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Editorial

Last few decades technological changes in every domain have been happening so fast. What we saw in the recent past is not seen today. Changes are inevitable. If any one ignore to adopt the changes will remain as a back bencher. There are many examples of failures in industrial sector for not switching over to new or user friendly rather smart technologies.

Life style of the people is rapidly changing and adopting to the changes in the society, technology and other factors. People living not only in urban areas even in remote areas are switching over to modern life style.

Scientists, researchers, industrial leaders and consultants are involving in exhaustive research activities and contributing well in innovating the new or modifying the existing products with latest available technologies. Academic and research institutions and professional bodies are creating a platforms to share the knowledge in recent developments. Conferences and seminars can help students, scientists and researchers working in various fields to abreast up-to-date on the latest trends and developments in technologies to narrow the gap. These platforms are a great opportunity to explore various ideas.

Presentations in conferences particularly international conferences provide a great opportunity to communicate one's research work to a gathering representing various parts of the world and can seek suggestions on the research work and also learn from the others' presentations and also to broaden professional network.

Every person will come across with a variety of materials in day to day life. Earlier, men were lived with limited variety materials such as wood, stone, clay and few metals. Due to the development and advancement of life style, people are expecting the products of better quality, good appearance, easy to use, durable and available at an affordable price.

In the perspective, the Bangalore Institute of Technology (BIT), Bangalore is organizing 3day international conference AMEMA 2023 with an objective to create a platform for talents from across the globe in the fields of advanced materials and their applications.

The editorial board of IJTE has accepted to publish only 38 selected research papers of AMEMA-2023 as a May 2023 special issue. We are sure that Vol. 46, May 2023 special issue of IJTE will be interesting and useful to the readers.

New Delhi **Editor**
08th May 2023

Contents

PERFORMANCE EVALUATION OF NEAR SURFACE MOUNTED TECHNIQUE FOR FLEXURAL STRENGTHENING AND U WRAPPING FOR SHEAR STRENGTHENING OF PRELOADED RC BEAMS

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ABSTRACT

Experimental study was used to investigate the effectiveness of the near surface mounted (NSM) technique and shear strengthening techniques by U wrapping, using carbon FRP laminates and wrap in concrete beams. When an RC beam is reinforced deficiently in shear and when it is highly loaded, it must be strengthened for shear. Since shear failure is very brittle and cannot be judged quickly strengthening of beams for shear is necessary. Bonding CFRP on external surface of beam and mounting the same near to the beam surface are two successful methods for shear strengthening of beams. Carbon fibre reinforced polymer (CFRP) strips have proven to be effective in shear strengthening reinforced concrete beams. Environmental effects, as well as design and construction flaws, can cause structural beams to lose their shear capability, necessitating rehabilitation. The application of additional load may necessitate the improvement of beams in order to increase their ability to contain the additional loads. The impact of the following main variables is explored in this project.

The project undertaken consists of strengthening of preloaded R-C beams for shear with NSM technique using CFRP laminates and wrap. Where, in this project six beams were casted, two were control specimens, two were shear strengthened with CFRP wrap, another pair of beams were shear strengthened with both CFRP laminate and wrap as well.

KEYWORDS *: NSM strengthening, Preloaded beams, Retrofitting*

INTRODUCTION

A large number of RC structural components of buildings including bridges require repair and strengthening around the world, emphasizing the extent of importance of these structures in the civil construction field will continue to grow considering the future. Due to the high strength-to-weight ratio, high durability (non-corrodible), easy handling, fast execution with minimum labour and varied accessibility of geometry, and dimensions the adoption of carbon fibre reinforced polymers (CFRP) for strengthening of beams. When an RC beam is less reinforced properly in shear or due to increased load due to occupancy change and other reasons, it must be shear strengthened. As the shear failure is unpredictable and brittle, it must be strengthened.

Externally bonded reinforcing (EBR) and near surface mounted (NSM) with CFRP are two shear strengthening solutions for RC beams. Wet lay-up CFRP sheets can be used in a variety of ways in the EBR technique with the cross section of the beam is completely wrapped. Wrapping System is a structural strengthening solution which utilizes the high tensile strength of carbon fibre while being incredibly light. When bonded to the outside of a concrete beam, it can give a lot of strength without adding weight, which would put more strain on foundations and other structural parts.

Wrapping systems are made up of a combination of textiles, mainly carbon, and an epoxy resin. The Wrapping System gives structures a lot of strength and protects them from additional corrosion and erosion. The impermeable substance will shield a building from further corrosion and moisture incursion, decreasing the requirement for continuous maintenance.

RESEARCH SIGNIFICANCE

Various researchers have contributed to the retrofitting of RC beams for flexure and shear capacity enhancement. However, very limited research takes care of the real-world application of these techniques as the beams that require these strengthening techniques would generally be subjected to cracks and deformations. To simulate the real-world damage in laboratory, an attempt is made by preloading the beam upto the desired extent and carefully retrofitting the members thereafter. In this study one such attempt is made to study the capacity enhancement of preloaded beams.

OBJECTIVES

1. To study the shear behaviour of strengthened preloaded R-C beams with the NSM technique using CFRP composites
2. To consider the performance of different configuration of shear strengthening
3. To compare the load-deformation behaviour of strengthened specimens with control beam.
4. To suggest the best technique in shear strengthening

METHODOLOGY

The brief methodology is described in Fig. 1 with the help of a flow chart.

SPECIMEN ID

CB- Control Beams

SPB- X- Beams with Only 'U' Wrapping

SPB- Y- Beams with Only 'U' Wrapping and NSM Embedment

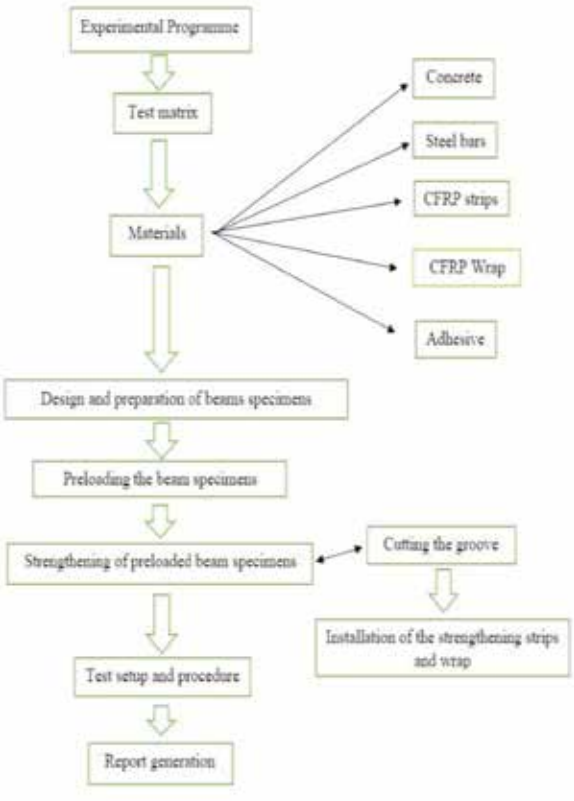

Fig. 1. Methodology of the experimental work

BEAMSPECIMENDESIGNANDREFINING

The experimental programme consists of six RC beams, each of which is 2600X200X200mm in size. Two beams are considered as control specimens, which, one control specimen is only provided with two of 12 mm dia main bars without stirrups. Another control specimen and remaining beams are reinforced with two 12mm bars as primary bars and two 8mm diameter bars as hanger bars. With stirrups of 2L-8mm dia bars at 300mm c/c, the beams should tend to fail in shear. An effective cover of 33mm was supplemented. A typical beam is shown in Fig. 2.

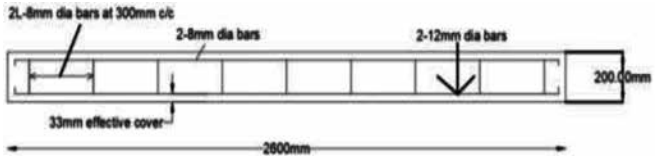

Fig. 2. Detailing of beam

MATERIALS USED IN THE STUDY

Concrete

M40 ready mix concrete was used. The slump of the mix and proportions are provided in Table 1.

Table 1. Concrete Mix Propotions

Slump (mm)	W/C ratio	Water (Kg/ m^3)	Cement (Kg/m^3)	Coarse aggre-gate (Kg/m^3)	Fine aggre-gate (Kg/ m^3)	Chemical admix-ture (Kg/ m^3)
50	0.38	191	420	1106	712	2.1

Steel bars

12 mm and 8 mm diameters of Steel bars with have been employed in this study.

The primary reinforcement is made of 12 mm bars, while hanger bars and stirrups are made of 8 mm bars.

CFRP laminate and CFRP wrap

The material was sponsored by FOSROC chemicals private limited. CFRP laminate of size 50mm wide and 1.4mm thick was used, which was having tensile strength of 2900 MPa and modulus of elasticity 150 GPa.

CFRP wrap with thickness 0.2mm, weight 200 gsm, tensile strength 3400 MPa and modulus of elasticity 2.3X105 MPa was used

Adhesive

Nitowrap-30 and Nitowrap 410 was used for CFRP wrap sponsored by FOSROC chemicals private limited.

EXPERIMENTAL PROGRAM

2-point loading was done to test the beam specimens as shown in Figs. 3 and 4.

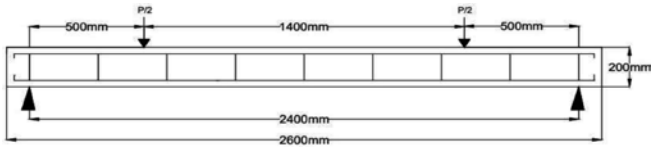

Fig. 3. Experimental set up

Fig. 4. Experimental setup of beam

Pre-loading of beam specimens

The remaining four beams, which will be reinforced with NSM CFRP strips and wrap, are preloaded with 60% of the ultimate load. With reference to control beams testing, a maximum load of 81KN was attained. As a result, the beams are preloaded with a 48.6KN load.

Preloaded beam specimen strengthening

Once the beams were preloaded, one set of two beams (SPB-X1 and SPB-X2) were U -wrapped with CFRP wrap up to 0.75m from either end of the beams

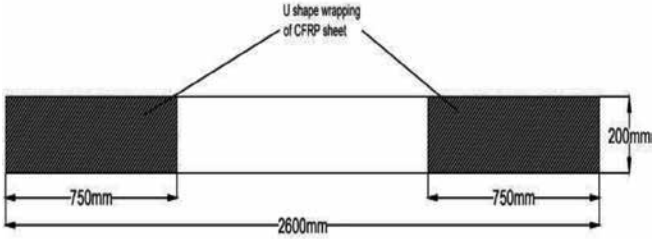

Figure 5 strengthening of beam with CFRP wrap

Second set of two beams (SPB-Y1 and SPB-Y2) were made with a 15 mm deep and 60 mm wide slot cut in the soffit up to 0.75m from either ends to insert the 1.4 mm thick and 50 mm wide CFRP strip, on this, CFRP sheet was U-wrapped up to 0.75m on either ends of the

beams. The CFRP strips were adhered to the grooves with epoxy glue. The epoxy was initially filled up to 5mm in the grooves, then CFRP strips were implanted and the epoxy was packed up to the surface.

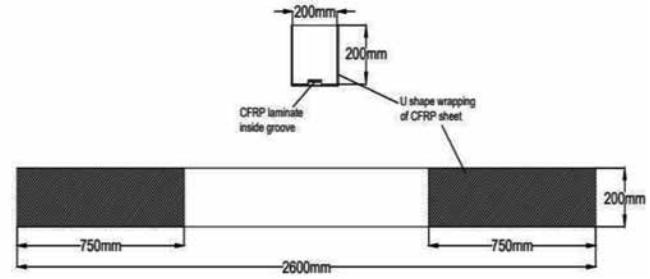

Fig. 6. Strengthening of beam with CFRP laminate and wrap

RESULTS AND DISCUSSION

Total of 6 beams were tested, which consists of 2 control beams, among them one is without stirrups and another is with stirrups, another 2 beams were strengthened with CFRP wrap in shear zone, remaining 2 beams were with NSM technique, groove cut at soffit of beam and placing of laminates and also wrapping it with CFRP wrap. They are tested in loading frame of 50 tons capacity at every 2kN load was applied until the specimens get failed. Where the obtained results are discussed below. The Load and corresponding deflections at first crack, service load and ultimate loads are presented in Table 2.

CONTROL BEAM SPECIMENS TESTING

To determine the ultimate load bearing capability, deflection, and fracture pattern, two control beams were tested until they failed. Readings of deflection and fracture width were recorded at every 2KN interval until the specimens failed. A Combined Load deflection curve is shown in Fig 7.

Control beam 1

During the testing of the first control specimen, a Shear crack was developed at a force of 14KN. The beam collapsed at a 76KN force. At failure load, the final deflection was 14.706 mm.

Control beam 2

During the testing of the first control specimen, a shear crack was developed at a force of 40KN. The beam collapsed at a 86KN force. At failure load, the final deflection was 12.455 mm.

TESTING OF STRENGTHENED SPECIMENS

Testing strengthened beam SPB-X1

Preloaded beam SPB-X1 which was U -wrapped with CFRP wrap up to 0.75m from either end of the beam was tested. The initial crack was at 40kN and ultimate load carrying capacity obtained at 102kN.

Testing strengthened beam SPB-X2

Preloaded beam SPB-X2 which U -wrapped with CFRP wrap up to 0.75m from either end of the beam was tested. The initial crack was at 38kN and ultimate load carrying capacity obtained at 116kN.

Testing strengthened beam SPB-Y1

Preloaded beam SPB-Y1 with a 15 mm deep and 60 mm wide slot cut in the soffit up to 0.75m from either ends to insert the 1.4 mm thick and 50 mm wide CFRP strip and U-wrapped up to 0.75m with CFRP sheet from either ends of the beam was tested. The initial crack was at 42kN and ultimate load carrying capacity obtained at 116kN.

Testing strengthened beam SPB-Y2

Preloaded beam SPB-Y2 with a 15 mm deep and 60 mm wide slot cut in the soffit up to 0.75m from either ends to insert the 1.4 mm thick and 50 mm wide CFRP strip and U-wrapped up to 0.75m with CFRP sheet from either ends of the beam was tested. The initial crack was at 52kN and ultimate load carrying capacity obtained at 102kN.

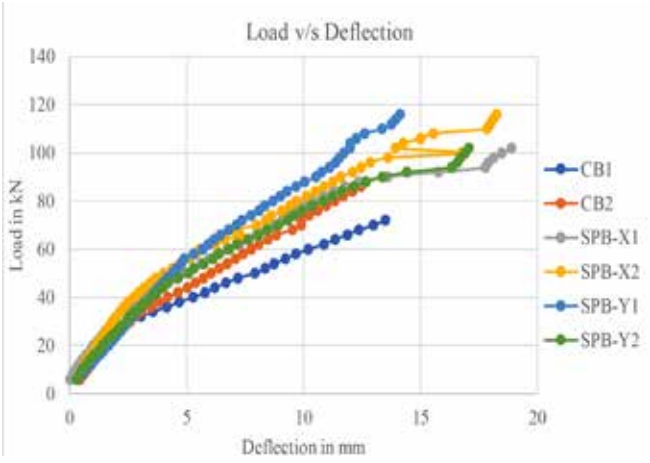

Fig 7. Load v/s Deflection of All Beams

Table 2. Load and Deflections of all beams at different stages

Beam Designation	First cracking load		Service Load		Ultimate load	
	Load (kN)	Deflection (mm)	Load (kN)	Deflection (mm)	Load (kN)	Deflection (mm)
CB-1	14	0.979	50.66	6.456	76	11.579
CB-2	40	3.428	57.33	5.821	6886	9.802
SPB-X1	40	2.704	68	6.695	102	14.011
SPB-X2	38	1.991	77.72	7.149	116	13.963
SPB-Y1	42	3.034	77.34	6.609	116	11.643
SPB-Y2	52	4.687	68	7.18	102	13.57

Crack pattern

Control beam 1

Figure 8 Crack pattern in CB-1

The pattern of cracks in control beam 1 is shown in the above figure. Stirrups are not provided in this beam. The first crack developed at load of 14 kN which is shear in nature. After that upon incremental load several such shear cracks developed. One such crack can be observed from the above figure, in which shear crack at 53 kN got propagated up to the top surface of the beam. Minor flexural cracks and flexural – shear cracks are also observed in the control beam 1.

Control beam 2

Figure 9 Crack pattern in CB-2

The pattern of cracks in the control beam 2 is depicted in the diagram above. At the load of 40 kN, the first crack occurred, which is shear in character. Following that, additional shear cracks appeared as a result of gradual loading. One such fracture may be seen in the above illustration, where a shear crack appeared at a force of 69 kN and propagated at load of 81 kN all the way to the beam's upper surface. Flexural - shear cracks and minor flexural cracks are also observed.

Beam SPB X-1

Figure 10 Crack pattern in SPB X1

In beam SPB X-1 preload of 60% failure load of control specimen is applied and CFRP U- wrap is provided at extreme sections of beam for a width of 0.75 m. The first crack is appeared at 40 which is flexure-shear crack. The deflection corresponding to first cracking load is 3.173 mm. As the load increases widening of crack occurred at 68 kN. Due to the CFRP wrapping in the shear critical zone of beam, major shear cracks were not visible.

Beam SPB X-2

Figure 11 Crack pattern in SPB X2

Beam SPB X-2 which has been preloaded by 48.6 kN and U- wrapped with CFRP at end developed first crack at a loading of 38 kN. From the above figure one perfect shear developed at 110 kN which is approximately 45 degrees. Another shear crack at 110 kN got propagated into the CFRP wrap.

Beam SPB Y-1

Figure 12 Crack pattern in SPB Y1

At a loading of 42 kN, the SPB Y-1 beam, which had been preloaded by 48.6 kN and Uwrapped with CFRP at the end, developed its first crack. One complete shear generated at 110 kN, which is roughly 40 degrees, as seen in the diagram above. Some flexural cracks can also seen in the beam up on loading.

Beam SPB Y-2

Figure 13 Crack pattern in SPB Y2

Figure 14 Shear crack occurred inside the wrapping

The first cracking load for beam SPB Y-2 is 52 kN. There are visible number of flexural cracks in this beam. But after ultimate failure of the beam when the CFRP wrap got de-bonded there are major shear cracks below CFRP wrap. Hence due to coverage of CFRP in most part of shear zone of beam the shear cracks are nonvisible. The reason behind non visibility of shear crack is because of non-replicability of cracks in beams on the CFRP wrap.

Failure modes

Figure 15 Control beam failure mode

The control beam 1 failed by shear at ultimate load of 76kN with maximum average deflection of 11.578 mm and maximum middle deflection of 14.706 mm. At 72 kN concrete near the supports spalled and dial gauges were removed for safety purpose. Most of the shear cracks were propagated up to the compression surface of the slab at the time of failure. The deflection profile of the failed control beam is shown in above figure.

Control beam 2 failed by shear. The beam failed at load of 86kN. There were three types of cracks, flexure, shear and flexure- shear cracks. Concrete spalling occurred at a load of 82kN.

Beam X-1

Figure 16 X1 failure mode

The beam X1 which is strengthened only by CFRP wrap failed at 102kN by shear. The above figures depict the failure of beam in which delamination and rupture of CFRP wrap has not been occurred at final load. The maximum deflection was about 18.892 mm and average deflection was 14.011 mm.

Beam X-2

Figure 17 X2 failure mode

The beam X2, which was mainly stiffened by a CFRP wrap, fractured at 116 kN. The failure of a beam in which CFRP wrap rupture occur at ultimate load is depicted in the diagrams above. The wrap got ruptured of about 11 mm from its original position at a distance of 750mm from the edge due to deflection. The maximum deflection was around 18.27 mm with an average of 13.963 mm. It is to be noted that the delamination of CFRP was not been occurred in this beam.

Beam Y-1

Figure 18 Y1 failure mode

Beam Y-1 which is strengthened with CFRP laminates by NSM technique and CFRP wrap failed at ultimate load of 116.43 kN. The major changes occurred in this beam related to other strengthened beams discussed above is the de- bonding of CFRP laminate with no delamination

of CFRP wrap. The cracks and their propagation in this beam has been delayed due to both CFRP laminates and wrap. The average and middle deflection at ultimate load are 11.643 and 14.13 mm respectively.

Beam Y-2

Figure 19 Y2 failure mode

Beam Y-2, which was strengthened with CFRP laminates and CFRP wrap using the NSM technology, miscarried at ultimate load of 102 kN. The de-bonding of CFRP laminate occurred at 76 kN with no delamination of CFRP wrap. Because of the CFRP laminates and wrap, the cracks and their propagation and deflection values in this beam has been reduced. The average and central deflection at 102 kN are 13.570 mm and 17.08 mm respectively.

CONCLUSION OF THE STUDY

The study on pre-loaded RC beam strengthened using CFRP laminate and wrap with NSM technique is undertaken. The U wrapping at shear zone was done for two beams of first set. The laminate as well as U wrapping was done for two beams of second set, by this study following results were observed.

- For strengthened beam group SPB-X first crack was advanced by 1 KN as compared to control beam CB-2. For strengthened beam group SPB-Y first crack was delayed by 7 KN as compared with control beam CB-2.
- Both strengthened beam group SPB-X and SPB-Y ultimate load carrying capacity was enhanced by 26.74% compared to control specimen.
- Preloaded beam group SPB-X and SPB-Y got a deflection of 13.987 mm and 12.606 mm, deflection was more compared to control specimens. By this we can conclude, shear strengthening of beams with NSM technique does not reduce deflection, as loading increases deflection increases.
- As strengthened specimens are U wrapped in shear zone cracks were unseen while testing, flexure cracks were appeared. After testing, U wrap was removed where shear cracks was found.
- There is no observed rupture of U wrap, but near to failure load or ultimate load debonding of laminate was happened.

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EXPERIMENTAL STUDIES ON JUTE FIBRE AND BANANA FIBRE USED AS FIXED AERATED BED FOR CANTEEN WASTEWATER TREATMENT

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ABSTRACT

In order to effectively remove organic matter and nutrients from municipal wastewater, a variety of fixed beds with greater surface areas are used. Fibrous materials are frequently thought to be a superior option for improved microbial support and treatment effectiveness due to the higher specific surface area. The goal of the current study was to compare the effectiveness of two different fibrous materials Banana fibre and jute fibre with higher specific surface areas. They were employed as packing media in two separate sewage treatment bioreactors in batch mode and under related experimental circumstances. For various contact times, the reactors were constantly aerated. According to the study, these fibrous media may be suitable for the effective removal of nutrients and organics found in sewage.

KEYWORDS *: Canteen wastewater, Jute fibre, Banana fibre.*

1. INTRODUCTION

Life cannot exist without the necessity of water. It exists in a variety of forms, including oceans, rivers, lakes, and groundwater, and covers around 71% of the Earth's surface. All life, including people and other creatures and plants, depends on water. It is essential for a variety of internal processes, including maintaining body temperature, circulating nutrients and oxygen, and getting rid of waste. These issues are being addressed through conservation, instruction, and sustainable management techniques. For instance, desalination and water recycling technologies can contribute to a greater supply of freshwater. The economy, the environment, and human health are all protected by wastewater treatment. Lack of wastewater treatment can cause land, water, and air pollution. The removal of impurities and pollutants from the water throughout the wastewater treatment process ensures that it is safe for reuse or disposal. Several procedures are used to treat wastewater in order to clean the water of toxins and pollutants. These procedures, which can be physical, chemical, or biological, are made to get rid of various kinds of contaminants. One of the most popular and efficient techniques for treating wastewater is biological treatment. It entails employing microorganisms to break down organic materials and other

impurities in the wastewater, including bacteria, fungi, algae, and protozoa. domestic wastewater strength reduction with two alternative bed materials the form of treatment used jute and banana fibre as filter media. To create a fixed bed that serves as a significant surface area for the development of microorganisms that may degrade organic compounds, the approach includes suspending fibres in wastewater. The specific features of the wastewater and the treatment system's operational circumstances may have an impact on the process' efficacy. The biological action that occurs in wastewater causes the organic molecules to break down, reducing the strength of the waste water.

2. MATERIALS AND METHODOLOGY

Banana fibre and jute fibre were the two natural fibres employed in this investigation.

Banana Fibre:

The source of banana fibre, a natural fibre, is the banana plant's stem. The banana plant is cultivated for its fruit, but the stem and leaves are typically thrown away. by using the banana's stem to produce fibre. Extraction of banana fibre involves breaking the stem into tiny pieces, submerging it in water, then scraping the fibre off the stem. The fibre is spun into yarn or woven into cloth after drying and washing. The exceptional mechanical and chemical properties of banana fibre make it a strong contender to be used as a filter media. The fibre can store a lot of water and is durable and sturdy. Since banana fibres are also antimicrobial, they can be employed in water filtering systems. Before employing banana fibres as a filter media, it is critical to determine how well they remove pollutants from water. The effectiveness of the filter media may be assessed by testing the water before and after filtration to quantify the quantity of contaminants removed. The type of pollutants in the water and the size of the pores in the filter media are important factors to consider.

Jute Fibre:

Considering its natural and renewable qualities, jute fibre might be a viable option for filter media. When jute fibres lose their effectiveness, they may be simply replaced with new ones since they degrade into a harmless substance. Jute fibres are also capable of capturing and eliminating impurities from water and have strong mechanical qualities, such as high tensile strength. A range of contaminants, including pathogens, organic compounds, and heavy metals, may be removed from water using jute fibres because of their high adsorption capacity. Jute fibres are also an appealing alternative for use as a filter medium since they are inexpensive and readily accessible. Jute fiber's efficiency as a filter medium is influenced by several variables, including the size of the fibres and the pore size of the filter. While the pore size dictates the size of the pollutants that may be trapped and removed, the fibre size impacts the surface area available for adsorption. Jute fibre is a potentially efficient and environmentally friendly filter medium for water filtration. However, more investigation and testing are required to maximize its performance as a filter medium and identify the best jute fibre pore size and structure for various water pollutants.

A. SAMPLING

Grab samples were collected in plastic cans rinsed with distilled water. Sample was collected from canteen wastewater. Samples were analyzed for the following parameters i.e., BOD, COD, Chloride, Sulphate, pH, Turbidity.

B. EXPERIMENTAL SET UP

The reactors utilized in this investigation were constructed for batch operation and down flow mode out of plastic and had a cylindrical form. Two reactors were created, each measuring 21.5 x 24 x 27 cm3 and 5 mm thick. Banana and jute fibre were placed in two reactors. The dissolved oxygen level inside the reactor was kept constant using aerators. A mesh is positioned 5 cm up from the

reactor's bottom. Plans were developed to collect the effluent from the reactor's bottom through a tap.

C. START UP OF THE REACTOR

Cow dung is seeded into the reactor along with domestic wastewater. Cow dung to wastewater ratio is 1:1. The fibre in the reactor is allowed to undergo acclimatization for a period of 7 days.

D. EXPERIMENT PROCEDURE

Banana and jute fibres are poured into the two reactors at a predetermined depth and packing density. The dissolved oxygen concentrations inside the reactors are kept constant by diffused aerators. The reactor was initially seeded with a 1:1 mixture of cow dung and wastewater. These reactors were then continually aerated for 7 days to allow the biomass in both reactors to mature and acclimatize. The initial properties of the wastewater used in the investigation are identified. Wastewater is supplied through the input pipe after the biomass development on the surface of fixed beds is complete. Up to a contact time of 72 hours, sampling is done every 24 hours. The effluent's final properties are established.

3. RESULTS AND DISCUSSION

In this present study banana fibre and jute fibre are the two natural fibres used. The packing density adopted was 141.6 kg/m3 and 147.9 kg/m3. Higher removal efficiency was found for the reactor filled with banana fibre with packing density 141.6 kg/m3 and 5 cm filter media depth in comparison with jute fibre reactor.

Table 1: Removal Efficiency of Jute Fibre reactor with Packing Density 147.9 kg/m^3 and 5 cm filter media depth.

JUTE FIBRE REACTOR									
PARAMETERS	INITIAL DAY	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY7	REMOVAL EFFICIENCY
BOD (%)	160	115	93	90	78	60	53	42.4	73.5
COD (%)	225	203	157	130	114	98	75	52.2	79.5
CHLORIDE (%)	285.6	230	201	182.7	158	121	112	100.24	64.9
SUSPENDED SOLIDS (%)	4	3.2	2.6	2	1.8	1.65	1.55	1.4	65
pH	8.41	8.35	8.3	8.4	8.37	8.33	7.813	7.45	Neutralizing to 7
SULPHATE (%)	60.93	55.78	50.937	45.70	35.31	24.125	20.562	17.06	72
TURBIDITY (%)	97.5	89.25	81.5	73.12	56.5	38.6	32.9	27.3	72

Chart 1: Removal Efficiency of Jute Fibre Reactor with Packing Density 147.9 kg/m3 and 5cm Filter Bed Thickness.

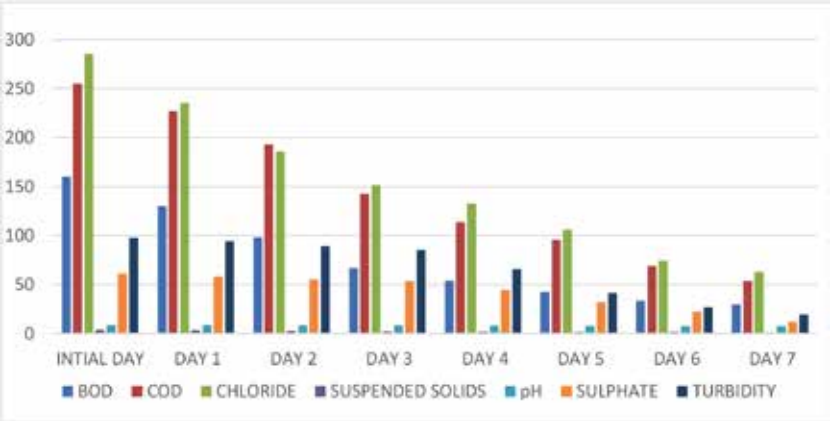

Table 2: Removal Efficiency of Banana Fibre reactor with Packing Density 141.6 kg/m3 and 5 cm filter media depth.

BANANA FIBRE REACTOR									
PARAMETERS	INITIAL	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY7	REMOVAL EFFICIENCY
BOD (%)	160	130	98	67.2	54	42.5	33.6	29.6	81.5
COD (%)	255	227	193	142.8	113.5	96	68.8	53.55	79
CHLORIDE (%)	285.6	235	186	151.368	133	105.9	74.5	62.83	78
SUSPENDED SOLIDS (%)	4	3.6	2.9	2.24	2.01	1.7	1.55	1.04	74
pH	8.41	8.39	8.25	8.2	7.9	7.6	7.5	7.5	Neutralizing to7
SULPHATE (%)	60.93	58.5	55.2	53.32	44.5	32	22.3	12.18	80
TURBIDITY (%)	97.5	94.2	89.5	85.31	66	41.5	27	19.5	80

Chart 2: Removal Efficiency of banana fibre Reactor with Packing Density 141.6 kg/m3 and 5cm Filter Bed Thickness.

CONCLUSIONS

The results indicate that a reactor with a packing density of 141.6kg/m3 has a slightly higher removal efficiency of organic materials and nutrients when compared to a reactor with a packing density of 147.9kg/m3. The reactor with packing density 147.9 kg/m3 filters material more quickly than the reactor with packing density 141.6 kg/m3. The banana fibre reactor performs better when comparing the removal efficiencies of the two reactors. Significant reductions were made in BOD, COD, and nutrients. The maximum removal rates for BOD, COD, chloride, sulphate, suspended particles, and turbidity are 81.5%, 79%, 78%, 80%, 74%, and 80%, respectively.

When compared to jute fibre, banana fibre exhibits a better removal efficiency. This is so that contaminants may be absorbed more effectively and have a larger surface area for microbial development due to the higher surface area and porosity of banana fibres.

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COMPARATIVE ANALYSIS OF OUTRIGGERS FOR RC BUILDING UNDER THE EFFECT OF WIND LOADS USING ETABS

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ABSTRACT

Over the past few decades, the number of tall structures has increased due to rapid growth in population, land scarcity, advancements in building materials & construction technology and structural systems. As a building's height rises, stability becomes an important factor. Tall structures are vulnerable to lateral loads such as earthquakes and wind loads and they must withstand these along with the gravity loads. In the design of tall structures, structural lateral systems such as shear frames, moment frames, braced frames, framed tube, super frames, and many others play an important role in increasing the stability of the structure. In recent times, Outrigger systems are gaining a lot of importance as lateral resisting systems as it increases the stability and strength of the structure. This mini-project is mainly consisting of a comparative study of the overall behavior of Virtual Outrigger and Conventional Outrigger systems for a tall building under the effect of wind loads using ETABS19 software.

KEYWORDS *: Tall building, Conventional outrigger, Virtual Outrigger, Base shear.*

1. INTRODUCTION

Tall buildings have fascinated mankind since the beginning of civilization. In today's modern era, cities are growing faster and availability of land is decreasing. Multistory structures are the most popular and effective way to handle these issues. The development of high-strength concrete, higher-grade steel and some new building methods has led to the development of new generation of tall structures.

Loading differs from tall buildings to low-rise buildings. Tall buildings are sensitive to lateral forces – wind and seismic forces along with the gravity loads. Tall building should have adequate strength & stiffness to withstand lateral loads. It is necessary to design the structure optimally for lateral forces, moments, story drift and deflection.

Over a period, structural engineers have developed various types of lateral resisting systems. One such is Bracing system; major drawback is, it becomes expensive as buildings exceed 30 floors. Therefore, in

order to overcome this problem, Outrigger system was introduced. Outriggers are lateral resisting systems, that can effectively minimize the lateral loads and strengthen the tall buildings. Here, the external and internal structures couple as whole to resist the lateral loads. Based on connectivity outriggers are classified as – Conventional Outrigger and Virtual Outrigger. In Conventional Outrigger system, the outriggers are directly connected from core to the columns located at the periphery of the structure. In Virtual Outrigger system, there is no direct connection between the core and the peripheral column. Using Outriggers reduced upto 50% displacement in both X & Y directions[4].

According to the studies, the belt truss & outrigger system are the most accepted method for withstanding the lateral loads as it increases the stability of the structure compared to traditional methods[2]. Virtual Outrigger system were compared with other lateral resisting systems and it was found to be a solution to the needs of structural stability, commercial utility, and economic viability of a building[3]. Virtual outrigger provided the best performance, increases the stiffness to structure and is the most effective systems against lateral loading than Conventional outrigger[4]. Using steel outrigger, overall performance increased effectively compared to concrete outrigger[5].

Based upon the literature survey, the Outrigger systems are gaining importance in tall building construction. Several research works have been carried out by various researchers around the world on different types of outriggers. Though according to finite element analysis, the Virtual Outrigger system is more effective than others, it lacks sufficient research. Tall buildings are sensitive to wind; hence the assessment of wind force and its effect should be considered while designing tall buildings. Since very few researches have been conducted on dynamic wind analysis of outrigger systems, this project mainly focuses on comparing the performance of Virtual and Conventional Outriggers under the effect of wind loads using ETABS19 software.

MODELLING AND ANALYSIS

Modelling

Tall building of 40 story having 28m x 28m plan dimension with each story height of 3.5m with core shear wall is considered. A typical design is having seven bays in X heading with equivalent spacing of 4m and seven bays in Y hearing with equivalent spacing of 4m (Referring to Table 1). Determining the behaviour of RC building by providing different types of Outrigger systems i.e, Conventional Outrigger as shown in Figure 1 & Virtual Outrigger as shown in Figure 2, using ETABS software.

Table 1: Properties used for modelling RC building in ETABS

Building Details	
Plan	28m x 28m
Floor to floor height	3.5m
Number of storeys	40
Total height of the building	140m
Materials used	
Compressive strength of Concrete (f_{ck})	40 N/mm^2
Tensile strength of steel (f_y)	550 N/mm^2 (Longitudinal bars)
	415 N/mm^2 (Confinement bars)
Sections used	
Beams	300mm x 600 mm
Columns	550mm x 800mm
	500mm x 700mm
	400mm x 600mm
Slabs	150mm thick
Core wall	250mm thick
Bracing	V bracing – ISWB 600

3. ANALYSIS

For the proposed building, different types of loads have been considered as per IS codes and Dynamic wind analysis have been conducted using the data mentioned in Table 2,3 & 4.

Table 2: Details of loads

Self-weight	Calculated by ETABS
Floor finish	1 kN/m^2
Live load	3 kN/m^2

Table 3: Details of Static Wind Analysis

Wind speed, V_b (m/s)	47 m/s
Terrain category	4
Risk Co-efficient (K_1)	1
Topography factor (K_3)	1

Importance factor (K_4)	1
X direction	Windward Co-efficient, C_P = 0.8
	Leeward Co-efficient, C_P = 0.25
Y direction	Windward Co-efficient, C_P = 0.8
	Leeward Co-efficient, C_P = 0.8

Table 4: Details of Dynamic Wind Analysis

Basic wind speed, V_b	47 m/s
Lateral dimension	a = 28 m
	b = 28 m
Height of the building from mean ground level (z,h)	140 m
Terrain category of the building	Terrain category 4
Interference Factor for Zone 2	1.25
Equivalent aerodynamic roughness factor, $Z_{0.4}$	2
Risk Co-efficient (K_1)	1
Topography factor (K_3)	1
Importance factor (K_4)	1
Hourly mean wind speed factor ($K_{2,i}$)	0.63
Design hourly mean wind speed, $V_{z,d}$: V_b x K_1 x K_2,I x K_3 x K_4	29.84 m/s
Wind directionality factor, (K_d)	0.9
Area averaging factor (K_a)	0.8
Combination factor (K_c)	0.9
Wind pressure, p_z	0.6 V_z^2
Design wind pressure, p_d	p_z K_d K_a K_c

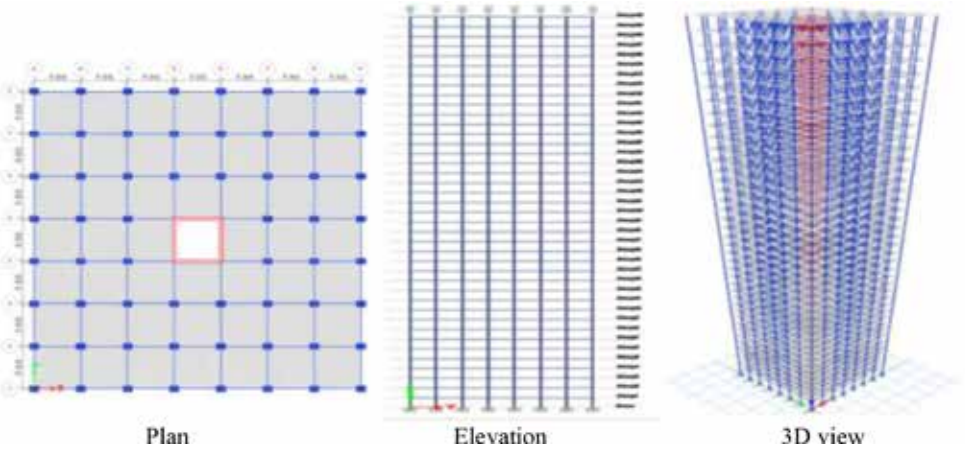


Fig.1 Typical floor plan, elevation & 3D view of Conventional Outrigger

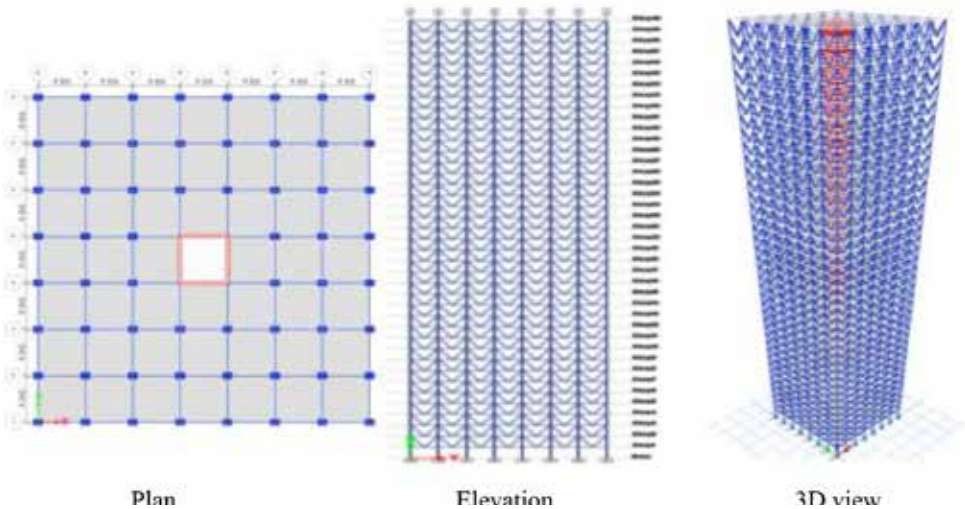


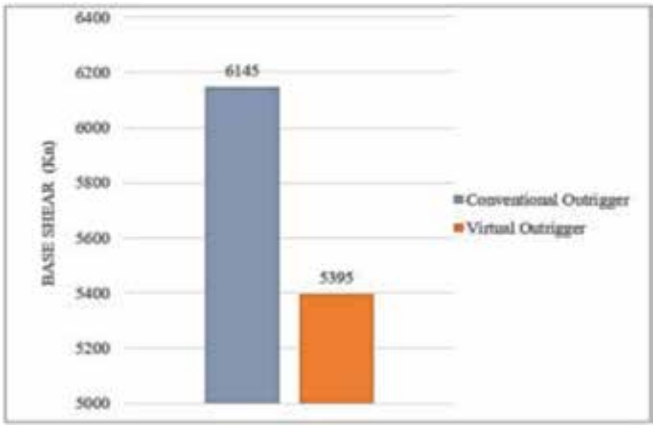
Fig 2. Typical floor plan, elevation & 3D view of Virtual Outrigger

4. RESULTS AND DISCUSSION

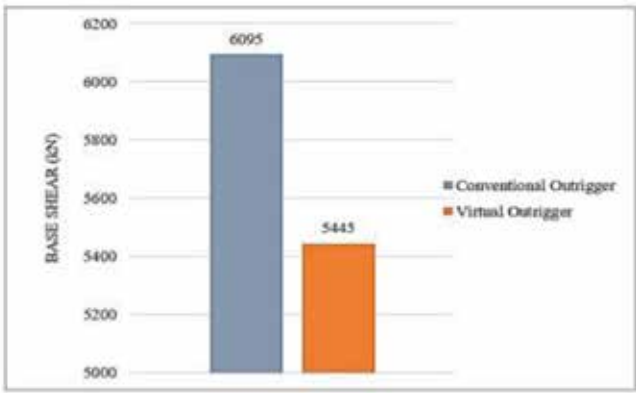
After conducting dynamic wind analysis for RC building using ETABS 19 software, following results were obtained and are compared based upon base shear, maximum story displacement and maximum story drift.

A. BASE SHEAR

MODEL TYPES	BASE SHEAR X - DIRECTION (KN)	BASE SHEAR Y- DIRECTION (KN)
Conventional Outrigger	6145	6095
Virtual Outrigger	5395	5445



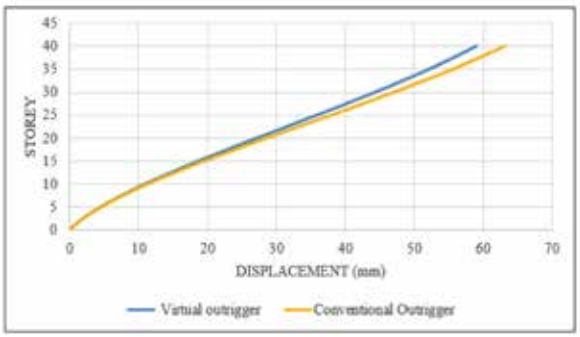
Graph 1. Base shear in X- direction (kN)



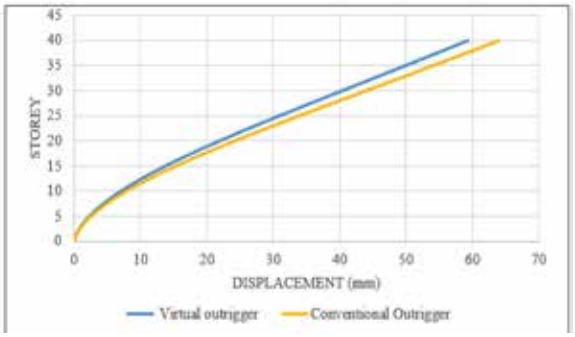
Graph 2. Base shear in Y- direction (kN)

As observed from the above result graphs 1 & 2, Conventional outrigger shows the maximum value compared to Virtual outrigger systems in both X and Y direction. Implementation of Virtual outrigger system, reduced base shear by 12 % in X-directionand 10.5% in Y direction.

B. MAXIMUM STORY DISPLACEMENT



Graph 3. Displacement due to wind gust in X-direction

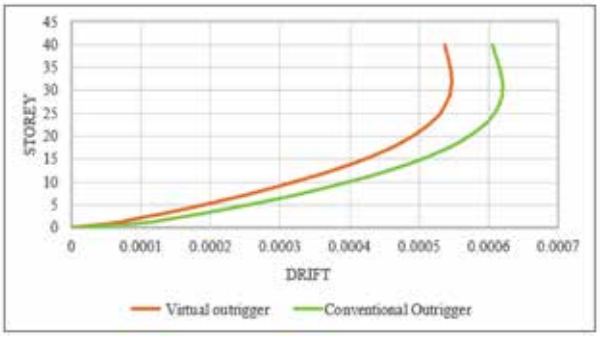


Graph 4. Displacement due to wind gust in Y-direction

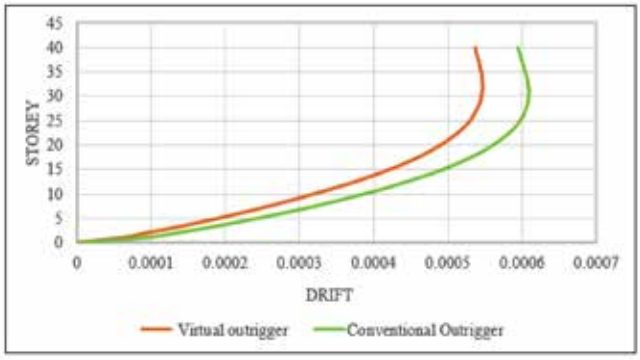
From the graphs 3 & 4, Conventional outrigger system has higher lateral displacement compare to Virtual outrigger system. This may lead to increase of shear reinforcement in columns. Virtual outrigger system was efficient in reducing the story displacement about 10% in both X & Y direction.

C. MAXIMUM STORY DRIFT

Virtual outrigger system shows less story drift compare to Conventional outrigger system as shown in graph 5 & 6. There is slight difference between values in X and Y direction. Virtual outrigger system was efficient in reducing the story drift by 15% in both X & Y direction.



Graph 5. Drift due to wind gust in X-direction



Graph 6. Drift due to wind gust in Y-direction

5. CONCLUSION

The present study is about the overall behaviour of outrigger system for regular RC building under the Dynamic wind analysis using ETABS19 software. The results obtained from the analysis of Conventional Outrigger and Virtual Outrigger were compared based upon maximum base shear, story drift and story deflection in both X and Y direction and following conclusions were made.

1. In case of base shear, Virtual outrigger reduced base shear about 12% in X-direction and 10.5% in Y direction.
2. Virtual Outrigger was effective in reducing the displacement by 10%. While analysing displacement result both the outrigger systems were under limited values as per IS code provisions.
3. Virtual outrigger was not only capable of controlling the story displacement but also reduced the drift by 15% both in X & Y direction.

From all the above points, though there wasn't a huge difference between two outrigger systems, yet implementation of Virtual outrigger system would be advantageous over Conventional outrigger, as it helps to overcome all the constraints. Thus, introduction of Virtual outrigger is no doubt a very efficient and reliable outrigger system.

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UTILIZATION OF FIBERS IN ASPHALT CONCRETE – A REVIEW

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ABSTRACT

Asphalt concrete is a complex material consisting of aggregate, asphalt, filler, and voids. It has been conventionally used for flexible pavement construction in the world because of its satisfactory performance. But pavement defects such as rutting, cracking, and potholes due to moisture had plagued the designers and researchers all the way. To upgrade pavement service quality, many modifiers were included in asphalt concrete. In the group of modifiers, the fiber-reinforced method has got more advantages. Types fibers used in asphalt concrete are steel fibers, polypropylene fibers, coir fibers, carbon fiber, etc., overall, this review paper can provide references and insights for researchers and engineers on the effects of fiber in asphalt concrete.

KEYWORDS *: Asphalt concrete, Fibers, Performance*

1. INTRODUCTION

A pavement structure can be constructed either as a flexible and rigid pavement according to structural behavior, but flexible pavement is generally preferred in India as it has more advantages over rigid pavement and economy. These pavements are layered structures with the following elements such as soil subgrade, base course, and surface course. Three main factors affecting asphalt concrete mixtures durability are water damage, thermal cracking, and aging. Due to increase in vehicles on the road and variation in climatic condition can cause damage to the pavement. There are other reasons too, like quality of the materials during construction and maintenance used. In some places, the temperature can change a lot and this also causes problems for the road. Over time, the road can get damaged and this causes serious problems like cracks and damage from moisture. Asphalt roads can work better if they add special ingredients to the mixture, like plastic and tiny threads. This makes the pavement structure stronger and more durable. This paper talks about adding different fibers to asphalt to enhance the performance. Moreover, talking about how using fiber-reinforced asphalt can make roads stronger and last longer by preventing them from getting damaged easily.

1.1 Essentialness of Bitumen Reinforcement

Bituminous concrete (BC) is a combination of bitumen and aggregates and is a susceptible material compared with to other materials utilized in civil engineering. The presence of moisture underneath the pavement causes the subgrade soil to become soft and reduces the strength of the base materials, leading to the deterioration of the pavement's structural integrity. Additionally, the amount of traffic contributes to wear and tear on the road, it attributing daily wear and tear to factors such as tire

marks and cracks in the pavement. Hence, researchers and experts are continually attempting to enhance the performance of asphalt roads. Improvement of the pavement performance can be achieved by refining the asphalt binder through various techniques.

1.2 The History of Fibers in bituminous Pavement

Hongou and Philips believed that the idea of using fibers to improve the behavior of materials is an old suggestion. People have been using fibers for a longer period to build structures like the arches which are located in China and are 4000 years old, which was made with a mix of fibers and clay. The Great Wall, which was built 2000 years ago, also used fibers. [1]

1.3 Mechanical impact of fibers in asphalt mixtures

The European Asphalt Pavement Association reports that Europe and the US manufactured 265.4 and 319 million tons of bituminous mixtures with fibers, respectively, in 2014 [2]. The statement mentioned in report has sparked a desire to enhance the effectiveness of bituminous mixtures, specifically in terms of their mechanical attributes and practicality when used on roads. The reinforcement of composite materials like asphalt mixtures is being looked into by incorporating fibers. With regard to blending techniques, established methods exist for creating asphalt mixtures using traditional bitumen. Despite the incorporation of new materials such as fibers, there is a shortage of guidelines on the appropriate procedures for producing asphalt mixtures using fibers [3]. There are two commonly recognized procedures. The initial approach is labeled as the wet process. Firstly, the fibers are combined with the binder ahead of the addition of aggregates and fillers utilizing this technique. The dry approach, also referred to as the second method, involves blending fibers and aggregates prior to the addition of bitumen to the mixture [4]. Typically, the dry method is preferred due to its ability to effectively disperse fibers and minimize the variability observed in experimental evaluations of asphalt mixtures [5, 6] During the production process of asphalt plants, a variety of additives, such as fibers, are often incorporated using specialized mechanisms. To prevent the clustering of fiber bundles in the mixture, certain plants may decide to extend the mixing time and keep the fibers dry. Moreover, in case the prescribed measures are not followed by asphalt plants, fibers can be added to the mixture manually as an alternative method [7].

In a recent study, the impact of fiber-altered asphalt containing rock wool, asbestos, cellulose, and glass wool fibers was investigated by Serfass and Samanos [8]. Several tests were administered, such as fatigue resistance, rutting resistance, low-temperature direct tension, and resilient modulus. In the city of Nantes, France, a series of experiments were conducted on a testing course. The initial findings demonstrated that mixtures altered with fiber had the greatest percentage of gaps, despite a 13 metricton axle load of 1.1 million times, outperforming unaltered asphalt and two other mixtures modified with elastomers. The authors concluded that the tested porous mixtures exhibit improved drainage, which ultimately results in reduced susceptibility to moisture-related damage. Another research utilized a fracture mechanics methodology to investigate how fiber reinforcement influenced crack resistance. Thus, according to the work of Jenq et al. Polyester and Polypropylene fibers were applied to enhance mixtures and subsequently assessed for elasticity, energy to fracture, and resistance to tension. The toughness of modified samples improved by 50-100% due to the increased fracture energy caused by the fibers, but there was no significant impact on elasticity and tensile strength results [9].

2. TYPES OF FIBERS IN ASPHALT CONCRETE

Coir Fibre: Coir fiber, derived from the tough outer husks of coconuts, is utilized in a variety of items including doormats, floor mats, mattresses, and brushes. Due to their affordability, eco-friendliness, and lightweight nature, the use of natural fibers is an advantageous alternative to synthetic fibers. Currently, coir fiber is gaining increased recognition as a natural fiber because of its accessibility, exceptional resistance to wear and tear, and superior durability. Coir is available in two different types, namely brown and white. The ideal material to be used in our experiment should meet certain standards, such as being made from mature coconuts and having a high level of strength and resistance to abrasion. Brown coir fits these requirements and is therefore the preferred option. coir fibers requirements for asphalt concrete is list listed in the Table 1.

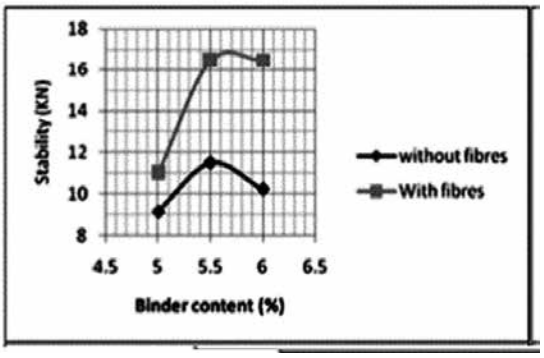
Table 1. Properties of coir fiber [10]

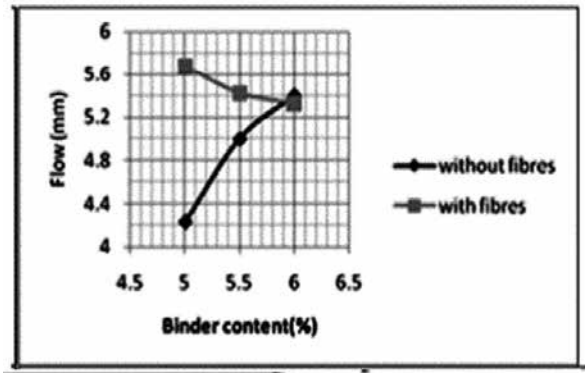
Property	Value
Diameter (mm)	0.1-0.4

Density (g/cm^3)	0.67-10.0
Natural moisture content (%)	11.44-15.85
Water absorption (%)	85-135
Tensile strength (MPa)	108.26-251.90
Modulus of elasticity (GPa)	2.5-4.5
Strain at failure (%)	13.7-41.0

Fig 1. Coir fiber

The incorporation of coir fibers into bituminous mixtures results in benefits, including an improvement in stability and air void content, as well as a reduction in flow value as shown in Fig. 2. The capability of bituminous concrete to enhance the resilience of flexible road pavement against damages caused by traffic loads arises from the diversity in stability and flow values [8]. The study concludes that the introduction of coir enhances the stability and voids but diminishes the flow value. Excellent stability and volumetric characteristics can be attained by using fibers that are 15mm long, with a fiber concentration of 0.52 percent and a binder concentration of 5.72 percent. The presence of coir fiber has been noticed to enhance the compressibility of the mixture. By adding this ingredient, the combination becomes stronger and able to withstand the pressure caused by wheels in motion.





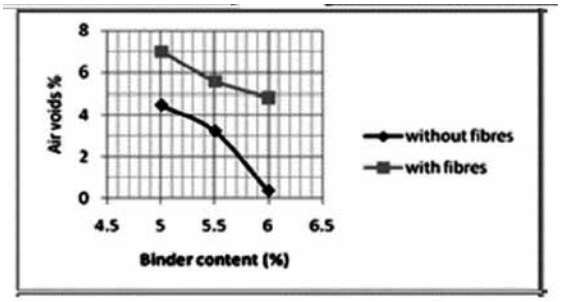


Fig 2. Comparison of BC and CFRBC properties [11]

Polypropylene Fiber: Polypropylene is the synthetic polymer that has the lowest density. Polypropylene has the highest fiber count per unit weight. This material boasts 52% less weight than polyester and a 26% weight reduction compared to nylon and acrylic. Polypropylene fibers are an excellent choice for reinforcement, for this reason. Furthermore, polypropylene fibers exhibit exceptional durability towards alkali and chemicals as well as chloride, and they possess a low level of thermal conductivity. Concrete is commonly strengthened with the usage of Polypropylene fibers. The concrete gains structural reinforcement from the polypropylene fibers in a three-dimensional manner. As a result, concrete gains enhanced strength and prolonged existence [12,13]. In the US, the utilization of polypropylene fibers as a modifier within asphalt concrete was also witnessed. The Ohio State Department of Transportation (ODOT) has released a guideline for incorporating polypropylene fibers into top-quality asphalt concrete [14]. The properties of polypropylene fiber are given in the Table 2.

Table 2: Properties of Polypropylene Fiber as specified by the Ohio Department of Transportation [14]

Characteristic	Value	Standard
Denier, grams per denier	4±1	ASTM D-1577
Length, mm	10±2	--

Tensile strength (minimum), MPa	276	ASTM D-638
Specific gravity, kg/m^3	910±4	ASTM D-792
Melting temperature, ^oC	160	--

Fig 3. Polypropylene Fiber

The ideal bitumen content was 5.5%, according to S. Tapkn et al. Since it is anticipated that the OBC for specimens with polypropylene fibers would be lower when the fatigue life of the specimen is expected to be longer, the production cost is decreased. It was established by the author's experiments and related research [15,16] that the ideal bitumen content could be lowered to 4%. According to this, bitumen is being saved by about 27%. The amount of polypropylene used in various experiments ranged from 0.3% to 1%, and depending on the volume of traffic, this ratio can be further adjusted to achieve the desired performance level. When this fiber is compared to natural filler bitumen it shows elastoplastic and adhesive behaviors.[15]. Tapkin S concluded that added 1% of polypropylene fibers increases the life of fatigue by 27%.

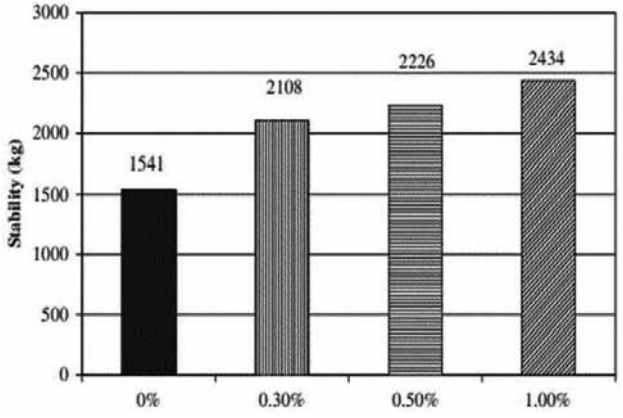


Fig 4a

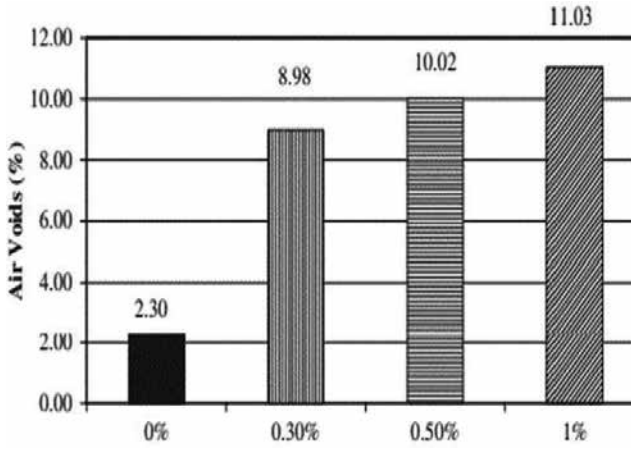


Fig 4b

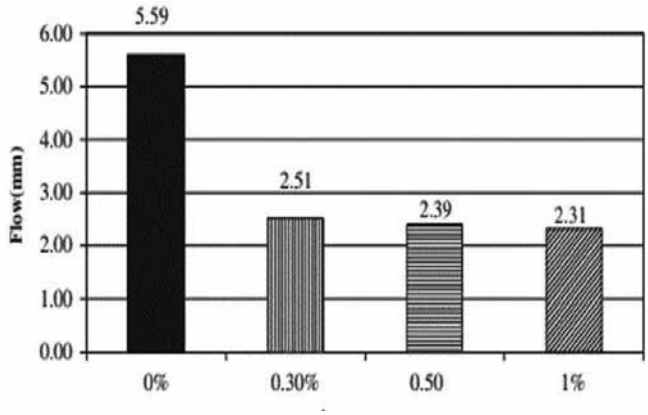


Fig 4c

Figure 4: Effect of polypropylene fibers on Marshall test properties

Steel fibers: Steel fibers are the most common in the building sector. The wire was split or cut into the necessary lengths. The primary fibers had rounded, incredibly smooth forms.[16]. Modern steel fibers are currently produced from drawn steel wire, cut sheet steel, or the melt extraction process, which produces fibers with a crescent-shaped section and are now utilized commercially [17]. Steel fibers are divided into two categories, regular carbon steel fiber, and stainless-steel fiber, depending on the material quality; normal carbon steel fiber makes up the majority. Steel fiber is categorized into five different shapes including long straight, corrugated, hook-shaped (shown in figure 3), head-shaped, and twisted styles. Steel fiber is categorized into cutting style, shearing style, milling style, and melt extraction based on the configuration of the section.

Table 3: Properties of steel fiber [18]

Length (mm)	Max. diameter (mm)	Slenderness ratio	Specific gravity	Modulus of elasticity (GPa)	Tensile strength (MPa)
60±%5	0.75±%5	80	7.8	200	2000

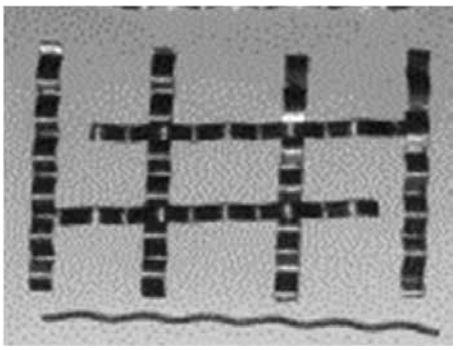
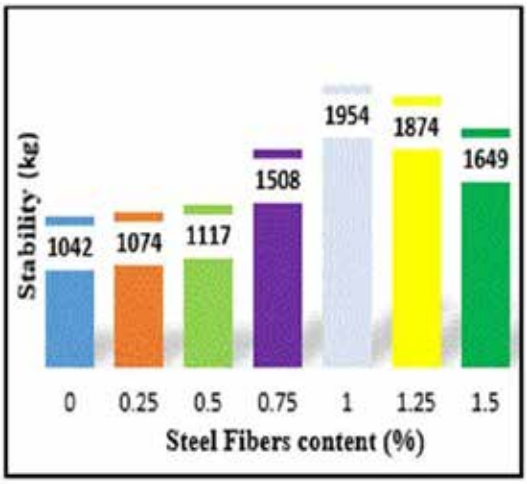
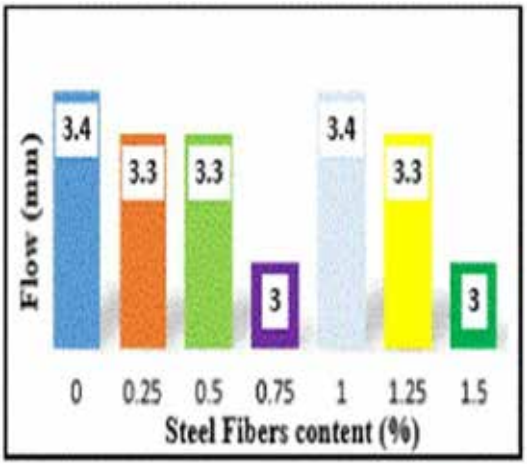


Fig 4: Steel Fiber [15]

Mohamed Fahmy et al, got results of steel fibers increased Marshall stability by about 87.52% at 1% steel fiber content which is considered the best performance stability among modified mixtures with steel fibers is shown Fig. 5. The addition of steel fibers decreased the Marshall flow compared to the control mixture by reason of clustering except at 1% steel fiber content which provided a flow value as same as the control mixture. This flow value that reached (3.4mm) was matched with the required specifications ranges and indicated the high flexibility of Hot Mix Asphalt (HMA) pavement to deform without cracking, and they have achieved the maximum value at 1% steel fiber content by raising the ratio by about 54.2 % in comparison to control mixtures, indicating that the inclusion of steel fibers had a significant impact on improving the indirect tensile strength.





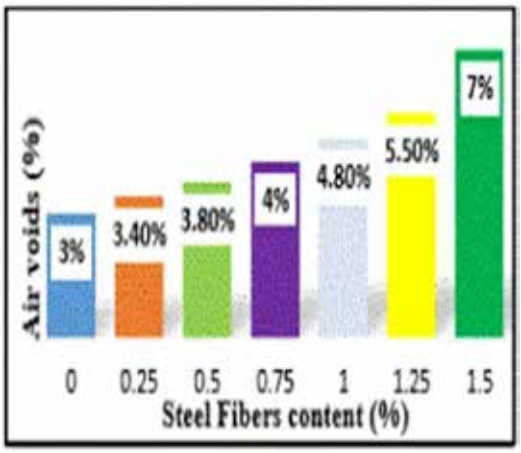


Fig 6. Effect of Steel Fibers on Marshall Properties [16]

Steel fibers were used in varied amounts (2 %t, 2.5 %, 3 %, 4 %, and 5 %) with 11 mm and 18 mm lengths, as illustrated by Aniruddh and Parveen Berwal (2016) [19]. The results indicated that bituminous concrete's durability significantly improved with 3.5 % steel fiber content with 11mm length. An improvement in the low temperature and fatigue performance of the asphalt mixture was reported. Through single steel fiber pullout tests, According to Park et al. (2017), [20] results show that steel fiber can enhance the toughness and tensile strength of bituminous concrete.

Carbon fiber: Carbon fibers has more benefit than other fiber types for the refinement of asphalt binder. Because the fibers are consist of carbon and asphalt

is a hydrocarbon, they are considered to be basically compatible. Due to the high mixing temperature (over 1000 o C) used in the production of carbon fibers, fiber melting is not significant problem. The tensile strength and other properties of the AC mixture, such as resistance to thermal cracking, should increase due to the high strength of the carbon fiber. When carbon fiber is added to a mixture, the stiffening effect that has been demonstrated by the addition of other fibers should also take place, extending the fatigue life of pavements. Since carbon fibers are the most compatible and effective fiber type for the modification of asphalt binder, it was hypothesized that they would be the best choice. Either polyacrylonitrile (PAN) or pitch precursors are used to create the carbon fibers.[21]

Carbon fiber leads to uniform outcomes and noticed that adding fiber does bear on the attributes of asphalt mixtures, especially a growth in its stability and the reductions in the sail worth along with an enhancement in voids in the mixture. The outcomes indicated that fibers have the potential to abstain structural trouble in the pavement, in the event of developing traffic loads, and therefore enhance exhaustion by expanding opposition to cracks or enduring deformation. Therefore, it comes to the conclusion that the results of adding carbon fiber to the asphalt combination will improve several of the mechanical aspects of the mixture like exhaustion and deformation in the bendy pavement [22]. Typical properties of carbon fibers are listed in Table 4.

Table 4. Typical properties of chopped carbon fibers [23]

Typical Properties	Unit	Value
Carbon fiber content	%	>98
Fiber diameter	μM	7
Fiber unit weight	Kg/m^3	1700
Fiber length	Mm	12
Metal contamination	-	<0.1g/1000g
Tensile strength	MPa	4150
Tensile modulus	GPa	230

The addition of fiber in bituminous mixtures increases stability and voids and decreases the flow value observed by Faten I Mussa et al, [23] as such, it can be said that carbon fiber has the capability to improve structural resistance to distress be present in road pavement due to traffic loads. Comparison to the control mixture, the fiber content of 1.5% by weight of the total mix resulted in the extreme performance with regard to stability; although, certain mechanical attributes of the combine mix could be compromised when the fiber content exceeds the 1.5% level as shown in fig. 6. Therefore, which affects the performance of carbon fiber-modified bituminous mixture due to length of the fiber and it must be ensured that individual fibers keep their linear configuration intact after the mixing process. To achieve these improvements, care must be taken to ensure that the fibers are evenly distributed throughout the mix.

Fig 7: Carbon fibers

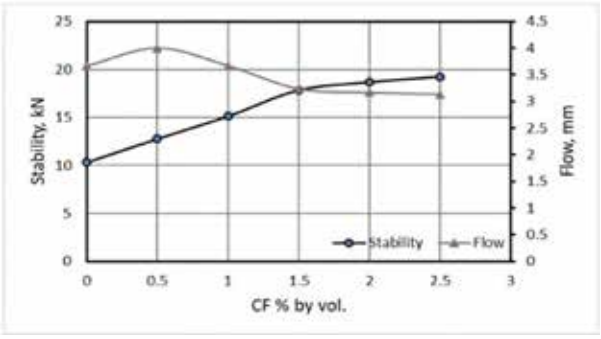


Fig 8. Marshall stability and flow values with carbon fibers (CF) [23]

3. CONCLUSION

This paper investigated the advantages of using random-inclusion fibers in flexible pavements as fiber reinforced bituminous-concrete (FRBC) materials.

- Utilization of fiber has strongly improved the performance of asphalt mixture such as rutting and fatigue cracking as per discussed in respective fiber type in this paper.
- Irrespective of types, the addition of fibers to the asphalt is promising option for enhancement of stability by reducing the flow value of the mix. Also the fiber asphalt mix provides an improvement in fatigue life of the pavement and potential to improves the structural resistance distress occurring in flexible pavement due to traffic and climatic.

- Many factors will govern the mechanical property of the fiber reinforced asphalt concrete among that fiber length is very important one.
- Natural fibers are environmentally friendly and economically viable because the natural fibers do not require manufacturing process and it can substitute for synthetic fibers.

As future research, the study of method for dispersing the fiber in bituminous mix should be done carefully to obtain a homogenous distribution within mix because different fiber has its respective properties and the mixing process depends on its properties. Also the study on combination of the different fibers in asphalt concrete need to studied properly.

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COMPARATIVE STUDY OF BEHAVIOUR OF U-BOOT SLAB AND CONVENTIONAL SLAB

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ABSTRACT

In this modern age of different type of structure are been observed which are more efficiency that the structures been made in past. In our project we have been specifically focused on design and constructions of slab in R.R.C buildings and bridges eliminating the traditional method of slab construction by using hallow blocks and making a voided slab which has many advantages over the regular span and is more efficient too. The purpose of the study is to analyse the voided slab by using U-boot slab and preparing report mentioning how efficient the voided slab can over and regular slab. Structure calculation and their outcomes are calculated in this paper comparing the traditional and u boot technology system

KEYWORDS *: U boot technology, Workability, Compression strength, split tensile strength, crack pattern and width.*

INTRODUCTION

The need for huge space structures has grown recently. The slabs in such buildings must be constructed with a somewhat large thickness to achieve the deflection criteria. The building, as well as the slabs, adds to this weight. Due to the requirement for massive supports (columns and footing), more building materials are used, which increases its cost of construction. A type of reinforced concrete slab called a "voided slab," also known as a "biaxial slab," uses air-filled gaps to reduce the amount of concrete required. The slab is one of the largest parts that consumes concrete and is a crucial structural component in the construction of a building. The void forms in the voided slab have shapes like spherical, donut, and cuboid. These voids make construction more affordable and less harmful to the environment. Voided slabs mainly deal with the concept of reducing concrete in the tension zone. This system which is having lighter slab than conventional solid slab is one of its main advantages. Voided slab can be created by using polypropylene which is a thermoplastic polymer. Polypropylene (PP) is also known as polypropene, is a thermoplastic polymer used in wide variety of applications. polypropylene belongs to a group of polyolefins and is partially crystalline and non-polar.

Bubble deck slab

A novel technology known as the bubble deck system was developed by Jorgan Breuning in Denmark in the middle of the 1990s to guarantee the elimination of unwanted weight by greater than 30% and to permit larger spans between supports. The formation of the Bubble Deck is a newly invented method that directly connects steel and air to produce a cell structure that behaves like a solid slab. For the first time, a bubble

deck has the same strength as a solid slab but is much lighter because extra concrete has been removed. With this approach, an organic cell structure that behaves like a solid slab is created by locking an ellipsoid between the top and bottom reinforcement meshes. Bubbles are made of recycled plastic which act as void formers allows good space between columns. The construction literally creates itself because of geometry of two well-known components, reinforcement, and hollow plastic balls, when the top and bottom reinforcement are linked in the usual way, a geometrical and statically bubble deck unit is evolved

LITERATURE REVIEW

Hussain A et.al (2021) [1] The main objective of this research was to experimentally compare bubble slabs with solid slabs when subjected to a finite number of repetitive four-point stresses. Six slab strips were produced in the same manner, apart from the cross-section type. Three were solid, while the other three were rendered invalid by the insertion of 70 mm-diameter balls. The ratio of the shear span to the effective depth (a/d) was also investigated. One slab of each type was therefore tested, with the a/d being either 2, 3.5, or 5. The applied loads were carried out ten times at a load of 25 kN, which is approximately 70% of the ultimate load as determined by the ACI-19 code. Thereafter, the applied loads continued gradually until the slabs collapsed. The findings showed that the presence of the balls caused the slabs to fail. Regardless of the a/d, the data showed that the presence of the balls caused slabs to collapse suddenly due to shear mode. The strength, stiffness, and toughness of the same type of slabs decreased as the a/d increased, whereas the ductility showed the reverse tendency. The mechanical measurements of the bubble slabs, omitting the service stiffness, significantly decreased when compared to solid equivalents. However, the stiffness depreciation was minimal less than 15%. Additionally, a sustainability analysis was done, and it revealed that the voided slabs were more environmentally friendly than solid ones since they produced less CO_2 and used less embodied energy 14% and 10% less, respectively than solid slabs

Shoeb Khan and Taslim Khan. (2020) [2] These experimental studies show that the U-Boot technology can sustain massive structures without using beams. A farm tool made of recycled polypropylene is called a U-Boot beton. Work-related voids that were inserted between the slab's top and bottom reinforcements. It is used to make slabs that can carry heavy loads without the use of beams or with huge spans. U-boot is flame-resistant. It is a recycled polypropylene formwork used to build lighter rafts and slabs. U-boot systems can be used in conjunction with other prefabricated technologies and other construction methods, such as post-tensioned steel and prefabricated slabs. the use of steel that has been partially tensioned in a hollow slab. It lessens the slab's thickness and weight. There are advantages connected to reduction in the building weight small size pillars and foundation, there are low chance of seismic effect on the buildings. Due to the fact, that the structural behaviour of this new kind of monolithic flat slab is the same as for solid slab, excluding slab-edge column connection, this new technology can be taken into considerations with the solid slR. Sagadevan, B.N. Rao (2019) [5] Biaxial voided slab behaviour under one-way flexure was examined through experimental research. For this experiment, recycled polypropylene was used to create the sphere and cuboid void shapes. The one-way flexural capacity of the slab was tested using a four-point bending test to determine how the void and its shape affected it. The findings of the experiment were then obtained. The one-way flexural test aids in the investigation of the use of voided slab in place of traditional solid slab. Considerations for the structural behaviour of the voided slab specimens included load versus defection behaviour, crack pattern, and load-bearing capacity. For the purpose of designing a biaxial voided slab, it is verified that the provision of the current IS 456 code are applicable. Like the solid slab, the voided slabs exhibit typical flexure behaviour. The cracks were visible and dispersed throughout the longitudinal direction in pure bending. The maximum load that could be supported by specimens with sphere- and cuboid-shaped cavities was the same as for a solid slab. In both longitudinal and transverse orientations, the reinforcing behaviour was unaffected by the presence of void formers.

Bhay M. Pande et.al (2018) [3] The current research addresses the various structural characteristics of voided slabs and bubble deck slabs as well as their advantages over conventional concrete slabs in terms of structural performance. By nearly removing all the concrete from a floor slab's midsection, which serves no structural use, a bubble deck slab can significantly reduce structural dead mass. Hollow high density polyethylene spheres in place of the unproductive concrete in the slab's middle reduce dead mass and improve floor

performance. One of the effective slab systems that can lower the self-weight of slabs is known as biaxial hollow slab system. The addition of the gaps results in a slab that is 30 to 40% lighter, reducing the loads on the columns, walls, foundation, and of course the entire building. The reduction in self-weight, a Bubble Deck slab features two-dimensional patterns of voids inside the slab. The relationship between bubble diameter and slab thickness affects how Bubble Deck slabs behave.

K. Subramanian et.al (2017) [4] This paper involves the experimental analysis of spherically voided biaxial slabs. The intention was to eliminate the unused concrete in slab constructions. Three voided slab specimens of size 2900x2900x100 mm were cast. The voids were created by introducing spherical-shaped high-density poly propylene void formers in between the compression and tension layers of the slab. Spacing was kept as a varying parameter, the spacing of the void formers which were kept was 20, 30 and 50 mm. The slabs were subjected to area loading. Comparison of load–deflection behaviour was carried out and the conclusions was drawn. Prior to the concrete being poured, steel mesh was placed over the surface of the void formers, solving the holding issue. The cracks started appearing in all tested materials at roughly 9 tonnes of loading and extended outward along the slab's edge in a yield line pattern, signifying a ductile flexural failure. The load deflection behaviour of voided slab of 50mm spacing confirmed that spacing of voids provided at 50 mm and above would give stiffer solid slab. Due to ductility, voided slab of 20mm spacing underwent the maximum deflection, whereas voided slab of 30mm spacing showed an increment of about 9.7% compared to voided slab of 50 mm. this system can be applied to the seismic zone effectively due to reduction in self-weight and thereby the seismic force on the structures. In less thick (100 mm) slabs, spherical-shaped void formers were employed, and the most amount of concrete could be reduced. In comparison to Voided 50mm slab, 20mm and 30mm have increased load carrying capacities of 13.12 and 5.45 percent, respectively.

EXPERIMENTAL PROGRAMME

Materials

Concrete

Concrete used in the present experimental work is of grade M20. The materials used for the concrete mix is OPC 53 grade cement (ACC cement), 20 mm and downsize coarse aggregate, M-sand as fine aggregate and tap water for mixing. Materials were uniformly mixed using concrete mixer of capacity 80 kg.

Table 1. Concrete mix design quantity for one batch concrete mixer

Concrete mix grade	M20
Mix ratio	1:1.76:3.04
W/C ratio	0.55
Slump in mm	80
Cement	13kg
Fine aggregates	23kg
Coarse aggregates	39.3kg
water	7.15 litre

Plywood

Wooden plywood moulds are used as formwork for casting of slabs. All the moulds ae cleaned and oiled before concreting to make demoulding easy. Fresh tap water was used for 28 days curing

Steel

Steel used in the present experimental work is of grade Fe550 HYSD bars of diameter 8mm are employed as reinforcement for the present work.

Polypropylene balls

Fig.1. Polypropylene bubble

Table 2. Properties of polypropylene balls given manufacturer

Properties	Unit	Average value
Form		Solid. Granular
Colour		White. Off-White
Odour		Odorless
Specific Gravity		0.85-0.95
Solubility		Insoluble
Melting point	°c	140-170
Auto ignition temperature	°c	>410
Tensile strength at yield	Mpa	36
Elongation at yield	%	10
Flexural modulus	MPa	1650

Table 3. weight of polypropylene balls

Bubble	value	unit
38mmdiameter bubble	4.154	gms
50mm diameter bubble	7.880	gms

MIX DESIGN OF CONCRETE

M20 grade is designed as per IS: 10262-2009. Mix proportion obtained for this study was 1:1.756:3.021 Mix proportion of M20 grade concrete for 1 cubic meter is given in the Table 4.

Table 4. Mix proportion for M20 grade concrete for 1m3.

Particulars	Quantity
Cement	358.473 kg
Water	197.16 kg
Fine aggregate	629.504 kg
Coarse aggregate	1083.069 kg
Water cement ratio	0.55

WORKABILITY

Slump cone test on fresh concrete was conducted and result was tabulated.

Fig. 2. Slump cone test.

Table 5. Test results on fresh concrete

Sl.no.	Tests	Results
1	Slump test	80 mm

Test on strength

Compressive strength test, split tensile strength test and flexural strength test were performed for 7days, 14days and 28 days on cube, cylinder and Prism specimens respectively. The results of these tests are presented below:

Table 6. Strength tests performed on concrete grade M20.

Sl.no.	Tests	No. of days	Results (N/mm^2)
1	Compressive strength	7	13.51
2		14	21.36
3		28	25.23
1	Split tensile strength	7	1.24
2		14	1.94
3		28	2.28
1	Flexural strength	7	2.63
2		14	3.5
3		28	3.94s

Fig. 3. Compression test, split tensile test, and flexural test

Experimental setup

Experimental procedure followed

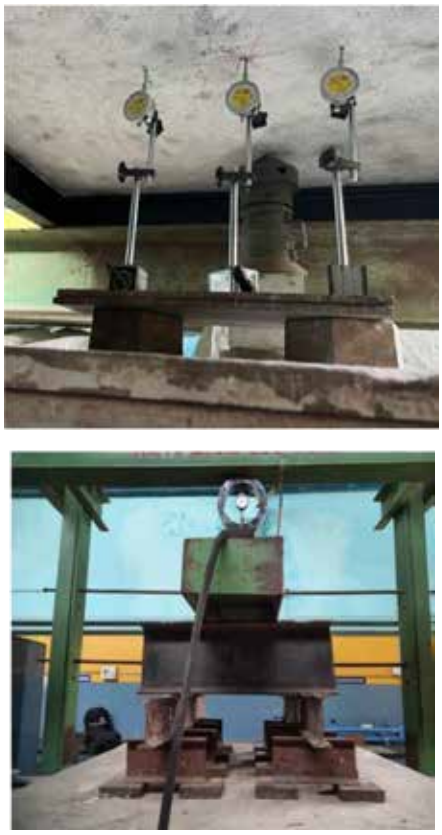


Fig 4. Experimental setup for testing in laboratory

- For testing of slabs, loading frame of 25Tonne capacity was used.
- Effective size of slab is 1.3 x 1.3 m and is simply supported on all four sides.
- Hydraulic jack of 50 Tonne capacity was used for loading the slabs.
- Applied load and deflection was measured by using installed proving ring and Dial gauges respectively.
- Three dial gauges were installed at the bottom centre of the column as shown in the fig.4.
- First crack loading was noted down simultaneously along with marking of cracks on the slab during loading.
- The three dial gauges were removed at the point of loading when the deflection was reached maximum in the dial gauges, for the purpose of safety then the loading was continued until the ultimate load is reached.

First crack load

Load analysis

Table 7. First crack load analysis data

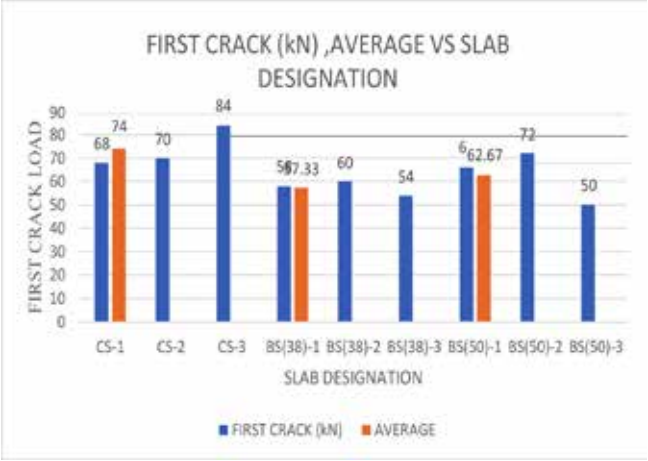
SLAB DESIGNATION	FIRST CRACK (kN)	AVERAGE
CS-1	68	
CS-2	70	74
CS-3	84	
BS (38)-1	58	
BS (38)-2	60	57.33
BS (38)-3	54	
BS (50)-1	66	
BS (50)-2	72	62.67
BS (50)-3	50	

The average first crack for control slabs was obtained at 74 kN load.

In the bubble slab, slab having a bubble diameter 38 mm the average first crack was obtained at 57.3 kN which was a much earlier propagated crack when compared to the conventional slab.

In a bubble slab bearing a bubble diameter of 50 mm, the average first crack was found at 62.67 kN which is higher to a bubble slab with a diameter of 38 mm, but the first crack appeared 11.33 kN sooner than it would have on a regular slab.

The preceding test results clearly demonstrate that neither the bubble deck slabs of 38 mm nor 50 mm diameter bubble have much of an impact on appearance of the first crack. The graph below shows a comparison of first cracks, their average, and slab designation.



Comparison of first crack load vs slab designation

Ultimate load

Ultimate load is the maximum load that a specimen can withstand. The table below shows the ultimate load for slab designation.

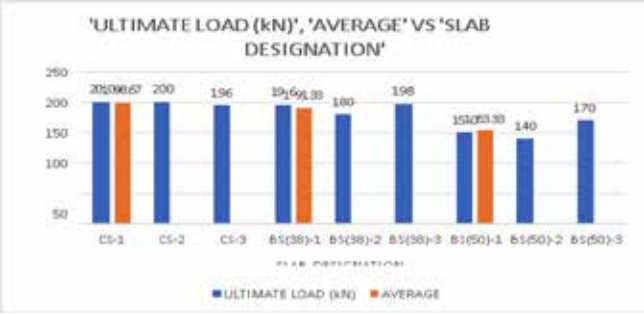
Table 7. Ultimate load analysis data

SLAB DESIGNATION	ULTIMATE LOAD (kN)	AVERAGE
CS-1	200	198.66
CS-2	200	
CS-3	196	
BS (38)-1	196	191.33
BS (38)-2	180	
BS (38)-3	198	
BS (50)-1	150	153.33
BS (50)-2	140	
BS (50)-3	170	

The average ultimate load taken by conventional slab was obtained as 198.66 kN.

- In the slab with bubble diameter of 38mm the ultimate load carrying capacity was
- 191.33 kN, which, is larger than 50 mm diameter slab and nearly equal to standard slab.
- In slab with bubble diameter of 50 mm the average ultimate load carrying capacity was 153.33 kN, which is a prominent decrease from both the conventional slab and the bubble slab of 38 mm.

As an outcome, test results show that the conventional slab can be replaced with a voided slab, but replacing the slab with a bubble of smaller diameter yields outcomes equal to conventional slab, for the slab's ultimate load carrying capacity when compared to a bubble with a larger diameter. However, since both bubble diameters were chosen to be below the neutral axis, using a smaller diameter bubble yields better results. The ultimate load, their average, and slab designation are shown in the accompanying graph.



Comparison of ultimate load vs slab designation

Deflection analysis

The deflection of the slab obtained along with their corresponding load for various slab designation are mentioned in the table below.

Table 8. Deflection analysis data

SLAB DESIGNATION	LOAD (kN)	DEFLECTION (mm)	AVERAGE LOAD (kN)	AVERAGE DEFLECTION (mm)
CS-1	176	20.3	171.33	18.5
CS-2	176	17.2		
CS-3	162	18		
BS (38)-1	180	16.2	173.33	16.73
BS (38)-2	178	17.8		
BS (38)-3	162	16.2		
BS (50)-1	118	11	124	11.63
BS (50)-2	106	11.9		
BS (50)-3	148	12		

- The average of three control specimens shows a deflection of up to 18.5 mm for average ultimate load being 171.3 kN.
- The bubble slab of 38 mm diameter bubbles exhibited average deflection of 16.73mm for 3 specimens casted and for an average ultimate load of 173.3 kN.

The bubble slab of 50 mm diameter bubble exhibited average deflection 11.63 mm for average ultimate load being 124 kN. It is conclusive from the results that the 38 mm bubble diameter slab exhibited a good hold in the deflection by having a average deflection of 16.73mm for average load of. 173.3 kN, where as the load taken by that of 50 mm diameter bubble slab is way too less than both 38mm bubble and control slab. From the aforementioned findings, it can be inferred that the usage of a voided slab should only be considered when the void created is little or when a lesser voided bubble is an option.

Comparison of Deflection vs slab designation

Percentage weight reduction

Table 9. Percentage reduction in weight of slab

SLAB TYPE	WEIGHT OF SLAB	WEIGHT REDUCTION PERCENTAGE
CONTROL SLAB	422.5Kg	0%
38mm DIAMETER BUBBLE SLAB	353.5Kg	16.30 %
50mm DIAMETER BUBBLE SLAB	334.53Kg	20.80 %

The weight of 38mm and 50mm bubble slab was 353.5 and 334.53 Kg respectively and the percentage reduction in weight came up to 16.3% and 20.8% when compared to control slab.

CONCLUSION

In the present experimental investigations, the conventional slab was compared with the voided slab and the voided slab with varying bubble diameter is compared. Three conventional slab was casted and three voided slab was casted for the diameter of bubble being 38mm and three voided slab of bubble diameter 50 mm. The testing was conducted by using a loading frame of 25tonne capacity and a hydraulic jack of 50Tonne was used to load the jack. The load was applied as uniformly distributed load. The following conclusions can be drawn from the present experimental work.

- The voided slab with the 38 mm diameter bubble shows results that are similar to that of conventional slab, the ultimate load carried by conventional slab is 193kN and the 38 mm diameter bubble slab has an average of 191kN of ultimate load.
- The 50 mm diameter bubble slab in comparison with both the conventional and the 38mm bubble diameter slab gives dissatisfied results. A bubble slab of 50 mm diameter is not desired.
- In comparison with the volume of the concrete, the 38mm diameter bubble slab has around 16.3 % reduction and 50 mm diameter bubble slab has around 20.8 % reduction in the volume of concrete when compared to conventional slab.

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EXPERIMENTAL STUDY ON FLEXURAL STRENGTHENING OF REINFORCED CONCRETE SLAB USING FABRIC REINFORCED CEMENTITIOUS MATRIX

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ABSTRACT

The fabric reinforced cementitious matrix (FRCM) is an effective strengthening technique as an alternate solution to overcome the drawbacks in the FRP strengthening technique that is replacing the epoxy by cement mortar. The experimental program consists of casting nine RC slabs, three were considered as control slabs and other six were strengthened and tested under uniformly distributed loading with different layers of Glass FRCM. The effectiveness of Glass FRCM is studied in terms of enhancement in the load carrying capacity of slab. The study brings at the possibility of strength enhancement most considerably. An attempt has done to evaluate the strength enhancement of reinforced concrete slab by strengthening using Glass FRCM by conducting experimental investigation.

INTRODUCTION

In the present world, strengthening applications for existing concrete structures and members have become an urgent necessity, strengthening the existing structural members to confirm their continuous operability and safety.

The use of modern structural materials is now being worked on by the engineering community because sustainability and cost-effectiveness are the main goals of strengthening technology. Repairing and improving the serviceability of structures may be necessary for a variety of reasons, including structural inadequacy caused by freeze- thaw cycles and inadequate concrete. In other situations, a structure might need to be upgraded to support heavier weights or to meet new standards. One of the main reasons that reinforced concrete constructions deteriorate is the corrosion of the steel reinforcement.

Since many of the existing structural elements are now regarded as being unsafe due to under design, higher loads stipulated by contemporary design regulations, overloading, or the lack of quality control, strengthening work is crucial. Older structural members need to be repaired or strengthened in order to keep their potential serviceability and meet the demands of both current and future construction projects. Repairing and strengthening structural parts rather than replacing them totally has become acceptable from an environmental

and financial standpoint, especially if a quick, effective, and simple strengthening technology is available.

Bruckner et al. [1] conducted an experimental examination to evaluate the strengthened beams' performance utilising FRCM. They employed textile-reinforced concrete with GFRCM, which is made of alkali-resistant glass fibre. They used 12 T beams in their investigation, nine of which were reinforced for shear bearing capability. The factors include the quantity of layers, anchorages, and techniques. The test results show that the loading capacity was significantly enhanced in order to maximise the impact of TRC strengthening. It is crucial to have mechanical anchorages. Strength increases of 17% and 33%, correspondingly, were seen for two and four layers.

Triantafillou et al [2] conducted an experimental investigation to determine the efficacy of employing textile reinforced mortar (TRM), which is made up of carbon fabric and polymer modified cementitious mortar with carbon fabric FRP, to shear strengthen RC beams. The study took into account the following variables: (1) Type of bonding agent; (2) Number of TRM or FRP strengthening layers; (3) Wrapping method; and (4) Type of loading. One control beam and five enhanced beams out of a total of six beams were investigated. While the other four beams were monotonically loaded, two beams were evaluated under cyclic loading. The TRM strengthening was shown to be 45% less effective than the FRP system, according to test data. Although TRM strengthening is less successful than FRP. Although TRM strengthening is less successful than FRP systems, the author finds that it is still a promising approach for shear strengthening for RC members.

Objectives

- To examine the flexural behavior of two-way RC slabs and compare it to that of reinforced slabs.
- To investigate the cracking load of slabs reinforced using glass fabric reinforced cementitious matrix and the improvement in ultimate load carrying capability.
- To examine how strength is increased in relation to various strengthening layers.
- To compare the performance of fabric-reinforced cementitious matrices in strengthened slabs with two and four layers to control slabs.

EXPERIMENTAL PROGRAMME

The trials were conducted to determine how well externally applied glass FRCM strengthened the flexural integrity of the RC slab. Nine slabs, each measuring 1100mmX1100mmX60mm. These nine slabs underwent two-point loading testing after being cast. The remaining 6 slabs were strengthened with glass FRCM in various levels and tested, with the remaining 3 slabs serving as the control slabs.

Table 1. Description of slabs

Total number of specimens	9
Control slabs	3
Strengthened slabs	6
Strengthening using 2 layers of Glass FRCM	3
Strengthening using 4 layers of Glass FRCM	3

Material: As per the guidelines of IS: 10262-2009 the mix proportion of M30 grade concrete was obtain to get workability of 100 mm slump.

Glass FRCM:

The glass fabric obtained by Shri Premolite Industries Ghaziabad (U.P), was used in the present experiments. The Properties are tabulated in Table 2.

Table 2. Test on glass FRCM

Sl. No.	Test Conducted	Results
1	Thickness (mm)	0.66
2	Mass / square meter (kg)	0.307
3	No. of holes / square meter	31781
	No. of holes / sq. inch	20
4	Tensile Breaking Load (N) a. Sample Width -36.0 mm b. Sample thickness - 0.66 mm c. Grip to grip length – 300 mm	1220

The average cube compressive strength of concrete on the day of testing of beams was

42.66 MPa The mortar grade adopted for this experimental study is MM7.5. As per the guidelines of IS: 2250-1981, the mix proportion for MM7.5 is cement: sand = 1:3. The water content is maintained to get working consistency.

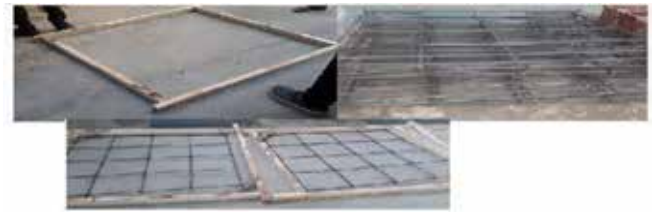

Fig 1. Form work of slabs

Procedure for Casting of slab specimens for flexural test

- The M30 grade concrete obtained from the mix design, mixed in pan concrete mixer.
- The form work used for casting of specimens was of wooden fabricated with accurate dimensions.
- As a first step installation of reinforcements into the formwork was completed. And then the thoroughly mixed concrete was poured in layers and compacted by hand.
- The top surface of the slab was finished using trowel. The concrete was allowed to set for 24 hours and then the formwork was removed carefully and the specimens was allowed for moist curing with gunny bags for a period of 28 days
- Along with each slab 12 cubes were cast from the same batch of concrete. All slabs were designed as 2-way slabs having same cross-sectional area [1.1m ×1.1m × 0.06 m] with reinforcement details for simply supported conditions as shown in Fig.1.

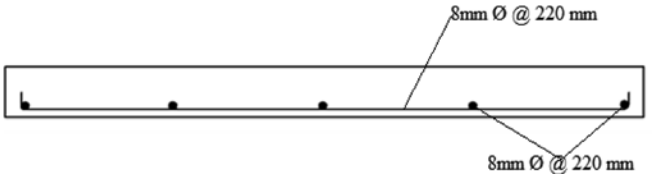

Fig. 2. Reinforcement Details of Simply supported Slabs.

Fig 3. Curing of slabs

Strengthening procedure of FRCM systems

Strengthening procedure of FRCM systems involves the following steps:

Step 1: The receiving substrate must first be prepared, which includes being thoroughly cleaned, then any damaged areas must be removed and replaced before applying the FRCM.

Step 2: Applying the first layer of cementitious matrix on the previously cleaned substrate, which has a nominal thickness of 5mm.

Step 3: To achieve proper impregnation, a layer of carefully chosen fiber network was pressed into the mortar.

Step 4: The second layer of matrix, nominally 5mm thick, was then applied.

Step 5: Up until the necessary number of layers of strengthened textile fiber networks are applied, this process of adding alternate cementitious mortar and the chosen textile fiber network must be repeated.

The placement of the FRCM system for strengthening is determined by the type of strengthening action required and the structural member that needs to be strengthened. If reinforcement is needed for beams or slabs to increase flexural strength, the composite is put in the tension zone, with the major direction of the fabric determined by the direction of the tensile stresses.

Fig. 4. Strengthening of slabs with glass FRCM

Testing of slab specimens

With similar loads and support circumstances, nine slab specimens measuring 1100X1100X60mm were created utilizing the limit state idea. 8mm dia. bars in fives were offered in both directions. All four edges have 115 mm roller bearing supports. In order to clearly see the specimen's crack pattern, white wash was additionally painted on the specimen. A 100 Tonne loading Jack was installed on top of the specimen to provide load, and a 25 Tonne loading frame was used for the setup. Additionally, a testing ring that was attached to a meter

to monitor load increments was fixed above the loading jack. To transfer the load from the loading jack to the specimen, a set of angle sections were provided on top of the specimen uniformly. The testing set up is as shown in the Fig 5.

Fig. 5. Setup of slab with UDL arrangement

Loading frame

For testing of the slab specimens, a loading frame with a 25-tonne capacity was utilized. The supports for the slab were made of mild steel and had solid 20 mm diameter M S rollers. These supports were attached to the loading frame's I-Section, which could be altered to accommodate different spans. On top of the specimen, three sets of angle sections were provided to evenly distribute the load from the loading jack. For load transfer, solid M S rollers measuring 32 mm in diameter and 200 mm in length were employed. The slab specimens' standard test setup is depicted in Fig. 6.

Instruments and measurements:

- Hand-operated pneumatic jack with a 50T capacity was employed as a loading jack. Use of a digital indicator was used to calibrate the jack.
- Dial gauge: Magnetic dial gauges were used to measure the deflections. The dial gauge's smallest increment was 0.01mm.
- Using a microscope, the crack width was determined and the smallest count was 0.01mm.

In addition to above, spirit level and plumb bob were used for accurate alignment levelling of the test set up.

Fig. 6. Testing of the slab specimen

Method of testing

The assumed loading became an evenly distributed load. If you want a natural bending or a second spot inside the centre of the slab, the weight is transferred to the slab using four MS plates that are 10 mm thick. A portable lever was used to apply the load in consistent increments up to the failure load. The initial load put in place became 2KN. Dial gauge readings for this load have been recorded in order to determine the slab's deflection. Dial gauge was used to measure the deflection at the slab's five locations (D1(C), D2(D), D4(A), D5(B), and CENTRE D3(E)), which are depicted in Fig. 7.The load was manually increased, and measurements from the dial gauge were obtained every 2.0 KN. At each level of loading, the measured deflection effects have been tabulated. The load associated with the initial crack was recorded. Every load increment left a distinct impression on the emergence of any new cracks as well as the spread of any existing ones. The corresponding

load levels have markings. Following the breakdown, the slabs were photographed and the crack pattern was noted. Each slab underwent testing for around two hours.

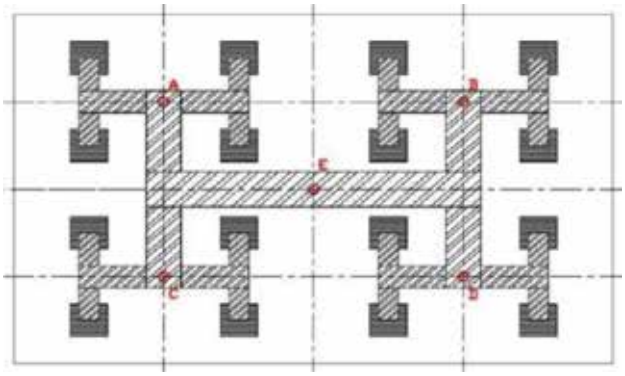

Fig. 7. Dial gauge arrangement

RESULTS AND DISCUSSIONS

Nine square slabs measuring 1100 mm x 1100 mm x 60 mm are used for the tests. All nine slabs were put through a simple support test. In the case of control slabs, the slabs were tested after 28 days of curing; the remaining 6 slabs were strengthened and tested after 28 days of curing. Tables and graphs are used to display the test findings and results. Each slab's behaviour is thoroughly studied in terms of its deflection, ultimate load carrying capacity, cracking load, and fracture pattern.

Combined load v/s deflection curve for slabs

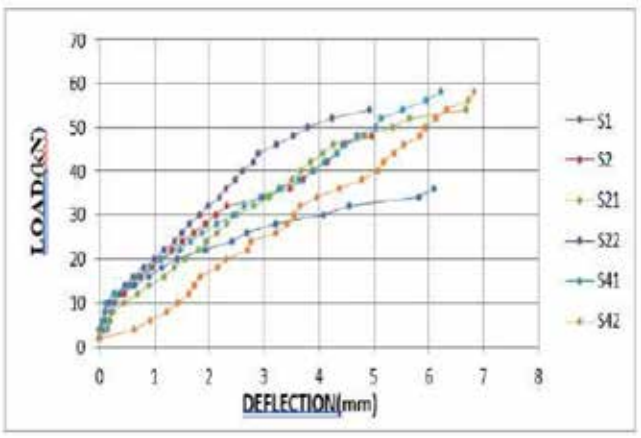

Fig. 8 Combined load v/s deflection curve for slabs

Figure 8 shows the load and accompanying maximum mid-span deflection for each slab. The figure demonstrates that all the Curves exhibit linear variation up to the first cracking level before behaving nonlinearly as load is increased further. The reinforced slabs with two layers of strengthening exhibited more when compared to the control concrete slab. The outcomes show that FRCM is technically feasible for reinforcing pre-existing RC slab-type parts. According to johanesen yield load enhancement, the strength enhancement was found to be 97% and 140% strengthening with 2 layers and 4 layers, respectively, in terms of ultimate capacity.

Fig. 9. Crack pattern of slab-S1 and S

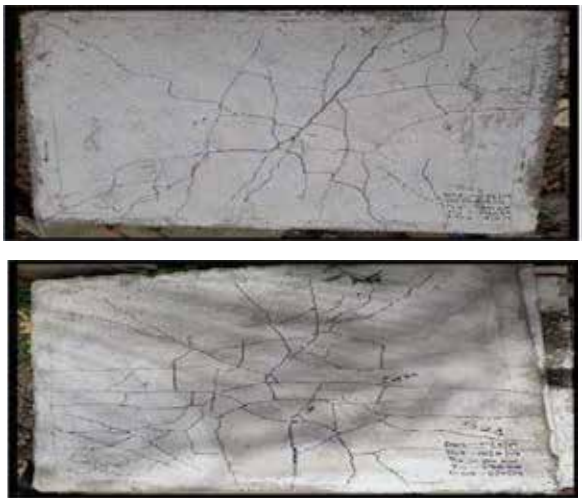

Fig. 10. Crack pattern of slab-S21 and S22

Fig. 11. Fibre break/rupture

Fig. 12 Crack pattern of slab-S41 and S42

CONCLUSIONS

- The addition of FRCM layers significantly boosted the flexural strength of two- way RC slabs. Therefore, it is suggested for the flexural strengthening of two-way RC slabs as a workable alternative retrofitting approach with obvious advantages over FRP.
- Initial stiffness, cracking load, and ultimate load capacity all rise as the number of GFRCM layers increases. At the stage of serviceability limit, the flexural resistance also rises.
- The laboratory results show that reinforcing existing RC slab-type elements with FRCM is technically feasible. According to johanesen yield load enhancement, the strength enhancement was determined to be 97% and 140% strengthening with 2 layers and 4 layers, respectively, for ultimate capacity.
- The impacts of GFRCM were noticeable, increasing strength and proper fabric amount while also leading to a steadily declining ductility.
- The slabs exposed to environmental conditioning showed no signs of delamination or debonding of the strengthening composites. Even though the fibre was visible after the two-layer reinforced slab failed.

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EXPERIMENTAL STUDY ON PERFORMANCE OF FLAT SLABS STRENGTHENED USING CARBON FIBER-REINFORCED POLYMERS

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ABSTRACT

Existing reinforced concrete (RC) slabs need to be strengthened for punching shear due to design defects, structural damage, increased loading, corroded reinforcement bars, and change in the use or function of the buildings. Slab–column connection of a fat plate structures is more susceptible to punching shear failure because of highly concentrated localized stresses. The additional resistance for punching shear will be provided by strengthening the existing slab-column connection. The best suited method to enhance the strength of slab-column connection is external strengthening without doing any damage to the structure. Hence, experimental investigations are carried out to determine the behavior of externally bonded RC slab–column connection under incremental gravity loadings. carbon fiber-reinforced polymer is used to strengthen the flat slabs by wrapping on the tension side of the specimen in two different patterns. For orthogonal wrap and skew wrap pattern, the average punching strength enhancement was, respectively, 33.87% and 47.58% in ultimate load.

KEYWORDS: *Slab–column connection, Fiber-reinforced polymers (FRP), Punching shear, Carbon fiber polymer-Strengthening*

INTRODUCTION

Many commercial and residential buildings are made up of flat slabs because of their usefulness as a suspended flooring system that allows for easier form work and quicker site operations. Despite their economic or cost benefits, punching failure of slab is one of the primary design failures in these kinds of constructions since it is a rapid and brittle failure that may cause the progressive failure of the structure. The creation and movement or propagation of a concrete crack surface, which begins at the column slab interface and spreads into depth of the slab in an angled or inclined direction away from the column, is what causes this punching failure. As a result, the concrete punching failure crack surface takes the shape of a pyramid's frustum. To reduce the development of inclined shear cracks, this type of failure is often addressed at the design phase by strengthening the concrete, thickening the slab, increasing size of the column, or inserting vertical steel stirrups or stud rails. However, numerous existing flat slabs are undergoing increasing loading as a result of changes in use, which may necessitate the adoption of requirements of strengthening for punching shear. Construction and design deficiencies are other reasons for which punching shear strengthening is required.

The punched shear strength of slabs is enhanced by

using CFRP sheet along with steel reinforcing bars as flexural reinforcement (M.R. Esfahani et.al., 2009). The punching shear strength of slab is underrated by the ACI Code, and this undervaluation gets worse as flexural reinforcement increases. The impact of flexural reinforcement on the punching shear strength of slab is suitably considered by the BS 8110 Code. Three alternative anchorage procedures were employed to strengthen eight specimens using pre-stressed vertical bolts: large surface anchorage, small surface anchorage, and small embedded anchorage (Micael M.G. Inácio et.al., 2012). The ultimate-load carrying capacity of the strengthened specimens was larger than that of the reference control specimen, increasing by an average of 54 percent, 21 percent, and 15 percent for the specimens strengthened with M10, M8, and M6 bolts, respectively. The efficacy of employing Carbon Fiber Reinforced Polymer (CFRP) sheets to strengthen flat slab to column corner connections was carried out (Bassam Q. Abdulrahman et.al., 2017). The results of the series of tested slabs indicate that strengthening improved the shear capacity by up to 23% in the slabs with holes, while it raised the punching shear capacity by 11% in the slabs without openings. CFRP composites have been employed using the Near Surface Mounted (NSM) techniques to boost flexural capacity, while the embedded through-section (ETS) technique has been used to strengthen punching (Joaquim A.O. Barros et.al., 2017). With increase in the Carbon fiber reinforcement ratio, the ultimate deflection of reinforced slabs reduced. Therefore, this research work focuses on studying the performance of RC slab–column connections strengthened using externally strengthened CFRP fabrics experimentally. The CFRP fabrics are wrapped using epoxy to tension face of the specimen in orthogonal and skew patterns and tested under incremental gravity loading.

TEST PROGRAM

Overview

To understand the behavior of slab–column, experimental study is conducted by applying incremental gravity loading through the column stub. The model specimens are of size 1300 mm ×1300 mm in plan with overall thickness of 80 mm were prepared with a central concentric column stub of size 150 mm×150 mm. The slabs were inverted and simply rested all around by considering support as point of contra flexure boundary. The reinforcement adopted for the slabs is 0.9% with a concrete mix of grade M20. HYSD steel bars of grade Fe 500 are used as reinforcement for both slabs and column stub. The column stub is provided with 8Nos of 8 mm diameter bars. The specimen details and the details of reinforcement are shown in Fig. 1.

Preparation of specimen and experimental setup

The current experimental work is conducted by casting six slabs. Among six slabs, two of them are un-strengthened slabs which are referred as control specimens. Remaining four slabs are strengthened using unidirectional CFRP fibers wrapped in orthogonal pattern and in skew pattern are shown in Fig. 2. The notations used for the different specimens are listed in Table 1.

The CFRP's are cut into a strip of length 1.3 m and width 165mm. The slab portion offset to the column face is prepared by removing dust and undulations, and then primer Nitowrap 30 is applied and cured for 1 day. The prepared CFRP is pasted using Fosroc epoxy Nitowrap 410 on the tension face of the slab. The CFRP is pasted at a distance of 75 mm from the face of column on all sides. After strengthening all the slabs are tested under incremental gravity loading and the difference in the behavior of the strengthened fat slab is compared with the control slab and hence the efficiency of the carbon fiber reinforced polymer in strengthening of slab is validated.

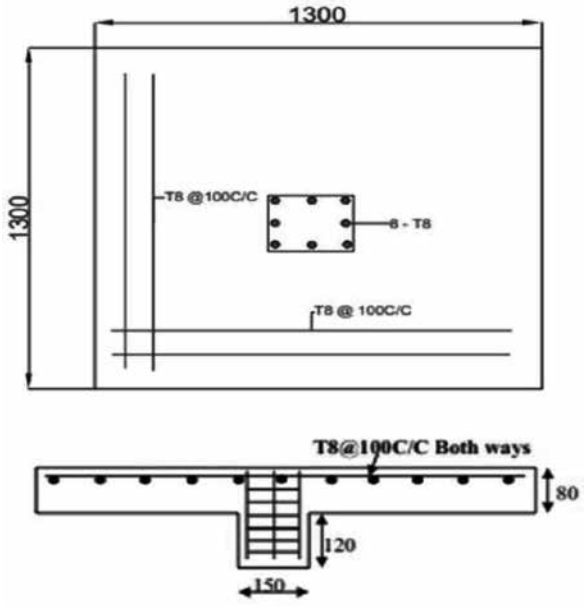

Fig. 1. Reinforcement details

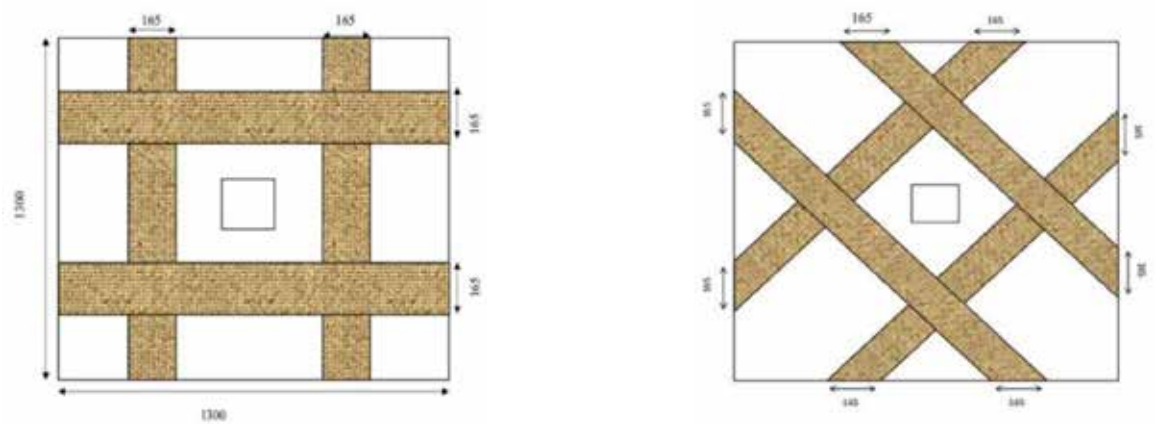

Fig. 2. Strengthening configurations

Specimens were supported on a frame of size 1200×1200 made up of an I-section with an overall depth of 100 mm and flange width of 75 mm. Specimens were subjected to gradually applied concentric load through the central column stub by means of 500 kN hydraulic jack at an increment of 2 kN and the slab corners were free to lift. The test setup is shown in Fig. 3.

Three dial gauges were used to record the central defection of the slab with an incremental load at a rate of 2 kN/min until the failure of specimen. Defections at the center of the slab are recorded for each incremental load and also crack propagation was examined until the failure of the specimen. The load at first crack and load at failure along with the corresponding defections were recorded.

Table 1. Specimen details

Specimen Notation	Description	Overall depth (mm)	F_c (Mpa)	f_y (Mpa)	P_t %	FRP Properties
C	Control Specimen	80	26.6	500	0.9	-
SO	Strengthened in orthogonal	80	26.6	500	0.9	Unidirectional CFRP with 0.43 mm thick E=250 GPa, f_{ten}=4900 Mpa
SS	Strengthened in skew pattern	80	26.6	500	0.9	Unidirectional CFRP with 0.43 mm thick E=250 GPa, f_{ten}=4900 MPa

Fig. 3. Test setup

RESULTS AND DISCUSSION

Failure mode and crack pattern

Figure 4 shows failure mode and crack pattern. All specimens were failed by punching shear. As the load applied is increased flexural radial cracks appeared in the tension side of the specimen and extended towards the edges of the slab until the specimen fails in shear. At ultimate load, slab failed suddenly due to punching and is characterized by sudden drop in load. The failure pattern consists of formation of conical shape in column vicinity and punching plane is in the range between 280 and 290 mm for control specimen from the column stub face.

For the CFRP strengthened specimens, initially when load is applied, several flexural cracks were appeared along the slabs, which are then propagated toward the edges of slab at further increase in the load. The punching plane is 335 and 245 mm for specimens strengthened with orthogonal wrap and skew wrap respectively, from the column stub face. Failure behavior details are tabulated in Table 2. It is to be noted that the number of cracks and their propagation were decreased in the strengthened specimen. The crack pattern of control and carbon strengthened specimen is shown in Fig. 4. The CFRP strengthened specimen is also failed by punching followed by debonding and rupture in fabric. From Fig. 4, The crack formations were reduced by usage of CFRP. In comparison to orthogonal and skew pattern of wrapping, complete debonding of the CFRP is happened in orthogonal wrapping pattern only. Only minor debonding was appeared in case of skew wrapping and overall crack formation was observed lesser in case of skew pattern.

Table 2. Failure behavior results

specimen	Mode of failure	CFRP failure	Crack location from face of column (mm)
C	Punching	-	280
SO	Punching	Debonding followed by Rupture	335
SS	Punching	Minor bonding	245

Fig. 4. Crack patterns in slabs. a) Control specimen, b) specimen with orthogonal wrapping pattern, c) specimens with skew wrapping pattern

Ultimate loads and defections

The control slabs failed at an average ultimate load of 124kN. The strengthened slabs failed at the load of 166kn and 183kN for orthogonal wrapping and skew wrapping, respectively, which is 33.87% and 47.58% more than the failure load of control specimen. The test results are tabulated in Table 3. At an ultimate load of 124 KN, the control slabs deflected upto

17.527 mm. In comparison to control specimens, orthogonally strengthened specimens exhibited deflection of 16.79 mm at 166 KN and slabs strengthened with skew pattern of wrapping exhibited a 15.421 mm deflection at an ultimate load of 183 KN. The reduction is 4.3% and 4.63% when compared with control specimens.

Table 3 Test results

Specimen	First crack load (kN)	Ultimate load (kN)	Deflection ultimate load (mm)	% increase in strength
C	49	124	17.527	
SO	54	166	16.792	33.87
SS	51	183	15.421	47.58

Load–defection behavior

For control specimen load–defection curve is as shown in Fig. 5 and load–defection comparison with strengthened slabs is plotted in Fig. 6.

Compared to different wrapping technique, skew pattern of wrapping has slight higher stiffness at post-cracking stage.

Table 4 Stiffness characteristics

Specimen	Pre-cracking stiffness (kN/mm)	Post-cracking stiffness (kN/mm)	% increase in pre-Cracking stiffness (Compared to C)	% increase in post-Cracking stiffness (Compared to C)
C	10.37	6.22	-	-
SO	10.98	7.8	5.5	20.25
SS	10.92	8.36	5.04	25.6

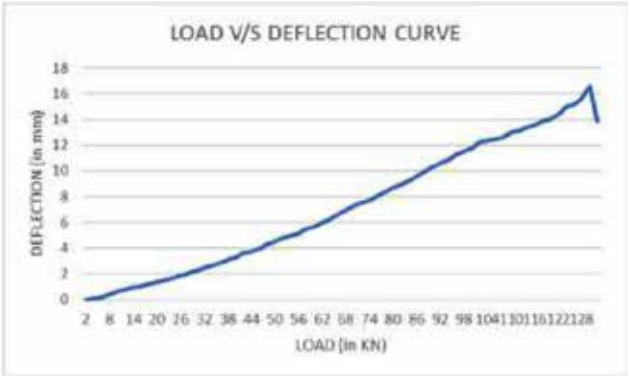

Fig. 5. Load–defection curve of control slab

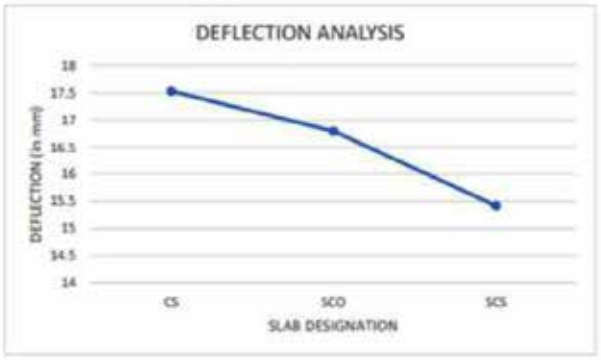

Fig. 6. Load–defection comparison

CONCLUSIONS

RC flat slabs strengthened using CFRP fabric in various orientations were the subject of the investigation. Totally six slabs were casted out of which two are control slabs (C-1, C-2). The remaining four slabs are strengthened using CFRP fabric. Two types of orientation were used for strengthening the slabs. Among four slabs two slabs are wrapped with orthogonal orientation (SO-1, SO-2) and other two slabs with skew orientation (SS-1, SS-2). All slabs were tested by applying point load at the center of the column and tested until the slab fails. The fallowing conclusions are drawn from the study.

1. It has been discovered that using CFRP fabric as a strengthening material helps strengthened flat slabs to have greater ductility and ultimate load carrying capacity.
2. The use of CFRP fabric caused delay in the initiation of first cracks in slabs. For orthogonally strengthened slabs the initiation of first crack was delayed by 6 KN compared with the control slab and for skew pattern slabs it was delayed by 2 KN.

3. The ultimate-load carrying capacity was increased by the usage of CFRP fabric. There was an increase of 33.87 percent of load carrying capacity for orthogonal orientation of wrapping and 47.58 percent for skew orientation of wrapping.
4. The deflection in both the forms of wrapping technique was reduced when compared with control slabs. As a result, it is concluded that deflection of slabs will be decreased by using carbon fiber as strengthening material.
5. Thus, it is evident that skew pattern of wrapping was more efficient as compared with orthogonal pattern of wrapping because there was more enhancement in load carrying capacity and more reduction in deflection value for skew pattern than orthogonal pattern of wrapping.
6. In all the strengthened slabs debonding of fabric was observed as load was applied. Additionally, it was shown that significant debonding of fabric occurs when the ultimate- load is imminent.

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A COMPARATIVE STUDY ON FLEXURAL STRENGTHENING OF PRELOADED RC T- BEAM USING NSM CFRP VERTICAL LAMINATES WITH DIFFERENT PERCENTAGES OF TENSION REINFORCEMENT

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ABSTRACT

Due to its exposure to a variety of loads and challenging climatic conditions, concrete structures are deteriorating at an alarming rate throughout the world. When problems persist despite our best efforts and cause stress, it causes us to doubt our comprehension even when we believe we can preserve order and come up with a workable solution. To prolong its life, every structure eventually needs strengthening or repairs. The quality of the building, the materials used, the surroundings, and the way the structure is used all affect how frequently these repairs are necessary. The deteriorating and existing reinforced concrete structures need to be repaired and retrofitted in order to fulfil the current design criteria and strength characteristics.

Carbon Fibre Reinforced Polymer (CFRP) Laminates are frequently used as the strengthening material for Reinforced Concrete (RC) projects due to their superior qualities when compared to other Fibre Reinforced Polymer (FRP) laminates. In the current experimental work, an effort is made to compare and evaluate the behaviour of RC T-beams that have been flexurally strengthened using the NSM technique and vertical CFRP laminates with two different percentages of tension reinforcement. The strengthened and control T-beams' working and ultimate loads are assessed. In addition, the load-deflection behaviour and failure modes of every strengthened and control T- beam are explored.

KEYWORDS *: Pre-loaded, Reinforced concrete t-beam, CFRP laminate, Flexural strengthening, NSM technique.*

INTRODUCTION

To achieve the necessary strength requirements and increase the structures' useful lives, reinforced concrete (RC) structures must be upgraded. Reinforced concrete structures are susceptible to a wide range of functional and structural impairments, including overloading, reinforcement corrosion, deformation and cracking, exposure to environmental changes, and long-term consequences.

The goal is to raise knowledge about a scientific evaluation of the underlying cause, the establishment of the methodology, and the proper application of materials for efficient restoration. Contractors and consultants will gain from the increased awareness. Building repairs are commonly found to have been unnecessarily delayed as a result of poor instruction. In order to extend the life of the structure, guarantee community safety, and reduce material and labour costs, it is necessary to quickly detect, assess, plan, and carry out repair work. Construction of a new structure is completely different than repair, rehabilitation, retrofitting, or strengthening. The term "retrofitting" refers to the process of altering something after it has been built. Generally speaking, it refers to the strengthening plan that combines new load requirements, new codal provisions, new safety requirements.

Retrofitting is the process of strengthening currently standing, damaged or undamaged structures is known as retrofitting. It is described as the process of incorporating brand-new features into already-existing buildings, historical buildings, bridges, etc. It is an increase in the initial strength that was present before the harm. An existing structure can be retrofitted to increase its durability and safety while lowering its susceptibility to harm. Retrofitting is done to prevent additional damage to the concrete and to strengthen structural elements made of deteriorated concrete. Reinforced concrete structural elements can become brittle due to poor design decisions, poor craftsmanship, and degeneration brought on by the aggressivity of hazardous agents. A few techniques used to retrofit elements in RCC structures include section enlargement, external plate bonding, external post-tensioning, grouting, and fibre reinforced polymer (FRP) composites. Two of the approaches that fall under the category of FRP composites are the externally bonded reinforcement (EBR) technique and FRP composites employing the near surface mounted method (NSM).

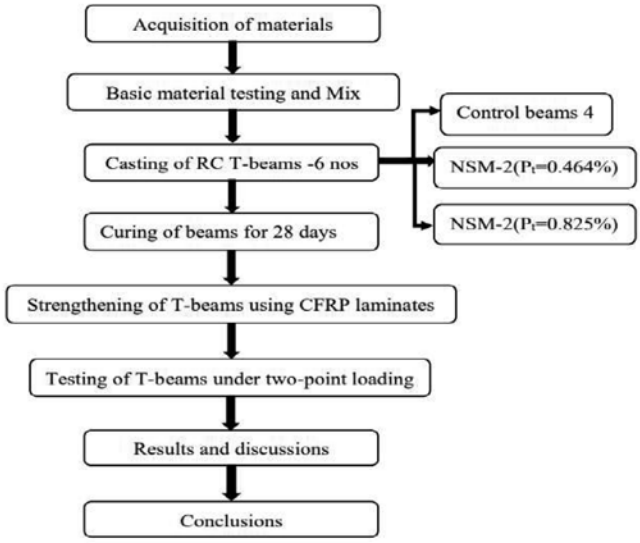
Depending on the extent of the damage and the required capacity for recovery, an appropriate retrofitting technique is selected and put into practise.

OBJECTIVES

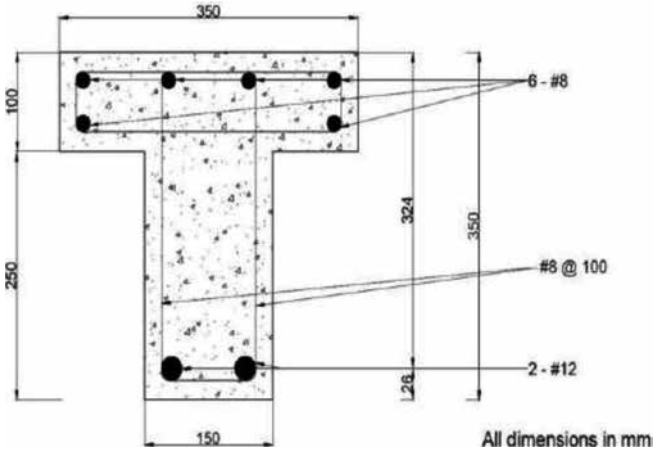
1. To examine and contrast the flexural behaviour of T-beams made of reinforced concrete and NSM CFRP laminates.
2. To assess each strengthened and regulate T-beam's working load and maximum load.
3. To analyse the load-deflection behaviour of the reinforced and controlled T-beams.
4. To examine how reinforced beams made with CFRP laminate in vertical orientation performed when tension reinforcement was applied at two different percentages (Pt=0.464% and 0.825%).
5. To investigate the debonding failure of all the reinforced RC T-beams' Carbon FRP strips.
6. To research how NSM CFRP strengthened T-beams fail.

METHODOLOGY

The following is a presentation of the experimental approach used for the project work.



SPECIMEN DETAILS



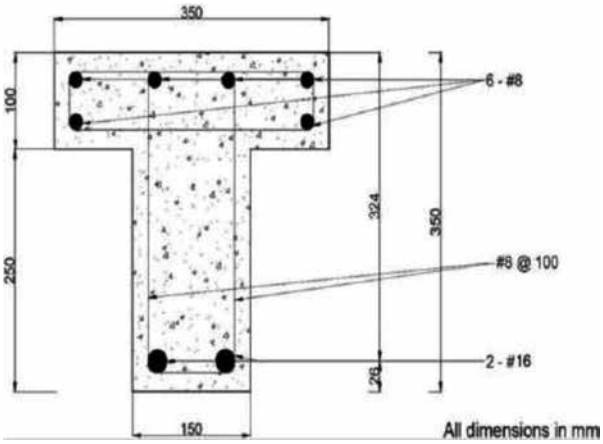


Fig. 1. Reinforcement details of T-Beam

The T-beam's cross-sectional measurements were determined according to Figure 1. Eight beams in total were cast, with two 12mm steel bars serving as the longitudinal tension reinforcement for four of the beams, two 16mm steel bars for the remaining four, and four 8mm hanger bars for the T-beam flange. Additionally, there were two-legged vertical stirrups of 8mm diameter spaced 100mm apart along the span. Eight T-beams each had a clear span of 2000 millimetres, and the concrete's grade is M20. Figure 2 depicts the reinforced concrete T-beam with formwork and a reinforcement cage.

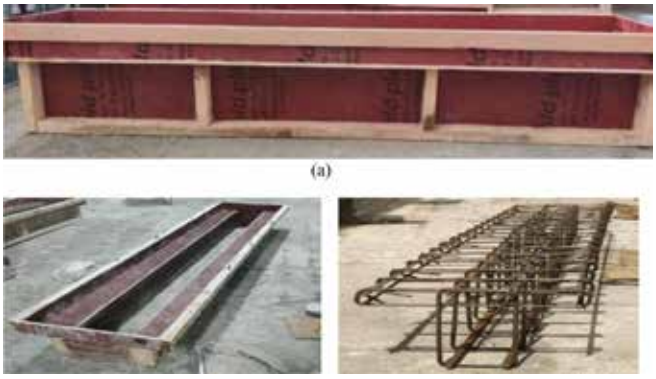


Fig. 2. (a)(b) Formwork of T-Beam, (c) Reinforcement cage of T-Beam

MATERIAL DETAILS.

- The materials used for the preparation of concrete underwent initial basic material testing in line with IS codal regulations in order to maintain the project's greater accuracy. These tests provide information on the properties of the material used to perform mix design in accordance with IS: 10262-2019, which is necessary to assess the mix percentage for M-20 concrete.
- To evaluate the compressive strength of concrete after seven, fourteen, and twenty- eight days, three 150 x 150 x 150 mm concrete cubes were cast. Concrete has a 24 Mpa compressive strength after 28 days. 75mm of slump and a water-cement ratio of 0.5 were used. Vertical stirrups and compression reinforcement were made consisted of vertical stirrups and 12mm and 16mm diameter tensile steel reinforcement for the T-beam with 8mm diameter of HYSD Fe550 grade bars.
- The manufacturer gave the aforementioned information. T-beams were reinforced using a 1.4 mm thick CFRP laminate with a tensile strength of 2900 MPa and an elasticity modulus of 177 GPa. This laminate is free of any harmful pollutants, chemicals, salts, or deleterious centimetre thickness.
- The manufacturer gave the aforementioned information. With the aid of Epoxy Nitobond PC40, the laminates were joined to the concrete. As shown in Fig. 3, the mixture of Nitobond PC40 base and hardener epoxy produces glue. Base is an off- white colour, while hardener is a black shade. We used an epoxy resin whose compressive strength was greater than 60N/mm2 after 24 hours and greater than 75Mpa after 7 days. The pot life is 30 minutes at 40 degrees Celsius and the specific gravity is between 1.80 and 1.90.

Fig. 3. Epoxy Nitobond PC40

EXPERIMENTAL PROGRAM

STRENGTHENING OF RC T-BEAMS

After twenty-eight days of curing, the RC T-beams were strengthened. Four T-beams, two of which had 12mm diameter bars as tension reinforcement and the

other two had 16mm diameter bars, were strengthened using CFRP laminates.

The many beams that are being strengthened are seen in Fig. 4.

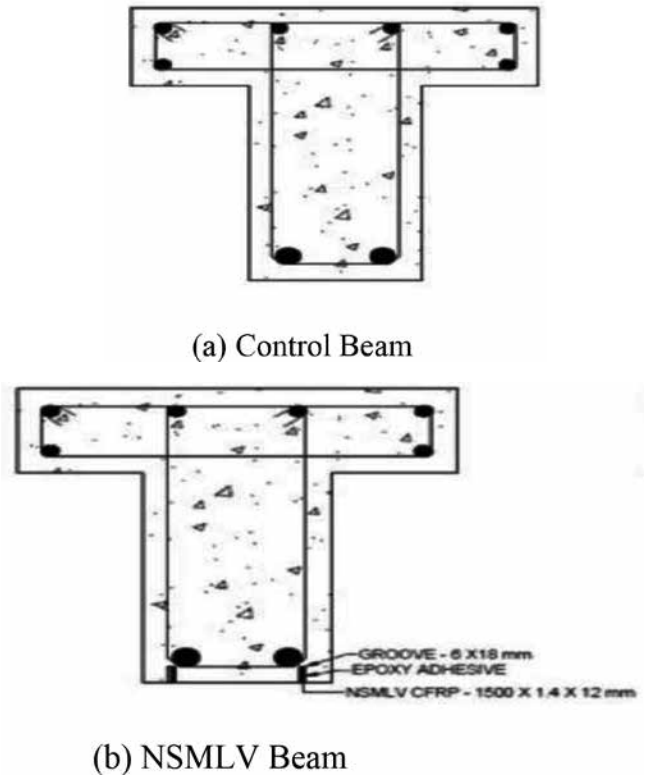


Fig. 4. Strengthening of T-Beams

RC T BEAM STRENGTHENING WITH NEAR SURFACE MOUNTED LAMINATE IN VERTICAL ORIENTATION (NSMLV):

1) Preparation of concrete surface for strengthening: The dimension required to cut a groove was marked on the beam's bottom surface. The marked area was cut using fine tooth blade or grinder in vertical direction to prepare a groove of size of 1500mm X 6mm X 20mm in accordance with length X breadth X depth respectively. The groove's bottom surface should be even and there should not be any undulation, patches etc. Therefore, a machine grinder was used to grind the groove's bottom surface. To prepare the surface for strengthening, the dust and chipped fragments were removed after grinding.

2) Laminate cutting: The CFRP laminates were cut to the required 1500mm length, with a thickness of 1.4mm and a width of 12mm.

3) Applying epoxy glue to the ground surface: The epoxy was composed of base and hardener, which were thoroughly mixed in a 3:1 ratio until the epoxy turned grey. To a depth of 4 mm, the groove was filled with epoxy. The laminate was then positioned atop the epoxy layer after this layer of epoxy had been applied. Epoxy was used to fill the remaining groove before it solidified. The epoxy was applied to the laminates and allowed to cure for 7 days before being tested to strengthen the structure.

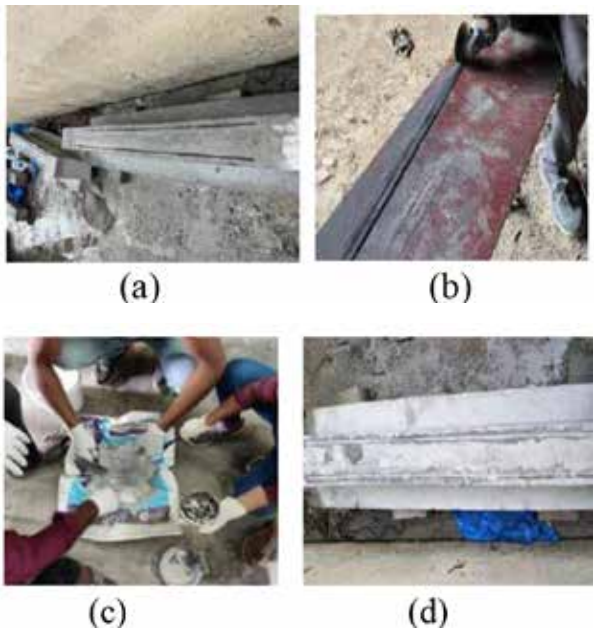


Fig. 5. (a) Vertical Grooves (6x18mm) (b) Laminate Cutting (d) Adhesive preparation (e) Application of adhesive, placing of laminates and finishing of surface

EXPERIMENTAL SETUP

The loading frame with a 100-ton capacity was used for the testing of the RC T-beams. The surfaces of the beams were allowed to dry after they had been cast in the lab and had been cured for twenty-eight days. At 1/3, 1/2, and 2/3 of the effective span from one end of the support, lines were marked on the beams. Under two-point loading, all simply supported T-beams were put to the test. The core region of this sort of loading arrangement, also known as the pure bending region, has a relatively uniform moment distribution and little shearing. The loading configuration is shown in Fig. 6. The load is applied using a hydraulic jackThe steel beam, which is positioned above the rollers on the flange of the beam, receives it after being transferred through the load cell. The test specimens were supported on

the rollers, 150 mm from the beam's ends being the furthest away. Three parts of 567mm each make up the 1700mm effective span. Three dial gauges were used to measure the deflections of the T-beams. One dial gauge was positioned 12 of the effective length from the support, just below the middle of the beam, and two dial gauges were positioned directly below the places of load application, at distances of 1/3 and 2/3 of the effective length.

Fig 6. Experimental Setup

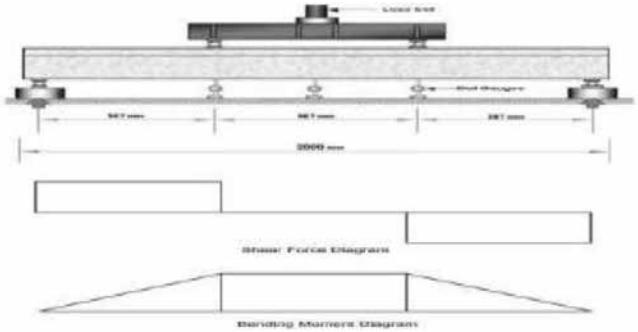


Fig 7. BMD and SFD

TESTING OF BEAMS

In the configuration described above, all eight specimens were tested. Four of these beams are designated as control beams because they don't have CFRP laminates. The final four beams are similarly loaded substantially up to the working load without CFRP laminates. In order to pre-load the beams before applying CFRP laminates, this is done.

Following the installation of CFRP laminates, the pre-laden beams are subsequently loaded once again till failure. The strain gauge measurement is deflected in accordance with each stage as the load is gradually increased and applied. The dial gauge's readings show how the beams have changed over time. When loads are applied to beams, the cracking load is the equivalent load that causes the first crack to appear. These beams are then loaded until failure, which corresponds to the ultimate load. As previously mentioned, for each increase in loads, previous dial gauge readings are taken at three points: at 1/3, 1/2, and 2/3 of the effective length from the one end of support. The test results for the RC T-beams under the two-point loading test are analysed and further explored in depth.

RESULTS AND DISCUSSION

Behaviour of Control T-Beams Control Beam-1 (CB-1). Testing was conducted on the 12mm diameter bottom bars (0.464% tension reinforcement) in the beams. The conventional experimental methodology covered in the aforementioned chapters was used. A 2KN increment was used to gradually increase the load. At L/3, L/2, and 2L/3 from one end of the support, the appropriate dial gauges were installed to measure the deflection values for each load increment. In the beginning, the concrete demonstrated its strength by withstanding the applied load. The T-beam's web had its first crack upon additional load increase in the pure-bending zone under the load of 76KN, with a corresponding deflection at this point of 1.34 mm. Additionally, cracks began to show up at the base of the web under 92 KN of load, and shear cracks showed up around 96 KN of strain. As the load is increased further, the beam's stiffness begins to decrease, which causes more flexural cracks to form in the T-beam's web. As the load was increased further, these flexural cracks began to spread; in other words, microcracks became macrocracks with the creation of effective failure planes, ultimately leading to failure. Beyond this point, cracks began to emerge at the bottom of the flange under a load of 108 KN, and as the load increased, they spread to the sides and top of the flange as well. The concrete at both supports was found to be crushed at a force of 138KN, indicating a local failure of the beam. The failure of the beam under the 166KN load— which was thought to be the T-beam's maximum load—was indicated by the reversal of the proving ring needle. Pure tension failure was the failure that was seen. Under a working load of 110KN, the deflection was 2.59 mm, and under a final load, it was 5.22 mm. The T-beam's web had little fractures in it before the failure load, but they became wider and eventually reached the flange, indicating that the web had failed. Fig. 8(a) depicts the CB-1 crack pattern. The load versus deflection curve is represented graphically in Fig. 8(b), accordingly.

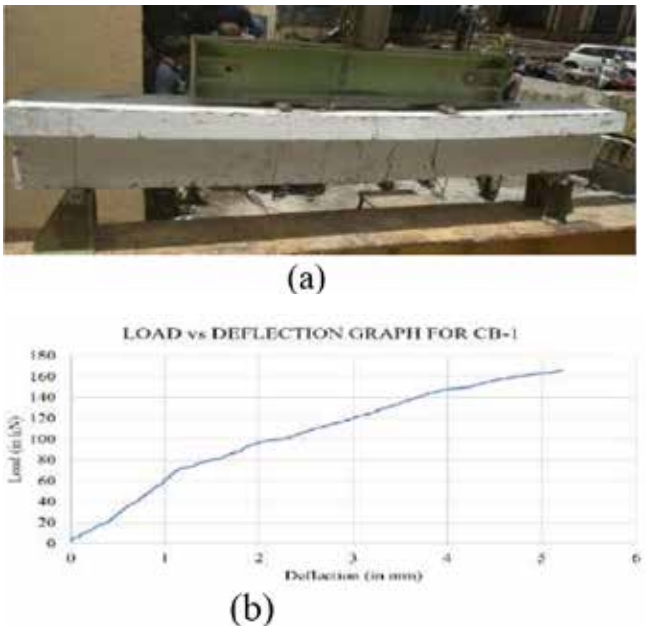


Fig. 8. Shows the crack pattern of CB-1 in (a) and a graphic representation of CB- 1's load-to-stress deflection in (b).

Control Beam-2 (CB-2): The 16mm bottom bars with a tension reinforcing percentage of 0.825% on the beams were tested. The above-discussed standard experimental protocol was followed. In the beginning, the concrete demonstrated its strength by withstanding the applied load. The T-beam's web had its first crack upon additional load increase in the pure-bending zone under the load of 86KN, with a corresponding deflection at this point of 1.56 mm. Additionally, with the 108 KN load, cracks began to show up at the shear span and the base of the web. As the load is increased further, the beam's stiffness begins to decrease, which causes more flexural cracks to form in the T- beam's web. These flexural cracks began to widen when the load was increased further. Beyond this point, cracks began to emerge at the bottom of the flange under a pressure of 124 KN, and as the load increased, they spread to the sides and top of the flange as well. The concrete at both supports was found to be crushed at a force of 148KN, indicating a local failure of the beam. The reversal of the proving ring needle under the force of 208KN, which was thought to be the T-beam's ultimate load, served as an indicator that the beam had failed. Pure tension failure was the failure that was seen. At the working load of 138KN, the deflection was 3.30 mm, and at the ultimate load, it was 5.46 mm. The T-beam's web had little fractures in it before the failure load, but they became wider and eventually reached the flange, indicating that the web had failed. Figure 9(a) depicts the CB-2 crack pattern, while Figure 9(b) illustrates the load versus deflection curve graphically.

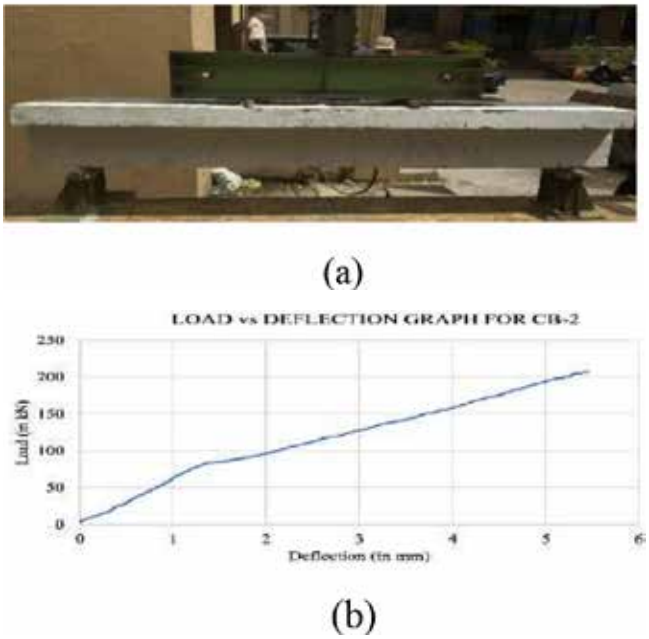


Fig. 9. shows the CB-2's crack pattern in (a) and (b) as well as a graphic representation of the CB-2's load-to-stress deflection.

Control Beam-3 (CB-3): The 16mm bottom bars with a tension reinforcing percentage of 0.825% on the beams were tested. In the beginning, the concrete demonstrated its strength by withstanding the applied load. The T-beam's web had its first crack upon additional load increase in the pure-bending zone under the load of 92KN, with a corresponding deflection at this point of 1.88 mm. Additionally, under the pressure of 108 KN, cracks began to show up at the base of the web. As the load is increased further, the beam's stiffness begins to decrease, which causes more flexural cracks to form in the T-beam's web. These flexural cracks began to widen when the load was increased further. Beyond this point, cracks began to emerge at the bottom of the flange under a weight of 128KN, and as the load increased, they spread to the sides and top of the flange as well. The concrete at both supports was found to be crushed at a force of 134KN, indicating a local failure of the beam. The reversal of the proving ring needle under the stress of 180 KN, which was thought to be the T-beam's

ultimate load, served as an indicator that the beam had failed. Pure tension failure was the failure that was seen. Under a working load of 120 KN, the deflection was 2.98 mm, and under a final load, it was 4.75 mm. The T- beam's web had little fractures in it before the failure load, but they became wider and eventually reached the flange, indicating that the web had failed. Figure 10(a) depicts the CB-3 crack pattern, whereas Figure 10(b) displays a visual representation of the load versus deflection curve.

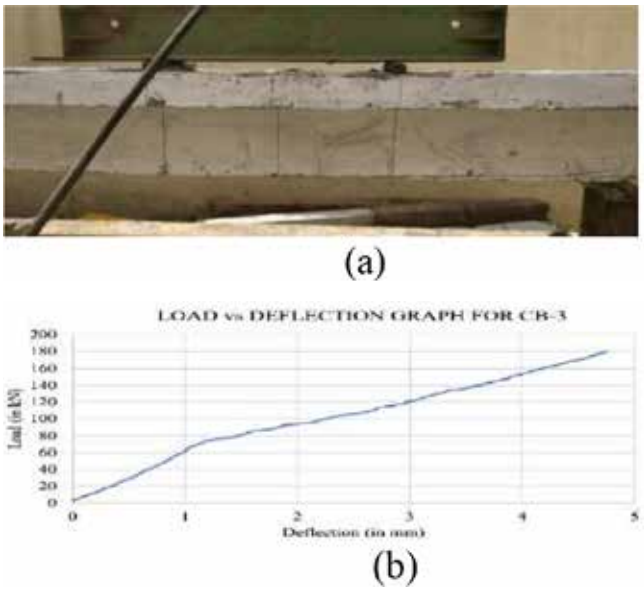


Fig. 10. (a) shows the crack pattern of CB-3 and (b) shows a graphic representation of CB-3's load-to-stress deflection.

Control Beam-4 (CB-4): Testing was conducted on the 12mm diameter bottom bars (0.464% tension reinforcement) in the beams. A 2KN increment was used to gradually increase the load. In the beginning, the concrete demonstrated its strength by withstanding the applied load. The T-beam's web saw its first crack upon additional load increase in the pure-bending zone under the load of 90 KN, with a corresponding deflection at this point of 1.54 mm. Additionally, with the 104 KN strain, cracks began to show up at the shear span and the base of the web. As the load is increased further, the beam's stiffness begins to decrease, which causes more flexural cracks to form in the T- beam's web. These flexural cracks began as the load was increased further. Beyond this point, cracks began to emerge at the bottom of the flange with a pressure of 114 KN, and as the load increased, they spread to the sides and top of the flange as well. The concrete at both supports was found to be crushed at a force of 144KN, indicating a local failure of the beam. The reversal of the proving ring needle under the stress of 180 KN, which was thought to be the T-beam's ultimate load, served as an indicator that the beam had failed. Pure tension failure was the failure that was seen. At a working load of 120 KN, the deflection was 3.43 mm, and at the maximum load, it was 9.70 mm. The T-beam's web had little fractures in it before the failure load, but they became wider and eventually reached the flange, indicating that the web had failed. Figure 11(a) depicts the CB-4 crack pattern, whereas Figure 11(b) displays a visual representation of the load versus deflection curve.

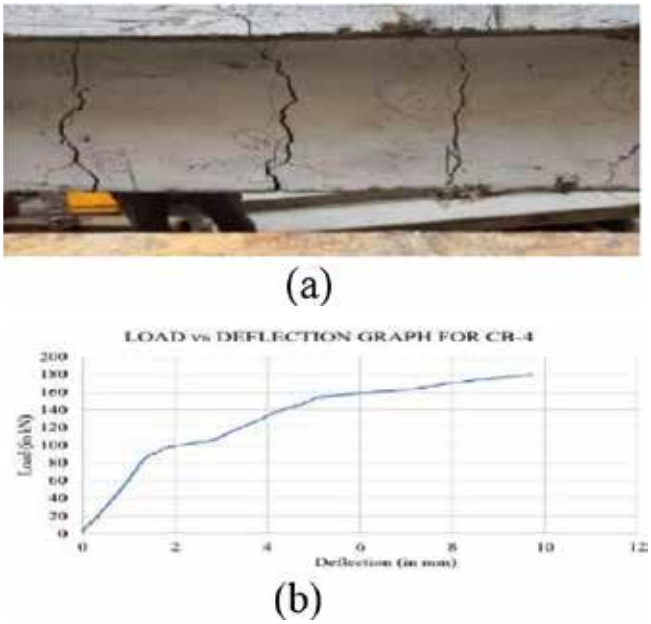


Figure 11. (a) The crack pattern of CB-4 and (b) a graphic representation of CB-4's load-to-stress deflection.

Behaviour of Strengthened T-Beam by NSM Technique

Near Surface Mounted in vertical orientation of laminate (NSMLV-1): Following the application of CFRP laminates, the beams that had been preloaded were put to the test. These beams had bottom bars with a diameter of 12 mm and a tension reinforcement percentage of 0.464%. The usual experimental protocol was used. Under a load of 36 KN, the T-beam's soffit and web experienced the first crack during subsequent load augmentation; the resulting deflection at this point was 0.93 mm. As the load is increased at the same rate, more flexure cracks and flexure-shear cracks that were started vertically in the flexural zone begin to form,

which causes the beam to deflect. In the shear zone of the beam, existing cracks widened and new ones appeared. Beyond this point, the web began to break with a load of 84 KN, and as the load increased, the cracks spread horizontally to the sides of the flange and then to the top of the flange. The debonding of the CFRP laminate began at one side under the pressure of 176 KN, which increased the stress further and caused the laminate and epoxy cover to rip off. The CFRP laminate along the concrete cover has peeled off as a result of severe concrete cracking at the midspan, which caused the beam to fail under 208KN of strain. Under the working load of 138 KN, the deflection was 4.01 mm, and under the maximum load of 208 KN, it was 10.58 mm. The flexural cracks in the T-beam's web deepened at the failure load and further extended vertically upward to the beam's flange, indicating that the web had failed. Figure 12(a) depicts the NSMV-1 crack pattern, while Figure 12(b) illustrates the load versus deflection curve graphically.

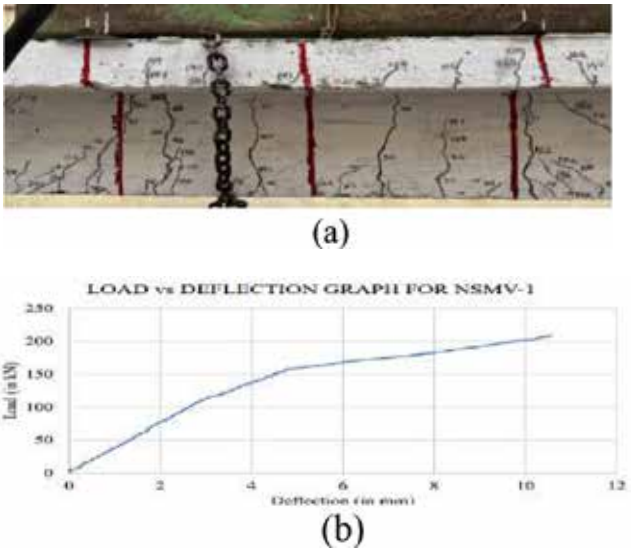


Fig. 12. shows the NSMV-1 crack pattern in (a) and (b) as well as a graphic representation of the NSMV-1 load-to-stress deflection.

NSMLV-2: Following the application of CFRP laminates, the beams that had been preloaded were put to the test. These beams had bottom bars with a diameter of 12 mm and a tension reinforcement percentage of 0.464%. The usual experimental protocol was used. Under a load of 32 KN, the T-beam's soffit and web experienced the first crack during subsequent load augmentation; the resulting deflection at this point was 0.85 mm. Existing cracks in the shear zone of the beam became wider as the load was increased at the same rate. Beyond this point, shear cracks began to emerge at the web with a load of 84 KN, and as the load increased, they spread horizontally to the sides of the flange and eventually to the top of the flange. Further increasing the stress, under the load of 178KN the CFRP laminate began to debond at one side, which caused the laminate to rip off along with the concrete cover. After the beam collapsed under a load of 220KN due to extensive concrete cracking at the midspan, the CFRP laminate covering the concrete cover peeled off. Under the working load of 146KN, the deflection was 4.82 mm, and under the ultimate load of 220KN, it was 14.81 mm. The flexural cracks in the T-beam's web deepened at the failure load and further extended vertically upward to the beam's flange, indicating that the web had failed. Figure 13(a) depicts the NSMV-2 fracture pattern, whereas Figure 13(b) displays a visual representation of the load versus deflection curve.

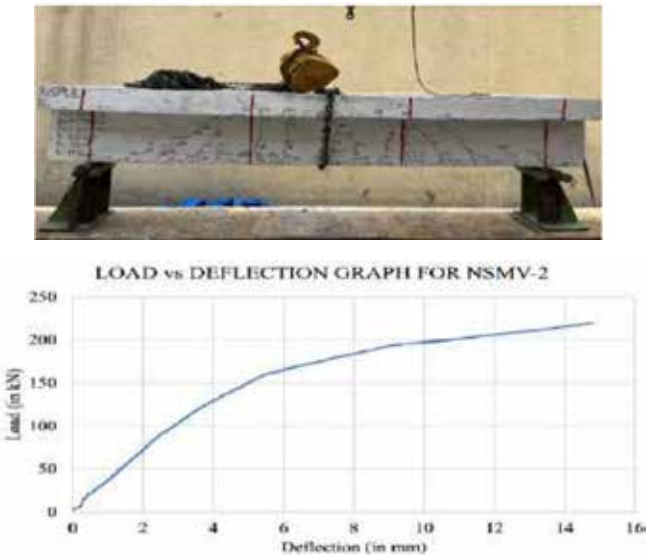


Fig. 13. shows the NSMV-2's crack pattern in (a) and (b) as well as a graphic representation of the load V/S Deflection of the NSMV-2.

NSMLV-3: Following the application of CFRP laminates, the beams that had been preloaded were put to the test. These beams featured bottom bars that were 16 mm in diameter (tension reinforcement percentage: 0.825%). The usual experimental protocol was used. When the load was increased further, the T-beam's soffit and web showed signs of the first crack in the pure-bending zone under a force of 38 KN, with a corresponding deflection at this point of 0.72 mm. As the load is increased at the same rate, more flexure cracks

and flexure-shear cracks that were started vertically in the flexural zone begin to form, which causes the beam to deflect. In the shear zone of the beam, existing cracks widened and new ones appeared. Beyond this point, the web began to show signs of shear cracking with a load of 82 KN, and as the load increased, the fractures spread horizontally to the sides of the flange and then to the top of the flange. The load was increased further, and at 330 KN, the CFRP laminate started to debond at one side, ripping off the concrete cover in the process. After the beam failed under a load of 362KN due to extensive concrete cracking at the midspan, the CFRP laminate covering the concrete cover peeled offBoth the working load of 240 KN and the ultimate load of 362 KN caused a deflection of 5.94 mm and 8.97 mm, respectively. The flexural cracks in the T-beam's web deepened at the failure load and further extended vertically upward to the beam's flange, indicating that the web had failed. Figure 14(a) depicts the NSMV-3 crack pattern, while Figure 14(b) illustrates the load versus deflection curve graphically.

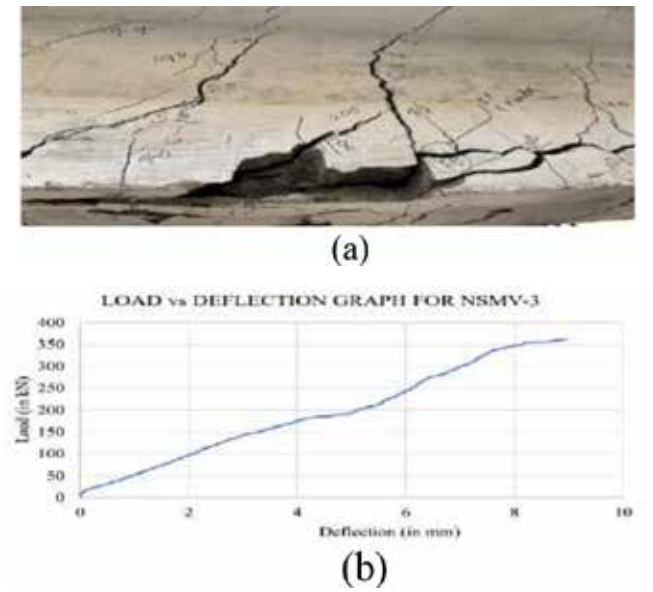


Fig. 14. shows the NSMV-3's crack pattern in (a) and (b) as well as a graphic representation of the NSMV-3's load-to-stress deflection.

NSMLV-4: Following the application of CFRP laminates, the beams that had been preloaded were put to the test. These beams featured bottom bars that were 16 mm in diameter (tension reinforcement percentage: 0.825%). The usual experimental protocol was used. Under a load of 36 KN, the T-beam's soffit and web experienced the first crack during subsequent load augmentation; the resulting deflection at this point was 0.43 mm. As the load is increased at the same rate, more flexure cracks and flexure-shear cracks that were started vertically in the flexural zone begin to form, which causes the beam to deflect. In the shear zone of the beam, existing cracks widened and new ones appeared. Beyond this point, the web began to show signs of shear cracking under a load of 84 KN, and as the load increased, the fractures spread horizontally to the sides of the flange and then to the top of the flange. As the load was increased, under the stress of 280 KN, the CFRP laminate began to debond at one end, which caused the epoxy cover to pull off along with the laminate. After the beam broke under a load of 308KN due to extensive concrete cracking at the midspan, the CFRP laminate covering the concrete cover peeled off. Both the working load of 204KN and the ultimate load of 308KN caused a deflection of 4.77mm and 8.73mm, respectively. The flexural cracks in the T-beam's web deepened at the failure load and further extended vertically upward to the beam's flange, indicating that the web had failed. Figure 15(a) depicts the NSMV-4 crack pattern, while Figure 15(b) illustrates the load versus deflection curve graphically.

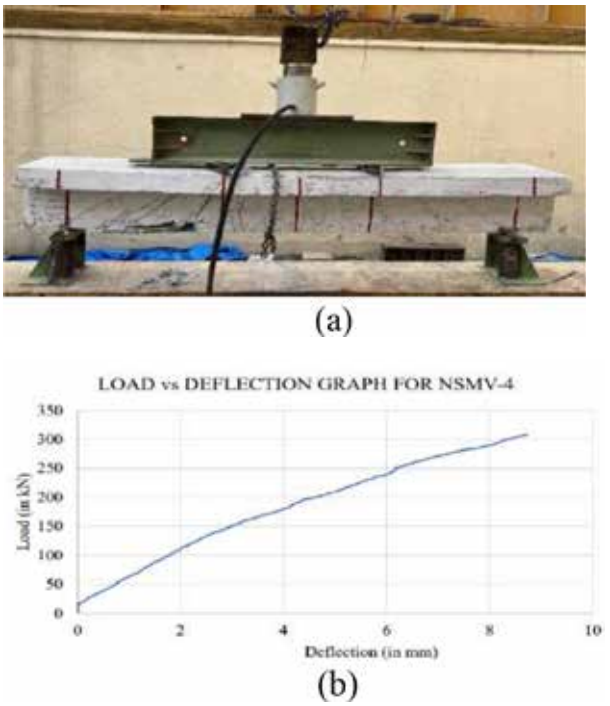


Fig. No. 15 shows the NSMV-4's crack pattern in (a) and (b) as well as a graphic representation of the NSMV-4's load-to-stress deflection.

COMPARATIVE STUDY ON THE BEHAVIOUR OF CONTROL AND STRENGTHENED T-BEAMS

Figures 16(a) and 16(b) display the combined load vs deflection curve for all control and strengthened beams employing NSM CFRP laminates. The figure shows that the ultimate load for the NSMV-enhanced beams was higher than for the control beams. The load deflection behaviour of NSMV T-beams was the same as that of control beams up until the first fracture emerged; however, after that point, the load deflection behaviour of the CFRP reinforced beams changed. Vertical hairline cracks started to emerge in the web and soffit of T-beams in the pure bending zone when the applied load approached the yield point for the beams reinforced with NSM CFRP laminates. The flexural cracks already present worsened as the load was increased. Additionally, new flexure-shear and shear cracks developed, although as compared to control beams, the CFRP reinforcement successfully reduced the crack width. At this point, the T-beam's web had cracks that ran vertically upward to the bottom of the flange. As the load increased, these cracks spread to the sides and top of the flange. The laminate in the NSM process suddenly debonds from the adhesive by ripping off the adhesive-filled cover section when more glue was added to the groove, which had previously provided resistance to deformation up to a point because of the tension stiffening provided by the adhesive. Before failing, the NSMV beams deformed more, and they also provided enough warnings before the failure happened. It has been noted that the tension-reinforced beams with NSM techniques of 0.464% and 0.825% increased the ultimate load by 23.69% and 72.68%, respectively, compared to the control beams. The NSMV beams' working and final deflections of 0.464% were 4.415mm and 12.695mm, respectively. Additionally, the NSMV beams' working and final deflections of 0.825% were 5.355mm and 8.85mm, respectively. As a result, the deflection in the NSMV reinforced beams at the failure load was almost twice as much as it was at the working load, showing that the necessary degree of deflection ductility was attained.

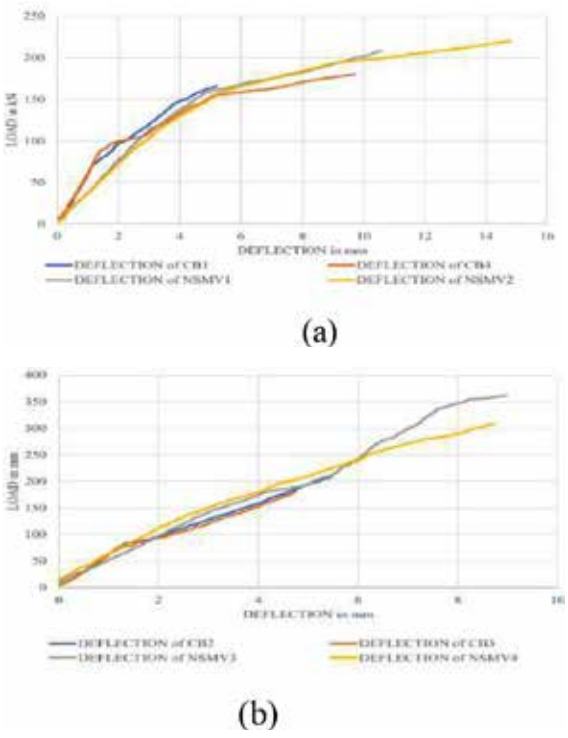


Figure 16(a) shows the combined load vs. deflection curve for the control beams and stronger T-beams using the NSM technique for beams having Pt=0.464%, and Figure 16(b) shows the combined load vs. deflection curve for the control beams and strengthened T-beams using the NSM technique for beams having Pt=0.825%.

As demonstrated in Tables 1 and 2, all strengthened beams behaved similarly to what was seen for the control beam up to the breaking load. Following the cracking load, it is clear that all NSMV beams experienced higher working and ultimate loads than control beams, with percentage increases of 23.69% and 72.68%, respectively. Additionally, the NSMV beams' deflections at ultimate load were higher than those of the control beams, demonstrating that the desired level of ductility had been attained. All of the beams' deflections under working loads, i.e., span/250 = 8, satisfied the IS 456:2000 criterion.

Beam designation	P_{cr} (kN)	P_w (kN)	Avg P_w (kN)	P_u (kN)	Avg P_u (kN)	% Increase compared to CB (%)
CB-1	76	110.667	**115.334**	166	**173**	-
CB-4	90	120		180		
NSMV-1	36	138.667	**142.667**	208	**214**	**23.69%**
NSMV-2	32	146.667		220		

(1)

Beam designation	P_{cr} (kN)	P_w (kN)	Avg P_w (kN)	P_u (kN)	Avg P_u (kN)	% Increase compared to CB (%)
CB-2	86	138.667	**129.334**	208	194	-
CB-3	92	120		180		
NSMV-3	36	241.333	**223.333**	362	335	**72.68%**
NSMV-4	36	205.333		308		

(2)

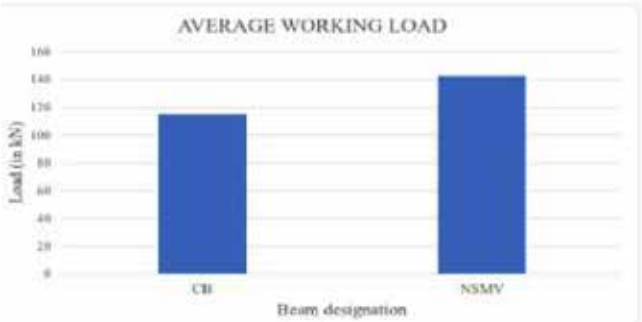
Beam designation	Δ_{cr} (mm)	Δ_w (mm)	Avg Δ_w (mm)	Δ_u (mm)	Avg Δ_u (mm)	Requirement as per IS 456:2000
CB-1	1.34	2.59	**3.01**	5.22	**7.46**	$\Delta_w < 8$
CB-4	1.54	3.43		9.70		**Satisfied**
NSMV-1	0.93	4.01	**4.415**	10.58	**12.695**	$\Delta_w < 8$
NSMV-2	0.85	4.82		14.81		**Satisfied**

(3)

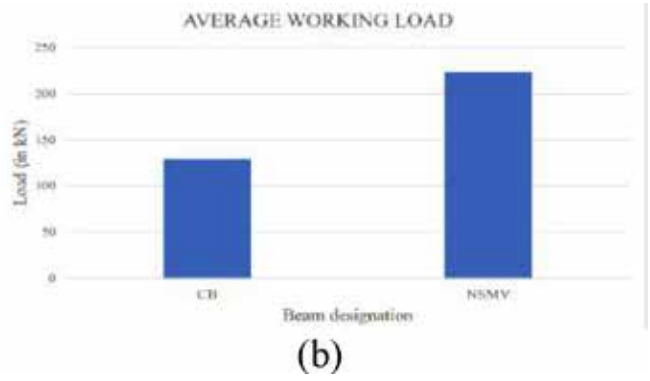
Beam designation	Δ_{cr} (mm)	Δ_w (mm)	Avg Δ_w (mm)	Δ_u (mm)	Avg Δ_u (mm)	Requirement as per IS 456:2000
CB-2	1.56	3.30	**3.14**	5.46	**5.105**	$\Delta_w < 8$
CB-3	1.88	2.98		4.75		**Satisfied**
NSMV-3	0.62	5.94	**5.355**	8.97	**8.85**	$\Delta_w < 8$
NSMV-4	0.43	4.77		8.73		**Satisfied**

(4)

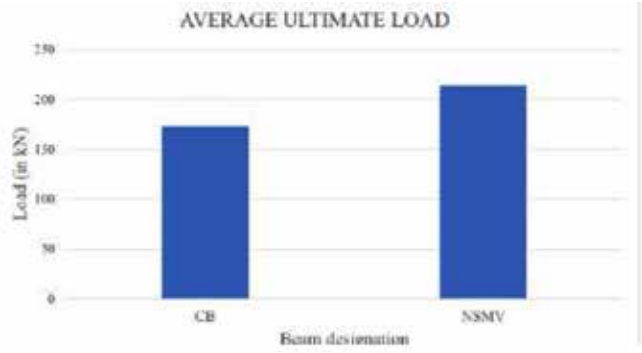
Table Nos. 1 and 2 show the experimental loads of control and strengthened T-beams with Pt values of 0.464% and 0.825, respectively. Table Nos. 3 and 4 show the experimental deflections of control and strengthened T-beams with Pt values of 0.464% and 0.825, respectively.



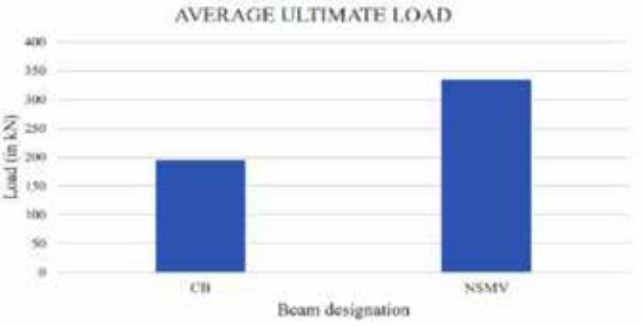
(a)



(b)



(c)



(d)

Fig. 17 (a) shows the average working load of control and strengthened T-beams with Pt=0.464%, (b) shows the average working load of control and strengthened T-beams with Pt=0.825%, (c) shows the average ultimate load of control and strengthened T- beams with Pt=0.464%, and (d) shows the average ultimate load of control and strengthened T-beams with Pt=0.825%.

CONCLUSION

It was decided to study and contrast the performance and behaviour of NSMV beams with control beams by flexural strengthening RC T-beams. Eight T-beams were cast and put to the test as part of the experiment. While the vertical stirrups and compression reinforcement

were made of 8mm diameter bars, the bottom bars of four of the beams were reinforced with 12mm diameter high yield strength deformed bars (Pt=0.464%) and the bottom bars of four other beams with 16mm diameter high yield strength deformed bars (Pt=0.825%). The following findings are reached based on the experimental work done:

- For control beams and strengthened beams with both percentages of steel, the deflection value under the working load was less than 8 mm, which is comparable to Span/250 and satisfies the serviceability standard as per IS 456-2000.
- The NSM approach improved the ultimate load to 23.69% over the control beams of Pt=0.464% and 72.68% over the control beams of Pt=0.825% when the laminate was oriented vertically.
- Up until a cracking stress, all reinforced T-beams behaved similarly to how the control beam did. Indicating the ductile behaviour of NSM beams and thus providing adequate warning before failure, the deflection at the failure load in NSM beams was greater than that of the control beams.
- Interfacial debonding at the FRP-adhesive interface close to the anchorage zone, concrete cover separation, and failure at the laminate-adhesive interface at the concrete-adhesive interface where the laminate and adhesive were peeled off together caused the NSM vertical laminate-strengthened beams to fail.
- Due to its high strength, ideal durability, and compatibility with concrete structures, NSM procedures using vertical CFRP laminates are thus shown to be beneficial in boosting the flexural strength of RC T-beams.

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ANALYSIS AND DESIGN OF SYSTEM INTEGRATION BUILDING

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ABSTRACT

Reinforced concrete (RC) is one of the most common constructions used in residential and commercial buildings due to its high compressive strength and adaptability to various forms and shapes. The use of RC in these structures requires an understanding of its structural system and load transmission mechanism, which includes a combination of structural elements such as slabs, beams, columns, and non-structural elements such as false ceilings. The proper utilization of the structural system helps resist gravitational and lateral loads while transmitting forces to the ground without compromising the integrity of the structure.

Economical construction of concrete structures requires the overall layout of the structure to account for feasibility and cost, which is typically learned through experience and study of past projects. However, the safety of individual members relies more on the theoretical analysis and design, following relevant codes of practice during construction to ensure structural integrity.

Civil engineers are tasked with designing RC structures which require an understanding of basic principles of structural design. Adherence to the relevant codes of practice during construction is essential for civil engineers to ensure the structural safety and integrity of reinforced concrete structures. Understanding the fundamental principles of structural design is imperative for civil engineers involved in projects utilizing reinforced concrete in order to produce safe and reliable engineering structures.

KEYWORDS *: Structural System, Constructability, Civil engineering.*

1. INTRODUCTION

Reinforced concrete (RC) is an essential construction material in residential and commercial buildings, and understanding its structural integrity, load transmission mechanism, and cost effectiveness is paramount for a successful structural system. RC structures are composed of structural elements, such as slabs, beams, and columns, as well as non-structural elements, such as false ceilings, doors, and windows. Structural elements are primarily responsible for resisting gravity and lateral loads while simultaneously transferring forces to the ground. Non-structural elements can also affect the structure's behavior under specific conditions, such as when dead loads are imposed or large openings for doors and windows are created.

When properly designed and detailed in accordance with RC codes of practice and standards, RC structures are effective in resisting both compression and tension forces. The high compressive strength of concrete and versatility in taking various shapes and forms makes

this combination an ideal material for many structural applications. The low tensile strength is offset by steel reinforcement, which enables an effective transfer of loads from structural to non-structural elements and ultimately to the ground.

To ensure the structural safety and integrity of RC structures, it is essential to adhere to the relevant codes of practice and standards. These codes provide guidelines on how to effectively design and construct a safe and durable structure. Furthermore, experience and studying past projects can help maximize economy by optimizing the overall layout and working within the parameters of constructability and cost.

In summary, RC structures are a popular building material due to its high compressive strength and versatility. When designed in accordance with the relevant codes of practice and standards, RC structural systems are effective in resisting heavier gravitational and lateral loads without sacrificing the stability and integrity of the structure. Following these codes and standards, as well as gaining experience from past projects, can ensure maximum economy and safety of RC structures.

2. LITERATURE REVIEW

2.1. Review of relevant literature on RC structures, including previous research, theories, and best practice:

In-depth coverage of the design process of reinforced concrete structures, covering topics such as load calculations, analysis and design of beams, columns, slabs, stairs and footings. The book also provides coverage on design of joint reinforcement and other related topics [1].

On the other hand, N. Krishna Raju's Design of reinforced concrete structures is an easy to understand guide for the design of reinforced concrete structures. It covers fundamentals of design, loads, analysis and design of different reinforced concrete structures like beams, columns, slabs, footings, and other related topics. The book also provides guidance on structural detailing [2].

Both books provide comprehensive coverage of the design of reinforced concrete structures, with S.S. Bhavikhatti's book providing more in-depth coverage on design details, while N. Krishna Raju's book provides an easy to understand introduction to the design process. Both books provide comprehensive guidance to engineers and architects in the design of reinforced concrete structures [1,2].

Reinforced concrete has long been one of the most widely used building materials in the world. It has the advantages of high compressive strength, great fire resistance, durability, and good adaptability to various forms and shapes (Palmquist and Muto, 2019). The performance of reinforced concrete structures is largely determined by the proper design and construction, which requires an understanding of the structural system and load transmission mechanism (Li et al., 2017). To ensure the safety of a reinforced concrete structure, it is essential to adhere to the relevant codes of practice during construction. In addition, familiarity with the characteristics of the structure and its components, such as types of material and reinforcement, is also necessary to ensure compliance with the applicable regulations[1,3].

By understanding the fundamental principles of structural design, civil engineers involved in projects utilizing reinforced concrete can design structures that are safe and reliable. Li et al. (2017) studied the design of reinforced concrete structures for seismic loading, proposing design criteria that take into account the behavior of the structure under transient and cyclic loadings. Additionally, Yang and Xu (2018) analyzed the use of non-structural elements, such as cladding and ceiling, to enhance seismic performance of the reinforced concrete frame. These studies provide valuable insights into the design process of reinforced concrete structures and can help civil engineers in designing safe and efficient systems [2, 4].

2.2. Identification of the existing knowledge

Although reinforced concrete is one of the most widely used construction materials, its design and construction is not without its challenges. In particular, there are certain limitations in the existing knowledge for civil engineers. Firstly, there is a lack of insight into the behavior of reinforced concrete structures under various loading conditions and the effect of non-structural elements such as cladding and ceiling on their performance. Additionally, the identification of failure modes and their impacts on the safety and serviceability of the structure remain largely unexplored. Furthermore, there is a lack of research on the use of recyclable and sustainable

materials in reinforced concrete structures. The use of such materials could contribute to the environmental sustainability of the construction while preserving its safety and durability. Finally, there is a need for an improved understanding of the interaction between the superstructure and its surrounding environment. As such, more research is needed to investigate the role of the existing ground motion in affecting the seismic performance of reinforced concrete structures.

2.3. Stages in Structural Design

- Idealizing the structure into frames and elements.
- Estimating and analyzing the loads.
- Designing sections and reinforcement arrangements.

2.4. Steps followed in structural planning

- Column positions
- Beam locations
- Spanning of slabs
- Layout and planning of stairs
- Type of footing

3. DESIGN METHODOLOGY

Analysing and designing Reinforced Concrete Structures through the use of analytic methods.

3.1 Working stress method (WSM)

3.2 Limit state method (LSM)

3.3 Ultimate load method (ULM)

3.1. Working stress method (WSM)

In the Working Stress Method, loads are applied to the structure and then the critical members of the structure are determined and designed accordingly. This method relies upon the assessment of proportions, based on the load requirements and the load-bearing capacity of the material. Design parameters are calculated by using the stresses developed in the structure, which are then kept within permissible limits.

3.2. Limit state method (LSM)

In the Limit State Method, the structure is designed based on the limit states that describe its performance. This is a more advanced and rigorous method than the WSM, as it involves assessing not only the critical members but also all the components of the structure. Thus, it is more efficient and effective in preventing failures of structures due to adverse loading.

3.3. Ultimate load method (ULM)

The Ultimate Load Method focuses on the deformations and stresses the structure will suffer under ultimate loads. This method is based on the ultimate strength of the material and the capacity of the structure to resist large deformations. The advantage of this technique is that it takes into account both static and dynamic loads and ensures that the structure can handle the maximum load it is likely to be subjected to.

The design of any reinforced concrete structure should always begin with an effective and rational design methodology, based on the applicable codes of practice and standards. The designer must understand the material's strength and how the critical elements of the structure interact together to provide a safe and efficient system that meets the requirements of the project. It is also important to consider the economy of the structure and the environment in which it is located.

4. DESIGN LOAD

The first step in the design process is to determine the types of loads that must be accounted for in the design. This involves identifying the specific types of loads that may affect the structure, such as dead loads, live loads, wind loads, and seismic loads, as well as any other unique loads that may be applicable to the specific structure.

The next step is to determine the magnitude of the loads, which is typically done using engineering calculations or load tables. This step also includes calculating the impact of any load combination scenarios that may affect the structure.

Once the loads have been determined and their magnitudes calculated, the engineer must then decide which materials and building techniques to use. This involves making a selection of materials that can support the loads without failing and creating a design that is cost effective, safe, and meets the project's specific requirements.

Finally, the actual design of the structure is done, which involves creating the detailed plans, sketches, and blueprints required to construct the structure. The plans must account for the loading and materials being used, as well as any design requirements such as drainage, waterproofing, and fire protection.

For design in steel structures, load combinations as per Indian Standard IS 875-1987 should be used. The load combinations for designs are specified under Part 5 of the IS 875-1987. The load combinations are as follows:

Sl. No.	Combinations
1	1.5(DL + LL)
2	1.2(DL+LL+EQX)
3	1.2(DL+LL+EQZ)
4	1.2(DL+LL-EQX)
5	1.2(DL+LL-EQZ)
6	1.5(DL+EQX)
7	1.5(DL+EQZ)
8	1.5(DL-EQX)
9	1.5(DL-EQZ)
10	(0.9DL+1.5 EQX)
11	(0.9DL-1.5 EQZ)
12	(0.9DL+1.5 EQX)
13	(0.9DL-1.5 EQZ)

5. STRUCTURAL SYSTEM AND LOAD TRANSMISSION MECHANISM IN RC STRUCTURES

Structural analysis is the phase of the design effort which involves determining the forces, (external reaction, shear force, moments, internal shears) acting on a structure and the resulting displacements due to applied loading. The aim of structural analysis is to gain an understanding of the response of the system to the loading, and to compare it to the expected performance.

5.1. Proposed Structure GUI

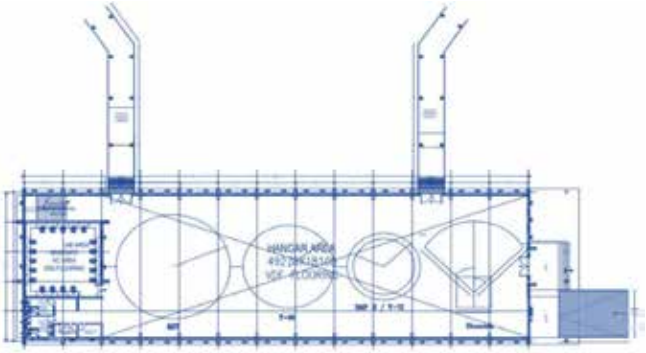


Fig.1 (a) GROUND FLOOR PLAN

Fig.1 (b) FIRST FLOOR PLAN

5.2 Proposed Structure Terms

The System Integration Building of 11m height, with a G+1 storey office attached to it, is located in the city of Chennai, India. With an area of 1091.328 sq. m, it is a RCC framed industrial structure with a storey height of 3.3 m each and is primarily used for the storage of machinery.

Materials used:

- Grade of concrete: M25
- Grade of steel: Fe500 and Fe415 (for confinement bars)
- Soil Bearing Capacity: 2 m below Natural Ground Level = 200 kN/m2
- Support conditions: Fixed

In Typical floors :	**In Terrace :**
Live Load = As per IS 875 part II:1987 Super Dead Load = Floor Finish - 1.5 kN/m^2. Ceiling Plaster Load - 0.50 kN/m^2. Partition Wall Load (if applicable) - 1.5 kN/m^2.	Live Load = 1.5 kN/m^2 Super Dead Load = Floor Finish - 1.5 kN/m^2. Waterproofing Load - 0.8 kN/m^2. Ceiling Plaster Load - 0.5 kN/m^2.

Wall load:

Type of wall	Beam size (Trail sections taken in mm)	Full Wall Load kN/m	85% of Full Wall Load kN/m
Main walls	230 X 450	3.3X0.23X20 =15.18	12.903
		6X0.23X20 =27.6	23.46
		3.5X0.23X20 =16.1	13.685
		4.2X0.23X20 =19.32	16.422
	300 X 750	3.3X0.3X20 =19.8	16.83
		6X0.3X20 =36	30.6
		3.5X0.3X20 =21	17.85
		4.2X0.3X20 =25.2	21.42
Parapet wall	-	0.115x 1.2 x 20 = 2.76	-

Seismic Load:

Seismic Zone: II (Z=0.10) Soil type: II

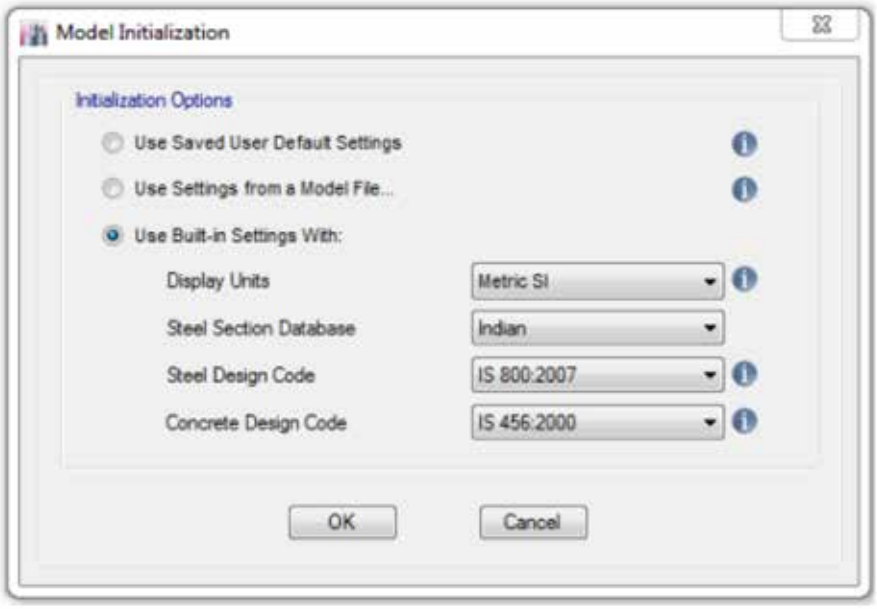
Importance factor: 1 Response reduction factor: 3

Damping: 5% IS 1893(Part-1):2016. EQ length (x): 0.26018 sec EQ width (y): 0.37037 sec

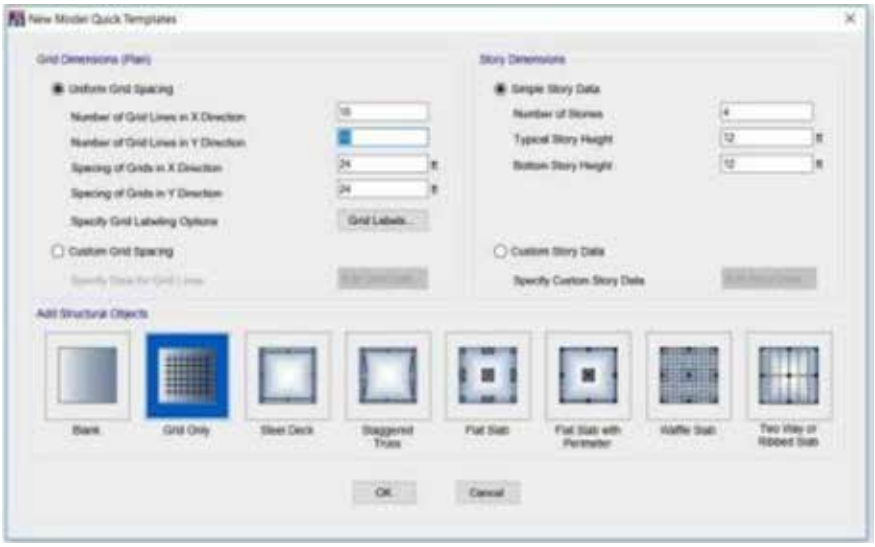
6. FUTURE TRENDS

In the future, reinforced concrete structures will continue to evolve to meet the changing needs of society. This will include the use of advanced materials and construction techniques to increase sustainability, energy efficiency, and seismic resistance. For example, the application of fiber- reinforced polymer technology to RC structures has the potential to improve their structural performance and minimize degradation due to environmental factors. Additionally, the addition of smart materials can be used to reinforce existing structures and improve their seismic response. Other emerging trends in reinforced concrete include the use of precast and tilt-up construction, as well as use of self-consolidating concrete and 3D-printed concrete. Finally, the use of prefabricated components and lightweight solutions is becoming increasingly popular in order to cut costs and speed up the construction process.

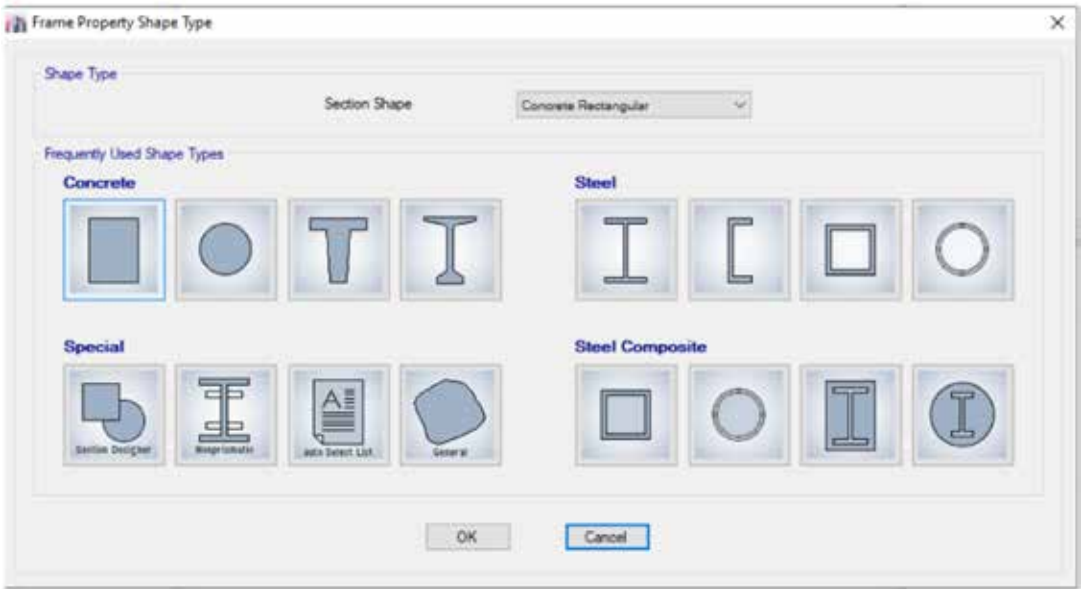
3D models are generated using a 3D modeling software like ETABS, Autodesk 3ds Max, Blender, or SketchUp. This step involves constructing walls, doors, windows, roofs, columns, stairs, and detailing for the project. The model should be constructed per the specifications set forth in the architectural plan. Additionally, any materials and textures should be added to the 3D model to provide a full representation of the project. Finally, the model is ready for rendering and/or further post-processing.



Model Initialization form



The New Model Quick Templates form can also be used to create new grid-based view templates, add text elements, image previews and color palettes to the templates, and customize the template to suit the user's needs and preferences. In addition, the form allows users to configure the view size, margins, background color and other layout specs, as well as save custom templates for future reuse.



Frame Property Shape Type form

6.1 Plan and 3D model after applying all properties

The plan for constructing a concrete structure should consider the structural members (columns and beams) that must be placed to support the entire load-bearing weight of the structure. The plan should also consider the layout of non-structural elements such as false ceilings, ducts, windows, and doors which affect the overall layout of the building. The 3D model should illustrate the overall layout of the structure including the placement of columns, beams, and other non-structural elements such as false ceilings, ducts, windows, and doors. The model should also visualize the actual dimensions of the structural members, such as beam width and depth in order to accurately assess the overall strength of each element. In addition, the model should provide information about the various materials and reinforcement used to construct the structure, including

steel bars, mesh, and other concrete reinforcements. Lastly, the model should account for the total load bearing capacity of the concrete structure.

6.1.1 Design checks and calculations:

Civil engineers must verify the structural integrity of the building with design checks and calculations for reinforced concrete structures. This includes checking the load bearing capacity of columns and beams, and ensuring that proper reinforcement is used. Additionally, civil engineers must check the compatibility of different members such as beam-column connections. Furthermore, engineers must calculate the deflection of members under different load conditions as well as verify if cracking of the concrete may result in structural failures. Finally, safety factors must also be considered with each design check and calculation for reinforced concrete structures to ensure the building's structural integrity.

Fig 2. 3D model created with ETABS

CONCLUSION

- The dimensions of the structural components have been checked to ensure compliance with serviceability criteria and are found to be sufficient for use.
- The results obtained from ETABS revealed that dead and live loads were more predominant than earthquake forces.
- It can be concluded that, when the storey height is increased, both the shear force and bending moment in beams and columns will also increase.
- In conclusion, the analysis and design results obtained from software are reliable when compared with manual calculations and design. This indicates that software is a reliable tool to predict the outcome of an engineering project. Moreover, software can save time and money, as well as increase the accuracy and efficiency of the engineering design process.
- ETABS software enables fast analysis and design process by reducing the time required.

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A STUDY ON HARDENED PROPERTIES OF CONCRETE WITH PARTIAL REPLACEMENT OF STEEL SLAG AS FINE AGGREGATE AND MARBLE WASTE AS COARSE AGGREGATE

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ABSTRACT

Disposing the waste materials directly into the environment can lead to various problems. Therefore, partial replacement of aggregates with steel slag and marble waste would lead to full-size environmental benefits which have been emphasized in this paper. Experiments had been conducted for M25 grade concrete and designed as per the IS code. The metal slag and marble wastes were appropriate cut down to the required measurement of high-quality and 'CA' respectively. Then the steel slag was blended with the concrete as 'FA' in the percentage of 25%, 35% and 45%. It was obtained that 35% was optimum percentage alternative of 'FA' as steel slag. Then the concrete is casted by partially replaced steel slag of 35% which is mixed with 'FA' as constant and marble with vary percentages of 35, 40 and 45% with 'CA' and allowed to cure for 28 days. The results were compared with conventional concrete. By partially replacing 40% of marble aggregate to coarse aggregate and 35% steel slag to fine aggregate mix were as found to be favorable.

KEYWORDS *: Steel slag, Marble waste, Durability.*

1. INTRODUCTION

Concrete is special amongst the most important building substances due to the fact it is designed specifically for civil engineering projects. It plays a virtual role in the sketch and construction of the nation's infrastructure. Aggregate occupies about 60 to 80% of the Total volume of concrete and affects the freshness and hardness residences of concrete. Out of the complete consumption of the concrete around 40 to 60% and high-quality combination consumes around 20 to 30% of the volume. To meet the world demand for concrete in the future, it is becoming a greater challenging task to locate appropriate choices to alternative aggregates for getting ready concrete. The purpose of this study is to find out the appropriate fabric for substitute of fine aggregate and coarse aggregate in concrete and discover the feasibility of utilizing the steel slag produced by way of steel mills and marble wastes produced by the marble quarries in Tamil Nadu place as a replacement for alternative aggregate in the concrete. Steel slag aggregates normally exhibit the manageable

to expand due to the presence of unhydrated free lime and magnesium oxides which hydrate in humid environments and the waste marble aggregates have about 10% water absorption characteristic of natural conventional aggregate, and additionally, compared to the Natural aggregate, the marble aggregate lacks finer components. If such merchandise is used in the concrete, it enhances each the mechanical and physical homes of concrete along with its durability.

2. OBJECTIVES

- To find the optimum percentage of steel slag when partially replaced with natural river sand.
- To find the optimum percentage of marble waste partially replace with natural stones.
- To find the mechanical properties of concrete when partially replace with steel slag and marble waste to some of the fine aggregate and coasre aggregate.

2.1 Literature Review

Rohit Jeengar [1], In this paper, The marble was partially replace with Coarse aggregate at varying % of 0,10,20,30,40,50%. It was concluded that 'compressive strength' of the concrete cubes after 7 & 28 days of curing increases till 40% replacement of marble waste to Coarse aggregate and decrease at 50% replacement.

Shailja Bawa, Asif Basheer, Baban kumar [2], this paper refers the effect of steel slag as partial replacement of fine aggregate was replaced with steel slag for 20,30,40% by with concrete cube and beams specimens were tested at 7,28,56,90 days of curing. The observed results showed that specimen containing 35% steel slag and 20% fly ash & 10% metakaolin has higher strength.

Ashok Vyas and Sudarshan Kore [3], In this study, marble aggregate was substituted for the traditional natural 2 coarse aggregate in various weight percentages (20, 40, 60, and 80% of the M10 concrete mix, developed in accordance with IS regulations). When coarse aggregate is replaced with marble aggregate, the compressive strength increases by 40%.

Krishna Prasanna and Venkata Kiranmayi [4], This paper deals with the implementation of steel slag as an affective replacement for fine aggregate. The specimen were casted after replacing fine aggregate partially varying % of steel slag namely 5%,10%,15%,20%,25%,30%,35% The test's findings revealed that there was an increase in strength at 35% slag ratio & decline beyond 25% replacement ratio.

3. MATERIALS AND METHODS

The different materials were used in this test program are as follow:

3.1 Cement

Ordinary Portland Cement (OPC) 53 grade cement is used (IS:8112,1989).

3.2 Fine Aggregate

As fine aggregate, the natural river sand was employed (size not more than 9 mm) (IS:383, 1970)

3.3 Coarse Aggregate

As coarse aggregate, natural stones that were accessible locally were employed. (Size more than 9 mm) (IS: 383,1970).

3.4 Water

Locally available natural water-such that the pH value of water should be less generally, less than 6 was used.

3.5 Steel Slag

The waste material coming over from the steel-producing industry is known as steel slag. Consideration is given to the fine material that was replaced, which passed through a 2.36 passing on 600 sieve. In Fig. 1 refers the steel slag.

Fig 1. Steel Slag

3.6 Marble Waste Aggregate

Industries that manufacture marbles produce marble waste. it is replaced to coarse aggregate, which passes through a 20 mm passing 12.5 mm sieve. Fig 2 refers marble waste and Tables 1 & 2 listed the material's physical characteristics.

Fig 2. Marble waste aggregates

Table 1. Physical properties of cement

SL No	Properties	Cement
1.	Specific Gravity	3.13
2.	Consistency	30%
3.	Initial Setting Time	57 min

Table 2: Physical Characteristics of Coarse and Fine Aggregates

Sl No	Properties	Fine Aggregate		Coarse Aggregate	
		FA	SA	CA	MW
1.	Specific Gravity	2.31	3.03	2.71	2.69
2.	Fineness Modulus	3.17	3.12	6.64	6.52
3.	Water Absorption	0.41	0.31	0.51	0.05

3.7 Mix Design

The process of choosing appropriate materials, such as cement, aggregate, and water, and their relative proportions with the aim of making concrete with the needed minimum strength, workability, and durability as efficiently as feasible is known as mix design. The primary goal is to reach the minimum strength and durability requirements. The second goal is to produce concrete as cheaply as possible. Ordinary grade concrete and standard grade concrete were the varieties of concrete utilized in this experiment Using IS: 10262 (2009), the mix proportion of ordinary grade and standard grade concrete is developed, and the mix proportion is obtained using the W/C ratio of 0.51. Fresh concrete was measured to have a 50 mm slump.

3.8 Mix Proportions

Concrete mixtures were made with varying percentage of steel slag and marble waste aggregate. The specimens were examined to determine the outcome of each experiment. The dry weights of the coarse and fine aggregates for each mixture were used to calculate the mix proportions. All specimens had a consistent water- cement ratio of 0.51. Making and Preparing Test Specimens Three numbers of cubes measuring 150 mm by 150 mm by 150 mm and three numbers of prisms measuring 100 mm by 100 mm by 500 mm were cast for each mixture, and they were each given a 28-day curing period.

3.9 Preparing and Casting of Test Specimens

Three numbers of cubes measuring 150 mm by 150 mm by 150 mm and three numbers of prisms measuring 100 mm by 100 mm by 500 mm were cast for each mix, and they were both 6 cured for 28 days.

3.10 Testing of Specimens

To determine the 'compressive strength' on concrete were casted three cubes and also to determine flexural strength on concrete were casted three prisms for each, this specimen as tested after 28 days of cured. The standards were followed when conducting these tests. The test findings were compared to the values of the standard concrete specimens using different percentages of marble and steel slag waste.

4. RESULTS AND DISCUSSION

Tables 3 and 4 provide the findings of the 'compressive strength' tests conducted on the concrete test specimens. The use of marble waste as 'CA' at varied percentages of 35%, 40%, and 45% resulted in an increase in the 'compressive strength' of the concrete, according to the data obtained. The 'compressive strength' values of all concrete mixes are increased by 1 when the percentage of the material is increased, matching those of the control concrete specimens. In Fig 3 refers compressive strength of the sample specimens.

Fig 3. Compressive strength

Table 3. Compressive Strength of Specimens Using Steel Slag at 28 days

Sl No.	Mix	Compressive Strength (N/mm^2)
1.	Conventional concrete	32.79
2.	25% Steel slag replacement to FA	32.64
3.	35% Steel slag replacement to FA	33.12
4.	45% Steel slag replacement to FA	32.84

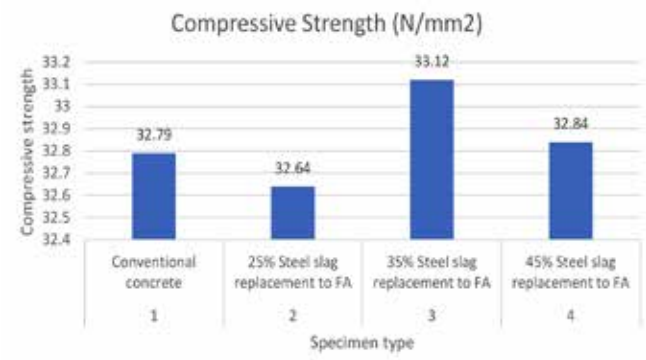

Fig 4. 'Compressive Strength' of Steel Slag Replacement to 'FA'

The higher strength was developed in the concrete specimens cast with 35% Steel slag and 40% marble waste.

Table 4. Compressive Strength Using Steel Slag and Marble Waste at 28 days

Sl No.	Mix	Compressive Strength (N/mm^2)
1.	Conventional concrete	32.79
2.	(35% Steel slag replacement to FA + 35% Marble waste replacement of CA)	32.21
3.	(35% Steel slag replacement to FA + 40% Marble waste replacement of CA)	33.29
4.	(35% Steel slag replacement to FA + 45% Marble waste replacement of CA)	32.94

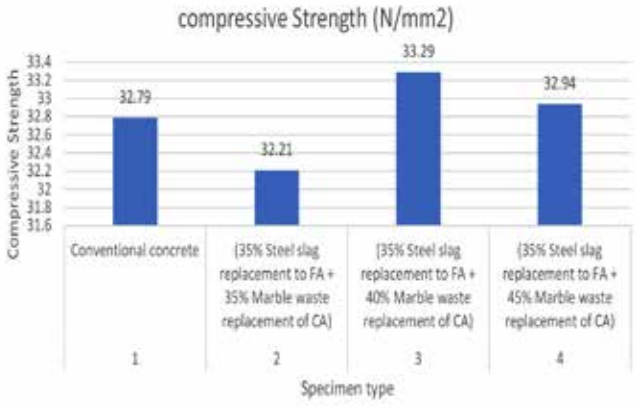

Fig 5. Compressive strength of steel slag replacement to 'FA' and marble waste replacement to 'CA'.

3.2 Flextural Strength Test

Prisms of size 100×100×500mm were cast, for every mix we casted 3 prisms, after the casting, demolded after 24 hrs and cured for 28 days. The specimens were take out from the water tank, weighted and tested for modulus of rupture under two-point loading in a flextural testing machine according to IS:516 (1959). The centre-to- centre distance between supports were measured and the maximum load P and the failure load is recorded. The modulus of rupture was calculated as per IS: 456 (2000). Fig 6 refers fextural test conducted.

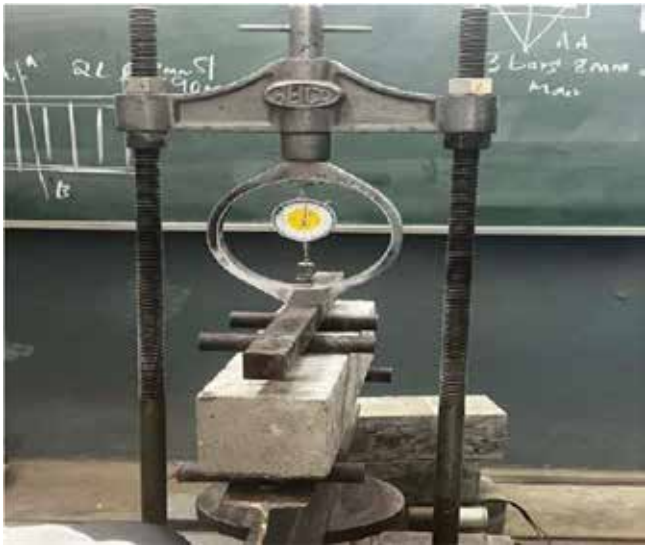

Fig 6: Flextural test

The specimens were examined to determine the outcome of each experimental 1. The dry weights of the coarse and fine aggregates for each mixture were used to calculate the mix proportions. All specimens had a consistent water-cement ratio of 0.51.Making and Preparing Test Specimens Three numbers of cubes measuring 150 mm by 150 mm by 150 mm and three numbers of prisms measuring 100 mm by 100 mm by 500 mm were cast for each mixture, and they were each given a 28-day curing period. In table 5 listed the flextural strength results.

Table 5. Test Results or Flextural Strength of specimens at 28 days

Sl No.	Mix	Average Flexural Strength (fb)(N/mm^2)
1.	Conventional concrete	6.69
2.	(35% Steel slag replacement to FA + 35% Marble waste replacement of CA)	6.68
3.	(35% Steel slag replacement to FA + 40% Marble waste replacement of CA)	6.81
4.	(35% Steel slag replacement to FA + 45% Marble waste replacement of CA)	6.77

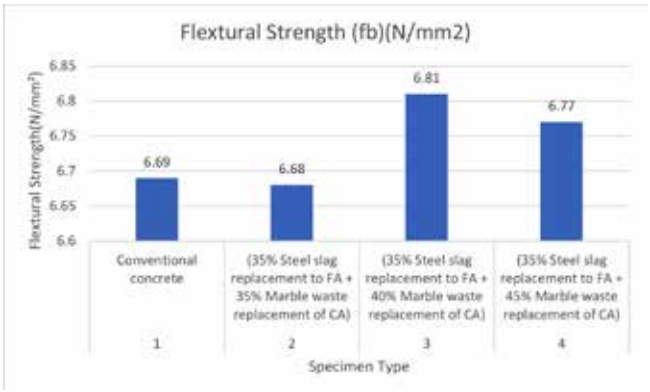

Fig 7. Flexural strength(N/mm^2)

CONCLUSION

It is observed that partial replacement of steel slag to fine aggregate and marble waste aggregate to coarse aggregate, for which mechanical properties has been conducted.

- The 'Compressive strength' of concrete has been increased by 1.01% compared to conventional concrete when steel slag is replaced by 35% to 'FA'.
- The 'compressive strength' of concrete has been increased by 1.52% when compared to conventional concrete when steel slag replaced to 'FA' and marble waste replaced to 'CA'.
- The Flexural strength of the concrete has been increased by 1.79% when compared to conventional concrete when steel slag replaced to 'FA' and marble waste replaced to 'CA'.

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STABILIZATION OF SOIL EFFECTED BY INDUSTRIAL EFFLUENTS – THROUGH MECHANICAL STABILIZATION

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ABSTRACT

In India, soil contamination is a significant environmental issue. The soil surrounding a water body, such as a lake, becomes contaminated when effluents from industries are dumped into the environment, which causes the embankment to deteriorate and allow water to seep into the ground. The land around the lake needs to be stabilised in order to stop this. The process of changing soil characteristics in order to improve the soil's engineering properties is known as soil stabilisation. Since chemical stabilisation is costly, the current research aims to stabilise the soil by mechanical means using waste materials such as lime (as primary stabiliser) and rubber tyre powder (as secondary stabiliser). This will improve the quality of the soil and be validated by carrying out various tests such as CBR, optimal moisture content, unconfined compressive strength, etc. In order to strengthen or improve the engineering qualities of the polluted soil, such as OMC and Liquid Limit, which are crucial in the current situation, we apply the ideal amount of stabilisers and their combination to the soil. and ensuring that it is suitable for civil works such as the subgrade for roads, railroads, canals, and embankments, among others.

KEYWORDS *: Mechanical stabilization, stabilizer, CBR, unconfined compressive strength, optimum moisture content.*

1. INTRODUCTION

One of the main issues in routine civil construction projects is dealing with soft subgrade/clayey soil. The same thing might happen when building a road or a motorway. Soil stabilisation is one of numerous methods for making improvements to soil. To increase the strength and durability of the soil, materials are blended and mixed with it during the soil stabilisation process. To put it another way, it is the aggregation of soil particles.

1.1 Mechanical Stabilization

It is the earliest technique for stabilising soil. By

altering the gradation of the soil and compacting it with various rollers, pestles, vibration techniques, and occasionally even blowing, the qualities of the soil are improved with this procedure. By eliminating air gaps, adding geotextile materials like clay liners and pipes, adding some graded aggregates, etc., the method aims to enhance the current soil mass. These steps are mostly taken to increase bearing capacity, strengthen the soil, and decrease permeability. Compaction serves to increase the soil's compressive strength, and geotextile fibre reinforcing boosts the soil's tensile strength.

1.2 Biological Stabilization

When bacteria are introduced into the soil, they leave behind CaCO3, which causes the soil to cement and plug, increasing its strength and bearing capacity. Technically known as "microbial induced calcite precipitation" (MICP), this technique precipitates calcium carbonate into the soil matrix using soil microbial activities. By holding soil particles together, the resulting calcium carbonate increases soil strength and lowers water conductivity.

1.3 Chemical Stabilization

This class of soil stabilisation primarily relies on chemical reactions between soil particles and chemical additives, which later build a powerful network that binds the soil grains together to produce the desired effect. The fundamental benefit of chemical stabilisation is that catalysts and inhibitors can be used to regulate the setting time and setting time.

2. MATERIALS & METHODOLOGY

Soil Sample: Contaminated soil sample was obtained from Jigani Lake, Bengaluru. The soil sample was dried in an oven at 110 degrees Celsius for 24 hours.

Lime: To obtain lime, limestone is first extracted from quarries and mines. To achieve the best performance in the production of acetylene, pure calcium oxide is fused with coke.

Rubber Tyre Powder: Tyres and tyre waste, such as tyre balls, tyre scraps, crumb and rubber powder, have been used in a variety of engineering applications, including seepage disperse and as absorbents, as well as for highways, in embankments, in erosion control and as aggregates as well, as a substitute for asphalt. The properties of the soil sample collected were tested in the laboratory which are tabulated as in Table 1

Table 1: Properties of Soil Sample

Properties	OMC (%)	MDD (g/cc)	CBR (%)	LL (%)	PL (%)	UCS (kg/cm^2)
Soil sample	23	1.1	3.9	45	29	0.8

3. EXPERIMENTAL WORK

The stabilizers were added to the soil sample in varying amounts as follows.

1) Soil sample + 5% lime
2) Soil sample + 5% lime + 5% Rubber Tyre Powder
3) Soil sample + 5% lime + 10% Rubber Tyre Powder
4) Soil sample + 5% lime + 15% Rubber Tyre Powder
5) Soil sample + 5% lime + 20% Rubber Tyre Powder

After addition of Stabilizers, various tests were carried out and the results obtained are tabulated as follows

Table 2: Liquid Limit

SAMPLE TYPE	LIQUID LIMIT
Soil sample	45
Soil sample + 5% lime	42.5
Soil sample + 5% lime + 5% RTP	39.8
Soil sample + 5% lime + 10% RTP	33.72
Soil sample + 5% lime + 15% RTP	27.9
Soil sample + 5% lime + 20% RTP	24.8

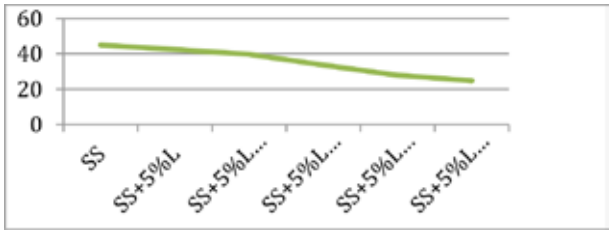

Chart -1: Variation in liquid limit

Table 3: Plastic Limit

SAMPLE TYPE	PLASTICLIMIT(%)
Soil sample	29
Soil sample + 5% lime	28.7
Soil sample + 5% lime + 5% RTP	29.2

Soil sample + 5% lime + 10% RTP	24.56
Soil sample + 5% lime + 15% RTP	20.61
Soil sample + 5% lime + 20% RTP	17.87

Table 4: Optimum Moisture Content

SAMPLE TYPE	OMC(%)
Soil sample	23
Soil sample + 5% lime	20.5
Soil sample + 5% lime + 5% RTP	18.23
Soil sample + 5% lime + 10% RTP	15.19
Soil sample + 5% lime + 15% RTP	14.6
Soil sample + 5% lime + 20% RTP	13.8

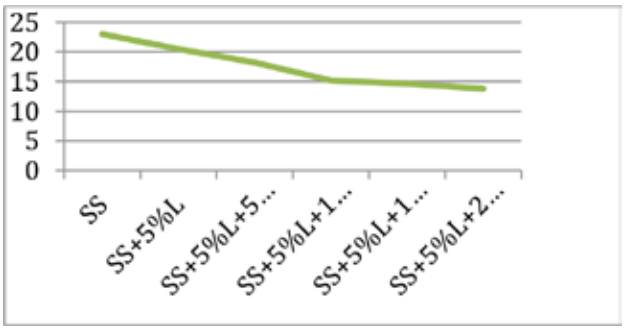

Chart 2: Variation in OMC

Table 5: Maximum Dry Density

SAMPLE TYPE	MDD(g/cc)
Soil sample	1.1
Soil sample + 5% lime	1.2
Soil sample + 5% lime + 5% RTP	1.39
Soil sample + 5% lime + 10% RTP	1.56
Soil sample + 5% lime + 15% RTP	1.7
Soil sample + 5% lime + 20% RTP	1.83

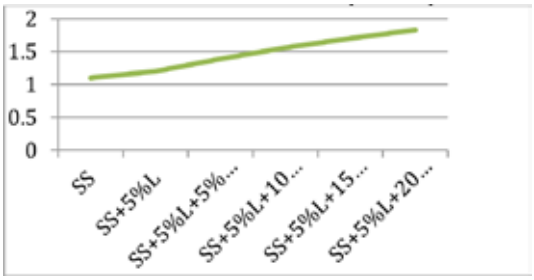

Chart 3: Variation in MDD

Table 6: Unconfined Compressive Strength

SAMPLE TYPE	UCS(kg/cm^2)
Soil sample	0.8
Soil sample + 5% lime	0.92
Soil sample + 5% lime + 5% RTP	1.1
Soil sample + 5% lime + 10% RTP	1.25
Soil sample + 5% lime + 15% RTP	1.4
Soil sample + 5% lime + 20% RTP	1.6

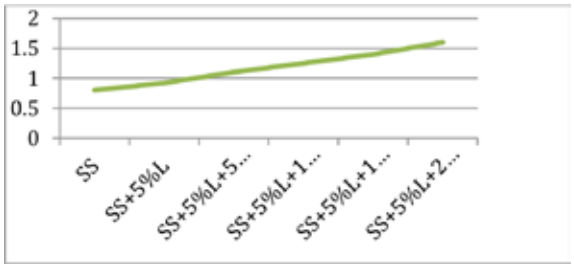

Chart 4 Variation in UCS

Table 7: California Bearing Ratio

SAMPLE TYPE	CBR(%)
Soil sample	3.9
Soil sample + 5% lime	4.3
Soil sample + 5% lime + 5% RTP	4.7
Soil sample + 5% lime + 10% RTP	5.2
Soil sample + 5% lime + 15% RTP	5.6
Soil sample + 5% lime + 20% RTP	6.01

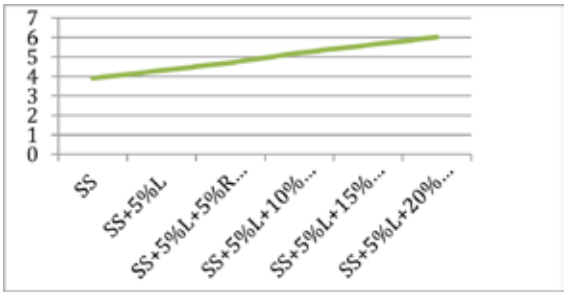

Chart 5: Variation in CBR

3. CONCLUSIONS

1. It should be noted that the liquid limit decreased from 45% to 24.8% and the plastic limit from 29% to 17.87% on adding 5% lime and 20% RTP.
2. Addition of 20% RTP and 5% lime increased MDD from

1.1 to 1.83 g/cm3 and decreased OMC from 23% to 13.8%.

3. In addition, the addition of 20% RTP and 5% lime increased the CBR and UCS values from 3.9% to 6.01% and from 0.8 to 1.6 kg/cm^2.

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EXPERIMENTAL INVESTIGATION ON RETROFITTING OF FLEXURAL DEFICIENT REINFORCED CONCRETE BEAMS USING FABRIC REINFORCED CEMENTITIOUS MORTAR

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ABSTRACT

Fabric reinforced cementitious mortar (FRCM) is an emerging and promising new class of structural material which finds its application in repair, retrofit and rehabilitation of RC and masonry structures. FRCM is considered as an alternative to ferrocement where the steel mesh reinforcement is replaced with such as carbon, basalt, PBO, glass mesh etc. This paper presents the effectiveness of FRCM in retrofitting of flexural deficient RC beams. Experimental tests are carried out on flexural deficient pre-cracked RC beams retrofitted with glass FRCM.

INTRODUCTION

Deterioration with time is the most common problem associated with RC structures due to aging, overuse, exposure to aggressive environments, lack of maintenance, internal reinforcement corrosion, excessive loading, poor design and application of external forces like earthquake etc. Hence there is an urgent need to come up with feasible economic alternative retrofitting and rehabilitation methods to restore the RC structures to its original capacity. Some of the commonly adopted methods to address the deterioration problem associated with RC structures are: (a) Installation of fibre reinforced polymer (FRP) composite systems, (b) Steel plate bonding, (c) Installation of the near surface mounted (NSM) bars and (d) External post tensioning.

FRP systems have gained worldwide acceptance and popularity to address the issues related to the strengthening of the existing RC structures due to High tensile strength light weight, relative ease of installation and resistance to corrosion. In spite this FRP systems, throws some drawbacks: such as Lack of vapour permeability – leads to accumulation of moisture, resulting in damage of the substrate, Poor behaviour at service temperature, Incompatibility with wet surface and non-sensitivity to low temperature application, Strength degradation when exposed to ultraviolet radiation, Poor fire protection, and Bonding agents could be a toxic hazard.

All these issues are primarily associated with the use of epoxy (organic binders) in FRP systems. One way of addressing this problem is by replacing the organic

binder with an inorganic binder like cementitious matrix. This idea of incorporating cement mortar with brand-new category of composites under the name FRCM, FRCM is a composite made of cement based mortar reinforced by fiber fabric identifies with the following acronyms: Textile reinforced mortar (TRM), Textile reinforced concrete (TRC), Mineral based composites (MBC) or Fiber reinforced cement (FRC).

Angelo et, al., (2011) carried out an experimental study on the effectiveness of carbon and PBO FRCM and compared it with carbon FRP. The results showed that both PBO- FRCM and carbon FRP contributed an equal amount of strength enhancement, whereas the carbon FRCM system showed marginal strength enhancement.

LITERATURE REVIEW

Saman Babaeidarabad et, al,. (2014) performed the experiments on beams retrofitted with PBO-FRCM under three-point bending. The flexural capacity of the PBO-FRCM strengthened beams is calculated based on the analytical methods given by ACI 549 code. And its suitability is assessed. The results indicated that PBO-FRCM improves the flexural strength of RC beams depending on the amount of PBO-FRCM applied (one ply and four plies). Sectional analysis following the methodology according to ACI 549 shows that predicted flexural strength underestimates the experimental results with reasonable accuracy.

Objectives:

- To study the behaviour of flexural deficient reinforced concrete beams retrofitted with glass FRCM
- To examine the cracking behaviour of the pre-cracked beam retrofitted with glass FRCM.
- To observe the modes of failures exhibited by the FRCM retrofitted beams.
- To study the effectiveness of glass FRCM with varying the number of layers.

EXPERIMENTAL PROGRAMME

The experiments were carried out to study the effectiveness of externally applied glass FRCM in retrofitting flexural deficient beams. Six beams of dimension 1700 mm X250 mmX125 mm were tested under a two-point load. The beams are designed as flexural deficient by adopting $\rho s = 0.74 \times (\rho s)B$, where ρs is the percentage of steel adopted for the flexural deficient section. $(\rho s)B$ is the percentage of steel required for the balanced section. The above designs are carried out as per IS 456: 2000 guidelines.

The reinforcement provided is HYSD bars of Fe -500 grade. The main parameter investigated in the present study is the number of glass FRCM layers (2 and 4).

Table 1: Description of beams

Sl. No.	Beam designation	No. of beams	Description
1	CB	2	Control beam
2	GFRB-2L	2	Pre-cracked beam retrofitted with 2 layers of glass FRCM
3	GFRB-4L	2	Pre-cracked beam retrofitted with 4 layers of glass FRCM

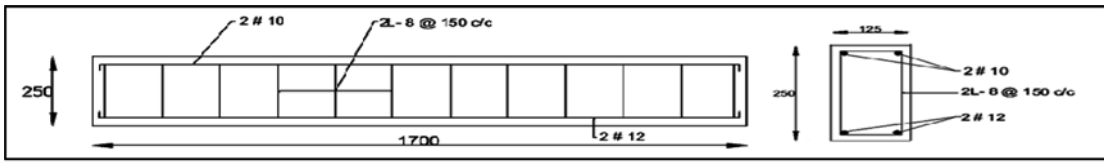

Fig 1. Details of reinforcement

Materials: M30. Grade concrete proportioned as per IS 10262-2019 guidelines with 100mm slump.

Glass fabric

The glass fabric obtained by Shri Premolite Industries Ghaziabad (U.P), was used in the present experiments.

The Properties are tabulated in Table 2.

Table 2: Properties of glass fabric

Sl. No.	Test Conducted	Results
1	Thickness (mm)	0.66
2	Mass / square meter (kg)	0.307
3	No. of holes / square meter	31781
	No. of holes / sq. inch	20

4	Tensile Breaking Load (N) a. Sample Width - 36.0 mm b. Sample thickness - 0.66 mm c. Grip to grip length – 300 mm	1220

The average cube compressive strength of concrete on the day of testing of beams was 42.66 MPa.

The mortar grade adopted for this experimental study is MM7.5. As per the guidelines of IS: 2250-1981, the mix proportion for MM7.5 is cement: sand = 1:3. The water content is maintained to get working consistency.

Fig 2. Testing of glass fabric

Retrofitting of pre-cracked beams

- The beams were loaded up to get the first crack under two-point loading conditions. The load was released and taken for retrofitting.
- The bottom surface of the beams was cleaned and made rough using a hammer to provide proper bonding.
- The cement Mortar of proportion 1:3 was prepared for required consistency
- Firstly, one layer of cement mortar was applied to the bottom surface of the beam then the glass fabric was laid and pressed.
- After that one more layer of mortar and glass fabric was laid and pressed.
- The above-said procedure was repeated for retrofitting of four layers of glass fabric.
- The retrofitted beams were cured for 28 days using wet gunny bags.

Experimental setup and testing procedure

- After curing, the control beams and the strengthened beams for 28 days, the beams were tested for ultimate strength.
- For easy identification of cracks, the beams were whitewashed before testing.
- The primary adjustments were made to ensure the load is symmetrically applied as shown in the figure.
- The beams were tested under two-point loading using a loading frame of 50 tons capacity.
- Three dial gauges are used to measure the deflection of the beams, under center, and the points below the loading.
- The crack width was also measured using the microscope with least count 0.003 mm.
- The increment of loading adopted throughout the experiment was 2 kN. And the deflection noted for each incremental loading.
- The Load at first crack, and the ultimate load for each beam were noted for controlled and strengthened beams.
- Three dial gauges are used to measure the deflection of the beams, under center, and the points below the loading.
- The crack width was also measured using the microscope with least count 0.003 mm.
- The increment of loading adopted throughout the experiment was 2 kN. And the deflection noted for each incremental loading.
- The Load at first crack, and the ultimate load for each beam were noted for controlled and strengthened beams.

Fig 4. Retrofitting of pre-cracked beams

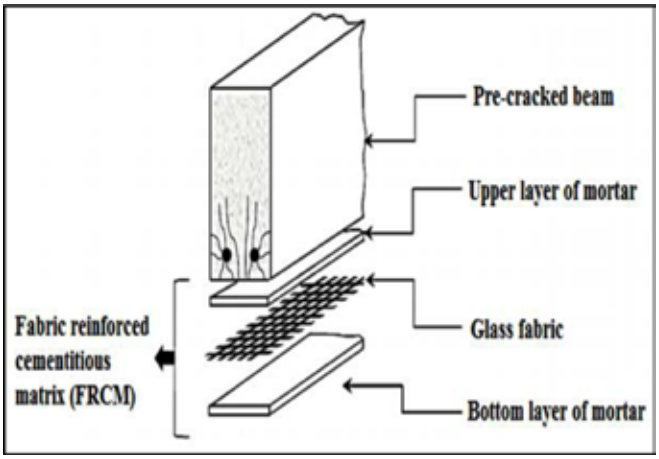

Fig 5. Flexural retrofitting of pre-cracked beam

Fig 6. Experimental setup of beam testing

RESULTS AND DISCUSSION

- The beam specimen was tested under four-point bending. The average cracking load and ultimate load of control beams were found to be 27 kN and 96 kN respectively. The mode of failure in control beams is due to the crushing of concrete in the compression zone after the yielding of steel reinforcement.
- The average cracking load and ultimate load of beams retrofitted with 2 layers of glass FRCM were found to be 39 kN and 119 kN respectively, and the beams retrofitted with 4 layers of glass FRCM were found to be 45 kN and 133.5 kN respectively. The mode of failure observed in the retrofitted beams is fabric rupture in the matrix exactly at the center of the beam.

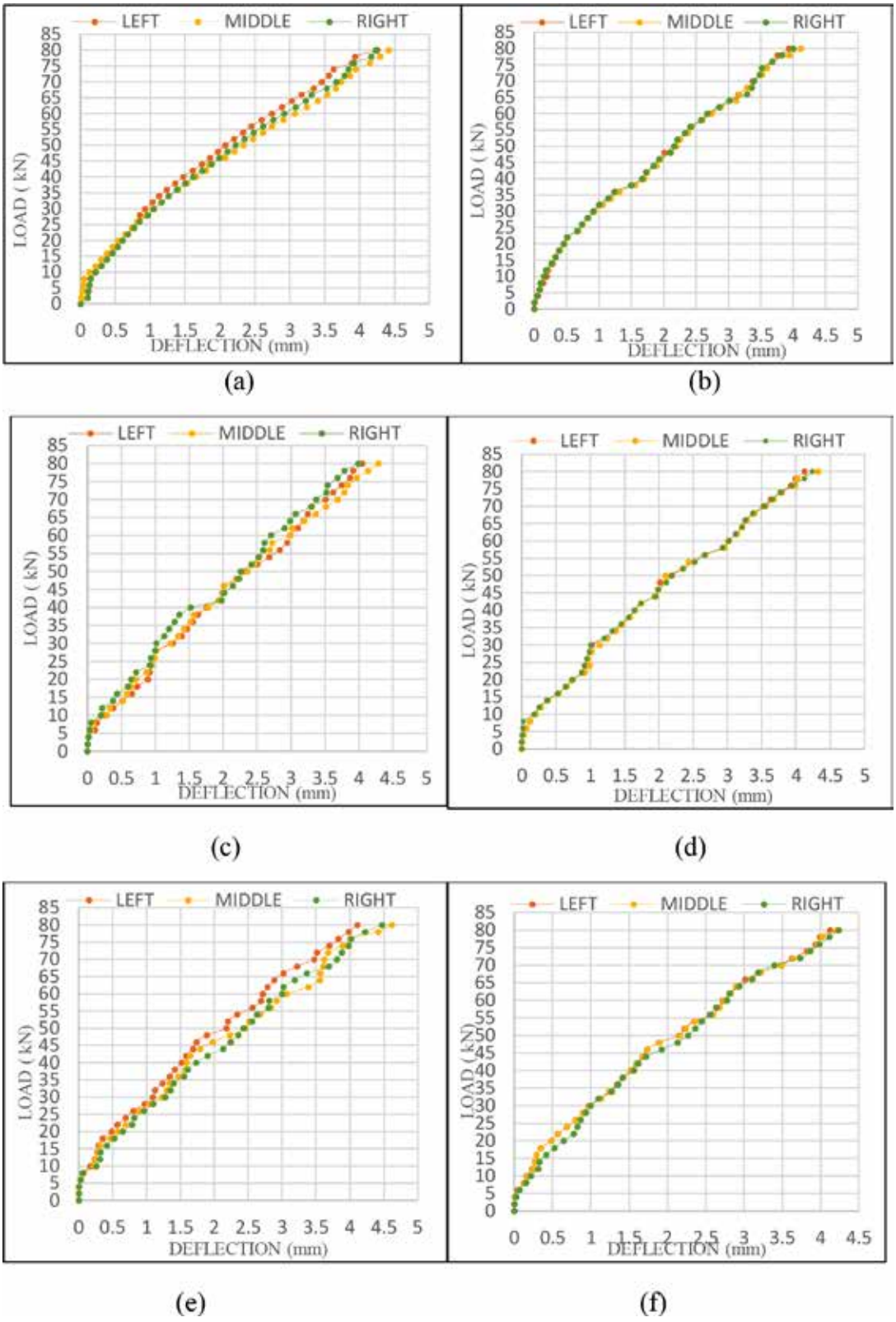

Fig 7. Load vs deflection curve of (a) control beam [CB-1], (b) control beam [CB-2], (c) retrofitted beam [GFRB-2L-1], (d) retrofitted beam [GFRB-2L-2], (e) retrofitted beam [GFRB-4L-1], (f) retrofitted beam [GFRB-4L-2].

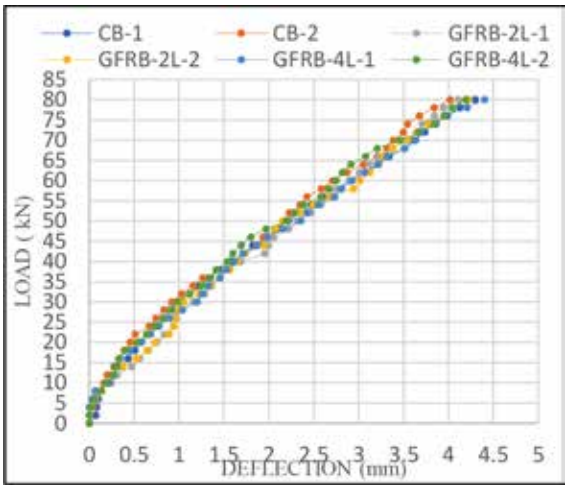

Fig 8. Combined load vs deflection curve of all beams

Combined load vs deflection

The load–deflection plot of control beams and retrofitted with glass FRCM are shown in the figure 8. It is observed that the control beams and retrofitted beams with glass FRCM have shown similar behaviour with respect to deflection and cracking. Enhancement in the cracking load and deflection in the retrofitted beams were observed and also reduction in the pre-cracking stiffness can be seen which indicates the ductile nature.

Table 3. Details of experimental results

Sl. No.	Beam designation	Cracking load [Pcr (kN)]		Ultimate load [Pu (kN)]
		Before retrofitting	After retrofitting	
1	CB-1	26		96
2	CB-2	28		96
3	GFRB-2L-1	26	38	120
4	GFRB-2L-2	30	40	118
5	GFRB-4L-1	28	44	135
6	GFRB-4L-2	28	46	132

Table 4. Variation in first crack load and ultimate load

Sl, No.	Beam designation	Average Cracking load [Pcr (kN)]		Average Ultimate load [Pu (kN)]	Increase in cracking load [Pcr (kN)]	Increase in ultimate load [Pu (kN)]	Percentage Increase in Cracking load	Percentage Increase in ultimate load
		Before retrofitting	After retrofitting					
1	CB	27		96	-	-	-	-
2	GFRB-2L	28	39	119	11	23	28.20	19.32
3	GFRB-4L	28	45	133.5	17	37.5	37.77	28.08

Fig 9. Crack pattern in control beam

Fig 10. Crack pattern in beam retrofitted with 2 layers of glass FRCM

Fig 11. Crack pattern in beam retrofitted with 4 layers of glass FRCM

Fig 12 Fabric rupture failure in beams retrofitted with 2 layers glass FRCM

CONCLUSIONS

- Retrofitting the beams with Glass FRCM is one of the easy and effective techniques for flexural strengthening.
- The experimental result shows that 28% and 38% enhancement in cracking load for two-layer and four-layered of glass FRCM.
- The ultimate load-carrying capacity of the beams increased about 19% for two layers and 28% for four layers of glass FRCM.
- Load deflection plots show a reduction in the pre-cracking stiffness, which indicates a ductile nature of the retrofitted beam.

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FABRICATION AND INVESTIGATION OF MECHANICAL PROPERTIES FOR MAGNESIUM ALLOYS BY STIR CASTING

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ABSTRACT

Magnesium alloys have numerous applications due to their high strength-to-weight ratio in comparison to aluminium alloys. Although these alloys cannot be used at high temperatures due to their susceptibility to burning, they play a crucial role in the production of electric vehicles, particularly in components such as wheels, the motor casing, frame, and body. The utilization of magnesium alloys in these parts reduces the weight of electric vehicles. In this study, we conducted four castings of magnesium alloys (Al40Z1, Mg60Al40, Al25Z1, Al15Z1) using stir casting equipment to investigate their mechanical properties. We conducted a series of tests including wear testing, Vickers micro hardness testing, Porosity and density testing. We also examined the microstructure of the alloys using an optical microscope. Our results revealed that the magnesium alloys became more brittle with an increase in aluminium percentage, and the hardness was higher for alloys with a higher percentage of aluminium. We also found that Al5Z1 had a lower density than the other castings. This study contributes to the understanding of the properties of magnesium alloys and provides valuable information for the development of new electric vehicle components.

KEYWORDS *: Magnesium alloy, Stir casting, Hardness, Porosity, Wear.*

1. INTRODUCTION

Magnesium alloys have emerged as a promising material for the construction of electric vehicles (EVs) due to their exceptional strength to weight ratio. This makes them ideal for building lightweight vehicle components like the body, frame, and wheels, as they can reduce the weight of an EV without sacrificing strength or safety. Magnesium alloys are roughly two thirds less dense than aluminium alloys and one fourth less dense than steel. However, magnesium is a highly reactive metal and can easily ignite when exposed to air at high temperatures. To avoid combustion, magnesium alloys should be handled carefully and stored in cool, dry areas away from any heat sources. Magnesium alloys have high thermal conductivity, which is essential for dissipating the heat generated by the EV's power train and battery pack. This property is critical for maintaining the performance and durability of these components. Magnesium alloys are also relatively cheap and widely available, making them a cost-effective alternative to other materials like carbon fibre and titanium. Nonetheless, the manufacturing process for magnesium alloys is complex, and this can add to the cost of production. Despite these obstacles, researchers and manufacturers continue to investigate the potential of magnesium alloys in the EV industry.

As a result, it's predicted that the use of magnesium alloys in EV construction will continue to expand in the coming years.

2. LITERATURE SURVEY

The latest research on magnesium alloys and their applications are discussed in this section.

The study conducted by Aatthisugan and Razal Rose [1] on fabricated magnesium composites using stir casting is an important contribution to the field of materials science. Their findings demonstrate that the use of stir casting results in composites that exhibit improved mechanical properties compared to traditional alloys, making them ideal for use in various applications. In addition, the historical overview provided by Alan A. Luo [2] sheds light on the development of magnesium casting and its structural uses, which has played a significant role in the advancement of many industries. This knowledge can be useful for researchers and engineers who are working on the development of new magnesium-based materials and alloys. Anil Kumar et al. [3] study on the casting of magnesium composites using flux provides valuable insights into the most suitable processes for fabricating these materials. Their findings highlight the importance of vacuum-assisted stir casting, and the need to carefully consider the ductility and ultimate tensile strength of composites when designing materials for specific applications. Jiangfeng Song et al. [4] research on the physical and chemical properties of magnesium and its alloys further emphasizes the potential of these materials for use in a wide range of applications. Their work underscores the need for continued research and development in this field, as magnesium-based materials can play a key role in the aerospace, transportation, electronic 3C, biomedical, and energy sectors. The study by S V Satya Prasad et al. [5] highlights the importance of considering the drawbacks of magnesium, such as its poor corrosion resistance, when designing materials for specific applications. By alloying magnesium with other elements, researchers can improve its properties and make it more suitable for use in a wider range of applications. Tian Li, et al,[6] conducted experiment on defects formed in AZ91 alloy. And they found there are two types of oxide layers are there that is single layered and multi layered. According to their experimental results and theoretical thermodynamic calculations, it was observed that fluorides present in the trapped gas were depleted before the consumption of sulphur. Finally, the overview provided by Arun Kumar Sharma et al.[7] on the fabrication process of magnesium-based materials using stir casting is a valuable resource for researchers and engineers. Their insights into the factors that affect the fabrication process can help to improve the quality and consistency of these materials, leading to more reliable and effective products. In summary, these studies provide important contributions to the field of materials science and highlight the potential of magnesium-based materials for use in various industries. Continued research and development in this field can lead to the development of new and improved materials that can address important challenges in areas such as transportation, energy, and healthcare.

3. EXPERIMENTAL WORK

3.1 Preparation of Materials

In this research, we used magnesium, aluminium, and zinc as our materials. The aluminium grade was 6061, and its composition is listed in Table 1. We cut the raw materials into small pieces to fit the furnace chamber, as shown in Figure 1. Stir casting equipment, shown in Figure 2, was used in the process. Composition alloy samples, shown in Table 2, were prepared for the experiment. The die was cleaned and graphite paste was applied to the surface of the mould cavity. The die was preheated to 400°C, while the furnace was heated to 750°C and argon gas supplied to avoid burning of magnesium by reacting with oxygen. Once the material was melted, the molten liquid was mixed with a stirrer at a rotational speed of 250 RPM. The die was placed in front of the outlet valve of the furnace pot, and the die input valve was straight aligned with it. The molten liquid flowed quickly into the mould cavity as the furnace outlet valve was opened by computer signal. The casting process was repeated for the other three composition alloys. After this we swich off machine and cools the die in open atmosphere. After cooled we open the die and taken out moulded samples. The final samples underwent a heat treatment process for 2 days at 350°C and were tested for mechanical properties, including hardness, wear, microscopic, density, and porosity tests. The A15Z1 composition alloy was found to have the best mechanical properties and was considered the most suitable for applications that require less weight and more strength, with lower density and higher strength compared to other alloys.

Fig.1. (a) Magnesium

Fig.1. (b) Aluminium 6061

Fig.1. (c) Zinc powder

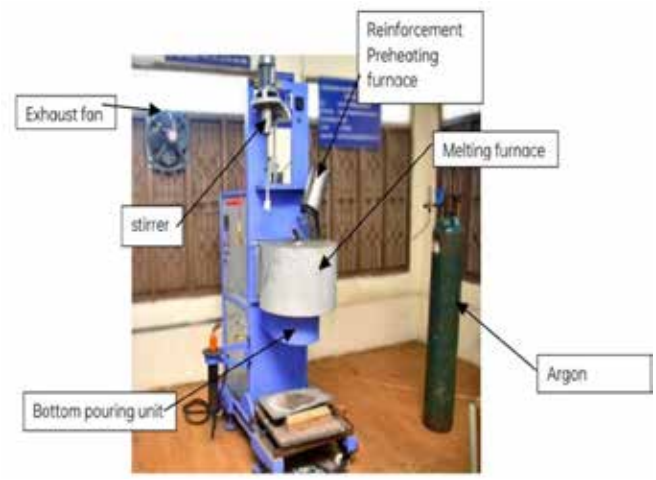

Figure 2. Stir casting machine

Table 1. Aluminium 6061

Element	Amount(wt%)
Aluminium	96.85
Magnesium	0.9
Silicon	0.7
Iron	0.6
Copper	0.25
Zinc	0.20
Titanium	0.10
Manganese	0.05
Others	0.05

Table 2. Composition of magnesium alloys

S.no	Name	Magnesium (%)	Aluminium (%)	Zinc (%)
1	A15Z1	15	84	1
2	A25Z1	25	74	1
3	A40Z1	40	59	1
4	M60A40	40	60	0

3.2 Hardness Test

We performed hardness test in Vickers micro hardness equipment by using diamond pointer indenter. And applying a load of 500KN the indentation made on the specimen. Then the micro image of the indentation is captured on the screen and by marking the indentation area hardness values are obtained. The values are shown in Table 3.

Table 3. Hardness values

S.no	Sample	Hardness value
1	A15Z1	136
2	A25Z1	216

3.3 Wear test

We performed Wear test on Disc wear testing machine, we had taken A15Z1 specimen for test of diameter 9mm and length 40mm round bar and the track diameter is considered as 70mm. Here we applied load 10N with constant Disc speed and by varying distance and time. We run 3 passes and the wear, coefficient of friction results is obtained in below Table 4 and graph are obtained. The process parameters at various levels are shown in below Table 4.

Table 4. Process parameters at various levels

Sl.no	Load (N)	Velocity (m/sec)	Distance (m)	Disc Speed (rpm)	Time of Travel (min)	Wear (μm)	Coefficient of Friction
1	10	0.5	500	137	16.67	61	0.445
2	10	0.5	1000	137	33.33	74	0.508
3	10	0.5	1500	137	50	89	0.576

The wear performance of alloys is determined using an ASTM G99 standard pattern pin-on-disc wear tester.

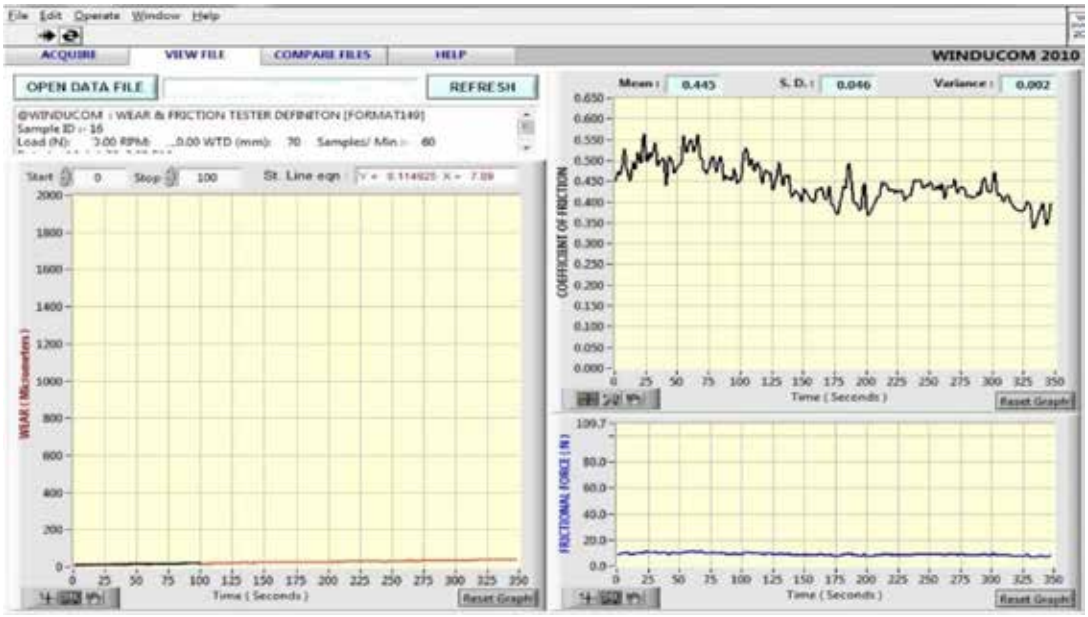

Fig.3. (a)Wear graph at Load = 10N, velocity =0.5m/s and distance = 500

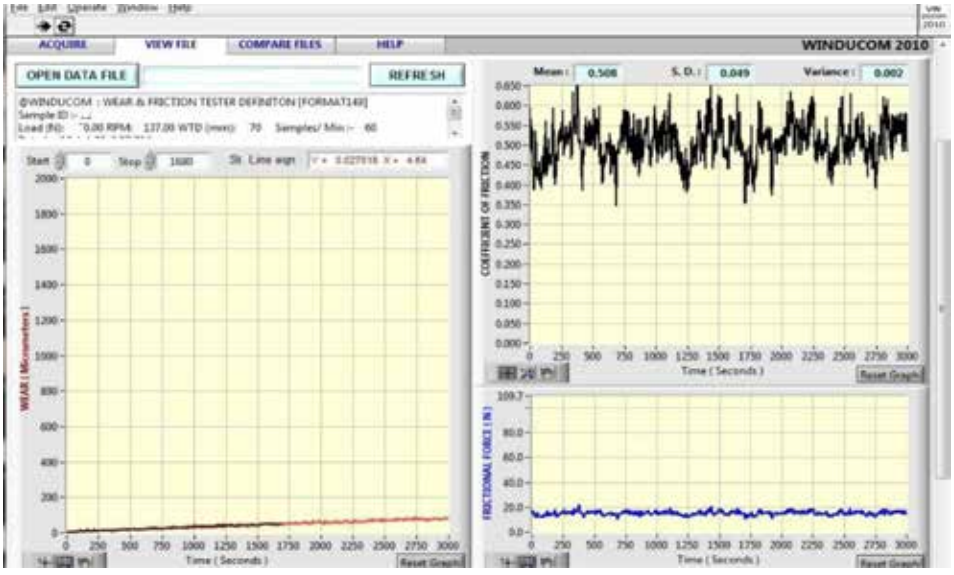

Fig.3. (b)Wear graph at Load = 10N, velocity =0.5m/s and distance = 1000 m

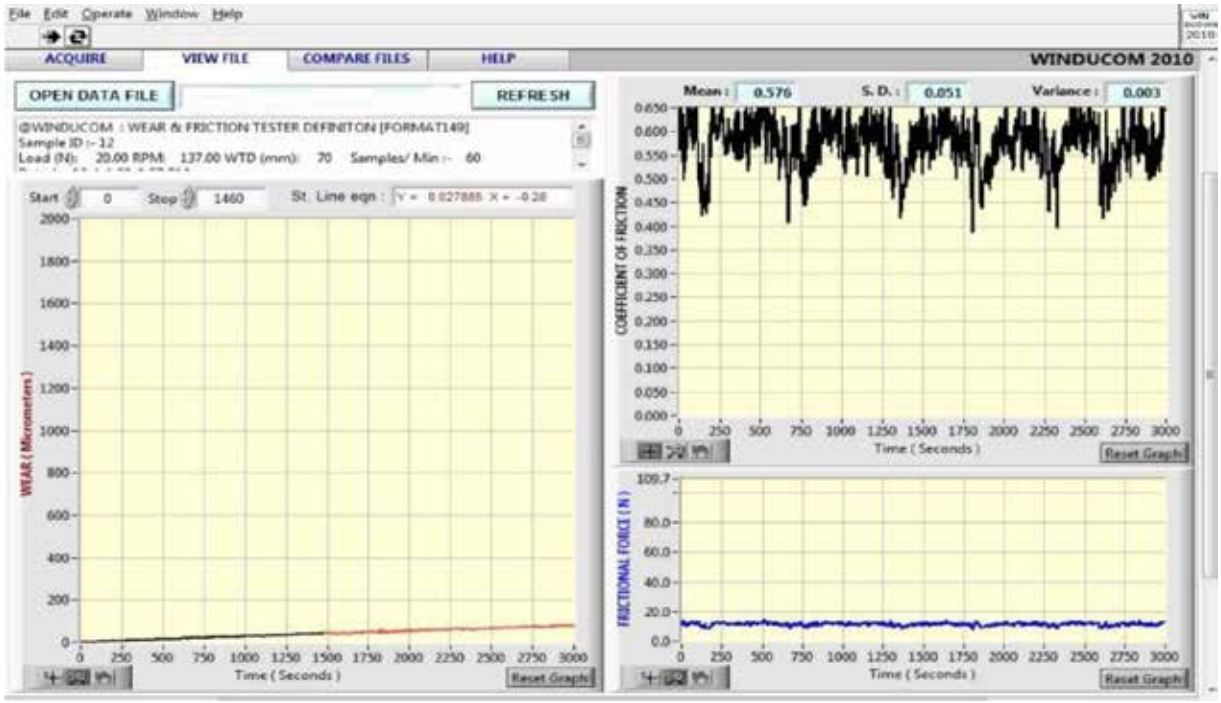

Fig.3. (c)Wear graph at Load = 10N, velocity =0.5m/s and distance = 1500 m.

3.4 Microstructure Test

For the study of microstructure, the castings are examined under the optical microscope. Before going for the inspection, the samples are prepared for surface finishing with a sequence ordered grades of silicon carbide papers, next we apply 1-micrometer aluminium powder paste on disc for polishing for smoother surface finish, in this preparation, the picric acid solution is used as etchant and applied for 10 seconds and washed out with water, after this we taken micro structure pictures by optical microscope. Finally, we analysed the structures of magnesium alloys that are shown below.

3.5 Density and Porosity test

For the castings the density was determined and the values are shown in table 5. By using a water beaker, the volume of the casting is found by dipping it into the water and by using the level in rise of water. The mass of the casting is measured by using a weighing machine. This is done based on the principle of Archimedes. By using the values of mass and volume the density of the castings is found. The formula used to find the density of the casting is given below

$$\text{Density} = \text{Mass/Volume} \quad (1)$$

Table 5. Density values for the castings

Sl.no	Sample	Density(g/cm^3)
1	A15Z1	1.3
2	A25Z1	1.41
3	A40Z1	1.52
4	M60A40	1.55

To find the porosity for the castings the theoretical and actual density values are needed. The theoretical density is measured by using the rule of mixtures. The below is the formula used for porosity

$$P = (1 - (\rho_a / \rho_t)) \times 100 \quad (2)$$

Where, P is porosity of the casting, ρ_a is actual density of the casting and ρ_t is theoretical density of the material. The calculated values of above parameters are shown in Table 6.

Table 6. Porosity and Density values

Sl.no	Actual density (g/ cm^3)	Theoretical density (g/ cm^3)	Porosity, %
1	1.42	1.84	22.82
2	1.68	1.91	12.04
3	1.82	2.03	10.34
4	1.85	2.02	8.41

4.RESULT AND DISCUSSION

4.1 Hardness test analysis

The detailed information of the hardness values of the castings are shown in the form of graph in figure 5. The graph shows that there is an increment in the hardness value of A25Z1 compared to A15Z1, that means the hardness value is more in the magnesium alloy having high percentage of aluminium.

Fig.4. Hardness values Graph

4.2 Wear test analysis

For A15Z1 the wear test is conducted and the wear, coefficient of friction was determined. For the remaining castings the wear test is not conducted due to the brittleness of material. These parameters are represented in the form of graph for the three passes and the graph is shown in the figure 6. In the below graphs we can see the wear and coefficient of friction is increments for every pass.

Fig.5(a) Wear Graph

Fig.5(b) Coefficient of friction Graph

4.3 Microstructure analysis

Metallographic investigation is a highly valuable tool for both feature control and investigative purposes. The images that are captured under the optical microscope is shown in the Figure 6. This shows the micro structure of the four different castings. The difference can be observed by seeing these microstructures.

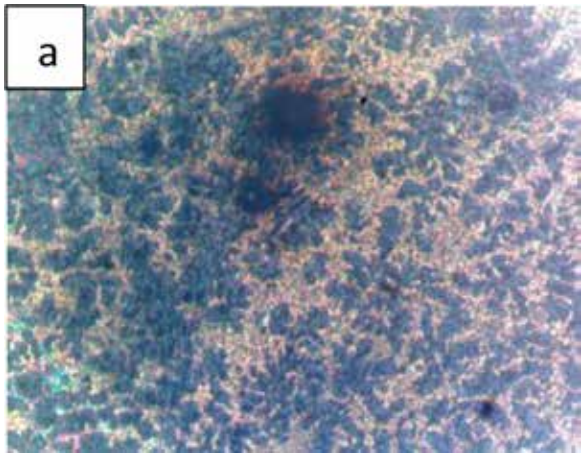

Fig.6. (a) A15Z1

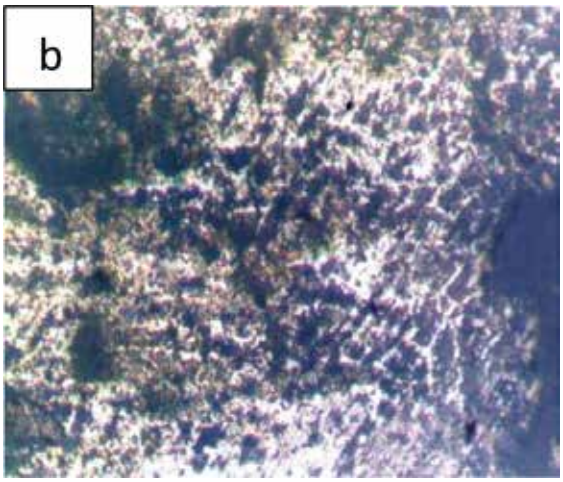

Fig.6. (b)A25Z1

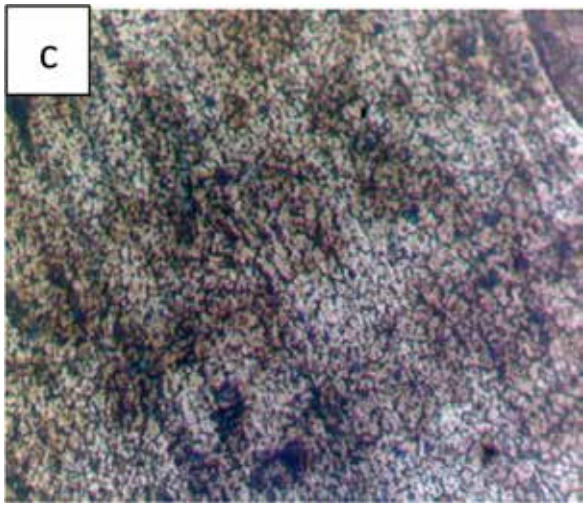

Fig.6. (c) A40Z1

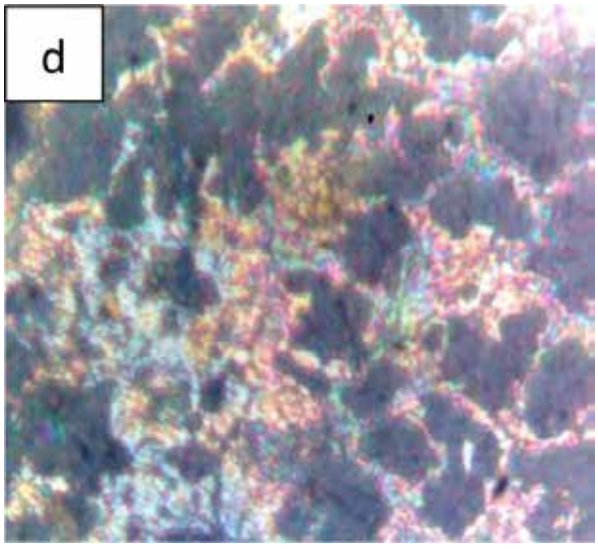

Fig.6. (d)A40M60

4.4 Density and porosity analysis

We calculated density and porosity of samples by theoretical and actual values, by comparing both of them we analysed density was decreased by increasing of magnesium percentage due to its less weight property, porosity had increases by increase in magnesium percentage, we had found A15Z1 had less density with light weight property, from graphs we understood that change in composition of alloy changes its density & porosity values increases with increase of magnesium.

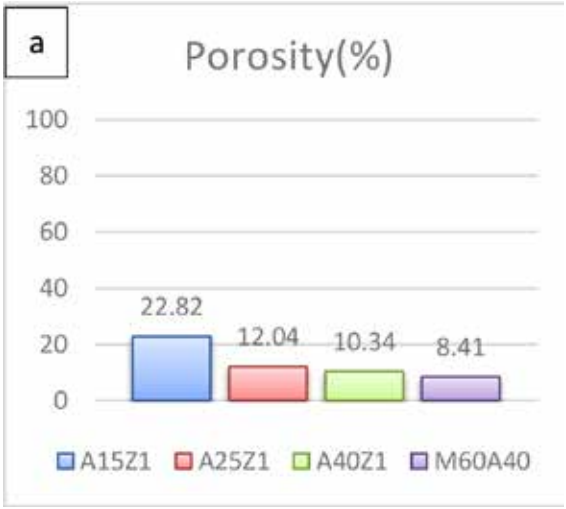

Fig.7 (a) Porosity Graph

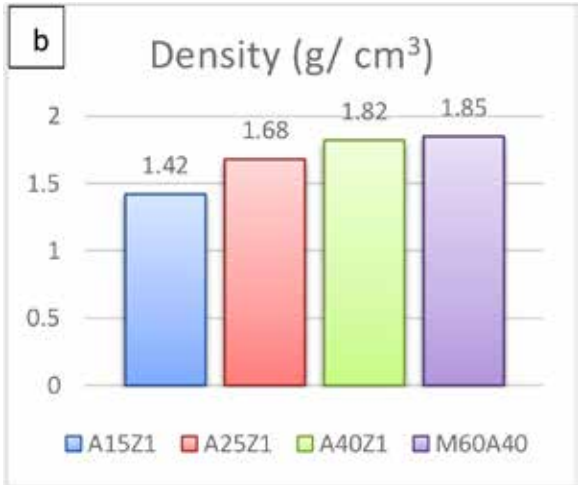

Fig.7 (b) Density Graph

5. CONCLUSION

After conducting Hardness test, we conclude that the hardness value increases with increase in percentage of aluminium in magnesium alloy. In wear test the results shows that the wear and coefficient of friction is getting

more for every increment of a pass. By calculating the porosity, we conclude that the porosity is increases with increase in magnesium percentage in magnesium alloys. While doing this research we are unable able to do the tests for all castings due to their brittleness property. The brittleness is increasing with the increase in Aluminium percentage in magnesium alloys. The A15Z1 is only casting that is examined by all tests and the density of A15Z1 is less compared to other castings. The disadvantage of A15Z1 is the porosity is high when compared to other castings. By studying all of these comparisons we had considered A15Z1 can used for the applications of EV and other low weight applications.

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MICROSTRUCTURE AND MECHANICAL PROPERTIES OF PERMANENT MOULD CAST ALUMINUM ALLOY A356-SIC COMPOSITES IN HEAT TREATED T6 CONDITION

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ABSTRACT

This paper details the investigations on A356-SiC composites stir-cast into permanent finger moulds in respect of their microstructures and mechanical properties like hardness, tensile strength as well as the analysis of tensile fracture and wear resistance. The study was carried out on the base alloy A356 in T6 heat treated condition with and without grain refinement and grain modification, and also on its composites with 2%, 4%, 6%, 8%, 10% and 12% SiC. Specimens were prepared for hardness, tensile tests and also for metallography. The results indicated that the SiC particles were evenly distributed in the alloy matrix. EDS revealed the presence of SiC in all the 6 composites. Hardness and tensile strengths generally increased with increase in SiC content.

KEYWORDS *: Permanent mould casting, A356-SiC composites, T6 heat treated, Microstructure, Mechanical tests, Fracture analysis.*

1. INTRODUCTION

Aluminium alloy based composites (AMMCs) are finding increased and newer applications day by day [1-4]. The LM type aluminium alloys are especially suited for automobile, marine and aerospace applications. The A356.0 is one such alloy which is used for making cast components like pump casings, engine blocks, impellers, cylinder heads, etc. [5-8]. The use of AMMCs as replacements for base alloys as been found advantageous in such applications including the Honda cylinder block [9]. The present work is aimed at understanding the microstructures and basic mechanical properties like hardness, tensile strength and tensile toughness and also the tensile fracture processes of composites prepared from permanent mold castings of stir-cast A356- SiC composites with single size SiC powders (100 μm) varying SiC contents.

2. MATERIALS AND METHODS

A356.0 (Al-7.25Si-0.45Mg) alloy ingots were stir-cast in the form of round bars of 300 mm length and 25 mm diameter as shown in Fig. 1. Optical Emission Spectrometer (Baird-Dv6E) at Advanced Metallurgical Laboratory, Bengaluru, was used to determine the chemical composition of the alloy is shown in Table-1.

The alloys were also grain refined and modified using master alloys (Al-5Ti-1B and Al-10Sr respectively), and tested for their properties.

Fig. 1. Permanent Mold Cast A356.0 Alloy

Table 1. Chemical Composition of A356.0 (Al-7.25Si-0.45Mg) Alloy

Element	Weight %
Si	7.18
Mg	0.34
Fe	0.13
Cu	0.05
Mn	0.027
Ni	0.03
Zinc	0.01
Others	0.15
Al	Balance

The physical properties of the base alloy A356 and the reinforcement SiCp are given in Table 2.

Table 2. Comparison of physical properties of A356 and SiC Particles

Property	A356	SiC
Melting Point, ^{O}C	750	2730
Boiling Point, ^{O}C	2425	3600
Density, kg/m^3	2670	3200
Crystal Structure	FCC	Hexagonal
Hardness	65	100
Tensile Strength, MPa	143	370

The base alloy A356 and A356-SiCp composites were all prepared in a similar manner by stir-casting into permanent finger molds. The different compositions of the 8 alloy/composites were designated as C1and C2 (Base A356), C3 to C12 (Composites) as given in Table 3 below.

Table 3. Designation of A356 and Composites

Sl. No.	Designation of Alloy/Composite	Grain Refiner & Grain Modifier Wt(gms)	Percentage of Silicon Carbide (wt %)
1	C1	-	-
2	C2	2.5 & 2.5	-
3	C3	2.5 & 2.5	2
4	C4	2.5 & 2.5	4
5	C6	2.5 & 2.5	6
6	C8	2.5 & 2.5	8
7	C10	2.5 & 2.5	10
8	C12	2.5 & 2.5	12

Microstructural Examination

The test specimens were polished to smoothness and etched with Keller's reagent. An Optical Microscope (Model NIKON LV-150, Fig.1) was used for study of the microstructures.

Fig. 2. Optical Microscope

Hardness Tests

A Rockwell Hardness tester (Fig.3), was used to conduct test as per ASTM E10 using test specimens with sufficient spacing between indentations and distance from the edges of specimens.

Fig. 3. MITUTOYO Vickers hardness Testing Machine

Tensile Tests

The tensile test specimens of diameter 6.35mm and gauge length of 26 mm, referring to ASTM E8 standard. Fig. 4(a) shows schematic of tensile specimen. The tensile tests were accomplished using a Hounsfield-type testing machine (Model TUE-C-400, Fig. 4(b) at a strain rate of 0.2mm/sec, at room temperature.

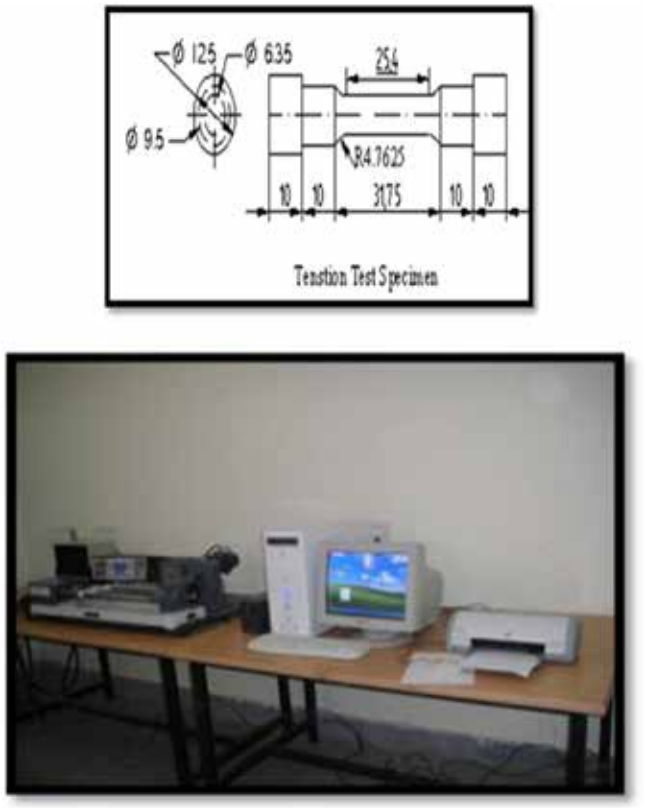


Fig. 4. Tensile testing (a) Schematic of Tensile Specimen (b) Tensile Testing Machine

The mechanical properties such as YS, UTS and % Elongation (ductility) were obtained from the data acquisition system of the bench tensometer. The average value of three test results was taken for each alloy/ composite. The fractured surfaces were photographed using LOM (Light optical Microscope) to study the mechanism of fracture.

III RESULTS AND DISCUSSIONS

Microstructure

The photomicrographs of T6 Treated A356, A356 + grain refiner and grain modifier, A356 + 2% SiC, A356 + 4% SiC, A356 + 6% SiC, A356 + 8% SiC, A356 + 10% SiC and A356 + 12% SiC are shown in the Fig. 5.

Microstructure of A356 Base Alloy and its Composites in the T6 Temper Condition

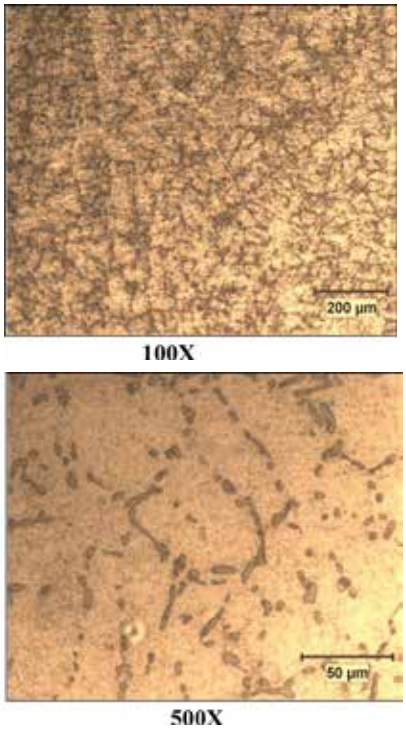


Fig. 5. Microstructure of T6 Temper A356.0 (C1)

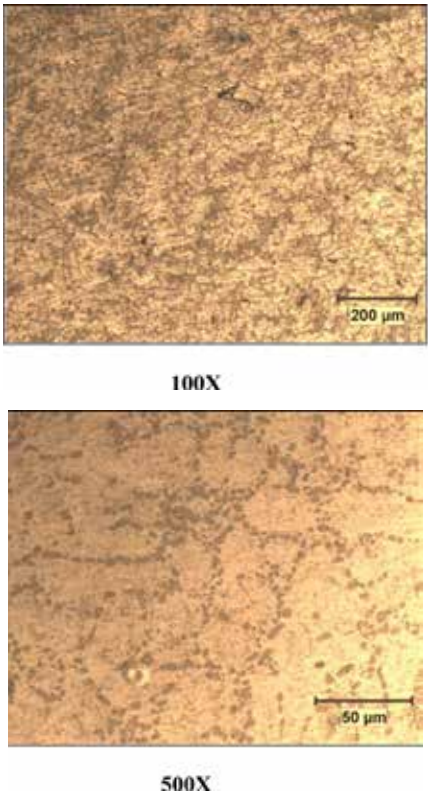
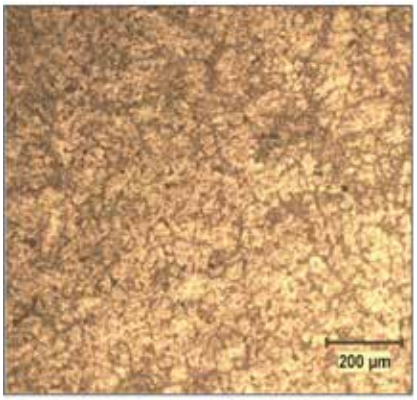


Fig. 6. Microstructure of C2 in T6 Temper



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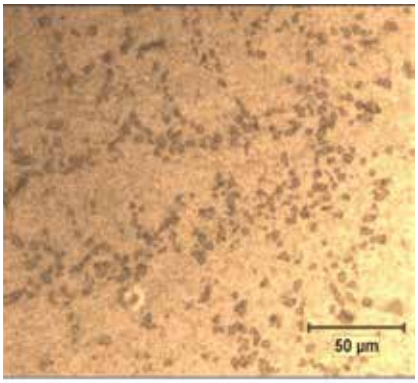

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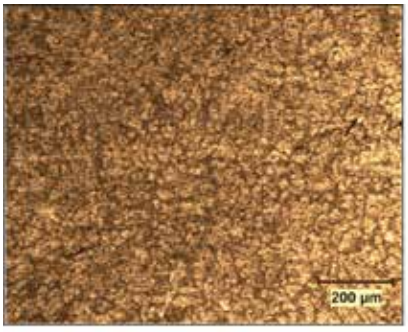
Fig. 7. Microstructure of C3 in T6 Temper



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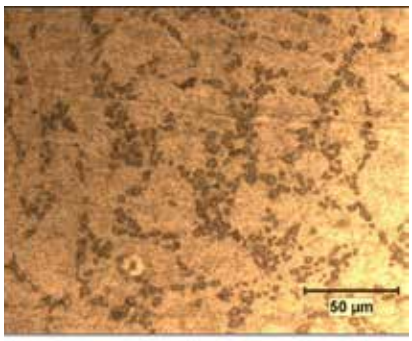

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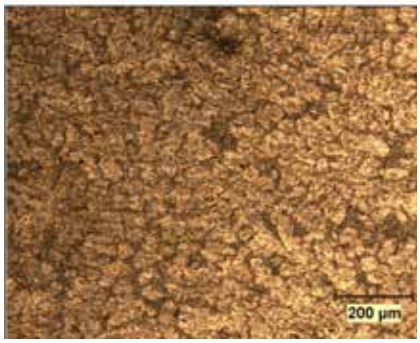
Fig.8: Microstructure of C4 in T6 Temper



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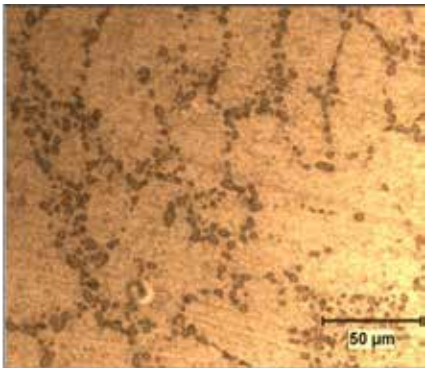

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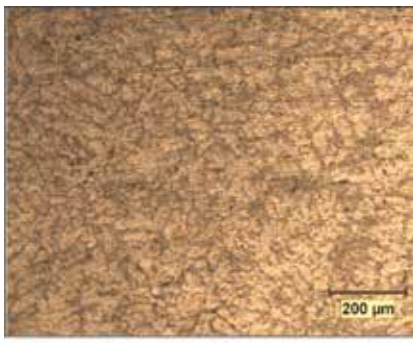
Fig. 9. Microstructure of C6 in T6 Temper



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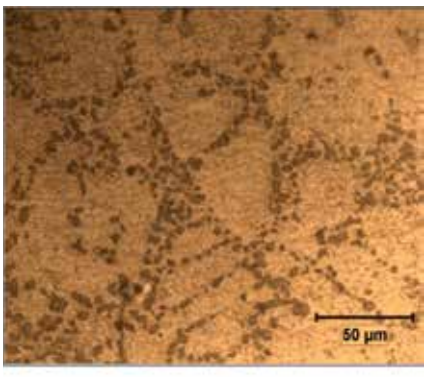

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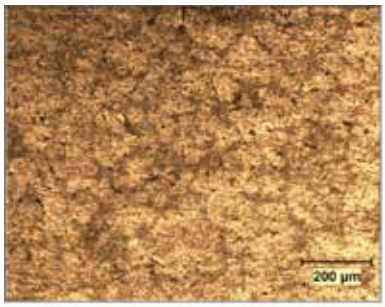
Fig: 10. Microstructure of C8 in T6 Temper



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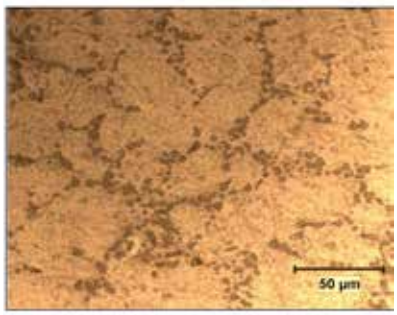

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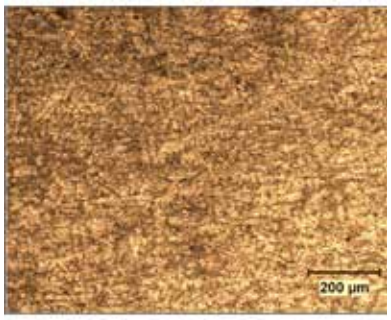
Fig. 11. Microstructure of C10 in T6 Temper



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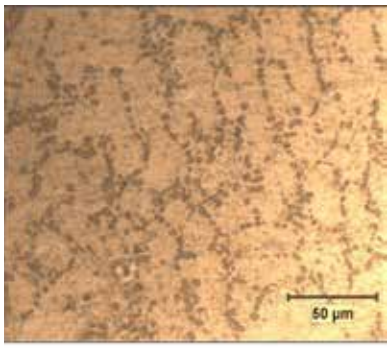


500X

Fig. 12. Microstructure of C12 in T6 Temper

Fig. 5 to 12. photomicrographs of T6 (a) base A356 alloy (b) A356+Grain Modifier+Grain Refiner (c) A356+2%SiC , (d) A356+4%SiC, (e) A356+6%SiC , (f) A356+8%SiC, (g)A356+10%SiC, (h) A356+10%SiC

Energy dispersive spectroscopy (EDS) spectrum

Figs. 13 and 14 are the EDAX patterns of C3 (A356+2% SiC) and C12 (A356+12% SiC) in the T6 temper condition.

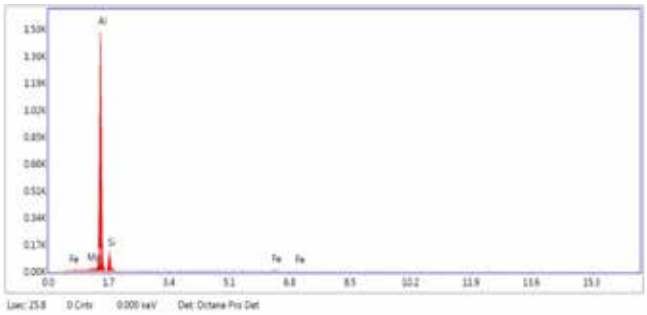
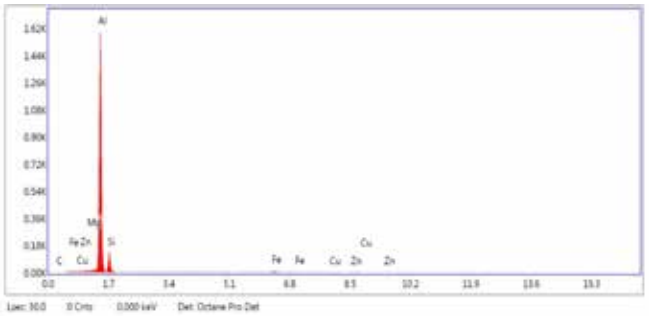


Fig.13. EDAX of A356+2% SiC(C3) in T6 Temper

Element	Weight %	Atomic %
MgK	0.75	0.84
AlK	78.35	79.49
SiK	19.46	18.96
FeK	1.44	0.71

Fig. 13. is the EDAX pattern of the tensile fracture surface of C3 confirming the general composition



Element	Weight %	Atomic %
C K	2.42	5.41
MgK	0.80	0.89
AlK	75.42	75.20
SiK	17.49	16.75
FeK	2.07	1.00
CuK	1.01	0.43
ZnK	0.79	0.33

Fig. 14. EDAX of A356+12% SiC(C12) in T6 Temper

Hardness

Table: hardness values of A356 alloy and it's composite with heat treatment

S/No	Composition	Designation	Hardness (Rb)
1	As- cast A356	C1	75.4
2	As- cast A356 +Grain Refiner+ Grain Modifier	C2	80
3	As- cast A356 +Grain Refiner+ Grain Modifier +2% SiC	C3	81.5
4	As- cast A356 +Grain Refiner+ Grain Modifier +4% SiC	C4	88.2
5	As- cast A356 +Grain Refiner+ Grain Modifier +6% SiC	C6	88
6	As- cast A356 +Grain Refiner+ Grain Modifier +8% SiC	C8	92.7
7	As- cast A356 +Grain Refiner+ Grain Modifier +10% SiC	C10	85.3
8	As- cast A356 +Grain Refiner+ Grain Modifier +12% SiC	C12	82

Tensile Test Result values of A356 alloy and its composite with heat treatment

SL.No	Composition	Designation	UTS (MPa)
1	As- cast A356	C1	162.5
2	As- cast A356 +Grain Refiner+ Grain Modifier	C2	170.2
3	As- cast A356 +Grain Refiner+ Grain Modifier +2% SiC	C3	193.8
4	As- cast A356 +Grain Refiner+ Grain Modifier +4% SiC	C4	205.8
5	As- cast A356 +Grain Refiner+ Grain Modifier +6% SiC	C6	205.2
6	As-cast A356 +Grain Refiner+ Grain Modifier +8% SiC	C8	214.8
7	As- cast A356 +Grain Refiner+ Grain Modifier +10% SiC	C10	201.8
8	As- cast A356 +Grain Refiner+ Grain Modifier +12% SiC	C12	200

Tensile Fracture Analysis

Fracture Surfaces of T6 Tempered Specimens

Figs. 15 to 22 are the SEM images of fracture surfaces of the T6 tempered specimens. Each figure shows two images, one at 200X and the other at a higher magnification of 500X.

a) A-356 Base Alloy T6 temper (C1)

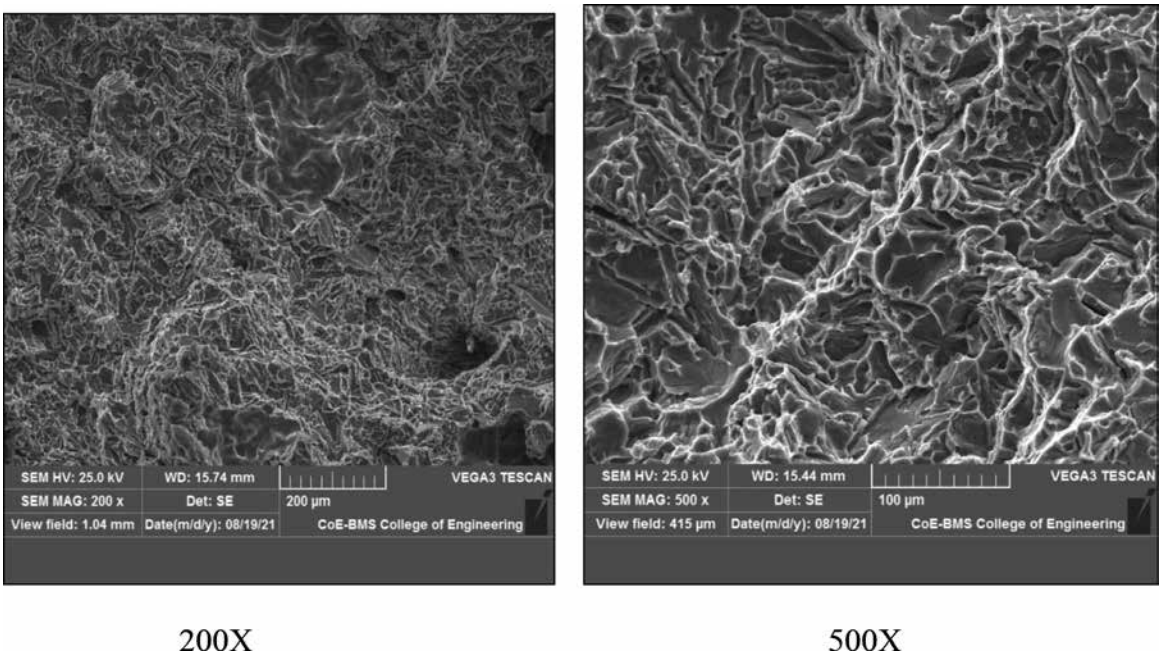


Fig. 15. Fracture Surfaces of A-356 Base Alloy T6 Temper (C1)

b) A-356 Base Alloy (GM+GR) T6 Temper (C2)

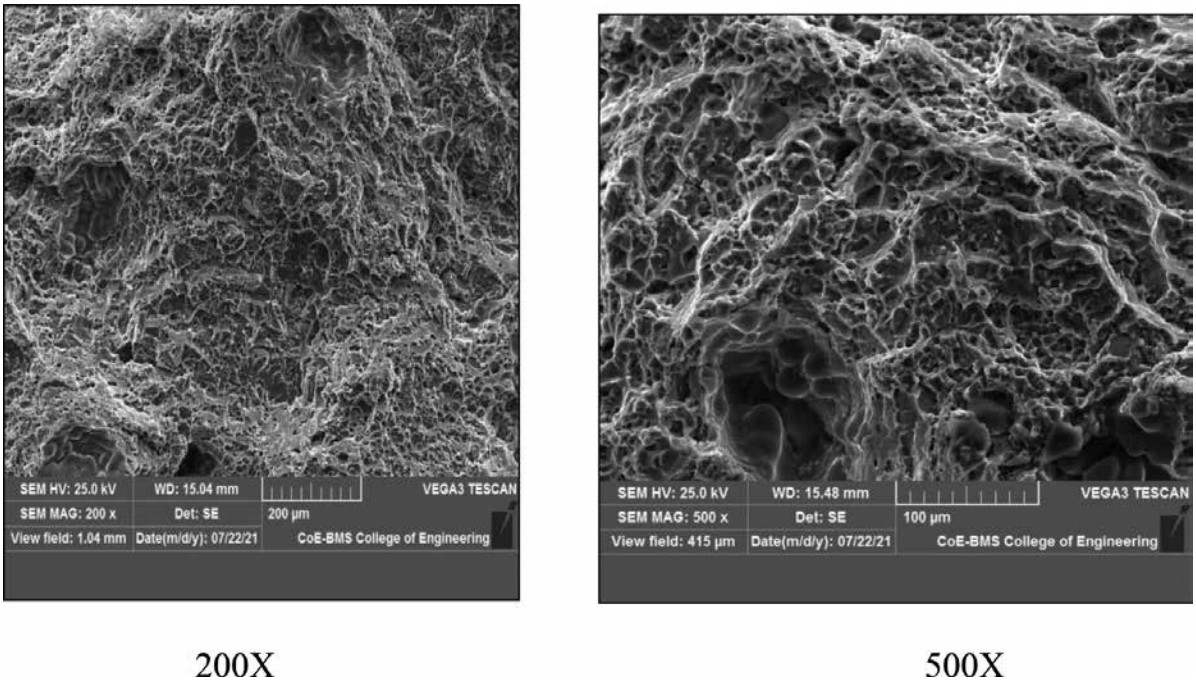


Fig. 16. Fracture Surfaces of A-356 Base Alloy (GM+GR) As-Cast (C2)

C) A-356 + 2% SiC Composite (C3)

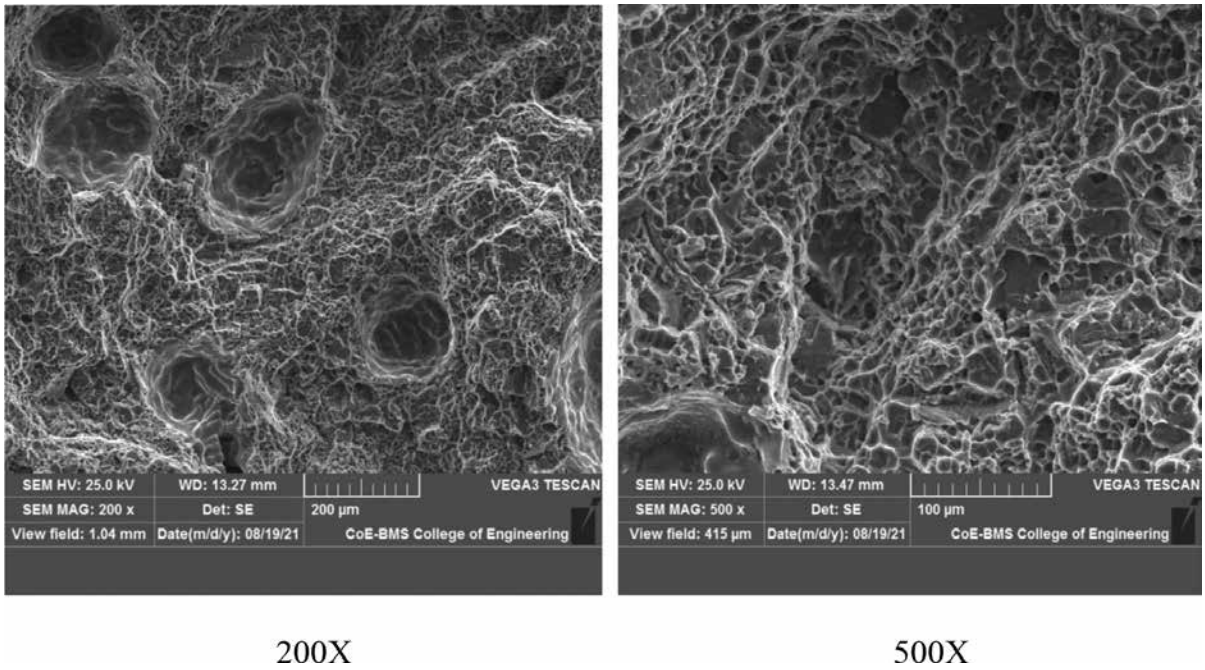


Fig. 17. Fracture Surfaces of A-356 + 2% SiC Composite (C3)

D) A-356 + 4% SiC Composite (C4)

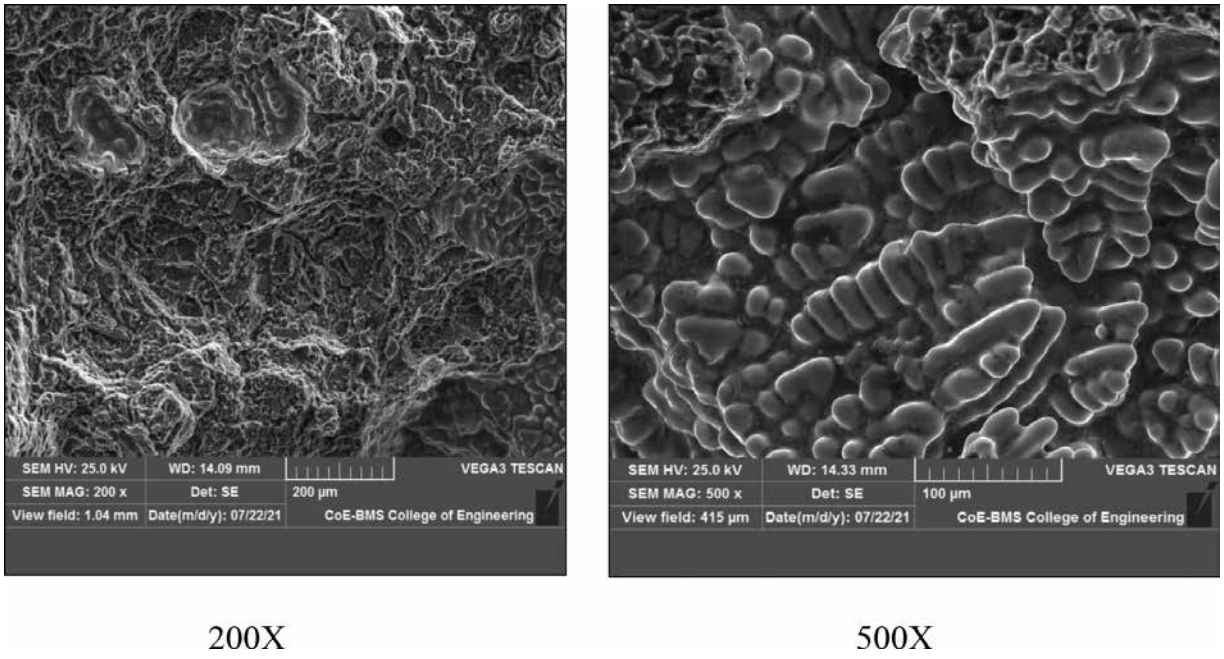


Fig. 18. Fracture Surfaces of A-356 + 4% SiC Composite (C4)

E) A-356 + 6% SiC Composite (C6)

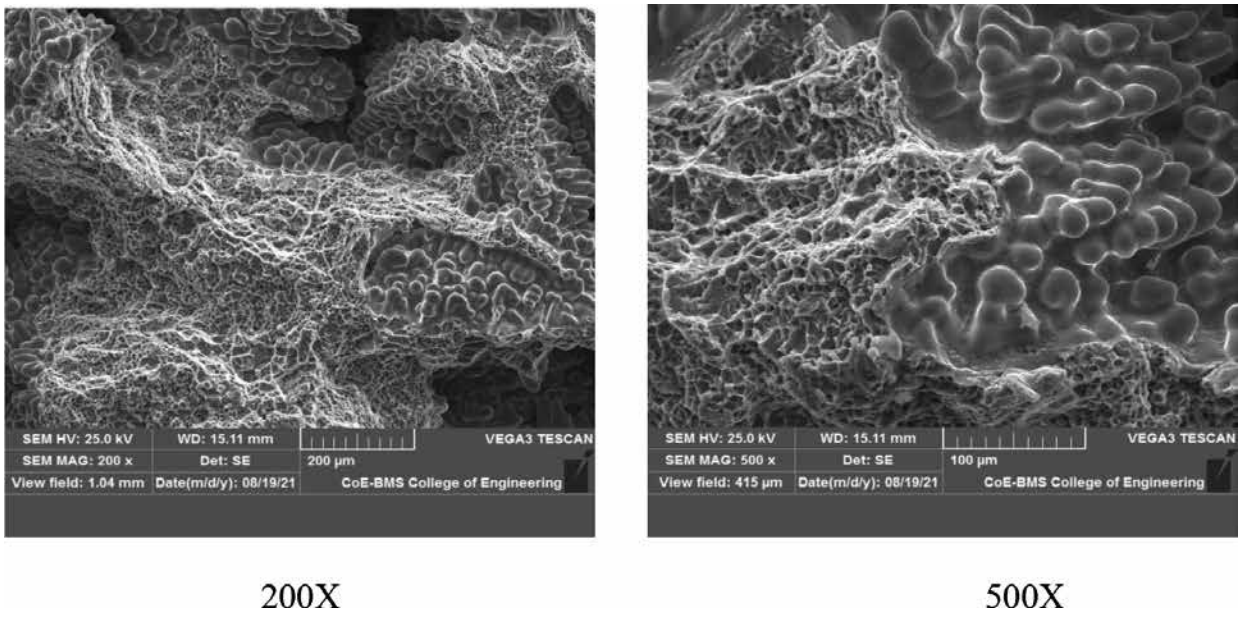


Fig. 19. Fracture Surfaces of A-356 + 6% SiC Composite (C6)

F) A-356 + 8% SiC Composite (C8)

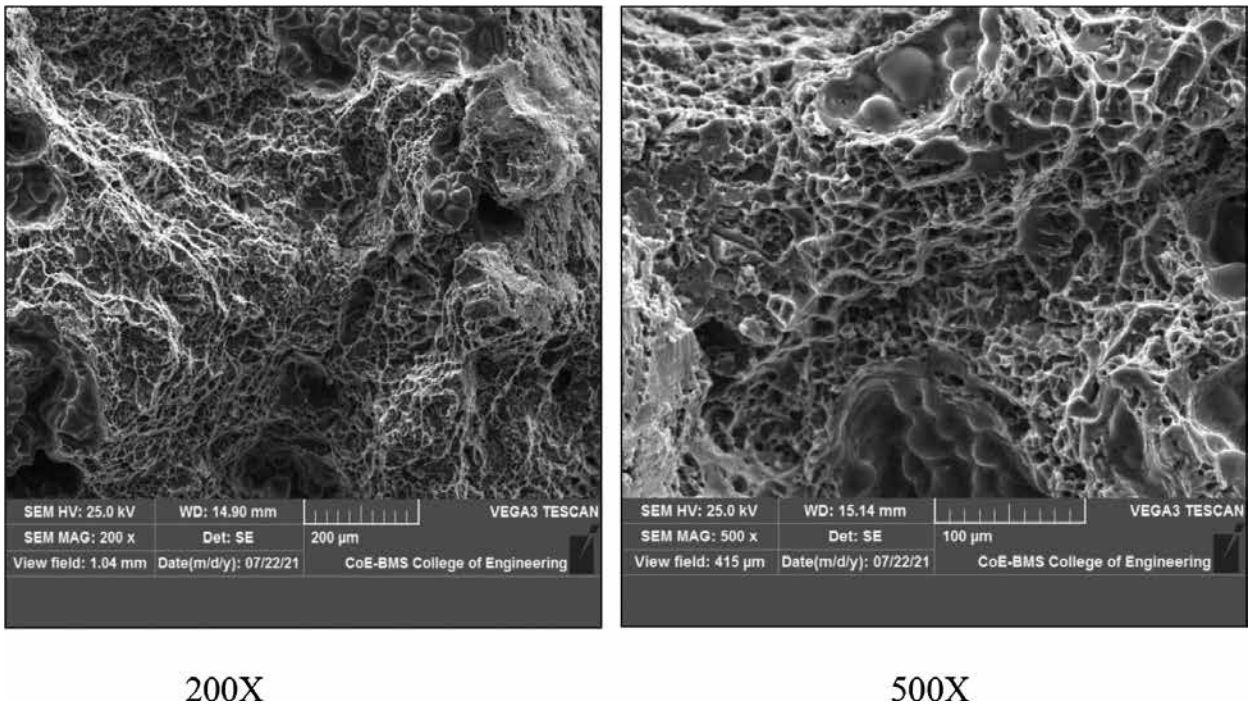


Fig. 20. Fracture Surfaces of A-356 + 8% SiC Composite (C8)

G) A-356 + 10% SiC Composite (C10)

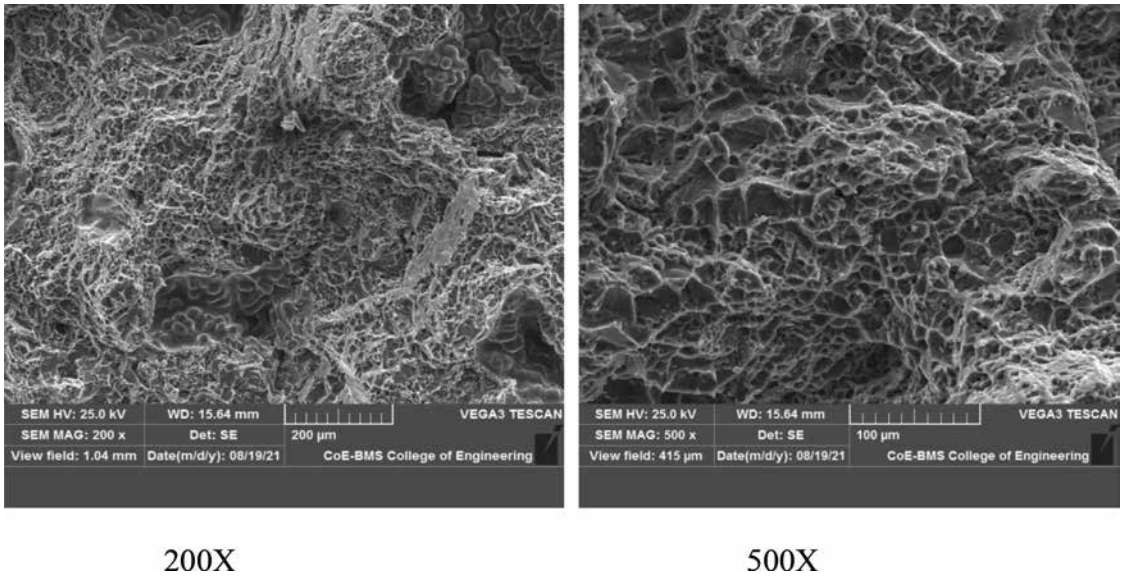


Fig. 21. Fracture Surfaces of A-356 +10% SiC Composite (C10)

H) A-356 + 12% SiC Composite (C12)

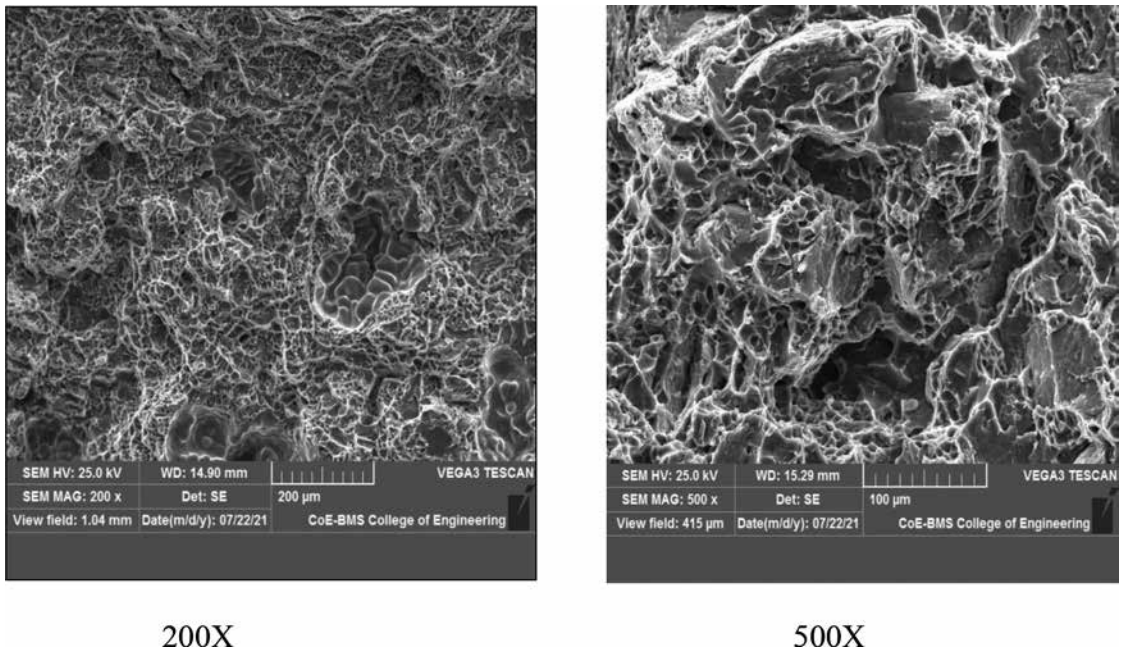


Fig.22. Fracture Surfaces of A-356 + 12% SiC Composite (C12)

Fig. 15 to 22. Fractographs of (a) base A356 alloy (b) A356+Grain Modifier+Grain Refiner (c) A356+2%SiC , (d) A356+4%SiC, (e) A356+6%SiC , (f) A356+8%SiC, (g) A356+10%SiC, and (h) A356+10%SiC.

IV CONCLUSIONS

The study on microstructure, mechanical properties and fracture analysis of the heat treated T6 A356 alloy and its composites with 2%, 4%, 6%, 8%, 10% and 12% SiC particulates has yielded the following results.

1) Composites of A356 aluminium alloy with SiC particles can be made easily by the stir-casting process, at least up to 12% SiC.
2) Uniform distribution of SiC particles in a dendritic

primary alpha-Al matrix is possible as ascertained by microstructural examination.

3) While an increase in the hardness values achieved was only 15% (by addition of 10% SiC), an increase in UTS of 65% could be achieved (8% SiC).

4) While the values of UTS and hardness for the A356 alloy and its composites showed poor correlation between them, the tensile toughness and % elongation had near perfect correlation.

5) From analysis of the tensile fracture surfaces which are predominantly ductile fractures, it is possible to infer that the A356 alloy and its composites with SiC particles as reinforcements could be used for automobile components with less possibility of brittle failures.

6) Overall, the present study has confirmed the vast applicability of the AMMCs of A356 with SiC particles in the automobile, marine and aerospace industries.

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NUMERICAL ANALYSIS ON POROUS TRAPEZOIDAL ENCLOSURE

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ABSTRACT

The current research aims to explore the buoyancy driven circulation in a porous non-square cavity with heat flow determined by a mathematical approach based on finite elements. The cavity is employed to study fluid flow, heat transfer, and has inclined walls, a bottom wall susceptible to heat flux, and a top wall with constant thermal effect. Heat fluxes are applied to the bottom wall both uniformly and unevenly. Regarding uniform and non-uniform heated walls and top cold walls, numerical simulations for Rayleigh numbers 101 to Ra–103 have been examined. The fact inside the enclosure with the porous medium positioned in the centre was examined using the isotherm pattern, streamline pattern, local Nusselt number, and mean Nusselt number. The average Nu is shown to be higher for heat flux boundary conditions at the bottom wall that are linearly changed.

KEYWORDS *: Trapezoidal cavity, Natural convection, Porous medium and Nusselt number*

NOMENCLATURES

Nu	Local heat transfer co-efficient
Ra	Rayleigh Number
K	Permeability, m^2
x, y	Dimensional Coordinates Along Two Directions
T_h	Heated Wall Temperature, ^0C
T_c	Cooled Wall Temperature,^0C
Nu_{avg}	Average Nusselt Number
y	Inclination Angle
u	Kinematic Viscosity, m^2 /S
μ	Dynamic Viscosity, N-S/ m^2
ψ	Stream Function
ψ	Dimensionless Stream Function
U	Velocity Along X Axis

1. INTRODUCTION

The transmission of fluids and heat has taken centre stage in many industrial and engineering applications. According to this research, though awareness of free convection in a closed porous cavity with a Heat function boundary condition has developed significantly over the past ten years. Triangle, square, round, and non-square cavities are typically employed in industrial settings.

Numerous researchers have carefully taken into account diverse cavities with variable boundary conditions and porous media. However, cavities with bottom wall heating have gotten less attention. There are numerous engineering applications where it is necessary to regulate the buoyant energy flowing through a fluid region contained in a cavity.

Saranya et al [1] presented the effect of heat flux on poroussquare cavity. They noticed that, despite the

uniformly varied heat flux throughout the bottom wall, there was a maximum rate of heat transfer at the heated wall's middle because there was a higher fluid flow rate in the cavity's central section. In a typical porous cavity with a steady heat flux on one vertical wall, Prasad [2] investigated the buoyant thermal effect. In order to confirm that radical and differential data reveal a broad dispersion of heat flux data in buoyant heat transfer in porous media, Peter Vadasz [3] developed analytical solutions. When the strong fluid flows are located in the centre of the enclosure, the buoyant circulation is higher.

Bader Alazmi et al.[4] have investigated the beginning circumstances for a constant wall heat flux in the absence of a local thermal limit. The results of fluctuating porosity and buoyant heat transfer were examined. Results were discovered in terms of heat lines and streamlines.

Mahapatra et al. [5], have used numerical simulations to study the interaction of the radiation effect and mixed convection. The research shows that radiation has a significant impact on buoyant heat transfer and can be controlled to

flow in a reversible manner for the enclosure. Following a thorough review of the literature, the authors feel compelled to summarise a few earlier studies that highlight the natural convection phenomenon in divided cavities. Mezrhab and Bchir [6] performed numerical simulations of laminar natural convection in a 2D air filled regular enclosure with a vertical partition of finite thickness. The computational model is defined by adiabatic horizontal end walls and temperature-varying vertical surfaces. The calculations, which included shadow effects, were performed using a finite volume-based computational approach. There are no major changes in heat transport through the enclosure, particularly at Ra.

Aparna et all [7] studied the heat flux impact in a trapezoidal cavity using finite element simulations with triangle elements. A numerical investigation of several Rayleigh numbers was conducted. Nusselt numbers and stream functions. The heat transfer is greatest for sinusoidally variable Ra and heat flux. Varol et al. [8] numerically performed fluid motion and buoyant energy in a porous cavity with constant isotherms and a non-isothermally bottom wall heated triangular cavity are analysed using the finite difference method. Darcy's guiding law was employed to construct the codes of porous media packed inside a cavity. The foregoing literature search reveals a scarcity of information on buoyant thermal flux in enclosures with bottom walls subjected to heat flux boundary conditions. The goal of this work is to numerically predict the heat transfer and fluid flow in a 2D porous non-square enclosure given thermal flux beginning conditions along the bottom wall.

The foregoing literature search reveals a scarcity of information on buoyant thermal flux in enclosures with bottom walls subjected to heat flux boundary conditions. The goal of this work is to numerically predict the heat transfer and fluid flow in a 2D porous non-square enclosure given thermal flux beginning conditions along the bottom wall.

2. POROUS GEOMETRY

Figure 1 shows the physical domain of a Non-Square Porous area. As you can see, the top wall is chilly, the left and right side walls are well-insulated, and the bottom wall has evenly and sinusoidally fluctuating boundary conditions.

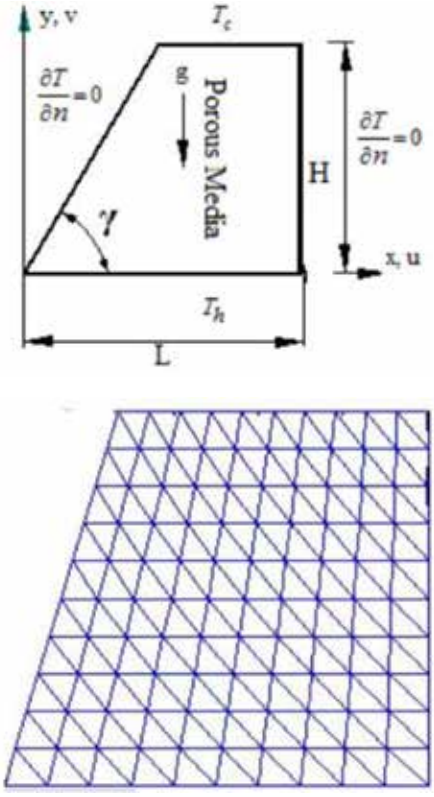

Fig. 1: Physical domain and Triangular Mesh for Right angle Trapezoidal cavity

3. PROBLEM FORMULATION

Assumptions are made in order to get the governing equations for the working model mentioned above,

- The heat exchange caused by radiation is minimal
- Flow of fluid with low Reynolds numbers
- The Newtonian and Boussinesq approximations serve as the working medium.
- Thermal equilibrium between a fluid and a porous media was achieved.
- Darcy's governing equation is applied to predict the flow inside the porous cavity.

For buoyant energy transfer, the dimensionless variables as

$$X = \frac{x}{L},\ Y = \frac{y}{L},\quad \psi = \frac{\psi}{\alpha},\quad \theta = \left(\frac{T - T_C}{T_h - T_C}\right) \tag{1}$$

Modified Rayleigh number

$$Ra = \frac{g\beta_T \nabla TKL}{\nu\alpha} \tag{2}$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \tag{3}$$

The velocity in X- direction can be described by

$$u = \frac{-K}{\mu}\frac{\partial p}{\partial x} \tag{4}$$

Velocity in vertical direction is given by

$$v = \frac{-K}{\mu}\left(\frac{\partial p}{\partial y} + \rho g\right) \tag{5}$$

The permeability K of porous medium is given by

$$K = \frac{D_p^2 \phi^3}{180(1-\phi)^2} \tag{6}$$

The buoyant parameter variation within the porous cavity is given by

$$\rho = \rho_\infty[1 - \beta_T (T - T_\infty)] \tag{7}$$

Momentum equation:

$$\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} = \frac{Kg\beta_T}{\gamma}\frac{\partial T}{\partial x} \tag{8}$$

Energy equation;

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right) \tag{9}$$

The continuity equation follows following stream functions such as

$$u = \frac{\partial \psi}{\partial y} \tag{10}$$

$$v = -\frac{\partial \psi}{\partial x} \tag{11}$$

Non-dimensional equations for porous cavities are

$$\left(\frac{\partial^2 \psi}{\partial X^2} + \frac{\partial^2 \psi}{\partial Y^2}\right) = -Ra\frac{\partial \theta}{\partial X} \tag{12}$$

4. BOUNDARY CONDITIONS

The boundary conditions for temperature with case (see Fig 1) are

$$\left.\begin{array}{l} \theta_h = 1 \text{ (Uniform heating, bottom wall)} \\ \theta_c = 0 \text{ (Top cold wall)} \\ \frac{\partial \theta}{\partial Y} = 0 \text{ (adiabatic inclined walls)} \\ \frac{\partial H}{\partial Y} = U\theta - \frac{\partial \theta}{\partial X} \quad \text{(Heat function)} \end{array}\right\} \tag{13}$$

5. SOLUTION METHODOLOGY

Based on a grid refinement research, calculations are carried out for a grid of size 41 X 41. For the purpose of solving the dimensionless governing equations, a finite element method known as Galerkin's residual is employed. Solving Eqn. (12) will yield the buoyant heat transfer values for the non-square cavity.

6. SIMULATION RESULTS

Using the finite element method, the grid independence for a porous square cavity with a regular mesh and triangle elements has been examined for mesh sizes of 11X11, 21X21, 31X31, 41X41, and 51X51.The average Nusslet number study with Ra = 500 for left side wall uniform heating is shown in the table. Since the average nusselt number stays constant at 41X41, 51X51, and 61X61 Grid Size and grows from 11X11 to 31X31, 41X41grid is utilised for all subsequent calculations.

Table 1. Mesh convergence study

Grid independence Test	
Grid Dimension	Average Nusselt No. $(\overline{Nu})$
11 X 11	10.3212
21 X 21	8.5325
31 X 31	7.1023
41 X 41	6.4456
51 X 51	6.4435
61 X 61	6.4401

The reference Aparna and Seetharamu [9] for linear heating has been compared to local parameters such as heat functions and stream functions. Using MATLAB, a code is created to produce isotherms and streamlines for 2D free convection issues in trapezoidal cavities.

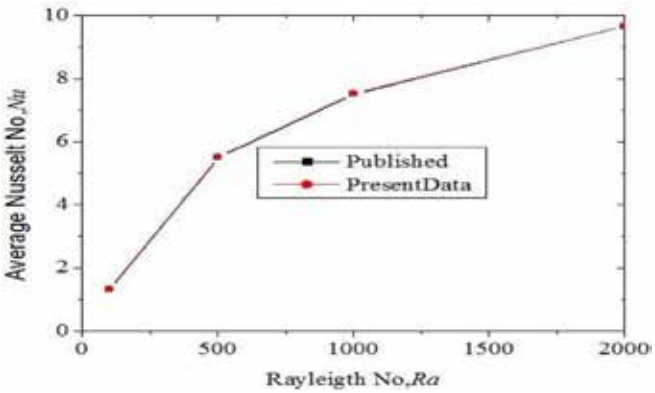

Fig. 2: Assessment of the present work with other published data for Non square enclosure at Ra = 500

To validate the current work, a 2D non-square enclosure filled with saturated water is used. Data is calculated using average Nusselt Numbers and the work has been explored for Ra = 500.Excellent agreement is established between the published data [9] and the current investigation, which has sidewall inclinations of 550 for non-square cavities.

Table 2 Validation of Average Nu with uniform heating is carried out with Published data of Aparna and Seetharamu [9]

$(\overline{Nu})$			
Ra	Present Study	Published Data [9]	Discrepancy, %
100	1.325	1.302	0.876
500	5.526	5.499	0.576
1000	7.525	7.505	0.306
2000	9.662	9.655	0.099

Figure 4 illustrates the relationship between Ra and the skin friction coefficient along a warm wall for a sinusoidal scenario. The predominant mode of heat transport at Rayleigh number Ra = 102 is conduction. In contrast, stream function curve magnitudes are quite tiny, and temperature contour stratification is located around the enclosure. As a result, the local heat transport is virtually linear. At Ra 1 x 103, convection becomes substantial. Near the corners, the fluid flow's size is incredibly small. At the start and finish of the local transfer of heat along the heated and cold surfaces, increasing and decreasing behaviour is seen.

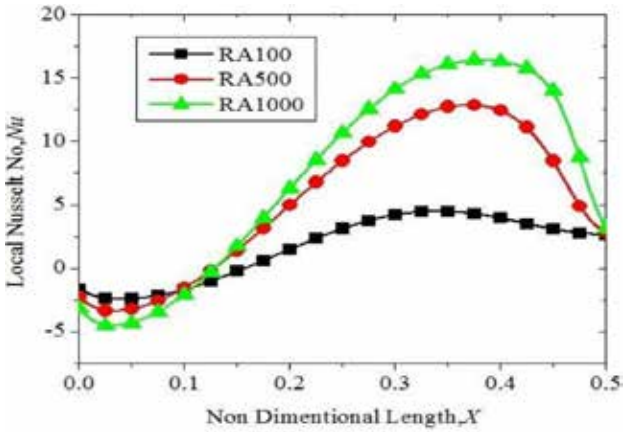

Fig. 3: Variation in local Nu with distance X for different Rayleigh Numbers with Sinusoidal temperature

Figure 4 shows a variation in the heating curve that is not uniform, but an asymmetry tendency is observed for the heated wall. The local Nu rises from -ve coefficients to positive values.

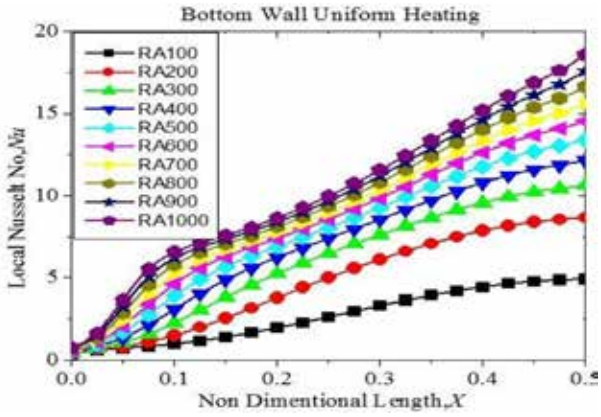

Fig. 4: Variation in local Nu with distance X for different Rayleigh Numbers with Uniform temperature condition

The top wall's local nusselt number is lower than the bottom wall's, and the maximum local nusselt number is found at about X = 0.49 from the hotwall in Fig. 4. Local nusselt numbers grow monotonically with an increase in Ra.

7. RESULTS AND DISCUSSION

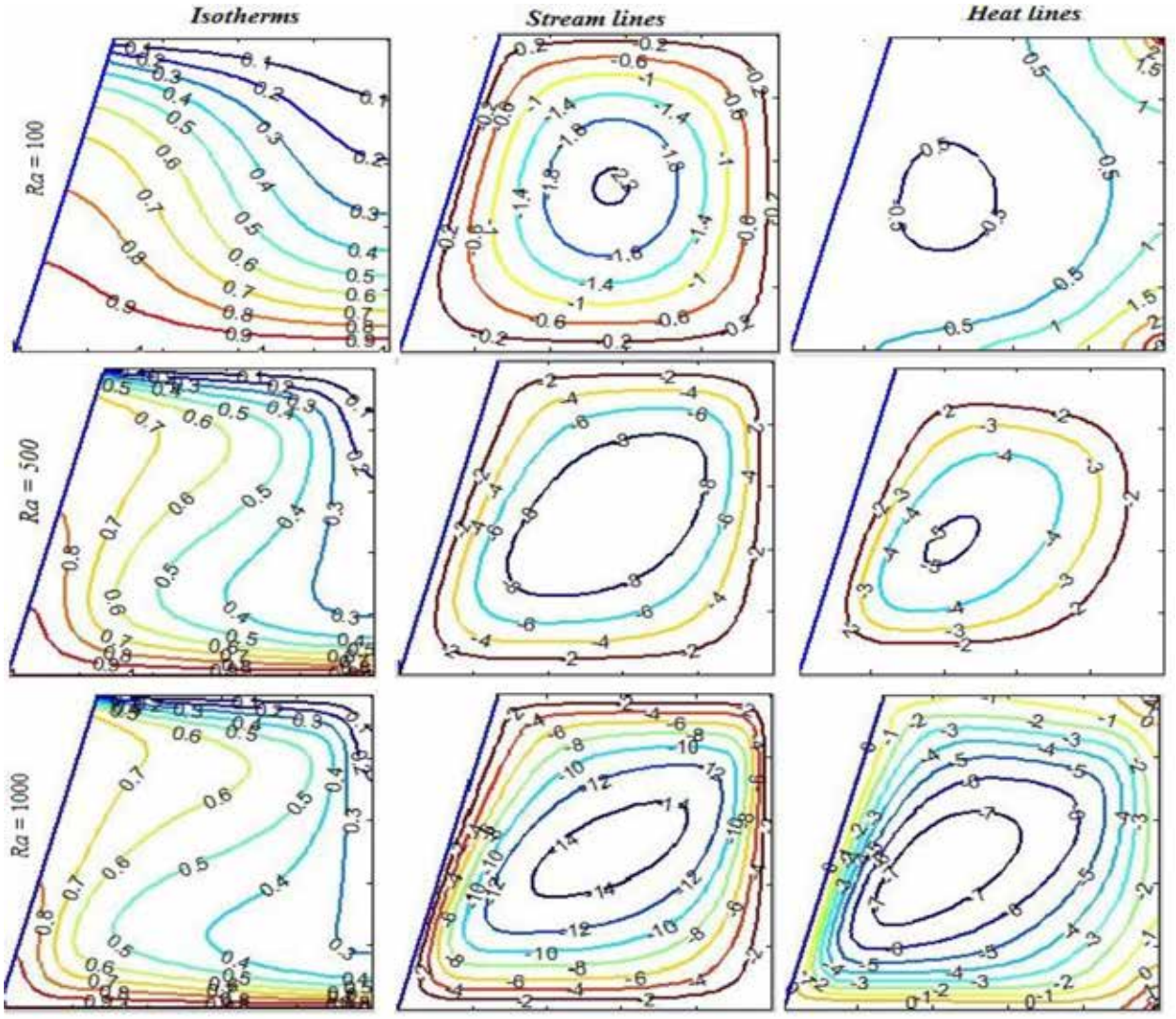

Figure.5Isotherms, Streamlines and Heat lines of bottom wall for Ra = 100, Ra = 500 and Ra = 1000 (Uniform Heating).

With the bottom wall exposed to a uniformly fluctuating heat flux boundary condition, Figure 5 displays the temperature contours, stream lines, and heat lines for Ra = 100 to 1000. Aspect ratio is regarded as being 1. The fluid on the left face rose as a result of the top and bottom walls' different temperatures. As a result, fluid rises from the centre of the left sidewall and moves towards the right side wall. The left sidewall's buoyant energy output is greater than the right sidewall's. Due to this, the isotherms' magnitudes for different Ra are virtually invariant, but the flow pattern changes as Ra rises. The isotherm contours that are extremely close to the hot wall (θ= 0.9) and cold surface (θ= 0.1) are nearly bent to the inclined wall. However, the smooth curves that encircle the heat flux walls are the isotherm contours,$\theta(0.8\geq \theta \geq 0.2)$.In comparison to Ra=100,500, the stream function that corresponds to Ψ=12 stretches more in the centre in Figure 6. Regarding streamlines, the number of elliptical loops created varies with magnitude values above 12, and a greater centre egg-shaped loop is obtained in non-square cavities compared to smaller Ra values.

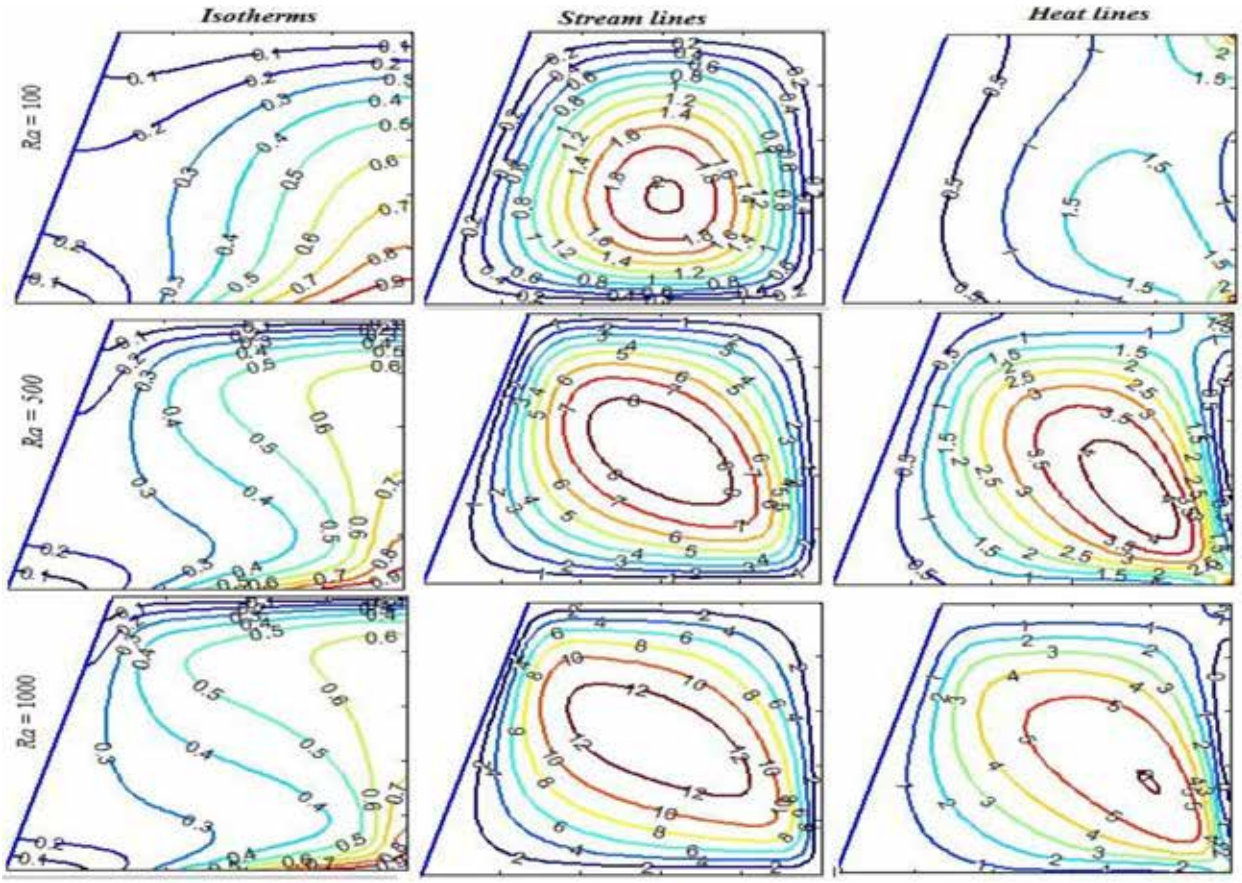

Figure.6: Isotherms, Streamlines and Heat lines of bottom wall for Ra = 100, Ra = 500 and Ra = 1000, (Sinusoidal heating).

In comparison to Ra = 100, 500, the stream function that corresponds to Ψ = 12 stretches more in the centre in Figure 6. Regarding streamlines, the number of elliptical loops created varies with magnitude values above 12, and a greater centre egg-shaped loop is obtained in non-square cavities compared to smaller Ra values.

8. CLOSED REMARKS

With a uniform and sinusoidal heat flux on the bottom wall, the aforementioned aimed to numerically studied the fluid flow and buoyancy driven heat transfer properties in a porous non-square cavity. The current study emphasises the impact of Ra on bottom wall heating in porous cavities. The FEM is utilised to forecast the issue at hand. It is possible to draw the following conclusions about this study:

- The largest thermal effect occurs at the bottom border of the cooled left wall in the event of linearly increasing heat flow on the bottom wall.
- The average Nu rises monotonically as modified Rayleigh numbers are increased.
- As Ra rises, the value of the velocity field rises as well, turning the conduction zone into a buoyant heat region.
- The average value of Nusselt number is higher for a bottom wall with a linearly varying heat flux.
- For square and non-square cavities, the right side heating wall's average Nu increases steadily as Ra rises, and this is more the case for uniform temperature than it is for the case when the temperature varies linearly for the walls.

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TRAINING NEEDS AND IMPLICATIONS

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1. INTRODUCTION

Successful job candidates require training in order to carry out their responsibilities well. To operate machinery, limit waste, and prevent accidents, workers must receive training. Supervisors, managers, and executives must also be trained in order for them to mature in thought and deed. They need training just as much as the workers need. In each organization, training and development are constant processes. Training and development simply refers to teaching certain knowledge, skills, and abilities to a worker. It is an effort to raise an employee's attitude or increase their knowledge and abilities in order to improve current or future employee performance. Training is the process of acquiring knowledge and skills so that someone may perform the assigned jobs effectively.

1.1 Company Profile in Brief

The establishment of Sri Raghavendra Engineering Systems Private Limited as a machine tool designing, Material Handling Systems & SPMS, and SS Fabrication Service Company took place in 1993. When asked to provide a variety of special purpose import substitute machine tools by one of its customers in 1993, the company made its entrance into machine tool manufacture.

2. PRODUCTS MANUFACTURED

1. CNC Lathes, Turning centers & solutions. (Sales Turnover: Rs. 194cr, 1292 Machines sold)
2. Vertical and Horizontal machining centers & solutions. (Sales Turnover: Rs. 110cr, 454 Machines sold)
3. CNC Cylindrical Grinding machines & solutions. (Sales Turnover: Rs. 37cr, 182 Machines sold)
4. Tool Turrets ATC's Tool Disk for World Markets. (Sales Turnover: Rs. 26cr, 3975 Units sold) 52% Export.

2.1 The organization's work flow model

- Certain components that cannot be produced in-house are outsourced to vendors. Other components used in machine construction are obtained from outside suppliers or produced in-house.
- Products made from sheet metal are treated and painted.
- Manufactured components are shipped for heat treatment and other processes as necessary.
- Depending on the sort of machine being built, an assembly kit is prepared.
- Machine assembly is carried out in accordance with the product line, and the finished item is tested at every stage of assembly.
- The distribution of all completed input components begins with their transfer to central repositories.
- The assembly process is dependent on the design department's BOM (Bill of Materials).

- After testing, the finished product is delivered to the dispatch counter for packing and shipping.

2.2 Study Design: Study Goals and Purpose

Objectives/purpose of study

1. To comprehend the important sectors' training requirements.
2. To comprehend the training strategies used by Sri Raghavendra Engineering Systems Private Limited to boost worker productivity.
3. To research the necessity for training and its implications for the worker.
4. To make suggestions for improvements to the current system in line with best practices for the sector.

3.0 DATA ANALYSIS AND INTERPRETATION

The employees' work experience at SRE Factory:

10% of the employees at SRE factory have the work experience of 10 years and above, 10% of the employees have the work experience between 5-10 years, and 80% of the employees have the work experience less than 5 years

Training programme requirements:

5% of the employees say that training is required before joining, 52% of them say it is required after joining, 10% say it is required monthly, 29% quarterly and 5% yearly.

Employee opinions on how training needs are identified:

15% of the employees believe that training need is identified on monthly basis, 50% of the employees believe on quarterly basis, 10% of the employees believe it is identified every half yearly and 25% of the employees believe the need is identified on yearly basis.

Preference of training in the company:

50% of the employees at SRE factory prefer On the job training, 10% of the employees prefer off the job, 5 % of the employees prefer Seminars and 35% of the employees prefer all of the above forms of training

Do you know what our organization's vision and objectives are for the next one to three years?

75% of the employees at SRE factory know the vision and goals and 25% of the employees do not know the vision and goals

Are you a goal focused individual?

80% of the employees at SRE factory are goal focused know their objectives and 20% of the employees are not focused on what they are doing in the organization

Do you sometimes say to yourself "I know what I mean, but I can't explain it"?

70% of the employees at SRE factory can explain very clearly what they mean and 30% of the employees fail to explain what they know.

Do you fail to speak up too frequently when you know you should?

45% of the employees fail to speak up when required at SRE factory and 55% of the employees are able to speak up when required

Do you have many days when you are busy all day, but relatively non-productive?

45% of the employees at SRE factory are busy all day yet non-productive and 55% of the employees say that they are productive and busy most of the time.

Usage of decision matrix to organize priorities and make decisions:

40% of the employees at SRE factory knowhow to use the decision matrix to prioritize and make decisions and 60% of the employees do not know how to use decision matrix

Finding a work-life balance

85% of the employees at SRE factory know how to balance work and rest, 15% of the employees do not know how to balance the work life and rest.

In a conflict situation, do you act calmly and carefully?

90% of the employees at SRE factory know to handle conflict situations calmly and carefully. 10% of the employees say that they do not know to handle a conflict situation

Reasons for enrolling in a training programme: 48% of the employees at SRE factory say that program objectives would influence them to join the training, 5% of the employees say location as the driver, 21 %

of the employees say Facilitator/presenter, 13% of the employees say that length of program and 13% of the employees say price would influence them to enroll into a training program

The classroom is the most efficient setting for instruction:

10% of the employees at SRE factory feel that classroom training is not very effective, 70%of the employees feel they are somewhat effective and 20% of the employees feel that classroom training is very effective

Video as the most effective method of training:

5% of the employees at SRE factory feel that video as a form of training is not very effective, 30%of the employees feel that they are somewhat effective and 65% of the employees feel that video as a form of training is very effective

Internet as the most effective method of training:

5% of the employees at SRE factory feel that Internet as a form of training is not very effective, 80%of the employees feel that they are somewhat effective and 15% of the employees feel that internet as a form of training is very effective

Induction was conducted in the organization:

95% of the employees at SRE factory have had the induction program when they joined and 5% of the employees have not had the induction program at the time of joining.

Briefing about the training objectives:

50% of the employees at SRE factory say that objectives were briefed to them before the training and 50% of the employees say that objectives were not told and briefed about in advance.

Training program is needful:

65% of the employees at SRE factory agree that training program is needful, 25% strongly agree that training program is needful, 5% of the employees disagree that training program is needful and 5% of the employees do not know if it beneficial or not.

Training equips you with the necessary skills:

55% of the employees at SRE factory agree that training provides the skills required for performing a task, 15 % of the employees strongly agree, 25% of the employees disagree that training provides the skills required and 5% of the employees strongly disagree that training provides the skill sets to perform an activity

Making Use of Training-Related Knowledge:

50% of the employees at SRE factory feel that they use the Knowledge gained from the training program, 5%of the employees feel that they don't use the knowledge from the training and 45% of the employees feel that they use the knowledge gained from the training sometimes

Freedom of expression during training:

95% of the employees at SRE factory have the freedom of expression during the training program, 5%of the employees feel that they do not have the freedom to express their views during the training program

Pre-test and post-test to check the effectiveness of training program:

70% of the employees at SRE factory feel that there should be a pre test and post test to check the effectiveness of training program and 30% feel that there is no necessity to have a pre and post test to check the effectiveness of the training program

Does your company sponsor training if the necessity for it is determined?

75% of the employees at SRE factory get the sponsorship from their company if the need for training arises and 25% of the employees say that their training needs sponsorship will not be provided by the company

Your training programme will assist you in:

30% of the employees feel that training program should help build better confidence to work better, 40%of the employees feel that training should help develop new skills, 25% of the employees feel that training should help adapt to the work environment better and 5% of the employees feel that training should help provide job satisfaction.

4.0 FINDINGS AND SUGGESTIONS

4.1 Findings

1. The majority of SRE personnel have fewer than five years of experience altogether.
2. Training needs are determined every three months.
3. Almost all new hires receive on-the-job training when they join the company.

4. The majority of employees are aware of the organization's goals and objectives
5. Employees receive communication training each year
6. The majority of employees are reluctant to speak up and share their opinions on issues
7. There is a lack of cooperation across divisions, which causes some individuals to be ineffective despite working nonstop.
8. The majority of staff members lack knowledge of how to prioritise work and make judgements using the decision matrix.
9. Objectives of the training programs are not stated clearly before the training
10. The employees have a strong belief that training would provide them the abilities they need to perform better, yet the objectives of the training programmers are not explicitly outlined before the training.
11. The firm conducts virtually little off-the-job training for its personnel.
12. When necessary, the business funds employee training.
13. Workers believe that training has given them the confidence they need and given them the opportunity to learn new skills.
14. The employee believes that a pre- and post-test will be beneficial. Training manuals and materials are rarely updated

4.2 Recommendations

1. Analyzing the training needs is extremely significant and required for any industry in order to match the rapid changes in technology and the current scenario. So, taking into account the changes in the corporate environment, the training programme should be revised.
2. Depending on the demand and technical advancements, regular training should be offered in the organisation.
3. Employees should receive department-specific training since they will comprehend it better and do the task better.
4. In order to improve the training programme and learning, feedback regarding the trainer should be collected.
5. The majority of SRE's staff members have fewer than five years of industry experience. The organisation will foster a more courteous environment and improved information sharing by hiring senior personnel.
6. All employees should be given the freedom to express themselves and their ideas, as doing so will foster innovation and increase job happiness.
7. Given that the majority of employees are unaware of how to use the decision matrix and prioritize their responsibilities, training on the decision-making process should be conducted.
8. Trainers should make sure that the training program's objectives are communicated to the participants before the training begins in order to increase enthusiasm among participants and to weed out any non-participants.

4.3 Trainers should brief the employees or train the employees with handling procedures with respect to the following as this would result in better organization behavior:

- Grievance
- Performance management
- Customer service skills
- Work place ethics
- Conflict management
- Strategic management
- Hiring and firing
- Presentation skills
- Stress management
- Cultural diversity
- Compensation and benefits
- Sexual harassment
- Recruitment and retention

- Workplace violence
- Supervisory skills

5.0 CONCLUSION

Every person in a business strives to make the company better: SRE Pvt Ltd in Bangalore, which has its name ingrained in the discipline of human resources and its methods, is no exception. To increase the effectiveness of training, the responsible department should set up development and training programmes.

According to the study's findings, SRE Pvt Ltd. in Bangalore has good overall effectiveness and can continue to improve in the future by implementing minor process adjustments. By determining their own training needs and participating in the organization's training programmes, employees actually gain something. Having personnel with improved skill sets and more productivity is advantageous to the company. The business provides a solid basis for career advancement.

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   c) www.raghavendrasystems.com/index.html

   d) Company reports:

   e) Company brochures

MECHANICAL AND TRIBOLOGICAL CHARACTERISATION OF AL6061 AND ZIRCON SAND

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ABSTRACT

The aim of this work is to investigate mechanical properties such as tensile strength, hardness and wear characteristics of as cast zircon sand reinforced aluminium 6061 matrix composites. Aluminium metal matrix composite specimens of varying Zircon sand (0, 2, 4,6 and 8 wt. %) were prepared by stir casting process. Brinell hardness, tensile strength and wear performance of the prepared composites specimens were analysed. The results showed that introducing zircon sand as particulates in Al6061 matrix increased tensile strengthens and hardness. 8 wt. % zircon sand reinforced AMC showed maximum hardness and tensile strength. Pin-on-disc wear test indicated that reinforcing Al6061 matrix with Zircon sand particles increased wear resistance. Frictional wear (μm) is low in 8 wt. % of Zircon sand compared to the lower wt. % zircon sand as reinforcement.

KEYWORDS *: AMC, Al6061*

1. INTRODUCTION

In recent years there is an increasing stress on high performance materials in all sectors of applications, be it aerospace, automobile or building or entertainment. Since, monolithic materials including metals and alloys do not meet these demands, a trend of developing new materials to meet these demands has emerged during almost last four decades. One such material is `composite material`, which is defined as a material having two or more dissimilar materials when combined together with suitable distribution exhibits improved properties than either of the individual materials. They differ from conventional alloys in that though the later also consist of two or more dissimilar materials, individual materials are chemically mingled in it while in the former, they are both physically and chemically separable. In composites, one phase is continuous phase called `matrix`, while the other is discontinuous, called `dispersoid` or `reinforcement` or `filler` depending on its role in the matrix. Composites have been classified depending on the nature of composite (natural: Ex: Wood or manmade: Ex: Concrete), type of matrix used (Metal, Polymer or Ceramics) or type of second phase used (Continuous or Discontinuous). Properties of these materials can be tailored by appropriate selection of matrix and dispersoids, content, size and shape of the latter as well as the processing method to fabricate them. In addition, the properties of boundaries

(Interfaces) between the constituents also contribute to the properties of composites. Properties can be enhanced with different heat treatment process.

2. LITERATURE REVIEW

A variety of light metals such as Al, Mg and Ti have been used as matrices rather than heavy metals such as Fe and steel in view of the existing possibility of enhancing their properties economically by conventional methods such as alloying and heat treatment. Further, due to their inherent light weight, good corrosion resistance, ease of handling, and a wide range of present and future applications, mostly Al and its alloys, both cast alloys [AA356 (LM25/AS7G), AA357, LM13, LM11 and LM30] and wrought alloys [Al-Si-Mg (6061), Al-Cu (2014/2024) and Al-Zn-Mg (7075) are mostly chosen as the matrices for MMC synthesis. Similarly a variety of materials in discontinuous and continuous form have been used as reinforcements [1-5]. Song et al. [6] have reported studies on Al alloy with carbon and Al_2O_3, while Tsong et al. [8] on BNp/SiCp composites. In both cases superior wear resistance over the monolithic composite or matrix alloys have been observed. Similarly, Gurcan and Baker [9] have reported Al6061-Al_2O_3/SiCp composite superior wear resistance compares to monolithic composite of Al6061-Al_2O_3 or the matrix alloy. Presently, there are more than 20 R & D and academic institutions in the country involved in the area of MMC, most of which have been concentrating on primary processing(solidification technique), secondary processing (extrusion, forging and rolling) and characterization of resulting composites. Very few attempts have been made on the product development while a number of groups are working in simulation and modelling also [9-10].Processing by both liquid metallurgy and semisolid techniques have been followed for the preparation of MMCs in the country, while their secondary processing particularly extrusion has been carried out with the capability demonstration of producing rods and tubes of various sizes and also products by forging [11]. Characterization of Al-MMC thus processed has been carried out through mechanical and tribological property evaluation to understand these observed properties.

3. EXPERIMENTAL WORK

3.1 Matrix Material

The base metal matrix chosen in the present study is the aluminium 6061 because it is one of the most extensively used of the 6000 series of aluminium alloys. It is a versatile heat treatable extruded alloy with medium to high strength capabilities. Chemical Composition of the Base Matrix: (Al 6061) is shown in Table1.

Table1: Chemical composition of Al6061

Element	Zn	Si	Cu	Mg	Mn	Ti	Cr	Fe	Other	Al
% by Wt	0.25	0.8	0.4	1.2	0.15	0.15	0.35	0.7	0.15	Balance

Reinforcing Material

The reinforcement material chosen was Zirconium Silicate or simply known as Zircon sand which is likely to enhance properties of the base material. Zircon sand particle used for this experiment is 75 microns (200 meshes).

Chemical Composition of Reinforcing Material: (Zircon sand)

Element	**ZrO_2**	**SiO_2**	**TiO_2**	**Fe_2O_3**	**Volatilities**
% by Wt	65.9%	32.2%	0.3%	0.07%	1.53%

Melting of Alloy and Specimen Preparation

Sieve test analysis was conducted on pulverized reinforcing material (Zircon sand) .Particle size of 75 microns was selected for the castings preparation. Required amount of aluminium alloy is taken in a ceramic crucible and is placed in a stir casting furnace. The electric power is supplied from external source to the furnace coil. After the aluminium attains the melting temperature the reinforcing material (Zircon sand) is added into the molten metal in calculated quantities so as to obtain the desired composition of the cast(0% to 8% by weight) through a stirring equipment. The molten metal is stirred well to obtain a well-defined vortex motion. Preheated particulate (300°C) Zircon sand was dispersed into the melt through this vortex. The stirring was continued until homogeneous mixture is obtained. The molten metal is poured into the mould, molten metal is allowed to solidify and the resulting casts are inspected for defects.

Figure 1: Melting furnace

Casted parts or specimens

The test specimens were machined from casted samples as per A.S.T.M standards and are presented in the figure.

Fig-2:Tensile test specimens

Fig-3:Wear test specimens

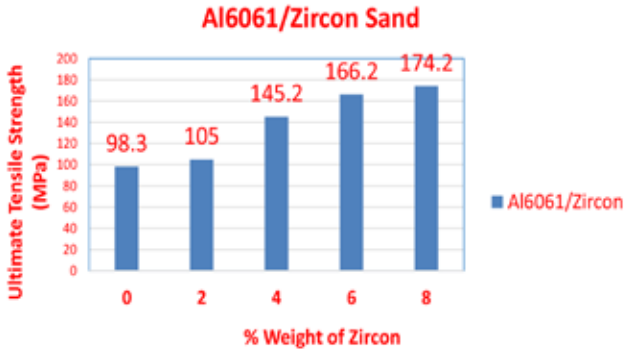
4. RESULTS AND DISCUSSIONS

Three different tests were conducted on the specimens to determine mechanical properties:

1) Tensile test 2) Hardness test 3) Wear test

4.1. Tensile Strength

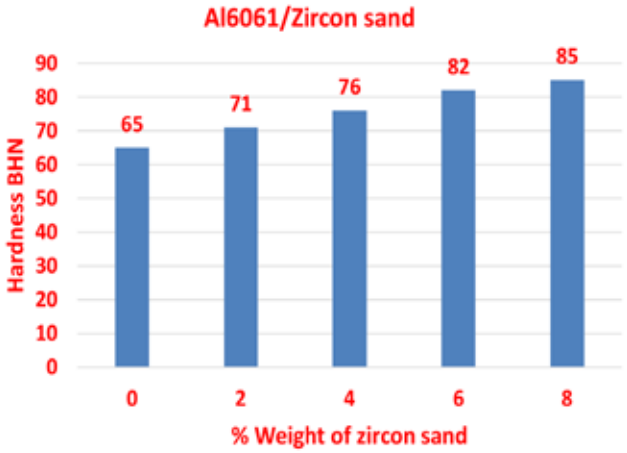
Tensile test was conducted on universal testing machine. The test carried out as per A.S.T.M standard. All the samples were tested for tensile strength. The samples were loaded till fracture and tensile strength measured.



Graph-1: Ultimate tensile strength

4.2. Hardness Test

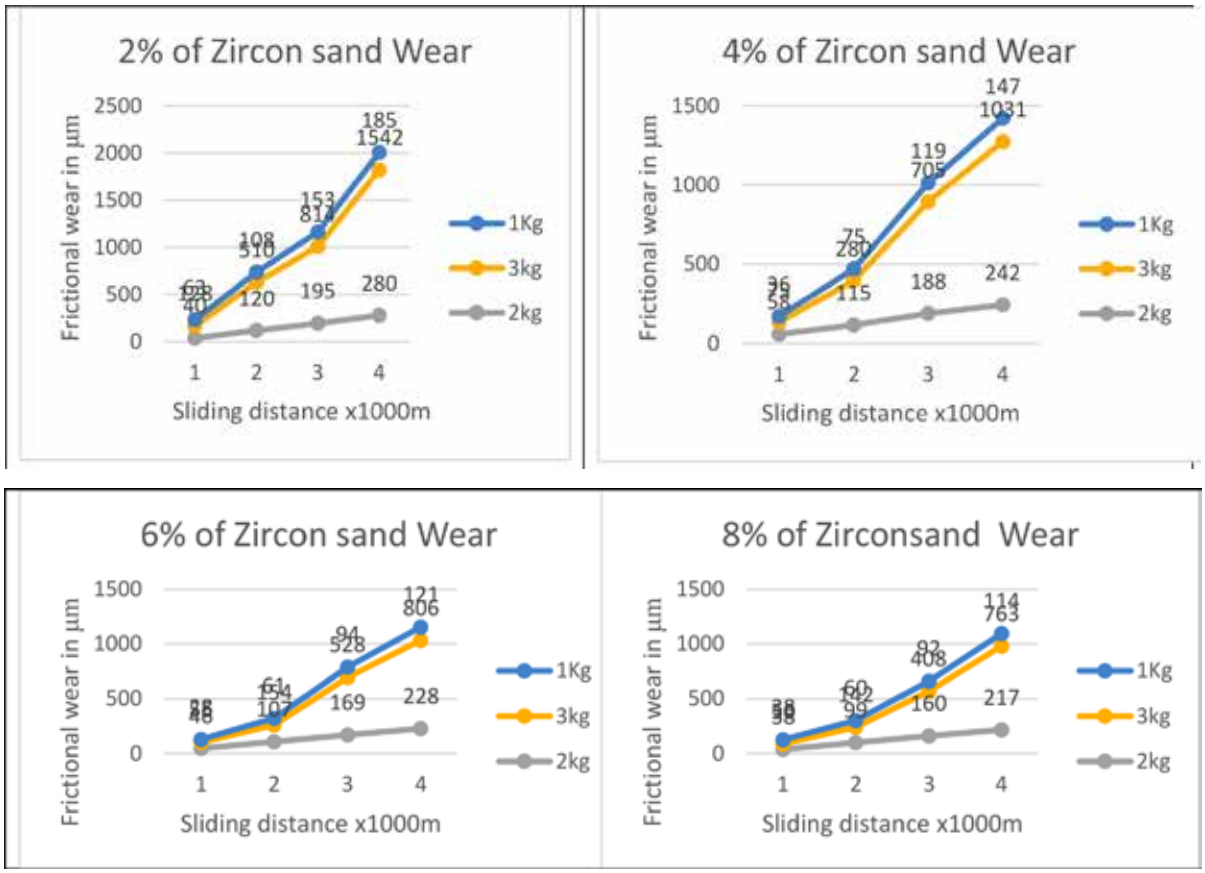
Hardness was determined by Brinell hardness test on the specimen. The test was carried out at three different locations on the specimen to negate the possible effect of indenter resting on the harder particles using ball indenter. The test was carried as per A.S.T.M standards.



Graph-2: Hardness test

4.3. Wear test

Wear test was conducted using pin-on-disc method at room temperature under dry sliding condition. Wear test was carried out on test specimen under three different loads of 1kg, 2kg and 3kg. The test specimens are prepared as per the requirement of the machine.



Graph-3:. Frictional Wear for various wt. % of Zircon sand

5. CONCLUSIONS

Al6061 based metal matric composites have been prepared successfully with the help of stir casting technique with uniform distribution of Zircon sand particles. The composites were tested for measuring the tensile strength, hardness and wear resistance values.

1. Hardness of aluminium alloy increases with increase in wt. % of Zircon sand. With 8 wt. % of Zircon sand BHN value increases up to 20%.
2. Tensile strength of composite increases with increase in wt. % of Zircon sand. With 8 wt. % of Zircon sand tensile strength value increases up to 77%.

3 Wear resistance of aluminium alloy increases with increase in wt. % of Zircon sand. With 8 wt. % of Zircon sand addition wear resistance enhanced significantly compared to 2 wt. % of Zircon sand.

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EFFECT OF NANOPARTICLES ON TRANSESTERIFICATION PROCESS

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ABSTRACT

The utilization of fossil fuels like diesel has contributed immensely to ecological challenges such as the emission of greenhouse gases. Hence, the motivation for sourcing energy that is renewable as well as easily accessible from relatively cheap materials. Biodiesel is a perfect replacement for petro-diesel because it is biodegradable, economically viable, and has lower toxicity. However, there are challenges associated with its utilization in engines. It also raises a NO_x emission which necessitates frequent engine component replacement owing to clogging, and it is ineffective to cold weather. To boost efficiency, nanoparticles can be combined with bio diesel blends. Moreover, the utilization of nanoparticle additives improves the performance of engines, rate of heat transfer, fuel mixture balance, thermo- physical characteristics, as well as the reduction in exhaust emissions. Copper oxide which is a transition metal oxide aids in the heat transfer from the engine down to the exhaust thus lowering the emission of Carbon monoxide, Unburnt Hydrocarbon, NO_x and increase in CO_2. As a result, CuO nanoparticles are thought to have a lot of potential as a diesel engine additive. Furthermore, the combustion behaviour, performance, and emission characteristics of diesel engines powered by CuO nanoparticle-containing biodiesel and blends were carefully investigated.

1. INTRODUCTION

Biofuels are receiving tremendous attention worldwide as renewable and alternative source of energy production. Biofuels can be produced with the help of various materials through different extraction methods and conversion processes. However technical problems faced in the large-scale production of biodiesel results in making the whole process uneconomical for commercialization. Thus, it becomes essential to develop efficient and cost effective technologies for harvesting, oil extraction and biodiesel production. This review presents an overview on harvesting, oil extraction and biodiesel production technologies for various materials[2].

India is looking at renewable alternative fuel sources to reduce its dependence on foreign oil. As India imports 70 % of the oil it, the country has been hit hard by increasing costs and uncertainty. Biodiesel fuel derived by the transesterification of non edible oil from Pongamia pinnata (Honge) meets the requirements of a diesel fuel. Further, its cultivation and use do not add to net global warming.

Biodiesel is a liquid biofuel obtained by chemical process called “Transesterification” in which fatty acids

present in crude oil of pongamia pinnata is converted into long chain esters. ASTM (American Society Testing and materials) defines biodiesel as mixture of long chain mono alkylic esters from fatty acids obtained from renewable resources, to be used in diesel engine. The biggest challenge modern industrial society is facing today is the decline and exhaustion of the fossil energy resources[4]. The Primary sources of energy that power our civilization are those fossil fuels. One of the most prominent alternative energy resources, attracting more and more interest in recent years with the price for crude oil is reaching heights, is biodiesel, which is possible substitute for petroleum-based diesel fuel. Many studies have shown that the properties of biodiesel are very close to petroleum-based diesel fuel. Therefore, biodiesel fuel can be used in diesel engines with little or no modifications.

Problem statement

The biggest challenge modern industrial society is facing today is the decline and exhaustion of the fossil energy resources. The Primary sources of energy that power our civilization are those fossil fuels. One of the most prominent alternative energy resources, attracting more and more interest in recent years with the price for crude oil is reaching heights, is Biodiesel. The study of biofuel-diesel fuel blends with nanoparticles is very timely because of arising problems such as the increasing cost of the fuel and health problems such as respiratory diseases which are caused by byproducts of combustion of fossil fuels such petroleum-based fuels.

Objectives

- To Extract Crude oil from Honge seeds.
- To Study the effect of Nanoparticles on Transesterification process.
- To check the basic fuel properties of different blends of biofuel and diesel fuel.
- To conduct the performance characteristics of four stroke diesel engine for diesel and bio diesel blend.
- To carry out emission analysis of four stroke diesel engine for biodiesel and diesel blend.
- To evaluate results.

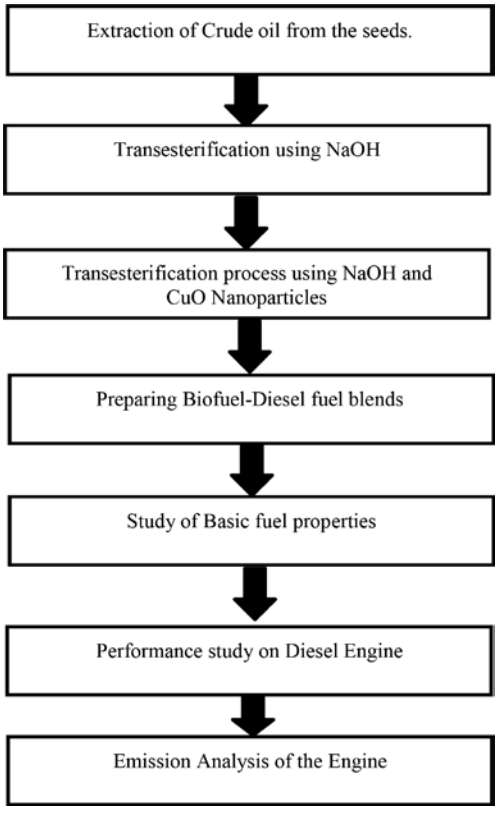
Autor	Title	Year	Extract
Manjunath Channappa gouda	Effect of copper oxide nano additive on diesel Engine performance operated with dairy scum Bio diesel	2018	This study explores the effect of copper oxide nano additive fuel blends on the diesel engine performance, combustion and emission characteristics. From the experimental study, it is concluded that the copper oxide nanoparticles (CuO) are the efficient metal additives as they improve the engine performance inturn BTE and BSFC and reduce HC, CO (except NOx) exhaust emissions of the diesel engine.
P. Kannan et al.	Effects of CuO nano additives on performance and emission characteristics of Putranjiva biodiesel	2021	CuO nanoparticle washighly preferred for its constructive thermal properties like heat capacity, heat conductivity, high melting temperature, and low thermal expansion. Also, environmentally friendly behavior with easy production characteristics and an on toxic synthesis route of CuO made it the preferable one over other. There are many holes on the CuO Nanoparticle surface, which may help the transesterification reaction. With an increasing number of pores within the catalyst, the catalyst's specific surface area increases, and the transesterification process occurs on the catalyst's surface.
Pankaj Mohan Rastogi etal.	Effect of CuO nanoparticles concentration on the performance and emission characteristics of the diesel engine running on jojoba (Simmonds Chinensis) biodiesel	2021	It can be accomplished that,fuel having nano-metal additives will enhance the engine combustion and reduced harmful exhaust emissions characteristics. Smaller size of CuO nanoparticles shall lead to improve the stability of fuel suspensions and prevent the test fuel clogging problems in fuel injectors.

Sarah Oluwabunmi Bitireetal	The impact of CuO nanoparticles as fuel additives in biodiesel- blend fueled diesel engine: A review	2021	The reviewed studies showed that CuO nanoparticles added to biodiesel blends improved the emission characteristics, engine performance, as well as combustion characteristics. Consequently, in comparison to biodiesel devoid of CuO nanoparticles, the BTE and BSFCmetricsexhibited substantial improvement. The addition of CuO nanoparticles to biodiesel also improved emission properties. CO, HC, and NOx are all green house gases that were reduced significantly.

1.3.1 Literature Survey on Sodium Hydroxide(NaOH)

Autor	Title	Year	Extract
Sandeep Kumar Duran	A review on oil extraction and biofuels production From various materials.	2020	The direct blending of oil with diesel does not require any further processing or pretreatment, which add no cost for using it. Acid or base, anyone can be used as catalyst for transesterification of oil. Most of the researchers uses NAOH and KOH as catalyst for biodiesel production.
P. Chitra. P. Venkata-chalam	Optimization of experimental condition for biodiesel production from Alkali catalyzed transesterification of Jatrophaoil.		The important factors that affect thetransesterification reaction are the amounts of methanol and NAOH reaction temperature and reaction time.

2. METHODOLOGY



2.1 Extraction of crude oil

The seeds of pongamia pinnata tree contain 30% to 35% of oil in it, which can be used as crude oil for biodiesel production. The seeds of pongamia were collected and cold pressed to obtain Crude oil.

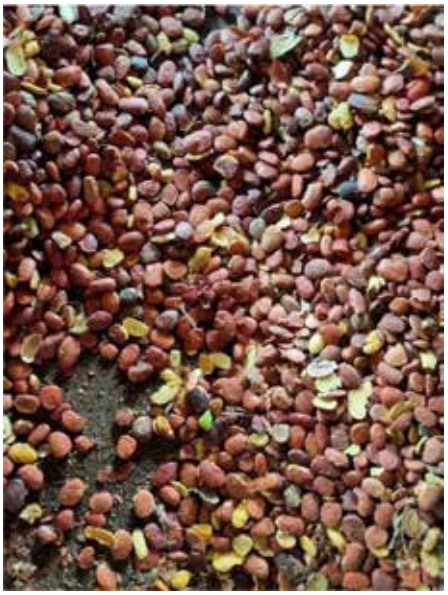


Figure 1. Seeds of Pongamia pinnata

Figure 2. Extraction of crude oil

2.2 Transesterification using NaOH

Transesterification is defined as the chemical conversion process of triglycerides with alcohol into alkyl esters with the help of a catalyst. Transesterification process Start with Free Fatty Acid Test (FFA Test). FFA Test is done by Titration in which Burette is filled with NaOH and distilled water and conical flask is filled with isopropyl Alcohol, crude oil and phenolphthalein n Indicator.[5][6]

Burette: NaOH+Distilled Water Conical Flask: isopropylalcohol+oil+Indicator End point: Pale pink FFA test is carried out by titrating and distilled water in burette against isopropyl Alcohol, crude oil and phenolphthale in indicator in a conical flask.

If FFA is greater than 4, the Acid esterification has to be done because if transesterification is done directly there will be formation of Soap instead of biofuel. As FFA is greater than 4 Acid esterification has to be done by heating a mixture of crude oil, methanol and H2SO4. The amount of H2SO4 is determined.

This mixture is heated. After heating it is kept in separation funnel to separate free fatty acids.

Now, the acid esterified oil is again done with FFA test with the same procedure and after its FFAcame out to be 4.79 which is greater than 4 so it is necessary to do acid esterification again. After two Acid esterification FFA came out to be 3.9 grams which was less than 4. Now we can go for Transesterification Process.

Figure 3. Titration end point

Figure 4. Acid Esterification

"Transesterification" is done by heating the acid esterified oil with methanol and NaOH The amount of NaOH will depend upon the value of FFA as shown in the table below.

After heating the solution, it is kept in the Separation funnel for 1hour 30minutes. Separation funnel separates the biodiesel from glycerin.

2.2.1 Washing of Biodiesel

Then extra process which has to be done after we obtain biodiesel from separation funnel is washing. Washing is done to remove methanol if present in the biodiesel.

Washing is done using hot water at 60 degree Celsius at least 6 times to obtain pure biofuel.

After Washing, the drying process has to be done to remove glycerin and water.

This is done by heating the biofuel at 140 degree Celsius for 15 minutes. After that, it is left for cooling. So, after Cooling our Biodiesel is ready.

Figure 5. Sodium Hydroxide

Figure 6. Transesterification

Figure 7. Separation Funnel

Figure 8. Washing

2.3 Transesterification with addition of CuO-nanoparticle

Transesterification begins with FFA test, it is carried out by titrating and distilled water in burette against isopropyl Alcohol, crude oil and phenolphthalein indicator in a conical flask.

As FFA is greater than Acid esterification has to be done by heating a mixture of crude oil, methanol and H2SO4. The amount of H2SO4 is determined by formula.

This mixture is heated, and after heating it is kept in separation funnel to separate free fatty acids. Now the acid esterified oil is again tested for FFA test with same procedure. Now FFA came out to be 3.9. As FFA is less than 4 we can go for Transesterification.

Transesterification is done by heating the acid esterified oil with methanol and mixture of NaOH and CuO as Catalyst[3]. The amount of NaOH will depend upon the value of FFA as shown in the table 1 and amount of CuO taken is 4% of the NaOH.

After heating the solution, It is kept in the Separation funnel. Separation funnel separates the biodiesel from glycerin. The next process which has to be done after we obtain biodiesel from separation funnel is washing. Washing is done to remove methanol if present in the biodiesel. Washing is done using hot water Celsius at least 6 times to obtain pure biofuel.

After Washing, the drying process has to be done to remove glycerine and water. This is done by heating the biofuel at 140 degree Celsius 15 minutes. After that it is left for cooling. So, after Cooling our Biodiesel is ready.

Figure 9. Titration end point

Figure 10. Addition of CuO Nanoparticles

Figure 11. Transesterification

Figure 12 Separation Funnel

Biofuel obtained when CuO Nanoparticles were added is 840ml which is more than that of Using NaOH. The yield of Transesterification Increases with addition of CuO Nanoparticles because it provides more Surface area for reaction to occur.

2.3.1 BlendsPreparation

The Obtained biofuel is blended with Diesel in the following manner,

- B10:900ml of diesel and 100ml of Biofuel
- B20:800ml of diesel and 200m l of Biofuel
- B100: Pure Biofuel

2.4 Basic fuel properties

- Calorific Value: The energy contained in a fuel or food,determined by measuring the heat produced by the complete combustion of a specified quantity of it. This is now usually expressed in joules per kilogram.
- Density: Density of fuel is "the mass of fuel per unit volume". In some cases the density is expressed as a specific gravity or relative density, in this case it is expressed in multiples of the density of some other standard material, usually water or air.
- Viscosity: A measure of resistance of the fuel to flow at a stated temperature. According to ISO, the kinematic viscosity of heavy fuels should be specified in centistokes at 100°C.
- Flash Point: Flash point is the lowest temperature at which a Fuel will form a vapor in the air near its surface that will "flash,"or briefly ignite,on exposure to an open flame. The flash point is a general indication of the flammability or combustibility of a liquid.
- Fire Point: The fire point of a fuel is the lowest temperature at which the vapor of that fuel will continue to burn for at least five seconds after ignition by an open flame of standard dimension.

2.4.1 Calorific Value Test using Digital Bomb Calorimeter

Description of the Apparatus:

The Digital Bomb Calorimeter consists of a heavy constant volume combustion chamber or "BOMB" Submerged in water. A sample of fuel to be tested is

placed in a crucible within the Bomb and can be ignited by burning the fuse wire. The water is constantly stirred. There will be rise in the temperature of water after combustion of the fuel which has to be noted.

The Combustion is at constant Volume, therefore all of the chemical energy released by the combustion will be converted into internal intrinsic energy of the combustion products, and most of this leave the bomb in the form of transferred heat. Since the temperature rise of the combustion products is small and the water vapour formed during combustion almost Condensed, this transferred heat will approximate the higher calorific value of the fuel sample. The bomb is filled with saturated Oxygen before combustion.

Calorific Value for B100:- CV=37470.5115kJ/kg

Calorific Value for B20:- CV=40212.046kJ/kg

Calorific Value forB10:-CV =43030.8242kJ/kg

2.4.2 Viscosity and Density

Redwood Viscometer

The Redwood Viscometer consists of the Silver-plated oil cup about 4.5cm in diameter and 9cm in deep, mounted in a chrome plated water bath. The water bath is mounted on the stand with leveling screw. The base of the cup has a central hole into which a jet is fitted with its bore in the axis of the cup. The level to which the oil is to be filled into the oil cup is given by an index fixed to the inside wall of the oil cup. The cylindrical water bath surrounds the oil cup and is provided for the oil with a tap for emptying. A ball valve for starting and stopping the oil flow is also provided. A stiff wire spring clip arrangement is mounted to hold the thermometer.

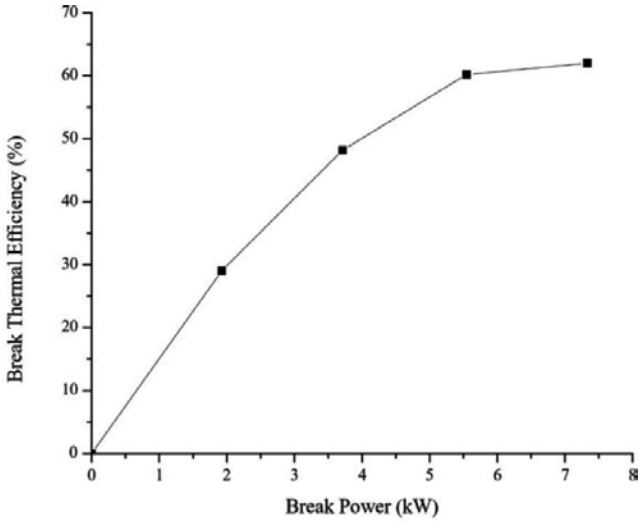
Table 1. Viscosity and Density Values

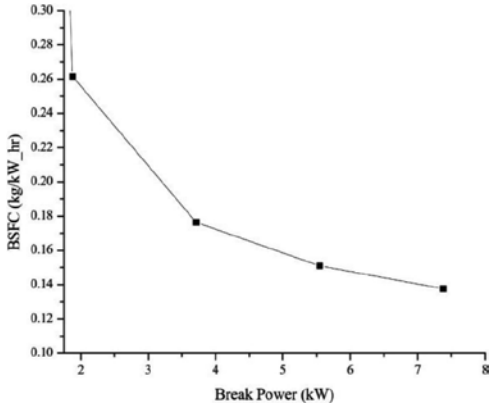
Fuel	Density(grams/cc)			Kinematic Viscosity(Centistokes)		
	Room Temperature	40°C	80°C	Room Temperature	40°C	80°C
B100	0.901	0.886	0.861	8.45	5.805	2.047
B20	0.832	0.819	0.801	3.60	2.494	0.531
B10	0.838	0.824	0.804	3.08	2.101	0.011

2.5 Engine performance test

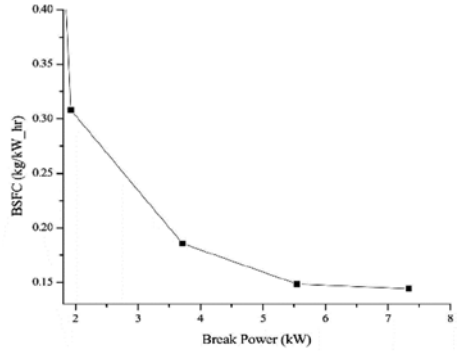
Engine Specifications:

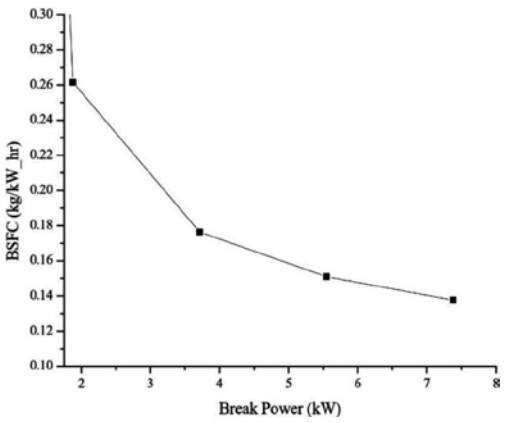
- Type: 4-Stroke, Single Cylinder Diesel Engine(water cooled), Compression Ignition
- Make: Kirloskar
- Rated Poweroutput:5HP, 1500RPM
- Bore and Stroke: 80mmx110mm
- Compression Ratio:16.5:1
- Cylinder Capacity:553cc
- Starting: By Hand Cranking/ Auto start
- Orifice Diameter:15mm
- Weight on Brake drum:F1in Kg
- Spring Balance Reading:F2inKg
- Brake Drum Radius (R):0.15 m
- Rope Radius (r): 0.1475 m





Graphs for B10





Graphs for B2

2.7.1. Engine Emission Table for Blend B10

Table 2. Emission table forB10

Load in Nm	CO (%)	HC (ppm)	Nox(ppm)	Co_2(%)
0	0.22	46	21	2.50
5	0.17	25	55	3.50
10	0.08	24	10	4.70
15	0.31	63	158	6.80
18	2.69	148	222	9.90

2.7.2 Engine Emission Table for Blend B20

Table 2. Emission Table for B20

Load in Nm	CO (%)	HC (ppm)	Nox(ppm)	Co_2(%)
0	0.18	51	16	2.70
5	0.17	32	46	3.60
10	0.09	23	120	4.90
15	0.23	55	181	6.80
18	2.43	140	225	9.80

3 RESULT AND DISCUSSION

3.1 Calorific value

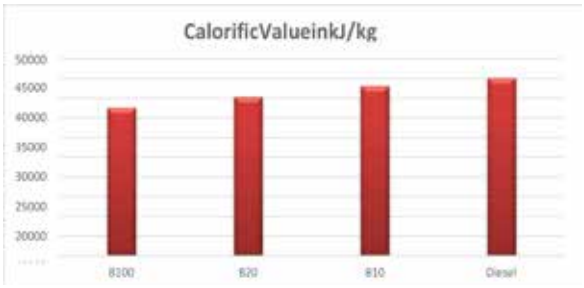


Figure 13. Calorific Value for different Blends Calorific Value for different Blends

3.2. Brake thermal efficiency

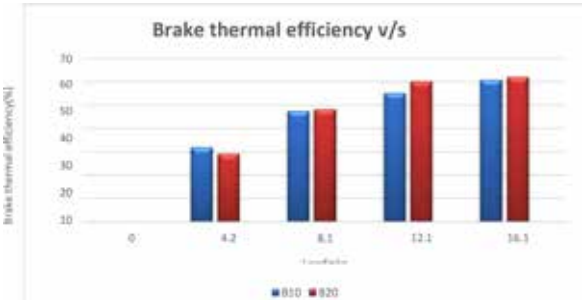


Figure 14. Thermal efficiency for different blends

3.3 Brake power

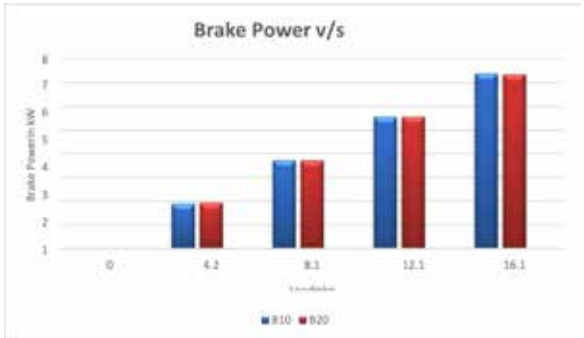


Figure 15. Brake Power for different blends

3.4 Brake specific fuel consumption

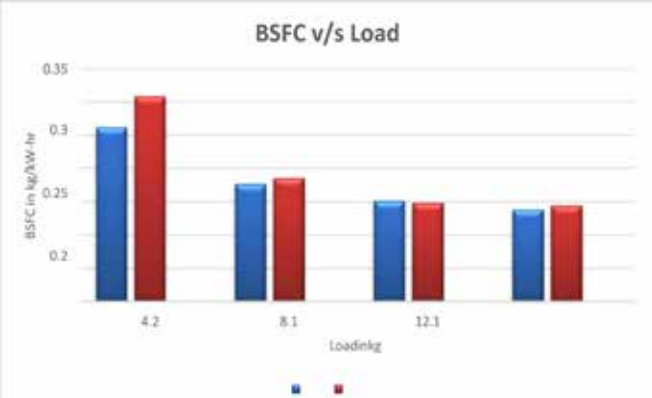


Figure 16. BSFC for different blends

- The figure 13 shows that Colorific Value of Pure Biodiesel increases on blend with the petroleum-based Diesel.
- Figure 14 Shows Brake thermal efficiency is increasing with increasing load for all blends of biodiesel and diesel.
- Figure 15 shows that Brake Power increases with increase in load.
- Figure 16 shows that BSFC decreases with increase in load.
- The combustion of bio fuel takes place completely in engine and increase in power with increase in load. It is because of the presence of oxygen in biodiesel which enhance the combustion as compared to diesel and biodiesel is more lubricant than diesel that provides additional lubrication.
- When using blends, biodiesel fuel is expected to decrease as compared to the consumption of diesel fuel. Specific fuel consumption (SFC) decreased sharply with increase in brake power for all fuel samples.

3.5 Emission test

Diesel consists of approximately 75% aliphatic hydro carbons (C10H20–C15H28) and about 25% aromatic hydrocarbons (e.g., benzene, styrene). The typical atomic mass concentrations are about 86% C, 14% H and a minor fraction of sulfur depending on crude oil source and cleaning quality.

Emission graph For B10

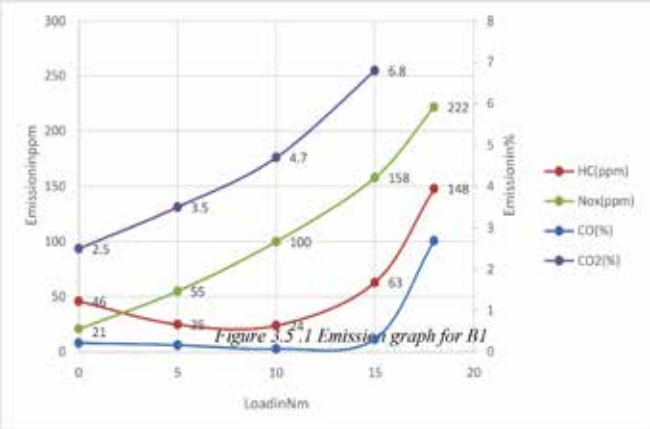


Figure 3.5.1 Emission graph for B1

Figure 17. Emission graph for B1

Emission Graph for B 20

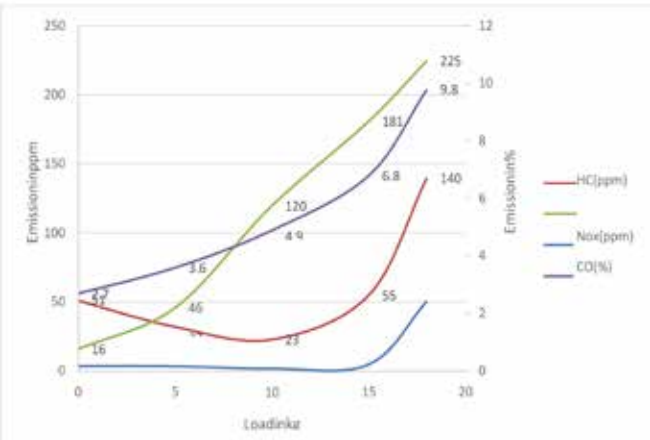


Figure 18 Emission graph for B20

From the emission Graphs we can conclude that

- NOx increases with increase in load for same blend because of increase in temperature in Engine.
- At Higher load emission of Unburnt Hydrocarbons (HC) for B20 is less than that of B10. So, blending of biodiesel reduces the emission of unburnt hydrocarbons.
- Carbon monoxide emission is less for B20.Blending of Biodiesel reduces the CO emission. Thus, results in increase in $C0_2$ emission.
- The emission of NOx is less at low load for B20, and it is more at higher loads when compared to B10.

4 FUTURE SCOPE

- Biodiesel is a safe alternative fuel to replace traditional petroleum diesel.
- Biodiesel has high Lubricity, and it is a clean Burning Fuel.
- Biodiesel is Renewable Source of Energy.
- Biodiesel acts like petroleum diesel, but it has less impact on human health as it produces less air pollutants.
- Biodiesel is Cost effective.

5 CONCLUSIONS

From our experiments and Observation following conclusions can be drawn,

- The Yield of Transesterification increases with addition of CuO Nanoparticles, Because CuO Nanoparticles provides more surface area for reaction to occur.
- Calorific Value of the pure biodiesel increases with blending with the petroleum- based diesel.
- For same load Brake power is almost same for different blends.
- Brake Specific Fuel Consumption decreases with increase in Brake power.
- The emission of unburnt hydrocarbons is less in B20 when compared to B10.Therefore, blending reduces the emission of Unburnt Hydrocarbons.
- The emission of CO decreases when we increase the percentage of biofuel in diesel.

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EVALUATION OF VIBRATING MECHANISM IN DRUM TRUCK TIPPERS

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ABSTRACT

This venture targets working on the proficiency and wellbeing of the tipper trucks while in real life. This undertaking zeroed in on playing out a definite examination of the exhibition, wellbeing, and cost parts of the current strategies of accomplishing that. The upsides and downsides of integrating a vibrator for the tipper truck are examined. This included broad FEA examination in the primer stage. The primary, vibrational, and weakness examination is finished for the basic parts which helped in choosing the plausibility of consolidating such a system. The basic parts for the examination are the foundation of the truck body, trunnion, sections for mounting the adaptive chamber, and the vibratory engine. The computer aided design models are ready as indicated by the business principles and investigations are performed. Irregular information for constrained vibration is created, which is utilized to perform examinations on the parts in FEA. A trial and error on a downsized model is likewise led to get the constant information for the framework. A vibration sensor would be consolidated utilizing Arduino, and the speed increase information of vibration are recorded and looked at by the hypothetical qualities. A similar report for the solidness examination is finished, with and without the vibrator. An itemized report for the adjustment of stroke length, siphon pressure/stream necessity, and so on is framed and looked at. The improvement in proficiency of unloading, efficient, and different boundaries is likewise thought of. The expense part of moving this framework in the market is additionally considered.

KEYWORDS *: DC Vibrator Motor, CAD model, Vibrator Prototype.*

1. INTRODUCTION

The principal burden of regular trucks is that labor supply is expected to dump material from them, which demands greater investment and additional expense to be paid for the labor supply. To dispose of these issues pressure driven worked tipping framework was developed. A dump truck is outfitted with an open or shut bed body and is pivoted at the backside. It is furnished with a water powered chamber to lift the front

end, permitting the material in the bed to be unloaded on the ground at the ideal spot of conveyance. A standard tipper truck is a body mounted on to a truck case. The bed is raised using a hydraulic driven chamber which is mounted under the body in the front-end switch strategy between the underside frame rails, and it is turned at the back of the truck. The Tipper trucks are utilized to convey the material and dump them any place essential. Generally utilized tipper trucks utilize an expanding adjustable chamber which slants the truck body, and hence compelling the material down affected by gravity. Today, all dump trucks are worked by hydraulic power and come in various setups, every one of which is intended to achieve some particular assignment. Nonetheless, these trucks have a few limits. Prior to emptying the material truck should be left according to the design. It requires more fuel and time at long last lessens proficiency. Likewise, mishaps might occur as there are chances of slipovers or turning in the event that the truck isn't left as expected in lopsided locales.

A simplest hydraulic circuit consists of oil reservoir, pump, relief valve, solenoid operated directional control valve, Hydraulic actuator, Connectors and lines. The tank is filled with oil and the pump creates a vacuum then sucks the oil from the tank. The pump is powered by the engine via a PTO (Power Take Off) unit which is connected to the engine and it transfers power from engine to the pump. The oil flows via a pressure relief valve, which as a safety valve, restricts the maximum pressure developed within the system. The direction-finding control valve controls the direction of motion of the hydraulic cylinders. In neutral position of the valves are to be controls the directions, fluid (oil) flows to the tank by pumping action without any pressure build-up; this type of position is called tandem position. This prevents oil from heating up due to pressure build-up. In this case, two Telescopic cylinders are powered to raise the truck body simultaneously. The return line filter in the tank line filters the oil which is going in the tank and thus completing the Hydraulic circuit.

A study conducted by M. Paz, et. al. [1] has explained the application of vibration for material handling in the industry is being presented. A patent awarded to John C. O'Connor [2] proposes a concept of vibratory dump trucks which would facilitate the loading and unloading of freight. Study by Vanliem Nguyen et. al. [3] concentrated on Modeling and Vibration Analysis of a Vibratory Roller for rough terrain application which was outfitted with various cab isolation mounts in which a unique model of vibratory roller was proposed. An examination by Nitinkumar Anekar et. al. [4] concentrated on Designing and Testing of uneven mass mechanical vibration exciter. Thomas Gillespie [5] studied the effects of vibration on the truck and modelled using the "Quartercar model" described in vehicle dynamics. N. Siva Nagaraju et. al. [6] has modelled , analysed and confirm to innova car chassis which is made of Frame by Varying of the Cross Section of this frame. A.Singh Patel et. al. [7] studied the analysis & optimization of the TATA 2518 TC manufacturing of Truck Chassis Frame elements which is using by the CAD Software. The existing chassis is very heavy for TATA 2518 TC and is taken for design and analysis. Several theoretical calculations are done for various types of vibrating mechanism, but the question remains that how much of the vibration is practically transferred to the vibrating body.

2. DESIGN APPROACH AND DETAILS

2.1 Technical specification

Vibration damping decreases the degree of vibration produced from plant components and their parts during modern use. It does this by scattering vibration energy, prompting a critical decrease in transmitted noise. Vibration damping materials adjust a gear's normal vibration recurrence, which decreases emanated clamour and expands the transmission loss of the equipment. Having a vibration damping material is a significant necessity while planning electronic frameworks, as it decreases the possibilities of any harm to electronic parts and associations. These types of vibration are to be exciters and are normally used in numerous tenders (applications) as: The electro-dynamic exciter, hydraulic exciter, mechanical exciter.

Table 1. Technical Specification of mechanical Exciters

Exciter type parameters ▶ Frequency	Maximum Displacement	Maximum Acceleration	Maximum Force	Excitation Waveform
Mechanical	20-50Hz	2.5cm	20g	4500N	Sinusoidal only

2.2 Design Details

Design method is applied in almost all the case to do basic calculations and then make a tentative model of it. After this, verify the design using simulation software like Ansys. Truck Body dimensions are Capacity – 10 Cu. M, Dimensions – 3877 x 2280 x 1180 mm,

Channels section used – 120 x 55 x 9 mm (depth x width x thickness).

Design process for the truck body

Considering how Indian drivers overload their trucks, weight of the material in the body was taken to be 490332.5 N (50 Ton). The number of channels to be used was decided based on the existing designs.

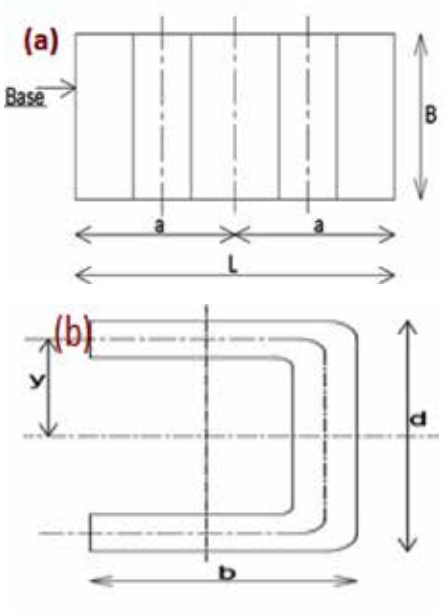

Figure 1. (a) Truck body base channel design (b). C channel section

Moment of Inertia for a C – Channel is given by:

$$I = (2b + d)(\frac{t^3}{3})$$

Moment Bending equation: (M/I) = (σ/y)

Distribution of the Load is assumed to be uniformly distributed: M = (wa^2/8)

Where w, for the figure above would be: w = (W/2B)

Where,

W = Weight of the truck body with material,a = Total length of the truck body B = Width of the truck body

Designing the Unbalanced mass

Unbalance systems can cause vibration in machines with turning part elements and how balancing propellers to an exact position can control extreme loading of bearings and finally avoid failure, thus expanding the life of machinery. Vibrator model dimensions Weight of unbalanced masses – 750 grams, Eccentricity – 5 cm, Shaft diameter – 20 mm, Material – Aluminum

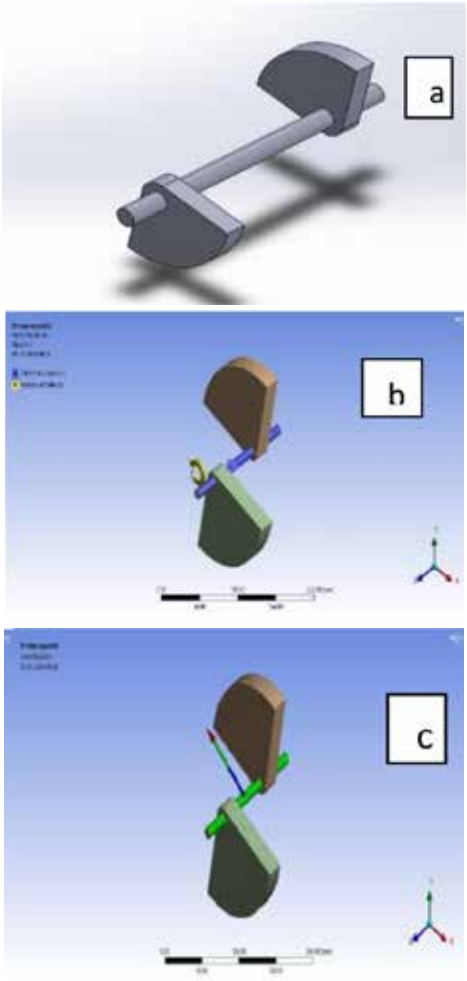

Figure 2. (a) CAD Model - Shaft with unbalanced mass at both ends

(b) FEA Analysis - Constraints for Structural analysis - Force and moment

(c) FEA Analysis - Constraints for Structural analysis - Force and moment

The CAD model shown, is of a shaft with unbalanced mass at both the ends. Balancing is of two types i.e., static and dynamic balancing. Mass IS placed opposite to each other with respect to the plane of the shaft axis. Static balancing is achieved and the dynamic balancing creates the vibration by the couple reaction. In an actual vibrator there would be mechanism to rotate the shaft (Electrical, Hydraulic, or Pneumatic) which would rotate the unbalanced mass. There will also be bearings and mounting positions to mount the vibratory motor on the truck. Here for concept demonstration only the unbalanced mass shaft is shown. The direction of force

exerted on the shaft due to the rotary unbalanced mass is shown in the Figure 2 and the direction of the couple moment is 90° to the direction of force. Understanding the magnitude and direction of force and couple helps in better selection and calculation of bearings. After bearings of the existing vibrators can be enhanced by having a proper idea about the force and moment.

Truck Body

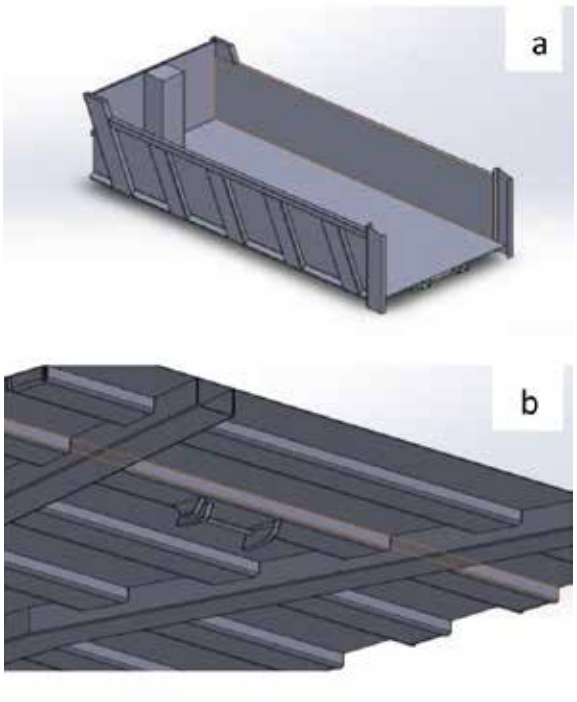

Figure 3. (a) CAD Model - Truck Body Isometric View (Gate Side),

(b) CAD Model - Position of the vibratory motor, with bearings

The CAD model of a truck body is subjected to vibrational loading. The C channel section was selected for the truck body based on bending stiffness and torsional stiffness. The sheet metal selected was of 1- millimetre thickness based on common automotive standards. The base was created first as a separate solid works part. After that the channel section for the side members were selected based on similar calculations and the modelling was done.

It is mentioned that there is a cylinder end which is lifted using hydraulic power and the hinge end which is at the end of the truck body. The cohesive and adhesive at the hinge end is broken down because of the flow of material from the top. A vibrator is needed for efficient removal. Figure 3 shows the location of the vibrator and how it is attached.

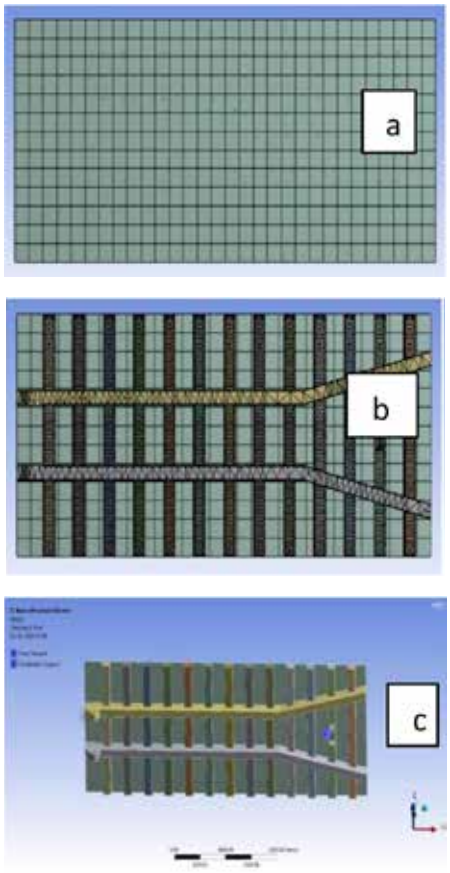

Figure 4. (a) FEA Analysis - Top view of Mesh

(b) FEA Analysis - Bottom View of the mesh of Base Plate, the mesh has 165593 Nodes and 66902 elements

(c) FEA Analysis - Constraints for Base Plate of Truck Body – Model Analysis

Table 2. FEA Analysis - Mode shapes - Natural Frequencies

Mode	1	2	3	4	5	6
Freq. (Hz)	0	2	19	23	24	42

The modal analysis is one of the very good dynamic possessions of assemblies underneath vibrational excitation. A style of shape is a particular example of vibration implemented by mechanical arrangement at a particular frequency. Mode shape is twisted example (method) of object at this frequency. In the event that we change the input frequency at that point item will distort at various pattern (mode). Mode shape varies with frequency. The exploratory or numerical policy of modal examination discoveries these mode

forms(shapes) and the frequencies.

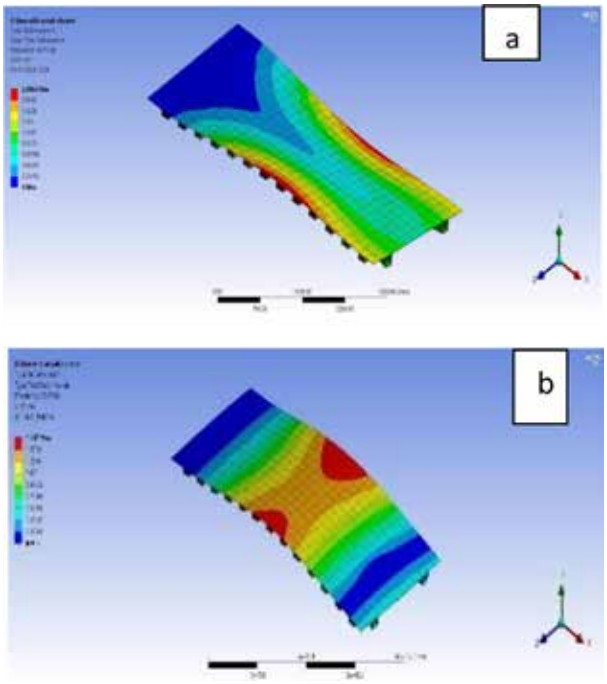

Figure 5. (a). FEA Analysis – Base - Mode shape Modal 3 (b). FEA Analysis – Base - Mode shape Modal 4

Closer the frequency ratio (*w/wn*) to 1, higher will be the amplitude. If the frequency ratio is equal to 1, then resonance will occur, which is detrimental to the machine. But it should be close to 1, so that the amplitude can be maximized in safe range. Fundamentally, the mode states of a system are obtained when you compute its reaction because of beginning conditions only.

3. CONCLUSIONS

- The forced damped vibration has been conducted which gives us a proper understanding of the functioning of vibratory motor and its application. Extensive numerical simulation has been performed to verify the existing structures used in the tipper. The simulation provides an indication that the structures can with stand the induced vibration.
- Cost versus productivity of the vibratory motor in truck tipping solutions needs to be validated and experimented thoroughly before a conclusive result can be obtained. The data collected by the vibration sensors is relatively accurate and can give us an idea about the vibration generated when tested in an actual truck.
- The simulations done so far indicate that the structures of the truck would be able to handle the vibrations and it will be subjected to the hydraulic cylinders as tested for the pulse test, which means they can absorb the vibration and can perform under this condition.

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DIGITALIZATION OF STORES OPERATION AND INVENTORY MANAGEMENT

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ABSTRACT

The purpose of this study is to explore the digitalization of stores operation in the manufacturing industry. The project focuses on achieving several objectives, including obtaining real-time stock data, improving the layout and aesthetics of the stores, and enhancing ergonomic features. Additionally, the study aims to develop standard operating procedures for stores, including dealing with non-moving items, saving man-hours, and creating a visual representation of the stores.

To achieve these objectives, the study utilized various technological solutions, such as Macro Enabled Excel sheets, AutoCAD for Layout Designing. These technologies enabled the project team to obtain real-time stock data and automate various processes, leading to significant man- hour savings.

Furthermore, the study looked into improving the physical layout and aesthetic appeal of the stores, enhancing employee experience and customer satisfaction. The ergonomic features of the stores were also enhanced, reducing employee fatigue and improving productivity.

Overall, the project aimed to create a more efficient, cost-effective, and customer-oriented stores operation for the manufacturing industry. The study's findings and recommendations can help other businesses in the industry to optimize their stores operation and achieve similar benefits.

KEYWORDS *: Digitalization, Man-hour savings, Cost-effective.*

1. INTRODUCTION

Digital transformation has emerged as a crucial component of boosting production and efficiency in a variety of industries in today's fast-paced business climate. The functioning of retail establishments in the industrial sector is one such area where digitalization may have a substantial impact. To ensure smooth manufacturing processes, cut expenses, and increase customer happiness, efficient store operations are essential.

In the manufacturing sector, digitization can reduce inventory by 15–30% and stock outs by up to 35%, according to a Deloitte analysis. The significance of real-time stock data for effective inventory management and decision-making is also highlighted in the paper.

This study intends to investigate how the manufacturing industry's retail operations have become more digital and how this has affected a variety of factors, including layout enhancement, aesthetic enhancement, ergonomic features, and standard operating procedures. The study makes use of a variety of technology tools and industry-recognized best practices to streamline shop operations and produce the required results. Overall, this study can help organizations trying to streamline

their manufacturing industry processes by offering insightful information about the possible advantages of digitalization in store operations.

2. BACKGROUND

The aims of the study or project on the digitization of store operations in the manufacturing business are explained in this literature review. Inventory levels can be optimised, stockouts can be decreased, and customer satisfaction can be raised by real-time stock data collection using automated systems like RFID and barcode scanners (Nishant et al., 2017). According to Zhang et al. (2018), an effective store layout can boost consumer happiness, lessen employee tiredness, and cut down on the time and effort needed for material handling. Through elements like lighting, colour, and music, aesthetically pleasant stores can increase consumer happiness and loyalty (Zhang and Luo, 2019). According to Ladeira et al. (2018), ergonomic factors including pleasant workstations and tools can increase employee productivity. Having standard operating procedures in place is crucial for ensuring operations are reliable and effective, cutting down on lead times,as well as enhancing client satisfaction (Almada-Lobo et al., 2019). These studies draw attention to the potential advantages of digitalization for retail operations and highlight the significance of the goals set forth in this study/project. Businesses in the manufacturing sector can optimize their processes and get comparable advantages by putting these digitalization goals into practice.

2.1 Research Questions

To fulfill the purpose of the study, the survey sought to answer the following research questions:

[1] How Much can the store's operation processes can be automated?

[2] How can the inventory be maintained and to know when exactly to reorder the stock?

3. METHODS

3.1 Problem identification and data collection

The first step involves identifying and documenting the problems faced in stores operation, followed by collecting relevant data to understand the extent and impact of these problems.

3.2 Analysis of data

Once the data is collected, the next step is to analyze it to identify patterns, trends, and insights that can help in problem-solving.

3.3 Finding the root cause for the problems

Based on the analysis, the root cause of the identified problems can be determined, which can help in developing targeted solutions.

3.4 Define and install solution

Solutions can then be designed and implemented to address the identified problems.

3.5 KPI monitoring

Key performance indicators (KPIs) can be defined and monitored to measure the success of the implemented solutions and ensure continuous improvement. This can include KPIs related to inventory management, employee productivity, customer satisfaction, and more.

4.0 MAIN THRUST OF THE PAPER

In recent years, the importance of digitalizing retail operations in the manufacturing sector has grown. This study's objectives were to investigate the possible advantages of digitalization in retail operations and to create solutions to enhance these procedures. The study's methodology included problem identification and data collecting, data analysis, problem root cause identification and solution definition and installation, and KPI monitoring.

This methodology allowed the study to identify a number of important goals, such as getting real- time stock data, improving the layout, aesthetics, ergonomics, standard operating procedures, non- moving items, reducing man-hours, and visualizations. Businesses in the manufacturing sector can optimize their operations, cut expenses, raise customer satisfaction, and increase staff well- being by putting these goals into practice.

5. FUTURE TRENDS

5.1 Predictive maintenance

AI-driven solutions are able to foresee and stop equipment breakdowns, cutting downtime and maintenance expenses. Machine learning algorithms that analyse massive amounts of data and find patterns that suggest possible equipment faults enable predictive maintenance. Predictive maintenance can

boost equipment uptime by up to 40% while lowering maintenance expenditures by up to 30%, according to a study by Li et al. (2021).

5.2 Autonomous robots

AI-powered robots are capable of carrying out dangerous and repetitive jobs like material handling, lowering the possibility of employee injury and boosting productivity. Sensors and machine learning techniques that autonomous robots use to navigate and carry out tasks in a changing environment. An investigation by McKinsey & Company (2019) found that autonomous robots could boost productivity by up to 30% and reduce labour costs by up to 60%.

5.3 Real-time inventory tracking

AI can make it possible to track inventory in real-time, boosting accuracy and lowering the danger of running out of goods and overstocking. RFID and other sensor-based technologies that offer real-time data on inventory levels and movements enable real-time inventory tracking. It can reduce human efforts and increase productivity and enhance profit of the company or theorganization it is something that can bring over a change in the operations and it can build better customer relations. Real-time inventory tracking can increase inventory accuracy by up to 98% and decrease inventory expenses by up to 25%, according to a study by Arif et al. (2021).

5.4 Customized client experiences

AI may evaluate customer data to deliver recommendations that are tailored to each individual, improving the customer experience and boosting customer loyalty. Machine learning algorithms that examine client data, such as purchase history and browsing habits, enable personalised recommendations. A 2018 Accenture study found that personalised recommendations might boost sales by up to 15%. Customer or the end user or the client is someone that has to be satisfied at the end he can enjoy better experience when there s a better effort that is to be put using the advances in the society the growing technology and the emerging use cases of artificial intelligence the betterment of customer experience is evident and with such great advances one can be assured of better experience.

5.5 Smart logistics:

AI can streamline logistics processes, such as route planning, scheduling, and delivery, lowering costs and boosting productivity. Machine learning algorithms that improve logistics operations based on real-time data, such as traffic and weather conditions, are what enable smart logistics. Smart logistics can speed up deliveries by up to 30% and cut transportation expenses by up to 20%, according to a Deloitte report published in 2019. Logistics is the barrier that connects the product from the production world to the customer and logistical optimization is something that enhances savings and increases profit AI application in logistics will move the process much faster and enhance customer satisfaction. It has to be the good logistics management that will increase the profits.

5.6 Energy efficiency

AI can optimise energy use in retail operations, lowering energy expenses and having a smaller negative impact on the environment. Machine learning algorithms that optimise energy use based on real-time data, such as occupancy and weather conditions, enable energy optimisation. An investigation by Navigant Research (2019) found that energy optimisation can cut expenditures by up to 30%.

6.0 CONCLUSION

In conclusion, the manufacturing business may greatly benefit from the digitalization of store operations in terms of productivity, efficiency, and customer happiness. The study/project sought to accomplish a number of goals, including gathering real-time stock information, optimizing the store layout, enhancing ergonomics, standardizing operating procedures, identifying non-moving items, lowering manual labor through automation, and utilizing visualization technology.

A technique that included problem identification, data collection and analysis, root cause analysis, solution definition, and KPI monitoring was suggested to accomplish these goals. The analysis of the literature showed that there are a number of studies that emphasize the significance of each of these goals and show how digitalization might help achieve them.

Stores may enhance their overall performance and give customers a better shopping experience by putting

these methods into practice. By enabling predictive maintenance, autonomous robotics, real-time inventory tracking, customized customer experiences, smart logistics, and energy efficiency, the usage of AI-powered technology can further increase the advantages of digitization.

In general, the digitalization of retail operations in the manufacturing sector is a development that has great promise for both firms and customers. Stores can boost operations, cut expenses, and increase customer happiness by applying the suggested technique and utilizing the most recent AI- powered technology, ultimately leading to business growth and success.

ACKNOWLEDGMENTS

You have my gratitude for helping you with the acknowledgments part of your paper. An example acknowledgment section is provided here for your reference:

I want to publicly thank Bangalore Institute of Technology for giving me a top-notch academic setting and a wealth of learning possibilities while I complete my bachelor's degree in industrial engineering and management there. I couldn't have finished this project without the information and abilities I've gained while studying.

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DESIGN MODIFICATIONS AND VALUE ANALYSIS OF A CHOPPING BOARD

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ABSTRACT

Chopping Board is a durable board which is used to place materials for chopping, scraping, slicing and dicing. The chopping board which is traditionally made of wood has lately been a vital component among the various kitchenary items.

This technical paper aims to elicit how to use the Value Analysis methods to analyse the existing design and come out with an improved design.

With evolution of chopping board from just a wooden slab to a wide variety of options, in this paper we try to add more value to it by usage of alternative material and modifying its design to drastically increase functionality. This is realized through introducing a strainer and cabins to lay the cut materials as additional features.

The above objectives are achieved by the implementation of systematic approach, Value Analysis Methodology encompassing techniques such as Functional Analysis, Decision Matrix, Evaluation Matrix.

With the attainment of both sell function and work function, it is thus hoped that the results of the study will assist the manufacturing companies to call for improved decisions regarding the design of the chopping board.

KEYWORDS *: Chopping board, Value analysis, Functional analysis, Decision matrix, Evaluation matrix, Work function.*

INTRODUCTION

Value Analysis is defined as an organised effort directed at analysing the functions of systems, equipment, facilities, service and supplies for the purpose of achieving the essential functions at the lowest life-cycle cost, consistent with required performance, quality, reliability and safety.

CONCEPT OF VALUE

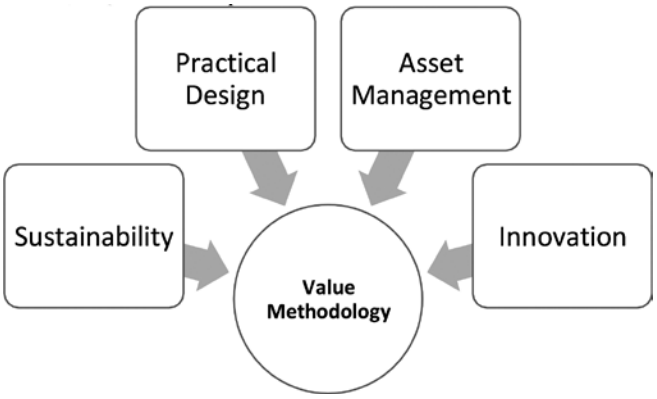
Value is the lowest possible cost of a product or a service performing a useful and essential function with required quality and reliability.

GOALS OF VALUE ENGINEERING

Improve project quality

- Reduce project cost
- Foster Innovation
- Eliminate unnecessary cost.
- Ensure efficient investments

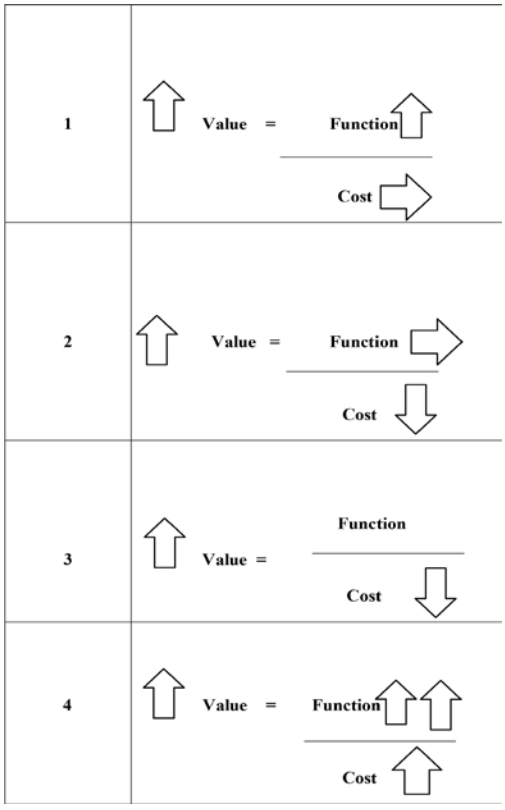
- Develop implementation pro



PHASES OF VALUE ANLYSIS

- Information Phase.
- Functional Phase
- Creative Phase
- Evaluation Phase
- Development Phase.
- Recommendation Phase
- Presentation Phase.

VALUE ENGINEERING CONCEPT



Chronological advancements towards Value Analysis

1932-1938: Lawrence D Miles worked as a design Engineer at GE under W.C.White, Manager of the Vacuum Tube Engineering Department.

1938-1944: Transferred to GE purchasing department, working under Harry Erlicher, VP Purchasing. He worked with vendors to obtain lower costs. Then with change of emphasis, he was asked to procure adequate quantity for the war effort.

1944-1947: Transferred to Locke Insulator, subsidiary of GE, as Manager of Purchasing. Saw first- hand both the productive and destructive forces of human attitude and practices, and their effect on appropriate designs and appropriate costs.

Fall, 1947: Returned to Schenectady and was placed under William Sredenschecky who gave him full support to produce an approach for GE to improve cost and productivity.

In December 1947, the basic Value Analysis Functional Approach was born.

OBJECTIVES OF THE RESEARCH PAPER

Chopping Board which is an essential element in the kitchen has room for modifications in design and functions. In the paper, we intend to realise the following objectives:

1. Improve functionality of the existing product.

2. Bring about ease in use.

3. Ensure better consumer satisfaction.

4. Uplift profitability of the organization.

1. INFORMATION PHASE

This is the first phase in Value Methodology in which all the relevant information regarding the project is gathered.

The available information of Chopping Board was collected from various sources and the summary is reproduced below:

Product: Chopping Board.

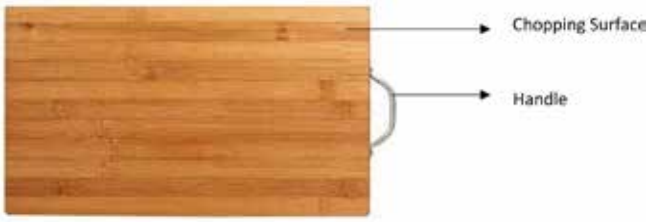
Material: Wood, Plastic, Bamboo, Rubber, Silicone, Steel.

Standard dimensions: 12” X 9” X 0.5”.

Purpose: Chop, scrape, dice.

Place: Professional and family kitchens.

A TYPICAL CHOPPING BOARD



MANUFACTURING OF CHOPPING BOARD

1. A hard wood board is taken and using a block plane a small amount of wood on either end is removed and this process is repeated until the cut surface doesn't wobble on the table.
2. With one face flat the board is run through a thickness planer to get two parallel and smooth faces.
3. Across cut sled is used on the table saw to get the end squares before chopping the board to final length.
4. A hole is drilled in any one of the corners to get a grip of chopping board.
5. A 150-grit sandpaper is used to provide a glossy finish.
6. A sandpaper or a router with a round-over or a chamfer bit is used to make the rough edges round.
7. De-natured alcohol is used on the board and dried up later to raise the grains to provide a smoother surface.
8. To give the wood protection from water, the process is finished off with food-grade mineral oil.

2. FUNCTIONAL PHASE

According to Lawrence. D. Miles, "The basic purpose of each expenditure is to fulfil a function."

The success of Value Analysis depends on careful analysis of the functions of the assembly/components. The objective is to clearly identify the tasks to be carried out by the assembly components.

The functions are classified as Basic or Secondary. A function is Basic if it is the prime or specific purpose for which the assembly or components were designed. A function is Secondary if it does not directly contribute to the basic function or it is only required to support the achievement of the basic function.

FUNCTIONAL ANALYSIS

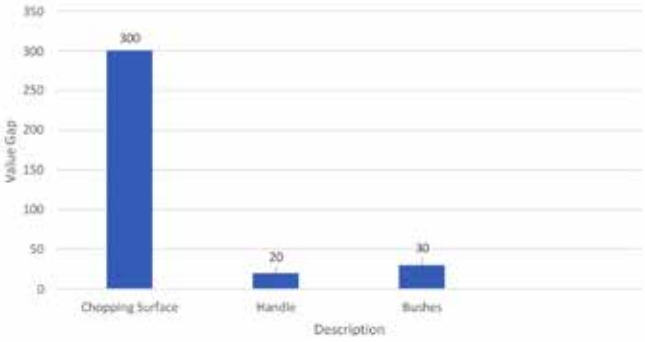
Table 1: Functional Analysis- Identification of functions

SL.NO	PART DESCRIPTION	Quantity	FUNCTION		CATEGORY	
			VERB	NOUN	Basic	Secondary
1	Chopping surface	1	Provide	Surface	X	
2	Handle	1	Hold	Board		X
3	Bushes	4	Provide	Support		X

COST-WORTH ANALYSIS

Table 2: Function Cost Worth Analysis- Decide which function has potential for value improvement.

SL.NO	DESCRIPTION	FUNCTION	PRESENT COST (C)	WORTH (W)	VALUE GAP (C-W)	RANKING
1	Chopping Surface	Provide Surface	350	50	300	I
2	Handle	Hold Board	30	10	20	III
3	Bushes	Provide Support	40	10	30	II



Graph 1: Description vs Value Gap

Table 3: Cost break-up of the product

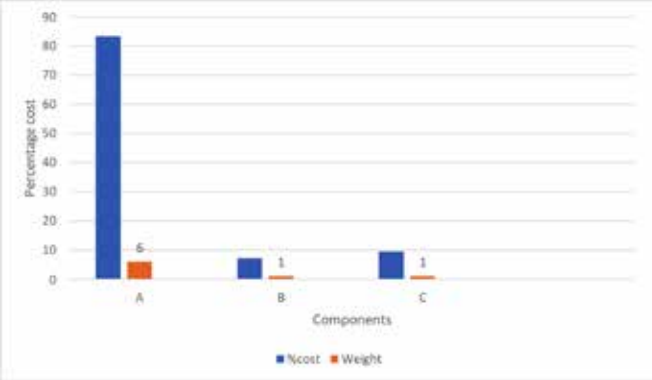
Part Name	Quantity	Cost (Rs)	% Cost
Chopping Surface – A	1	350	83.33
Handle – B	1	30	7.17
Bushes – C	4	40	9.50

	B	C	
A	A3	A3	6
	B	B1	1
		C	1

Major Performance-3

Medium Performance- 2

Minor Performance- 1



3. CREATIVE PHASE

'What else could do the same function?' is the central theme of the creative phase. The ranking of the functions based on value gap in the descending order are the indicators where to pinpoint for getting maximum advantage.

In order to generate more ideas, brainstorming technique is followed. The following ideas were generated:

1) Plastic sheet.

2) Plate

- Ceramic.
- Steel.
- Plastic.

3) Kitchen Slab.

4) Food Processor.

5) Press Vegetable chopper.

6) Rolling Board.

7) Multi-featured Chopping Board.

4. EVALUATION PHASE

The creative ideas generated during the brainstorming session are critically examined and few of the proposals are finalised.

Table 4. Evaluation of ideas found from Creative Phase

Sl. No	Ideas	State of Art 10: Off Shelf 1: New Technology	Cost to Develop 10: No cost 1: High cost	Probability of implementation 10: Excellent Chance 1: No chance	Potential cost benefit 10: Large savings 1: No savings	Time to implement 10: Extremely short 1: Extremely long	Features 10: with additional features 1: Without additional features	Total Ranking
1	**Plastic Sheet**	10	9	9	9	9	1	**47(II)**
2	**Plate**	9	8	8	8	9	2	**44(III)**
3	**Kitchen Slab**	10	8	8	8	8	1	**43(IV)**
4	**Food Processor**	8	3	8	3	3	10	**35(VI)**
5	**Press Vegetable Chopper**	9	5	7	5	4	1	**31(VII)**
6	**Rolling Board**	9	8	8	7	7	1	**40(V)**
7	**Multi-featured Chopping Board**	9	7	9	7	7	10	**49(I)**

Table 5: Evaluation of alternative with respect to desirable features

Ideas ⇩ Parameters	1	2	3	4	5	6	7
Durability	0	1	1	1	1	1	1
Maintenance	1	1	1	0	0	1	1
Appearance	0	0	0	1	1	0	1
Ease of Use	1	1	1	0	0	1	1
Compactness	1	1	0	0	1	1	1
Total	3	4	3	2	3	4	5
%	60	80	60	40	60	80	100

1- YES 0- N0

5. DEVELOPMENT PHASE

This phase allows the manufacturers to determine the most preferred alternatives amongst the various proposed alternatives. Advantages and Disadvantages are listed and ranked to determine which alternative should be implemented.

Table: Decision Matrix

Parameters →	Performance Rating	Hygiene and Ease of Use Rating	Customer Satisfaction rating	Total
Weightage → / Alternatives ↓	9	8	7	
Existing Product: Multi-featured Chopping Board	4 / 36	4 / 32	4 / 28	96
Plastic Sheet	2 / 18	2 / 16	2 / 14	48
Plate	3 / 27	2 / 16	2 / 14	57

4	Excellent
3	Good
2	Fair
1	Poor

The most feasible ideas are selected. Advantages and Disadvantages of each feasible idea are listed to select the best alternative.

Sl No	Ideas	Advantages	Disadvantages	Ranking
1	Plastic Sheet	i) Easily Available ii)Cheap in cost iii)Easy use	i) Shaky and unbalanced ii) Non-durable.	II
2	Plate	i)Easily Available	i) Wobbly Surface ii) Difficulty in use	III
3	Multi-featured Chopping Board	i)Multi-use ii)Cost effective iii) Consumer Satisfaction iv) Compact	i)Not sturdy compared to wooden board.	I

6. RECOMMENDATION PHASE

The Evaluation Matrix indicated that alternative of (Multi-featured Chopping Board) is preferred to the existing product and the other proposed alternatives. The function benefit analysis is done for the preferred alternative and the existing one as shown below:

Situation Before- Existing Product	Situation After-
Single Use	Multi use- 1. cabins to hold cut vegetables or culinary items like knife, scraper etc. 2. Strainer for straining when necessary or can again be used as a cabin
Less Economical	More Economical
More manufacturing cost and raw material cost	Less manufacturing cost and raw material cost.

The numerical evaluation sheet for the proposed alternative is shown below:

	B	C	
A	A3	A3	6
	B	B2	2
		C	1

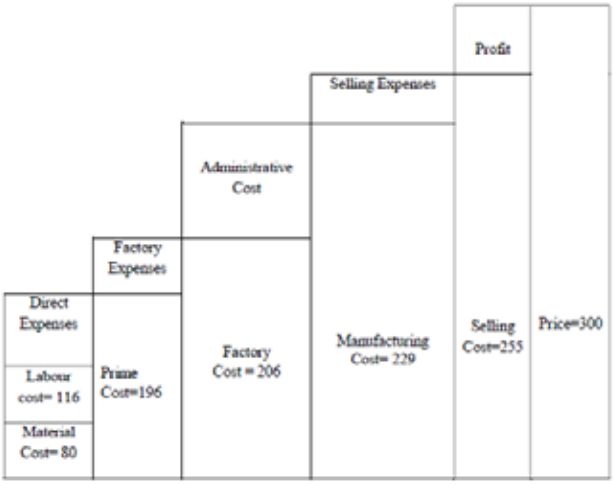
Major Performance-3

Medium Performance- 2

Minor Performance- 1

COST BREAK-UP FOR THE PROPOSED ALTERNATIVE

Labour Cost (Rs)	116
Material Cost	80
Factory Cost	206
Manufacturing Cost	229
Selling Cost	255
Total Cost	300

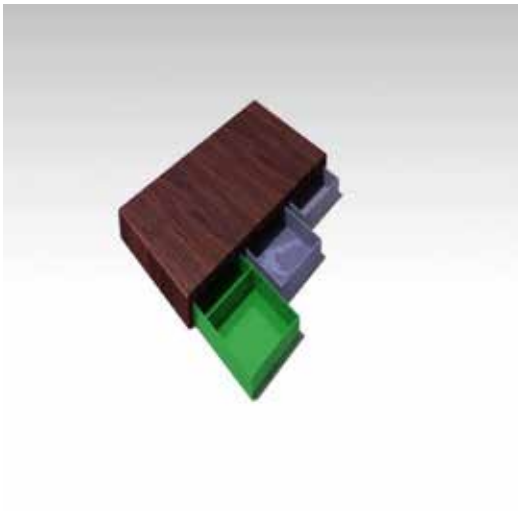


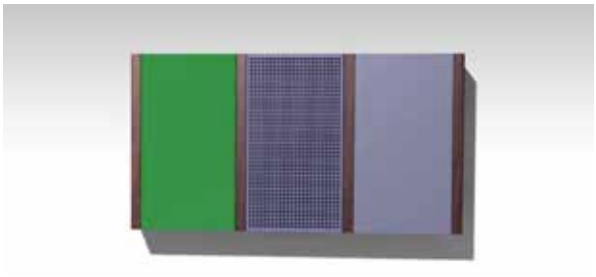
7. PRESENTATION PHASE

This phase presents the function-based creativity in the chosen product along with the monetary aspects.

Present Cost (Rs)	420
Proposed Cost(Rs)	300
Saving(Rs)	120
% Saving	40

Proposed Alternative Designs





KEY POINTS ON IMPLEMENTATION

For Manufacturers	For Customers
Reduced Manufacturing cost	High Return-on- Investment
Reduced lead time	High customer satisfaction
Better brand recognition	Multi-featured product

CONCLUSION

The Value Analysis process and procedures are generally well-defined and well understood at all levels in the

industry. Value Analysis has well formulated techniques of evaluation of cost and functions of the product considering key criteria like consumer satisfaction, functionality, ease of use, durability and so on. From the case study, we observe that there has been an increase in functionality of the chopping board due to the additional features such as cabins used to lay the cut vegetables and the provision of an extra compartment which can act as a strainer when necessary or can again be used as a cabin when the strainer function is not required. The cabins can as well be used to store culinary material like knife, scrapper etc when the chopping board is not in use. The traditional material of wood has been replaced by polypropylene material which helps in reduction of manufacturing cost and hence helps to cut down on the total price of the material. Though the product provides multiple uses, it maintains its ease of use. The above reasons lead to better consumer satisfaction and sell function is also satisfied. We hence try to provide an upgraded design for a simple chopping board.

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APPLICATION OF VALUE ENGINEERING FOR COST REDUCTION ON A WAIST BELT- A CASE STUDY

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ABSTRACT

Value Engineering is a proven management technique that can make valuable contributions to value enhancement and cost reduction in design of a belt. A case study on the design of a belt is discussed in which the product is changed according to Value Engineering Methodology. This paper introduces how to apply theories and methods of Value Engineering in the design of a belt. Value Engineering with its different phases can be implemented on any product and its design. To find the best possible alternative from the choices, we have used tools such as Function Analysis, Functional Evaluation and Decision Matrix, which gives the most appropriate results.

***KEYWORDS** : Value engineering, Function analysis, Functional evaluation, Decision matrix, Design of a belt.*

1.0 INTRODUCTION

The Concept of Value: Value is the lowest cost to reliably provide the required function or service at a desired time and place within essential quality. It can be described by the below equation

Value = Function of the Item Cost of the Item/ Cost of the Item

Advent of Value Analysis: The concept of Value Analysis began during the Second World War. Due to the war, there was an acute shortages of skilled labor and raw materials. Also, a ban imposed by the government on many of the resources, forced Lawrence Miles and Harry Erlicher of General Electric Co. to start looking for acceptable substitutes which led them to believe and observe that these substitutions often reduced costs and improved the product as a whole. What started out to be a hunt for necessities turned into an organized creative problem solving technique for product improvement. This technique was called 'Value Analysis'.

Definition of Value Analysis: According to Lawrence D. Miles, "a problem solving system which has an organized and creative approach, which has its purpose of effective identification of unnecessary cost, the cost which neither provides quality nor use, nor appearance, nor customer feature is called Value Analysis".

2.0 INFORMATION PHASE

A belt is a flexible band or strap, typically made of leather or heavy cloth, and worn around waist. Waist belts are items of clothing used by the young and old. The actual use of this belt is to keep the pants tight at the waist. They are made in different widths and lengths to suit customers. The buckles used are of different attractive designs and are detachable and fitted as per customer's choice. The manufacturing process of the belt is very simple which means that it can easily be fabricated in small scale units.

2.1 Origin of the Belt : Belts have been documented as a male clothing since the bronze age. The first form of belt wasn't used for fashion purposes, but as a means for men to hold tools and even weapons as was in the

case of soldiers and emperors. Prior to 1920s the belt was used as a decorative and as a utilitarian part of military uniforms. Moreover, prior to that trousers did not even have a belt loop. However by the mid 18th century sports wear had already incorporated them.

2.2 Function of the Belt: The belt today primarily serves as a means to tighten trousers around the waist. Waist Belts also in some cases are used to store tools and other items especially in construction sites and some heavy large scale industries.

Some also use the belt for decorative purposes.

2.3 Manufacturing the Belt: The manufacturing process primarily involves 5 steps.

i) Leather for the is procured from a tannery. At the tannery the leather undergoes various tanning processes like soaking, dehairing, degreasing and bleaching. Following this chemicals are used to stabilize the leather and prevent rot. Finally the leather is dried and sent for preparation.

ii) This leather is measured and cut to requisite size. The tail end of the belt is also cut. The belt is later run through a beveling machine to create an angled edge and smoothen the edges giving a polished finish.

iii) The other end of the leather(opposite the tail end) is folded to accommodate the buckle.

iii) Holes are punched at the tail end to allow size adjustment of the belt.

Another set of holes are punched at the folded end to accommodate the tongue of the buckle.

iv) The buckle and the belt loop is inserted at the folded end of the leather strip.

v) Logo and other inscriptions are heated and pressed using a heated press or an inscription tool.

Case Study: is done on a waist belt. Value Analysis is done as per following steps on the design of a belt:

a) Function analysis worksheet is prepared for different parts of the product.

b) Functional analysis is done for each part.

c) Numerical evaluation sheet is prepared.

d) Creativity Worksheet is made.

e) Alternatives are selected through decision matrix.

f) Recommendations are made.

g) Conclusion.

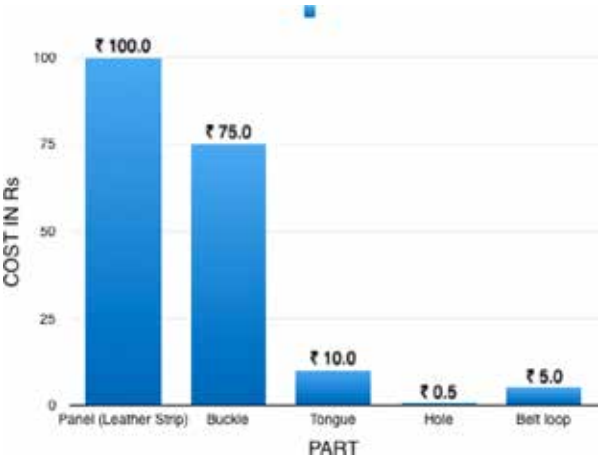
3.0 FUNCTIONAL PHASE

Parts of Belt: The parts of the belt is as shown in the figure below:

Fig 1: Parts of a waist belt

Table 1: Function Analysis Worksheet

Sl no.	Part Name/ Description	Quanti ty	Function		Part	
			Verb	Noun	Basic	Second ary
1.	Panel (Leather Strip)	1	hold	trouser	✓	
2.	Buckle	1	adjust	Panel- length	✓	
3.	Tongue	1	hold	position		✓
4.	Hole	6	Insert	tongue		✓
5.	Belt loop	1	hold	belt		✓

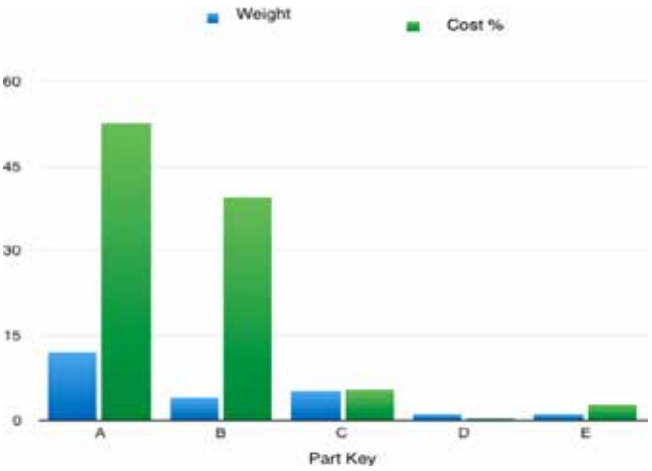


Graph 1: Cost of each part of waist belt(in Rupees)

Detailed functional evaluation of different parts of a waist belt with weight and percentage cost in the product as shown in the table below :

Table 2: Function Analysis Worksheet

Key Letter	Part	Function	Weight	%Cost
A	Panel (Leather Strip)	Hold trouser	12	52.49%
B	Buckle	Adjust length	04	39.37%
C	Tongue	Hold belt	05	5.25%
D	Hole	Insert tongue	01	0.26%
E	Belt loop	Hold belt	01	2.62%



Graph 2: Components Cost% and Weight

NUMERICAL EVALUATION SHEET

	B	C	D	E	TOTAL
A	A3	A3	A3	A3	12
	B	C1	B2	B2	04
		C	C2	C2	05
			D	D1	01
				E	01

Major Performance: 3

Medium Performance: 2

Minor Performance: 1

4.0 CREATIVE PHASE

The main function of this phase is to find out what else may be done in order to get the same function, assuming cost as a constraint.

Alternatives are listed below and a ranking for these is provided based on the given parameters in order to obtain maximum advantage:

1. Use of a Velcro based panel which eliminates holes and buckles.
2. Use of Intertwined panel which eliminates creation of holes.
3. Use of a easy withdraw clip buckle with length adjusters minimizing the number of parts, creation of holes.
4. Use trouser adjusters with side tabs that eliminate the requirement of a belt as a means to hold trousers.

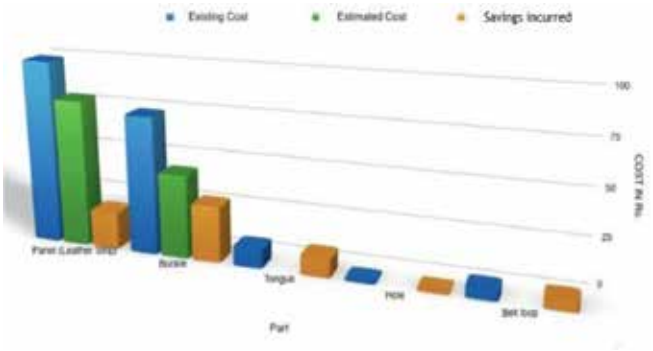
Evaluation of above 4 ideas against the 5 parameters to check feasibility.

Table 4: Forced Decision Matrix

Comparison Parameters	**1**	**2**	**3**	**4**
Durability	0	0	1	1
Maintenance Requirement	1	0	1	0
Appearance	1	1	0	0
Ease Of Use	1	0	1	0
Compactness	1	0	0	1
TOTAL	4	1	3	2
%	40	10	30	20

Table 5: Function-Cost-Worth Analysis

Part Name	Function		Existing Cost In Rs.	Worth		Savings	Ranking
	Verb	Noun		Tentative Alternative	Estimated cost		
Panel (Leather Strip)	hold	trouser	100.00	Heavy Cloth with Velcro	80.00	20.00	II
Buckle	adjust	length	75.00	Plastic	45.00	30.00	I
Tongue	hold	position	10.00	Eliminated	00.00	10.00	III
Hole	Insert	tongue	0.50	Eliminated	00.00	0.50	V
Belt loop	hold	belt	5.00	Eliminated	00.00	5.00	IV
TOTAL			190.50		125.00	65.50	



Graph 3: Component's Existing Cost, Estimated Cost and Value Gap

5.0 EVALUATION PHASE

Parameters of Interest

A: Durability B: Ease of Use

C: Maintenance Requirement D: Appearance

	B	C	D	TOTAL
A	A2	A1	A1	4
	B	B1	B2	3
		C	C1	1
			D	1

Major Performance: 3

Medium Performance: 2

Minor Performance: 1

Alternative 1: Heavy Cloth with Velcro

Alternative 2: Plastic Buckle

Evaluation of the 2 alternatives is done by considering various factors like rigidity, durability and appearance.

Parameters weightage	Durability	Ease of Use	Maintenance Requirement	Appearance	Total
Alternatives	4	3	1	1	
Existing	3 / 12	3 / 9	3 / 3	4 / 4	28
Alternative-1	3 / 12	5 / 15	3 / 3	3 / 3	33
Alternative-2	4 / 16	4 / 12	1 / 1	1 / 1	30

Table 6: Evaluation Matrix

5	Excellent
4	Very Good
3	Good
2	Fair
1	Poor

6.0 RECOMMENDATION PHASE

The evaluation matrix indicates that the first alternative is better than the existing as well as the second alternative. The cost benefit analysis is also done for both alternatives along with the existing one as shown below,

Table 7: Cost Benefit Matrix

Sl no.	Part Name	Existing	Alternative 1	Alternative 2
1	Panel (Leather Strip)	100.00	80.00	50.00
2	Buckle	75.00	00.00	45.00
3	Tongue	10.00	00.00	00.00
4	Hole	0.50	00.00	00.00
5	Belt loop	5.00	00.00	00.00
TOTAL		190.50	80.00	95.00

Based on Evaluation Matrix as well as the cost benefit analysis, alternative-I is recommended.

7.0 IMPLEMENTATION PHASE

The alternative 1 is suggested as the best alternative.

8.0 CONCLUSION & FUTURE SCOPE

From this case study, it is observed that how the Value Engineering is used for the cost reduction without the change in the product function & its values. A proper design matrix is prepared for choosing the appropriate alternative from the feasible choices available. The total saving which can be incurred per product by the implementation of above recommendations are 50.13% for alternative-II and 58% for alternative-I.

The Value Engineering process and procedures are generally well defined and well-understood at all levels in the industry. VE is recognized as an effective way to improve the performance of a product with reduction in cost and maintaining the quality. The quality

(qualifications & experience) of the team leader is a key ingredient to the success of the Value Engineering program. It is more effective and influential on the performance, quality, and cost of a product when done relatively early in the production schedule.

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EVALUATING CUSTOMER AWARENESS TOWARDS MIVAN SHUTTERING TECHNOLOGY IN CONSTRUCTION COMPANY", WITH REFERENCE TO NAVAMI BUILDERS

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ABSTRACT

Mivan shuttering technology is a relatively new construction method that has gained popularity in recent years due to its numerous benefits. However, the success of this technology depends on the level of awareness among customers, particularly those in the construction industry. This study aims to evaluate customer awareness towards Mivan shuttering technology by analyzing survey data collected from construction professionals and other stakeholders in the industry. The results indicate that while awareness of Mivan shuttering technology is increasing, there is still a significant knowledge gap among customers. Many customers are not aware of the benefits of this technology and are hesitant to adopt it due to concerns about cost and lack of experience with the method. However, those who have used Mivan shuttering technology report high levels of satisfaction with the results and are likely to use it again in the future. Based on these findings, the study recommends that more efforts should be made to increase customer awareness of Mivan shuttering technology and to address concerns about cost and implementation.

KEYWORDS *: Mivan formwork, Time saving, Cost-effective.*

1. INTRODUCTION

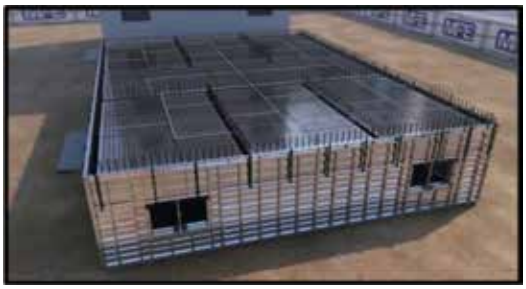
A kind of aluminium formwork, Mivan shuttering has travelled across the globe and proved to be an economical variant to the traditional method of construction which is labor-intensive and time- taking. Mivan technology construction is economical when it is a large construction [1][2].

Formwork is defined as temporary structure whose purpose is to provide support and containment for fresh concrete until it can support itself. It moulds the concrete to the desired shape and size and controls its position and alignment [3][4]. The development of formworks is parallel with the growth of concrete construction throughout the 20th century. The advancement of technology, increase of population and the space limitation led the way to construct high-rise buildings. But the task was not very easy at the beginning but now the man made the task easy by inventing new machinery and new techniques [5][6][7]. The most important factor in terms of cost, quality and speed in a high-rise building construction project is the type of the formwork used in the project [8][9].

1.1 Advantages of Mivan Shuttering

- Mivan Formwork requires relatively less labor.
- Faster completion of floors.

- Lesser number of joints and reduced leakages.
- Smooth finishing of wall and slab.
- Low maintenance.
- More seismic resistance.
- Huge carpet area.
- Good quality construction work.



2.0 BACKGROUND

When the construction companies were started, they used traditional method of construction, which cost them more. As the technology improved there were lot of research going on in the field of construction and they introduced new technology called MIVAN SHUTTERING TECHNOLOGY which is used to construct building and panels. This made us to select the project called Mivan shuttering technology

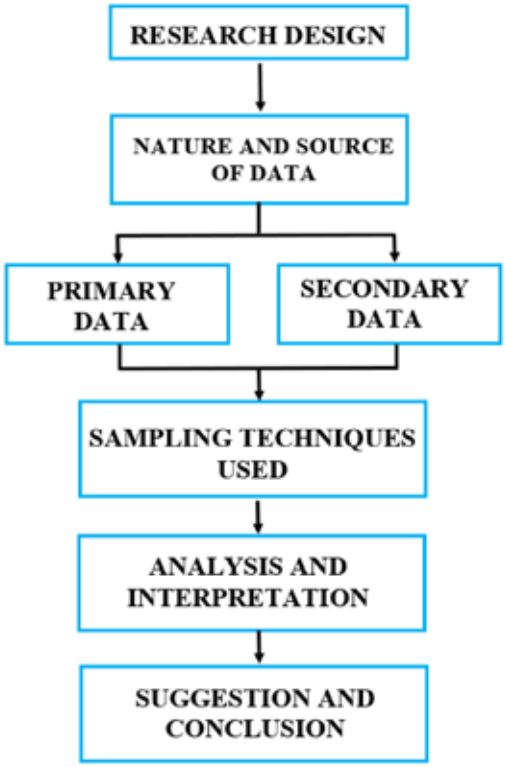
2.2 Research Questions

To fulfill the purpose of the study, the survey sought to answer the following research questions:

[1] How to evaluate customers awareness towards mivan shuttering?

[2] How to suggest customer about Mivan shuttering technology

3.0 METHODS FLOW DIAGRAM



3.1 Research Design

Research design refers to the framework of research methods and techniques that are chosen by a researcher. The design that is chosen by the researchers allow them to utilise the methods that are suitable for the study and to set up their studies successfully in the future as well.

There are three types of research designs, Exploratory, Descriptive, and experimental. In this study Descriptive Research Design is used.

Descriptive research design is a type of research design

that aims to obtain information to systematically describe a phenomenon, situation, or population. More specifically, it helps to answer the what, when, where, and how questions regarding the research problem, rather than the why.

3.2 Nature and Source of Data

Data can be defined as the quantitative or qualitative values of a variable. Data can be numbers, images, words, figures, facts, or ideas. All the collected data cannot be helpful or useful. To get information from data one must interpret data into the meaningful information. There are various methods to interpreting data. Data sources are broadly classified into Primary Data and Secondary Data.

❖ Primary Data

Primary data refers to the first-hand data gathered by the researcher himself. The tool used to collect Primary Data is a Questionnaire. The methods used to collect primary data is Survey method using structured questionnaire.

❖ Secondary Data

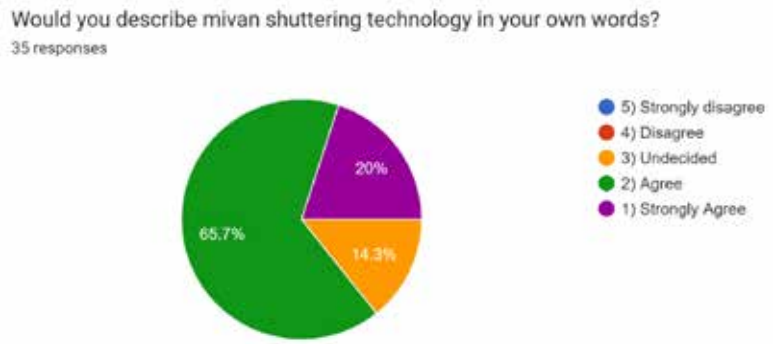
Secondary data refers to data that is collected by someone other than the primary user. Common sources of secondary data for social science include censuses, information collected by government departments, organizational records and data that was originally collected for other research purposes.

3.4 Sampling Techniques Used

Sampling is a process used in statistical analysis in which a predetermined number of observations are taken from a larger population. The methodology used to sample from a larger population depends on the type of analysis being performed, there are 2 types of sampling: Probability sampling and non-Probability sampling. Under probability sampling there are 4 types of sampling techniques such as simple random sampling, systematic random sampling, stratified sampling, and cluster sampling. Under non-probability sampling there are again 4 types: Convenience sampling, judgement sampling, quota sampling, snowball sampling.

3.5 Analysis and Interpretation

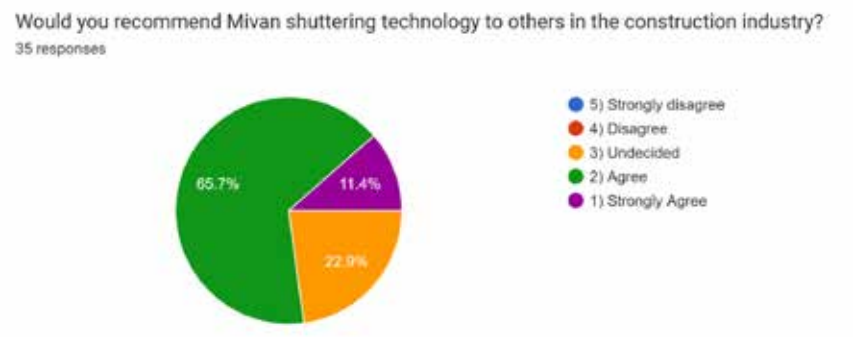
❖ To understand how mivan shuttering technology helps construction companies like Navami builders



People knowledge about Mivan shuttering	Percentage
Strongly Disagree	-
Disagree	-
Undecided	14.3%
Agree	65.7%
Strongly Agree	20%

INTERPRETATION: The total strength has responded to the agree option which is 65.7% with the majority and there are also20% people who have strongly agreed to the statement and 14.3% of people yet to decide.

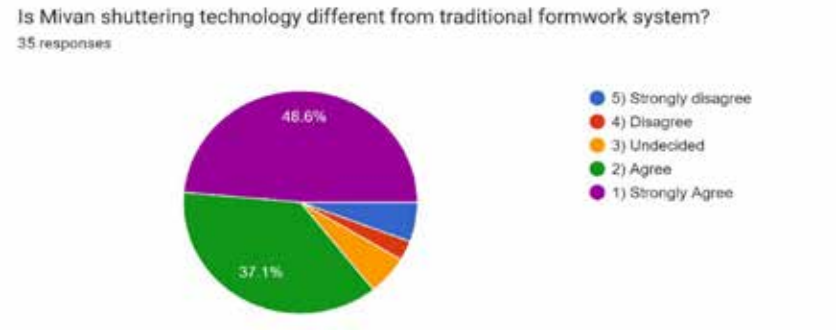
INFERENCE: Here to conclude that the majority of people have selected to agree option with percentage of 65.7%.



Would you recommend Mivan shuttering technology to others in the construction industry	Percentage
Strongly Disagree	-
Disagree	-
Undecided	22.9%
Agree	65.7%
Strongly Agree	11.4%

INTERPRETATION: The total strength have responded to the agree option which is 65.7% with the majority and there are also 22.9% people who have strongly agreed to the statement and 11.4% of people yet to decide.

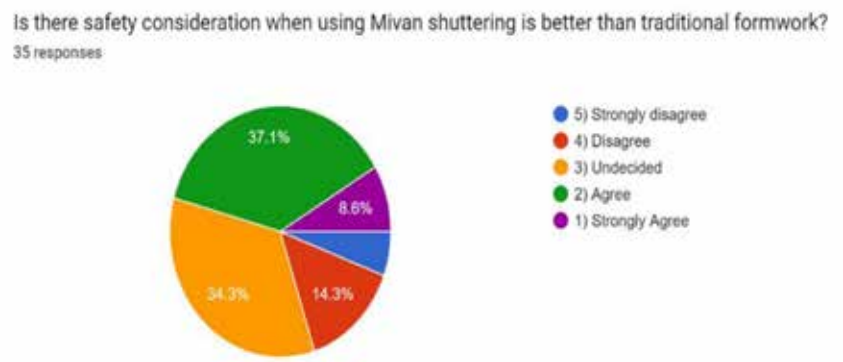
INFERENCE: Here to conclude that the majority of people have selected to agree option with percentage of 65.7%



Is Mivan shuttering technology different from traditional formwork system	Percentage
Strongly Disagree	8%
Disagree	5.1%
Undecided	10%
Agree	37.7%%
Strongly Agree	48.6%

INTERPRETATION: The total strength has responded to the strongly agree option which is 48.6% with the majority and there are also 37.7% people who have agreed to the statement, 10% of people yet to decide, some people with 5.1% have disagreed to the statement and there are people with 8% people who strongly disagree.

INFERENCE: Here to conclude that the majority of people have selected to strongly agree option with percentage of 48.6%.

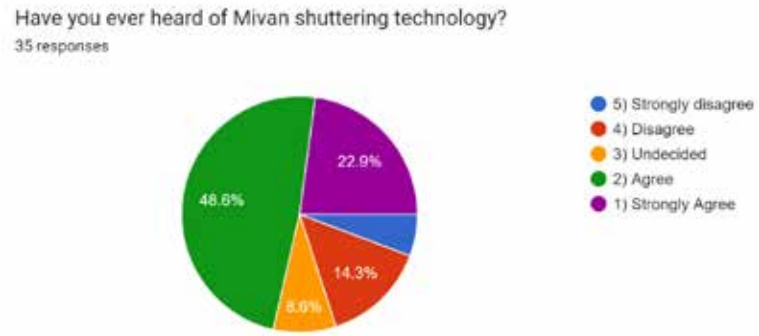


Is there safety consideration when using Mivan shuttering is better than traditional formwork	Percentage
Strongly Disagree	7%
Disagree	14.3%
Undecided	34.3%
Agree	37.1%
Strongly Agree	8.6%

INTERPRETATION: The total strength has responded to the agree option which is 37.1% with the majority and there are also 8.6% people who have strongly agreed to the statement, 34.3% of people yet to decide, some people with 14.3% have disagreed to the statement and there are people with 7% people who strongly disagree.

INFERENCE: Here to conclude that the majority of people have selected to agree option with percentage of 37.1%.

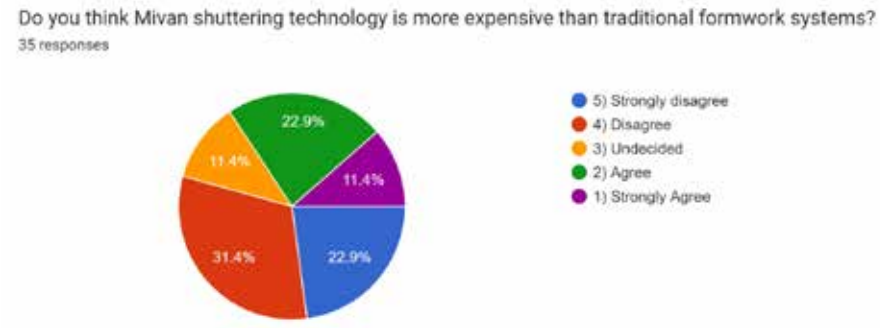
❖ **To evaluate customer awareness towards Mivan shuttering technology**



Have you ever heard Mivan shuttering technology	Percentage
Strongly Disagree	6%
Disagree	14.3%
Undecided	8.6%
Agree	48.6%
Strongly Agree	22.9%

INTERPRETATION: The total strength has responded to the agree option which is 48.6% with the majority and there are also 22.9% people who have strongly agreed to the statement, 8.6% of people yet to decide, some people with 14.3% have disagreed to the statement and there are people with 6% people who strongly disagree.

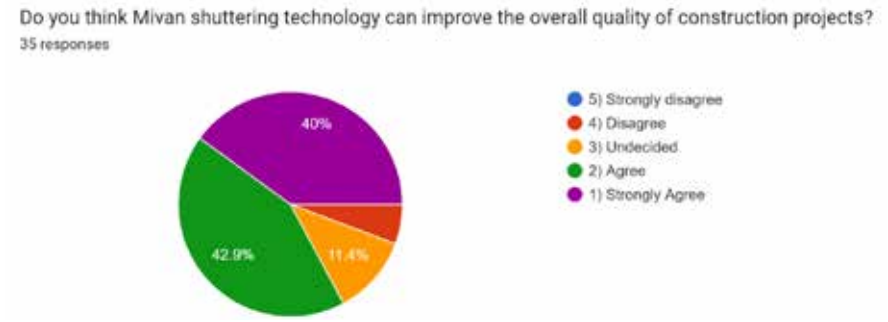
INFERENCE: Here to conclude that the majority of people have selected to agree option with percentage of 48.6%.



Do you think mivan shuttering is more expensive than traditional formwork systems	Percentage
Strongly Disagree	22.9%
Disagree	31.4%
Undecided	11.4%
Agree	22.9%
Strongly Agree	11.4%

INTERPRETATION: The total strength has responded to the disagree option which is 31.4% with the majority and there are also 11.4% people who have strongly agreed to the statement, 11.4% of people yet to decide, some people with 22.9% have strongly disagreed to the statement and there are people with 22.9% people who agree.

INFERENCE: Here to conclude that the majority of people have selected to disagree option with percentage of 31.4%.

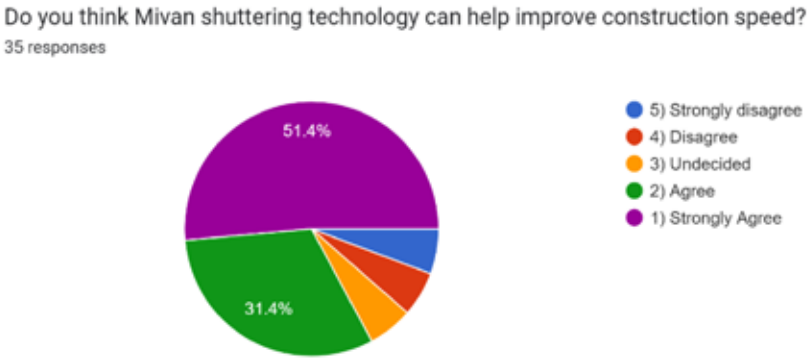


Do you think mivan shuttering can improve the overall quality of construction projects	Percentage
Strongly Disagree	-
Disagree	6.1%
Undecided	11.4%
Agree	42.9%
Strongly Agree	40%

INTERPRETATION: The total strength have responded to the agree option which is 42.9% with the majority and there are also 40% people who have strongly agreed to the statement,11.4% of people yet to decide, some people with 6.1% have disagreed

INFERENCE: Here to conclude that the majority of people have selected to agree option with percentage of 42.9%.

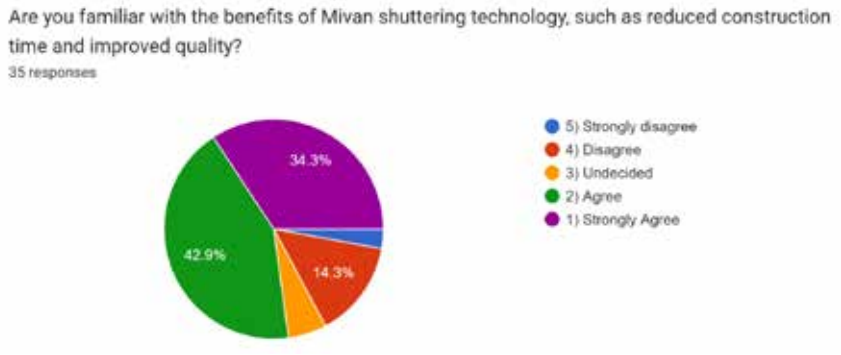
● **To suggest customer about mivan shuttering technology**



Do you think Mivan shuttering technology can help improve construction speed	Percentage
Strongly Disagree	5%
Disagree	6%
Undecided	5.1%
Agree	31.4%
Strongly Agree	21.4%

INTERPRETATION: The total strength has responded to the agree option which is 31.4% with the majority and there are also 21.4% people who have strongly agreed to the statement,5.1% of people yet to decide, some people with 6% have disagreed there are people with 5% people who strongly disagree.

INFERENCE: Here to conclude that the majority of people have selected to agree option with percentage of 31.4%.



Are you familiar with the benefits of Mivan shuttering technology, such as reduced construction time and improved quality	Percentage
Strongly Disagree	2.1%
Disagree	14.3%
Undecided	7%
Agree	42.9%
Strongly Agree	34.3%

INTERPRETATION: The total strength has responded to the agree option which is 42.9% with the majority and there are also 34.3% people who have strongly agreed to the statement, 7% of people yet to decide, some people with 14.3% have disagreed there are people with 2.1% people who strongly disagree.

INFERENCE: Here to conclude that the majority of people have selected to agree option with percentage of 42.9%.

3.6 Suggestion and Conclusion

According to the above survey data, people are aware about the mivan shuttering technology. Although they have acute knowledge about its cost and future development, they have a positive attitude towards it.

From this we can conclude that though mivan shuttering technology is not up to mark at this particular period of time, it can be improved and accelerated in the future and may emerge as a trending technology in construction field.

4.0 MAIN THRUST OF THE PAPER

- To understand how Mivan shuttering technology helps construction companies like Navami builders
- To identify the uses of Mivan shuttering technology in construction companies
- To evaluate customer awareness towards Mivan shuttering technology
- To suggest customer about Mivan shuttering technology

5.0 FUTURE TRENDS

- Faster construction
- Cost-effective
- Improved quality
- Flexibility
- Reduced environmental impact

6.0 CONCLUSION

In conclusion, the analysis of customer knowledge of Mivan shuttering technology has shown that, despite this technology's recent rise in popularity, many customers still don't know much about it. This is mostly because traditional construction techniques have been employed for a considerable amount of time, and clients are typically more familiar with these techniques. However, the benefits of Mivan shuttering technology in terms of speed, affordability, quality control, and sustainability make it a workable substitute for conventional construction techniques.

It is advised that construction firms and developers actively promote the advantages of Mivan shuttering technology through advertising and other marketing channels in order to increase client awareness. In order to aid clients in making educated selections, they should also give them comprehensive information about the capabilities, benefits, and limitations of the technology. To guarantee that construction employees are proficient in using the technology, it is also crucial to offer them training and support.

ACKNOWLEDGMENTS

I heartily thank Bangalore Institute of Technology for giving me a top-notch academic setting and a wealth of learning possibilities while I complete my bachelor's degree in industrial engineering and management there.

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ABSTRACT

The website's primary purpose is to provide a platform for users to buy and sell goods and service online. A clean and user-friendly interface is crucial for the website's success. The website should be easy to navigate, and users should be able to find what they are looking for quickly. The website should have a registration system that allows users to create an account and manage their listings. The website should provide users with tools to manage their listings, including adding, editing, and deleting listings. The website should have a robust search system that allows users to find relevant listings based on keywords, location, and other filters. The website should have a secure payment gateway that allows users to make payments for their purchases. The website should have an admin panel that allows the site owner to manage the website, including managing users, listings, payments, and site content. The website should be secure to protect user data and prevent fraud. The website should be optimized for mobile devices, as many users access the internet on their smartphones.

KEYWORDS *: Website, Time saving, Cost-saving*

1. INTRODUCTION

Our website provides a platform for buyers and sellers to connect and trade goods and services online. We understand the importance of convenience, accessibility, and security when it comes to buying and selling online. Therefore, we have designed our website to offer all three. Our website provides a user-friendly interface that makes it easy for anyone to browse and post ads. Our platform is accessible on any device, making it convenient for users to buy or sell from anywhere. We also offer a variety of categories to cater to different needs and interests, such as Textbooks, stationary,and more.

We take the security of our users very seriously, and we have implemented measures to protect the interests of all parties involved. Our website uses secure payment options, user verification, and feedback systems to ensure that every transaction is secure and reliable.. We understand that trust is a critical factor in online buying and selling, and we aim to provide a trustworthy platform that users can rely on.

1.1 Advantages of Bit Cart

Online websites are available 24/7, which means that users can browse and post ads at any time from anywhere with an internet connection. Online buy or sell websites have a global reach, which means that buyers and sellers can connect with people. This increases the likelihood of finding the perfect buyer or seller. Online buy or sell websites typically have lower costs compared to traditional methods. For example, there are no costs associated with printing and distributing flyers or advertisements. Online websites give users greater control over the buying and selling process. Buyers can browse through multiple listings and compare prices, while sellers can set their own prices and manage their ads. Online buy or sell websites provide secure payment options that protect the interests of both buyers and sellers. This reduces the risk of fraud and ensures that every transaction is safe and reliable.

2.0 BACKGROUND

When The concept of online buy and sell websites began in the mid-1990s, with the emergence of the first online marketplace, eBay. Since then, online buy and sell websites have become increasingly popular and have revolutionized the way people buy and sell goods and services. The growth of online buy and sell websites has been fueled by advances in technology and the widespread adoption of the internet. These websites offer a range of features, including secure payment options, user verification, and feedback systems, which have made online buying and selling more reliable and trustworthy.

2.1 Research Questions

To fulfill the purpose of the study, the survey sought to answer the following research questions:

[1] How to evaluate customers awareness towards mivan shuttering?

[2] How to suggest customer about Mivan shuttering technology?

3.0 METHODS

3.1 Scope

The first step is to define the scope of the website, including the types of goods or services that will be sold, th target audience, and the features and functionalities of the platform.

3.2 Design and Development

Once the scope has been defined, the next step is to design and develop the website. This includes creating wireframes, mockups, and prototypes to visualize the user interface and experience.

3.3 Back-end Development

The back-end development involves coding and creating the databases and servers required to power the website's functionality. This includes payment gateways, user authentication, and data management.

3.4 Testing

After the website has been developed, it's essential to test it thoroughly to ensure that it is working correctly and that all features and functionalities are functioning as intended. User testing can also be conducted to identify any usability issues.

3.5 Launch

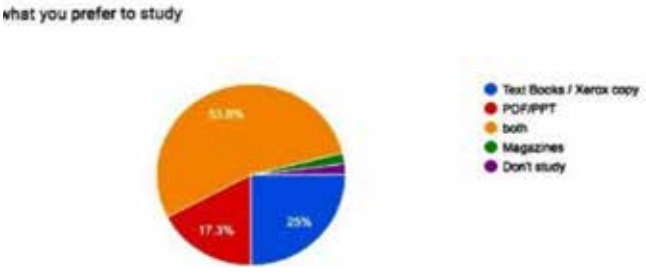
Once testing is complete, and any issues have been resolved, the website can be launched. This involves deploying the website on a web server and making it available to the public.

3.6 Maintenance and Updates

After launch, the website will require ongoing maintenance and updates to ensure that it remains secure and functioning correctly. This includes regular updates to the software, security patches, and bug fixes.

3.7 Marketing

Finally, it's essential to market the website to attract users and drive traffic to the platform. This includes search engine optimization, social media marketing, and paid advertising.



4.0 MAIN THRUST OF THE PAPER

The advantages and disadvantages of online marketplaces and e-commerce, and how they have transformed the way people buy and sell goods and

services. It would also focus on the technology and strategies used to create successful online buy and sell platforms, as well as the challenges that need to be addressed to ensure the security, reliability, and sustainability of these platforms. Additionally, the paper could explore the impact of online buy and sell websites on the global economy and consumer behavior, and provide insights into future trends and developments in this rapidly evolving field.

5.0 FUTURE TRENDS

5.1 Mobile-First Approach

As more people use mobile devices to access the internet, online marketplaces will need to prioritize mobile optimization and design.

5.2 Artificial Intelligence (AI)

AI-powered tools like chatbots and personalized recommendations will become more prevalent, improving the user experience and increasing sales.

5.3 Voice-Activated Commerce

With the rise of smart speakers and voice assistants, users will be able to buy and sell goods and services using voice commands. 5.4 Blockchain Technology: Blockchain technology can be used to create secure and transparent transactions, which could increase trust and reduce fraud in online marketplaces.

5.5 Social Commerce

Social media platforms will continue to integrate e-commerce features, allowing users to buy and sell products within the social media ecosystem.

6.0 CONCLUSION

In online buy and sell websites have revolutionized the way we shop and do business, providing a convenient and accessible platform for buyers and sellers to connect and transact. These platforms offer a range of benefits, including cost savings, convenience, and access to a global market. However, they also come with challenges such as security concerns, competition, and the need for ongoing maintenance and updates. Looking to the future, the continued evolution of technology and changing consumer preferences will drive new trends and developments in the online buy and sell space. As such, it will be important for businesses to stay up to date with the latest trends and technologies to remain competitive and provide the best possible experience for their users.

Acknowledgments

You have my gratitude for helping you with the acknowledgments part of your paper. An example acknowledgment section is provided here for your reference:

I want to publicly thank Bangalore Institute of Technology for giving me a top-notch academic setting and a wealth of learning possibilities while I complete my bachelor's degree in industrial engineering and management there. I couldn't have finished this project without the information and abilities I've gained while studying I would like to thank my Guide for providing valuable guidance and feedback throughout the project.

I would also like to acknowledge the contributions of the team members involved in the development of the online website, without whom this project would not have been possible.

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CONDITION MONITORING- A CRITICAL REVIEW

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ABSTRACT

Condition monitoring-based maintenance involves monitoring the health of machinery through measurement of machinery and lubricant parameters such as vibration, oil life index, and contamination index, etc., the work has been carried out in Bharat Earth Movers Ltd., Mysore, with the objective of condition monitoring. The faultsin various machineries have been diagnosed and remedial measures have been suggested based on vibration analysis and oil analysis. Corrective actions are taken and found improvement in performance.

KEYWORDS *: Condition monitoring, Vibration and oil analysis.*

1. INTRODUCTION

Condition monitoring or condition-based maintenance involves monitoring the health of machinery through the measurement of machinery and lubricant parameters such as vibration, oil life index, corrosion index, contamination index, etc.

Monitoring by definition is an act of extracting information from a specific system by means of an appropriate sensing instrument [1][2]. Vibration monitoring consists of acquiring vibration signals and using that information for diagnostics, vibration signature analysis is known to indicate the health of a rotating and reciprocating machine[3][4].

Oil analysis consists of acquiring index values, % viscosity change, and large contaminants [5][6]. These provide information about the suitability of the lubricant for further use and the condition of the lubricated metal surfaces [7][8]. Condition monitoringof equipment is very much important to increase productivity and reduced downtime through increased availability of machinery [7][9][10].

2. MONITORING INSTRUMENTS

The monitoring instruments used for this work of Vibration meter riovibro (Model VM - 63), Spectrum analyzer/Dynamic balancer (Model IRD - 880), Visgage, Oil view analyser Model – 5100[11][12].

Vibration meter RIOVIBRO, model VM-63, measurement range: Displacement: 0.001 to 1.999 mm p-p, Velocity: 0.01 to19.99 cm/s rms, Acceleration: 0.1 to 199.9 m/s^2 peak. Pocketable vibration meter "RIOVIBRO" is best suited for on- site measurement. RIOVIBRO gives the displacement (peak to peak) in millimetres, velocity (RMS) in *cm/s* and acceleration (peak) in m/s^2.The RMS velocity is converted into peak velocity by multiplying the RMS velocity by √2. The dominant frequency at a location is calculated [13][14].

Oil view analyzer model-5100 is a multifunctional predictive maintenance tool for immediate, on-site

evaluation of in-service lubricating oils. The analyzer system consists of a sensor grid that screws onto a standard 100 ml oil sample bottle. The oil `view software runs on any IBM PC-compatible computer.

2.1 Vibration analysis of Khosla Compressor (KC-1)

Khosla air compressor is a double-acting horizontal crass head type and is built in two each row consists of two opposed cylinders. The compressor is driven by a 90 KW, 1460RPM electric motor through a V-belt drive. Compressed air is used for the operation of some of the machine tools and the assembly of equipment.

Technical specification and other relevant details of the Khosla compressor (KC - 1) Including block diagram (Fig 1) of the machine is given below.

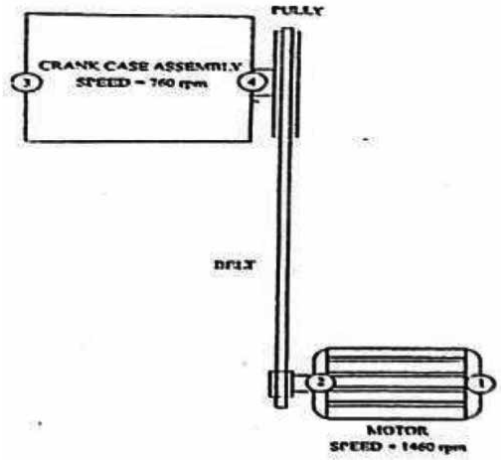


Figure 1.0 Block diagram of Khosla Compressor (KC-1)

2.2 Vibration data collection

Overall vibration and vibration signatures were taken on 13-10-98 and 22 -12-98 in the horizontal, vertical, and axial direction at the bearing points. These signatures have been analyzed to identify faults in the machinery like oil whirl, unbalance, mechanical looseness, electrical problems, misalignment, bad drive belts, bad bearings, and bad gears. The vibration levels were measured before and after corrective action were taken and have been analyzed for any malfunction in the machine.

From vibration severity ranges in accordance with ISO 2372, this Khosla compressor belongs to class V, for which the maximum permissible vibration is 40 mm/sec (peak) or 28 mm/sec (RMS), but it has been decided to take the maximum permissible vibration as25 mm/sec (peak) or 18 mm/sec (RMS).

Observations

1. Maximum vibration measured before corrective action as shown in table 1.1=14.708 mm/sec (peak)
2. Vibration signatures in velocity mode at the bearing point I show vibration peak at a frequency 1 x CPM (i.e. 1x1460 =1460CPM). The 1 x CPM amplitudes are 08, 24 and 34 mm/See in horizontal, vertical, and axial directions respectively. The amplitudes of vibration are quite high in the axial direction.
3. Vibration signatures in velocity mode at bearing point 2 show vibration peak at a frequency 1 x CPM (i.e. 1x 1460- 1460CPM) and 2 x CPM (i.e. 2 x 1460- 2920CPM). The I x CPM amplitudes are 06, 10, and 15 mm/sec in horizontal vertical, and axial directions respectively. The 2 x CPM amplitude is 05 mm/sec in the horizontal direction.
4. Vibration signature in velocity mode at bearing point 3 shows a vibration peak at a frequency 22 x CPM (i.e. 22 x 1460=32,120 CPM). The 22 x CPM amplitude is 08 mm/sec in the axial direction.

Recommendations

- Check for misalignments or Bent shaft
- Check for electrical or mechanical unbalance of motor shaft.
- Check for tightness of motor bolts.
- Ensure good lubrication for bearing points

2.2 Corrective action at BEML

One of the foundation bolts of the motor was broken, it was replaced by a new one and all blots and nuts were tightened, the V-belt drive was aligned, and lubrication was ensured at the bearing point.

Observations after corrective action

1. Maximum vibration measured, after corrective action as shown in Table 1.2=11.466 mm/sec (peak)
2. Vibration signatures in Velocity mode on bearing point I show vibration peak at a frequency I x CPM (i.e. 1 x 1460 CPM). The 1 x CPM amplitudes are 03, 02, and 26 mm/sec in horizontal, vertical, and axial directions respectively. The amplitude is reduced compared to before the corrective action.
3. The vibration signatures in velocity mode on bearing point 2 show a vibration peak ata frequency 1 x

CPM (i.e. 1x 1460 CPM). The 1 x CPM amplitudes are 02, 03, and 07 mm/sec in horizontal, vertical, and axial directions respectively. The amplitude isreduced compared to before the corrective action.

4. Vibration signature in velocity mode at bearing point 3 shows a vibration peak at a frequency of 22 x CPM. The 22 x CPM amplitude is 02 mm/Sec in the axial direction.

Table 1. Overall vibration level of Khosla Compressor (KC-1) before corrective action

Point	Direction	Velocity peak (mm/sec)	Alarm peak (mm/sec)	Remarks
1	H	4.95	25.0	Normal
	V	9.89	25.0	Normal
	A	13.72	25.0	Acceptable
2	H	6.36	25.0	Normal
	V	13.15	25.0	Acceptable
	A	14.708	25.0	Acceptable
3	H	1.98	25.0	Good
	V	2.12	25.0	Good
	A	2.404	25.0	Good
4	H	1.979	25.0	Good
	V	2.969	25.0	Good
	A	3.667	25.0	Good

Table 2. Overall vibration level of Khosla Compressor (KC-1) before corrective action

Point	Direction	Velocity peak (mm/sec)	Alarm peak (mm/sec)	Remarks
1	H	2.55	25.0	Good
	V	5.52	25.0	Normal
	A	11.46	25.0	Acceptable
2	H	3.82	25.0	Good
	V	7.21	25.0	Normal
	A	8.34	25.0	Normal
3	H	1.84	25.0	Good
	V	1.98	25.0	Good
	A	0.85	25.0	Good
4	H	1.84	25.0	Good
	V	2.55	25.0	Good
	A	1.27	25.0	Good

H – Horizontal V-Vertical A-Axial

3. OIL ANALYSIS OF HORIZONTAL BORING AND MILLING MACHINE (352001)

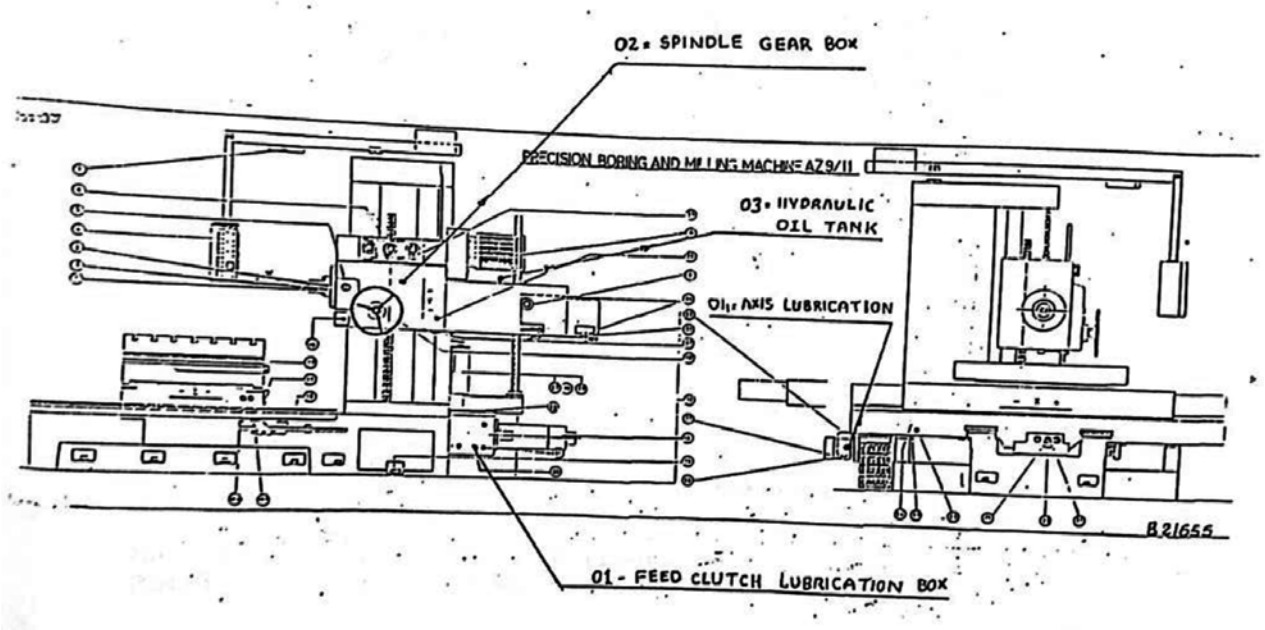
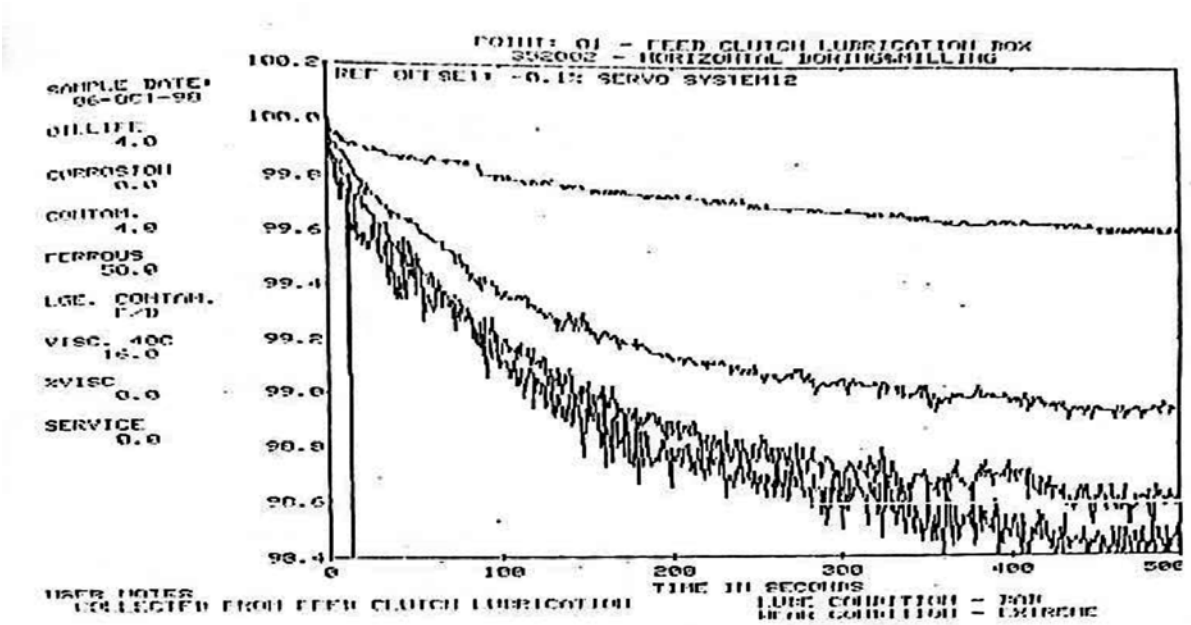


Figure 2. horizontal boring and milling machine (352001)

Point ID	:	01	Milling machine		
Point description box	:	Feed clutch lubrication	Location	:	Machine shop
			Oil used	:	Servo Spin - 12
Machine ID	:	352001	Machine diagram, data plot and oil view data history are exhibited in Figures 2 and 3respectively		
Machine description	:	Horizontal boring and			



OilView Data History
****

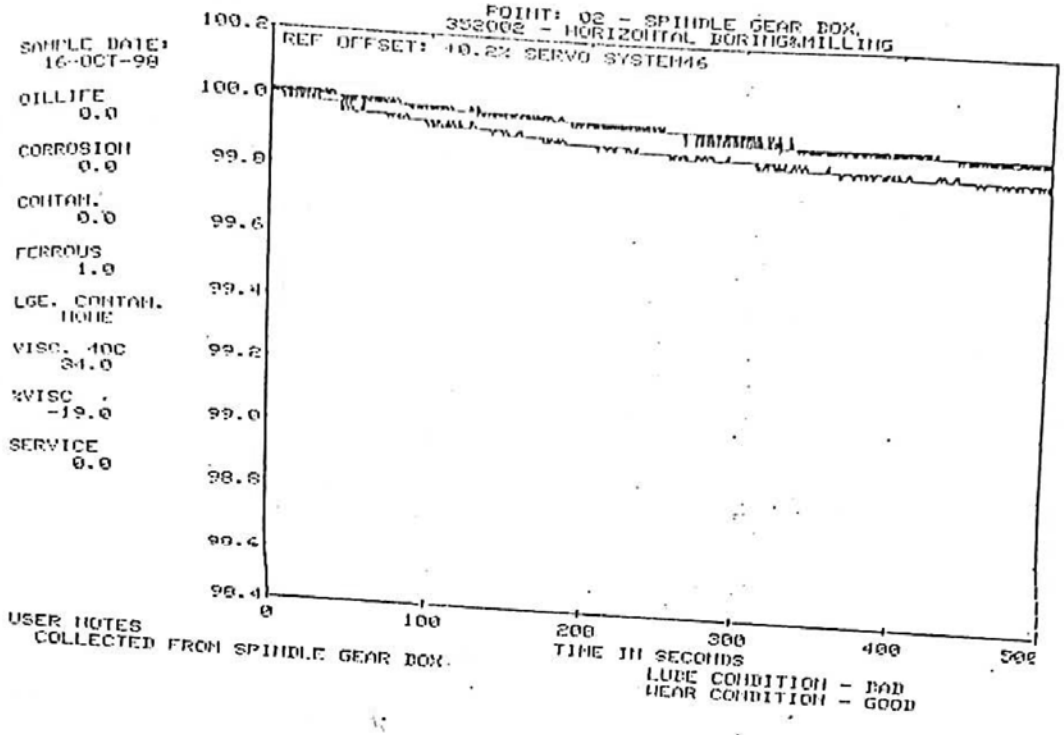
Machine : 352002 - Horizontal Boring&milling
Point : 01 - Feed clutch Lubrication box

Sample Date: 06-OCT-98 0.0 Hours

OilLife	4.0	Corrosion	0.0	Contam.	4.0
Ferrous	50.0	Visc. 40C	16.0	Lg Contam.	F/D
%VChange	0.0	51FW	N/A		

Collected from Feed clutch Lubrication
Lube Condition - Bad Wear Condition - Extreme
Check - Breather, Shop Mic, Mechanical
Action - Remove Contaminants (water?)
Estimated % moisture content 0.0000
In Solution 0.0000 Dispersed 0.0000 Free 0.0000

Figure 3



OilView Data History
****

Machine : 352002 - Horizontal Boring&milling
Point : 02 - Spindle Gear Box

Sample Date: 16-OCT-98 0.0 Hours

OilLife	0.0	Corrosion	0.0	Contam.	0.0
Ferrous	1.0	Visc. 40C	34.0	Lg Contam.	None
%VChange	-19.0	51FW	N/A		

Collected from Spindle Gear Box
Lube Condition - Bad Wear Condition - Good
Check - Viscosity, Dilution, Shop Mic, Particles?
Action - Change oil
Estimated % moisture content 0.0000
In Solution 0.0000 Dispersed 0.0000 Free 0.0000

***** END OF LISTING *****

Figure—4.0

OBSERVATIONS

Oil life	0.0
Corrosion	0.0
Contam	0.0
Ferrous	5.0
% Visc change	0.0
Lg Contam	F / NF
Lubrication condition	Good
Wear condition	Bad

All the index values are within the limit, and indicate that large ferrous and non- ferrous particles such as iron, copper, aluminum, tin lead or chrome, were detected. Probably much larger than 60µm

Recommendations

1. Change filter and retest
2. Check breather and particles

Point ID : 02

Point description : Spindle gear box

Machine ID : 352001

Machine description : Horizontal boring and Milling machine

Location : Machine shop

Oil used : Servo System - 46

Machine diagram, data plot and oil view data history is exhibited in Figures 2 and 5 respectively.

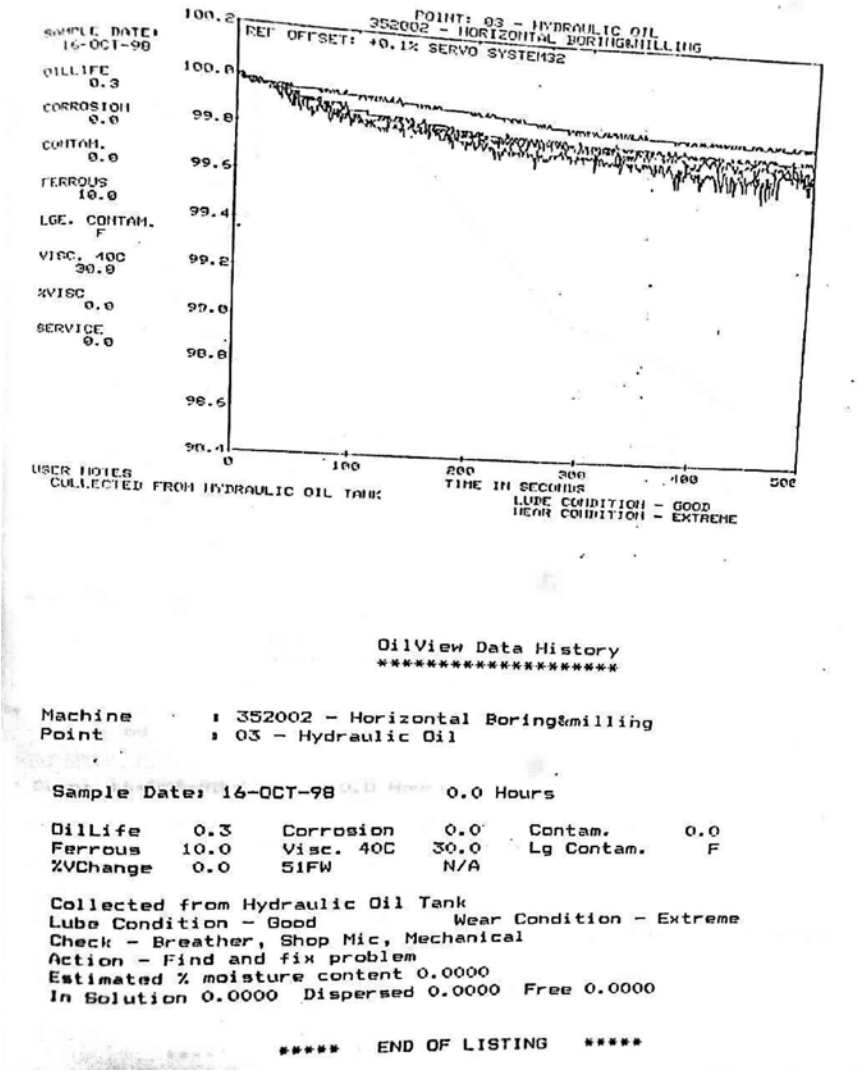


Figure 5.

Corrective action taken at BEML

The filter has been changed, gear box dismantled and found there was wear out in the clutch plates. New clutch plates were assembled.

3.1 Observations

Oil life	0.3
Corrosion	0.0
Contam	0.0
Ferrous	1.0
% Visc change	-4.8
Lubrication condition	Good
Wear condition	Bad

All the index values are within the limits.

3.2 Corrective action taken at BEML – NIL Recommendations

1. Change particles

Point ID : 03

Point description : Hydraulic oil tank

Machine ID : 352001

Machine description : Horizontal boring and Milling machine

Location : Machine shop

Oil used : Servo System - 46

Machine diagram, data plot and oil view data history are exhibited in Fig 2 and 5 respectively.

3.3 Observations

Oil life	8.6
Corrosion	0.0
Contam	7.4
Ferrous	1152.6
% Visc change	10.0
Lg Contam	F / NF / D
Lubrication condition	Extreme
Wear condition	Extreme

Oil analysis shows that ferrous content was very much more, and also indicates that large ferrous content, non-ferrous content and droplet are observed, probably much larger than 6µm.

Recommendations

1. Remove contaminants (water)
2. Check breather and particles.

3.4 Corrective action taken at BEML

There was too much of wear in the gears of the gear box. Gear box bearings were replaced. The impeller of the pump was found to be worn out and pump was replaced. Oil and filter were changed.

Point ID : 04

Point description : Axis lubrication

Machine ID : 352001

Machine description : Horizontal boring and Milling machine

Location : Machine shop

Oil used : Servo way-68

Machine diagram, data plot, and oil view data history are exhibited in Fig 2 and 6 respectively.

3.5 Observations

Oil life	9.1
Corrosion	7.4
Contam	0.0
Ferrous	0.0
% Visc change	-19.3
Lg Contam	None
Lubrication condition	Extreme
Wear condition	Good

The oil life index value is in the margin, the corrosion index value is extreme and the %viscosity change also comes under bad.

Recommendation

1. Check viscosity and dilution
2. Change the oil

3.6 Action BEML

The lubrication oil has been changed.

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A STUDY ON CONSUMER PREFERENCE TOWARDS DISCOUNTED WEDNESDAY AT KFC

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ABSTRACT

To delve into the preferences of consumers when it comes to discounts offered on Wednesdays at KFC, a study was undertaken using a mixed-methods approach. Over 115 participants were surveyed and interviewed to collect both qualitative and quantitative data. The outcome of this research revealed that customers place high value on Wednesday discounts, with most indicating their willingness to frequent KFC more often if such promotions persisted. Moreover, survey findings suggested that offering price incentives does not necessarily mean compromising food quality or service delivery but instead augments customer satisfaction levels. This paper concludes by discussing the implications of these results for fast-food companies in general and recommends strategies based on customer preferences towards promos like those proffered at KFC on Wednesdays to boost business performance.

KEYWORDS *: Consumer preference, Discount, Fast food, KFC*

INTRODUCTION

Products and services play a vital role in all businesses. The quality of the services provided by each KFC branch is one of the main factors for KFC to increase their customer satisfaction over years, as its actual product not only consists of quality chicken but also a satisfactory service to its target customer.

The fast-food market is saturated with many chains vying for customers. To stay ahead of the competition, companies must find ways to stand out. Offering

discounts and deals has become a popular strategy, but its effectiveness remains unclear. KFC, known for their crispy fried chicken and mouth-watering sides, has experimented with various discounting strategies to attract more consumers. Their latest scheme centers on offering discounts exclusively on Wednesdays. This article aims to study consumer preferences towards this particular promotion at KFC restaurants across different cities in Karnataka locations. The focus will be on whether this strategy can increase sales by attracting those who had not considered visiting previously or favoured other fast-food chains due to price-related factors. The thesis statement suggests that the Wednesday discount promotion at KFC significantly impacts customer behaviour and boosts sales figures. It emphasizes how vital it is to understand pricing strategies in highly competitive industries like fast food by examining customer preferences. By conducting surveys among customers who have visited during the discounted hours on Wednesdays, we aspire to provide valuable insights into what drives customer behaviour when selecting where they want eat: low prices or quality food? Furthermore, our research will explore if there are any demographic differences regarding responses towards promotions such as these – do younger people prefer specials over older generations? Are certain ethnic groups more likely than others to take advantage of discounted offers? In conclusion, analysing consumer preferences toward Wednesday's discounts offered by KFC could potentially help similar establishments leverage promotional pricing strategies effectively while providing value for money spent by clients. By understanding what motivates customers' choices concerning where they dine out and why they choose a particular restaurant over another one may benefit all parties involved in making informed decisions about pricing policies that work best for everyone involved in the enterprise.

RESEARCH OBJECTIVE

1. To study the advertisement of KFC.

2. To study preferences of KFC foods.

3. To study impact on business with respect to discounts.

BACKGROUND

Following an exhaustive exploration on consumer behaviour, a hypothesis was formed indicating that discounts offered by KFC restaurants on Wednesdays would have a substantial impact. To test this hypothesis, a survey comprising of 10 questions was developed and dispersed to consumers at various locations throughout the state. The sample size included 115 individuals aged between 18-65 years old. These survey questions were created based on educational articles that had suggested factors which influence consumer preference towards discounts provided by fast-food establishments such as KFC. These factors encompassed price level, brand loyalty, product quality and location convenience. To ensure data validity obtained from respondents, the surveys were confidentially conducted with no personal information collected. Collected data from participants underwent in-depth analyses using descriptive statistical techniques including frequency dispersion and percentage calculations to deduce preferences for Wednesday discounts at KFC. Further statistical analysis will be executed to establish relationships amidst variables that affect consumer disposition for discounted food items served during weekdays at fast-food joints like KFC.

SUMMARY OF RESPONDS

Table 1. Based on gender

Response	Frequency	Percentage (%)
Male	68	68
Female	32	32

Table 2. Based on age

Response	Frequency	Percentage (%)
Below 20 years old	45	39.1
20-30 years old	20	17.3
30-40 years old	20	17.3
40-50 years old	15	13.04
50 years old and above	15	13.04

Table 3. Based on nationality

Response	Frequency	Percentage (%)
Indian	98	85.2

The demographic profiles of the respondents are shown in above Tables. We collected 100 responses from the survey. Table shows that the majority of the respondents were Indian males (69%) from Indian in the age group of 20 to 29 years old. The difference between the percentage of females and males was 32%. According

to the age range of respondents, more respondents (39.1%) were below 20 years old, it also considers as the highest-ranking among other respondents age group. By nationality, the majority (85.2%) were Indian.

Table 4. How consumer got to know about Wednesday discount at KFC

Response	Frequency	Percentage (%)
Flyers	11	9.6
Social Media	87	75.7
Newspaper/ Magazine	3	2.6
Family and relatives	3	2.6
Recommendation from friends	1	0.9
The brand	1	0.9
Their branch	2	1.7
Advertisement	1	0.9
Self-discovered	3	2.6

MAIN THRUST OF THE PAPER

The findings from a recent study on consumer preferences regarding discounts offered by KFC on Wednesdays reveal that specific day discounts significantly impact customer behaviour, resulting in increased sales. Research suggests that customers are more likely to visit KFC outlets when such promotions are available, particularly midweek. This outcome aligns with previous literature confirming the public's inclination toward discounted products. One of the reasons for this trend could be attributed to fast-food chains' convenience and speedy service delivery at affordable prices. Offering additional discounts adds extra value to these already attractive features, which states that quality customer service improves customer satisfaction. All three studies show there is a significant correlation between offering Wednesday-specific markdown deals and boosted revenue for KFC restaurants worldwide. Moreover, it seems like KFC's "Wednesday Special" campaign strategy resonates positively with younger generations who consume fast food frequently but have lower disposable incomes than working professionals. Providing such options encourages loyalty among this demographic segment while also drawing new customers looking for budget-friendly alternatives. In conclusion, research indicates overwhelming support for weekday-special offers like those provided by KFC's Wednesday program since they significantly influence consumer purchasing decisions and enhance total income streams globally. These results have profound implications for fast-food organizations seeking ways to boost sales volume and improve patronage through targeted discount programs.

FUTURE TRENDS

The examination on the inclinations of customers for discounts given on Wednesdays at KFC proposes that targeted discounts can substantially affect consumers' behaviour, causing an increase in sales. By creating a sense of urgency and exclusivity, companies can stimulate patrons to avail themselves of the deal while it lasts through incentives provided during specific days. One interpretation derived from this finding is that clients are motivated by savings and actively search for opportunities to save money while eating out. This infers that restaurants may benefit from extending similar promotions or deals throughout other days of the week as well. Moreover, businesses can expand their reach and zero in on particular demographics by promoting these offers through social media platforms and email marketing outreach campaigns. Another implication implies that corporations need strategic pricing policies if they want to remain competitive within the fast-food industry. As many consumers base their purchasing decisions exclusively on value-for-money considerations, providing regular promotions could be crucial for attracting customers into stores. To conclude, future research might explore how varying types of discounts impact consumer behaviour and whether certain promotional strategies appeal more with distinct demographics than others do. Additionally, examining how technology-based loyalty programs could enhance patron engagement would provide valuable insights into compelling ways for restaurants to attract new business

while retaining existing clientele. Overall, this study showcases why understanding customer preferences when developing promotional tactics aimed at boosting sales in highly competitive markets such as fast food is pivotal.

CONCLUSION

To draw meaningful conclusions about customer behaviour and preferences with regards to KFC's Wednesday discounts, this study was conducted. The results obtained provide valuable insights into what motivates customers to visit the restaurant on a particular day of the week. Data was collected from a sample of customers who had visited KFC in the past month using surveys, which were then analysed through descriptive statistics. The findings showed that most consumers found discount offers attractive, leading them to pick Wednesdays over other days when visiting KFC. As a result, offering deals like these can serve as an effective marketing tactic for increasing foot traffic and drive sales volume through targeted promotional activities based on specific days or times. These observations highlight the importance of companies constantly monitoring consumer preferences while adjusting their marketing strategies accordingly. Therefore, it is vital to identify similar opportunities that allow businesses like KFC to bring potential revenue gains by attracting price-sensitive consumers who might not have considered visiting otherwise. In conclusion, this research emphasizes how providing special deals on certain days could significantly increase profits for restaurants such as KFC by appealing to those looking for great value offerings. Additionally, varying promotions boosts customer satisfaction levels since they receive differentiated offerings - something worth considering from any company's standpoint seeking steady growth and success in today's business landscape.

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ANALYTICAL STUDY ON DTDC

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ABSTRACT

DTDC is a prominent logistics and courier services company in India, providing a wide range of domestic and international courier services, parcel delivery, freight transportation, e-commerce solutions, and supply chain solutions. The company has a widespread network of branches and service centers across the country and operates through multiple modes of transportation including air, road, and rail. With a strong market presence in India and a growing international footprint, DTDC has become a trusted provider of logistics services to various sectors including e-commerce, healthcare, automotive, and retail. This abstract provides an overview of DTDC, highlighting its services, network, and market presence, and emphasizes the company's commitment to innovation, customer service, and operational excellence in the dynamic logistics and courier industry.

KEYWORDS *: Logistics, Supply chain, Warehousing*

INTRODUCTION

DTDC (Desk to Desk Courier) is a leading logistics and courier services company based in Bangalore, India. Established in 1990 by Subhasish Chakraborty, DTDC has grown to become one of the largest courier companies in India with a widespread network of branches and service centers across the country. The company offers a comprehensive range of services, including domestic and international courier services, parcel delivery, freight transportation, e-commerce solutions, and supply chain solutions. DTDC operates through a multi-modal transportation network that includes air, road, and rail, and serves customers in various sectors such as e-commerce, healthcare, automotive, and retail. With a strong market presence in India and a growing international footprint, DTDC has established itself as a trusted provider of logistics and courier services, catering to the needs of individuals, small and medium-sized enterprises (SMEs), large corporations, and e-commerce companies. The company is known for its commitment to innovation, customer service, and operational excellence, and continues to adapt and evolve in the dynamic logistics and courier industry.

DTDC is a leading Indian logistics and courier services company that specializes in domestic and international courier services, parcel delivery, freight transportation, and e-commerce solutions. Conducting an analytical study on DTDC involves analyzing various aspects of the company, such as its history, operations, market presence, competitive landscape, financial performance, and future prospects.

LITERATURE REVIEW AND RESEARCH GAP

DTDC has built a strong network of branches and service centers across India, establishing a wide coverage and reach to cater to the growing demand for logistics and courier services in the country. The company has invested significantly in its infrastructure, technology, and workforce to meet the evolving needs of its customers and the industry.

DTDC offers a comprehensive range of services, including domestic and international courier services, parcel delivery, freight transportation, e-commerce solutions, and supply chain solutions. Its services cater to a diverse customer base, including individuals, small and medium-sized enterprises (SMEs), large corporations, and e-commerce companies, across various sectors such as e-commerce, healthcare, automotive, and retail.

The company operates through a multi-modal transportation network that includes air, road, and rail, enabling efficient and reliable transportation of shipments across India and internationally. DTDC has strategic partnerships with major airlines, shipping lines, and logistics providers, enabling it to offer seamless and reliable services to its customers.

DTDC has a customer-centric approach, focusing on delivering exceptional service quality and meeting customer requirements. It has invested in advanced technology solutions, including online tracking, automated processes, and digital platforms, to enhance its operational efficiency and provide a seamless customer experience.

DTDC has also been at the forefront of innovation in the logistics and courier industry in India. It has introduced various value-added services such as cash-on-delivery, reverse logistics, and e-commerce solutions to cater to the evolving needs of the e-commerce sector. The company has received numerous awards and recognition for its excellence in customer service, operational efficiency, and industry leadership.

In addition to its strong market presence in India, DTDC has been expanding its international footprint through strategic partnerships and alliances with global logistics providers. It has established offices and operations in several countries, including the United States, United Kingdom, Canada, Australia, Singapore, and China, among others.

DTDC is committed to sustainability and corporate social responsibility and has implemented various initiatives to reduce its environmental footprint, promote employee welfare, and support local communities.

Overall, DTDC has a rich background as a leading logistics and courier services company in India, with a strong network, comprehensive services, a customer-centric approach, a commitment to innovation, and a growing international presence.

STATEMENT OF THE PROBLEM

DTDC, which stands for Desk to Desk Courier and Cargo, is a leading courier and logistics company based in India. The main motive of DTDC is to provide reliable and efficient courier and logistics services to its customers.

DTDC's motive can be broken down into several key aspects:

Customer satisfaction: DTDC aims to achieve maximum customer satisfaction by providing high-quality courier and logistics services. This includes timely delivery of packages, efficient tracking systems, professional customer service, and reliable handling of shipments.

Business growth: DTDC's motive is to grow its business by expanding its network, offering a wide range of services, and catering to the evolving needs of its customers. This includes exploring new markets, forging strategic partnerships, and staying ahead of the competition through innovation and technology.

Trust and reliability: DTDC strives to build trust and reliability among its customers, partners, and stakeholders. This is achieved by maintaining transparency in its operations, adhering to ethical business practices, and delivering on its promises consistently.

Employee empowerment: DTDC recognizes the importance of its employees in delivering exceptional customer service. The company aims to empower its employees by providing them with the necessary training, resources, and opportunities for growth and development.

Social responsibility: DTDC is committed to being a socially responsible organization. This includes initiatives to promote environmental sustainability, community welfare, and corporate governance. DTDC also participates in various social causes and engages in philanthropic activities to contribute positively to society.

Innovation and technology: DTDC recognizes the importance of innovation and technology in the logistics industry. The company strives to stay at the forefront

of technological advancement s and leverage them to enhance its service offerings, optimize operations, and improve overall customer experience.

In summary, the main motive of DTDC is to provide reliable and efficient courier and logistics services, achieve customer satisfaction, drive business growth, build trust and reliability, empower employees, fulfil social responsibilities, and embrace innovation and technology.

OBJECTIVES OF THE STUDY

DTDC is expected to continue to grow and evolve in the future, with several key trends likely to shape its path. Here are some potential future trends for DTDC:

E-commerce Integration: As e-commerce continues to flourish globally, DTDC is likely to further integrate its services with e-commerce platforms and provide specialized solutions for the e-commerce sector. This may include offering customized logistics solutions for e-commerce companies, optimizing last-mile delivery, and providing value-added services such as reverse logistics and cash-on-delivery.

Technology and Automation: Technology and automation are expected to play a significant role in the future of logistics and courier services. DTDC is likely to invest in advanced technology solutions, including data analytics, artificial intelligence, robotics, and automation, to enhance its operational efficiency, improve tracking and visibility, and streamline its processes.

International Expansion: DTDC has been expanding its international footprint in recent years and is likely to continue this trend in the future. The company may establish new offices, partnerships, and alliances in key international markets to strengthen its global presence and cater to the growing demand for cross-border logistics and courier services.

Sustainability and Green Initiatives: Sustainability is expected to be a key focus for logistics companies in the future, including DTDC. The company may implement green initiatives such as using renewable energy sources, optimizing transportation routes to reduce carbon emissions, and adopting eco-friendly packaging solutions to minimize its environmental footprint.

Customer Experience and Personalization: With increasing customer expectations, DTDC is likely to focus on delivering exceptional customer experience and personalization. This may include offering customized services, real-time tracking, and digital interfaces for customers to manage their shipments, as well as providing proactive communication and support throughout the shipment journey.

Supply Chain Solutions: DTDC may further expand its supply chain solutions to cater to the growing demand for end-to-end logistics services. This may include offering integrated supply chains solutions, such as warehousing, inventory management, and value-added services, to provide a seamless and efficient supply chain experience for its customers.

Diversification into New Markets and Industries: DTDC may diversify into new markets and industries to tap into emerging opportunities. This may include expanding into new verticals such as healthcare, automotive, and perishables, or exploring new markets such as rural areas and tier-2/3 cities in India to cater to the evolving needs of different customer segments.

In conclusion, DTDC is likely to continue its growth trajectory in the future, driven by trends such as e-commerce integration, technology and automation, international expansion, sustainability, customer experience, supply chain solutions, and diversification into new markets and industries. By staying agile, innovative, and customer-centric, DTDC can position itself as a leading logistics and courier services provider in the dynamic and evolving logistics industry.

RESEARCH METHODOLOGY

An analytical study on DTDC courier would require a research methodology that includes the following steps:

Define the research problem and objectives: The first step would be to clearly define the research problem and objectives. The research problem could be to identify the root causes of the issues and complaints reported by customers, while the objectives could be to analyze the data and provide recommendations for improvement.

Develop a research design: The research design should specify the type of research, the sampling method, and the data collection techniques to be used. The research could be quantitative, using statistical methods to analyze the data, and a purposive sampling method could be used to select data points that are representative of customer complaints. Data collection

techniques could include surveys, interviews, and focus groups.

Collect data: The data collection process should be conducted in a systematic and ethical manner. The data collected could be both primary and secondary. Primary data could be collected through surveys, interviews, and focus groups, while secondary data could be obtained from sources such as company reports, industry reports, and academic literature.

Analyse data: The collected data should be analysed using appropriate statistical tools and techniques. The data analysis could involve descriptive statistics, regression analysis, correlation analysis, and factor analysis. The goal would be to identify the root causes of the issues and complaints reported by customers and to provide recommendations for improvement.

Interpret findings: The findings of the study should be interpreted in the context of the research objectives and the research problem. The results should be presented in a clear and concise manner, using tables, graphs, and charts where necessary.

Draw conclusions and make recommendations: Based on the findings and interpretations, conclusions should be drawn, and recommendations made for improvement. The recommendations should be practical, actionable, and specific to the issues identified in the study.

Report the findings: Finally, the findings and recommendations should be documented in a research report, which should be well-structured, logical, and written in concise and clear language. The report should include an executive summary, introduction, methodology, findings, conclusions, and recommendations. It should also include a discussion of the limitations of the study and suggestions for future research.

ANALYSIS OF DATA

To analyse the data on DTDC courier, the following steps could be taken:

Data cleaning: The first step would be to clean and prepare the data for analysis. This involves checking for missing values, outliers, and errors, and taking appropriate actions such as imputing missing values, removing outliers, and correcting errors.

Descriptive statistics: Descriptive statistics such as mean, median, mode, standard deviation, and range can be used to summarize and describe the data. This can provide a better understanding of the distribution of the data and help to identify any patterns or trends.

Inferential statistics: Inferential statistics such as t-tests, ANOVA, and regression analysis can be used to test hypotheses and draw conclusions about the data. For example, regression analysis can be used to identify the relationship between the number of complaints and the time taken to deliver a package.

Data visualization: Data visualization techniques such as bar charts, pie charts, and scatter plots can be used to visually represent the data and identify any patterns or trends. This can help to communicate the findings to stakeholders and decision-makers in a clear and concise manner.

Text analytics: Text analytics can be used to analyze customer reviews and feedback to identify common themes and issues. This can provide insights into the areas that need improvement and help to prioritize actions.

Root cause analysis: Root cause analysis can be used to identify the underlying causes of the issues and complaints reported by customers. This can involve using tools such as fishbone diagrams, Pareto charts, and 5 Whys to systematically identify and analyze the contributing factors.

Benchmarking: Benchmarking can be used to compare DTDC's performance with that of its competitors or industry standards. This can provide insights into areas where DTDC needs to improve and help to set performance targets.

By using these methods to analyse the data on DTDC couriers, it is possible to identify the issues and root causes and provide recommendations for improvement.

FINDINGS

Without conducting a specific study or analysis, it is not possible to provide specific findings on DTDC couriers. However, based on general industry trends and news reports, some potential findings could include:

Customer complaints: DTDC may receive customer complaints related to late deliveries, damaged packages, poor customer service, and high shipping fees. These

complaints may be due to issues with the company's operations, processes, or customer service.

Competition: DTDC may face stiff competition from other courier and logistics companies operating in India, such as Blue Dart, FedEx, and DHL. To stay competitive, DTDC may need to offer faster and more reliable delivery services, lower prices, and better customer service.

Technology: DTDC may need to invest in technology to improve its operations and enhance the customer experience. This could include adopting new tracking systems, using drones for delivery, and implementing artificial intelligence and machine learning to optimize logistics.

Expansion: DTDC may be looking to expand its operations to new regions or countries. This could involve partnerships or acquisitions to gain a foothold in new markets and increase its customer base.

Regulatory compliance: DTDC may need to comply with various regulations related to courier and logistics operations, such as licensing, security, and data protection. Failure to comply with these regulations could result in fines, penalties, and damage to the company's reputation.

Overall, the findings on DTDC courier would depend on the specific research question, methodology, and data analyzed.

CONCLUSION

DTDC is a well-established logistics and courier company in India with a strong presence in the market. It has a rich background and has grown into one of the largest players in the industry since its founding in 1990. DTDC has a comprehensive range of services, a widespread network of branches and service centers, and strategic partnerships with global logistics providers, enabling it to cater to the diverse needs of its customers across various sectors.

DTDC has been at the forefront of innovation in the logistics and courier industry in India, introducing value-added services and leveraging technology to enhance its operational efficiency and customer experience. It has a customer-centric approach and focuses on delivering exceptional service quality, which has earned it recognition and awards in the industry.

DTDC has also been expanding its international footprint, establishing offices and operations in several countries, and leveraging its global partnerships to provide seamless cross-border logistics solutions. The company is committed to sustainability and corporate social responsibility, implementing various initiatives to reduce its environmental footprint and support local communities.

DTDC's future is expected to be shaped by key trends such as e-commerce integration, technology and automation, sustainability, customer experience, supply chain solutions, and diversification into new markets and industries. These trends are likely to impact DTDC's operations and strategies, and the company will need to stay agile and innovative to maintain its competitive edge in the evolving logistics landscape.

Overall, DTDC has a strong market position, a customer-centric approach, and a commitment to innovation, sustainability, and corporate social responsibility, which are likely to contribute to its continued growth and success in the logistics and courier industry in India and internationally.

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A STUDY OF CHALLENGES ON GLOBAL LOGISTICS MANAGEMENT

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ABSTRACT

The study on challenges in global logistics management aims to identify and analyze the obstacles that companies face when managing their logistics operations across international borders.

The research methodology employed a mixed-methods approach, combining a literature review, semi-structured interviews with logistics professionals, and a survey of companies engaged in global logistics.

The study found that the key challenges in global logistics management are related to supply chain disruptions, regulatory compliance, transportation infrastructure, and cultural differences. Additionally, technology adoption, talent management, and sustainability concerns were identified as emerging challenges.

The study concludes that companies need to adopt a holistic approach to global logistics management that considers these challenges and implements strategies to address them, including collaboration with partners, leveraging technology, and investing in talent development.

The findings of this study have important implications for businesses seeking to optimize their global logistics operations and remain competitive in today's global marketplace.

KEYWORDS *: Transportation, Warehousing, Inventory management, Customs and regulations, Sustainability, Technology, Risk management, Outsourcing, Customer service, Collaboration, Communication, Globalization*

INTRODUCTION

Global logistics management is a critical component of supply chain management that involves planning, implementing, and controlling the movement and storage of goods and materials across international borders. It plays a crucial role in ensuring that products are delivered efficiently and effectively to customers while minimizing costs and maximizing profits for businesses.

However, global logistics management faces numerous challenges that impact its effectiveness and efficiency. These challenges include transportation infrastructure limitations, customs and regulatory compliance issues, supply chain disruptions, fluctuating demand, and geopolitical risks, among others.

To understand these challenges in-depth, this study aims to explore the key issues facing global logistics management and their impact on businesses operating in

international markets. The study will analyze the latest trends and practices in global logistics management and evaluate the effectiveness of existing strategies and approaches.

The study will identify the best practices for overcoming these challenges and propose recommendations for businesses to enhance their global logistics management capabilities.

This study will provide valuable insights into the challenges facing global logistics management, highlighting the importance of effective logistics management in achieving business success in the global marketplace.

BACKGROUND

Global logistics management is the process of planning, organizing, and controlling the flow of goods and services from one country to another. It involves managing complex supply chains, dealing with customs regulations, navigating different languages and cultures, and ensuring the timely delivery of goods. As global trade has expanded in recent decades, the challenges of managing logistics on a global scale have become increasingly complex.

There are several key challenges that companies face when it comes to global logistics management. One of the biggest challenges is dealing with the complexities of customs regulations and trade agreements. Each country has its own set of customs regulations and import/export laws, which can make it difficult to navigate the process of moving goods across borders.

Trade agreements between countries can have a significant impact on logistics operations, as they may dictate the types of goods that can be imported or exported and the tariffs that must be paid.

Another challenge of global logistics management is managing supply chain complexity. As companies expand their operations across multiple countries, their supply chains become more complex, involving multiple suppliers, transportation modes, and distribution centers.

MAIN THRUST OF THE PAPER

Global logistics management is highly dependent on complex supply chains that span across different countries and regions. Disruptions in the supply chain, such as transportation delays, port closures, trade disputes, or natural disasters, can significantly impact the flow of goods and services, leading to delays, increased costs, and operational inefficiencies.

Managing logistics on a global scale requires adherence to various regulatory requirements, including customs regulations, trade agreements, export controls, and sanctions. Navigating through different regulatory frameworks and ensuring compliance can be complex and time-consuming, and failure to comply with regulations can result in penalties, fines, and legal disputes.

Transportation is a critical component of logistics management, and global logistics often involves complex transportation networks that include air, sea, rail, and road transportation. However, challenges such as inadequate transportation infrastructure, congestion at ports, limited transportation capacity, and geopolitical tensions can hinder the smooth movement of goods, leading to delays and increased costs.

Managing logistics across different countries and regions requires dealing with diverse cultures, languages, and business practices. Communication challenges, differences in work styles, and cultural nuances can create misunderstandings, delays, and inefficiencies in global logistics operations.

Global logistics management has a significant impact on the environment, including carbon emissions from transportation, waste generation, and resource consumption. Increasing concerns about sustainability, environmental regulations, and social responsibility are influencing logistics operations, requiring companies to adopt sustainable practices and mitigate their environmental impact, which can add complexities and costs to global logistics management.

Labour practices and human rights issues, such as poor working conditions, low wages, exploitation, and child labour, can be prevalent in some countries involved in global logistics operations. Ethical concerns related to labour and human rights can create controversies and

reputational risks for companies involved in global logistics, and addressing these issues requires careful monitoring and management.

Global logistics operations involve the exchange of vast amounts of data, including sensitive information such as

customer details, product specifications, and financial transactions. Cyber security threats, data breaches, and data privacy regulations pose risks to the confidentiality, integrity, and availability of logistics data, which can have severe consequences for logistics operations and stakeholder trust.

Geopolitical tensions, trade disputes, and protectionist policies among countries can disrupt global logistics operations, such as imposing tariffs, sanctions, or embargoes. These geopolitical and trade challenges can create uncertainties, increase costs, and disrupt supply chains, making global logistics management more complex and challenging.

The logistics industry is constantly evolving, with advancements in technology and innovation shaping the landscape. However, keeping up with rapidly changing technologies, such as automation, artificial intelligence, block chain, and digitalization, can be a challenge for global logistics operations, requiring companies to adapt and invest in new technologies to remain competitive.

Global logistics operations are subject to economic and financial risks, such as currency fluctuations, inflation, interest rates, and economic instability in different countries. These risks can impact costs, pricing, and profitability, and require careful financial management and risk mitigation strategies.

FUTURE TRENDS

Supply chain resiliency: The COVID-19 pandemic has exposed vulnerabilities in global supply chains, leading to disruptions in logistics operations. In the future, there may be an increased focus on building resilient supply chains that can withstand unexpected shocks, such as pandemics, natural disasters, or geopolitical tensions. This could involve diversifying sourcing locations, increasing stockpiles of critical goods, and investing in technology for improved visibility and agility in supply chain operations.

Sustainability and environmental regulations: As concerns over climate change and environmental sustainability continue to grow, logistics management may face challenges in meeting stricter regulations related to emissions, waste, and resource usage. Companies may need to adopt greener practices, such as using electric vehicles, implementing circular economy principles, and reducing waste in their logistics operations.

Technology disruption: Technology continues to evolve rapidly, and logistics management is not exempt from its impact. Advancements in automation, robotics, artificial intelligence, and the Internet of Things (IOT) could transform the way logistics operations are conducted, leading to potential challenges in adapting to and integrating these technologies into existing logistics processes. Companies may need to invest in new technologies, reskill their workforce, and overhaul their IT infrastructure to stay competitive.

Trade policies and geopolitical shifts: Changes in trade policies, trade agreements, and geopolitical dynamics can significantly impact global logistics management. For example, trade disputes between countries, shifts in global trade routes, and changes in customs and import/export regulations could result in disruptions, delays, and increased costs in logistics operations. Companies may need to closely monitor and adapt to changing trade policies and geopolitical situations to minimize disruptions and ensure smooth operations.

Talent management: The logistics industry relies heavily on skilled talent, including supply chain managers, logisticians, and truck drivers. However, there may be challenges in attracting, retaining, and developing a skilled workforce in the future due to changing demographics, labour market dynamics, and technological disruptions. Companies may need to invest in training and development programs, offer competitive compensation and benefits, and implement innovative HR practices to address talent management challenges in logistics.

E-commerce and last-mile delivery: The continued growth of e-commerce is changing the landscape of logistics management, with increasing demand for faster, more flexible, and convenient last-mile delivery options. This could pose challenges in terms of optimizing delivery routes, managing increased parcel volumes, and meeting customer expectations for quick and efficient deliveries. Companies may need to invest in advanced routing and optimization technologies, expand their last-mile delivery networks, and adopt innovative delivery models, such as drones or autonomous vehicles.

Cyber security and data privacy: With the increasing digitization of logistics operations and the reliance on data-driven technologies, cyber security and data privacy will become critical concerns. Protecting

sensitive information, preventing cyber-attacks, and ensuring data privacy compliance could pose challenges for global logistics management. Companies may need to invest in robust cyber security measures, implement data encryption protocols, and comply with relevant data privacy regulations to safeguard their logistics operations and maintain customer trust.

Global trade and political uncertainties: Geopolitical tensions, trade disputes, and political uncertainties in different parts of the world can impact global logistics management. Changes in trade policies, tariffs, and trade agreements can disrupt supply chains, lead to delays, and increase costs. Companies may need to closely monitor global trade dynamics, diversify their sourcing and distribution networks, and have contingency plans in place to mitigate risks arising from geopolitical uncertainties.

CONCLUSION

The increasing complexity of global supply chains poses significant challenges in terms of coordination, visibility, and risk management. The reliance on multiple stakeholders, transportation modes, and regulatory frameworks across different countries adds layers of complexity that can impact the efficiency and effectiveness of logistics operations.

The rapid pace of technological advancements and digitization is transforming the logistics landscape, creating opportunities for optimization and automation, but also challenges in terms of data security, interoperability, and talent acquisition. Adopting and integrating advanced technologies such as artificial intelligence, block chain, and Internet of Things can enhance visibility, agility, and traceability in global logistics, but also requires investment, expertise, and change management.

Geopolitical and trade uncertainties, such as trade disputes, tariffs, and political instability, can disrupt global supply chains, creating challenges in terms of demand volatility, lead times, and inventory management. The changing regulatory landscape, including customs regulations, trade agreements, and environmental regulations, also adds complexity and compliance requirements that impact logistics operations and cost structures.

Sustainability and environmental considerations are emerging as critical challenges in global logistics, with increasing pressure to reduce carbon emissions, minimize waste, and adopt green practices. This requires rethinking traditional logistics practices and exploring alternative transportation modes, packaging solutions, and reverse logistics processes.

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A STUDY ON IMPACT OF DIGITAL MARKETING ON LOGISTICS MANAGEMENT

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ABSTRACT

This article aims to investigate the impact of digital marketing on logistics management and its implementation. The importance of various digital platforms as instruments for the same is also explored. In recent years, digital marketing has gained significant prominence in various business sectors, including logistics. It enables logistics companies to establish direct relationships with customers, improve customer service, and ultimately increase profitability. Additionally, digital marketing tools facilitate the transportation of goods by enabling logistics companies to reach customers directly through various digital marketing channels.

The importance of implementing digital marketing in logistics cannot be exaggerated, as it helps build trust with customers and leads to improved conversion rates and customer retention. Diverse digital platforms such as social media and search engine optimization are crucial components in the implementation of digital marketing in logistics. Social media platforms provide logistics companies with the opportunity to engage with customers, share critical updates, and receive feedback. On the other hand, search engine optimization techniques enhance logistics companies' online visibility, making it easier for customers to locate them online.

KEYWORDS *: Digital marketing, Logistics management, Social media.*

INTRODUCTION

Logistics refers to the intricate process of managing the transportation and supply of goods in a timely and efficient manner while ensuring their good condition upon delivery. The handling of operations is an integral part of the logistics industry, which predominantly caters to business-to-business (B2B) services. Given the dynamic nature of the industry, it is essential for logistics companies to implement digital tools in their marketing department to keep pace with the times.

Digital marketing is a modern approach that involves promoting goods and services through various digital channels. In the wake of the COVID-19 pandemic, digital marketing has played a critical role in enabling businesses to reach their targeted customers. For logistics and supply chain management companies, digital marketing has emerged as a major factor in their success. In the B2B buying landscape, logistics industries and supply chains require content marketing to build customer confidence and foster stronger relationships, which were traditionally built through one-on-one meetings.

With a growing number of clients seeking logistics services online, it is imperative for logistics brands to have a significant online presence that is easily accessible to their clients. The logistics industry has witnessed a surge in the number of brands due to the economic

boom in the country, driven by an influx of tourists and businesses. In this context, digital marketing provides a distinct advantage, enabling companies to establish their expertise and reputation in the industry.

To remain competitive, companies operating in the logistics industry must keep abreast of the latest marketing strategies and adapt them accordingly. This will not only increase the efficacy of their marketing efforts but also enable them to explore new perspectives and approaches.

BACKGROUND

The term digital marketing was coined initially in the 1990s, with the birth of the internet and the Web 1.0 platform, which allowed users to search for their desired information; nonetheless, there was no option for sharing the information. It was at this age that the Archie search engine was developed, to index FTP sites. Storage capacity of computers in the 1980s had already been increased to store voluminous data, and companies started switching to database marketing and other online techniques.

Logistics management emerged by the British Army far before the eruption of the First World War where a military supply chain system was evolved by building infrastructure, for example, railway tracks, roads, airfields, ports, supply stores and vehicles to shift weapons and troupes. In the United States, which began its agricultural commodities distribution system. This in due course led to the commencement of the official Logistics Management Science in the US in 1964. For commerce and industrial sector, logistics plays a vital role in decreasing costs which consequently increases profit.

LITERATURE REVIEW

"Integrating Digital Marketing and Logistics: A Review and Research Agenda" by Cheng Zhang and Lei Huang (2021)

This paper provides a comprehensive review of the literature on the integration of digital marketing and logistics. The authors argue that digital technology has created new opportunities for improving the efficiency and effectiveness of marketing activities, but that companies need to develop new skills and capabilities to take advantage of these opportunities. They propose a research agenda for future studies on digital marketing and logistics integration.

"Digital Marketing and Logistics Integration: A Literature Review and Research Agenda" by Nan Li and Yanqiu Wang (2021)

This paper reviews the literature on the integration of digital marketing and logistics, with a focus on the challenges and opportunities of implementing digital marketing logistics in practice. The authors identify several key factors that impact the success of digital marketing logistics implementation, including organizational structure, technology infrastructure, and employee skills and capabilities.

"Digital Marketing Logistics: A Framework for Digital Marketing Management" by Jihong Chen and Wenjie Liu (2019)

This paper proposes a framework for managing digital marketing logistics, which includes supply chain management, marketing automation, data analytics, and customer experience management. The authors argue that effective management of these components is critical to the success of digital marketing logistics implementation.

"Digital Marketing and Logistics Integration: A Conceptual Framework and Research Agenda" by Mohamed Zaki, Mark Xu, and Xinghua Gao (2019)

This paper proposes a conceptual framework for integrating digital marketing and logistics, which includes four key components: customer engagement, data analytics, logistics coordination, and technology integration. The authors argue that successful implementation of digital marketing logistics requires a holistic approach that integrates these components.

"Logistics in Digital Marketing – Advantages and Challenges" by Lena Borg and Maria Fregidou-Malama (2019)

This paper discusses the advantages and challenges of logistics in digital marketing. The authors argue that logistics can play an important role in improving the efficiency and effectiveness of digital marketing activities, but that companies need to develop new skills and capabilities to manage the logistics of digital marketing effectively.

STATEMENT OF PROBLEM

Need to study

To emerge in such a competitive market where the target crowd expects you to be rapid and connected at all times, digital marketing technologies can aid you win the game.

Considering the challenges and problems that logistics and supply chain businesses come across, here are the reasons to implement digital marketing in logistics management –

1. Most suitable customers are identified and targeted.

2. Grants an opportunity to become a Thought Leader.

3. Benefits with results which can be measured.

4. Enhances Customer commitment.

5. Boosts the rates of conversion.

Scope of study

More than half of customers find companies through social media news feeds, and companies can also reach the target customers by the means of social media. The most aiding tool for Logistics Industry is Digital Marketing. A detailed study on the impact of digital marketing on Logistics management can benefit in many ways as such knowing what techniques can be implemented in the logistics business in order to boost customer satisfaction, enhance sales and thereby increase revenue and profit.

OBJECTIVES OF STUDY

The various objectives the study are listed as follows;

• To know the influence of digital marketing on logistics management.

• To get the idea of discrete tools and techniques of digital marketing that can be applied in logistics management.

• To recognize the ways of digital marketing through which audience engagement can be built with the brand of the company.

• To know the importance of social media as a tool of digital marketing.

RESEARCH METHODOLOGY

The collection of Data is the process of congregating and measuring information on variables of interest, in an organized manner that allows one to answer the stated research questions, test hypothesis, and evaluate the results.

The primary objective of collection of data is to utilize it to derive useful comprehension that can help the company to prosper in terms of better productivity, quicker results, lesser time spent and greater profit ratio and finally improved return on investment.

The data may be classified on the following basis

I. On the basis of nature of the data:-

There are two types of data under this classification:

1. Primary Data.

2. Secondary Data.

II. On the basis of the method of collection:-

There are four types of data under this classification:

1) Observational data.

2) Experimental data.

3) Simulation data.

4) Derived data.

This article is prepared using the secondary data which was derived by various researchers to know the aftermath of digital marketing and its strategies on logistics management and industries. This is a qualitative data which consists of the techniques of digital marketing that assists the transport business to achieve its goals and objectives.

ANALYSIS OF DATA

There are certain strategies the logistics industries can use to refine their marketing online. Some of those include paid ads, whilst others are with regard to harnessing organic traffic, but they all give out the motive of getting users to your site and making them into customers.

Below are given six useful strategies of digital marketing for logistics management:-

1) Search Engine Optimization(SEO)

Search Engine Optimization(SEO) is a strategy that includes optimizing your web content to rank Google search results. The idea is that when users search for something regarding what you have on your website, they can find get your page in search results and visit your site.

The key to SEO is to gratify all Google's ranking algorithms. Firstly, that means targeting suited keywords in your content. If you have your content on what logistics is all about, you can target the keyword 'what is logistics?' and can get your page to rank for that particular page

Some other SEO tactics are as follows;

- Earning adequate backlinks.
- Using Hypertext Protocol (HTTPs).
- Optimizing images.
- Using Internal links on your site.
- Setting up Google Business Profile.

With a flourishing run SEO course of action, you can bring vast amounts of site traffic from Google.

2) Pay per Click (PPC) advertising

Organic results are not the mere way to reach users through Google search results; you can set up pay per click advertising as well as running ads at the top of Google's search engine results pages.

To initiate a PPC campaign, you can make use of Google ads. There you can build your ads and bid on particular and specific keywords that you want to target. Whenever somebody searches for a keyword, Google will show ads on the basis of:

▪ The amount of Bid

▪ Quality score

With the excellent bidding strategy and a high enough score of Quality, you can get your ad to show for all right searches.

3) Social Media Marketing

The social media platforms are the significant opportunities to reach a fresh audience. A social media page or an account can be created and you can post in there what are all that you do, serve with the help of pictures and videos and feedback videos of the happy customers can be posted on that social media page which helps the users to know your business better.

Paid Social Media advertising can also be harnessed, which lets you to place ads in social media feeds of users. These advertisements generally even permit you to spot demographics and locations, making sure the most related possible audience.

By means of the consolidation of organic posts, paid advertisements, social media has the capacity to be an incredibly impactful strategy.

4) Web Design & Development

Finally, nearly all your online marketing is intended to lead users back to one place – your website. So, for any of it to be influencing, your site has to have a compelling web design.

Having a great web design means having a site that's perspective, functional and visually pleasing. The following are the ways for bringing those traits to your site:

- ❖ Make a Mobile friendly site.
- ❖ Navigations should be simplified.
- ❖ Maximize your page speeds.
- ❖ Use huge white.

A site which fails to meet these essentials will be expected to end up with a notably high bounce rate, meaning many of its visitors will have hit the "back" button not long after arriving at the page.

But when your site fulfills the audience's needs and expectations, they'll be ready to stick around longer and possibly end up converting.

5) Content Marketing

Content marketing is another transportation strategy, which includes creating informative web content to captivate users to your site. The content you create can be written, like blog posts, or it can be some form of multimedia, such as video.

The web content needs to communicate valuable information of your business to the users and customers despite of any format you use. It should be ensured that the web content should match the user's intent. If the content on your site don't match with the user's intent, users will realize the page has no value for them and they will leave and if this repeats, the Google will pick up on it and rank the site lower in search results.

6) Email Marketing

The last strategy in the list is Email Marketing, which is at its most effective when used as a remarketing strategy. Remarketing is when you target people who have already visited your site in the past, and that's exactly what email marketing does.

An email list can be built using forms on your website, motivating people to submit their addresses in return for receiving a newsletter. Using those mail ids, you can send the business related information such as special offers, discounts to the users. It is important to ensure that you send only relevant information to your customers.

FINDINGS

After a brief study on the utilization of digital marketing tools, these are the key findings that we can get,

1) Customer connection is what you need.

2) Digital marketing trends shouldn't be overlooked.

3) Budgets are going up.

4) The significance of proper web content on the website of any business

5) Apt tools of digital marketing can help boost the business.

6) The importance of digital marketing in logistics management.

CONCLUSION

To conclude, the significance of digital marketing in logistics cannot be overstated. The utilization of digital marketing empowers logistics businesses to establish credibility with their customers, resulting in improved conversion rates and customer retention. By executing suitable digital marketing strategies and tools, logistics firms can differentiate themselves from their competitors and attain superior outcomes.

The incorporation of diverse digital platforms, including social media and search engine optimization, is imperative in the implementation of digital marketing in logistics. Social media platforms provide logistics companies with an avenue to interact with their customers, disseminate vital information, and receive constructive feedback. In contrast, search engine optimization techniques facilitate the enhancement of logistics companies' online presence, rendering them more accessible to customers online.

In recent years, digital marketing has garnered immense attention in various business sectors, and logistics is no exception. By leveraging digital marketing tools, logistics enterprises can cultivate direct customer relationships, deliver superior customer service, and ultimately augment their profit margins.

Further work:

The evaluation of the impact of digital marketing on supply chain management and logistics performance, such as delivery times, inventory management, and order accuracy and the comparison of the effectiveness of different digital marketing channels and platforms in logistics, such as email marketing, social media, and paid search advertising.

By addressing these research areas, we can gain a deeper understanding of how digital marketing can be leveraged to optimize logistics operations, enhance customer relationships, and drive business growth.

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WORK-LIFE BALANCE IN I.T SECTOR IN BANGALORE-INDIA: IMPACT ON GENDER AND MARITAL STATUS

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ABSTRACT

This paper is focusing on especially in the workforce of the Information Technology sectors to look into the work-life balance of the employees in IT sectors mainly in Bangalore-India. From the collected data it needs to indentify how the role of organizational support, policies, management and the leadership can help the employees to balancing life and work in the organization. Work-life balance is to adjust time and make time for family, friends, community participation, spirituality, personal growth, self care, and other personal activities, it is need to understand how to adjust time and fulfil additional demands of the workplace.

- To study the impact of Gender towards Work life balance of employees in IT Sector of Bangalore
- To Study the impact of marital status towards Work life balance of employees in IT Sector of Bangalore

The result shows that Married employees see the variables like flexible time, job sharing, work from home and getting leave when it's required to maintain a balance between professional and personal life will improve and help them to maintain their work life balance. Whereas unmarried are just opposite with their views and flexible enough to have flex timing , job sharing, work from home and leave to manage life. When comes to health both married and unmarried feel exhausted.

In case of male and female respondents both felt that their long working hour job affecting their personal life where they have no time for timely food and workout Companies who have taken initiative to encourage work-life balance for their employees are started attracting candidates to join in new opening; working condition has improved, work-life balance helping organization to save time and money for training, helping to increase employee involvement.

KEYWORDS *: Work-life balance, Employee, Age, Gender, Marital status, Family, Organization.*

INTRODUCTION TO WORK-LIFE BALANCE

Work-life balance is a concept that encourages the efforts of employees to divide their time and energy between work and the other important features of their lives. Work-life balance is to adjust time and make time for family, friends, community participation, spirituality, personal growth, self care, and other personal activities, it is need to understand how to adjust time and fulfil additional demands of the workplace. Work-life balance is supported by employers who established policies, procedures, actions, and expectations that facilitate employees to easily to bring balance in their lives. To chase the work-life balance reduces the stress employees' experience. When they spend the maximum of their days on work-related activities and feel that they are actually neglecting the other important aspects of their lives, and as a result bring stress and unhappiness

in life. Work-life balance enables employees to feel as if they are paying attention to all the important aspects of their lives Work-life balance is to balancing two broad areas of work life and non-work life. Non-work includes the family and personal life. Research on Work-life Balance in IT sectors started pretty late in India when in early nineties IT sector started booming and companies started working mainly with US clients. In United States Information Technology sector started growing fast and their demand for knowledgeable employee of information technology professional started gearing up. The changes in the economic condition of the country, increasing number of multinational companies, large openings for talented candidates and more opportunities for higher education have created a platform for people to enter into the corporate world. A main work that happened was preparation of software and also as a services providers to software mainly countries like the United States of America and to other customers. The major growth of information technology is mainly because of the development in the areas like, system integration, infrastructure management services, web services, service-oriented architecture, software testing, software development, information technology consulting, custom application development and maintenance and body shopping. After the huge growth of IT sectors in India major changes in traditional working culture has been noted, standard duration of working hours have changed drastically because of demographical location and globalization. Large numbers of IT companies' not following standard 9-5 (eight) hours rule, For them it shifted from eight hours job to twenty four hours a day and seven day a week (24X7).On demand many employees need to work on Saturdays and Sundays as well. In addition there are changes in pattern in the working hours, based on their client's demographical location. Some employee have to work in odd hours like starting from early evening till early next morning considering as a continuous night shift job. Increasing workloads have pressurised employees to more commitment to their work, though increasing working hour will not increase the productivity of the employee, constant work pressure leads to lack of social life, stress and exhaustion leads to lower the productivity, ill health with boredom and frustration.

Every aspect of life the right balance is not possible, people from different back ground has different types of balancing in life. Whereas, undue work pressure leads to stress to employee, people start feeling pressure in different aspects of their work environment in order to high expectation from the supervisor and management. Many IT companies taken initiative to encourage work-life balance for their employees and increased the level of job satisfaction for their employees. Companies trying to promote Work-Life Balance through many initiatives including flexi hour, work from home, provision for crèche and day care facilities for employee's kids.

LITERATURE REVIEW

Job involvement is defined as one's association with his job It was found in studies that too much of involvement in job or family area may result in conflict in job or family life. (Kanungo 1982)

Initially the researchers studied the work family interface and referred to it as Work stress is defined as one of job related hassles (Greenhaus & Beutell, 1985). One the other hand, family stress is the stress within the family due to family related issues (Ford et al 2007). Work hours are the hours spend to complete the responsibilities of the work. (Greenhaus and Beutell 1985) Conflict between work and family is bi-directional (Frone et al., 1992).Work to family conflict occurs when work demands interfere with family and individual finds it difficult to meet family responsibilities due to work. Family to work conflict arises when family demands interfere with work. But, family and work are not only the sources of burden and strains, rather they can also be a source of support and growth (Barnett,1998).Hence, work and family may not always conflict and can be a source of facilitation. Grzywacz et al. (2007) laid the conceptual foundation for work family facilitation and defined it as 'the extent to which an individual's engagement in one social system, such as work or family, contributes to growth in another social system'. Hence there can be spillovers (both negative and positive) between the two spheres of work and non-work and there is a need for balancing. Clark (2000) defines work-life balance as satisfaction and good functioning at work and at home, with minimum of role conflict. Kirchmeyer (2000) defines a balanced life as "achieving satisfying experiences in all life domains" and states that to achieve satisfying experiences in all life.

Hill et al. (2001) too reported that gender was not significantly correlated to work family balance

indicating that men and women report similar levels of work-family balance.

Especially in Indian society people used to live in Joint family. In this family system people used to take care of the children among themselves. Mostly marriages were arranged by the senior members in the family and the rate of divorces were very less in number in the society, but now slowly joint family disappearing (Patel 2005), people prefer to stay in nuclear family where both husband and wife need to work to manage the expenses(Amato et al. 2003). Byron (2005) has explained about job involvement, work hours, work stress and work support whereas from the family aspect he included time spent with family and family activities, family stress, family support and family conflict. Ford et al (2007) in his study also mentioned Job involvement. The main problem, mostly all new mothers face is the absence of a family support system, they have constant worries where they will keep their baby safely if they want to continue their working?(Singh 2011). In spite of significant growth in women employee in the corporate there is no changes in the prototype of household responsibility for women in society (Singh 2004). Fuß et al. (2008) found that socio- demographic factor of age group was a significant predictor of work interference in family. The younger was the participant, the higher was the perceived work interference in family. According to Doble & Supriya (2010), for women employee both family life and working life is equally important and they feel the same types of responsibility.

Thriveni & Rama (2012) found significant relationship between demographic variables (age, marital status, income) and work-life balance of women employees. Satyanarayana & Shanker (2012) examined the work-life balance of 100 employees working in IT enabled services and found that among young employees(Because of this reason woman employees consider both work and family roles equally significant and stress themselves to manage both uniformly.

(Kanungo 1982) said that Job involvement is defined as one's association with his job It was found in studies that too much of involvement in job or family area may result in conflict in job or family life.

The factors which have taken into consideration in working life are job involvement, job stress and work hour, work load. The factors have taken in family aspect are family involvement, family stress and family hours.

Data Interpretation

Table 1. Demographical Profile of Respondents (IT Sector)

Variable	Number	Percentage
Age		
20-30 years	65	36
31-40 years	77	43
41-50 years	36	20
50 above	2	1
Total	180	100
Gender		
Male	118	56
Female	62	34
Total	180	100
Marital status		
Married	163	91
Unmarried	17	9
Total	180	100
Parent (with child)		
Yes	127	71
No	53	29
Total	180	100

The above table (Table 1) had shown the demographic profile of respondents in IT sector. The respondents were divided into male and female categories in the sample, out of 180 respondents 36% are less than 30 years, 43% are between 31-40 years, 20% are between 41- 50 years and 1% are above 50 years. Marital status of an employee plays an important role as for a study on work-life balance. In this category employees seek stability in their job because of family and increased responsibilities. Therefore, expectation would be different from the married and unmarried sections of the society. In this data it had been shown that more respondents are married (91%) than unmarried (9%). Numbers of respondent with children are high in number 71%with one or two children than those respondents (29%) who are without children.

Data Analysis

Table 2. Perceived improvement in WLB*- Work-Life Balance of Male and Female in IT Working Professional

Variable	Male	Female	X^2	p value	Conclusion
Provide flexi time	Yes 114	Yes 60	0.0034	.953546	ns* p<0.05
	No 4	No 2			
Job sharing option	Yes 95	Yes 58	5.4205	.019902	sig p<0.05
	No 23	No 4			
Work from home	Yes 110	Yes 61	2.2843	.130693	ns p<0.05
	No 8	No 1			
Leave to manage family life	Yes 113	Yes 59	0.0346	.852401	ns p<0.05
	No 5	No 3			

Notes: Significant at 95% confidence level, degrees of freedom = 1, *ns= not significant,

*WLB=Work-life balance

From the above Table 2 it has been observed that both male and female see the above variables like flexible time, job sharing, work from home and getting leave when its required to maintain a balance between professional and personal life will improve and help them to maintain their work life balance. The Chi square test indicates that other than Job sharing option there is no significant relationship between the above variables and with male and female respondents.

Table 3. Perceived improvement in WLB*-Work life Balance of Married and unmarried in IT working Professional

Variable	Male	Female	X^2	p value	Conclu-sion
Provide flexi time	Yes 161	Yes 8	71.7549	<.00001	sig p<0.05
	No 2	No 9			
Job sharing option	Yes 145	Yes 5	39.2999	<.00001	sig p<0.05
	No 18	No 12			
Work from home	Yes 155	Yes 4	76.5006	<.00001	sig p<0.05
	No 8	No 13			
Leave to manage family life	Yes 158	Yes 4	92.1617	<.00001	sig p<0.05
	No 5	No 13			

Notes: Significant at 95% confidence level, degrees of freedom = 1, *ns= not significant,

*WLB=Work-life balance

From the above Table 3 it has been observed that Married employees see the above variables like flexible time, job sharing, work from home and getting leave when its required to maintain a balance between professional and personal life will improve and help them to maintain their work life balance. Whereas unmarried are just opposite with their views and flexible enough to have flex timing , job sharing, work from home and leave to manage family life. The Chi square test indicates that relationship between these variable are significant with married and unmarried respondents. Unmarried respondents are not much concerned about their personal and family life.

Table 4. Perceived adverse impact- Work-Life Balance of Male and Female in IT Working Professional

Variable	Male	Female	X^2	p value	Conclusion
Health	Yes 159	Yes 58	0.0838	.772189	ns at p<0.05
	No 4	No 4			
Sleep	Yes 103	Yes 56	0.3632	.5467761	ns at p<0.05
	No 15	No 6			
Stress	Yes 96	Yes 42	4.211	.040162	sig at p<0.05
	No 22	No 20			
Exhaustion	Yes 112	Yes 54	3.4638	.062725	ns at p<0.05
	No 6	No 8			

Notes: Significant at 95% confidence level, degrees of freedom = 1. ns – Not significant.

The above table 4 shows that four variables has taken into consideration for analysing in order to understand the adverse impact of work and professional life in health and their personal life. About 92% of men and 94% of women felt that the work affected their health. About 87% of men and 90% of women felt that the work affected their sleep. About 81% of men and 68% female felt stress affecting their life because of work pressure. Approximately 95% male and 87 % female respondents said they felt exhaustion because of their work. The above Chi square had shown that both male and female respondent felt that both health and exhaustion affecting because of their work. The Chi square test indicates that there is a no significant relationship between health and exhaustion and sleep but they have some difference in option about stress where Chi Square test indicate these variables are significant.

Table 5. Perceived adverse impact-Work life Balance of Married and unmarried in IT working Professional

Variable	Male	Female	X^2	p value	Conclusion
Health	Yes 159	Yes 16	0.67	.413051	ns at p<0.05
	No 4	No 1			
Sleep	Yes 157	Yes 15	2.3687	.12387	sig at p<0.05
	No 6	No 2			
Stress	Yes 161	Yes 15	7.8674	.005034	sig at p<0.05
	No 2	No 2			
Exhaustion	Yes 157	Yes 16	0.1996	.0655047	ns at p< 0.05
	No 6	No 1			

Notes: Significant at 95% confidence level, degrees of freedom = 1. ns – Not significant.

The above table 5 shows that four variables has taken into consideration for analysing in order to understand the adverse impact of work and professional life in health and their personal life for both married respondents and unmarried respondents. The above Chi square had shown that both married and unmarried respondent felt that both health and exhaustion affecting because of their work. The Chi square test indicates that there is a no significant relationship between health and exhaustion but they have some difference in option about stress and sleep where Chi Square test indicate these variables are significant.

Table 6. Spill over* of work into family life- Work life Balance of Male and female in IT working Professional

Variable	Male	Female	X^2	p value	Conclusion
Long Working hour	Yes 117	59	2.9798	.84308	ns at p<.05
	No 01	03			
Worry about job when Not in work	Yes 110	61	0.4584	.498388	ns at p<.05
	No	8			
No time for food and Work-out	Yes 114	54	0.1707	.679489	ns at p<.05
	No 4	8			
Miss quality time with family and friends	Yes 110	55	2.2843	.130693	ns at p<.05
	No 8	07			

Notes: Significant at 95% confidence level, degrees of freedom = 1.*ns= not significant. * Spill-over theory

The above table 6 had shown that other than both male and female respondents felt that their long working hour job affecting their personal life where they have no time for timely food and workout also most of the respondent felt they experience frequent thoughts about their work when they are not in their work place which has impact on their personal life. Majority said they miss quality time with family as well as friend because of tremendous work load and deadlines The Chi Square test proved that there is no significant association between the above variables with male and female as in all the cases $p<0.05$.

Table 7. Spill over* of work into family life- Work life Balance of Married and unmarried in IT working Professional

Variable	Male	Female	X^2	p value	Conclusion
Long Working hour	Yes 159	16	0.67	.413051	ns at p<.05
	No 4	1			
Worry about job when Not in work	Yes 155	15	1.3794	.240201	ns at p<.05
	No 8	02			
No time for food and Work-out	Yes 154	15	1.0458	.306476	ns at p<.05
	No 9	02			
Miss quality time with family and friends	Yes 158	16	0.3786	.53838	ns at p<.05
	No 5	01			

Notes: Significant at 95% confidence level, degrees of freedom = 1.*ns= not significant. * Spill-over theory

The above table 7 had shown that other than both married and unmarried respondents felt that their long working hour job affecting their personal life where they have no time for timely food and workout also most of the respondent felt they experience frequent thoughts about their work when they are not in their work place which has impact on their personal life. Majority said they miss quality time with family as well as friend because of tremendous work load and deadlines The Chi Square test proved that there is no significant association between the above variables with married and unmarried as in all the cases $p<0.05$.

Table 8. Initiative taken by Companies to improve the quality of work life- Work life Balance of Male and female in IT working Professional

Variable	Male	Female	X^2	p value	Conclusion
WLB Initiative taken By company	Yes 115	Yes 59	0.6651	.414749	ns* at p<0.05
	No 3	No 3			
WLB policy will Increase the productivity	Yes 117	Yes 60	1.4028	.236252	ns at p<0.05
	No 1	No 2			
WLB will help to retain Employees in organization	Yes 113	Yes 56	2.0965	.1476	ns at p<0.05
	No 5	No 6			
WLB will make organization More successful and effective	Yes 110	Yes 57	0.1001	.75166	ns at p<0.05
	No 8	No 5			

Notes: Significant at 95% confidence level, degrees of freedom = 1.ns= *not significant,

*WLB=work-life Balance

The Above table (Table 8) had shown the IT companies who has taken initiative to improve the quality of work life of their employees. Majority (99%) of male and (96%) female said WLB policy in WLB will improve the productivity of the company it will help to retain their employees and also organization will be more effective and successful. The Chi Square test proved that there is no significant association between the above variables with male and female as in all the cases p<0.05.

Table 9. Initiative taken by Companies to improve the quality of work life- Work life Balance of Married and Unmarried in IT working Professional

Variable	Male	Female	X^2	p value	Conclusion
WLB Initiative taken By company	Yes 158	Yes 14	3.4498	.63261	ns* at p<0.05
	No 5	No 2			
WLB policy will Increase the productivity	Yes 159	Yes 16	0.67	.413051	ns at p<0.05
	No 4	No 1			
WLB will help to retain Employees in organization	Yes 160	Yes 15	5.6143	.017815	sig at p<0.05
	No 3	No 2			
WLB will make organization More successful and effective	Yes 161	Yes 15	5.6606	.01735	sig at p<0.05
	No 2	No 2			

Notes: Significant at 95% confidence level, degrees of freedom = 1.ns= *not significant,

*WLB=work-life Balance

The Above table (Table 9) had shown the IT companies who has taken initiative to improve the quality of work life of their employees. Majority of married and unmarried said company has taken initiative on WLB, also WLB policy in company will improve the productivity of the company. There is some difference found in this research on whether WLB policy will help to retain of employee or WLB policy will make organization more successful and effective. The Chi Square test proved that there is no significant association between the WLB initiative taken by company and improvement of productivity with married and unmarried as in all the cases p<0.05.

CONCLUSION

From the above findings we can conclude here that both male as well female believe that heavy workload and long working hour has an adverse effect in their personal life, but they believe that working from home flexible working time child care facilities will improve them to maintain their work-life balance. The spill-over work

into family life had impact as both male and female felt they didn't get enough time to spend quality times with their family and friends.

Marital status of an employee plays an important role as for a study on work-life balance. In this category employees seek stability in their job because of family and increased responsibilities. Therefore, expectation would be different from the married and unmarried sections of the society. In this data it had been shown that more respondents are married i.e; 89% than unmarried 11%.

There is a no significant relationship between health and exhaustion but they have some difference in option about stress and sleep where test indicate these variables are significant.

Majority of male and female respondents believe that the IT companies who has taken initiative to improve the quality of work life of their employees like WLB policy will improve the productivity of the company it will help to retain their employees and also organization will be more effective and successful.

The paper concludes with that the WLB policies initiative which has taken by most of the companies has a positive impact to improve the work-life balance for both female and male. In future more such initiatives may take by IT sector so that it will help the IT industry to sustain their business.

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CHARACTERISTIC POLYNOMIALS OF ORIENTED GRAPHS

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1. INTRODUCTION

For a given graph G, the set of all eigenvalues is called the spectrum of G. The sum of absolute values is defined as the graph energy by Gutman and Trinajsti´c in [6]. In [2], spectra of some graph types are obtained. As the eigenvalues of cycles and paths being trigonometric algebraic numbers are different than other classes of graphs, these two classes need special attention when there is the spectral study of graphs. In [3], the polynomials and recurrence relations for the spectral polynomials of these two graph classes were obtained. In particular, it was shown that we can obtain the spectra of the cycle graph C_{2n} and path graph P_{2n+1} without detailed calculations just in terms of the spectra of C_n and P_n, respectively. In [1], graph energy is calculated for prime graphs.

A directed graph (or digraph) is a graph that is a set of vertices connected by edges where each edge has a direction associated with it. The direction of an edge is shown by an arrow put on the edge. The main difference between a graph and digraph is that the edges in the latter one are ordered. An edge connecting two vertices u and v in a graph is denoted by uv and in this case, we say u and v are adjacent to each other. If we denote an edge connecting two vertices u and v in a directed graph, we have to choose either uv or vu and the former one reads as u is adjacent to v and v is adjacent from u, where the latter one reads as v is adjacent to u and u is adjacent from v. Although very rare, there are situations that allow an edge to be bidirected in a directed graph. That is, both of the edges uv and vu may be amongst the edges of the directed graph.

A directed graph is called oriented graph if no pair of vertices in it is linked by two symmetrical directed edges. That is, an oriented graph can have no bidirected edges (i.e. in an oriented graph, at most one of uv and vu for every vertex pair u and v may be an edge of the graph). There are results obtained for the energy of directed graphs in [7, 8, 9, 10]. Throughout this paper, we take G to be a finite, simple, connected, oriented graph unless stated otherwise.

Recall that the number of non-isomorphic oriented graphs having n = 1, 2, 3, · · · vertices are 1, 2, 7, 42, 582, 21480, 21422888, · · · (see the OEIS A001174), respectively, and the number of connected oriented graphs on n = 1, 2, 3, · · · vertices are 1, 1, 5, 34, 535, 20848, 2120098, · · · , respectively, (see OEIS A086345).

Similarly to classical adjacency matrix for classical graphs, in oriented graphs, we can define an adjacency

matrix OA(G) = [a_{ij}] where

$$a_{ij} = \begin{cases} 1 & \text{if } v_i \text{ is adjacent to } v_j \\ 0 & \text{if not.} \end{cases}$$

Once again, note that we do not have a symmetrical matrix as in the ordinary adjacency matrix as v_i is adjacent to v_j does not mean v_j is adjacent to v_i. In this paper, the adjacency matrices of oriented graphs are calculated. Let G be an oriented graph and let λ_i's be the eigenvalues of the adjacency matrix A. As well-known, λ_i's are the roots of

$$\det(\lambda I_n - A) = 0. \quad (1)$$

The left hand side of Equation (1) is a polynomial of of degree n and will be denoted by P(G).

2 CHARACTERISTIC POLYNOMIALS OF SOME ORIENTED GRAPH CLASSES

In this section, we compute the characteristic polynomials *P(G)* of some oriented graph classes *G*.

First we have a useful result:

Lemma 2.1. Let G_1 and G_2 be two connected oriented graphs of order 1 and 2, respectively. Then

$P(G_1) = \lambda$ and $P(G_2) = \lambda^2$.

Proof. The characteristic matrix of G1 is [λ] with determinant λ. The characteristic matrix of the oriented graph G_2 is $\begin{pmatrix} \lambda & -1 \\ 0 & \lambda \end{pmatrix}$ or $\begin{pmatrix} \lambda & 0 \\ -1 & \lambda \end{pmatrix}$ both having determinant λ^2.

This result can be generalized to oriented path graphs:

Theorem 2.2. The characteristic polynomial of an oriented path graph P_n is

$P(P_n) = \lambda^n$.

Proof. First we prove the result for a path graph P_n with all the edges $v_{i-1}v_i$ having the same orientation from v_{i-1} to v_i, for $i = 2; 3; 4; .....n$

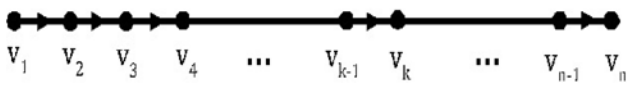

Figure 1: An oriented path graph

The characteristic polynomial of this oriented graph is obtained by means of the determinant

$$P(P_n) = \begin{array}{c|cccccccc} & v_1 & v_2 & v_3 & \cdots & v_{k-1} & v_k & \cdots & v_n \\ \hline v_1 & \lambda & -1 & 0 & \cdots & 0 & 0 & \cdots & 0 \\ v_2 & 0 & \lambda & -1 & \cdots & 0 & 0 & \cdots & 0 \\ v_3 & 0 & 0 & \lambda & \cdots & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ v_{k-1} & 0 & 0 & 0 & \cdots & \lambda & -1 & \cdots & 0 \\ v_k & 0 & 0 & 0 & \cdots & 0 & \lambda & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ v_n & 0 & 0 & 0 & \cdots & 0 & 0 & \cdots & \lambda \end{array}_{n \times n}.$$

This determinant is an upper triangular determinant and therefore the result is obtained.

It is not difficult to see that there are $2^{n-1}/2 = 2^{n-2}$ different orientations of P_n. We now want to show that P (Pn) is independent from the choice of orientation of the edges of P_n. We do this by showing that the change in the orientation of any edge does not effect the characteristic polynomial.

Let us change the orientation of an arbitrary edge $v_{k-1}v_k$ from v_k to v_{k-1} as in Fig. 2:

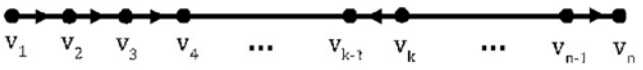

Figure 2: An oriented path graph with only one orientation reversed

The characteristic polynomial of this graph is

$$P(P_n) = \begin{array}{c|cccccccc} & v_1 & v_2 & v_3 & \cdots & v_{k-1} & v_k & \cdots & v_n \\ \hline v_1 & \lambda & -1 & 0 & \cdots & 0 & 0 & \cdots & 0 \\ v_2 & 0 & \lambda & -1 & \cdots & 0 & 0 & \cdots & 0 \\ v_3 & 0 & 0 & \lambda & \cdots & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ v_{k-1} & 0 & 0 & 0 & \cdots & \lambda & 0 & \cdots & 0 \\ v_k & 0 & 0 & 0 & \cdots & -1 & \lambda & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ v_n & 0 & 0 & 0 & \cdots & 0 & 0 & \cdots & \lambda \end{array}_{n \times n}.$$

Note that the only dierence between (1) and (2) is that the two entries $a_{k-1;k}$ and $a_{k;k-1}$ are transpozed. So both determinants are equal as required.

This result can easily be generalized to any acyclic graph as follows:

Corollary 2.3. Let T_n be any oriented acyclic graph with n vertices. Then

$P(T_n) = \lambda^n$.

So we can say that if an oriented graph having n vertices has no cycles, then its characteristic polynomial is λ^n. This situation is not true in general. There are exceptions as we shall see below:

Theorem 2.4. The characteristic polynomial of an oriented cycle graph C_n is

$$P(C_n) = \begin{cases} \lambda^n - 1 & \textit{if all orientations are the same} \\ \lambda^n & \textit{otherwise.} \end{cases}$$

Proof. If all the orientations are the same, then we have

$$P(C_n) = \begin{array}{c|cccccc} & v_1 & v_2 & v_3 & \cdots & v_{n-1} & v_n \\ v_1 & \lambda & -1 & 0 & \cdots & 0 & 0 \\ v_2 & 0 & \lambda & -1 & \cdots & 0 & 0 \\ v_3 & 0 & 0 & \lambda & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ v_{n-2} & 0 & 0 & 0 & \cdots & -1 & 0 \\ v_{n-1} & 0 & 0 & 0 & \cdots & \lambda & -1 \\ v_n & -1 & 0 & 0 & \cdots & 0 & \lambda \end{array}_{n\times n}.$$

If we calculate this determinant according to the first column, we get two (n–1) (n–1) determinants

$$P(C_n) = \lambda \begin{vmatrix} \lambda & -1 & 0 & \cdots & 0 & 0 \\ 0 & \lambda & -1 & \cdots & 0 & 0 \\ 0 & 0 & \lambda & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & -1 & 0 \\ 0 & 0 & 0 & \cdots & \lambda & -1 \\ 0 & 0 & 0 & \cdots & 0 & \lambda \end{vmatrix} + (-1)^n \begin{vmatrix} -1 & 0 & 0 & \cdots & 0 & 0 \\ \lambda & -1 & 0 & \cdots & 0 & 0 \\ 0 & \lambda & -1 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 0 & 0 & \cdots & -1 & 0 \\ 0 & 0 & 0 & \cdots & \lambda & -1 \end{vmatrix}$$

$= \lambda^n - 1.$

Secondly, let at least one orientation be different than the others. Let us name this edge as $e = v_k v_{k+1}$.

Then

$$P(C_n) = \begin{array}{c|cccccccccc} & v_1 & v_2 & v_3 & \cdots & v_{k-1}v_k & \cdots & v_{n-1}v_n \\ v_1 & \lambda & -1 & 0 & \cdots & 0 & 0 & \cdots & 0 & 0 \\ v_2 & 0 & \lambda & -1 & \cdots & 0 & 0 & \cdots & 0 & 0 \\ v_3 & 0 & 0 & \lambda & \cdots & 0 & 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ v_{k-1} & 0 & 0 & 0 & \cdots & \lambda & 0 & \cdots & 0 & 0 \\ v_k & 0 & 0 & 0 & \cdots & -1 & \lambda & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ v_{n-1} & 0 & 0 & 0 & \cdots & 0 & 0 & \cdots & \lambda & -1 \\ v_n & -1 & 0 & 0 & \cdots & 0 & 0 & \cdots & 0 & \lambda \end{array}_{n\times n}$$

The upper right (k –2) (n–k +2) matrix is a zero matrix, so $P(C_n) = \lambda^{k-1}\ \lambda^{n-(k-1)} = \lambda^n$ giving the result. If more than one edge, say v_{i1} –1 v_{i1}, v_{i2}–1 v_{i2}, ..., v_{ik}–1 v_{ik}, change their orientations, then

$$P(C_n) = \lambda^{i_1-1} \cdot \lambda^{i_2-1-(i_1-1)} \cdots \lambda^{n-(i_k-1)} = \lambda^n$$

as required.

Let us continue our study of unicyclic graphs. The following result helps us to obtain the general result for unicyclic graphs and has very important consequences:

Lemma 2.5. Let G be a connected oriented graph, $v \in G$ and let G+e = G+vu be the graph obtained by adding the oriented pendant edge e = vu to G, see Fig. 3. Then

$P(G + e) = \lambda \cdot P(G)$.

This is independent from the choice of the orientation of e.

Figure 3: Adding an edge to G

Lemma 2.5 guarantees that the orientation of any pendant edge added to a connected graph is not important and just multiplies the polynomial by λ. Therefore adding k oriented pendant edges to a connected graph G means that the characteristic polynomial of G will be multiplied by k. The following results are just some applications of Lemma 2.5.

Proof. Let the orientation of the new edge vu be from u to v (the proof is similar if the orientation is

from v to u). Let the characteristic matrix of G be P(G): The characteristic matrix of G+e would be

$$P(G + e) = \begin{vmatrix} P(G) & A \\ B & \lambda \end{vmatrix}$$

where A is an (n x 1) – column matrix and B is a (1 x n) – row matrix. Also all entries in A and B are zero except for only one entry which is –1. Therefore the result follows.

Now we know that adding a new oriented pendant edge to an oriented graph G multiplies the characteristic polynomial of G by λ. Applying this consecutively, we can give alternative proofs of Thm. 2 and Cor. 3. The following are some other consequences:

Corollary 2.6. Let G' be the oriented graph obtained by adding k oriented pendant edges to an oriented graph G. Then

$P(G') = \lambda^k \ P(G)$.

Corollary 2.7. Let G be a graph (not necessarily an oriented graph) obtained by joining a graph G_1 with a path P_{k+1} by identifying one of two endpoints of the path with a vertex of G_1, see Fig. 4. Then

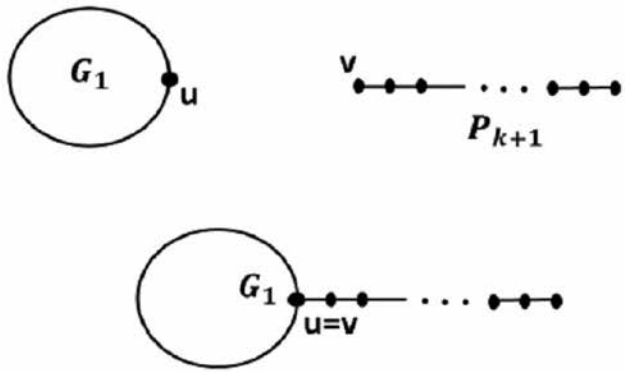

Figure 4: Adding a path to a graph

$P(G) = P(G_1) \cdot \lambda^k$.

Using Lemma 2.5, we can give the formula for the characteristic polynomial of oriented star graphs which is also valid for ordinary star graphs:

Corollary 2.8. For an oriented star graph S_n with n vertices we have

$P(S_n) = \lambda^n$.

Corollary 2.9. For an oriented tadpole graph $T_{r;s}$, we have

$P(T_{r;s}) = P(C_r) \cdot P(P_s) = P(C_r) \ \lambda^s$.

Corollary 2.10. Let G be a unicyclic oriented graph with n vertices having a cycle of length $k \leq n$.

Then

$P(G) = P(C_k) \ \lambda^{n-k}$.

3 CONCLUSION

Spectral study of graphs is a widely studied subject due to its applications related to chemical energy. In this paper, the spectral polynomials of oriented graphs are studied. Characteristic polynomials of several important oriented graph classes are found. The effect of edge addition on the characteristic polynomial of an oriented graph is determined. The characteristic polynomial of an oriented acyclic graph is given. As there is no spectral study on oriented graphs, this work will play an important role in the area. The target of this paper can also be applied to oriented graphs in terms of omega index [4, 5] as a future project. This would imply a new classification via integers.

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SQUEEZING FLOW THROUGH NUMERICAL-HERMITE WAVELET METHOD

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ABSTRACT

Squeezing flow is not only found in chemical, mechanical, and electrical engineering but also has applications in other fields, as squeezing flows can be noticed in numerous hydrodynamic instruments and machines. Due to the emphasis on squeezing flow, we have considered axisymmetric fluid flow squeezed between infinite plates in the current study. The Hermite wavelet method (HWM) is recommended to solve highly non-linear boundary value problems. To verify the validation and convergence of the planned scheme, the model problem is solved with HWM and also compared with different numerical methods. To the best of the author's knowledge, the current problem has not be attempted before with our methods. Graphical study has be finished to determine how the Reynolds number (Re) affects the velocity profile. The scrutiny exposes that HWM gives a more accurate level when compared to PM, HPM, HAM, OHAM, and MOHAM.

KEYWORDS *: Squeezing flow, Hermite wavelet, numerical method.*

1. INTRODUCTION

For many fascinating and significant events seen in several branches of science and industry, nonlinear equations are widely employed as mathematical models. They are motivated by issues in a variety of disciplines, including engineering, control hypothesis, physics, materials discipline, economics, and quantum mechanics. This extraordinary issue focuses on how the HWM is helped to explain solution of nonlinear differential equations. Hermite wavelet theory is fundamental in the disciplines of image processing, signal analysis, computer engineering, and numerical modelling. Copious mathematicians have investigated the models using various sets of solution strategies for decades. It is quite challenging to solve these models analytically, let alone comprehend them using normal differential equations. If we are unable to solve these issues analytically, it is preferable to use numerical procedures. The wavelet procedure is helped to crack highly nonlinear ODEs as well as PDEs. Wavelets allow a broad range of functions and operators to be accurately represented [1-3]. Wavelets also provide a relationship with quick numerical methods [4]. Many fluid flow troubles have been solved in up to date years [5-8] using the Hermite wavelet.

The inexact mathematical solution of the squeezing fluid flow connecting parallel never-ending plates is studied [9]. Stefan[10] carried out an early investigation of the squeeze flow by considering the behaviour of Newtonian fluids and neglected inertial force in the equation of motion later, Stefan's work was continued by the admittance of inertial effects and alternative constitutive connections to the Newtonian fluid model. Gupta and Gupta [11] studied Thorpe's [12] report indicated that the

solution to the perturbation problem existed for a small value of Reynolds' number and that the report failed to meet the requisite boundary conditions. His effort be only limited by a small Reynolds number by Gupta and Gupta. Afterwards the Verma[13] extended his work for different values of Re in squeezing flow parallel channels. Bujurke et al. [14] investigated the computer unlimited series for squeezing flow connecting plates by Pade approximation. Smyrnaios and Tsamopoulos [15] employed the finite element technique for the Squeeze flow of Bingham plastics.

In this article, the squeezing of axisymmetric liquid flow between never-ending parallel plates with Reynolds number effects is studied using numerical-Hermite-wavelet method. Our findings are contrasted with previously published solutions. The HWM is found to be additional effective and also less time-consuming, giving a higher level of accuracy. Even this technique can be excellently used for fluid flow problems.

2 FORMULATION OF THE PROBLEM

Consider an incompressible, viscous fluid flowing axi-symmetric between two infinite parallel plates. The gap H fluctuates gradually over time and can be taken for granted to be constant for small values of the two plates with respective velocities V with governing nonlinear equations in dimensionless form [9]

$$f^{(iv)}(x)+\mathrm{Re}\, f'''(x) f(x)=0. \tag{1}$$

$$f(0)=f''(0)=0, f(1)=1, f'(1)=0. \tag{2}$$

Where $\mathrm{Re}=\rho H \Big/ \left(\frac{2\mu}{V}\right)$ is the Reynolds number.

3 THE FUNDAMENTAL NOTION OF THE HERMITE WAVELET TECHNIQUE

The HWM is used to explain the issue in the present article. In the numerical results of differential equations, wavelet analysis has recently attracted a lot of interest. The precision and simplicity of these wavelet-based approaches are demonstrated by [5-8].

4 NUMERICAL-HERMITE WAVELET METHOD

Consider,

$$f^{(iv)}(x)=B^T\varphi(x) \tag{3}$$

$$f'''(x)=f'''(0)+B^T\left[T\varphi(x)+\overline{\varphi}(x)\right]. \tag{4}$$

Integrate (4) with respect to x from 0 to x.

$$f''(x)=f''(0)+xf'''(0)+B^T\left[T'\varphi(x)+\overline{\varphi}'(x)\right]. \tag{5}$$

Integrate (5) with respect to x from 0 to x.

$$f'(x)=f'(0)+x\ f''(0)+\frac{x^2}{2}\ f'''(0)+B^T\left[T''\varphi(x)+\overline{\varphi}''(x)\right]. \tag{6}$$

Integrate (6) with respect and it varies from 0 to x

$$f(x)=f(0)+x f'(0)+\frac{x^2}{2}f''(0)+\frac{x^3}{6}f'''(0)+B^T\left[T'''\varphi(x)+\overline{\varphi}'''(x)\right]. \tag{7}$$

Put x = 1 in (6) and (7) we get

$$f'(1)=0=f'(0)+\frac{1}{2}\ f'''(0)+B^T\left[T''\varphi(x)+\overline{\varphi}''(x)\right]\Big|_{x=1} \tag{8}$$

$$f(1)=1=f'(0)+\frac{1}{6}f'''(0)+B^T\left[T'''\varphi(x)+\overline{\varphi}'''(x)\right]\Big|_{x=1} \tag{9}$$

Solving (8) and (9) extract *f'* (0) and *f'''* (0) as

$$f'(0)=-\frac{1}{2}\Big[-3+3B^T\left[T'''\varphi(x)+\overline{\varphi}'''(x)\right]-3B^T$$

$$\left[T''\ \varphi(x)+\overline{\varphi}''(x)\right]-B^T\left[\ T''\varphi(x)+\overline{\varphi}''(x)\right]\Big]\Big|_{x=1} \tag{10}$$

$$f'''(0)=-3+3B^T\left[T'''\ \varphi(x)+\overline{\varphi}'''(x)\right]\Big|_{x=1}$$

$$-3B^T\left[\ T''\varphi(x)+\overline{\varphi}''(x)\right]\Big|_{x=1} \tag{11}$$

Using *f'* (0) & *f''* (0) are zero, Substitute (10) and (11) in (7) we get

$$f(x)=-\frac{x}{2}\left[\begin{matrix}-3+3B^T\left[T'''\ \varphi(x)+\overline{\varphi}'''(x)\right]\Big|_{x=1}\\ -3B^T\left[T''\varphi(x)+\overline{\varphi}''(x)\right]\Big|_{x=1}\end{matrix}\right]-B^T\left[T''\varphi(x)+\overline{\varphi}''(x)\right]\Big|_{x=1}$$

$$+\frac{x^3}{6}\left[\begin{matrix}-3+3B^T\left[T'''\varphi(x)+\overline{\varphi}'''(x)\right]\Big|_{x=1}\\ -3B^T\left[T''\varphi(x)+\overline{\varphi}''(x)\right]\Big|_{x=1}\end{matrix}\right]+B^T\left[T'''\varphi(x)+\overline{\varphi}'''(x)\right. \tag{12}$$

In organize to generate an algebraic system of equations, you must replace $f^{(iv)}$, *f'''*, *f''*, *f'*, *f* into the governing equations and combine them using the collocation points $x_i=\frac{2i-1}{2N}$, where *i* = 1,2,3... *N*. We may retrieve the unknown coefficients of the Hermite wavelet by solving this, which gives Hermite wavelet-numerical results for the equations (1-2).

5 RESULTS AND DISCUSSION

In the present article, the squeezing of axi-symmetric liquid flow between never-ending parallel plates is investigated by using HWM. The problem was resolved by various values of Reynolds number. The validity of the results calculated by HWM is confirmed by comparing the results with the numerical scheme, which can also be observed in Table 1. Further, Table 2 gives the comparison of HWM with MOHAM solution for various values of Re. The contact of various Re values on the normalised velocity has also been investigated through graphic research. Figs.1(a) and 1(b) depict how Re affects the velocity profile. Because the Reynolds number represents the proportion of inertial to viscous forces in a fluid, it may take scaling special effects into report and be helped to forecast fluid behaviour on a wider scale. Due to this, the velocity increases as the value of Re increases. In Figs. 2(a) and 2(b), the effects of varying Reynolds numbers are plotted.

6 CONCLUSION

In this paper, the squeezing of axisymmetric fluid flow between infinite plates is investigated using HWM. Owing to the purpose of validation, the calculated outcome was examined through the numerical scheme. The obtained results show the efficiency of HWM over other numerical schemes. HWM is a additional stable scheme in terms of time and accuracy compared to other stated schemes. The velocity increases as the value of Re Reynolds number increases.

Table 1 Validation of HWM with NUM, MOHAM, HAM, PM, OHAM and HPM [9]

x	*f (x)*						
	HWM	NUM	MOHAM	HAM	PM	OHAM	HPM
0	0	0	0	0	0	0	0
0.15	0.232179	0.232179	0.232178	0.232179	0.232546	0.231996	0.232546
0.30	0.451603	0.451603	0.451605	0.451603	0.453690	0.451343	0.453690
0.45	0.646353	0.646353	0.646357	0.646354	0.650927	0.646147	0.650927
0.60	0.805988	0.805988	0.805989	0.805988	0.811982	0.805894	0.811982
0.75	0.921867	0.921867	0.921863	0.921867	0.926616	0.921852	0.926616
0.90	0.987176	0.987176	0.987183	0.987176	0.988531	0.987177	0.988531

Table 2 Evaluation of HWM with MOHAM [9] for Reynolds numbers Re = 0, 2 &10

x	*f (x)*					
	Re = 0		Re = 2		Re =10	
	HWM	MOHAM	HWM	MOHAM	HWM	MOHAM
0	0	0	0	0	0	0
0.15	0.223312	0.223312	0.232168	0.232168	0.215791	0.215791
0.3	0.4365	0.4365	0.451582	0.451582	0.421326	0.421326
0.45	0.629438	0.629438	0.646327	0.646327	0.608988	0.608988
0.6	0.792	0.792	0.805961	0.805961	0.77452	0.77452
0.75	0.914063	0.914063	0.921846	0.921846	0.915387	0.915387
0.9	0.9855	0.9855	0.987169	0.987169	1.00335	1.00335

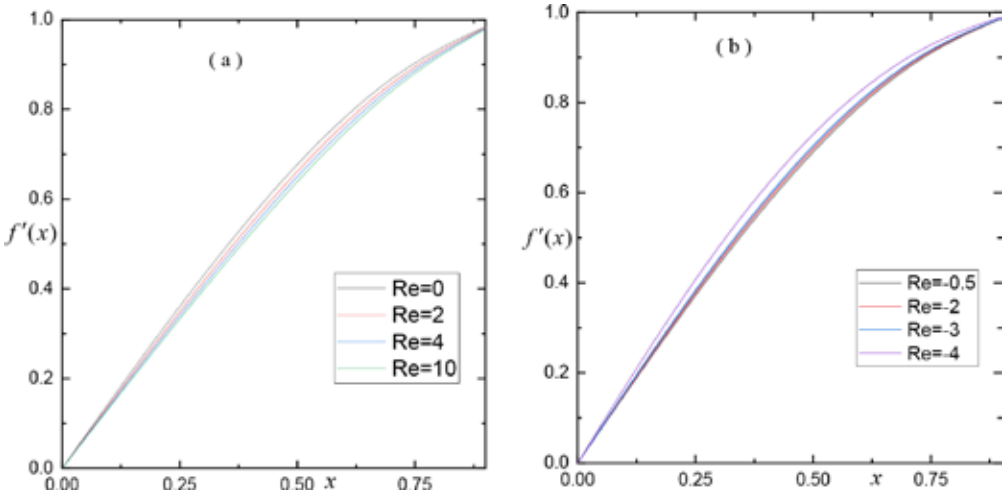

Fig. 1.Significance of *f' (x)* with (a) individual standards of Re (b) various values of Re

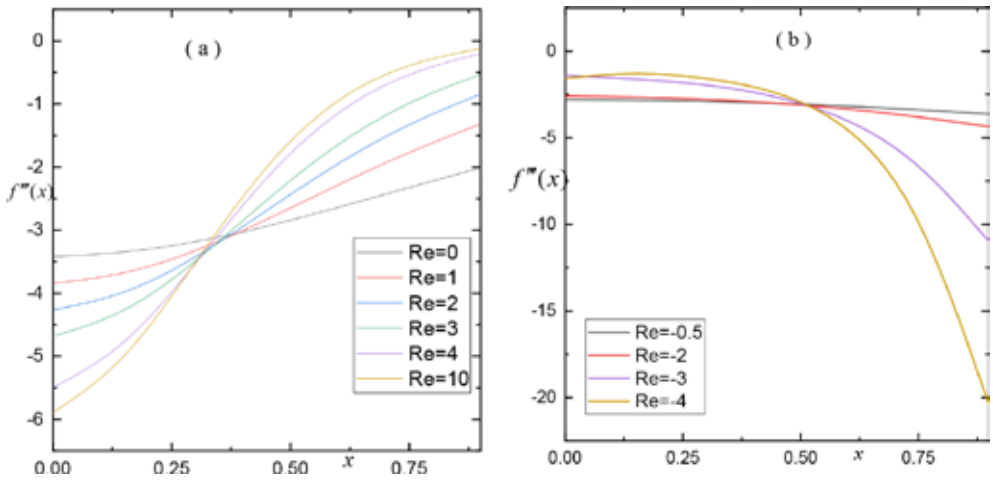

Fig. 2. Significance of *f'''(x)* with (a) individual standards of Re (b) various values of Re.

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STATISTICAL ANALYSIS OF DAILY RAINFALL FOR AGRICULTURAL PLANNING AT SELECTED REGIONS OF KARNATAKA THROUGH MARKOV CHAIN PROCESS

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ABSTRACT

Understanding rainfall pattern of a region is crucial for making decisions in various factors like agricultural patterns, management of water, tourism, fisheries, etc. In this study, Markov chain first order model using transition probability matrices is used to study the probability of occurrence of rainy and non rainy days. Daily rainfall data for 30 years of Dakshina kannada, Uttara kannada, Udupi, Bangalore rural, Bangalore urban and Ramanagara was collected from KSNDMC. Daily rainfall data was analyzed talukwise of the selected districts. The results obtained shows that the chance of having a no rain is 79.18% (Devanahalli), 75.82% (Nelamangala), 78.30% (Doddaballapura),80.82% (Hosakote), 70.61% (Bangalore(N)),72.53% (Bangalore(S)),76.93% (Anekal),78.57% (Channapatna), 77.27% (Ramanagara),76.99% (Magadi),80.55% (Kanakapura), 61.92% (Mangalore), 60.55% (Puttur), 61.81% (Bantwala), 59.18% (Sulya), 59.73% (Beltangadi), 59.62% (Karkala), 62.91% (Kundapura), 61.54% (Udupi),65.48% (Ankola), 64.29% (Bhantkal), 67.86% (Haliyal), 62.91% (Honnavara), 64.38% (Karwar), 63.19% (Kumta), 66.81% (Mundgod), 63.84% (Siddapura), 62.84% (Sirsi), 64.29% (Supa) and 65.38% (Yellapura). The results obtained can be used for short term processes.

KEYWORDS *: Rainfall, Transition matrix, Markov chain model.*

1. INTRODUCTION

Indian economy has its dependence on rural contribution where the Agriculture has its role as a vital component. It is necessary for the study of various parameters on which the Agriculture is more dependent. The important parameter which results in ups and downs of Agriculture and other various activities is Rainfall. This importance leads to the study of occurrence and amount of rainfall in both local and global level. This paper has been concentrated at local level to understand the occurrence of rain, based on the historical records for short term process.

1.1 Study Area

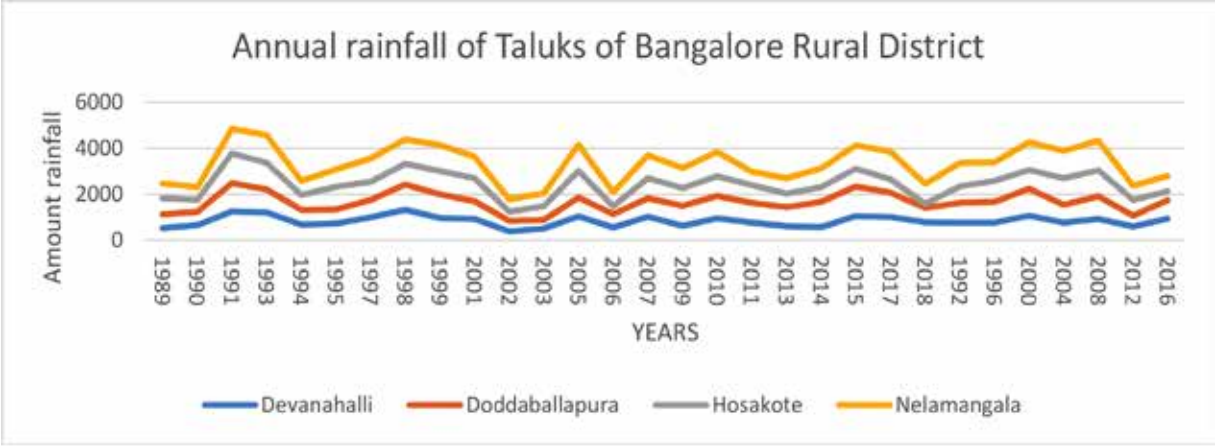
Many studies have taken over Climate change, in particular over Rainfall for larger scale considering State and district level for both short and long term processes. In the state Karnataka, Agriculture is heavily dependent on Southwest monsoon rains as water is the predominant source for agriculture. In this study, it is concentrated to understand the rainfall pattern and occurrence of rain

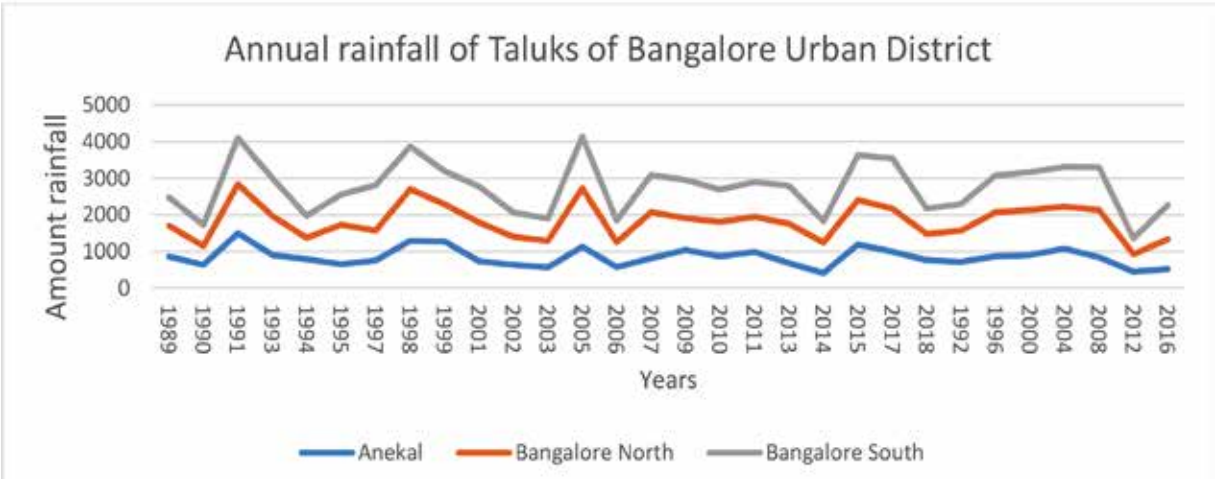
at taluk level. The taluks of selected districts have been considered for the study and the districts are Bangalore rural, Bangalore urban, Ramanagara from South Interior Karnataka which receives moderate rainfall and Dakshina Kannada, Uttara Kannada, Udupi from Coastal Karnataka which receives heavy rainfall. The detailed taluk list is tabulated in the Table 1.

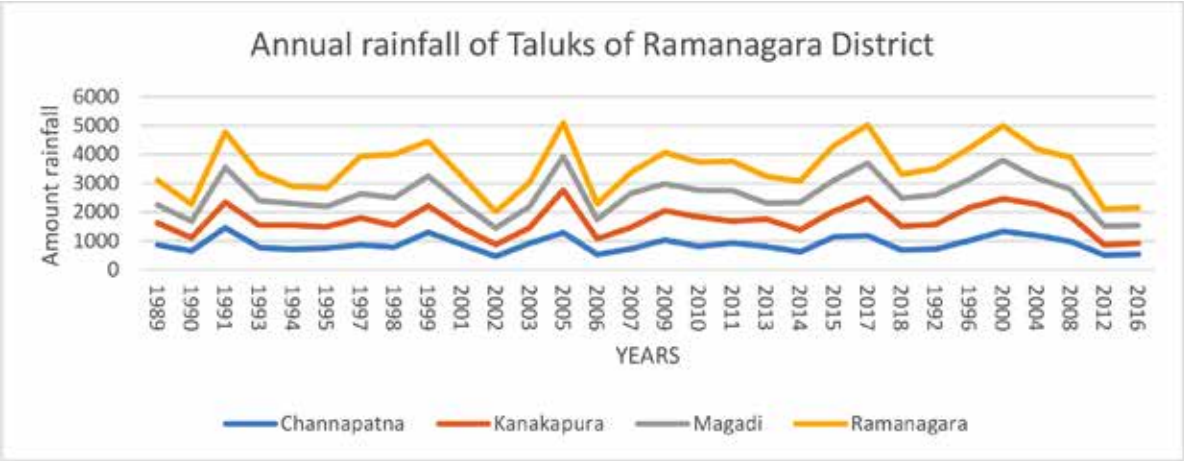
Districts	Taluks	Districts	Taluks	
Bangalore Rural	Devanahalli Doddaballapura Hosakote Nelamangala	**Dakshina Kannada**	Mangalore Bantval Beltangadi	Puttur Sulya
Bangalore Urban	Bengaluru North Bengaluru South Bengaluru East Anekal	**Uttara Kannada**	Ankola Bhantkal Haliyal Honnavar Karwar Kumta	Mundgod Siddapura Sirsi Supa Yellapur
Ramanagara	Ramanagara Channapatna Magadi Kanakapura	**Udupi**	Karkala Kundapura Udupi	

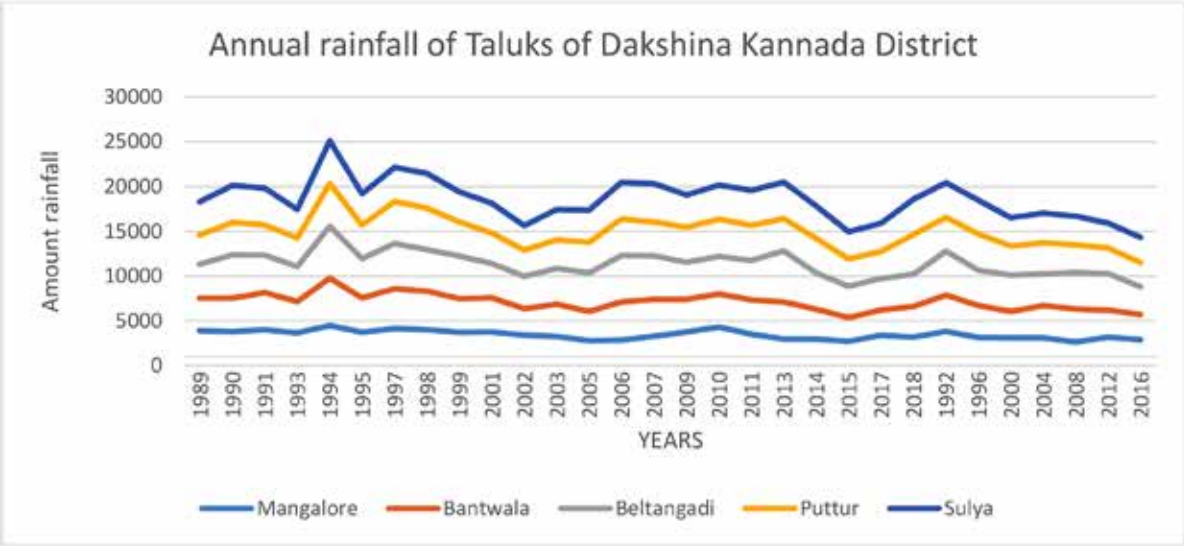
2. DATA AND METHODOLOGY

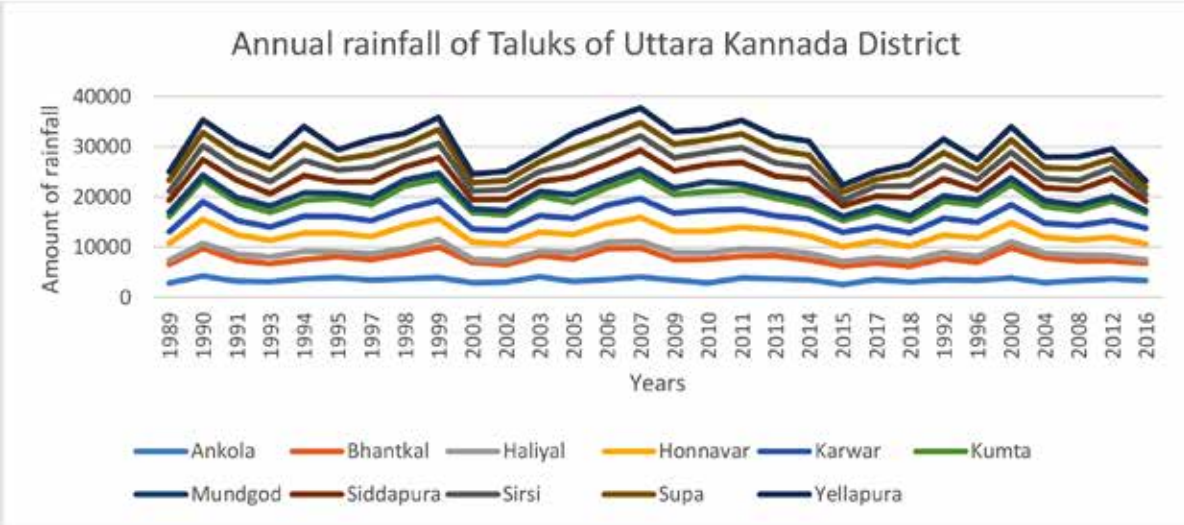
Thirty years of daily rainfall data from 1989 to 2018 of all the taluks of districts chosen was collected for the prediction of occurrence of daily rainfall from Karnataka State Natural Disaster Meteorological center (KSNDMC), Bangalore. Using Excel, the annual rainfall of all taluks of selected districts is computed and plotted below.

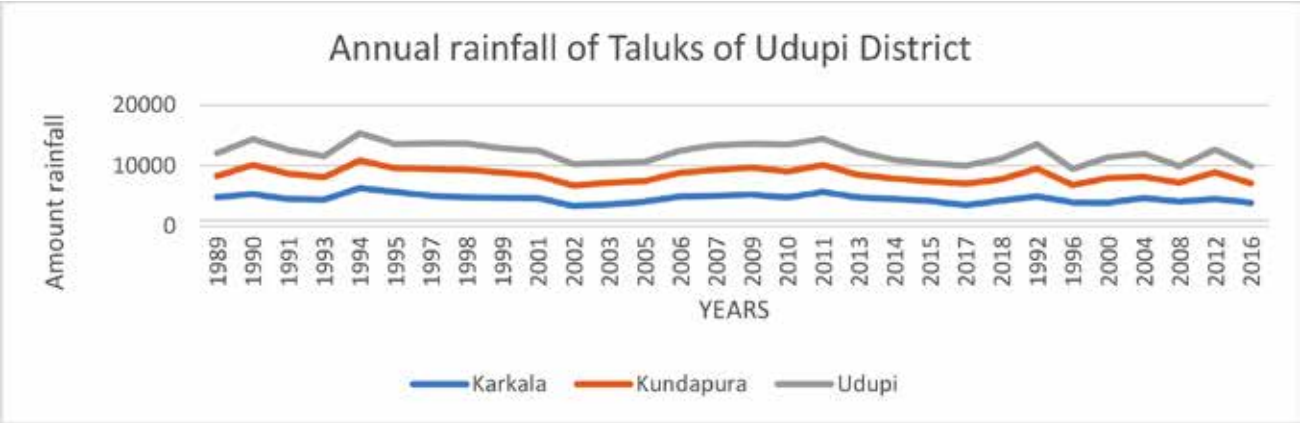




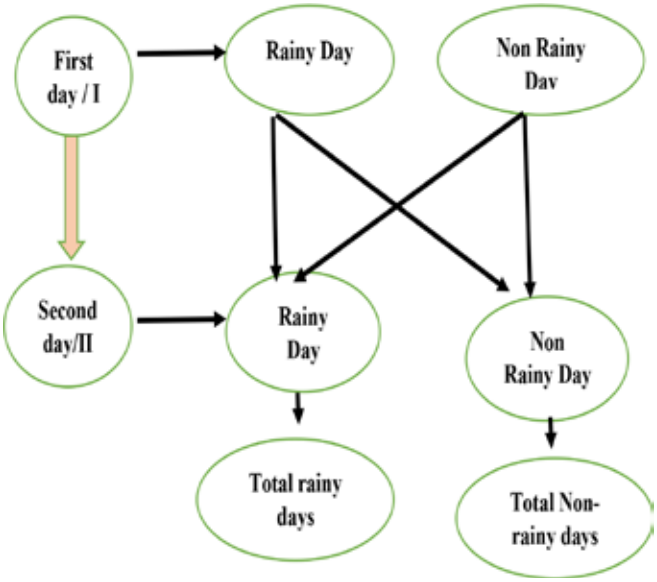

Annual rainfall of Taluks of Ramanagara District
Amount rainfall
6000
5000
4000
3000
2000
1000
0
1989 1990 1991 1993 1994 1995 1997 1998 1999 2001 2002 2003 2005 2006 2007 2009 2010 2011 2013 2014 2015 2017 2018 1992 1996 2000 2004 2008 2012 2016
YEARS
Channapatna
Kanakapura
Magadi
Ramanagara


Annual rainfall of Taluks of Dakshina Kannada District
Amount rainfall
30000
25000
20000
15000
10000
5000
0
1989 1990 1991 1993 1994 1995 1997 1998 1999 2001 2002 2003 2005 2006 2007 2009 2010 2011 2013 2014 2015 2017 2018 1992 1996 2000 2004 2008 2012 2016
YEARS
Mangalore
Bantwala
Beltangadi
Puttur
Sulya


Annual rainfall of Taluks of Uttara Kannada District
Amount of rainfall
40000
30000
20000
10000
0
1989 1990 1991 1993 1994 1995 1997 1998 1999 2001 2002 2003 2005 2006 2007 2009 2010 2011 2013 2014 2015 2017 2018 1992 1996 2000 2004 2008 2012 2016
Years
Ankola
Bhantkal
Haliyal
Honnavar
Karwar
Kumta
Mundgod
Siddapura
Sirsi
Supa
Yellapura



Many studies have been carried for the prediction of rainfall. Most research papers have used widely various Statistical methods to predict occurrence of rainfall as they are well suited for assessment of accuracy. Several studies have used Markov chain process for the study of daily occurrence of rainfall. The two state first order Markov chain was the first stochastic model introduced by Gabrial and Neuman in 1962. Few authors like G V Srinivasa Reddy (2008), Senthilvelan.A (2012), Wubengeda(2014), Abubakar UsmanYusuf (2014), N.M. Alam(2015), K.N.Krishnamurthy (2015), Rahmtalla Yousif adam(2016), M. Ray (2018), A.O. Ibeje(2018), Phyu Thwe(2019), Prabir Kumar Das (2020) have made use of Markov chain process to predict occurrence of daily rainfall and weekly rainfall. As it is an effective method, it has found its importance in prediction of climate parameters providing the result with less error using the previous data. In this paper, two state Markov chain process have been carried out considering rainy and non rainy day as two states. For the daily rainfall prediction, the collected 30 years data is used for the analysis and the data is sorted out into number of rainy days and non-rainy days considering the day as rainy day if the amount of rainfall received is greater than zero mm otherwise non rainy day using Excel. Depending on the Classification of rainy and non-rainy day, the two state transition matrix with respect to total number of rainy/non rainy days for each year is developed in comparison with the previous rainy day/non rainy day and is as follows



Comparison of Rainy and Non Rainy day, Transition matrix development model

Further, the limiting probability is calculated based on the initial probability. In this paper, the initial probability is assumed to be 50% chance of occurrence of rain after a rainy day and 50% chance of occurrence of no rain after a non rainy day. To attain the steady state, MATLAB software is used to compute Transition matrix of higher power.

3. RESULTS & DISCUSSION

The detailed analyzation of the data and rainfall occurrence prediction of Devanhalli taluk from Bangalore rural district is taken to demonstrate the process carried and is as follows. The data is segregated into number of rainy days and non rainy days and the comparison is given in the Table 2.

Table 2

1989

No. of rainy & Non rainy days

No. of rainy days	56
No. of Non rainy days	309
	365

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	272	36	308
Rainy	36	20	56
			364

1990

No. of rainy & Non rainy days

No. of rainy days	71
No. of Non rainy days	294
	365

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	254	39	293
Rainy	39	32	71
			364

1991

No. of rainy & Non rainy days

No. of rainy days	83
No. of Non rainy days	282
	365

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	238	43	281
Rainy	43	40	83
			364

1992

No. of rainy & Non rainy days

No. of rainy days	71
No. of Non rainy days	295
	366

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	249	45	294
Rainy	45	26	71
			365

1993

No. of rainy & Non rainy days

No. of rainy days	92
No. of Non rainy days	273
	365

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	230	42	272
Rainy	42	50	92
			364

1994

No. of rainy & Non rainy days	
No. of rainy days	81
No. of Non rainy days	284
	365

Comparison			
I\II	Non Rainy	Rainy	Total
Non Rainy	234	49	283
Rainy	49	32	81
			364

1995

No. of rainy & Non rainy days	
No. of rainy days	69
No. of Non rainy days	296
	365

Comparison			
I\II	Non Rainy	Rainy	Total
Non Rainy	258	37	295
Rainy	37	32	69
			364

1996

No. of rainy & Non rainy days	
No. of rainy days	68
No. of Non rainy days	298
	366

Comparison			
I\II	Non Rainy	Rainy	Total
Non Rainy	259	38	297
Rainy	38	30	68
			365

1997

No. of rainy & Non rainy days	
No. of rainy days	53
No. of Non rainy days	312
	365

Comparison			
I\II	Non Rainy	Rainy	Total
Non Rainy	276	35	311
Rainy	35	18	53
			364

1998

No. of rainy & Non rainy days	
No. of rainy days	71
No. of Non rainy days	294
	365

Comparison			
I\II	Non Rainy	Rainy	Total
Non Rainy	258	35	293
Rainy	35	36	71
			364

1999

No. of rainy & Non rainy days	
No. of rainy days	62
No. of Non rainy days	303
	365

Comparison			
I\II	Non Rainy	Rainy	Total
Non Rainy	264	38	302
Rainy	38	24	62
			364

2000

No. of rainy & Non rainy days	
No. of rainy days	82
No. of Non rainy days	284
	366

Comparison			
I\II	Non Rainy	Rainy	Total
Non Rainy	244	39	283
Rainy	39	43	82
			365

2001

No. of rainy & Non rainy days

No. of rainy days	47
No. of Non rainy days	318
	365

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	289	28	317
Rainy	28	19	47
			364

2002

No. of rainy & Non rainy days

No. of rainy days	26
No. of Non rainy days	339
	365

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	316	22	338
Rainy	22	4	26
			364

2003

No. of rainy & Non rainy days

No. of rainy days	41
No. of Non rainy days	324
	365

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	296	27	323
Rainy	27	14	41
			364

2004

No. of rainy & Non rainy days

No. of rainy days	46
No. of Non rainy days	320
	366

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	288	31	319
Rainy	31	15	46
			365

2005

No. of rainy & Non rainy days

No. of rainy days	67
No. of Non rainy days	298
	365

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	255	42	297
Rainy	42	25	67
			364

2006

No. of rainy & Non rainy days

No. of rainy days	52
No. of Non rainy days	313
	365

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	281	31	312
Rainy	31	21	52
			364

2007

No. of rainy & Non rainy days

No. of rainy days	79
No. of Non rainy days	286
	365

Comparison

I\II	Non Rainy	Rainy	Total
Non Rainy	247	38	285
Rainy	38	41	79
			364

2008

No. of rainy & Non rainy days		Comparison			
No. of rainy days	74	I\II	Non Rainy	Rainy	Total
No. of Non rainy days	292	Non Rainy	246	45	291
	366	Rainy	45	29	74
					365

2009

No. of rainy & Non rainy days		Comparison			
No. of rainy days	152	I\II	Non Rainy	Rainy	Total
No. of Non rainy days	213	Non Rainy	161	51	212
	365	Rainy	51	101	152
					364

2010

No. of rainy & Non rainy days		Comparison			
No. of rainy days	166	I\II	Non Rainy	Rainy	Total
No. of Non rainy days	199	Non Rainy	145	53	198
	365	Rainy	53	113	166
					364

2011

No. of rainy & Non rainy days		Comparison			
No. of rainy days	89	I\II	Non Rainy	Rainy	Total
No. of Non rainy days	276	Non Rainy	234	42	276
	365	Rainy	41	47	88
					364

2012

No. of rainy & Non rainy days		Comparison			
No. of rainy days	78	I\II	Non Rainy	Rainy	Total
No. of Non rainy days	288	Non Rainy	263	37	300
	366	Rainy	36	29	65
					365

2013

No. of rainy & Non rainy days		Comparison			
No. of rainy days	94	I\II	Non Rainy	Rainy	Total
No. of Non rainy days	271	Non Rainy	247	42	289
	365	Rainy	42	33	75
					364

2014

No. of rainy & Non rainy days		Comparison			
No. of rainy days	59	I\II	Non Rainy	Rainy	Total
No. of Non rainy days	306	Non Rainy	269	36	305

	365	**Rainy**	36	23	59
					364

2015

No. of rainy & Non rainy days		**Comparison**			
No. of rainy days	102	**I\II**	**Non Rainy**	**Rainy**	**Total**
No. of Non rainy days	263	**Non Rainy**	214	48	262
	365	**Rainy**	49	53	102
					364

2016

No. of rainy & Non rainy days		**Comparison**			
No. of rainy days	76	**I\II**	**Non Rainy**	**Rainy**	**Total**
No. of Non rainy days	290	**Non Rainy**	250	39	289
	366	**Rainy**	39	37	76
					365

2017

No. of rainy & Non rainy days		**Comparison**			
No. of rainy days	100	**I\II**	**Non Rainy**	**Rainy**	**Total**
No. of Non rainy days	265	**Non Rainy**	223	41	264
	365	**Rainy**	41	59	100
					364

2018

No. of rainy & Non rainy days		**Comparison**			
No. of rainy days	86	**I\II**	**Non Rainy**	**Rainy**	**Total**
No. of Non rainy days	279	**Non Rainy**	230	48	278
	365	**Rainy**	48	38	86
					364

Based on the comparison of rainy and non rainy days, Transition matrix is calculated. Using MATLAB software, the positive integral power of the transition matrix is computed to attain the steady state. These steady state values of the transition matrix are used to find the Limiting probability. The limiting probability, prediction results of rainfall days and error found with the actual data is tabulated in the Table 3.

Table 3

Year	Limiting Probability		Prediction		Error	
	Non Rainy day	Rainy Day	No. of Rainy days	No. of Non Rainy days	For Rainy day	For Non Rainy day
1989	84.60	15.38	1686	9270	26.49	6.99
1990	80.49	19.51	2137	8820	6.79	1.80
1991	77.20	22.80	2499	8459	8.96	2.37
1992	80.55	19.45	2131	8826	7.05	1.87
1993	74.73	25.28	2770	8188	20.80	5.50
1994	77.75	22.25	2438	8519	6.33	1.68
1995	81.04	18.96	2077	8880	9.41	2.49
1996	81.37	18.63	2041	8916	10.97	2.91
1997	85.44	14.56	1595	9362	30.42	8.05
1998	80.50	19.51	2138	8820	6.76	1.80
1999	82.97	17.03	1866	9091	18.61	4.92
2000	77.54	22.47	2462	8496	7.38	1.94
2001	87.09	12.91	1415	9542	38.30	10.14
2002	92.86	7.14	783	10174	65.87	17.43
2003	88.74	11.26	1234	9723	46.18	12.22
2004	87.40	12.60	1381	9576	39.78	10.53
2005	81.59	18.41	2017	8940	12.04	3.19
2006	85.71	14.29	1565	9392	31.73	8.40
2007	78.30	21.71	2379	8579	3.74	0.98
2008	79.73	20.27	2221	8736	3.12	0.83
2009	58.25	41.77	4577	6382	99.59	26.33
2010	54.40	45.61	4998	5961	117.96	31.20
2011	75.38	24.63	2698	8260	17.67	4.67
2012	81.79	18.21	1996	8961	12.97	3.43
2013	79.40	20.60	2258	8699	1.54	0.41
2014	83.79	16.21	1776	9181	22.55	5.97
2015	72.39	27.61	3025	7932	31.93	8.45
2016	79.18	20.82	2282	8676	0.49	0.13
2017	72.53	27.49	3012	7948	31.36	8.27
2018	76.37	23.63	2589	8368	12.90	3.41

From the results, it is absorbed that the error obtained is less from the year 2016. Thus, the result can be used for the prediction, which says the occurrence of rain after a rainy day is 20.82% and the occurrence of no rain after a non rainy day is 79.18%.

This way each year data of thirty years of all taluks of selected districts is analyzed and subjected to Markov chain process.

4. CONCLUSION

This paper witnesses the effectiveness in using the Markov Chain method to develop the model for analyzing and predicting the probability of occurrence of rain in a given day. This model would be helpful for the local stake holders of the districts selected and use the results for the short term agricultural purposes.

5. ACKNOWLEDGEMENT

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CHARACTERIZATION, OPTICAL AND PHOTOCATALYTIC STUDIES OF UV LIGHT DRIVEN SM^{3+} DOPED ZRO_2 THIN FILM BY SOL-GEL METHOD

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ABSTRACT

In this study, ZrO_2 and Sm^{3+} doped ZrO_2 thin film were prepared via sol-gel route. Scanning electron microscopy (SEM) and Powder X-ray Diffraction (PXRD) were used to characterise the synthesised materials. Under UV light irradiation, the produced thin film photocatalytic activities were evaluated for its ability to decolorize indigocarmine (IC) aqueous solutions. When compared to pure ZrO_2 thin film, the Sm^{3+} doped ZrO_2 thin film exhibits higher catalytic performance. The Sm^{3+} doped ZrO_2 photocatalyst also has outstanding recycling performance with a small loss in% decolorization after four cycle cycles. This study provides information on a possible photocatalytic excellence for the treatment of waste water.

KEYWORDS *: Sm^{3+} doped ZrO_2 thinfilm, SEM, Photocatalytic performance, decolorization*

INTRODUCTION

Materials at nano scale with various varieties (nano-powder, nano-rods, nano-thin films, nano-tubes, nano-flower and nano-wires) finds many applications in various fields owing to their novel properties like surface tailoring ability, improved solubility etc. [1-6]. From the last two decades researchers showing their attention towards the nano-sized metal oxide based semiconductors owing to their attractive properties and potential applications.

Among the metal oxide based semiconductors, ZrO_2 has set up a wide variety of applications in CO_2 reduction, water splitting, solar cells, sensors, photo catalysis, telecommunication, etc. owing to its chemical stability, low toxicity and large energy gap of 3.2 eV [7-11].

In particular, ZrO_2 is used as catalyst for photocatalytic decolorization of organic pollutants due to their rich catalytic efficiency and nontoxic end products. With the evolution of ink, fabric, Paint and paper industries, large amount of pollutants containing organic dyes are released, which is dangerous to the nature. Thus a suitable and economic route (photo reduction, photocatalytic) is very much required to decrease the number of the pollutants before releasing into the water environment. It was observed that many researchers doped rare earth ions into the host lattice to enhance the catalytic activities. Among RE ions, Sm^{3+} used as suitable activator which shows intense luminescence, thin bands in visible and UV spectrum due to f orbital transitions which do not interact with the ligand orbitals [12,13].

In present study, we prepared Sm^{3+} (1-9 mol%) activated ZrO2nanostructured thin films by sol-gel route. structural, optical and photocatalytic studies of ZrO2:Sm3+(1-9 mol %) nanostructured thin films were investigated and discussed in detail.

EXPERIMENTAL

A series of Sm^{3+} activated ZrO_2 thin films were synthesized on glass substrate via sol-gel technique by using analytical grade with 99% purity Zirconium of acetate Dihydrate ($Zr(CH_3COO)_2.2H_2O$) (used as precursor), Sodium hydroxide (NaOH), Ethanol (CH_2COOH)(reagent), Samarium(Sm_2O_3) and distilled water(solvent medium). In this method stoichiometric amount of Sodium Hydroxide and Zirconium Acetate Dihydrate dissolved in suitable capacity of distilled water in separate beakers and well stirred with a duration of 5 minutes then both solutions were poured to the beaker , then ethanol and dopant was added to drop wise, then the solution was deposited on glass substrates via the dip coating route with 20 mm/min of withdrawal speed, then thin films were dried out by keeping in oven with temperature of about 200 °C for 2hrs further followed by Calcination at 500 °C for 1 h to eliminate the organic compounds from the thin films.

CATALYTIC STUDIES

Photocatalytic experimental studies were carried for the decolourisation of AR dye by taking 250 ml dye solution of 20 ppm and 60 mg of prepared catalyst were taken in a circular glass beaker (surface area of 176.6 cm^2) under UV light(mercury lamp) source and Irradiation was carried out by focusing UV light into the mixture for the period of 105 minutes. Further, reaction mixture of ~ 5 ml was taken out in equal interval of times (~15 min) to evaluate degradation rate of the prepared material.

RESULTS AND DISCUSSIONS

Fig.1a indicates the XRD results of pure and 1-9 mol % Sm3+ doped thin films prepared by sol-gel method. All the obtained peaks at (100), (002), (101), (102), (110), (103), (200), (112) and (201) were well indexed with the [JCPDS Card No. 36- 1451] and confirm the hexagonal wurtzite structure of the prepared sample [14]. Also it was noticed that no other peaks (impurity) were observed in the XRD profile indicates the purity of the sample and sharp peaks confirms the crystallinity of the material. Further, Debye– Scherrer's equation and WH method was employed (Fig.1b) to estimate the average crystallite size of the material and relation is expressed as fallows [15,16].

$$d = \frac{K\lambda}{\beta\cos\theta} \quad (1)$$

$$\beta\cos\theta = \frac{0.9\lambda}{D} + 4\varepsilon\sin\theta \quad (2)$$

Where, K: constant, λ: wavelength of X-ray, β: full width half maximum and ε: strain, equation 2 gives straight line between '4sinθ' and 'β cosθ' (Fig.2a), slope of the line gives the strain and the intercept on y-axis gives crystallite size (D), dislocation density and σ_{stress} were calculated using the following equations and all the estimated results are tabulated in Table 1.

$$\delta = \frac{1}{D^2} \quad (3)$$

$$\sigma_{stress} = \varepsilon E \quad (4)$$

Further, unit cell volume and lattice parameters were calculated for the plane (101) using the following relations was found to be 51 Å3 and a = b = 3.255 Å, c = 5.2016 Å, respectively.

Addition of dopant ions did not alter the crystalline nature of the material, however slight modifications in the lattice parameters was observed which is owing to the dissimilarity in the ionic radius between the Sm^{3+} and the host. Peak intensity decreases with addition of dopant concentration was noticed which is owing to the local symmetry breakdown [15].

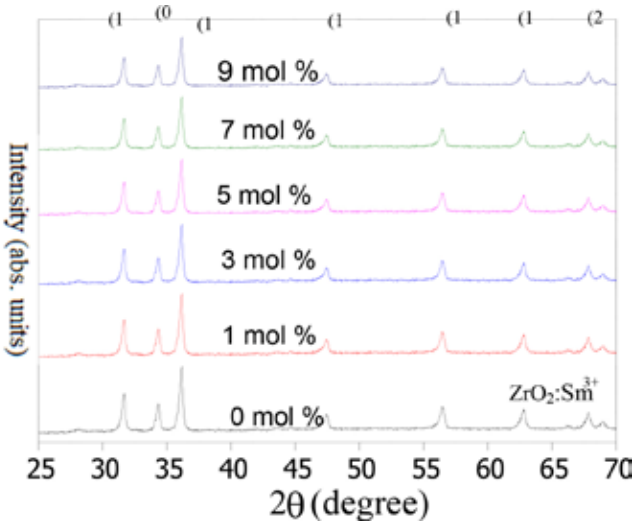

Fig.1a. X-Ray diffraction patterns of ZrO_2:Sm^{3+} (1-9 mol %) thin films

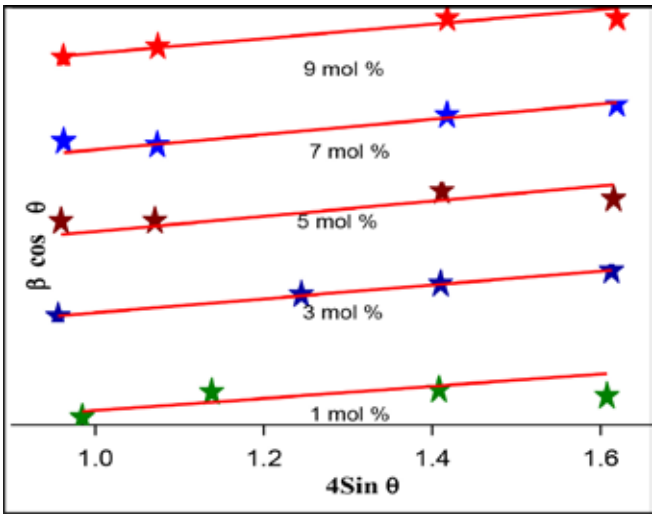

Fig. 1b. W-H patterns of ZrO_2:Sm^{3+} (1-9 mol %) thin films

Table 1. Lattice parameters of Sm^{3+}(1- 9 mol %) doped ZrO_2 samples

ZrO_2:Sm^{3+}	Crystallite Size (nm) Scherrer's	Dislocation density δ 10^{-3}	Micro-strain ε (10^{-3})	Crystallite Size (nm) W-H plot
0 mol %	26	1.47	1.12	23
1 mol %	30	1.11	1.10	25
3mol %	32	0.97	1.08	26
5 mol %	33	0.91	1.09	29
7 mol %	34	0.86	1.02	30
9 mol %	36	0.77	1.0	33

Surface morphology and shape of the prepared materials were examined by Field effective Scanning electron microscopic technique (FESEM) and the obtained FESEM pictures illustrated in the Fig.2. FESEM images illustrate the nano-spirals, nano-rings, spherical shaped morphology, small voids with well-defined boundaries; also rod shaped morphology was noticed.

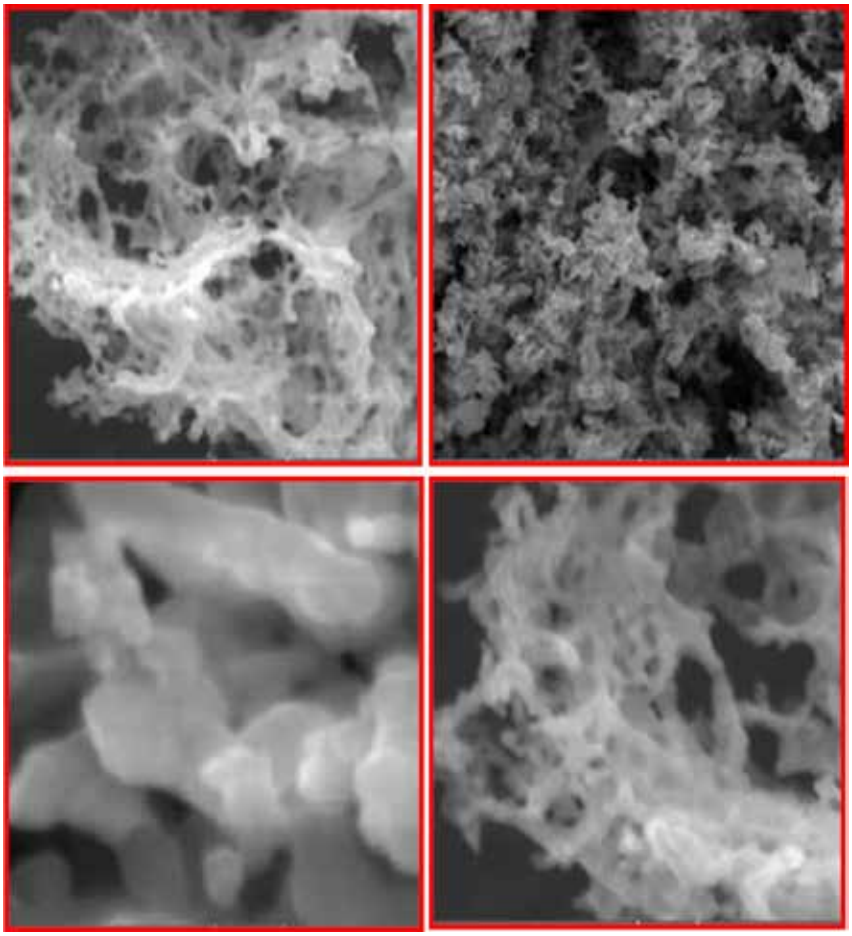

Fig.2. FESEM images ZrO_2 : Sm^{3+} thinfilms

Optical studies of pure and doped ZrO_2 thinfilms was characterised by UV–visible diffused reflectance spectroscopy, obtained results are depicted in Fig. 3 and the DRS spectra shows low absorption wavelength at 374 nm indicates good optical quality of prepared materials which is owing to large exciton binding energy.

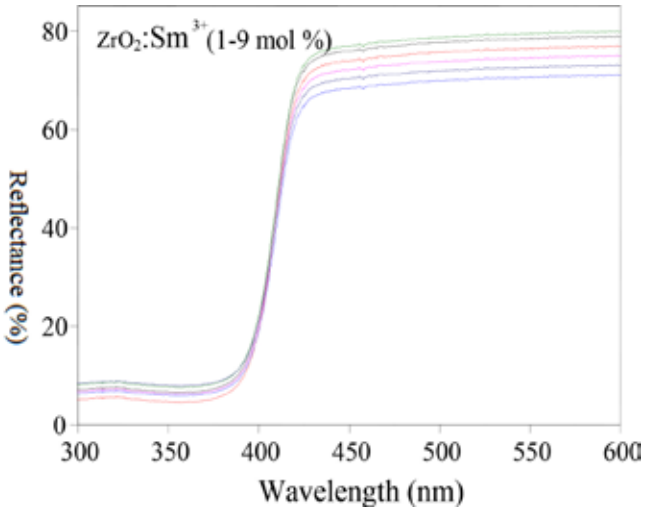

Fig. 3. DRS spectra of ZrO2:Sm3+(1-9 mol %) thin films

Optical band gap of ZrO_2 and ZrO_2 : Sm^{3+} thin films (Fig. 5(b) was calculated by using well known Kubelka-Munk function F(R), and relation is [17].

$$F(R) = \frac{(1-R)^2}{2R} \quad (5)$$

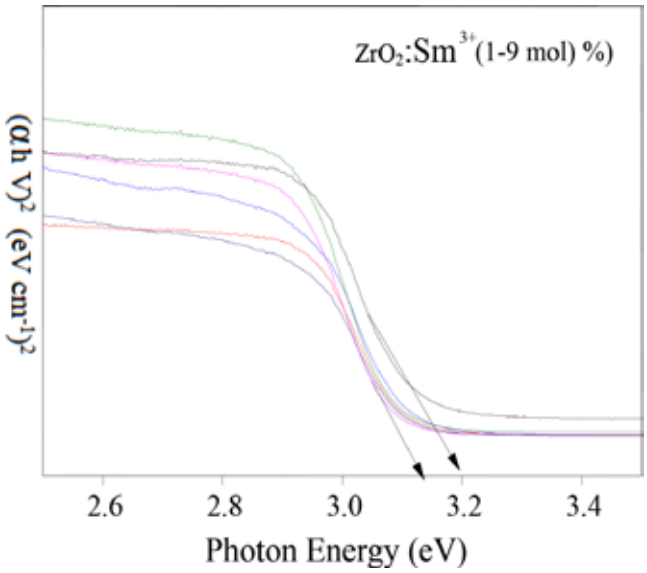

Fig. 4. Band gap spectra of ZrO_2:Sm^{3+}(1-9 mol %) thin films

Fig. 5 indicates the UV-VIS spectra of the AR dye in presence of Sm^{3+} activated ZrO_2 thin films under various illumination times of UV light.

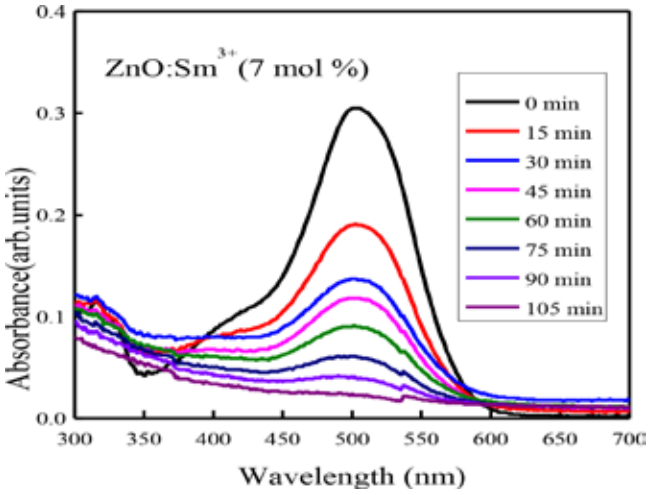

Fig. 5. Absorbance spectra of ZrO_2:Sm^{3+} (7 mol%) Photocatalyst.

It was noted that absorption peak of AR dye decreases, indicates the degradation of AR molecules under UV light irradiation. Further, insignificant degradation of AR dye was observed in dark conditions and in the absence of ZrO_2 which confirms that degradation of AR dye is due to presence of photo excited Sm^{3+} activated ZrO_2 samples. The trend of AR degradation with the presence of prepared 1-9 mol % of Sm^{3+} activated ZrO_2 thinfilms s under UV light irradiation are given in Fig. 6 and 95% of AR dyes were degraded during 105 min. The photo catalyst activity of ZrO_2: Sm^{3+} samples are ranked in the order of 7 mol ZrO_2: Sm^{3+} > 5 mol % ZrO_2: Sm^{3+} > 3 mol % ZrO_2: Sm^{3+} > 9 mol % ZrO_2: Sm^{3+} > 1 mol % ZrO_2: Sm^{3+}. Langmuir-Hinshelwood kinetics model was used to degradation of AR dye and its kinetics are represented as ln (C/Co) = −k t, Where k be the rate of constant apparent reaction, C be the AR initial concentration, t be the reaction time and Co be the concentration of AR dye with t, and the obtained kinetics values prepared material are given in Table 2. [18-22].

The improved catalytic activity was noted for 7 mol % doped ZrO_2: Sm^{3+} catalyst under UV light was observed due to separation of charge carriers which is attributed to the excess production of hydroxyl radicals and absorption band shift to longer wavelengths. Many researchers reported that catalytic performances of the prepared material are based on the factors such as

crystallite size, morphologies, textures and the dopant concentration. Among, the morphologies of the material and activator concentration played an key role on the photo catalytic activities [23].

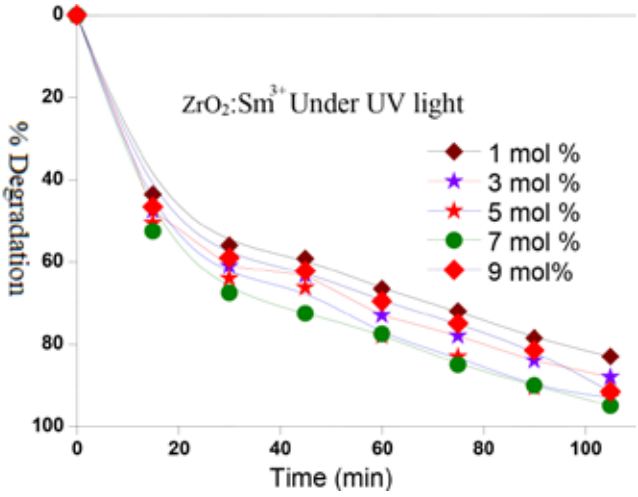

Fig. 6. Plot of % degradation of AR dye under UV light

Table 2. Kinetics studies on Sm^{3+} (1- 9 mol %) doped ZrO_2 thinfilms under UV light illumination

Photocatalysts	% D	K × 10^{-3} min^{-1}
ZrO_2:Sm^{3+} (1 mol %)	83	23
ZrO_2:Sm^{3+} (3 mol %)	92	27
ZrO_2:Sm^{3+} (5 mol %)	93	28
ZrO_2:Sm^{3+} (7 mol %)	95	29
ZrO_2:Sm^{3+} (9 mol %)	91.5	26

Addition precise quantity of sm^{3+} cations leads to the production of defects which act as trap centres, results in a elevated surface barrier, narrower space charge region, however disproportionate quantity of sm3+ in the catalyst may lead to creation of defects, act as the recombination centres which adecrease the catalytic efficiency. In the present study, ZrO_2:Sm^{3+} thin films exhibit higher surface-to-volume ratios resulting in the brilliant photocatalytic degradation of AR under UV light.

CONCLUSION

Sol-gel synthetic route was used for in-situ synthesis of ZrO_2:Sm^{3+} (1-9 mol %) thin films. Crystallite size and Hexagonal Wurtzite structure of the ZrO_2:Sm^{3+} catalyst was confirmed by XRD results. ZrO_2:Sm^{3+} (1-9 mol %) catalysts prepared by sol-gel route exhibits excellent photocatalytic activity under light, attributed due to morphology and higher content of oxygen vacancies. All the obtained results indicate that of Sm^{3+} activated ZrO_2 material is a suitable prominent catalyst for degradation of pollutants.

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SYNTHESIS AND CHARACTERIZATION OF FE-CO-NI NANOCOMPOSITES FOR PHOTOCATALYTIC DYE DEGRADATION IN WASTE WATER

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ABSTRACT

Bimetallic nanomaterial composites are of great interest in scientific research and applications in dye degradation from wastewater. Iron-Cobalt and Nickle nanoparticles with enlarged spherical cages evenly distributed on the exterior of the activated carbon has attracted the attention of researchers in recent times. Examination of photocatalytic degradation of Crystal Violet (CV) is of high importance due to its relevance in unravelling the physicochemical along with electrochemical properties of metal oxide composites. In the current investigation, Cobalt oxides synthesized via combustion route were probed using X-Ray Diffraction (XRD) and implemented to degrade crystal violet (CV) dye from waste water. by observing the variation of concentration of the used photo catalyst. Langmuir and Freundlich isotherms were implemented to examine the equilibrium which indicated a good agreement with results obtained with Langmuir's model. Application of Langmuir equation showed the highest capacity of 79.2168 mg/g and the kinetic study showed the dye adsorption over the surface of Nanoparticles fulfilled pseudo-second-order kinetics model. A comparison of Photocatalysis, adsorption and electrolysis is made for degrading the CV dye. 61.5 % and 59.80 % of elimination of dye was observed through photocatalysis and adsorption respectively with initial CV concentration of 25mg/L and 50mg/L respectively. However, electrolysis showed 86 % elimination at a concentration of 50mg/L.

KEYWORDS *: Ferricoxide/Cobalt oxide/NickelOxide/Grapheneoxide, Crystalviolet, Nanoparticles, Photocatalysis.*

1. INTRODUCTION

Now a day's people are concerned throughout the globe about the access to clean water. Population increase is drastically increasing which automatically leads to decrease in availability of fresh water. A severe need for efficient materials in purification of water with low cost and energy [1] is arising. In this regard nanoscale materials play a vital role due to compact size, huge

surface area, large pores and various lattice defects [2]. Nanoparticles are very much suitable for environmental remediation because of its eco-friendly nature, good oxidizing ability, economical and prolonged stability against photo corrosion and chemical corrosion [3]. Interestingly, the combination of UVlight and TiO_2 removes both chemical species and pathogens simultaneously in polluted water [4]. Semiconductor TiO_2 has been reported to possess oxidative and reductive catalytic nature towards some organic and inorganic pollutants. Hence, it is observed that the total organic carbon is removed from waters polluted with organic wastes using Nano particles aided with ultraviolet light [5]. Azo dyes in water with spectrum of colors offering 10,000 shades of color are found to be toxic, carcinogen and bio recalcitrant [6]. These are squandered in mechanical effluents in wrapping up forms [7].

Colors and shades are widely used in various industries despite its toxicity and harmful release Around 10,000 sorts of colors and shades are delivered every year around the world. About20-30% colors are squandered in mechanical effluents amid the material coloring the wrapping up forms [7]. Colors and shades are broadly utilized, within the materials, plastics, calfskin and restorative industry to color items Most of the dyestuffs, counting azo colors are poisonous and must be expelled over release, into accepting photosynthesis [8]. In present research is done by using mixed metal oxide nanocomposites for dye degradation studies.

2. EXPERIMENTAL

2.1 Reagents

Analytical grade Ni(NO3)2.6H2O ,Co(No3)2.6H2O, Fe(NO3)2.6H2O, Graphene powder, citric acid anhydrous and other reagents of high purity was purchased from Sigma Aldrich and hence was used without any additional purification.

3. SYNTHESIS

3.1: Sample 1: Synthesis of nano metal oxides by using combustion method

Ni(NO3)2.6H2O and Co(No3)2.6H2O were used as precursors for the cations. citric acid anhydrous was used as the fuel.

Stoichiometric ratios of Nickel nitrate hexahydrate Ni(NO3)2.6H2O, cobalt nitrate hexahydrate Co(No3)2.6H2O were dissolved in distilled water and Stoichiometric amount of of citric acid anhydrous was added. The solution was magnetically agitated for 10 minutes. After homogenization, the solutions were heated at 500 ^oC for 30 minutes.

3.2: Sample 2

Ni(NO3)2.6H2O and Co(No3)2.6H2O were used as precursors for the cations. citric acid anhydrous was used as the fuel.

Stoichiometric ratios of Ni(NO3)2.6H2O and cobalt nitrate hexahydrate Co(No3)2.6H2O were dissolved in distilled water and required amount of citric acid anhydrous and graphene powder was added. The solution was stirred using a magnetically agitated for 30 minutes to get homogeneous solution followed by heating at 450- 500 ^oC for 60 minutes.

3.3: Sample 3

Fe(NO3)2.6H2O and Co(No3)2.6H2O were used as precursors for the cations. citric acid anhydrous was used as the fuel. Stoichiometric ratios of Fe(NO3)2.6H2O and Co(No3)2.6H2O were dissolved in distilled water and required amount of of citric acid anhydrous and graphene powder was added .The solution was stirred using a magnetic stirrer for 20 minutes to get homogeneous solution. After homogenization, the solutions were at 450- 500 ^oC for 60 minutes.

4. CHARACTERIZATION

X-ray diffraction (XRD) analysis:

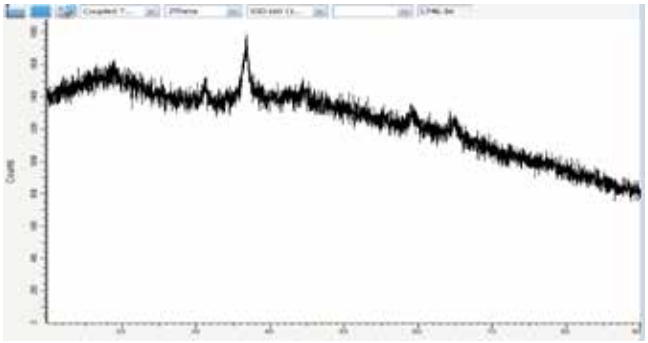

Fig. 1. XRD profiles nanoparticles of different metal oxides. These profiles indicate the formation of crystalline particles of a particular material, XRD profile nickel oxide, cobalt oxide

Sample 1: The XRD indicates the crystallinity of the materials and crystal phases. The prepared sample was cobalt oxide, nickel oxide nanocomposite shown in the

Fig: 1 .The sample XRD pattern showed different peaks at 31.680, 36.460, 55.530, 65.270 which matches ICDD card number 01-074-1656.[9]

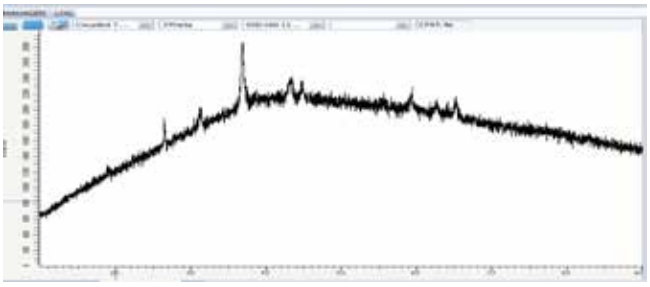

Fig. 2. XRD profiles nanoparticles of different metal oxides. These profiles indicate the formation of crystalline particles of XRD profile grapheme coated nickel oxide, cobalt oxide.

Sample 2: The XRD indicates the crystallinity of the materials and crystal phases. The prepared sample was graphene coated cobalt oxide, nickel oxide nanocomposite shown in the Fig: 2.The sample XRD pattern showed different peaks which matches PDF:38-0175.[10]

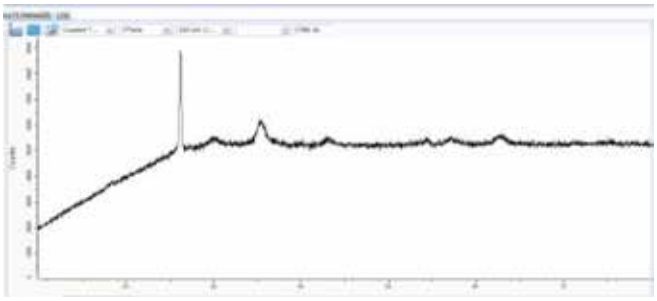

Fig. 3. XRD profiles nanoparticles of different metal oxides. These profiles indicate the formation of crystalline particles of XRD profile grapheme coated cobalt oxide and iron oxide.

Sample 3: The XRD indicates the crystallinity of the materials and crystal phases. The prepared sample was graphene coated iron oxide, nickel oxide nanocomposite shown in the Fig: 3,The sample XRD pattern showed different peaks which matches JCPDS #22-1086.[11]

5. PHOTOCATALYTIC DEGRADATION OF PHARMACEUTICAL POLLUTANTS

5.1: Crystal violet dye degradation

The action of varying quantity of catalyst (Sample-1) on degradation of CV was analysed using varying quantities of catalyst from 0.0005 mg to 0.0015 mg by keeping CV concentration of 5.0 mg/L. The degradation effectiveness of catalyst Sample-1 on CV is shown in Figures 4 & 5, which shows that the rate of degradation elevates significantly with increasing quantity of catalyst. The reactivity is due to the increase in active sites on the surface with the increasing quantity of catalyst sample-1 up to 0.15 mg. The maximum degradation efficiency was 43.90 percentage in 120 minutes.

The action of varying quantity of catalyst (Sample-2) on degradation of CV was examined varying catalyst from 0.0005 mg to 0.0015 mg by maintaining CV concentration of 5.0 mg/L. The degradation effectiveness of Nano catalyst Sample-2 on CV is shown in Figures 6 & 7, which makes evident that the rate of degradation elevates drastically with a high quantity of catalyst. The observed reactivity is due to the increase in active sites on the surface with the increase in amount of catalyst sample-2 up to 0.10 mg. Due to increased turbidity of suspension caused by absorption when the quantity of catalyst exceeded 0.0010 mg, the penetration of sunlight was reduced. A high degradation efficiency of 41.1percentage was obtained with 0.0010mg of catalyst sample-2 in 120 minutes.

The consequence of amount of catalysts (Sample-3) on degradation of CV was evaluated utilizing varying quantity of catalyst from 0.0005 mg to 0.0015 mg by keeping CV concentration of 5.0 mg/L. The degradation effectiveness of catalyst Sample-3 on CV is shown in figure 8 & 9, which shows that the rate of degradation increases significantly with increase in amount of catalyst. This is due to the increased availability of active sites on the surface with the increase in amount of catalyst sample-1 up to 0.15 mg. The best degradation efficiency of 85.5 percentage was achieved with 0.0010mg of catalyst sample-3 in 120 minutes.

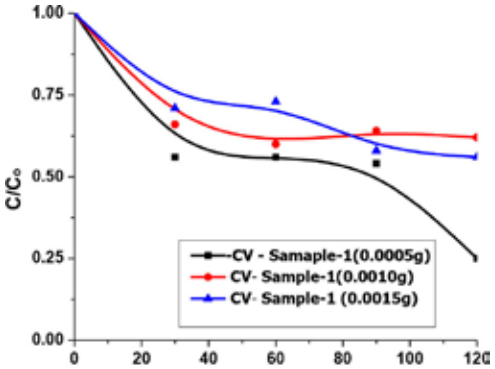

Figure-4: Effect of amount of catalyst (Sample- 1) on Degradation of CV ([CV]= 5.0 mg/L, T=298K)

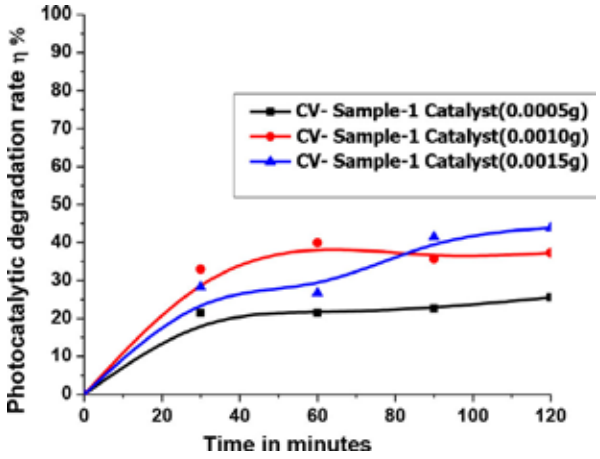

Figure 5. Effect of amount of catalyst (Sample-1) on Degradation of CV ([CV]= 10.0 mg/L, T=298K)

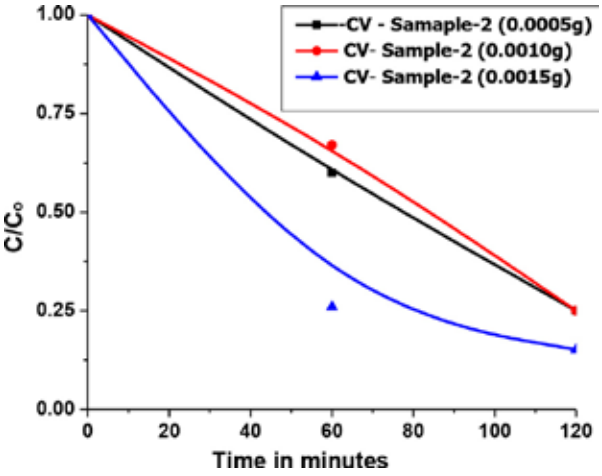

Figure 6. Effect of amount of catalyst(Sample-2) on Degradation of CV ([CV]= 5.0 mg/L, T=298K)

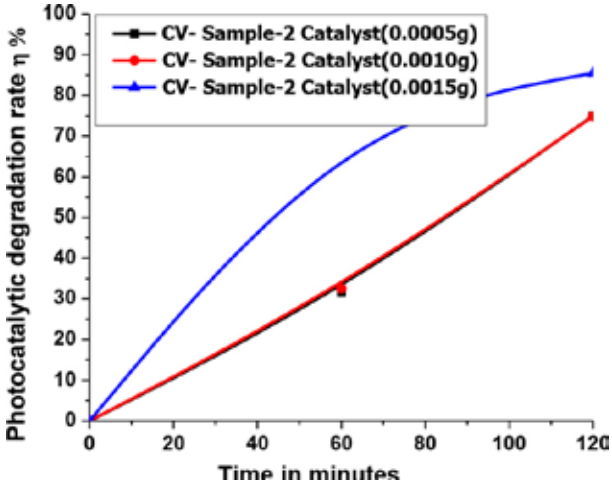

Figure 7. Effect of amount of catalyst(Sample-2) on Degradation of CV ([CV]= 5.0 mg/L, T=298K)

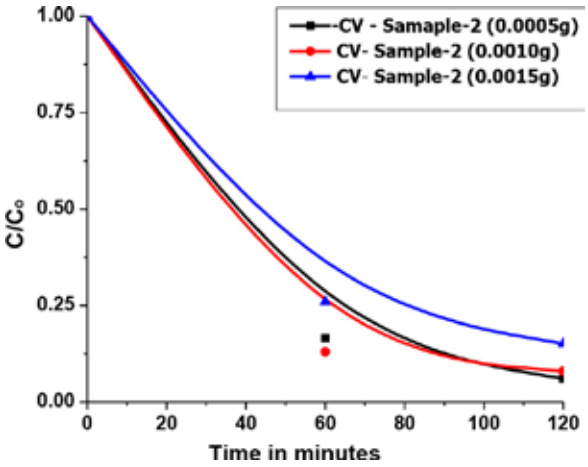

Figure 8. Effect of amount of catalyst(Sample-2) on Degradation of CV ([CV]= 5.0 mg/L, T=298K)

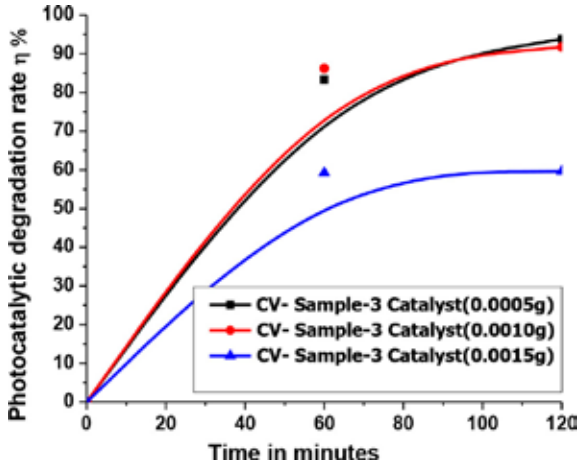

Figure 9. Effect of amount of catalyst(Sample-2) on Degradation of CV ([CV]= 5.0 mg/L, T=298K)

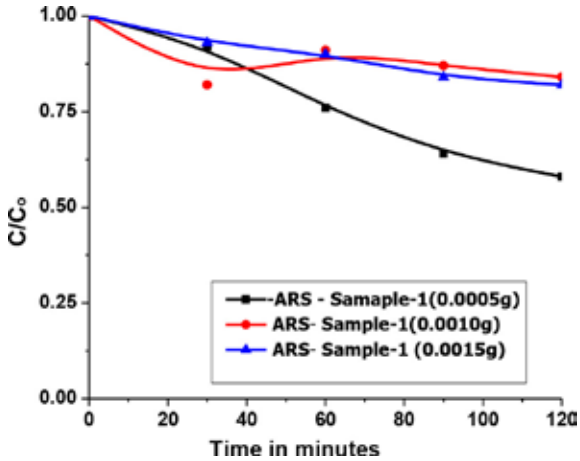

Figure-10. Effect of amount of catalyst (Sample-1) on Degradation of ARS ([ARS]= 10.0 mg/L, T=298K)

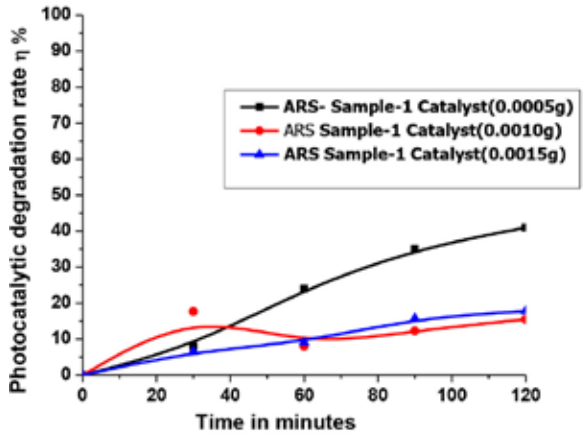

Figure 11. Effect of amount of catalyst (Sample-1) on Degradation of ARS ([ARS]=10.0 mg/L, T=298K)

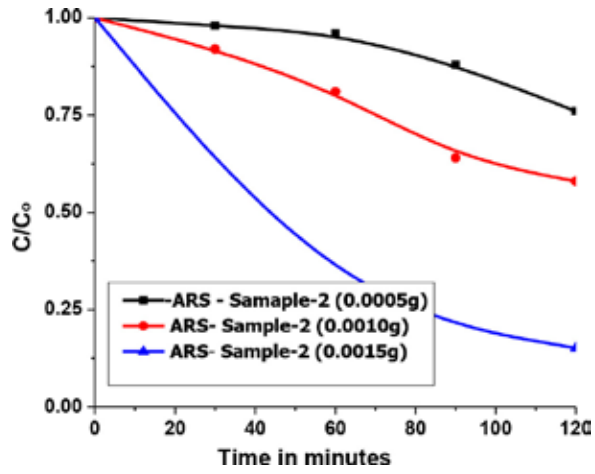

Figure 12. Effect of amount of catalyst(Sample-2) on Degradation of ARS ([ARS]= 5.0 mg/L, T=298K)

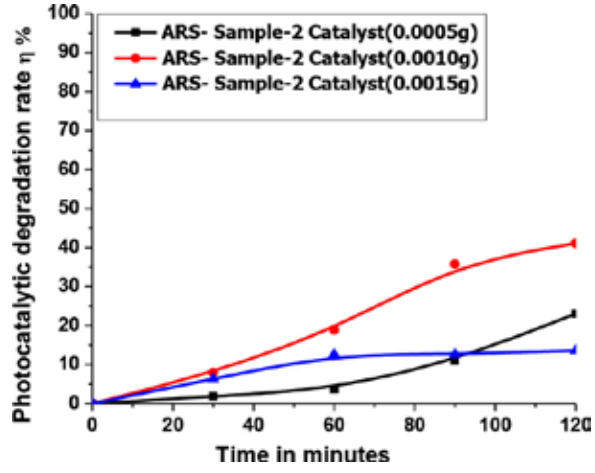

Figure 13. Effect of amount of catalyst(Sample-2) on Degradation of ARS ([ARS]= 10.0 mg/L, T=298K)

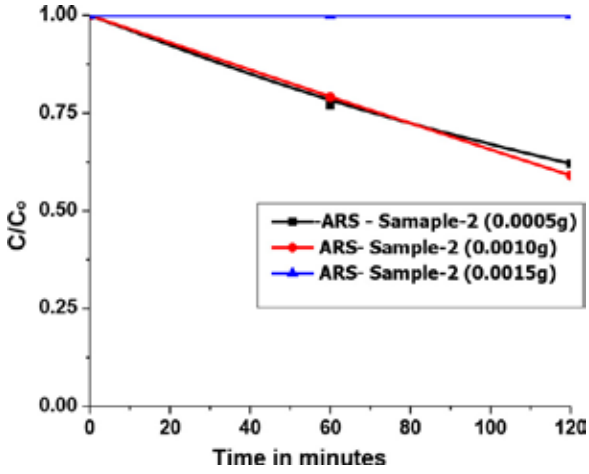

Figure 14. Effect of amount of catalyst(Sample-2) on Degradation of ARS ([ARS]= 5.0 mg/L, T=298K)

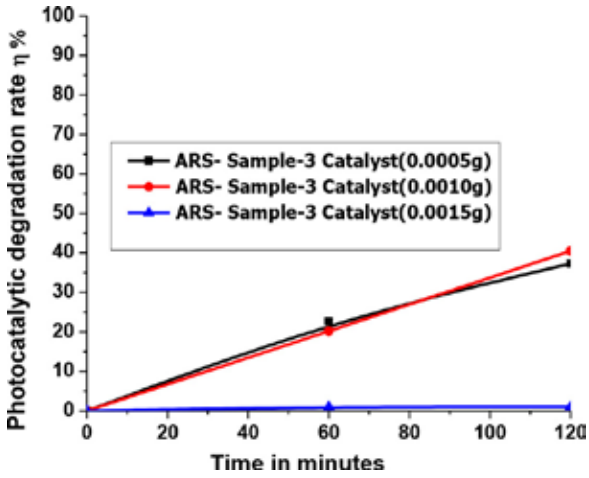

Figure 15. Effect of amount of catalyst(Sample-2) on Degradation of ARS ([ARS]= 5.0 mg/L, T=298K)

CONCLUSION

It is evident from the present study that degradation of CV dye is higher in the first 30 minutes and over 80.0% degradation was obtained by absorption of dye on the exterior of the catalyst and then reaching 92.89% in 150 minutes. A depleted degradation rate was observed under similar conditions in the absence of light with degradation being 60.0% in 150 minutes observed in the direct UV light. The degradation rate was only 17.80% in the same period in the direct UV light without catalyst. With the catalyst exceeding 2.5 mg, the turbidity of suspension hindered the penetration of sun light and the catalyst aggregates scattered the light thereby proving to be not beneficial. Maximum degradation rate was observed with 0.0025g/L of

catalyst. Catalyst Sample- 2 & 3 can acts as an efficient catalyst for degradation of CV dye. Sample-1, 2 & 3 could not act as an efficient catalyst for degradation of ARS dye due to a similar charge.

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INDIAN BENTONITE CLAY DERIVED GREEN CATALYTIC MATERIAL FOR ESTERIFICATION OF P-CRESOL WITH PHENYL ACETIC ACID UNDER MICROWAVE IRRADIATION

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ABSTRACT

A green heterogeneous catalytic material derived from treatment of Indian Bentonite clay with aqueous solution of p-Toluene sulphonic acid (p-TSA) is reported for esterification of phenyl acetic acid with p-cresol. p-TSA treatment not only introduced acidity to the clay sample but also resulted in improved surface characteristics. The change in surface characteristics of catalyst samples after treating with various concentrations of p-TSA was characterized using various techniques like XRD, BET surface area and TPD ammonia. Reaction conditions were optimized and under optimum conditions effect of various catalyst samples and mode of heating in the esterification of phenyl acetic acid with pcresol were investigated. Bentonite clay treated with 0.5M p-TSA was found to exhibit optimum activity for the said reaction. Reactions under solvent free microwave irradiation were found to be advantageous and faster compared to that of conventional heating methods.

KEYWORDS *: Heterogeneous, Bentonite clay, p-cresyl phenyl acetate*

1. INTRODUCTION

Clays are the naturally occurring, abundantly available, low cost, eco-friendly, noncorrosive, and nontoxic materials. Several categories of clay minerals such as kaolin's, Smectite and palygorskites-sepiolite with different structure and composition are available [4]. These materials can be modified appropriately to alter their pore size, structure and activity and are used as heterogeneous catalysts to catalyze many organic transformations [1-3]. Among these clays, Smectite type are most commonly used as heterogeneous catalysts for organic transformations mainly due to their large surface area, varying physicochemical property, outstanding surface acidity and recyclability [3]. Smectic clays occur in different forms such as Na, Ca, Mg, Fe and Li-Al silicates. Na or Ca composed smectic clays are known as Bentonites which exhibit 2:1 layered structure in which central octahedral sheet is sandwiched between two silica tetrahedral sheets. Octahedral sheet consists of Mg^{2+} or Al^{3+} metal cations surrounded by six oxygen or hydroxyl anions. Tetrahedral sheet consists of Si^{4+} cation surrounded by four oxygen anions. Replacement of an Al^{3+} in octahedral layer with Mg^{2+} results in a net negative charge. These negative charges present in octahedral layers are compensated by positive charges of Ca^{2+} or Mg^{2+} cations present in the interlayer position. Further, these interlayer cations are exchangeable and can be replaced with varieties of different charged chemical species. Hence, physicochemical properties of Bentonites can be easily modulated to obtain verities of materials with different pore size, surface area which could be employed as heterogeneous solid catalytic materials in many organic transformations [3,4].

Several methods have been reported for the modification of Clay minerals to impart catalytic activity. Few of them are acid activation, cation exchange, and pillaring[3].Acid activation includes, treating clays with mineral acids such as hydrochloric, sulphuric, nitric and phosphoric acids to replace interlayer cations with hydrogen ions [5].In cationic exchange process, the interlayer cations naturally present in clays are exchanged with cations of higher charge or polarizability[3]. Acidity of these cation exchanged clays is mainly attributed to dissociation of water molecules coordinated to cation to release proton. Ability of cation to dissociate coordinated water to produce proton depends on polarizability of cation. The Polarizing effect of exchangeable cations like Al^{3+}, Ce^{3+}, Fe^{3+}, Cr^{3+} depends on charge to size ratio and also to number of coordinated water molecules. Cations with smaller size, greater charge and more number of coordinated water molecules can dissociate water easily, thus imparting higher acidity to Bentonite clay [5,6]. In case of pillared clays, stable inorganic molecules are introduced between the layers so as to increase the interlayer spacing subsequently enhancing surface area. Pillaring can prevent collapsing of layered structure of clay upon heating [7]. Porous clay hetero-structure (PCH) modified pillared clays use surfactant directed method to bring silica pillars into the interlamellar site of the clay [3]. Various semi-synthetic materials derived from clay by impregnation of different metal oxides which exhibit wide range of surface properties, acidity and thermal stability have been reported [8,9]. These modified forms of Bentonite clay have been extensively employed in waste water treatment, synthesis of biodiesel and various organic transformations such as condensation, esterification, alkylation, acylation, reduction, oxidation, addition and substitution reactions [3,10].

p-cresyl phenyl acetate is an ester used extensively in industrial applications mainly in the production of floral soaps, perfumes, fragrance's, flavor's, cosmetics, and plasticizers.

Due to their ease of availability, environmental friendliness and cost effectiveness, modified clays have been used as heterogeneous catalysts for esterification reactions under both solvent and solvent free conditions. These catalysts are considered to be green solid acid catalysts due to its non-toxicity, eco-friendliness and reusability. Organic reactions carried out through microwave irradiation have more advantages than conventional heating due to rapid in core volume heating, less time with higher reaction rate. Combination of microwave heating with eco -friendly clay derived heterogeneous catalyst under solvent free conditions can be considered to be an effective Green synthesis approach for the esterification reaction.

Several homogeneous and heterogeneous acid catalysts have been employed in the esterification of phenyl acetic acid with p-cresol. Reddy.et.al.[14] reported synthesis of pcresyl phenyl acetate using metal ion exchanged clays in the presence of solvent under conventional heating. This method uses organic solvent which is hazardous and toxic and also involves longer reaction

time and tedious separation procedure.

Thus in the present work, we report Indian Bentonite clay derived heterogeneous green catalyst for the esterification of phenyl acetic acid with p-cresol. Clay was activated to enhance acidity by treating with para-Toluene sulphuric acid (p-TSA). Esterification of phenyl acetic acid with p-cresol was investigated under solvent free conditions using microwave irradiation. This novel method of using reusable, separable, heterogeneous clay catalyst under solvent free condition with microwave irradiation is a green route for synthesis of p-cresyl phenyl acetate.

2. MATERIALS AND METHODS / EXPERIMENTAL

Finely powdered Bentonite clay was procured from Asha Pura chemicals, India. Chemicals used in the study namely Para Toluene sulphonic acid (p-TSA), phenyl acetic acid, pcresol were procured from S.D. Fine Chemicals, India. Para cresol was distilled and dried over anhydrous CaCl2 prior to use. Phenyl acetic acid and p-TSA were used directly without further purification.

2.1. Activation of Bentonite clay using p-TSA

Bentonite clay was activated by treating with p-TSA. In a typical procedure, 10 g of bentonite clay was weighed into a 250ml round bottom flask and 100mL of aqueous solution of p-TSA of known concentration (0.1M, 0.3M, 0.5M and 1M) was added. The mixture was heated under microwave radiation at 100°C for 10 min. Microwave heating was carried out in START-S microwave lab station equipped with inbuilt infrared temperature control and magnetic stirrer. After the completion of treatment, the reaction mixture was centrifuged and washed with hot water multiple times until centrifugate was neutral to separate solid clay catalyst. Further, catalyst samples were dried at 373K for 5hrs and finally ground to a fine powder. The clay catalyst samples treated with 0.1M, 0.3M, 0.5M and 1M p-TSA solutions were designated as 0.1M PBT, 0.3M PBT, 0.5M PBT, and 1MPBT respectively. The untreated clay was designated as UBT.

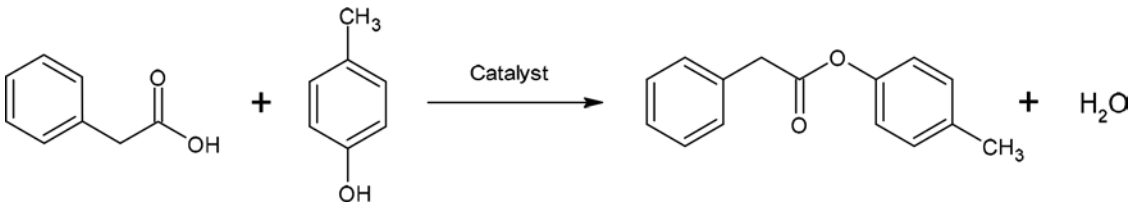
2.2. Characterization of p-TSA treated clay catalysts

The catalyst samples, 0.1M PBT, 0.3M PBT, 0.5M PBT, 1MPBT and UBT were characterized using various techniques. Bruker powder X-ray diffractometer was used to obtain Powder X-ray diffraction data. Quanta Chrome Nova-1000 BET surface analyzer was used to measure Brunauer-Emmett-Teller (BET) specific surface area and nitrogen adsorption-desorption isotherms at liquid nitrogen temperature. Temperature programmed desorption (TPD) with ammonia was employed to measure the total acidity of original and p-TSA treated clays samples.

2.3. Catalytic activity of p-TSA treated clay catalyst (Esterification)

Esterification reactions were carried out under microwave irradiation in START-S microwave lab station which is equipped with software and an inbuilt infrared temperature sensor to control the temperature online.

In a typical procedure, a known amount of p-cresol, phenyl acetic acid (Scheme-1) and clay catalyst samples were taken in a 50 ml microwave glass reactor vessel. Teflon coated magnetic stirrer was added to the reaction mixture and reactor vessel is fitted with an air cooled condenser. The reaction was carried out under microwave heating with constant stirring at a specific temperature and for a known period of time without using solvent. In order to evaluate the activity of UBT, 0.1M PBT, 0.3M PBT, 0.5M PBT and 1M PBT clay samples, various reaction parameters such as reaction temperature, mole ratio of reactants, reaction time and amount of catalyst on conversion of phenyl acetic acid were studied. Reaction mixture was analyzed in Gas chromatograph, Chemito (GC1000) equipped with TR-WAX capillary column (30 m length, 0.32 mm thickness and 0.5m ID) with Flame ionization detector.



Scheme -1: Schematic representation of esterification of phenyl acetic acid with p-cresol

3. RESULTS AND DISCUSSION

3.1. Characterization of p-TSA treated catalysts

Powder XRD patterns of clay samples are shown in Figure 1. No significant change was observed between the XRD patterns of original and p-TSA treated bentonite clay samples. This clearly shows that structural integrity of the clay remains intact after p-TSA treatment. Enhanced specific surface area, acidity (Bronsted and Lewis) and both micro and mesoporosity was observed with increase in the p-TSA concentration from 0.1M to 0.5M (Table-1). However, beyond 0.5Mp-TSA, concentration no significant changes in catalyst characteristics were observed.

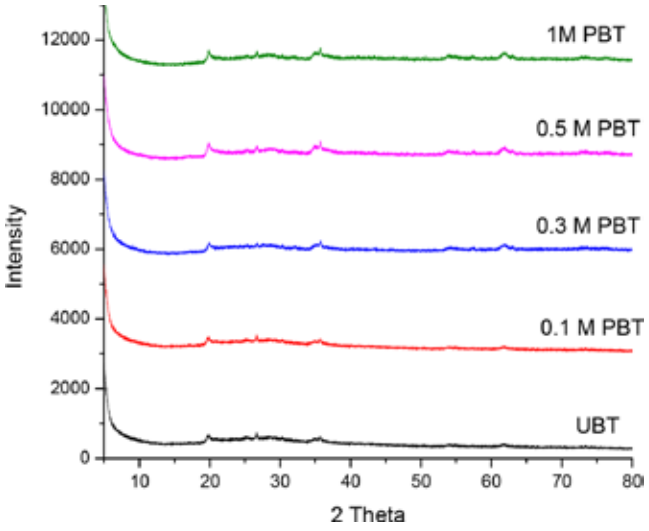


Figure 1. XRD patterns of untreated and p-TSA-treated clays

3.1.1. Surface area of p-TSA treated catalysts

The surface characteristics like the specific surface area, average pore volume and average pore diameter of untreated and p-TSA-treated clays were tabulated in Table 1. The surface area of Bentonite clay increased with increase in the concentration of p-TSA. It was found to be 29.6 m^2g^{-1} for UBT and 133 m^2g^{-1} for 0.5M PBT. This increase in surface area with increase in concentration of p-TSA is apparently due to removal of Al from octahedral layer, creating a vacant space in hexagonal rings of clay structure. The Al thus removed from framework is moved to interlayer space and contributes to acidity. A significant increase in surface area is achieved from 0.1M PBT to 0.5M PBT due to removal of available aluminum ions in the framework. Further, after all accessible aluminium ions are completely removed; there is no much change in surface area with increase in concentration of p-TSA to 1 M.

3.1.2. Acidity of p-TSA treated catalysts

Acidity of the acid treated clay samples is mainly due to removal of aluminium from the frame work of clay and subsequent movement to interlayer space where it dissociates coordinated water molecules producing protons. These protons are responsible for the Bronsted acidity of the acid treated catalyst [14]. Bronsted acidity of the p-TSA treated clays is also attributed to same phenomenon. To measure the acidity of the clay catalysts samples TPD ammonia was employed. Here, one ammonia molecule is adsorbed on each Bronsted acid site forming NH^{4+} ion [19]. Ammonia desorbed in µmol/g of clay as measured by TPD ammonia technique for various clay samples is given in the Table 1. As the concentration of p-TSA increases from 0.1M to 0.5M the amount of ammonia desorbed is also increased. Further no change in ammonia desorption is observed when concentration of p-TSA increases from 0.5M to 1M. This clearly shows that the amount of Bronsted acid sites increase with increase in the concentration of p-TSA till 0.5M and remains almost same for 1M.

Table 1. Surface characteristics and TPD-NH3 of p-Toluene sulphonic acid treated catalyst samples.

Catalyst	Surface area (m^2g^{-1})	Average Pore Volume (cm^3/g)	Average Pore Diameter (Å)	Amount of Interlayer Al (milli equiv./g clay)	TPD ammonia desorbed (µmol/g of clay)
UBT	29.6	0.037	50.27	-	-
0.1M PBT	92.1	0.079	34.10	0.25	62
0.3M PBT	110	0.093	34.93	0.39	153
0.5M PBT	133	0.117	35.31	0.68	218
1M PBT	133	0.117	35.31	0.70	218

3.2. Catalytic synthesis of p-cresyl phenyl acetate

The catalytic activity of the original and p-TSA treated clay samples are evaluated in the esterification of p-cresol with PAA. Reactions were carried out under MW irradiation. For comparison, the esterification reaction was also conducted under conventional heating in a temperature-regulated oil bath equipped with a magnetic stirrer under reflux conditions. Reactions under microwave irradiation were found to proceed at much faster rate than under conventional heating. But, the same conversion and yield was observed in both modes of heating. The reaction carried over the conventional method required 6 hr to achieve maximum yield, whereas the same was accomplished in 60 min under microwave irradiation. This is due to different modes of heat transfer from source to the reaction mixture. In conventional mode, the heat from the source transferred to oil bath, to the reaction mixture through reaction vessel. In this process, there is heat loss each step and also more time is needed to achieve thermal equilibrium. Whereas, in MW mode of heating microwave radiation directly interacts with the change in dipole of the molecules present in reaction mixture resulting rapid molecular rotation and collision leading to in core volumetric rapid heating of reaction mixture. This results in the attainment of thermal equilibrium faster than conventional mode of heating.

3.2.1. Effect of Temperature

In order to study the effect of temperature on the esterification of phenyl acetic acid with para cresol, series of reactions were conducted varying temperature from 363 K to 463 K with 0.5M PBT clay catalyst under otherwise similar experimental conditions with the application of a maximum microwave power of 1000 W. A profound effect of temperature on esterification reaction was observed. The variation in conversion of phenyl acetic acid with temperature is shown in Figure 2. Conversion of phenyl acetic acid increased with the increase in temperature from 363 K to 463 K. This increase in conversion is tandem with increase in temperature indicates the endothermic nature of the reaction.

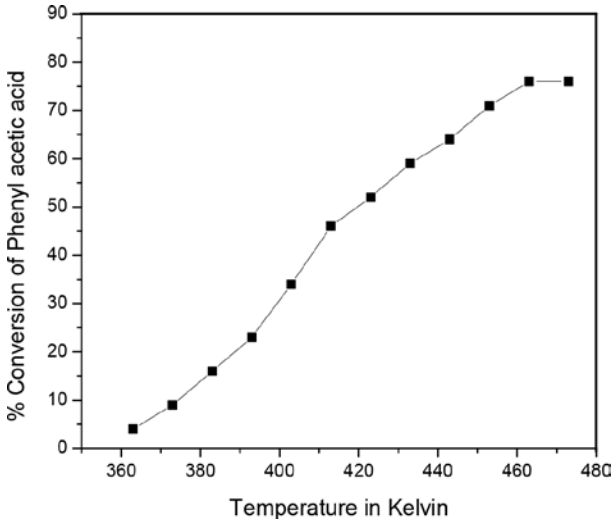


Figure 2. Effect of Temperature on conversion of phenyl acetic acid

Conditions: Reaction time: 60 minutes, Molar ratio of reactants 1:2, Catalyst amount 1g, Catalyst: 0.5 M PBT, Maximum MW power 1000W.

3.2.2. Effect of Catalyst Amount

In the present study, the catalyst amount was varied in the range of 0.1- 2.0 g to examine the effect of catalyst amount on the conversion of phenyl acetic acid. Figure-3 exhibits the effect of catalyst amount on the conversion of phenyl acetic acid. The conversion increases with an increase in catalyst amount from 0.1 to 1.0g which is apparently due to the hike in the number of active catalytic sites. Beyond 1.0 g, the activity of the catalyst was found to be constant.

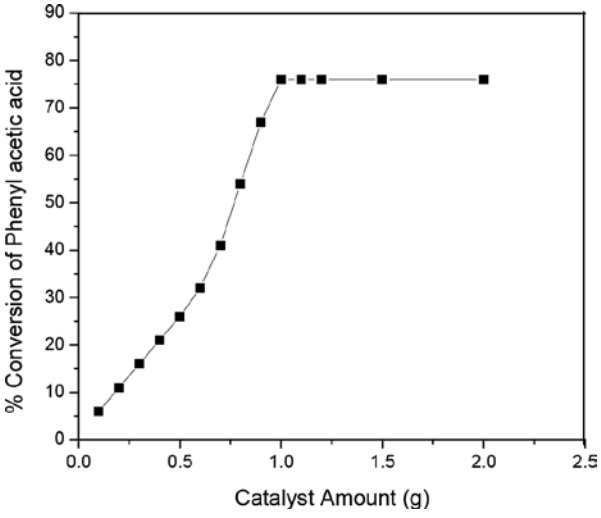


Figure-3: Effect of catalyst amount on conversion of phenyl acetic acid

Conditions: Reaction time: 60 minutes, Molar ratio of reactants 1:2, Catalyst: 0.5 M PBT, Temperature: 463 K, Maximum MW power 1000W.

3.2.3. Effect of Reaction Time

The effect of reaction time for synthesis of p-cresyl phenyl acetate was investigated and results are illustrated in Figure 4. An increase in ester yield on increasing in time duration of the reaction from 0 to 60 minutes with microwave irradiation is observed. Subsequently, beyond 60 minutes, there was no appreciable increase in yields. This may be attributed to attainment of reaction equilibrium. For comparison, under otherwise similar conditions, the reactions were conducted with conventional heating varying reaction time duration from 0 to 360 minutes. Conversion increased with increase in time similar to the trend observed with microwave heating, but with much longer duration. Conversion stabilized in 360 minutes under conventional heating compared to 60 minutes under microwave heating. Faster reaction rate under microwave heating is attributed to direct, rapid in-core, volumetric heating of reaction mixture under microwave irradiation. However, the final yield and equilibrium conversion was observed to be similar under both modes of heating.

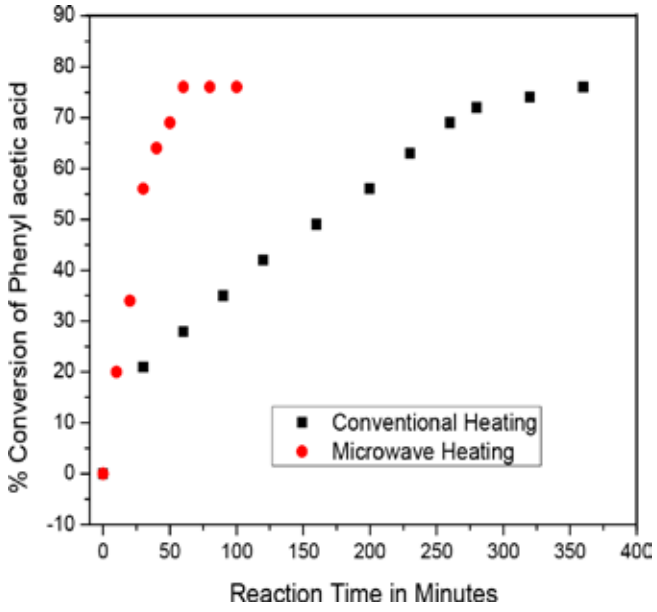


Figure 4. Effect of Reaction time on conversion of phenyl acetic acid

Conditions: Molar ratio of reactants 1:2, Catalyst amount 1g, Catalyst: 0.5 M PBT, Temperature: 463 K.

3.2.4. Effect of Catalyst Type

Catalytic activity of untreated and p-TSA treated clay samples namely as 0.1M PBT, 0.3M PBT, 0.5M PBT,1MPBT and UBT were evaluated under optimum reaction conditions of 463 K, 1.0 g of catalyst, 1:2 mole ratio and for 60 minutes duration under microwave heating. No conversion of phenyl acetic acid was observed on UBT. In case of p-TSA treated clay samples conversion increased from 0.1M PBT to 0.5MPBT. No significant variation is observed between and 0.5M PBT and1M PBT. This variation is in accordance with TPD ammonia desorbed (μmol/g of clay) values. Esterification is a Bronsted acid catalyzed reaction, therefore conversion of phenyl acetic acid is clearly linked to number of acid sites available in the catalyst samples. Number of Bronsted acid sites increased from 0.1M PBT to 0.5M PBT resulting in increased conversion. Similar conversion over 0.5M PBT and 1M PBT samples is due to similar number of acid sites. The results of the study are shown in Table 2.

Table 2. Effect of various p-TSA treated catalysts in Esterification

Catalyst	% Conversion
UBT	19
0.1 M PBT	34
0.3 M PBT	58
0.5 M PBT	76
1 M PBT	76

Conditions: Reaction time: 60 minutes, Molar ratio of reactants 1:2, Catalyst amount 1g, Temperature: 463 K, Maximum MW power 1000W.

3.2.5. Effect of mole ratio of reactants

Effect of molar ratio of reactants on conversion of phenyl acetic acid was studied by varying phenyl acetic acid to p-cresol mole ratio from 3:1 to 1:3 with 1g of 0.5M PBT catalyst at 463 K. No variation in conversion was observed when amount of phenyl acetic acid was increased but, a clear increase in conversion was observed when amount of p-cresol was increased. This clearly indicates the interaction of p-cresol with acid site of the catalyst during esterification. Conversion remained almost same when mole ratio was further increased from 1:2 to 1:3 shown in Table 3 [13].

Table 3. Effect of Mole ratio of reactants

Molar Ratio of Reactants	% Conversion
3:1	29
2:1	38
1:1	54
1:2	76
1:3	77

Conditions: Reaction time: 60 minutes, Catalyst: 0.5 M PBT, Catalyst amount 1g, Temperature: 463 K, Maximum MW power 1000W.

3.2.6. Catalyst Recyclability

Major advantage of a heterogeneous catalytic reaction carried over solid acid catalyst is the recovery and reusability of the catalyst after the reaction. In order to check the reusability of clay catalyst used in this reaction, it was collected after each reaction cycle, washed thoroughly with deionised water, dried at 383 K for about 5 hours and tested again in second cycle under otherwise similar experimental conditions. The results are summarized in Table 4. Activity of regenerated catalyst sample was found to be similar to that of original catalyst even after third cycle. This clearly shows that the catalyst is not deactivated during the reaction and it can be recovered and reused.

Table 4. Reusability of the catalyst

Catalyst	% Conversion
Fresh	76
First Recycle	75
Second Recycle	74
Third Recycle	72

Conditions: Reaction time: 60 minutes, Molar ratio of reactants 1:2, Catalyst amount 1g, Catalyst: 0.5 M PBT, Temperature: 463 K, Maximum MW power 1000W.

4. CONCLUSION

Synthesis of p-Cresyl phenyl acetate by esterification of phenyl acetic acid with p-cresol over modified environmental friendly clay derived catalysts under solvent free, microwave irradiation is a green synthesis procedure. The catalyst exhibited good activity as well as selectivity with reusability. Reactions under microwave heating were observed to be very much faster with reaching equilibrium conversion in just 60 minutes compared to 360 minutes under conventional heating. Among various catalysts studied catalyst treated with 0.5 M p-TSA (0.5M PBT) exhibited optimum catalytic activity. The other optimum conditions favoring the formation of p-cresyl phenyl acetate are a temperature of 463 K, mole ratio of 1:2, and catalyst loading of 1g with 60 minutes under microwave irradiation.

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OXIDATION KINETICS OF ORANGE G BY CHLORAMINE-T IN THE PRESENCE OF HCL AND NAOH MEDIUMS: A SPECTROPHOTOMETRIC APPROACH

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ABSTRACT

Orange G (OG) is a widely used synthetic azo dye. Kinetics and mechanism of oxidation of OG by Chloramine-T (CAT) in HCl and NaOH medium have been spectrophotometrically investigated under pseudo first-order conditions (λmax =478 nm) in the temperature range of 298 -316 K. Under similar experimental conditions, reactions in both HCl and NaOH mediums follow a first-order dependence of rate on [OG]o. Reaction constants and Activation parameters have been computed. Benzene and 1,2-dioxo-naphthalene-4,6-disulfonic acid were identified as the oxidation products of OG with CAT in HCl and NaOH mediums. From the experimental data, related rate law and plausible mechanism of reaction have been deduced for the observed kinetics.

KEYWORDS *: Orange G, Chloramine-T, Kinetics, Oxidation.*

1. INTRODUCTION

Azo dyes are the most used among synthetic dyes due to their ability to produce brilliant shades. Production of azo dyes follows a simple and cost effective process. Due to these reasons, production of azo dyes has seen a huge increase over last few decades [1-4]. The azo group present in the azo dyes acts as the chromophore. This group is generally linked to either benzene or naphthalene rings on either sides. The $-SO_3H$ or $-SO_3Na$ and -OH groups which are attached to benzene and naphthalene rings increases the solubility of azo dyes in water [5,6] Orange G (OG) is a synthetic azo dye having the chemical name 1- phenylazo-2-naphthol-6,8-disulfonic acid disodium salt and represented by the chemical formula $C_{16}H_{10}N_2Na_2O_7S_2$. Orange G is used in histology in many staining formulations [7]. It is a tracking dye used in nucleic acid electrophoresis to track DNA front in agarose gels and also in SDS-capillary electrophoresis as a standard. Orange G has been extensively used in applications like coloring of silk and wool materials and also in the manufacturing of wood, paper, ink, and color pencil. As it is released to water after usage, Orange G is found extensively in textile wastewaters [8-10]. Orange G can cause irritation in the respiratory and gastrointestinal tracts and it is considered to be a potential health hazard substance. In aqueous solutions, anaerobic biomass is also affected by this Orange G dye.

Alok D. Bokare et al [11] studied use of Iron-Nickel bimetallic nanoparticles for reductive degradation Orange G in aqueous solution. Asem A Atia et al [12] investigated removal of Orange G through adsorption on magnetic silica which is modified with amine functional groups. J.P.Shubha et al [13] studied mechanistic investigation of oxidation of Orange G by chloramine-B and bromamine-B in acid medium by spectrophotometric method. Orange G degradation by ultrasound irradiation in the presence of heterogeneous photocatalyst Titanium dioxide (TiO_2) was explored by Jagannathan madhvan et al [14]. Bagasse fly ash was used as adsorbent for the removal of Orange-G dye by Indra D. Mall et al [15]. M. Muthukumar et al [16] studied removal of Orange-G from aqueous solutions by electrochemical method. JianhuiSun et al [17] studied the degradation Orange G (OG) on nitrogen-doped TiO_2 photocatalysts under sunlight exposure. M.A.Meetani et al [18] carried out photocatalytic degradation of Orange G with Ultra voilet (UV) light in the presence of Titanium dioxide (TiO_2) mixed with 20% of chromium oxide catalyst. Nalenthiran et al [19] investigated the catalytic ozonation of Orange G in the presence of Au-Bi_2O_3/ Bi_2O_3 nanocatalysts. G. Thennarasu et al [20] studieded photocatalytic degradation of OG using synthesized nanocrystalline Znic Oxide as a photocatalyst and sunlight as the irradiation source. Fenton oxidation process was investigated by Sheng-Peng Sun et al for decolorization of Orange G in aqueous solution by [21]. Degradation of OG in aqueous solutions by persulfate with ferrous ion was studied by Xiang Rong Xu and Xiang Zhong Li [22] .

Detailed literature survey revealed that, mechanistic and kinetic investigation oxidation of Orange G (OG) by Chloramine – T (CAT) has not been reported so far. Therefore, in this study, we are reporting the mechanistic and kinetic investigation of oxidation of Orange G by CAT in both acidic HCl and basic, NaOH mediums.

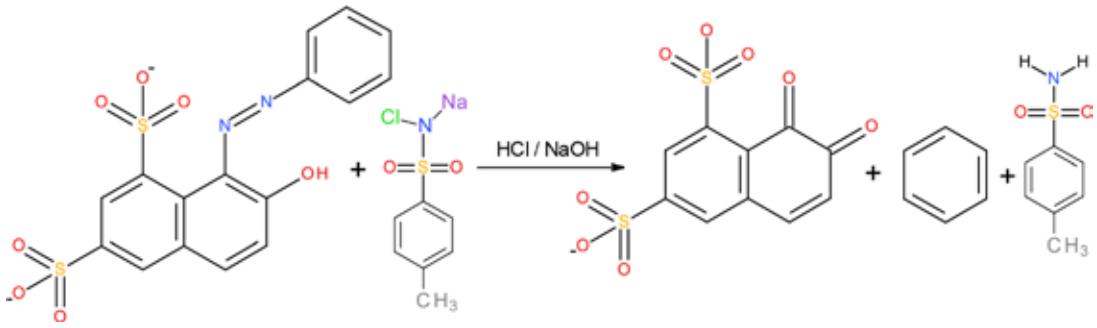
2. EXPERIMENTAL WORK

2.1 Spectrophotometric Kinetic Procedure

All experiments of kinetic investigations were carried out using an UV-visible spectrophotometer, Chemito UV-2100. A temperature range of 298K to 316K was used in this investigation process, to conduct kinetic runs. A constant required temperature fir a kinetic run was maintained within an accuracy of ±0.1K using a digital temperature control system. All kinetic experimental processes were conducted under pseudo first- order conditions, in which [oxidant]o was taken in excess compared to [OG]o with constant concentration of HCl and NaOH medium at temperature of 298K . All oxidation reactions were effected in glass stoppered pyrex boiling tubes. The exterior surface of the glass stoppered Pyrex boiling tubes used in the experiments were coated with Black colour to avoid any photochemical effect on the reaction conversion. All the reactants, namely OG dye, HCl or NaOH solutions and water (to maintain same volume for all the runs) and the required amounts of oxidant, were taken in separate boiling tubes and kept in the thermostat at temperature of 298K for 30 minutes. Then, quickly a calculated amount of oxidant, CAT was added to initiate the oxidation process into the reaction mixture containing the substrate OG dye, and HCl or NaOH. After that, immediately a 3 mL of this reaction mixture was transferred to a cuvette through pipette and it is placed in spectrophotometer. The kinetic experimental runs were conducted at wavelength of 478 nm which is the λmax for OG dye, upto two half-lives. The absorbance readings at imitial time, t = 0 (D_o) and at time, t = t (D_t) were noted down from the spectrophotometer. The plots of log (D_o/D_t) versus time were obtained from the data. These plots were employed to determine pseudo-first-order rate constants (k) and the values were reproducible within ±5%. Origin 8.5 software was used for the regression analysis of the experimental data to evaluate the regression coefficient, r.

2.2 Reaction Stoichiometry

Eeaction stoichiometry was determined from the reaction of the reaction mixture having different ratios of oxidant, CAT to OG dye in the presence of 0.1 $moldm^{-3}$ of HCl or NaOH medium at temperature of 298K for about 48 hours. The iodometric titration procedure was followed to calculate the left out oxidant, CAT after the process of oxidation. Results showed that OG dye reacted with oxidant CAT in the ratio of 1:1 at temperature of 298 K. One equivalent of CAT was consumed by one equivalent of substrate at 298K. This, same 1:1 stoichiometry was observed in both HCl as well as NaOH mediums. From the reaction stoichiometry and analysis of oxidation products, a possible reaction scheme was deduced and is represented in the Reaction scheme 1 shown below.



Reaction Scheme 1: Reaction scheme for the stoichiometric oxidation of OG dye by Chloramine -T.

2.3 Analysis of the oxidized products of OG dye

For determining the oxidized products of OG dye, the reaction was carried out between OG dye and oxidant in the stoichiometric ratio in both acid and alkaline mediums for 48 hours at temperature of 298K. The progress and completion of the reaction was monitored by thin layer chromatography. After completion of reaction, the products were initially neutralised by adding dilute HCl or NaOH and were extracted into ethyl acetate. The products were identified to be benzene and 1,2-dioxo- naphthalene-4,6-disulfonic acid. These oxidized products of OG dye were further confirmed by LC-MS analysis. LC-MS spectra of the reaction sample after completion of the oxidation reaction is depicted in Figure 1. It was also revealed from the spectra that, 1,2-dioxo-naphthalene-4,6- disulfonic acid and benzene do not undergo any further reaction with CAT under the present experimental conditions.

The reduction product of CAT was identified to be para toluenesulfonamide (PTS) by paper chromatography. This was again confirmed among other products by LC-MS analysis.

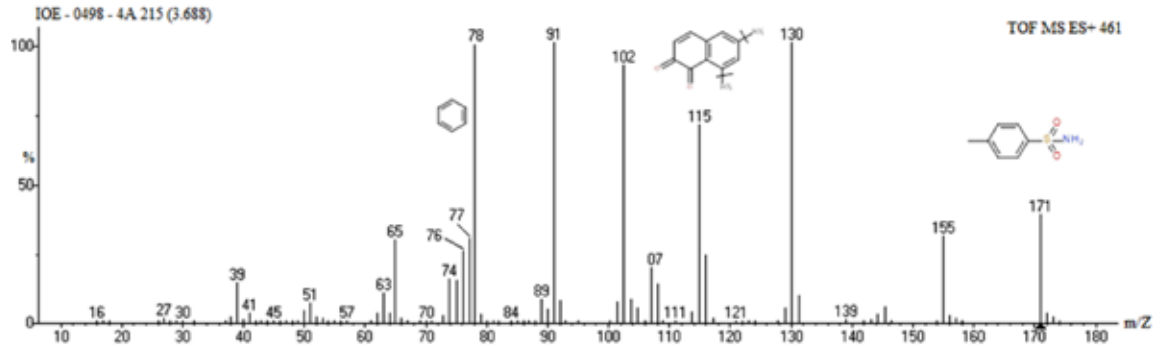


Figure 1. LC-MS spectra recorded after the oxidation reaction of OG dye with CAT.

3. RESULTS AND DISCUSSION

Ultra voilet-Visible spectra for the oxidation process of OG dye by CAT in the presence of HCl and also in the presence of NaOH were recorded separately under different time intervals. These spectra as shown in the Figure 2, clearly proved the of 75 % and 100 % de- colorization of OG dye at 45 minutes and 24 hours respectively. Similar de-colorization was observed both in the presence of HCl and NaOH.

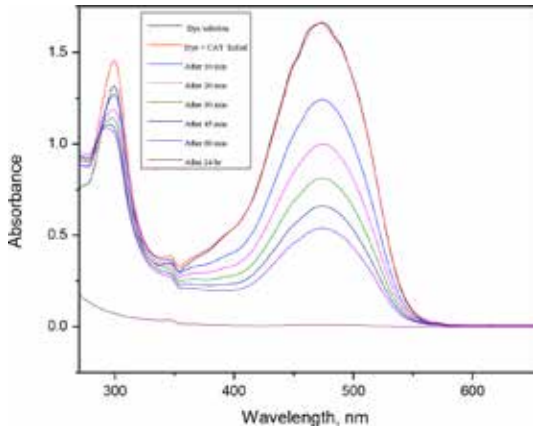


Figure 2: UV-Visible spectrum recorded during de-colorization OG dye at different intervals of time.

3.1 Effect of Concentration of OG Dye on its oxidation Rate

The kinetics of oxidation of OG dye by oxidant, CAT was investigated at different initial concentrations of the reactants, under pseudo first-order conditions, taking [oxidant]o >> $[OG]_o$, in both HCl and NaOH medium at temperature of 298 K. Under these pseudo first-order conditions keeping constant [Oxidant]o, [HCl]/ [NaOH] and temperature, only the initial concentration of dye $[OG]_o$ was varied. The plots of log (Absorbance) versus time were drawn and found to be linear with r>0.9952, indicating a first-order dependence of rate on $[OG]_o$ in both HCl and NaOH mediums. The linear nature of these plots in both mediums, along with the constancy of the slopes obtained at different $[OG]_o$, clearly proves the first-order dependence of rate on $[OG]_o$. The pseudo first-order rate constant values (k) obtained from these experiments are recorded in Table 1.

Table 1: Effect of varying initial dye concentration, $[OG]_o$ on the rate of oxidation.

$[NaOH]_o$ = 3.0 X 10^{-3} mol/dm^3, $[CAT]_o$ = 3.0 X 10^{-4} mol/dm^3, μ = 0.3 mol/dm^3 T= 299 K, [HCl] = 3 × 10^{-3} mol/dm^3

	10^4k (s^{-1})	
10^5 $[OG]_o$ mol dm^{-3}	NaOH	HCl
1.0	2.03	3.33
2.0	2.12	3.44
3.0	2.09	3.36
4.0	1.98	3.35
5.0	2.11	3.21

3.2 Effect of changing concentration of oxidant, CAT on the reaction rate

Under the identical experimental conditions, keeping the concentration of [OG]0, [HCl]0 or [NaOH]o and also temperature constant, an increase in the initial concentration of oxidant, [CAT]0 resulted in the increase in the value of k. Representative spectrophotometric absorption values for the oxidation of OG dye by oxidant, CAT in HCl and NaOH medium are depicted in Table 2. Linear plot of log(absorbance) vs time which is used to determine the rate constant values for the oxidation of OG dye by CAT in HCl and NaOH medium is shown in Figure 3. Then, the plot of logk vs log[CAT] was obtained which is shown in Figure 4. This plot of logk vs log[CAT] was found to be linear exhibiting the slope of 1.069 (R2 = 0.9917) and 1.068 (R2 = 0.979) respectively for HCl and NaOH medium indicating first order dependence of rate on the concentration of oxidant, [CAT]. The first order dependence of rate on the concentration of oxidant, [CAT] was further confirmed by the plot of k vs [CAT] which was linear and also passed through the origin in both the cases.

Table 2: Effect of varying [CAT]o on the rate of oxidation of OG dye.

$[NaOH]_o$ = 3.0 X 10^{-3} mol/dm^3, $[OG]_o$ = 4.0 X 10^{-5} mol/dm^3, μ = 0.3 mol/dm^3 T = 299 K, [HCl] = 3 × 10^{-3} mol/dm^3

		NaOH		HCl	
10^4[CAT] mol dm^{-3}	5+log[CAT]	10^4k (s^{-1})	5+logk	10^4k^1 (s^{-1})	5+logk
1.0	1	0.59	0.771	1.11	1.045
1.5	1.176	0.78	0.892	1.81	1.258
2.0	1.301	1.11	1.041	2.34	1.369
3.0	1.477	2.03	1.307	3.35	1.525
4.0	1.602	2.51	1.399	5.03	1.701
5.0	1.689	2.85	1.455	6.29	1.798

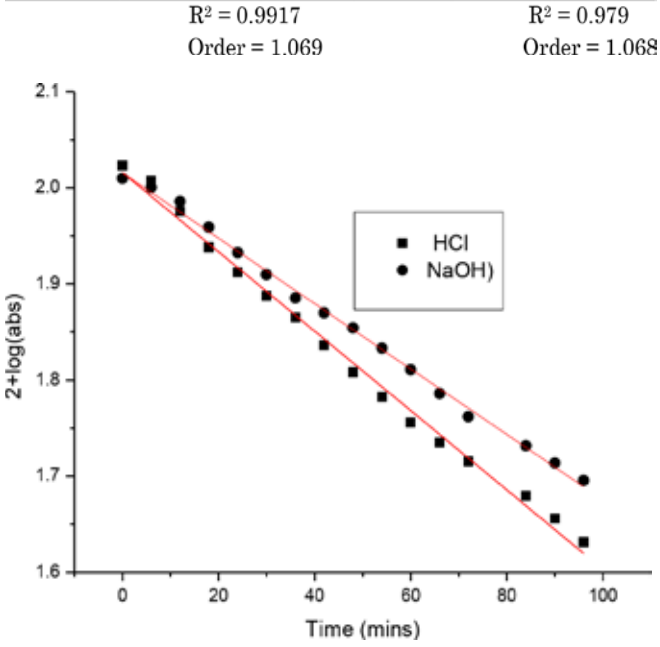


Figure 3: A plot of log (absorbance) vs time for the oxidation of OG dye by CAT in HCl and NaOH medium

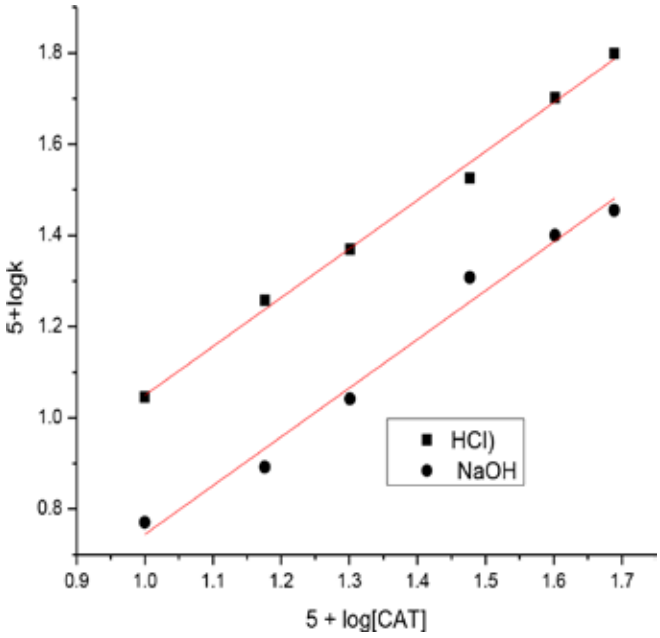


Figure 4: Plot of log k vs log [CAT].

3.3 Effect of varying concentration of HCl and NaOH mediums on the rate of oxidation of dye

It was observed from the results of the experiments that rate of oxidation of OG dye was increased with increase in concentration of HCl. The order with respect to HCl was determined from the plot of logk vs log[HCl] which is displayed in Figure 4. The plot was found to be linear with a slope of 0.537 (R2 = 0.989), which clearly showed the fractional order dependence of rate on the concentration of [HCl].

The rate of oxidation of OG dye was studied at different concentrations of NaOH by carrying out reactions keeping other experimental conditions constant. It was clearly demonstrated that the rate of oxidation of the OG dye was decreased with increase in concentration of NaOH. The order of the reaction with respect to concentration of NaOH was determined from the plot of logk vs log[NaOH] which is shown in Figure 4. The plot was found to be linear with a negative slope of -0.834 (R2 = 0.997) which clearly revealed inverse fractional order dependence of rate on [NaOH]. The rate constant values determined at different concentration of HCl and NaOH are shown in Table 3.

Table 3: Effect of varying [HCl]o and [NaOH]o on the rate of oxidation of OG dye.

$[OG]_o$ = 4.0 X 10^{-5} mol/dm^3, $[CAT]_o$ = 3.0 X 10^{-4} mol/dm^3 μ = 0.3 mol/dm^3 T= 299 K.

		NaOH		HCl	
10^4[HCl]/ 10^4[NaOH] mol dm^{-3}	5+log[HCl]/ 5+log[NaOH] mol dm^{-3}	10^4k (s^{-1})	4+logk	10^4k (s^{-1})	4+logk
1.0	1	4.83	0.684	1.98	0.297
2.0	1.301	2.79	0.445	2.89	0.461
3.0	1.477	2.03	0.307	3.35	0.525
4.0	1.602	1.55	0.19	4.19	0.622
5.0	1.698	1.25	0.097	4.76	0.678
		R^2 = 0.988 Order = 0.537		R^2 = 0.997 Order = -0.834	

3.4 Effect of varying halide ion concentration on the oxidation rate

In order to study the effect of concentration of halide ions on the rate of oxidation of OG dye, the concentration of halide ions (Cl- and Br- ions) was varied in the range of 1× 10-3 to 10 × 10-3 under both HCl and NaOH mediums. It was clearly observed that in HCl medium, the change in concentration of Cl- and Br- ions had negligible effect on the rate of oxidation reaction. It was also revealed that rate of oxidation of OG dye depends on only [H+] and not on [halide]. Similarly, even in NaOH medium also, the change in concentration of halide ions had negligible impact on the rate of oxidation of dye. The values of rate constants detrmined at different chloride and bromide ion concentration in both HCl and NaOH medium are tabulated respectively in Table 4 and Table 5.

Table 4: Effect of chloride ions on the rate of oxidation of OG dye

[NaOH] = [HCl] = 3.0 X 10^{-3} mol/dm^3, $[OG]_o$ = 4.0 X 10^{-5} mol/dm^3, μ=0.3 mol/dm^3 [CAT] = 3.0 X 10^{-4} mol/dm^3 T= 299 K.

	10^4k (s^{-1})	
10^4 [NaCl] mol dm^{-3}	NaOH	HCl
1.0	2.00	3.32
2.0	2.08	3.66
5.0	1.99	3.34
10.0	2.04	3.50

Table 5: Effect of bromide ions on the rate of oxidation of OG dye

[NaOH] = [HCl] = 3.0 X 10^{-3} mol/dm^3, $[OG]_o$ = 4.0 X 10^{-5} mol/dm^3, μ = 0.3 mol/dm^3, [CAT] = 3.0 X 10^{-4} mol/dm^3 T= 299 K

	10^4k (s^{-1})	
10^4 [NaBr] mol dm^{-3}	NaOH	HCl
1.0	2.11	3.38
2.0	2.08	3.71
5.0	1.96	3.42
10.0	2.18	3.54

3.5 Effect of varying PTS concentration on the rate of oxidation reaction

The effect of reduction product of CAT,that is p- toluene sulfonamide (PTS) on the rate of oxidation of OG dye was studied by varying concentration of PTS in the range of 1× 10-3 to 4 × 10-3 keeping all other experimental parameters constant. Increase in concentration of PTS showed a negligible effect on the rate of oxidation reaction in both HCl and NaOH medium. The values of rate constants obtained at different concentration of PTS are tabulated in Table 6. This clearly proved the absence of the role of PTS in the rate determining step of the reaction.

Table 6: Effect of concentration of PTS on the rate of oxidation.

[NaOH] = [HCl] = 3.0 X 10^{-3} mol/dm^3, $[OG]_o$ = 4.0 X 10^{-5} mol/dm^3, μ = 0.3mol/dm^3, [CAT] = 3.0 X 10^{-4} mol/dm^3 T= 299 K.

	10^4k (s^{-1})	
10^4 [PTS] mol dm^{-3}	NaOH	HCl
1.0	2.10	3.30
2.0	1.98	3.56
3.0	2.08	3.25
4.0	2.07	3.56

3.6 Effect of ionic strength variation on the rate of oxidation of OG dye

To study the effect of the ionic strength (μ) of the medium, NaClO4 was used in the reaction and its concentration was varied in the range of 0.1 to 0.4 mol/dm3 by keeping other experimental conditions constant in both HCl and NaOH medium. The values of rate constants determined at different concentration of $NaClO_4$ are summarized in Table 7. It was clearly observed that rate of oxidation of OG dye increased with increase in concentration of $NaClO_4$ in both HCl and NaOH medium. A plot of log k vs $\mu^{1/2}$ was found to be linear with positive slope which is shown in Figure 6. Therefore, ionic strength of the medium was maintained constant at 0.3 mol/dm^3 of $NaClO_4$ concentration for all remaining kinetic runs.

Table 7: Effect of varying ionic strength on the rate of oxidation

[NaOH] = [HCl] = 3.0 X 10^{-3} mol/dm^3, [OG]o = 4.0 X 10^{-5} mol/dm^3, [CAT] = 3.0 X 10^{-4} mol/dm^3 T= 299 K.

			NaOH		HCl	
$[NaClO_4]$ mol dm^{-3}	μ	$(\mu)^{1/2}$	10^4k (s^{-1})	5+logk	10^4k (s^{-1})	5+logk
1.0	0.005	0.07	1.12	1.049	2.05	1.312
2.0	0.04	0.200	1.42	1.152	2.36	1.373
3.0	0.18	0.424	2.03	1.307	3.35	1.525
4.0	0.32	0.565	2.58	1.412	4.25	1.628

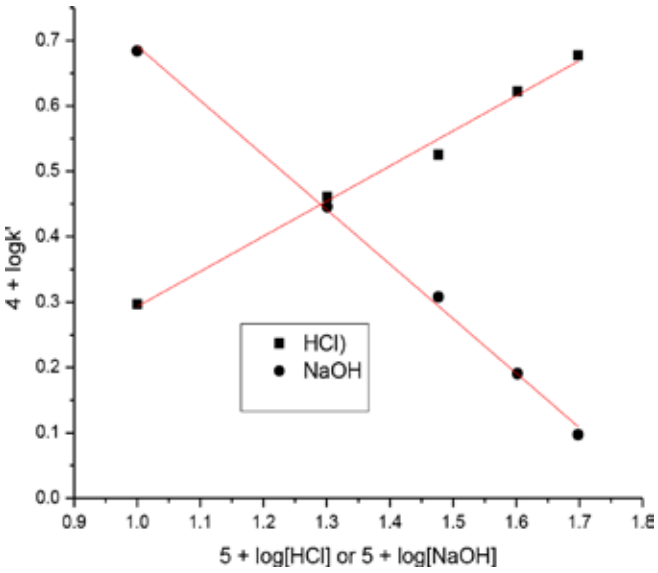


Figure 5: Plot of log k vs log [HCl] and log [NaOH]

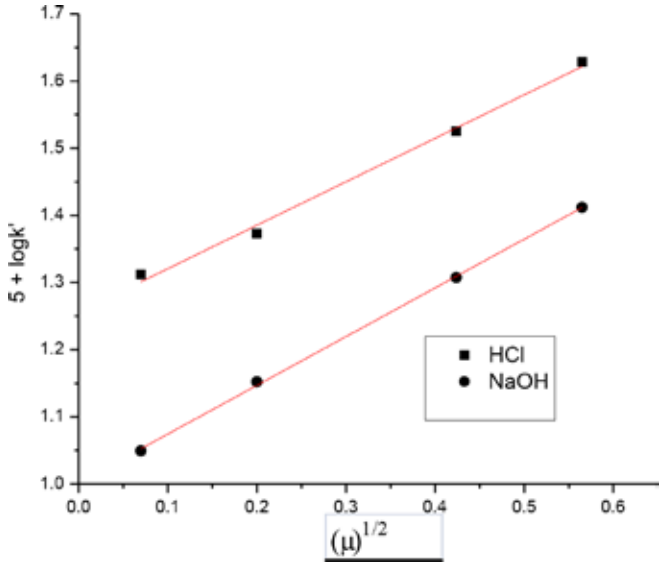


Figure 6: Plot of log k vs μ1/2

3.7 Effect of varying dielectric constant of the medium on the rate of oxidation of OG dye.

Methanol at different volume compositions (0-20% v/v) was used in the experiment to investigate the effect of dielectric constant of the medium on the rate of oxidation reaction in both HCl and NaOH medium. Experiments revealed the rate of oxidation of OG dye to be decreasing with increase in the concentration of methanol in both HCl and NaOH medium. The rate constant values determined from the experiments are tabulated in Table 8. The linear plot of logk vs 1/D was obtained with R2 = 0.997 and R2 = 0.998 values respectively for HCl and NaOH medium. The slope was found to be negative as depicted in Figure 7.

Table 8: Effect of dielectric constant on the rate of oxidation of OG dye

[NaOH] = [HCl] = 3.0 X 10^{-3} mol/dm^3, $[OG]_o$ = 4.0 X 10^{-5} mol/dm^3, [CAT] = 3.0 X 10^{-4} mol/dm^3 μ = 0.3 mol/dm^3 T= 299 K.

			NaOH		HCl	
%MeOH (v/v)	D	1/D	10^4k (s^{-1})	5+logk	10^4k (s^{-1})	5+logk
0	76.73	0.0130	2.03	1.307	3.35	1.525
5	74.50	0.0134	1.56	1.193	2.79	1.445
10	72.37	0.0138	1.125	1.096	2.16	1.334
20	67.48	0.0148	0.77	0.886	1.22	1.086
			R^2 = 0.997			R^2 = 0.993

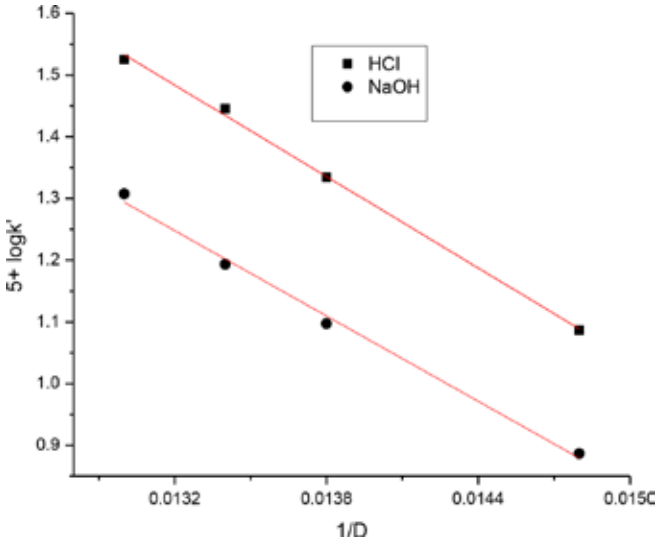


Figure 7: Plot of log k vs 1/D

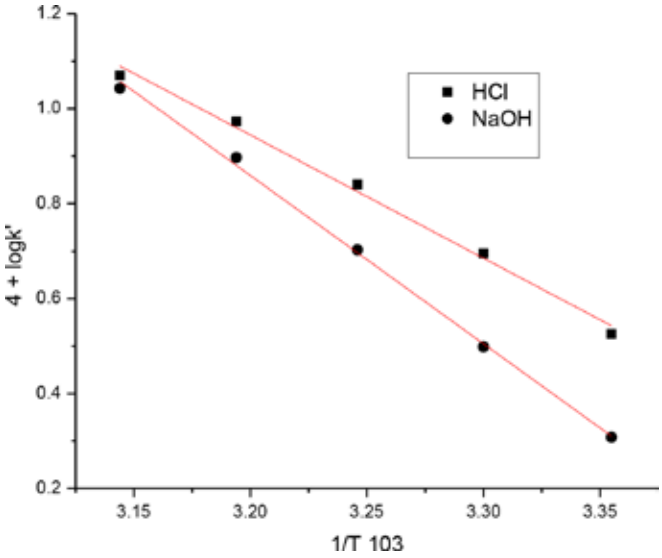


Figure 8: Arrhenius plot of log k vs 1/T

3.8 Effect of varying temperature on the reaction rate of oxidation of OG dye

The effect of temperature on the reaction rate of oxidation of OG dye was investigated by conducting the experiments at five different temperatures while maintaining all other experimental conditions constant. Arrhenius plots of logk vs 1/T were obtained for HCl and NaOH mediums with R^2 = 0.992 and R^2 = 0.993 respectively. The plots were linear as shown in Figure 8. The rate constant values calculated at different temperatures in both mediums are shown in Table 9. Using these Arrhenius plots, activation energy (Ea), frequency factor (A), entropy of activation (ΔS#), enthalpy of activation (ΔH#), and free energy of activation (ΔG#) were calculated and shown in Table 11.The rate of transition state formation and conversion of transition state to products could be understood from these values of activation parameters.

Table 9: Effect of varying temperature on the rate of oxidation.

[NaOH] = [HCl] = 3.0 X 10^{-3} mol/dm^3, $[OG]_o$ = 4.0 X 10^{-5} mol/dm^3, [CAT] = 3.0 X 10^{-4} mol/dm^3 μ = 0.3 mol/dm^3.

		NaOH		HCl	
Temperature (K)	**10^3 (1/T) (K^{-1})**	**10^4k (s^{-1})**	**4+logk**	**10^4k (s^{-1})**	**4+logk**
298	3.355	2.03	0.307	3.35	0.525
303	3.300	3.15	0.498	4.95	0.694
308	3.246	5.04	0.702	6.92	0.840
313	3.194	7.89	0.897	9.39	0.973
318	3.144	11.04	1.043	11.74	1.069

(HCl) R^2 = 0.992, Slope = -2593.5, (NaOH) R^2 = 0.998, Slope = -3543.1

4. CONCLUSIONS

Investigation of kinetics and mechanism of oxidation reaction of OG dye by Chloramine-T (CAT) as oxidant in both HCl and NaOH medium by spectrophotometric method under pseudo first-order conditions, with λmax =478 nm, in the temperature range of 298 -316 K clearly revealed that under otherwise similar experimental conditions, reactions in both HCl and NaOH mediums follow a first- order dependence of rate on initial concentration of dye, [OG]o. From the experimental data, reaction constants and activation parameters were computed. Benzene and 1,2-dioxo-naphthalene-4,6-disulfonic acid were identified as the oxidation products of OG dye with CAT as oxidant in HCl and NaOH mediums. The study revealed that, the activation parameters such as energy of activation and other thermodynamic parameters were found to be moderate under acidic as well as basic medium. The low enthalpy of activation obtained from the results suggests that no major bond breaking or forming is involved before formation of transition state. Further, low enthalpy along with negative entropy of activation indicates an associative mechanism during the formation of the transition state. Higher degree of order on moving from initial ground state to the transition state is indicated from negative entropy of activation.

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EXPLOITING THE PHOTO STABLE PROPERTIES OF COUMARIN DERIVATIVE FOR THE DETECTION OF METAL IONS IN SOLUTIONS

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ABSTRACT

Metal ions are essential in many biochemical and physiological functions if they are in low concentrations and become dangerous when certain limit is exceeded. Their detection even at low concentration is very much required. This research article register the detection of Cu++ using a coumarin derivative 3-(Bromoacetyl) coumarin by spectroscopic methods. Metal ions are capable of decreasing the absorbance (OD) and emission intensity of the coumarin derivative dissolved in methanol. The sample concentration is maintained at 10-5M. The addition of Cu++ decreases OD by nearly 72% . The absorption peak is located at 270nm and remains undisturbed with the addition of metal ion and increase in the concentration of metal ion. This indicates that the ground state is not affected. Emission spectra are recorded by exciting the sample at a wavelength 272nm. When metal ion concentration is increased a gradual decrease in the emission intensity from 1025 to 487 (about 53% decrease) is observed. This is a clear indication of successful quenching effective binding between the host (coumarin) and the guest (metal ion) with no modifications in the excited state properties.

The experimental data is handled using Benesi-Hildebrand plots which are found to be linear. Binding constant is evaluated by taking the ratio of intercept and slope. The higher value of binding constant represents the formation of stable complex between metal ion and studied compound. The studied coumarin derivative has greater affinity towards metal ions. It can play a vital role in the designing of metal ion sensor

KEYWORDS *: Metal ions, Coumarin, Binding constant*

INTRODUCTION

Biologically effective fluorescent organic molecules such as derivatives of coumarins, boronic acids, imdazoles, thiophenes etc. play important roles in the design metal ion sensors. They are also used to study binding interactions of biomolecules namely proteins, lipids and carbohydrates.

i. Metal ions

Actually Metal ions are formed when a metal lose electrons in the higher energy level and become positive ion called cation. Non metals, on the other hand, gain electrons and become negative ions called anions. Metal ions have been identified as key players in the biological system for billions of years. Some of the examples are here. Zinc metal ion may not be harmful but can pose threat in bulk quantities. Copper deficiency leads to several health problems such as anemia, bone abnormalities, osteoporosis etc and also becomes toxic to the extent of damaging DNA and Alzheimer disease if it is taken in excess.[1-3]. Some of the toxic metal ions such as copper, zinc, nickel, cadmium, mercury, lead, arsenic etc are getting added to the environment through various means. They enter and accumulate in living organisms through air, water and soil. The detection of these environmental poisons is done through techniques such as atomic absorption spectroscopy, UV-VIS and fluorescence spectroscopy, etc [4,5]

ii. Spectroscopic method

In spectroscopic method a low concentration solution is prepared by dissolving Coumarin in solvents of different viscosity and polarity. Absorption and emission spectra are recorded. Metal ions in aqueous solution, with very low concentration (10-3M) are then added to it in steps and the spectra are re-recorded. The addition of metal ions leads to reduction in the absorbance (OD) or emission intensity (AU) (sometimes increase also!) [6,7]. This kind of spectroscopic variations indicates that there is some effect of metal ion on the coumarin and this effect is nothing but binding interaction. The extent of binding and binding sites are calculated by calculating binding constant (Ka) enthalpy and Gibbs free energy (ΔG)

iii. Coumarin derivative

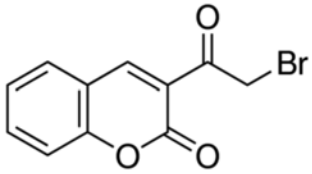
The name 'Coumarin' is derived from 'Coumarou'-tonka bean, from which coumarin itself was isolated in 1820[8]. Coumarin is classified as a member of the benzopyrone family of compounds, all of which consist of a benzene ring joined to a pyrone ring. Coumarins comprise a very large class of compounds found throughout the plant kingdom. Coumarin is also found in fruits, green tea and other foods such as chicory. Coumarins are well known laser dyes, exhibit strong fluorescence in the UV and VIS region, exhibit biological properties. They are used as therapeutic agents, in electronic and photonic applications, charge transfer complexes, solar energy collectors, colorants, dye laser media etc [9-11].

EXPERIMENTAL

In this connection, we have chosen a coumarin derivative namely 3-(Bromoacetyl) coumarin (C11H7BrO3. Molecular Weight 267.08) (C1) purchased from Sigma Aldrich. Its molecular structure is as in Fig.. It is dissolved in Methanol - a spectroscopic grade solvent. To begin with, sample solution is prepared with a concentration of 10-6M in Methanol (ML) by standard method.

Cu++ metal ion of concentration 1mM is prepared by dissolving Copper nitrate in 1000 ml of double distilled water. It is then added to sample solution in the step of 0.1ml, 0.2ml, 0.3ml, 0.4ml, 0.5ml, 0.6ml, 0.7ml, 0.8ml, 0.9ml and 1ml.

The absorption spectra of all the samples are recorded using UV-Visible Spectrometer (UH5300). The scanning wavelength range is 200nm-500nm with a scanning speed of 0.5nm.



RESULTS AND DISCUSSIONS

In host–guest chemistry, the formation of a complex is a basic and important process. The binding constant (K_a),an essential parameter for the quantitative analysis of the complex formation has to be determined. In fact it is used as a criterion for the evaluation of the host-guest complexation process. Other Thermodynamic parameters like enthalpy, entropy and Gibbs free energy are also more suitable standards.

Binding affinity between Coumarin derivatives and metal ions can be determined using UV-VIS and fluorescence spectroscopic method which has an edge over other methods because of sensitiveness, rapidness and requirement of very little sample [12-18]

K_a values are calculated using a derived equation called Benesi-Hildebrand(B-H) equation that connects

the spectroscopic variations (both OD and AU) to the concentration of metal ions [19].

At equilibrium,

Coumarins (host) + Metal ions (guest) → Complex

[C] *[M]* *[CM]*

The binding constant (or association constant) is given by

$$K_a = \frac{[CM]}{[C][M]} \quad (1)$$

Assuming [M]>>[C], one can prove that [19].

$$\frac{A}{\Delta A} = \frac{m}{nK_a}\frac{1}{[M]} + \frac{m}{n} \quad (2)$$

Where,

A the absorbance (OD) in the absence of metal ions

$\Delta A (= A_0 - A)$ the change in OD

$[M]$ the metal ion concentration

m and n constants (depend on the molar extinction coefficients of host and complex formed)

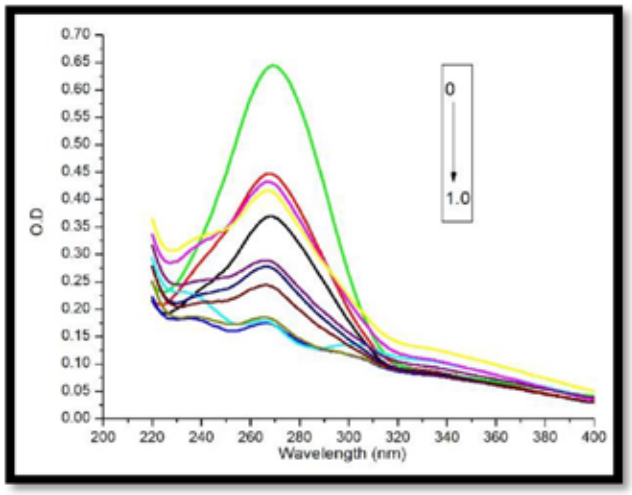
A graph of equation (2) is linear and K_a is obtained from its y- intercept and slope. Using binding constant, Gibbs free energy changes (ΔG) of complexes are evaluated using the equation

$$\Delta G = -(RT)\ln K \text{ (kJ mol}^{-1}\text{)} \quad (3)$$

Gibbs free energy change represents the spontaneity/ non- spontaneity of compound–Metal ion binding.

1. Binding study by UV-spectroscopy:

The absorption spectra of 3-(Bromoacetyl) coumarin (C1) in the solvent methanol with and without copper ion (Cu++) is presented below



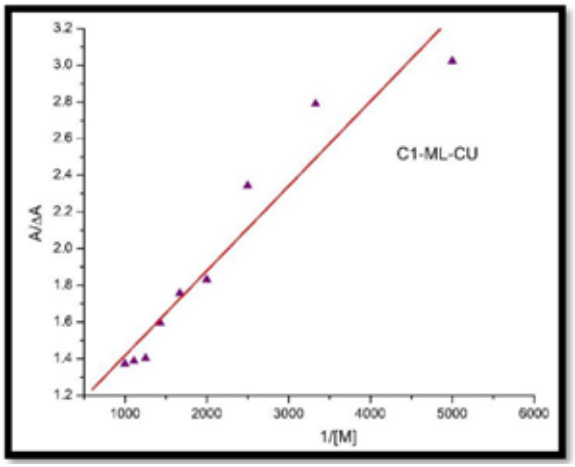
Absorption spectra of 3-(Bromoacetyl) coumarin in the solvent methanol. The arrow mark indicates the increasing order of Cu++ concentratio

The absorption peak is located at 270nm and initial absorbance is (OD) 0.647. The addition of metal ion causes progressive decrease in OD. The final OD is around 0.176 at 1mM of Cu++. This clearly shows that there is a binding interaction between Cu++ and 3-(Bromoacetyl) coumarin and this bonding is becoming more and more significant with the increase of metal ion concentration; however the absorption peak is not shifted. Hence ground state is not affected by the metal ion.

The binding constant is calculated using the following data. A plot of A/ΔA versus 1/[M] using Benesi-Hildebrand equation is as follows

Table.1. Experimental data of 3-(Bromoacetyl) coumarin (C1) in the solvent methanol

Sl. No	Conc of metal ion [M]mM	1/[M] $\times 10^3$	(A)OD	ΔA	A/ΔA
1	00	--	0.647	--	--
2	0.1	10	0.451	0.196	3.301
3	0.2	5	0.433	0.214	3.023
4	0.3	3.33	0.415	0.232	2.789
5	0.4	2.5	0.371	0.276	2.344
6	0.5	2	0.294	0.353	1.833
7	0.6	1.67	0.279	0.368	1.758
8	0.7	1.43	0.242	0.405	1.597
9	0.8	1.25	0.186	0.461	1.403
10	0.9	1.11	0.181	0.466	1.388
11	1.0	1.0	0.176	0.471	1.373

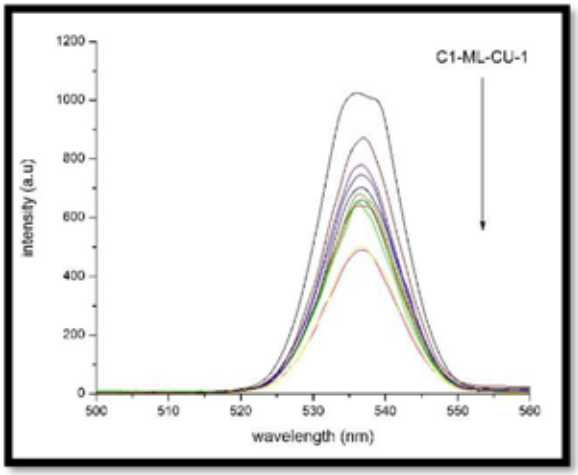


B-H plot of 3-(Bromoacetyl) coumarin (C1) in the solvent methanol along with Cu++ metal ion using absorption data

It is a linear fit graph with very good correlation coefficient of 0.9620. The y- axis intercept is 0.9556 and the slope is 4.617×10^{-4}. Binding constant is found to be 20.69×10^{2} M^{-1}. The higher value of binding constant represents the formation of stable complex between metal ion and studied compound. The Gibbs free energy is calculated using equation (3). Gibbs free energy is an indicative of spontaneity/non- spontaneity of compound – Cu++ binding and its value is -19.033 KJmol-1. The negative value represents the spontaneity of compound – Cu++ interaction [16].

2. Binding study by fluorescence-spectroscopy

The fluorescence emission of the sample is done using Perkin Elmer spectro fluorometer (LS-55). The slit width is kept at 5nm. All the samples are excited at the wavelength of 270nm which corresponds to absorption peak and the emission spectra are recorded. The initial fluorescence intensity is 1025 AU and decreases gradually with the increase in the concentration of metal ion without any shift in the emission peak. Fluorescence intensity has been effectively quenched by the metal ion and the added impurity is acting as a quencher.



Emission spectra of 3-(Bromoacetyl) coumarin (C1) in the solvent methanol. The arrow mark indicates the increasing order of Cu++ concentration.

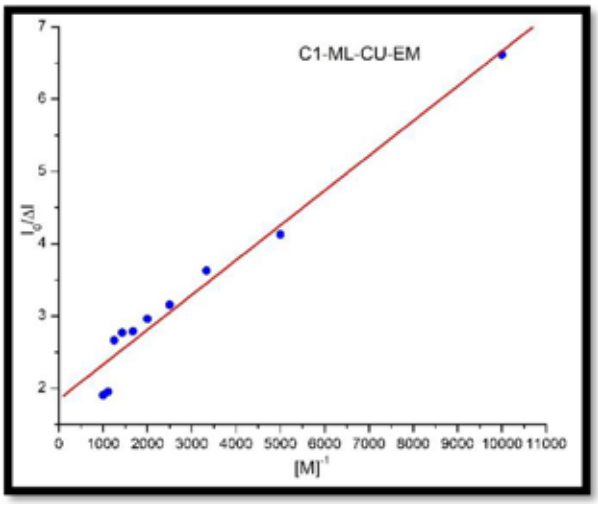
The spectral data is processed using two equations namely Benesi- Hildebrand equation (Eq.2) and modified S-V equation(Eq.4) [6,20]

$$log\left(\frac{I_0 - I}{I}\right) = logk + n\log[M] \quad (4)$$

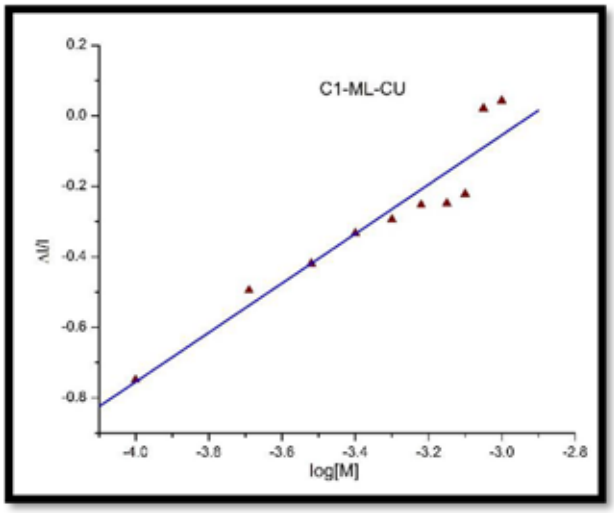
Where n is the number of binding sites. The other symbols have their usual meaning. Linear fittings of the experimental data obtained from emission studies (Table 2) showed that within the investigated concentration, the results exhibited a good linear relationship. The linear plots are as shown below

Table.2. Experimental data obtained from emission spectra of 3-(Bromoacetyl) coumarin (C1) in the solvent methanol with varied concentration of Cu++ concentration

Sl. No	Conc of metal ion [M]mM	1/[M] $\times 10^3$	log[M]	I	ΔI	$I_0/\Delta I$	log(ΔI/I)
1	00	--	---	1025	---	---	---
2	0.1	10	-4.00	870.05	154.95	6.615	-0.749
3	0.2	5	-3.69	776.62	248.38	4.127	-0.495
4	0.3	3.33	-3.52	742.42	282.58	3.627	-0.419
5	0.4	2.5	-3.40	700.23	324.77	3.156	-0.333
6	0.5	2	-3.30	678.83	346.17	2.961	-0.294
7	0.6	1.67	-3.22	657.52	367.48	2.789	-0.253
8	0.7	1.43	-3.15	655	370	2.771	-0.248
9	0.8	1.25	-3.10	640.48	384.52	2.665	-0.222
10	0.9	1.11	-3.05	499.86	525.14	1.952	0.021
11	1.0	1.0	-3.00	487	538	1.905	0.043



B-H plot of 3-(Bromoacetyl) coumarin (C1) in the solvent methanol with varied concentration of Cu++ concentration



Modified S-V plot of 3-(Bromoacetyl) coumarin (C1) in the solvent methanol with varied concentration of Cu++ concentration

In both the cases linear fit is obtained with a very good correlation coefficient. The binding constants and number of binding sites are calculated and the obtained values are tabulated in the following table. It is evident form the table that the order of binding constant value calculated using both absorption and emission data is more or less same. The value of n is approximately equal to one indicating that there is one binding site in metal ion for coumarins derivative during the interaction. The negative Gibbs free energy calculated in each case is also mentioned in the same table.

Table 3. The values of binding constants and Gibbs free energy and number of binding sites obtained from different methods

Method	Binding constant(k) M^{-1} ($\times 10^2$)	Gibbs free energy($-\Delta G$) kJ mol^{-1}	No of binding sites
Absorption spectroscopy	20.69	19.033	-----
Fluorescence spectroscopy (B-H equation)	38.35	20.57	-----
Fluorescence spectroscopy (modified SV equation)	1.11	11.74	0.7 ≅1

CONCLUSIONS

The obtained values of binding constants clearly indicate that the studied coumarin derivative is capable of binding effectively with the metal ion Cu++.These results encouraged us to proceed with more spectroscopic studies using different metal ions such as Ni++, Pb++, Zn++, Hg++ etc. Before arriving at the solid conclusion that the studied compound can be used as a metal ion sensor we need to do further investigations such as effect of pH, temperature and solvent environment.

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