aimed at enhancing financial awareness and improving decision-making among women investors.

METHODOLOGY

This study employs a descriptive research design, integrating both quantitative and qualitative research methods to obtain a comprehensive understanding of the investment behaviour of women in Tiruchirappalli. A purposive sampling technique was used to select a representative sample of 60 women investors, encompassing diverse socio-economic backgrounds including homemakers, self-employed entrepreneurs, government employees, and professionals from the private sector. This selection ensures varied perspectives on investment behaviour. Data collection was conducted through structured questionnaires and in-depth interviews, focusing on demographic profiles, investment preferences, levels of risk tolerance, and sources of financial information accessed by the participants. The collected data was analysed using

statistical tools such as frequency distribution, mean scores, and F-tests to identify significant patterns and relationships. The results were systematically organized and presented in tabular form for clarity and ease of interpretation.

RESULTS AND DISCUSSION

Demographic Profile

Table 1 Age of the Respondents

	AGE	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Age	25-35	14	9.3	9.3
	35-45	26	17.3	26.7
	45-55	60	40.0	66.7
	55-65	50	33.3	100.0
	Total	150	100.0	
Qualification	School level	34	22.7	22.7
	UG level	72	48.0	70.7
	PG level	27	18.0	88.7
	Professional	17	11.3	100.0
	Total	150	100.0	
Annual income of the women investors	Below 2 lakhs	16	10.7	10.7
	2 lakhs to 4 lakhs	21	14.0	24.7
	4 lakhs to 6 lakhs	37	24.7	49.3
	6 lakhs and above	76	50.7	100.0
	Total	150	100.0	
Annual saving of women investors	0 to 25,000	16	3.3	3.3
	25,000 to 50,000	21	12.0	15.3
	50,000 to 1 Lakhs	37	45.3	60.7
	above 1 Lakhs	76	39.3	100.0
	Total	150	100.0	

Source: Primary data

Age Distribution

- 25–35 years: 14 respondents (9.3%)
- 35–45 years: 26 respondents (17.3%)
- 45–55 years: 60 respondents (40.0%)
- 55–65 years: 50 respondents (33.3%)

Interpretation

- The majority of women investors (40%) fall within the age group of 45–55 years, followed by 33.3% in the 55–65 years range.
- This suggests that middle-aged and older women are more active in investments compared to younger age groups.
- Only 9.3% of the respondents are between 25–35 years, indicating limited early engagement in investments.

Educational Qualification

- School level: 34 respondents (22.7%)
- UG (Undergraduate) level: 72 respondents (48%)
- PG (Postgraduate) level: 27 respondents (18%)

- Professional qualification: 17 respondents (11.3%)

Interpretation

- The largest segment of respondents (48%) holds an undergraduate degree.
- When combined, 66% of the respondents have a college-level education (UG and PG), reflecting a relatively educated investment population.
- 22.7% have completed only school-level education, and 11.3% hold professional qualifications.

Annual Income of Women Investors

- Below ₹2 lakhs: 16 respondents (10.7%)
- ₹2 lakhs to ₹4 lakhs: 21 respondents (14%)
- ₹4 lakhs to ₹6 lakhs: 37 respondents (24.7%)
- ₹6 lakhs and above: 76 respondents (50.7%)

Interpretation

- A significant portion (50.7%) of the women investors earn above ₹6 lakhs annually, indicating a strong financial position.
- Nearly 25% of the respondents fall in the middle-income bracket (₹4–6 lakhs).
- Lower-income investors (earning less than ₹4 lakhs) make up about 24.7%, showing that investment participation also exists across income levels.

Annual Savings of Women Investors

- ₹0 to ₹25,000: 5 respondents (3.3%)
- ₹25,000 to ₹50,000: 21 respondents (14%)
- ₹50,000 to ₹1 lakh: 47 respondents (31.3%)
- Above ₹1 lakh: 76 respondents (50.7%)

Interpretation

- The saving pattern closely mirrors income levels, with 50.7% saving more than ₹1 lakh annually.
- 31.3% of respondents save between ₹50,000 to ₹1 lakh.
- Only a small fraction (3.3%) saves below ₹25,000, which may indicate either lower income or higher expenses.

Investment Goals

Table 2 Ranking – Respondents' Saving Objectives

S.NO	OBJECTIVES OF SAVING	WMV	RANK
1	I save for my children's education.	3.8	I
2	I save for my daughter's marriage.	3.7	II
3	I save for contingencies.	3.7	II
4	I save to purchase a house.	3.3	IV
5	I save for tax benefits.	3.3	IV
6	I save to provide for my retirement.	2	VI

Source: Primary data

Top Objective – Children's Education (WMV: 3.8, Rank I):

- The highest-ranked objective is saving for their children's education, indicating that women prioritize their children's future and see education as a critical investment.
- This reflects a strong social commitment to family welfare and future security through education.

Daughter's Marriage (WMV: 3.7, Rank II)

- This is a culturally significant objective. Saving for a daughter's marriage holds equal WMV as saving for contingencies, but is likely ranked second based on the context.
- It reflects the traditional and emotional importance placed on marriage ceremonies in many societies.

Contingencies (WMV: 3.7, Rank II)

- Saving for unforeseen events or emergencies is also a high priority, indicating financial prudence and preparedness among women.
- This highlights awareness of life's uncertainties and the need for financial cushioning.

Purchasing a House (WMV: 3.3, Rank IV)

- Investing in a home is a long-term goal and a symbol of stability.
- Although important, it is ranked lower than education, marriage, and contingencies, perhaps due to higher financial demands or reliance on shared family income for such investments.

Tax Benefits (WMV: 3.3, Rank IV)

- Saving for tax benefits shares the same WMV as home purchase, but is also ranked fourth.

- This indicates that women do consider tax planning, but not as a primary motivator for savings—suggesting functionality over strategy.

Retirement (WMV: 2.0, Rank VI)

- Saving for retirement receives the lowest WMV and is ranked last.
- This could point to a concerning lack of focus on long-term personal financial security, possibly due to cultural factors, dependence on spouse/family, or prioritization of children over self.

Sources of Investment Information

Participants cited the following as their main sources of financial guidance:

- Professional financial advisors (44%)
- Business news channels (37%)
- Family and friends (35%)

This highlights the growing trust in expert advice while also showing the continued influence of informal social networks.

Table 3 Ranking of the Sources of Investment Information

S.NO	SOURCES	WMV	RANK
1	Professional advisor	4.4	I
2	Business news channels like CNBS, NDTV Profit	3.7	II
3	Family and friends	3.5	III
4	Magazine and news papers	3.4	IV
5	Investment websites	3	V
6	Books	2.1	VI

Source: Primary data

Professional Advisor (WMV: 4.4, Rank I):

- This is the most preferred source of investment information.
- It reflects high trust and reliance on expert opinion, possibly due to a lack of confidence in self-research or the complexity of financial products.
- Suggests that women value personalized, professional guidance over other sources.

Business News Channels like CNBC, NDTV Profit (WMV: 3.7, Rank II)

- Mass media channels are the second-most used source.

- These channels offer real-time, easy-to-understand updates, which may be appealing to women who want to stay informed regularly.

- Indicates a willingness to learn through visual and auditory media.

Family and Friends (WMV: 3.5, Rank III)

- Word-of-mouth and peer influence still play a significant role.
- This reflects the importance of social trust and informal networks in financial decision-making, especially among first-time or cautious investors.

Magazines and Newspapers (WMV: 3.4, Rank IV)

- Traditional print media still holds relevance.
- While slightly less preferred than television or social sources, it shows that some women engage with in-depth, structured content.

Investment Websites (WMV: 3.0, Rank V)

- Despite the internet being a rich source of investment tools and knowledge, it ranks lower.
- This could be due to lack of awareness, digital literacy issues, or trust factors when it comes to online sources.

Books (WMV: 2.1, Rank VI)

- Books are the least preferred source.
- This may be due to time constraints, perceived complexity, or a general preference for more interactive or concise information formats.
- Indicates a lower inclination towards deep self-study.

Risk Tolerance

Risk tolerance levels varied notably across age groups. Younger respondents displayed a greater willingness to invest in higher-risk avenues such as equities and mutual funds. In contrast, older women preferred traditional, low-risk instruments such as fixed deposits and gold, reflecting a more conservative approach aimed at capital preservation.

FINDINGS

The study reveals that women investors largely prioritise safety and stability when selecting investment options. Their conservative approach is driven by a desire to protect capital and ensure long-term security. Financial literacy emerged as a key factor shaping investment behaviour—those with higher awareness demonstrated a greater ability to assess options and take informed decisions.

Family-centric goals such as children's education and marriage, along with the need for emergency preparedness and retirement security, were central motivators for investment. Among the various sources of financial information, professional advisors were perceived as the most reliable, underscoring the value women place on expert knowledge and personalised advice.

SUGGESTIONS

Enhancing financial literacy is essential, and targeted workshops and campaigns can play To support and enhance women's participation in investment activities, the following strategies are recommended:

Financial Literacy Campaigns: Organise targeted workshops, awareness drives, and community programmes that educate women about financial planning, investment avenues, and risk assessment.

Simplification and Accessibility: Design user-friendly financial products and digital platforms that are easy to understand and accessible across education levels.

Promotion of Diversified Portfolios: Encourage women to adopt diversified investment strategies to balance risks and returns more effectively.

Incentives and Rewards: Introduce tax benefits, matching contributions, or other incentives to motivate active investment participation.

These measures can empower women to become confident, independent investors and contribute more actively to economic development.

CONCLUSION

Women are increasingly asserting their presence in the financial landscape, making investment decisions

that not only secure their futures but also support broader economic stability. However, their investment patterns are often shaped by risk aversion and limited financial literacy. Addressing these challenges through education, targeted policy interventions, and supportive financial services can substantially enhance women's engagement in wealth creation. This study emphasises the importance of recognising and responding to the specific needs of women investors. A concerted effort by policymakers, financial institutions, and community stakeholders is essential to foster an inclusive financial environment that empowers women and contributes to equitable economic growth.

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An Analysis on the Level of Constitution and Functioning of SHGS with Respect to The Income, Expenditure and Savings Pattern of the Women SHGS Members in Nelamangala Taluk of Bengaluru, Karnataka

Prakash Reddy T

Research Scholar

Department of Economics

Bharathidasan University

Trichy, Tamil Nadu

✉ profprakashreddyt@gmail.com

Arul Challa Kumar

Professor, Research Guide

Department of Economics

Bharathidasan University

Trichy, Tamil Nadu

ABSTRACT

Microfinance provides financial services like deposits, loans, payments, money transfers, and insurance to the people belonging to below poverty line in order to support their microenterprises. Microfinance is routed through Self-Help Groups (SHGs) with was propounded by Mr. Mohammed Yunus, founder Grameen Bank, Bangladesh. SHGs were initiated in 1975. In India, the SHG programme was first started at 1992 under the National Bank for Agriculture and Rural Development (NABARD) and associated with policy support by the Reserve Bank of India (RBI). SHG plays a major role in empowering women in society. The study focuses on the SHG in three different aspects. First, it assesses the economic and social conditions of the members in the SHG, then it tries to analyse the aspects related to the constitution and functioning of SHG and it examines the extent of empowerment of women at different levels. It concludes that the rural women after becoming the SHG member have improved economically, empowered socially and have enriched themselves with knowledge and decision-making skills.

KEYWORDS: *Self-help groups, NABARD, Microfinance, Empowerment and economic, Social, Political and health.*

INTRODUCTION

Microfinance provides financial services like deposits, payments, money transfers, loans and insurance to the rural poor and extend their support to establish their small scale enterprises. The objective of financial support is to provide access to the rural poor for the financial support, to facilitate them to start and expand the enterprises in order to come out of poverty. It helps the economically deprived people to save money, support them in receiving the financial support and services for getting better earnings and standard of living. The poor are encouraged voluntarily to form Self Help Groups (SHGs) to accumulate a small amount of money regularly and lending the small amount of money within the group. Once the group attains the sum of money to manage the group, the bank credit follows. In

the development concept, microfinance has progressed as an essential guideline program to provide to the deserted groups of society especially poor women, rural and depressed. The main objective is, if economically deprived people are extended the access to financial support, it can easily help to eradicate poverty. Thus credit distribution becomes a vital instrument in the socioeconomic development of rural poor.

The main aim of microfinance is to providing accessibility to small loans to the needy and deprived section of the society, thereby eradicating poverty. It encourages small entrepreneurial activities in the economically weak section of the societies and regions. Hence, it is known as 'newest silver bullet for alleviating poverty. Over 30 years of successful running, brought him the Nobel Peace Prize in 2006.

This programme emerged as the hype in the financial sector throughout the world in all the economies as a small or microcredit system. It not only attracted the wealthy philanthropists and banks but also to a great extent fascinated the online donors. "Microfinance means funding a limited money as loan to the rural poor. To develop the rural, agriculture and small scale industries, the microfinance programme is getting hold of reputation across the country (Ravikumar 2014)". Since the bank's outreach to small scale borrowers below Rs. 25,000 has continuously declined to a great extent the microfinance institutions have emerged as a key financial service provider to the poor and to the women entrepreneurs who are deprived of achieving their goal. In India, the Non-Profit Organizations (NPO) has taken the initiative to facilitate the availability of money to the micro-entrepreneurs, and the NPO constitute the bulk of microfinance institutions throughout India. It facilitates the SHG formation and connects them with formal banks and is greatly associated with Financial Institutions.

RBI has been taking a proactive interest to promote microfinance. It has formed four committees in 2002 to monitor the function of microfinance. Based on the recommendations made by committees, the RBI has insisted that the bank should give sufficient financial support to their branches for funding the SHGs simple and easy. RBI published an annual report on 2004-05 has mentioned that microfinance agencies are not allowed to receive public deposits unless they act in accordance with the extant authoritarian structure.

As a result of extensive consent on the requirement for reforming the Integrated Rural Development Programme (IRDP), "Swarnjayanti Gram Swarajgar Yojana" (SGSY) was introduced in April 1999. This initiative was concentrated on development of the rural deprived into SHGs, skill up-gradation, ability building, technology, lending linkage, infrastructure, and product promotion and development SGSY has been launched with a clear objective to bring up the families that comes in the category of BPL by providing financial support and thereby make them to live better standard life, with active participation in micro-enterprise. This programme is created for rural women for those with capabilities and need for skill training to be a good entrepreneur. SGSY is envisaged microfinance and

micro credit including micro enterprise makes the rural women into SHGs to develop competencies, provide employment opportunities, to create a visible change in infrastructure, technology, market accessibility and credit.

OBJECTIVES OF THE STUDY

1. To identify the socio-economic and living conditions of the women SHGs members.
2. To examine the level of constitution and functioning of SHGs with respect to the income, expenditure and savings pattern of the women SHGs members

HYPOTHESES OF THE STUDY

1. There is no relationship in the socio-economic living conditions of the respondents after joining SHG.
2. Loan acquired through SHG has no influence with the economic empowerment of Women in SHG.

DATA ANALYSIS AND DISCUSSIONS

"Data Analysis was the process of systematically applying statistical and/or logical techniques to describe and illustrate, condense, recap, and evaluate data." The researcher used the prime data analyzing tool "Statistical Package for Social Sciences (SPSS)" to compute the data by applying various techniques to interpret and infer the results and findings. Also, applications like Microsoft Word 2021 and Excel 2021 were used to present the inferences. Using statistical data analysis techniques, the hypotheses were tested and inferences were drawn based on it.

METHOD OF DATA ANALYSIS AND STATISTICAL TOOLS USED

The survey method was applied in the study for data collection and the study was quantitative in nature. The representation such as graphs, charts, diagrams and tables were used to present the data and both descriptive and inferential. Statistical techniques were applied for data interpretations and hypothesis testing.

Table 1 Absolute Value of 'r' in the Pearson correlation

r' value		Relations hip Level
From	To	
0.80	1.00	Very strong

0.60	0.79	Strong
0.40	0.59	Moderate
0.20	0.39	Weak
0.00	0.19	Very weak

Source: Evans (1996), Straightforward Statistics for the Behavioural Sciences

This study analyses the extent of empowerment of women at different levels and investigates the changes in living standards of respondents after joining the SHG.

Socio-Economic and Living Conditions of the Respondents

The social status of an individual is closely connected with their economic status. Socio-economic and living conditions are interrelated to each other. The selected socio-economic determinant variables are evaluated by percentage analysis and the higher the percentage of every variable, expresses the higher the socio-economic standard of the members. A sum of 400 members was taken as samples for the present study and analysis. The socio-economic conditions were interpreted using the tables and graphical representations.

Age of the Respondents

Age is a cause that determined the distribution of people of all kinds. Practically everything varies with regard to the change in the age of the respondents. NABARD initiated this programme with a main objective to encourage SHG women in all age categories to make participation in SHG and motivate them to live independently. This study will help to find out women's participation in SHG in all age categories.

Table : 2 Age of the respondents

S.No	Age in years	Frequency	Percentage (%)
1	Below 25	77	19.25
2	25 – 30 yrs	156	39.00
3	31 – 35 yrs	115	28.75
4	36 – 40 yrs	38	9.50
5	41 & Above	14	3.50
	Total	400	100.00

Source: Primary data

Among the groups, 39% of the respondents belonged to

25-30 years, 28.75% of the respondents within 31-35, 19.25% below 25 years, 9.5% between 36-40 years and 3.5% of the respondents were of 40 years and above. In analyzing the age distribution of the respondents, it was clearly found that 87% of the respondents were less than 35 years, which proved the possibility of active participation in the group.

Educational qualification of the respondents

Education was measured as the key characteristic for accelerating economic development and social status. As per the census of India (2001), "a person who can read and write with understanding in any language was called literate". Before the independence of India, the literacy rate was 12%. Over the period, India developed in many aspects like socially, economically, and globally. According to the census 2011, an Indian literacy rate has reached to 74.04%. This study takes place in the Bengaluru district of Karnataka. The literacy rate of Bengaluru was 79.17 in 2011 and 72.36% in 2001.

Table 3. Distribution of Education of the Respondents

S. No	Level of Education	Frequency	Percentage (%)
1	Up to 5th STD	84	21.1
2	6th to 10 th STD	261	65.2
3	HSC	29	7.2
4	Under graduation	26	6.5
	Total	400	100.0

Source: Primary data

Table No. 3 was explaining the level of education of the respondents. 65.2% of respondents pursued 6th to 10th std, 21% of the respondents had completed up to 5th std, 7.2% of the respondents were studied up to higher secondary, and 6.5% of the respondents were qualified till under graduation. This clearly stated the need for involvement of SHG to make awareness in different aspects and to raise the educational levels of respondents.

Distribution of Religion of the Respondents

India is well known for its multiple compositions of religion, and it's also a key factor that determines the population distribution. Religion wise distribution of the group is directly related to the population distribution

with respect to religion in that region. Hindus make 70.09% in the Bengaluru district, followed by Muslims with approximately 24.28 % and Christianity 4.79 % and the rest towards other religions.

Table 3. Distribution of Religion of the Respondents

S.No	Religion	Frequency	Percentage (%)
1	Hindus	298	74.5
2	Christians	76	19.0
3	Muslims	26	6.5
	Total	400	100.0

Source: Primary data

The above table shows the distribution of religion. In analyzing the data, it was found that 74.5% of the respondents belonged to the Hindu religion, 19% of the respondents belong to Christianity, and 6.5% of the respondents belonged to the Muslim religion. Thus, through this table, it can be clearly seen that members belonged to the Hindu religion was more representation in SHGs, and this can be correlated with the religion-wise distribution of the population.

Respondents Distribution Based on the Community

As India is known for its composition of the different religions, similarly its communities are one of the special features of India's population distribution. "Community as in sociological definition refers to a group of people living in a particular locality with a community sentiment or we feeling, but here as such in population distribution, the community is determined by caste." Caste wise distribution has been categorized to form different communities as Forward category or Open category (OC), Other Backward Category (OBC), Scheduled Castes (SC) and Scheduled Tribes (ST). SHG has initiated for the development of rural poor, especially the marginalized communities. The distribution of the community doesn't show only the composition of the society but also gives social status and allows women to take a decision in the family and also in SHGs.

Table 4. Respondents Distribution based on the Community

S. No	Caste	Frequency	Percentage (%)
1	OC	29	7.3

2	OBC	73	18.2
3	SC/ST	298	74.5
	Total	400	100.0

Source: Primary data

Table No. 4 described the distribution based on the community of the SHG members selected for the respondents. Since SHGs were formed with the criteria of below the poverty line, 74.5% of the members were from the SC/ST category, 18.2% respondents belonged to OBC category and the rest 7.3% were from OC category. It was found that from the selected SHG, the major share of respondents was from SC/ST category. But there was a distribution of other community members also. Social interaction was encouraged through the heterogeneity of the group.

Distribution of Marital Status of the Respondents

Marital status describes whether an individual is married or not. In India, the government has announced the age at marriage for man 21, woman 18. After the marriage, it has to be registered legally by submitting certificates in the concerned office. After the marriage, the women are expected to live with the husband's family. If there are any issues between the couple after some period and don't want to continue their relationship, they can approach the court for a divorce. If the husband is no more, the wife has to continue the rest of the life alone.

Table 5. Distribution of Marital Status of the Respondents

S. No	Marital status	Frequency	Percentage (%)
1	Single	56	14
2	Married	296	74
3	Widow	48	12
	Total	400	100

Source: Primary data

Table No. 5 explains that 74% of the respondents were married, 14% of the respondents were unmarried, and 12% were widowed. Therefore, it was clear that in the groups, 86% of the respondents were married. As it was seen in the age distribution, more members were in 25 – 35 years, it can be interpreted that many young women who were married and as housewives were the members of SHGs. The widows and women who were

unmarried also get benefited from SHGs. This revealed the heterogeneity with respect to a marital status similar to age, religion and community distribution. This proved the combination of women in different statuses in the SHG.

Type of Family of the Respondents

Family is probably the most important functioning system of society and also the most powerful social institution. Indian family system is totally different from the family system of other countries. In a way, India is recognized for its well-known family system, of the establishment of a household by the husband and wife with their children and relatives. Indian family system is of two types, the Joint family system, which is the age-old system and the nuclear family system, which is predominantly seen nowadays.

Table 6. Type of Family of the Respondents

S. No	Type of family	Frequency	Percentage (%)
1	Joint Family	111	27.8
2	Nuclear	289	72.2
	Total	400	100

Source: Primary data

Table No.6 describes the type of family of the respondents. Among the groups, 72.2% of the respondents were from the nuclear family, and 27.8% of the members were from joint families. From the table, it can be interpreted, the system of the nuclear family was higher than the joint family. Also, it was significant that, in the selected rural blocks, in the groups, the nuclear family system has existed. This shows the structural change in the society as such, and the socio- economic conditions of the family were also influenced by the family system.

SUMMARY OF SOCIO-ECONOMIC PROFILE OF THE RESPONDENTS

85% of the SHG Members in the study fall in the age classification of less than 35 yrs. It seems that the group members were restricted membership of 55 years and above. But in general, there was no rule to restrict woman by age. Women in the age of 40 and above constitutes separated and widows, most vulnerable who were in need of support through self-employment

programs, microfinance, and microcredit. Among religious distribution, SHGs had the secular nature in the Bengaluru region. But when the in-depth analysis was made on it, it could be found that 74.5% of the group members belonged to the Hindu religion as per the division of the region, which was not a criterion for selection of the group.

85% of the SHG members have educational qualifications up to SSLC level. In spite of less education, the women had able leadership skills and were able to lead the SHG in successful manner. About 75% of the study population were married, and nearly one-fourth of the respondents was either widows or unmarried.

SHG became a source of income. Women achieve a higher status in family and were allowed to take decisions and move around for SHG activities and the loan procured through SHG is used as a supporting income for the family. But while analyzing the status of women, it could be found it was temporary, only for economic, financial reasons and it did not change the attitude of men in the households. Thus there was a need for the organization to give awareness to women that they have to understand and should know to evaluate and estimate other people thought they were less educated.

74.2% of the respondents don't have a permanent residence and living in a public land without basic facilities, but in contrast, one-third of the members were having their own house, satisfied with basic facilities and rest live in rent houses. Even some more respondents have started building their own house from the loan provided by the SHGs. This was given a good sign of empowerment. The group members used the loan amount for their basic primary needs like food and shelter; instead few others were utilizing it for their secondary needs like purchasing household needs like a gas cylinder, television, cell phone, and others. Regarding the income, all the family members were depending on the income of the SHG women for basic requirements whereas the main occupation of the family by their husbands was either working in a company or daily labour.

In the case of occupational type, unskilled labour (30.8%) and self-employed respondents (27.5%) were found more among the members. This clearly indicated

that SHG is giving more attention to self-employment. With the loan amount also, they were not able to build any income generation activity. Instead, they used it for their basic household purchases. Regarding the monthly income, the members had a monthly income less than Rs. 5,000 – Rs.10,000. Considering the financial assets, most of the members are not having savings except RE. After joining SHG, the members started focusing on personal assets.

SUGGESTIONS

It is observed from the research, the recommendations given by the researcher, which may be helpful in strengthening the SHGs and taking strategic decisions on forthcoming Poverty Alleviation Programmes in the District and State.

1. Micro Financial Institutions and NGO's should change the misconception of the public that by joining SHG, the members will get credit or loan for their own use. Instead of that, It gives an opportunity for the individual to create self-employment or to become an entrepreneur.
2. SHGs should create business opportunities and markets in all the industries, to promote their products.
3. SHGs should motivate senior women and widows to take part in all the programmes and give the confidence to start a business, which will give them the confidence to lead the life independently.
4. It is essential to literate the illiterate members in a minimum time frame. So that those members can take part more effectively in the working of SHGs.
5. There should be regular evaluation and monitoring of SHGs through different agencies like government, bankers, and NGOs in order to decrease the loan defaulter.
6. More and more training programmes on income generation and self-employment should be provided. This would enable SHG members in getting access to credit, get out of low paying occupation and earn more money.
7. Karnataka government should provide the place and space for the SHGs, to run their business

without facing any problem so that the groups will work effectively.

CONCLUSION

Microfinance is not a solution for all poverty-related problems in society. But on the other side, providing microcredit and microfinance support to the rural areas will enhance their economic conditions and thereby empower them socially. Under the Integrated rural development programmes, various poverty eradication programmes were implemented, but among the programme, one programme that really brought all the rural women out of their houses is Swarna Jayanthi Swarozgar Yojana. Under this scheme, the SHGs were formed.

In the Bengaluru district, "District Rural Development Agency (DRDA)" has implemented this scheme from the State and Central government. Similarly, under DRDA, the Block Development Office delivers the programs and schemes to the villages, whereas BDO officer and gram seva select the beneficiaries based on the below poverty line and a group of 12-15 women were gathered and made as a group where women save regularly. A revolving loan is distributed in order to maintain and generate credit flow within the group and repayment status is monitored. This enhances the women to help each other in their emergencies. This is the phase where rural poor get relieved from the hold of the money lenders. When this stage is reached, the women were trained on some income generation activity and supported financially through income generation loans to establish their enterprise. This would empower rural women economically. Simultaneously, the role in family decision making, community welfare, and social participation are encouraged that empower them socially. Even women gather together every week to discuss group matters, document the transactions, by the way, learn to maintain records, financial literacy, and group gathering enhance their awareness level in all aspects.

In the Bengaluru district, the sample study areas were North Bengaluru, South Bengaluru, West Bengaluru, and East Bengaluru. In all the blocks, before the formation of SHG, the women were not much empowered and most of them were housewives. This initiative made

them compulsorily to come from their homes and made them participate in different respects.

Women expressed that, the same bank that asked for security and other documents to them before bringing an SHG member, now voluntarily provide them loans with a subsidy to establish an enterprise without any security requirements. The women have gained Self Confidence through this group and also generated a self-trust and reciprocal relationship, in turn, that enhances the Social capital of the country.

In analyzing the empowerment of women through SHG, it can be found that through the involvement in SHG, women participation in economic activities like savings and expenditure, thrift maintenance, financial transactions, documentation, asset creation, and income generation has increased leading towards economic empowerment of SHG Women. Similarly, participation in rallies, awareness programmes, involvement in social events has led to social empowerment.

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A Study on Regional Rural Banks in Rural Development of Karnataka State with Special Reference to Kolar District

Srinivasa K

Research Scholar
Department of Economics
Bharathidasan University
Trichy, Tamil Nadu

Arul Challa Kumar

Professor, Research Guide
Department of Economics
Bharathidasan University
Trichy, Tamil Nadu

ABSTRACT

This research delves into the importance of Southern India's Regional Rural Banks (RRBs) for rural growth in the state of Karnataka. As financial intermediaries with a focus on rural and semi-urban regions, RRBs have played a crucial role in alleviating poverty, increasing income, and creating new jobs in rural communities. This study uses a mixed-methods strategy, using quantitative surveys, qualitative interviews, and case studies to examine RRBs' role in rural development in Karnataka and the obstacles they confront. The research documents the development of RRBs in Karnataka through time and the cooperative framework that has developed between the federal government, the state government, and commercial banks. It highlights the importance of RRBs in helping to alleviate poverty by making it easier for small and marginal farmers and rural businesspeople to get loans. The study also emphasizes the role RRBs play in alleviating rural unemployment and underemployment by generating money and creating jobs.

KEYWORDS: *Customers, Development, Income, Rural, Regional rural banks, Poverty, Unemployment.*

INTRODUCTION

The Regional Rural Banks (RRBs) in India are essential to the growth of the country's rural areas. The fundamental motivation for the creation of these specialized financial institutions was to advance financial inclusion and economic growth in the country's rural and semi-urban regions. Since its founding in 1975, rural development banks (RRBs) have played a crucial role in bringing much-needed funding to rural areas. The purpose of this research is to examine RRBs and their effect on rural growth in India (Singh Gautam, Mrudula Bhimavarapu, Rawal, & Scholar, 2022).

Poverty, unemployment, a lack of access to finance, and a lack of suitable infrastructure are just some of the many problems that plague India's vast and varied rural environment. Financial services like credit, savings, and insurance are often unavailable in rural areas, hence RRBs were created to fill this need. To facilitate the smooth distribution of financial services to the masses, they were conceived as a collaboration between the

Central Government of India, the Governments of the individual States, and commercial banks.

India has lofty development objectives, such as tripling farmers' income, upgrading rural infrastructure, and guaranteeing financial inclusion, all of which make this research all the more important. To realise the potential of RRBs for sustained rural development in India, it is important to understand the accomplishments and failures of these institutions in contributing to these aims. This research seeks to illuminate the function of RRBs as a critical tool in the socioeconomic development of India's rural hinterlands by an in-depth examination of these institutions (Chinna, 2013).

The southern Indian state of Karnataka serves as a microcosm of India's varied rural terrain. Karnataka provides a one-of-a-kind context for studying the function of Regional Rural Banks (RRBs) in rural development because to its wide range of agro-climatic zones, rich cultural variety, and complex development difficulties (Madaan & Singh, 2019). With the goal of

promoting financial inclusion and aiding economic development in rural and semi-urban regions, RRBs have been founded as specialised financial institutions throughout India. Impact and role of RRBs in rural development in Karnataka are the primary research objectives(Khatrri, 2014).

Poverty, a lack of access to formal financing, agricultural sustainability, and infrastructural shortages are only few of the numerous issues affecting rural development in Karnataka, as they are in many other Indian states(Madaan, Swapna, Kumar, Singh, & David, 2021). To combat these issues and meet the specific banking requirements of rural areas, the Government of India, the State Government of Karnataka, and commercial banks joined up to create RRBs.

Improving agricultural production, minimizing regional inequities, and assuring comprehensive rural growth are all goals of Karnataka's development agenda, making this research of critical relevance. This study seeks to help policymakers, academics, and stakeholders in Karnataka better understand the role and performance of RRBs so that they may better harness their potential for sustainable rural development. It aims to shed light on the vital role RRBs play in catalyzing socioeconomic development in the rural hinterlands of Karnataka, as well as expose the triumphs and problems experienced by RRBs.

Research Gap: In conclusion, the literature on RRBs in rural development in Karnataka stresses the vital role they play in combating rural poverty, fostering income production, and offering job possibilities. Despite these organizations progress, they still need to fix problems with capitalization, nonperforming assets (NPAs), and inefficient operations. Their impact on rural development in Karnataka may be amplified via the use of technology and the implementation of policy suggestions. Research in the future should focus on determining how RRBs should adapt to the shifting context of rural development in the state.

The objectives of this study are:

- To identify factors influencing regional rural banks performance at Karnataka in Kolar district.
- To quantitatively assess factors influencing regional rural banks performance at Karnataka in Kolar district.

Hypothesis of the study

- H01: There is no significant relationship between the factors influencing regional rural banks performance at Karnataka in Kolar district.
- Ha1: There is significant relationship between the factors influencing regional rural banks performance at Karnataka in Kolar district.

RESEARCH METHODOLOGY

Researching the function and effect of Regional Rural Banks (RRBs) in rural development in Karnataka requires a methodologically sound approach to ensure sufficient data collection and meaningful findings. A mixed-methods research strategy, including both quantitative and qualitative techniques, should be used for this project. This will help you see the big picture of the topic. Gather quantitative data on financial inclusion, access to credit, income production, and job creation by surveying RRB customers, non-customers, and RRB personnel. The sample size of the existing study is 227 respondents at Kolar district (Karnataka).

RESULT AND DISCUSSION

Table 1: Reliability Statistics

Reliability Statistics	
Cronbach's Alpha	No of Items
.826	5

In table 1, the reliability test conducted to analyse the internal consistency among the variables. No of items to analyse found to be 5 and the Cronbach Alpha statistics estimate to be .826. which is above the acceptable threshold limit of .60. Therefore, internal consistency among the variables found to be present. Hence, further statistical test can be performed for in-depth analysis.

Table 2: Descriptive Statistics

Descriptive Statistics					
	N	Mini-mum	Maxi-mum	Mean	Std. Deviation
Poverty alleviation	227	1	5	1.30	.461
Income generation	227	1	5	4.44	.741
Improved standard of Living	227	1	5	4.33	.803

Employment creation	227	1	5	4.19	.967
Rural unemployment	227	1	5	4.31	.725
Valid N (listwise)	227				

Table 2 analyzed the descriptive statistics of the study related to the factors influencing Regional rural banks in Karnataka and stated that income generation (Mean=4.44 and standard deviation=.741) is the most influencing factor followed by improved standard of living (Mean=4.33 and standard deviation=.803). Poverty alleviation (Mean=1.30 and standard deviation=.461) found to be the least influencing factor in the study.

Table 3: One-Sample Statistics

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
Poverty alleviation	227	1.30	.461	.031

Income generation	227	4.44	.741	.049
Improved standard of Living	227	4.33	.803	.053
Employment creation	227	4.19	.967	.064
Rural unemployment	227	4.31	.725	.048

Table 3 analyzed the one sample statistics of the study related to the factors influencing Regional rural banks in Karnataka and stated that income generation (Mean=4.44 and standard deviation=.741 and standard error=.049) is the most influencing factor followed by improved standard of living (Mean=4.33 and standard deviation=.803 and standard error=.053). Poverty alleviation (Mean=1.30 and standard deviation=.461 and standard error=.031) found to be the least influencing factor in the study.

Table 4: One-Sample Test

One-Sample Test						
	Test Value = 0					
	T	df	Sig. (2tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Poverty alleviation	42.618	226	.000	1.304	1.24	1.36
Income generation	90.006	225	.000	4.438	4.34	4.54
Improved standard of Living	89.126	226	.000	4.326	4.22	4.43
Employment creation	65.105	225	.000	4.186	4.06	4.31
Rural unemployment	81.625	226	.000	4.313	4.22	4.41

Table 4 analyzed the t test statistics of the study related to the factors influencing Regional rural banks in Karnataka and stated that income generation (t=90.006) is the most influencing factor followed by improved

standard of living (t=89.126). Poverty alleviation (t=42.618) found to be the least influencing factor in the study.

Table 5: ANOVA Analysis

		Sum of Squares	df	Mean Square	F	Sig.
Poverty alleviation	Between Groups		1.983	4	.496	2.405
	Within Groups	45.557	221	.206		
	Total	47.540	225			
Income generation	Between Groups		9.941	4	2.485	4.817
	Within Groups	113.499	220	.516		
	Total	123.440	224			
Improved standard of Living	Between Groups		3.997	4	.999	1.619
	Within Groups	136.445	221	.617		
	Total	140.442	225			
Employment creation	Between Groups		20.789	4	5.197	6.038
	Within Groups	189.371	220	.861		
	Total	210.160	224			
Rural unemployment	Between Groups		11.678	4	2.920	6.029
	Within Groups	107.016	221	.484		
	Total	118.695	225			

Table 5 analyzed the ANOVA analysis and stated that all the variables understudy having significance value .000 or .001 which is less than the acceptable threshold limit of .005. Hence, the ANOVA analysis is positively correlated.

CONCLUSION

Research on the role of Regional Rural Banks (RRBs) in rural development in the Indian state of Karnataka paints a nuanced picture of the RRBs' influence, problems, and possibilities for accelerating rural Karnataka's socioeconomic change. This study has contributed significantly to our understanding of RRBs and their function within the context of rural development in Karnataka by integrating quantitative data analysis with qualitative interviews and case studies.

RRBs have historically developed into vital financial intermediaries thanks to initiatives shared by the federal government, state governments, and commercial banks. Their goal all along has been to help those who don't have access to traditional financial services and to encourage economic development in remote areas. Rural development banks have made significant contributions in this regard to the state:

1. Reducing Extreme Poverty: By making loans available to small and marginal farmers, RRBs have helped alleviate poverty by fostering

economic growth via increased productivity in the agricultural sector.

2. Production of Money and the Making of Jobs: By providing funding for a wide range of rural economic activities, these organizations have helped to reduce rural unemployment and underemployment.
3. Economic Diversity: By bringing banking services to rural and urban regions that had access to them before, RRBs have widened the scope of financial inclusion.

However, the research also reveals that RRBs in Karnataka suffer the following difficulties and limitations:

1. Problems with Capitalization: Inadequate capitalization hinders the capacity of many RRBs in the state to service the credit needs of rural residents.
2. Assets that are not producing income: Some RRBs' bottom lines have taken a hit due to their high levels of nonperforming assets (NPAs), calling for action to improve asset quality.
3. Effectiveness in Operations: The efficiency of RRBs may be hampered by operational inefficiencies, which can cause delays and lower service quality.

The paper suggests many policy solutions to solve these problems and increase their impact on rural development:

1. Recapitalization: Increasing RRBs' access to capital will allow them to better serve the credit requirements of rural areas.
2. Enhancing Capabilities: Improvements in credit evaluation, risk management, and customer service for RRB employees via training and capacity-building initiatives.
3. Adopting New Technologies: Increasing the use of electronic banking methods to increase RRBs' accessibility and productivity.
4. Financial Education: Spreading the word about the benefits of banking and financial planning to underserved communities in remote areas.

Overall, Regional Rural Banks in Karnataka have been quite successful in fostering rural growth, although they can always do better. Their role as stimulants of rural economic development is highlighted by this research. By resolving the highlighted problems and adopting the suggested policies, RRBs may strengthen their position as drivers of rural development, making Karnataka a better, more equitable place.

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A Study on Green Marketing Practices and its Impact in Kanchipuram District

S. Vijaya Lakshmi

Ph.D., Research Scholar

H. H. The Rajah's College (Autonomous)

(Affili. to Bharathidasan University, Tiruchirappalli)

Pudukkottai, Tamilnadu

C. Thiruchelvam

Principal and Research Supervisor

Naina Mohammed College of Arts and Science

(Affili. to Bharathidasan University, Tiruchirappalli)

Aranthangi, Tamilnadu

M. Mohamed Rahmathullah

Co-Supervisor

H. H. The Rajahs College (Autonomous)

(Affili. to Bharathidasan University, Tiruchirappalli)

Pudukkottai, Tamilnadu

ABSTRACT

Green marketing has emerged as a vital strategy for aligning business practices with environmental sustainability. It extends beyond the traditional marketing mix to include public policy awareness and regulatory compliance. With rising global concern for ecological preservation, consumers are increasingly seeking environmentally responsible products and services. This shift is particularly relevant in regions like Kanchipuram District, where green marketing has the potential to influence consumer choices, retailer practices, and manufacturing standards. This study investigates the awareness, implementation, and challenges of green marketing in the district, offering insights into its socio-economic impact and proposing practical strategies for sustainable growth. By examining the behavior and expectations of key stakeholders, the research aims to support more effective green marketing adoption in the region.

KEYWORDS: *Green marketing, Environmental sustainability, Kanchipuram district, Consumer behavior, Sustainable growth.*

INTRODUCTION

Growing environmental concerns have prompted businesses worldwide to adopt sustainable practices, with green marketing emerging as a key response. In India, increasing awareness among consumers has led manufacturers and retailers to incorporate eco-friendly approaches into their operations. Green marketing involves the design, promotion, and delivery of products and services that minimize environmental harm while meeting consumer expectations of quality, price, and convenience. It encourages a holistic shift across production, consumption, and disposal stages to reduce ecological impact. In the context of Kanchipuram District, this transition is especially significant. Rising awareness about global warming, pollution, and

waste has pushed both consumers and businesses to consider green alternatives. Although the initial costs of implementing green practices may be high, their long-term benefits—such as brand trust, resource efficiency, and environmental preservation—underscore the importance of sustainable strategies. This study explores how green marketing is understood and applied in the region, highlighting both opportunities and challenges, and offering recommendations to improve adoption and effectiveness across sectors.

IMPORTANCE AND NEED OF THE STUDY

There has been a significant shift in government policy towards promoting and supporting green

marketing, and awareness of this concept is steadily increasing among Indian consumers. This shift has created a growing market for sustainable and socially responsible products and services. Green marketing has thus become an essential part of modern marketing practices, influencing both environmental and social dimensions. The impact of green marketing extends to various aspects of consumer and business behavior. However, many people continue to face challenges due to limited awareness about environmental safety and responsible consumption. In extreme cases, the lack of environmental consciousness has even led to serious consequences, including health risks and loss of life. These outcomes are closely tied to lifestyle choices that overlook sustainability and safety. Given these concerns, it is important to understand how green marketing practices affect the socio-economic conditions and lifestyles of consumers, retailers, and manufacturers. For the balanced and sustainable development of the nation, analyzing the influence of such practices is essential. This study aims to identify the challenges faced by these stakeholders and to suggest appropriate solutions. The motivation for choosing this research topic—Green Marketing Practices and Their Impact in Kanchipuram District—arises from the need to explore these issues in a focused and practical manner.

STATEMENT OF THE PROBLEM

In recent decades, environmental concerns have become a pressing issue for civil societies, businesses, and institutions worldwide. The increasing severity of environmental problems has led to significant changes in how businesses operate, with a growing emphasis on sustainability and social responsibility. Today, companies are not only focused on short-term profits but also on long-term goals that promote environmental protection and eco-friendly practices. A key challenge for marketers is anticipating future environmental trends and aligning their strategies accordingly. Consumers are increasingly aware of issues such as global warming, greenhouse gas emissions, pollution, and the energy crisis. This heightened awareness compels both businesses and consumers to adopt greener choices in their production, marketing, and consumption patterns. Green marketing—defined as the development and promotion of products and services

that are environmentally safe—has thus become a critical component of modern corporate strategy. It involves not only adjusting the traditional marketing mix (product, price, promotion, and place), but also understanding and aligning with public policy and environmental regulations. There is growing global evidence that consumer behavior is shifting toward more sustainable practices. As a result, the demand for environmentally friendly and socially responsible goods and services is increasing. In this context, it becomes essential to examine how green marketing strategies are implemented and what impact they have on various stakeholders. This study seeks to understand the green marketing practices and their socio-economic impact in Kanchipuram District, focusing on consumers, retailers, and manufacturers. It aims to assess how these practices contribute to environmental protection while also influencing lifestyle, business behavior, and local development.

SCOPE OF THE STUDY

This study examines the green marketing practices and their impact on consumers, retailers, and manufacturers in the Kanchipuram District. It explores the strategies adopted by these three groups, with a particular focus on the factors that influence consumer preferences, methods of green manufacturing, and retail-level sustainability initiatives. The study also considers consumer opinions to understand the local awareness and acceptance of green marketing, aiming to contribute to the development of more effective and sustainable marketing practices in the district.

Objectives of the Study

To understand the concept and significance of green marketing.

To examine the green marketing practices adopted by consumers in Kanchipuram District.

To evaluate the green marketing initiatives of retailers in Kanchipuram District.

To analyse the sustainable marketing strategies of manufacturers in Kanchipuram District.

HYPOTHESIS OF THE STUDY

Null Hypothesis (H_0)	Alternative Hypothesis (H_1)
1. Consumers have a positive perception of green marketing.	Consumers have a negative or neutral perception of green marketing.
2. Retailers' attitudes are positively influenced by green marketing.	Retailers' attitudes are negatively or neutrally influenced by green marketing.
3. Manufacturers' intentions are positively influenced by green marketing.	Manufacturers' intentions are negatively or neutrally influenced by green marketing.
4. Consumer behaviour is positively influenced by green marketing.	Consumer behaviour is negatively or neutrally influenced by green marketing.

PILOT STUDY

A pilot survey was conducted with 50 respondents to evaluate whether the questionnaire aligned with the research objectives. The researcher identified challenges in gathering accurate responses regarding consumer perceptions, retailer attitudes, and manufacturer intentions toward green marketing. As a result, the questions were reviewed and adapted to better reflect the respondents' understanding of how green marketing influences consumer behaviour. Some participants felt that the questionnaire was too lengthy. Based on their feedback, several questions were added, removed, or revised. The improved questionnaire was then retested, and data collection continued once it met the research objectives.

METHODOLOGY OF THE STUDY

This study investigates green marketing practices and their impact on consumer satisfaction and post-purchase behaviour. It adopts both descriptive and analytical approaches and relies on primary and secondary data sources. The methodology section outlines the process used to ensure reliable and valid results. It includes details about the study population, sampling plan, research location, data collection tools, and methods of analysis. Data was collected through structured questionnaires and analyzed using appropriate statistical tools to measure the strength and relevance of the findings. This

section also acknowledges the limitations of the study, especially in relation to primary data collection.

Sources of Data

To achieve the objectives of the study, both primary and secondary data were used. Primary data was collected directly from consumers, retailers, and manufacturers regarding their green marketing practices and their impact on satisfaction. In addition, secondary data was gathered from reliable sources such as Government of India publications, Tamil Nadu State Government reports, annual reports, and bulletins issued by relevant departments. These sources helped provide background information and context for the study.

Sampling Plan

Given the large population in the selected research area, it was not feasible to interview every respondent. Therefore, a representative sample was selected for the study. Many consumers, retailers, and manufacturers were hesitant to share details about their perceptions and awareness of green marketing. As a result, data was collected only from those willing to participate. The study used the simple random sampling method to ensure fairness in selection. To include individuals from various socio-economic backgrounds, cluster sampling was also used. This combination allowed for a more comprehensive and inclusive sample.

Location of the study

The study was conducted in Kanchipuram District, targeting respondents between the ages of 20 and 65. These included consumers, retailers, and manufacturers engaged in green marketing practices. A total of 720 questionnaires were distributed across the district. Out of these, 615 were returned, and after removing 15 incomplete responses, 600 valid responses were used for analysis. The sampling and data collection followed the simple random method to ensure unbiased representation.

Statistical tools for analysis

This research is based primarily on data collected from consumers, retailers, and manufacturers through structured questionnaires. In addition, secondary data from published sources such as books, journals, magazines, and government reports have also been used.

After collection, all data were carefully examined, edited for accuracy, and organized into tables for analysis. The data were analyzed using the Statistical Package for the Social Sciences (SPSS).

The following statistical tools were applied in the study:

Measures of Central Tendency (mean, median, mode)

Measures of Dispersion (standard deviation, variance)

One-Way Analysis of Variance (ANOVA)

K-Means Cluster Analysis

Multiple Discriminant Analysis

Multiple Regression Analysis

Chi-Square Test

Percentage Analysis

These tools were chosen to understand patterns, test relationships, and evaluate the impact of green marketing practices among different respondent groups.

CONCEPTUAL FRAME WORK

The present study is built upon three key dimensions of green marketing practices:

Consumers' Perceptions and Behaviors

Attitudes of Retailers

Attitudes of Manufacturers

These dimensions form the foundation for analyzing how green marketing awareness influences stakeholders' actions and decision-making processes in the Kanchipuram district.

DATA ANALYSIS AND INTERPRETATION

Table 1: Association between the Demographic Variables and the factors that affecting the consumer's thought in Green marketing

Factors	Awareness	Attention	Support	Protection	Safety and Promotion
One Way ANOVA					
Age	0.511	0.754	2.791*	5.948**	0.512
Educational	1.663	4.132**	4.020**	6.653**	2.098
Occupation	1.860	1.692	2.086	5.891**	0.450
Income	1.635	4.667**	0.969	7.069**	5.108**
Paired Sample "t" Test					
Gender	73.031**	71.256**	76.636**	86.023**	132.761**
Marital Status	80.090**	76.821**	82.897**	99.668**	136.985**

** - 1% level of Significance: * 5% level of significance

Regarding the association between demographic variables and the factors influencing consumers' thoughts on green marketing and products, the following results were observed:

For the demographic variable Age, the factors Environmental Protection and Environmental Support showed statistically significant associations at the 1% and 5% significance levels, respectively. In terms of Educational Qualification, the factors Attention, Environmental Support, and Environmental

Protection were statistically significant at the 1% level. With respect to Occupation, none of the factors were statistically significant at the 1% or 5% levels, except for Environmental Protection, which showed significance at the 1% level. Regarding Monthly Income, the factors Attention, Environmental Protection, and Environmental Safety and Promotion were found to be statistically significant at the 1% level. For Gender and Marital Status, paired sample t-tests were conducted, revealing that all factors influencing consumers' thoughts on green marketing and products were statistically significant at the 1% level.

Table 2: Association between the factors that affecting the consumers thought in Green Marketing

Correlation	Awareness	Attention	Support	Protection	Safety and Promotion
Awareness	1	0.206**	0.092*	0.306**	0.082*
Attention		1	0.136**	0.037	0.307**
Support			1	.353**	0.205**
Protection				1	0.035
Safety and Promotion					1
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

In the detailed analysis, the factors Awareness, Attention, Environmental Support, Environmental Protection, and Environmental Safety and Promotion were examined for their intercorrelations to assess the strength of relationships among them. The results, presented in Table 4.54, indicate that all factors are significantly correlated with each other at the 1% and 5% levels of significance. Notably, Environmental Support showed the highest correlation with Environmental Protection ($r = 0.353$), followed by its correlation with Environmental Safety and Promotion ($r = 0.205$). The factor Awareness was also positively correlated with Environmental Protection ($r = 0.306$). Similarly, Attention demonstrated a positive correlation with Environmental Safety and Promotion ($r = 0.307$). Overall, the correlations among the factors ranged from moderate to high. The lowest significant correlation was observed between Awareness and Environmental Safety and Promotion ($r = 0.082$) at the 5% significance level. Furthermore, no significant correlation was found between (1) Attention and Environmental Protection, and (2) Environmental Protection and Environmental Safety and Promotion.

Table 3 :Multiple Regression Analysis

Dependent Variable	Independent Variable	Regression Co efficient(Beta) Value	Standard Error
Support	(Constant)	2.927	0.915
	Awareness	-0.042	0.035
	Attention	0.071	0.036*
	Environmental Protection	0.586	0.064**

	Environmental Safety and Promotion	0.135	0.031**
	R Value	0.410	
	R ² Value	0.268	
	F Value	30.124**	
	Number of Samples	600	
	Durbin Watson Test value	2.013	

Regarding the antecedents of Environmental Support among consumers inclined towards green marketing and green products, the F-ratio was found to be 30.124, indicating that the regression model is statistically significant, as the p-value is less than the 0.01 significance level. Additionally, Beta coefficients were calculated to assess the relative importance and impact of the independent variables on the dependent variable. The highest beta value was observed for Environmental Protection ($\beta = 0.586$). The coefficient of determination, R, was 0.410, and the R² value was 0.268, suggesting that approximately 26.8% of the variance in Environmental Support is explained by the independent variables included in the model. Factors such as Attention, Environmental Protection, and Environmental Safety and Promotion were identified as significant positive predictors of Environmental Support at the 1% and 5% significance levels. In contrast, Awareness had a negative beta value and was not a significant predictor. To check for multicollinearity among the variables, the Durbin-Watson test was performed, yielding a value of 2.013, which falls within the acceptable threshold. This confirms that multicollinearity is not an issue among the factors considered in the study.

Table 4: Canonical Discriminant Function coefficients in discriminant Analysis

Factors that affecting by consumer thoughts	Discriminant Function
Awareness	-0.065
Attention	0.161
Environmental Support	0.096
Environmental Protection	0.161
Environmental Safety and Promotion	0.144
Constant	-7.110

Source: Primary data

Based on the Canonical Discriminant Function (CDF) analysis and the coefficients derived in this study, the discriminant function model can be expressed as:

$$\text{Discriminant Function} = -0.065 \times F_1 + 0.161 \times F_2 + 0.096 \times F_3 - 0.161 \times F_4 - 0.144 \times F_5 - 7.110$$

where:

F_1 = Awareness

F_2 = Attention

F_3 = Environmental Support

F_4 = Environmental Protection

F_5 = Environmental Safety and Promotion

The multivariate results, including the canonical correlation and Wilks' Lambda values, are presented in the accompanying table..

Table 5: Canonical Correlation and Wilks' Lambda values

Canonical Correlation	The Wilks' Lambda Value	Chi-square Value	Degree of freedom	Level of Significance
.179	.968	19.368**	5	Significant

* Significant at 1% level

The associated Chi-square test examines the hypothesis that the means of the discriminant functions are equal across all groups. A small and significant Chi-square value indicates that the discriminant function effectively distinguishes between the groups better than chance. From the table above, Wilks' Lambda is 0.968 and the Chi-square value is 19.368, both demonstrating that the overall analysis is statistically significant at the 1% level. Further details of the inter-correlations within the groups are presented in Table 6.

Table 6 Table showing Pooled within Groups Matrices value

Pooled Within-Groups Matrices ^a						
Within Groups Matrices	Awareness	Attention	Support	Protection	Safety and Protection	
Covariance	F1	11.498	2.289	0.912	1.873	1.042
	F2	2.289	10.702	1.205	0.174	3.618
	F3	0.912	1.205	8.634	1.851	2.149
	F4	1.873	0.174	1.851	3.256	0.181
	F5	1.042	3.618	2.149	0.181	14.047
Correlation	F1	1.000	0.206	0.091	0.306	0.082
	F2	0.206	1.000	0.125	0.029	0.295
	F3	0.091	0.125	1.000	0.349	0.195
	F4	0.306	0.029	0.349	1.000	0.027
	F5	0.082	0.295	0.195	0.027	1.000
a. The covariance matrix has 598 degrees of freedom.						

Table 7: Showing Box's M Test of Equality of Covariance Matrices

Log Determinants		
Gender	Rank	Log Determinant

Male	5	10.082
Female	5	10.519
Pooled within-groups	5	10.379

Source: Primary Data

Test of Equality of Covariance Matrices through Box's M test

This test is used to compare the variations within multivariate samples, specifically assessing whether two or more covariance matrices are equal, i.e., testing the assumption of homogeneity. The detailed results of the discriminant analysis are presented below in Table 8.

Table 8: Box's M Test of Equality of Covariance Matrices result

Test Results		
	Test of equality of Covariance Matrices Through Box's M test	31.353
F	Approx.	2.071
	df1	15
	df2	1277381.006
	Sig.	0.009

Source: Primary Data

From the above table, it is observed that the log determinant values are similar, which indicates that the groups considered in this study do not have significantly different covariance matrices.

Table 9: Showing Prior Probabilities for Groups

Prior Probability				Functions at Group Centroids
Gender	P	Cases	Function	
		Unweight	Weight	
Male	0.500	264	264.000	0.205
Female	0.500	336	336.000	-0.161
Total	1.000	600	600.000	

Source: Primary Data

The mean discriminant function scores for each group, as shown in the above table, are used to classify cases—in this study, gender serves as the grouping variable. The two groups, Male and Female, have prior cutoff values of 0.500 each. Therefore, it is concluded that these cutoff points represent the optimal thresholds for classification based on the group centroids.

Table 10 Canonical Discriminant Function Coefficients

Factors that affecting the consumer thoughts in Green Marketing	Canonical Discriminant Function Coefficients
Awareness	-0.065
Attention	0.161
Support	0.096
Protection	0.161
Safety and Promotion	0.144
Constant	-7.110

Source: Primary Data

From the above results, the Zc values for factors such as Awareness, Attention, Environmental Support, Environmental Protection, and Environmental Safety and Promotion were found to be lower. Consequently, respondents with these lower Zc values are classified into the male group.

Table 11 Classification Results

	Classification		Predicted Group Membership		Total
	Percentage	Gender	Male	Female	
Original	No.	Male	80	184	264
		Female	65	271	336
	%	Male	30.3	69.7	100
		Female	19.3	80.7	100

From the above table, while computing from the group sizes, it is noticed that 80.7 % percentage of the female respondents were found to be sensitive towards the discrimination, and 30.7 % percentage of the male respondents were found to be specificity towards the perception.

Table 12: Structure Matrix

Sl. No.	Variables	Function (R)
1	Awareness	0.048
2	Attention	0.684
3	Environmental Support	0.534
4	Environmental Protection	0.351
5	Environmental Safety and Promotion	0.739

Source: Primary data

The pooled within-groups correlations among discriminating variables and homogeneous acknowledged discriminant function variables, ordered by the absolute size of their correlation within the function, were analyzed. From the structure matrix (denoted by R), it was revealed that the greatest difference of opinion between male and female consumers was observed for the "Safety and Promotion Score" (0.739), followed by the "Attention Score" (0.684). The third highest was the "Environmental Support Score" (0.534), followed by the "Protection Score" (0.351). The lowest correlation was found for the awareness factor, with a value of 0.048. Contributions of other variables related to marketing performance in discriminating between male and female consumers were found to be less than 7%. The graphical representation of the discriminant analysis variables is shown below. The graph indicates minimal overlap between genders, leading to the conclusion that a clear discriminating difference exists between the male and female groups in this study.

MAJOR FINDING OF THE STUDY

It is recommended that consumers voluntarily choose to buy green products, even if their prices are higher, to contribute to environmental preservation. This price difference is often due to the high costs of green raw materials and advanced green technologies, many of which are imported. Consumers are also encouraged to commit to avoiding the use of plastic bags when shopping and instead bring their own reusable and recyclable bags. They should firmly refuse plastic bags offered by retailers or marketers. Additionally, consumers should optimize resource use through various practical actions such as turning off electronic appliances when not in use, reducing, recycling, and reusing e-waste, and opting for refillable containers for liquid products. It is important to minimize waste by fully consuming or using products like food items, medicines, fruits and vegetables, cosmetics, and other goods, thereby reducing environmental impact.

SUGGESTIONS OF THE STUDY

The study reveals that many consumers still lack genuine awareness of green marketing. To improve knowledge of green marketing practices, government agencies and NGOs should organize awareness

programs such as street plays, TV shows, debates, and other outreach activities. Retailers, manufacturers, and other stakeholders can be engaged through orientation programs and award recognitions for exemplary green sales practices. Although a majority of respondents claim to be aware of green products, this awareness often appears superficial or overstated. A deeper analysis shows that many who profess awareness do not fully understand what constitutes a green product or that purchasing such products contributes to environmental protection. Marketers must take the initiative, recognizing that consumers are concerned about the environment and willing to contribute. They should develop effective promotional strategies to educate consumers about green products, their usage, and the positive environmental impact, which will not only benefit the planet but also enhance the brand's reputation and goodwill over time. The study highlights the crucial role of government and other stakeholders in actively educating consumers to become responsible green consumers. Moreover, it is important to use clear and meaningful environmental product claims and to secure credible eco-certifications or endorsements from reputable third parties. Educating consumers about the significance of these endorsements will further strengthen trust and informed purchasing decisions.

CONCLUSION

The findings of this study suggest that green marketing holds substantial potential for transforming business practices in Kanchipuram District. While awareness among consumers, retailers, and manufacturers is generally satisfactory, actual implementation remains limited by knowledge gaps and practical challenges. Retailers, in particular, play a critical role and are encouraged to increase the availability of green products, adopt sustainable packaging, and foster eco-conscious consumer behavior through education and incentives. Strategies such as opening more organic retail outlets, using energy-efficient resources, and engaging consumers with green campaigns can further strengthen the local green marketing ecosystem. Categorizing retailers as energy savers, awareness builders, and green motivators provides a practical framework for driving sustainable change. Promoting the use of recyclable materials and reducing non-biodegradable

waste must become central to everyday marketing operations. The study highlights that shifting toward green marketing is not merely a trend but a necessity for long-term environmental and economic sustainability. With coordinated efforts among stakeholders and proper implementation of the suggested measures, Kanchipuram District can become a regional model for environmentally responsible marketing practices.

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Emotional Intelligence and its Impact on Job Satisfaction: An Empirical Study on Bank Employees in Kancheepuram District

N. Pattabi

Ph.D. Research Scholar
Department of Commerce
Bishop Heber College, (Autonomous)
(Affili. to Bharathidasan University, Tiruchirappalli)
Tiruchirappalli, Tamilnadu

A. Ravikumar

Asso. Prof. & Research Supervisor, P.G. & Research
Department of Commerce
Bishop Heber College, (Autonomous)
(Affili. to Bharathidasan University, Tiruchirappalli)
Tiruchirappalli, Tamilnadu

ABSTRACT

This study investigates the impact of emotional intelligence (EI) on job satisfaction among bank employees in the Kancheepuram District. Both emotional intelligence and job satisfaction are recognized as multidimensional constructs, necessitating a detailed comparison of their respective dimensions. Exploratory Factor Analysis (EFA) was employed to identify the core dimensions of EI and job satisfaction, while Structural Equation Modeling (SEM) was used to analyze the relationships between these dimensions and to test the proposed hypotheses. The findings reveal a significant positive relationship between emotional intelligence and job satisfaction. Employees with higher levels of emotional intelligence tend to report greater satisfaction with their jobs, suggesting that emotional competencies play a critical role in enhancing workplace well-being and organizational effectiveness.

KEYWORDS: *Emotional intelligence, Job satisfaction, Bank employees, Structural equation Modeling, organizational behavior, Kancheepuram district.*

INTRODUCTION

Emotional Intelligence (EI) refers to the ability to perceive, understand, manage, and regulate emotions in oneself and in others. As a psychological construct, EI encompasses a range of competencies crucial for interpersonal effectiveness and emotional well-being. In the context of the workplace, particularly within the banking sector, emotional intelligence has emerged as a key predictor of job satisfaction, performance, and organizational commitment. Banking professionals often operate in high-pressure environments, dealing with financial transactions and human interactions on a daily basis. Employees who can manage stress, resolve conflicts, and build positive relationships are better positioned to experience job satisfaction. According to Mayer and Salovey (1995), emotional intelligence consists of the ability to recognize and regulate one's own emotions as well as those of others—skills that are increasingly essential in modern, competitive workplaces. This study aims to

empirically examine the relationship between emotional intelligence and job satisfaction among bank employees in the Kancheepuram District. By analyzing the underlying dimensions of both constructs, the research seeks to provide valuable insights for managers and HR professionals seeking to foster a more emotionally intelligent and satisfied workforce.

OBJECTIVES OF THE STUDY

1. To examine the influence of emotional intelligence on job satisfaction among employees in public and private sector banks.
2. To analyze the impact of emotional intelligence on various dimensions of job satisfaction in public and private sector banks.

Hypothesis of the study

1. There is a significant association between demographic factors and emotional intelligence with respect to job satisfaction.

2. There is a significant association between demographic factors and the various dimensions of emotional intelligence

RESEARCH METHODOLOGY

Research Design:

This study adopts a descriptive research design, which provides a systematic approach to investigating the current state of emotional intelligence and its impact on job satisfaction among bank employees. Descriptive research is concerned with explaining and interpreting present conditions, behaviors, relationships, and trends within a specific context. It is particularly suitable for examining existing organizational practices, employee perceptions, workplace dynamics, and observable patterns across demographic groups. The design facilitates the collection and analysis of data to present an accurate picture of the association between emotional intelligence and job satisfaction in public and private sector banks. Although often used in exploratory or preliminary research, descriptive designs can also generate tentative hypotheses for future studies.

Method of Data Collection

Primary data were collected using a structured questionnaire administered to employees of public and private sector banks in Kancheepuram District. The questionnaire included validated scales to measure various dimensions of emotional intelligence and job satisfaction. Data collection was conducted systematically to ensure reliability, and responses were analyzed using appropriate statistical tools to examine relationships between variables and test the proposed hypotheses.

Area of the Study

This research is conducted in the Kancheepuram District of Tamil Nadu. The study focuses specifically on employees working in selected public and private sector banks operating within the district.

Data and Sample

A total of 150 employees from both public and private sector banks were selected using the convenience sampling method. The sample includes staff from various banks located in Kancheepuram District. To

facilitate data collection, bank managers were contacted in advance and personally briefed about the objectives and scope of the study. After addressing their queries and securing consent, employees were invited to participate by completing the research questionnaire.

Limitations of the Study

The study is geographically limited to public and private sector banks in Kancheepuram District. Banks in other districts were excluded due to practical constraints and the focused nature of the research area.

DATA ANALYSIS AND INTERPRETATION

Demographic Profile of the Respondents

The demographic characteristics of the respondents are presented in Table 1. This profile provides insights into how emotional intelligence influences employee behavior in the workplace, specifically within public and private sector banks. Percentage analysis has been employed to interpret the demographic data and assess the distribution of employee responses across different categories in both banking sectors.

Table 1 Demographic Profile of the Respondents

	Profile	Frequency	Percentage
Gender	Male	80	53
	Female	70	47
Age	Below 25 years	55	37
	26 - 35 years	47	31
	36 – 45 years	29	19
	Above 45 years	19	13
Education	Graduation	28	19
	Post-Graduation	65	43
	Professional	48	32
	Others	9	6.0
Family	Nuclear family	110	73
	Joint family	40	27
Annual Income	Less than 2,00,000	50	33

	2,00,000 to 5,00,000	50	33
	5,00,000 to 8,00,000	27	18
	8,00,000 and above	23	15
Total	150	100.0	

The demographic characteristics of the respondents indicate that a majority (53%) were male. Most respondents (37%) were under the age of 20, followed by 31% in the 26–35 age group. In terms of educational qualifications, postgraduates comprised the largest segment (43%), followed by professionals (32%). This suggests that education level may influence emotional intelligence and its impact on workplace behaviour. Additionally, a significant proportion (73%) of respondents belonged to nuclear families. Regarding annual income, 33% of the respondents reported earning less than ₹2,00,000, highlighting the presence of lower-income employees within the sample.

Table 2. Test of emotional intelligence on job satisfaction based on their gender

Satisfaction level	Gender		Total
	Male	Female	
Highly Satisfied	47	33	80
Highly Dissatisfied	42	28	70
Total	89	61	150

H0= There is no significance difference between emotional intelligence on job satisfaction and gender.

H1 = There is significance difference between emotional intelligence on job satisfaction and gender.

Chi-square – emotional intelligence on job satisfaction on their gender

Chi-square	Value	Degrees of freedom	Significance
Pearson Chi-Square	1.663a	1	0.197 (NS)

Source: Output generated from SPSS NS – Not Significant

Based on the obtained results, the significance value exceeds 0.05. Therefore, the null hypothesis is accepted and the alternate hypothesis is rejected. It can be concluded that there is no statistically significant difference between emotional intelligence and job satisfaction with respect to gender.

Table 3. Test emotional intelligence on job satisfaction based on their age

Satisfaction level	Age				
Total					
	Below 25 years	26 -35 Years	36 -45 years	Above 46	
years					
Highly Satisfied	26	23	14	10	73
Highly Dissatisfied	29	24	15	9	77
Total	55	47	29	19	150

H0 = There is no significance difference between emotional intelligence on job satisfaction and age.

H1 = There is significance difference between emotional intelligence on job satisfaction and age.

Chi-square – emotional intelligence on job satisfaction on their age

Chi-square	Value	Degrees of freedom	Significance
Pearson Chi-Square	1.663a	1	0.197

Source: Output generated from SPSS NS – Not Significant

The results show a significance value greater than 0.05; therefore, the null hypothesis is accepted, and the alternate hypothesis is rejected. This indicates that there is no significant difference between emotional intelligence and job satisfaction across different age groups.

Table 4. Reliability statistics for emotional intelligence on job satisfaction

RELIABILITY STATISTICS

RELIABILITY STATISTICS	
Cronbach's Alpha	No. of items
0.955	22

The table indicates that an acceptable level of reliability

for psychometric tests begins at 0.65. In this analysis, most of the reliability values exceed this threshold. The overall Cronbach's alpha for the study's dimensions is 0.955, reflecting a high internal consistency of 95.5%.

Table 5 KMO and bartlett's test for emotional intelligence on job satisfaction

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.929
Bartlett's Test of Sphericity	Approx. Chi-Square	3650.467
	Df	496
	Sig.	.000

The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy assesses the proportion of variance among variables that might be common variance, indicating the suitability of the data for factor analysis. A KMO value closer to 1.0 suggests that the data are highly adequate for factor analysis, while a value below 0.50 indicates insufficient adequacy. In this study, the KMO value is 0.929 (92.9%), which demonstrates excellent sampling adequacy for conducting factor analysis.

Emotional Intelligence and Its Impact on Job Satisfaction

Previous studies have established a strong relationship between emotional intelligence and job satisfaction across various work settings. Employees with high emotional intelligence can recognize negative emotions such as frustration and stress, and by effectively managing these emotions, they can reduce stress levels. This ability serves as a powerful tool for both public and private sector employees. Key factors influencing job satisfaction include general job satisfaction, present job satisfaction, pay satisfaction, supervision satisfaction, and co-worker satisfaction. These attributes, identified from earlier research, help in ranking the aspects that most significantly impact employees' mindsets and overall job satisfaction.

Table 6. Emotional Intelligence and Its Impact on Job Satisfaction

Perception	WAM	Rank
General Job Satisfaction	4.53	2

Present Job satisfaction	3.28	6
Pay Satisfaction	4.83	1
Supervision Satisfaction	4.21	3
Co-workers Satisfaction	3.47	5
Others	3.55	4

The most important positive attribute preferred by employees in both public and private sector banks is Pay Satisfaction, with a high mean score of 4.83. This is followed by General Job Satisfaction (4.53), Supervision Satisfaction (4.21), Other factors (3.55), Co-worker Satisfaction (3.47), and Present Job Satisfaction (3.34). These perceptions are crucial considerations when designing marketing messages aimed at employees. However, there also exist some negative perceptions among employees regarding the impact of emotional intelligence on job satisfaction, which warrant further attention.

FINDINGS

- Since the significance value is greater than 0.05, the null hypothesis is accepted and the alternative hypothesis is rejected. It is concluded that there is no significant difference between emotional intelligence and job satisfaction based on gender.
- Similarly, with a significance value above 0.05, the null hypothesis is accepted and the alternative hypothesis is rejected. Therefore, there is no significant difference between emotional intelligence and job satisfaction across different age groups.
- The reliability statistics for the emotional intelligence and job satisfaction measures indicate strong internal consistency. Most reliability values exceed the acceptable threshold of 0.65 for psychometric tests, with the overall Cronbach's alpha for the study being 0.955 (95.5%), demonstrating excellent reliability.
- Various attributes influencing employees' perceptions, both positive and negative, about emotional intelligence and its impact on job satisfaction have been identified. These

perceptions are important considerations when formulating effective marketing and organizational communication strategies.

DISCUSSION AND CONCLUSION

This empirical study confirms that emotional intelligence plays a significant role in influencing job satisfaction among employees in both public and private sector banks within the Kancheepuram District. The analysis revealed that key dimensions of job satisfaction—including general job satisfaction, pay satisfaction, supervision, co-worker relationships, and satisfaction with current job roles—are positively correlated with various facets of emotional intelligence. These findings highlight the critical importance for organizational leaders to integrate emotional intelligence as a fundamental element of employee development and workplace culture. Cultivating emotional awareness, empathy, and self-regulation among employees can lead to higher job satisfaction, lower turnover rates, and enhanced overall productivity. The study strongly recommends that top management embed emotional intelligence training into their strategic human resource initiatives. Such efforts will foster a positive, resilient, and collaborative organizational environment, enabling the workforce to better manage workplace challenges, resolve conflicts effectively, and build trust at every level of the institution. In conclusion, prioritizing emotional intelligence not only benefits individual employees but also strengthens organizational performance, making it an essential focus for sustainable growth in the banking sector.

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Analyzing the Growth of Sport Management Research in India (2010-2025): A Scientometric Approach

Kishore Kumar T

Ph.D. Research Scholar
Dept. of Physical Education and Centre for Research
H.H. The Rajah's College (Autonomous)
(Affili. to Bharathidasan University, Tiruchirappalli)
Pudukkottai, Tamilnadu
✉ ckishorekumart@gmail.com

A. S. Nageswaran

Associate Professor & Head
Dept. of Physical Education and Centre for Research
H.H. The Rajah's College (Autonomous)
(Affili. to Bharathidasan University, Tiruchirappalli)
Pudukkottai, Tamilnadu
✉ asnageswaran@gmail.com

ABSTRACT

This scientometric study investigates the research output in the field of Sport Management in India from 2010 to 2025, based on data sourced from the Scopus database. The search incorporated key terms such as “sport management,” “sports administration,” “sports marketing,” “sports governance,” “sports policy,” and “sports development,” limited to Indian-affiliated institutions. The retrieved dataset comprises peer-reviewed journal articles, conference papers, book chapters, and review articles. After removing duplicates and irrelevant records, the dataset was refined to focus on core literature in the field. The study tracks annual publication counts, with cumulative publication numbers calculated for each year. To evaluate the growth trends, two scientometric indicators—Relative Growth Rate (RGR) and Doubling Time (DT)—were applied. RGR was computed as the increase in the natural logarithm of cumulative publications between two successive years, and DT was derived using the formula $DT = 0.693 / RGR$. The results of these analyses were tabulated and visualized to display publication trends and growth behaviors in Indian Sport Management research. Data processing and visualization were conducted using Microsoft Excel and Python. This study provides insights into the growth patterns of Sport Management research in India, offering valuable information for researchers, policymakers, and educators in the field.

KEYWORDS: *Sport management, Scientometric study, Scopus database, Research output, Relative growth rate, Doubling time.*

INTRODUCTION

Sport has become an increasingly central player in the context of global economic and social development, prompting a growing need for structured managerial and operational frameworks (Ratten, 2010). This demand has catalyzed the emergence of sport management as a legitimate and dynamic academic discipline, addressing the intricacies of managing sport organizations, events, and institutions in both professional and grassroots contexts. As sport's societal and economic influence expanded, research in sport management gained traction, evolving from a niche topic into a well-recognized field of study with interdisciplinary roots, particularly in marketing, sociology, and organizational behavior (Funk, 2019).

During the early development phase of the discipline, from 1990 to 2000, sport management scholarship predominantly revolved around athlete programs and training-related issues, with limited emphasis on its commercial dimensions (Ciomaga, 2013). However, the decade that followed marked a clear shift toward commercialization and management-centric themes, reflecting a broader alignment with mainstream business disciplines. Marketing, in particular, emerged as the dominant influence, driving the theoretical and practical orientation of sport management research (Shilbury, 2011a; Ciomaga, 2013). While this evolution helped solidify the field's academic standing, it also triggered concerns about the potential erosion of sport's intrinsic social and cultural value (Zeigler, 2007; Gammelsæter, 2021).

These conceptual tensions, alongside the exponential increase in sport management publications in the past decade (Pellegrini et al., 2020), underscore the necessity for a systematic assessment of the field's structure, evolution, and thematic direction. Given sport management's multifaceted nature—spanning governance, leadership, marketing, event management, policy, and community development—there is a pressing need to map the academic terrain using objective and replicable methods. In this context, bibliometric analysis offers a powerful methodological tool to analyze publication patterns, citation networks, author collaboration, and thematic trends within scholarly outputs (Martínez-López et al., 2018; Tiberius et al., 2020).

Earlier contributions have laid important groundwork. For instance, Ciomaga (2013) conducted a longitudinal analysis of three prominent journals over the period 1987–2010, providing insights into the field's reliance on adjacent disciplines. Shilbury (2011a, b) further examined the citation behavior within sport management and marketing journals, highlighting the increasing influence of sport marketing research in broader academic circles. These foundational studies revealed how journal visibility, citation impact, and disciplinary legitimacy evolve over time—especially as more sport management journals gain indexing in the Social Sciences Citation Index (SSCI), improving their academic footprint.

Despite these valuable insights, recent and rapid developments within the field warrant an updated and more holistic scientometric perspective. Notably, the expansion of indexed sport management and marketing journals, along with the diffusion of emerging theories, suggests that past assessments may now be outdated or incomplete (Budler et al., 2021). Consequently, there is a compelling need to undertake a comprehensive bibliometric investigation focused on the last decade of scholarship to better understand the current structure and trajectory of the field.

The aim of this study is therefore to provide a quantitative and thematic mapping of sport management research using bibliometric performance indicators and coupling techniques. By analyzing key academic outputs from five core journals—Journal of Sport Management, Sport

Management Review, European Sport Management Quarterly, International Journal of Sport Marketing & Sponsorship, and Sport Marketing Quarterly—this study seeks to capture publication trends, influential authors and institutions, collaborative networks, and thematic clusters that have shaped the discipline since 2011.

The study proceeds as follows: the next section outlines the methodology used for data collection and bibliometric analysis. This is followed by a presentation of the results, which include descriptive indicators, citation patterns, and thematic evolution through bibliometric coupling. The final sections discuss the implications of the findings, acknowledge limitations, and offer conclusions regarding future directions for sport management research.

METHODOLOGY

This scientometric study aims to evaluate the research output in the field of Sport Management in India from 2010 to 2025 using data retrieved from the Scopus database. An advanced search was performed using a combination of key terms such as “sport management,” “sports administration,” “sports marketing,” “sports governance,” “sports policy,” and “sports development,” limited to documents affiliated with Indian institutions. The search results included peer-reviewed journal articles, conference papers, book chapters, and review articles. The retrieved data were refined to remove duplicates and irrelevant records, ensuring the dataset represented core literature in Sport Management. Annual publication counts were extracted, and the cumulative number of publications was calculated for each year. Scientometric indicators such as Relative Growth Rate (RGR) and Doubling Time (DT) were employed to analyze growth trends over time. RGR was computed as the increase in the natural logarithm of cumulative publications between two successive years, while DT was derived using the formula $DT = 0.693 / RGR$. The results were tabulated and visualized to provide a clear depiction of the publication trends and growth behavior in Indian Sport Management research. All data processing and visualization were performed using Microsoft Excel and Python.

Table 1: Year Wise Publications in the Sports Management

Year	Publications	Cumulative	ln(W)	RGR	DT
2010	4	4	1.386294		
2011	1	5	1.609438	0.223144	3.105624
2012	2	7	1.94591	0.336472	2.059605
2013	2	9	2.197225	0.251314	2.757502
2014	1	10	2.302585	0.105361	6.577417
2015	5	15	2.70805	0.405465	1.709148
2016	5	20	2.995732	0.287682	2.408909
2017	5	25	3.218876	0.223144	3.105624
2018	8	33	3.496508	0.277632	2.496112
2019	4	37	3.610918	0.11441	6.057144
2020	20	57	4.043051	0.432133	1.603672
2021	14	71	4.26268	0.219629	3.155327
2022	21	92	4.521789	0.259109	2.674553
2023	16	108	4.682131	0.160343	4.321994
2024	34	142	4.955827	0.273696	2.532008
2025	15	157	5.056246	0.100419	6.901102

Fig. 1: Number of Publications

The scientometric profile of Sport Management literature between 2010 and 2025 illustrates a progressive yet uneven growth trajectory. The publication count began modestly with only four articles in 2010 and showed minimal increments through 2014. The Relative Growth Rate (RGR) during this early period fluctuated between 0.1 and 0.4, while the Doubling Time (DT) varied widely — at times exceeding 6 years — indicating inconsistent scholarly interest. A significant turning point occurred in 2020, where the number of publications surged to 20, marking the highest RGR of 0.432 and the

shortest DT of 1.60 years. This acceleration continued through 2024, culminating in the highest output of 34 publications, though 2025 experienced a dip to 15. Despite this fluctuation, the cumulative output steadily rose, with the overall trend suggesting a maturing and diversifying field. In recent years, although the RGR has started to decline (dropping to 0.101 in 2025), the total output remains strong, and the extended DT reflects a stabilizing discipline. These findings are comparable to other emerging fields like Green Chemistry, where early volatility gives way to gradual consolidation. The scientometric indicators suggest that Sport Management research is transitioning into a phase of sustained, though slower, scholarly development with potential for influential, targeted studies.

Table 2: Author-wise Publication count in Sport Management Research (2010-2025)

S. No.	Author Name	No. of Publications
1	Nimkar, N.	5
2	Bagchi, A.	4
3	Suresha	4
4	Yousaf, A.	4
5	Anil Kumar, K.M.	3
6	Itani, M.N.	3

7	Mehra, V.	3
8	Rai, J.S.	3
9	Raizada, S.	3
10	Sawhney, R.S.	3
11	Sharma, A.	3
12	Singh, A.	3
13	Singh, P.	3

Author Productivity and Collaboration in Indian Sport Management Research

An analysis of author productivity in Sport Management research in India, based on Scopus data from 2010 to 2025, reveals that a limited number of authors contributed significantly to the research output in this domain. Among the prolific contributors, Nimkar, N. leads with 5 publications, followed by Bagchi, A., Suresha, and Yousaf, A., each with 4 publications. Other notable contributors with 3 publications each include Anil Kumar, K.M., Itani, M.N., Mehra, V., Rai, J.S., Raizada, S., Sawhney, R.S., Sharma, A., Singh, A., and Singh, P.

These findings suggest that while the field is still emerging in India, a core group of authors are actively engaged in advancing Sport Management research. However, the relatively low number of publications

per author indicates that the field is characterized by moderate individual productivity.

To assess collaborative research trends, the degree of collaboration (C) was calculated using Subramanyam's formula:

$$C = \frac{N_m}{N_m + N_s} \quad C = \frac{N_m}{N_m + N_s}$$

Where:

- N_m is the number of multi-authored papers
- N_s is the number of single-authored papers

The analysis revealed a high level of collaboration with an aggregate degree of collaboration of 0.95, indicating that 95% of the publications were co-authored, reflecting a strong tendency towards teamwork and joint authorship in the field. This trend aligns with the broader global patterns in interdisciplinary and applied fields like Sport Management.

Although citation data for individual Indian authors was limited, insights from related global studies suggest a strong correlation between publication volume and citation impact (Parker et al., 2013). As the field matures in India, similar patterns of influence and scholarly impact are likely to emerge, especially among highly productive contributors.

Table 2: Institution-wise Research Productivity in Sport Management (India, 2010–2025)

Institution	Publications	Total Publications	Mean Publications	Median Publications	Mode Publications	Standard Deviation	Skewness
Symbiosis School of Sports Sciences	11	82	4.32	3	3	2.34	1.96
Symbiosis International Deemed University	10	82	4.32	3	3	2.34	1.96
Christ University	7	82	4.32	3	3	2.34	1.96
IBS Hyderabad	5	82	4.32	3	3	2.34	1.96
Delhi Technological University	4	82	4.32	3	3	2.34	1.96
University of Mysore	4	82	4.32	3	3	2.34	1.96
Indian Institute of Management Indore	4	82	4.32	3	3	2.34	1.96
Chandigarh University	4	82	4.32	3	3	2.34	1.96
Guru Nanak Dev University	3	82	4.32	3	3	2.34	1.96
Punjabi University	3	82	4.32	3	3	2.34	1.96
Vellore Institute of Technology	3	82	4.32	3	3	2.34	1.96

King Saud University	3	82	4.32	3	3	2.34	1.96
University of Delhi	3	82	4.32	3	3	2.34	1.96
Ajman University	3	82	4.32	3	3	2.34	1.96
University of Kota	3	82	4.32	3	3	2.34	1.96
Institute of Management Technology, Ghaziabad	3	82	4.32	3	3	2.34	1.96
ICFAI Foundation for Higher Education, Hyderabad	3	82	4.32	3	3	2.34	1.96
Saveetha School of Engineering	3	82	4.32	3	3	2.34	1.96
Saveetha Institute of Medical and Technical Sciences	3	82	4.32	3	3	2.34	1.96
Symbiosis Institute of Business Management, Pune	3	82	4.32	3	3	2.34	1.96

The analysis of research productivity in Sport Management across institutions from 2010 to 2025 reveals a concentrated yet evolving landscape in India. A total of 82 publications were recorded, with Symbiosis School of Sports Sciences leading the pack, contributing 11 publications, followed closely by Symbiosis International Deemed University with 10 publications. These findings underscore the significant role of the Symbiosis institutions in shaping the research landscape of Sport Management, likely due to their specialized programs in sports sciences. Institutions like Christ University, with 7 publications, reflect a growing interdisciplinary interest in the field, integrating sports management with broader social sciences.

The analysis further highlights a modest but emerging interest in Sport Management research among business and technical institutions, such as IBS Hyderabad, Delhi Technological University, and IIM Indore, each contributing 4 publications. This suggests that Sport Management is increasingly being recognized as an interdisciplinary field, connecting business, engineering, and public policy. However, the majority of institutions, such as Guru Nanak Dev University, Punjabi University, and VIT, contributed only 3 publications each, indicating that while the field is expanding, much of the research remains in its infancy, with several institutions still in the early stages of engagement.

The data also points to a notable presence of international institutions like King Saud University and Ajman University, highlighting the potential for cross-border

academic engagement in Sport Management research. The Saveetha School of Engineering and Saveetha Institute of Medical and Technical Sciences suggest a growing recognition of the technical and health-related aspects of sports management, driven by the increasing commercialization of sports.

Scientometrically, the average number of publications per institution stands at 4.32, with the median and mode both at 3, signifying that a large portion of institutions contribute fewer publications. The standard deviation of 2.34 and a skewness of 1.96 indicate a right-skewed distribution, where a few institutions significantly outpace the rest in terms of output. This skewness reflects an uneven research distribution, with a small number of institutions leading the charge in this emerging field. Overall, the research output suggests that Sport Management is gaining traction, particularly in private and semi-autonomous universities, though there is substantial room for growth in government institutions and elite business schools.

Table 3: Top Country-wise Research Collaboration with India in Sport Management (2010–2025)

S. No.	Country	No. of Collaborative Publications
1	United Kingdom	10
2	Malaysia	8
3	United Arab Emirates	8
4	Saudi Arabia	7

5	China	4
6	France	4
7	Indonesia	4
8	Poland	4
9	Serbia	4
10	South Africa	4

The analysis of the collaborative publications table indicates a significant global engagement in research, particularly in the field of Sport Management. The United Kingdom stands out as the top collaborator, with 10 publications, followed closely by Malaysia and the United Arab Emirates, each contributing 8 publications. This suggests a strong academic relationship between India and these countries, potentially due to similar research interests and shared focus on developing sports management and sciences.

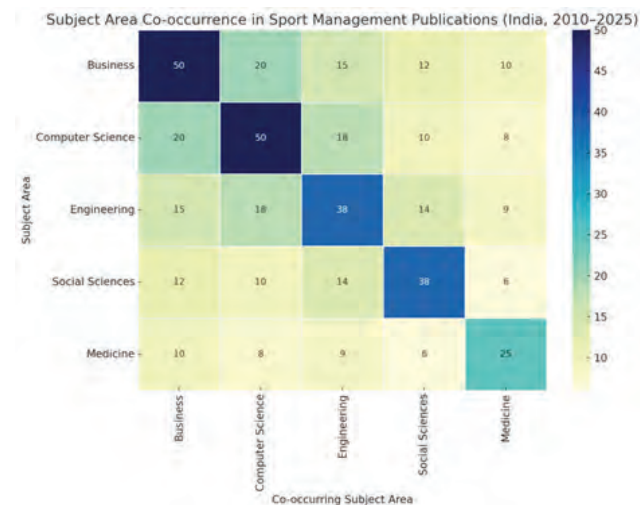
Saudi Arabia, with 7 collaborative publications, represents a growing academic and research partnership between India and the Middle East, highlighting the region's interest in sports-related research. The presence of countries like China, France, Indonesia, Poland, Serbia, and South Africa, each contributing 4 publications, further expands the international reach of Indian research, indicating that Indian researchers are actively engaging with a diverse range of countries to advance knowledge in sport management.

The table also demonstrates that Indian researchers have collaborated with over 80 countries in the broader research area of Medicinal Plants, which underscores the extensive global network that Indian researchers are part of. This reflects a broader trend in Indian academia, where international collaboration is not only enhancing research outputs but also promoting cross-border academic partnerships.

In conclusion, the collaborative data highlights the growing importance of international cooperation in advancing research in Sport Management. These collaborations enrich the quality and diversity of the research, foster cross-cultural exchanges, and help Indian researchers remain at the forefront of global academic developments in this field. The involvement of countries from various regions, especially those in Europe, Asia, and the Middle East, signals a well-rounded and global approach to research in sport sciences.

Table 4: Subject Area-wise Distribution of Sport Management Publications in India (2010–2025)

S. No.	Subject Area	No. of Documents Published
1	Business, Management and Accounting	50
2	Computer Science	50
3	Engineering	38
4	Social Sciences	38
5	Medicine	25
6	Decision Sciences	24
7	Mathematics	23
8	Economics, Econometrics and Finance	21
9	Physics and Astronomy	11
10	Psychology	9
11	Health Professions	8



Here's the heatmap showing the co-occurrence of subject areas in Indian Sport Management publications. The numbers indicate how many articles are jointly tagged under the respective pairs of subjects.

For example:

- 20 articles are tagged under both Business and Computer Science.

- 15 articles overlap between Business and Engineering.
- 10 articles appear under both Business and Medicine.

This visualization highlights the interdisciplinary intersections in the field — especially the strong link between Business, Computer Science, and Engineering.

CONCLUSION

This study employed bibliometric methods to analyze India's contribution and international collaboration in sport management research using data exclusively from the Scopus database. Covering the period from 2010 to 2025, the analysis included 157 publications affiliated with Indian institutions, of which 57 were internationally co-authored. The findings offer both theoretical insights and practical implications for researchers, institutions, and policymakers in the field of sport management.

The bibliometric analysis facilitated the identification of leading countries collaborating with India, co-authorship trends, and India's publication growth in this emerging discipline. Although India's overall contribution to global sport management research remains limited, the upward trend in publication output and collaboration rate—36.31% of Indian publications involving international co-authorship—demonstrates growing global engagement. The United Kingdom, Malaysia, and the United Arab Emirates emerged as India's most frequent collaborators, revealing patterns aligned with geopolitical and regional academic ties.

Thematically, Indian research has primarily focused on areas such as sport event management, development through sports, and sports governance, reflecting both global priorities and local socio-cultural relevance. However, limited engagement with emerging theoretical models, such as fan behavior or sport-specific identity constructs, suggests the need for deeper conceptual integration within the field. Strengthening India's scholarly identity in sport management may involve developing indigenous frameworks and addressing sport's broader social functions.

Practically, this study offers guidance for Indian researchers and institutions seeking to improve visibility and impact. Identifying strong collaborative networks—particularly with countries having higher

global output—can help in accessing new research directions and increasing citation potential. The data also highlight the importance of fostering institutional policies that support international research collaboration, interdisciplinary approaches, and capacity-building.

This study is constrained by certain limitations. The bibliometric data were collected solely from the Scopus database, which may not cover all relevant literature in sport management. Publications indexed in other databases such as Web of Science or regional repositories were not included, and this may affect the comprehensiveness of the results. Additionally, while this study focused on publication output and collaboration, it did not delve into citation metrics or article impact, which could be explored in future research. The reliance on quantitative methods further means that the findings represent structural trends rather than qualitative assessments of research quality.

In summary, this study provides a foundational understanding of India's scholarly footprint and global interactions in sport management research as captured in Scopus. As the field continues to evolve, India's role can be further enhanced through sustained international collaboration, thematic expansion, and deeper theoretical engagement, ultimately contributing to the global sport management knowledge base.

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Impact of Stress – An Analysis Among Engineering and Management Students in Tiruchirappalli City, Tamilnadu

A. Boaz

Assistant Professor
Department of Commerce
(Research Scholar-Part Time)
Bishop Heber College (Autonomous)
(Affiliated to Bharathidasan University)
Trichy, TamilNadu
✉ antonboaz@gmail.com

G. Gnanaraj

Research Supervisor, Asso. Professor and Head (Retd),
Department of Commerce
(Research Scholar-Part Time)
Bishop Heber College (Autonomous)
(Affiliated to Bharathidasan University)
Trichy, TamilNadu
✉ ggnans@gmail.com

ABSTRACT

Students experience enormous amounts of stress, whether a student of a school or a college, in the family or among their peers. Also, students ride the roller coaster every day in the hectic schedule. In this prevailing competitive world, the level of stress is understood to be on the higher side among the Engineering and Management students owing to their academic and personal reasons. This paper consists of objectives, need and significance, methodology, analysis, findings, suggestions and conclusion. This paper highlights the conceptual understanding on stress management, level of stress among Engineering and Management students, reasons for stress and stress management. The objectives are to study the level of stress among the engineering and management students & to know the various causes that create stress among engineering and management students. Students do their jobs themselves to ensure they are done properly and they feel irritated or angry if the car or traffic in front seems to be going too slowly/ they become very frustrated at having to wait in a queue. Female Management students are likely to experience stress related ill health either mental, physical or both. By inculcating the habit of enhancing interpersonal skills and shall seek the help of others in completing their tasks so that the level of stress may come down.

KEYWORDS: *Stress management, Symptoms of stress, Engineering and management student's stress, Mental health, Physical health.*

INTRODUCTION

Stress is a dynamic condition in which an individual is confronted with an opportunity, demand or resource related to what the individual desires and for which the outcome is perceived to be both uncertain and important. Stress is not necessarily bad in and of itself. Although stress is typically discussed in a negative context, it also has a positive value. Stress in its positive form – eustress – is necessary, healthy, and enjoyable. However, the negative form – distress – can be damaging if left unmanaged.

Symptoms of Stress

- Nervousness, constant worry

- Easily provoked to anger
- Unable to relax
- Physical ailment
- Suicide

NEED AND SIGNIFICANCE OF THE STUDY

The students who pursue engineering and management courses undergo a high level of stress due to academic assignments, college environment, extracurricular, workload, time management and parent pressures. It is essential to understand and analyze the reasons for stress and measures to reduce stress to improve their overall performance. Hence, this study is designed.

REVIEW OF LITERATURE

Charles J. Hobson & Linda Delunas of Indiana University Northwest conducted a study on Efficacy of Different Techniques for Reducing Stress: A Study among Business Students in the United States. The Objectives and findings of the study are narrated. The effects of three commonly recommended stress reduction strategies were empirically evaluated in a sample of 233 working adults attending evening MBA or undergraduate business classes part-time at an urban state university campus in the United States. A self-experiment protocol was utilized to assess the effectiveness of: (1) deep breathing, (2) imagery, and (3) progressive relaxation in reducing resting pulse rate. All subjects used each of these techniques on three occasions; measuring resting pulse before each trial and after each trial. This allowed for the calculation of a mean change in pulse rate across three applications for each technique for all subjects. Major findings included: (1) all three techniques demonstrated statistically significant mean reductions in pulse rate per minute; deep breathing – 7.22, imagery – 5.74, and progressive relaxation – 5.26, (2) comparative analyses documented a statistically significant superiority of deep breathing over the other two techniques, (3) there were no differences in mean effectiveness for the three techniques between men and women, and (4) 88% of the sample experienced success in reducing stress with all three techniques.

Ablanado-Rosas, Jose Humberto, Blevins, Randall C, Gao, Hongman, Teng, Wen-Yuan, White, Joann conducted a study on The impact of occupational stress on academic and administrative staff, and on students: an empirical case analysis. The Objectives and findings of the study are narrated. This study examined the impact of occupational stress among academic staff, administrative staff, and students in a well-established US university environment. The results show that there are different correlations associated with stress such as organisational demand, health issues, and stress management. Findings suggest that occupational stress levels differed between academic staff, administrative staff, and students. However, at the aggregate level, stress levels were similar by either gender or age. Different stress factors, such as work overload, feeling overwhelmed, and interrelated relationships were

analysed. Students reported significant outcomes from stress: having sleep problems, depression, and irritability

Antoniou, A.-SPolychroni, Viachakis, A conducted a study on Gender and age differences in occupational stress and professional burnout between primary and high-school teachers in Greece. The Objectives and findings of the study are narrated. This study identified the specific sources of occupational stress and the professional burnout experienced by teachers working in Greek primary and secondary schools. A special emphasis is given to gender and age differences. Design/ methodology/approach - A cross-sectional design was used. Two self-report measures were administered to a sample of 493 primary and secondary school teachers, a self-report rating scale of specific occupational stressors and the Maslach Burnout Inventory (education version). Findings - The most highly rated sources of stress referred to problems in interaction with students, lack of interest, low attainment and handling students with 'difficult' behaviour. Female teachers experienced significantly higher levels of occupational stress, specifically with regard to interaction with students and colleagues, workload, students' progress and emotional exhaustion. Younger teachers experienced higher levels of burnout, specifically in terms of emotional exhaustion and disengagement from the profession, while older teachers experienced higher levels of stress in terms of the support they feel they receive from the government. Practical implications - The findings will help to implement effective primary and secondary level prevention programmes against occupational stress taking into account how males and females and younger and older teachers perceive stress at work. Originality/ value - The study is a significant addition to the teacher stress and burnout literature, especially in Greece where few relevant studies exist dealing with these problems.

OBJECTIVES OF THE STUDY

The objectives of the study are listed below:

1. To study the impact of stress among the engineering and management students
2. To know the various causes that create stress among engineering and management students
3. To identify the measures to reduce the stress of engineering and management students

METHODOLOGY

Sampling method

Convenience sampling method was used to collect necessary primary data for the study. Sample size: 300 college students (196 Engineering students and 104 Management students) from Tiruchirappalli city

Data Collection

Primary data

A questionnaire was adapted from The International Stress Management Association (ISMAUK) administered to collect primary data.

Secondary data

Considerable secondary data has also been collected from journals, magazines, previous research papers and newspapers.

LIMITATIONS OF THE STUDY

Since the selected sample size is small when compared to the total population, this study cannot be generalized to other areas.

Table 1: Level of stress among MBA Students

Particulars	Male		Female		Total	
	Count	Percentage	Count	Percentage	Count	Percentage
Students scored 4 points or less	0	0.0	0	0.0	0	0.0
Students scored 5 to 13 points	30	40.5	22	73.3	52	50.0
Students scored 14 points and above	44	59.5	8	26.7	52	50.0
Total	74	100.0	30	100.0	104	100.0

Primary Field Data

From the Table-01, it is inferred that 73.3% of female MBA students and 40.5 % of male MBA students are likely to experience stress related ill health either mental, physical or both. And 59.5% of the male MBA

DATA ANALYSIS AND RESULTS

The collected data was tabulated and analyzed using percentage analysis method.

General interpretations for the questionnaire administered to collect primary data

4 points or less: You are least likely to suffer from stress-related illness.

5 - 13 points: You are more likely to experience stress related ill health either mental, physical or both. You would benefit from stress management / counseling or advice to help in the identified areas.

14 points or more: You are the most prone to stress showing a great many traits or characteristics that are creating unhealthy behaviours. This means that you are also more likely to experience stress & stress-related illness e.g. diabetes, irritable bowel, migraine, back and neck pain, high blood pressure, heart disease/strokes, mental ill health (depression, anxiety & stress). It is important to seek professional help or stress management counseling. Consult your medical practitioner.

Adapted from: The International Stress Management Association (ISMAUK) www.isma.org.uk

students and 26.7% of female MBA students are more likely to experience stress & stress-related illness e.g. diabetes, irritable bowel, migraine, back and neck pain, high blood pressure, heart disease/strokes, mental ill health (depression, anxiety & stress)

Table 2: Level of stress among Engineering Students

Particulars	Male		Female		Total	
	Count	Percentage	Count	Percentage	Count	Percentage
Students scored 4 points or less	0	0.0	0	0.0	0	0.0
Students scored 5 to 13 points	76	55.9	18	30.0	94	48.0
Students scored 14 points and above	60	44.1	42	70.0	102	52.0
Total	136	100.0	60	100.0	196	100.0

Primary Field Data

It is inferred from the Table-02 that 55.9 % of male Engineering students and 30.0 % of female Engineering

students are likely to experience stress related ill health either mental, physical or both and 70.0 % of the female Engineering students and 44.1% of male Engineering students are more likely to experience stress & stress-related illness e.g. diabetes, irritable bowel, migraine, back and neck pain, high blood pressure, heart disease/strokes, mental ill health (depression, anxiety & stress)

Table 3: Level of stress among the Students (Gender based analysis)

Particulars	Male		Female		Total	
	Count	Percentage	Count	Percentage	Count	Percentage
Students scored 4 points or less	0	0.0	0	0.0	0	0.0
Students scored 5 to 13 points	106	50.5	40	44.4	146	48.7
Students scored 14 points and above	104	49.5	50	55.6	144	51.3
Total	210	100.0	90	100.0	300	100.0

Primary Field Data

It is clearly interpreted from the Table -03 that 50.5% of male students and 44.4 % of female students are likely to experience stress related ill health either mental, physical or both. And 55.6 % of the female students and 49.5 % of male students are more likely to experience stress & stress-related illness e.g. diabetes, irritable bowel, migraine, back and neck pain, high blood pressure, heart disease/strokes, mental ill health (depression, anxiety & stress)

Chi-Square Test 2

	Stress Factor	
	Yes	No
Male	2716	2480
Female	1224	1074

NullHypothesis: There is no Significance Difference between Gender and stress level

AlternateHypothesis: There is a significant Difference between Gender and stress level

TabulatedValue: @ 5% LOS – 3.84

CalculatedValue: 0.133

Result: Accept Ho, since calculated vale < Tabulated Value

Interpretation: There is no association between Gender and stress level

Table 4: Consolidated Analysis

Particulars	MBA students mentioned yes		ENGG students mentioned yes		Total	
	Count	%	Count	%	Count	%
I frequently bring work home at night	60	57.7	130	66.3	190	63.3
Not enough hours in the day to do all the things that I must do	48	46.2	138	70.4	186	62.0
I deny or ignore problems in the hope that they will go away	52	50.0	108	55.1	160	53.3
I do the jobs myself to ensure they are done properly	88	84.6	168	85.7	256	85.3
I underestimate how long it takes to do things	66	63.5	84	42.9	150	50.0
I feel that there are too many deadlines in my work / life that are difficult to meet	56	53.8	98	50.0	154	51.3
My self confidence / self esteem is lower than I would like it to be	50	48.1	86	43.9	136	45.3
I frequently have guilty feelings if I relax and do nothing	54	51.9	116	59.2	170	56.7

I find myself thinking about problems even when I am supposed to be relaxing	80	76.9	116	59.2	196	65.3
I feel fatigued or tired even when I wake after an adequate sleep	42	40.4	134	68.4	176	58.7
I often nod or finish other people sentences for them when they speak slowly	34	32.7	84	42.9	118	39.3
I have a tendency to eat, talk, walk and drive quickly	64	61.5	122	62.2	186	62.0
My appetite has changed, have either a desire to binge or have a loss of appetite / may skip meals	46	44.2	84	42.9	130	43.3
I feel irritated or angry if the car or traffic in front seems to be going too slowly/ I become very frustrated at having to wait in a queue	68	65.4	138	70.4	206	68.7
If something or someone really annoys me I will bottle up my feelings	66	63.5	114	58.2	180	60.0
When I play sport or games, I really try to win whoever I play	80	76.9	148	75.5	228	76.0
I experience mood swings, difficulty in making decisions, concentration and memory is impaired	50	48.1	122	62.2	172	57.3

I find fault and criticize others rather than praising, even if it is deserved	28	26.9	32	16.3	60	20.0
I seem to be listening even though I am preoccupied with my own thoughts	86	82.7	148	75.5	234	78.0
I find myself grinding my teeth	34	32.7	42	21.4	76	25.3
Increase in muscular aches and pains especially in the neck, head, lower back, shoulders	52	50.0	96	49.0	148	49.3
I am unable to perform tasks as well as I used to, my judgment is clouded or not as good as it was	48	46.2	88	44.9	136	45.3
I find I have a greater dependency on alcohol, caffeine, nicotine	16	15.4	20	10.2	36	12.0
I find that I don't have time for many interests / hobbies outside of work	56	53.8	96	49.0	152	50.7
My drive to opposite gender decrease with change in time	52	50.0	52	26.5	104	34.7

Primary Field Data

FINDINGS, SUGGESTIONS AND CONCLUSION

Major findings

Some of the findings from this study are 85.3 % of the respondents have agreed that they do their jobs themselves to ensure they are done properly, 68.7 % of

the respondents have opined that they feel irritated or angry if the car or traffic in front seems to be going too slowly/ they become very frustrated at having to wait in a queue, 76.0 % of the respondents agreed that when they play sport or games, they really try to win whoever plays opposite, 78.0 % of the respondents have agreed that they seem to be listening even though they are preoccupied with their own thoughts, 73.3% of female MBA students are likely to experience stress related ill health either mental, physical or both, 59.5% of the male MBA students are more likely to experience stress & stress-related illness, 55.9 % of male Engineering students are likely to experience stress related ill health either mental, physical or both, 70.0 % of the female Engineering students are more likely to experience stress & stress-related illness, 50.5% of male students are likely to experience stress related ill health either mental, physical or both and 55.6 % of the female students are more likely to experience stress & stress-related illness.

SUGGESTIONS

The suggestions based on the findings are the students shall inculcate the habit of enhancing interpersonal skills and shall seek the help of others in completing their tasks so that the level of stress may come down, the students shall learn how to handle failures by listening to motivational speakers, reading related books. The students shall involve in sports, games, yoga, meditation and extracurricular activities to divert their mind from unnecessary strain, the students shall learn art of multi-skilling, prioritize their work and execute their works in order to reduce pressure and trauma, the students shall attend counseling and mentoring sessions by their faculty members and experts to share their burdens and get relieved from their worries and tensions and the students shall seek advice from psychiatrists and medical practitioners in order to reduce the fatigue and stress level.

CONCLUSION

Stress is a common phenomenon among professional degree students. Due to academic assignments, peer pressures, performance metrics, the Engineering and Management students are easily provoked to anxiety and constant worry. Therefore, the student's performance is largely affected. Hence, the students should learn and acclimatize to the given situations. Counseling, yoga, physical exercise, sports and spiritual activities comes handy to manage their stress effectively.

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info@sru.edu.in

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