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FABRICATION AND EXPERIMENTAL ANALYSIS OF REINFORCEMENT RECYCLED TYRE RUBBER PARTICULATE COMPOSITE

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Abstract— **Waste tyres are increasing now-a-days and causing many hazardous effects. They can be recycled in different ways such as by burning for fuel, generating oils, reinforcement in Portland cement and in resins etc. Objective of this study was to determine the structural properties such as tensile, compressive and flexural properties, and dynamic properties such as damping characteristics. Composites consisting of various weight percentages of recycled tyre rubber particulate and epoxy resin are successfully prepared. All the tests are performed and a comparative study is done with various weight percentages of recycled tyre rubber particulate in the composite. The variation of particles weight percentages influences the properties. In the present case, tensile, compressive, and flexural strength are decreasing in nature with increase in the reinforcement of tyre rubber particulate in the composite. Tensile, compressive and flexural strength are maximum for 10% (by weight) tyre rubber particulate reinforcement composite. In impact damping test, logarithmic decrement, damping ratio, and loss factor are determined for various weight percentages of tyre rubber particulate reinforcement in the composite. Loss factor is maximum for 30% (by weight) tyre rubber reinforcement composite.**

Index Terms— **Recycled Tyre Rubber particulate Composites, Tensile, compressive and flexural strength, Impact damping test.**

I. INTRODUCTION

Solid waste management is one of the major environmental issues in the world. Waste tires are becoming a major environmental problem. Every year a large amount of waste tires is produced. These tires are thermoset and are almost resistant to biological degradation. World annually, nearly 13.5 million tons of waste tires emerge. Analysis shows that there is almost 1 million tonnes of tire scraps in India. These reserves are dangerous due to environmental hazards, fire hazards and provide breeding grounds for mosquitoes. In ways such as landfill, pyrolysis and incrementation, the deficiencies in the disposal of waste tires encouraged research on waste tires and recycling techniques. Thus, recycling waste tires is a major challenge for both environmental and economic reasons.

Figure 1.1: Used tyres waste in an open area

Several approaches have been proposed to deal with the problem of used tires, such as converting it into a solid fuel burner into tire-derived fuel, using pyrolysis to recover valuable chemical components, non-tire applications Including and using them for various rubbing. Filler in plastic / hardening To obtain impact-resistant plastic and thermoplastic alkometers, rubber wastes can be used extensively by adding waste rubber to the plastic. Typically, there are ground for small particles which go into useless tire ground tire rubber (GTR), which are still thermoset. Recycled rubber chips have been used in asphalt concrete. The use of recycled tire rubber in portland cement concrete is an attractive choice. A technical and economically attractive alternative is the use of recycled tire rubber in the production of tire rubber particulate composites.

A. Composition of Tyres:

There are many different compounds and elements in the tire because they are engineering miracles, which are expected to deal with the heat and cold, high speed, abrasive conditions, and often not enough air pressure. They are expected to walk thousands of miles and maintain their essential qualities despite frightening driving habits and sometimes poorly constructed or constructed roads.
Tires are made up of many different rubber compounds, many different types of carbon black, fillers such as clay and silica,

and chemicals and minerals that allow vulcanization or accelerate it. The tire has many types of clothes for reinforcement and there are many types and sizes of steel. The tire is a mixture of natural rubber (14%) and butadiene rubber (27%).

Table 1.1: The Composition of a Tyre: Typical Components

Ingredients	**% Composition**
Rubber/Elastomers	45- 47
Carbon Black	21.5- 22
Metal	12- 25
Textile	0- 10
Zinc Oxide	1- 2
Sulphur	1
Additives	5- 7.5
Carbon-basedmaterials, total	67- 76

Source: The Waste & Resources Action Programme, 2006

II. Literature Review

Tyre and Tyre Recycling

Tyre recycling is the process of recycling vehicles tyres that are no longer suitable for use on vehicles due to wear or irreparable damage. Recently, amounts of waste tyres are being raised with development of the automotive industry. In case of Landfill or incineration of waste tyres, environmental pollution and economic problems are causing through waste of resources. As one of theways to prevent this problems, crushed waste tyre powder used to composite material manufacturing. After physically removed the bead wire from the waste tyres, the waste tyre powder gained mechanical fracturing through crushers and grinders. In addition, through a magnetic force mats and a dust collector, iron components and fibers were removed. The waste tyre powder was ground by a shear crushing method and a 2-stage disk mill method instead of cutting crushing one. Rubber chips of various sizes can be obtained crushing or grinding step. Shear crushing method and 2-stage disk mill method are composed of two drum-type blades with different rotation speed and direction [1].

Recycled Tyre Rubber Composites

Several publications have been published in concern with the use of rubber from scrap tyres in portland cement concrete (PCC) mixtures, particularly for highway applications. **D. Raghavan and H. Huynh** [2] prepared the recycled tyre rubber-filled cementitious composite. They studied its wokability, mechanical properties and chemical stability. Two different shapes of rubber particles were used- one is granules of about 2 mm diameter and other is shreds having sizes 5.5mm×1.2mm and 10.8mm×1.8mm (length × diameter). They reported that the addition of rubber decreases the flexural strength and plastic shrinkage due to cracking in the mortar. The crack length and crack width due to plastic shrinkage were reduced for mortar containing 10.8mm×1.8mm rubber shreds compared with a mortar without shreds.

The addition of rubber particles in a cementitious matrix may lead to new composite materials with interesting properties. The particle size of the scrap tyres used has a significant effect on many properties [3]. The smaller rubber particles resulted in a lower density and apparent porosity, as well as the highest mechanical compressive strength of the composites [4]. On the other hand, increased rubber fractions caused a reduction of the density and strength. A lower water content resulted in a higher apparent density and compressive strength.

Nehdi, M. and Khan, A. [5] represented the overview of engineering properties and potential applications of cementitious composites containing recycled tyre rubber. They reported about the effect of using rubber in concrete on density (unit weight) and on air content. Crumb rubber of different sizes is used in the concrete. Due to the low specific gravity of rubber, the unit weight of rubcrete mixtures decreases as the percentage of rubber increases.

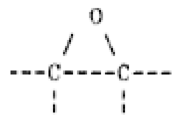
Gintautas Skripkiūnas, et al. [6] reported damping properties of concrete with rubber waste additives. The influence of rubber waste additive on hardened concrete damping characteristics and strength properties were evaluated. Compressive and flexural strength of concrete are decreased with increasing tyres rubber waste additive amount. The addition of rubber waste to concrete decreases the dynamic modulus of elasticity but increases damping decrement of the concrete. The amount of rubber waste has more noticeable effect on concrete damping properties than particles size distribution. He suggested that concrete with rubber waste can be used for isolation of structure-borne-noise in buildings, foundations and industrial floors.
The use as toughening additive for resins has also been reported.

Paulo J. R. O. Nóvoa, et al. [7] reported mechanical performance of polyester resins modified with powder from scrap tyre rubber. A low reactivity unsaturated polyester resin (UPR), containing 39 wt % styrene was used in this investigation. A constant rubber powder content (5%) was used throughout all modified resin systems. From flexural properties and Charpy impact behaviour of the fully cured systems it is clear that all composite systems showed a systematic decrease in performance. There appears to be a small positive shift in flexural properties for system, where a higher pre-treatment temperature was involved. They also reported that toughness can be improved if rubber is purified prior to utilization.

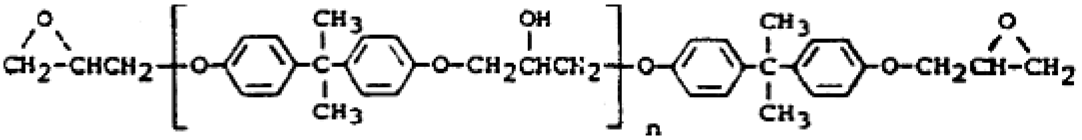
III. MATERIALS AND METHOD

A. Epoxy and Hardener

Epoxy resins are polider resins, which contain more than one epoxy group, which are able to consume in the thermoset form. These resins do not produce volatile products, despite treatment, in spite of the presence of volatile solvent. The name of epoxy may be named as oxide, such as ethylene oxide (epoxy ethen), or 1,2-epoxide. The epoxy group, also known as opoxine, is bonded with an oxygen atom with two carbon atoms, which are bound by the following bonds in their turn:



The most simple epoxy resin is prepared by Apich-Llorohydryan (ECH) (106-89-8) with the reaction of Bephenol A (BPA) (80-05-7). The value of N varies from 0 to 25.



Epoxy application resins are widely: adhesives, bonding, building materials (flooring, paving and aggregates), composites, laminates, coatings, molding, and textile finishing. He has recently found use in the air- and spacecraft industries.

Epoxy resins used to prepare the active hydrogen-containing compounds to react, which is dihydro-Halojenn with Apiclorohaidrin. Reacting with Bisfenol A (BPA) (80-05-7), caustic Apiclorohaidrin (Isiac) (L06-89-8) in the presence of soda, the Daicliseedil Essential Daifenol A (Dijibeepia) (L675-54-3) Produces. . Here n is approximately zero (0.2). When the resin is liquid n <1 and solid when n> 2. Polyesters, phenolic polyamide and Epoxies are important classes of thermoset resins.

Table 3.1: Mechanical properties ofepoxy

Tensile Strength	**Compressive Strength**
85 MPa	190 Mpa

General purpose epoxy resin was purchased from M / s Parikh Resins Limited, Kanpur, UP, India. It is a colorless, odorless and non-toxic. Its business name is PG 100. This epoxy is a fluorine-based epoxy resin and has a hard fluorine structure. Resin can be stored for at least one year if they are stored in cool, dry conditions in the original containers. It is also good solvent and has good chemical resistance in a wide range of temperature. There are versatile applications in technical and industrial applications. Apart from Hardening, there is treatment at room temperature and atmospheric pressure. In the current investigation, it has been used as a matrix material. Hardner SY31 (B) is a white liquid. Hardner SY31 (B) is also purchased from M / s. Parich Resins Limited, Kanpur, UP, India. It has been used as a cure agent. In all the materials developed in the current investigation, 10% wt / wt has been used.

B. Recycled Tyre Rubber Particles

Recycled tire rubber particles are collected from the surrounding tire retreading center in Aligarh. Tires of trucks, buses, cars and tractors are kept in retreating centers. The grinding wheel of the tire is grinding, which is made of steel wires in radial directions. These wires causes abrasion on the tyre surface and small particles are generated and a rough surface on the tyres is resulted. This surface is now ready for retreding. The particles size between 100-200μm is obtained using two sieves of 100 μm and 200 μm successively. Recycled tyre rubber particles are used as reinforcing agent. Particles are black in colour.

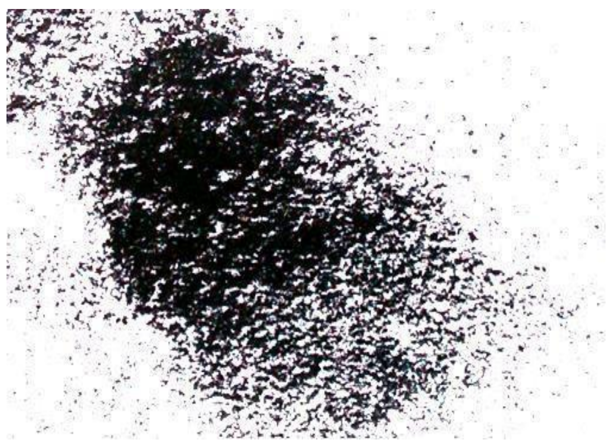


Figure 3.1: Recycled Tyre Rubber Particles

C. Method of Specimen Preparation

Samples are fabricated using open mold casting techniques. For the size of 300mm × 100mm × 6mm size, compression test sampling for molding of tensile and fluxural test samples, sample for sample casting 100mm × 100mm × 25.4 mm and test sample 300mm × 100mm Damp-ing sample for 4 mm.

Are making. To remove the mold plate plate easily, the interior of the mold is coated with petroleum jelly. Epoxy PG100 and Hardner SY 31 (B) are added in the ratio of 10: 1. A similar mixture is prepared to insert sample plates. Beams are prepared by mixing different weight percentages or beams (10%, 20% and 30%) in 100-200 square meters of recycled tire rubber particles in the epoxy and hardener mix and mixing them in the same molded molds. Are. Plates are treated at room temperature (about 300C) for 24 hours. After proper treatment, the plates are carefully taken out of the mold. Different sizes of the sample are then cut from mixed plates according to the test standards.

D. Tensile Test Specimens

Figure 3.2 shows tensile test samples of various structures of rubber particles ie 10%, 20% and 30% (by weight) with epoxy resin of tire rubber reinforcement.

(1)

(2)

(3)

Figure 3.2: Specimens for Tensile Test

E. Compressive Test Specimens

Figure 3.3 shows specimens for compressive test. These specimens are made of 10%, 20% and 30% (by weight) reinforcement of tyre rubber particles with epoxy resin. The numbering 10, 20 and 30 on the specimens is representing the %wt. reinforcement of tyre rubber particles.

(1) (2) (3)

Figure 3.3: Specimens for Compressive Test

F. Flexural Test Specimens

Figure 3.4 shows the flexural test specimens prepared by reinforcing 10, 20 and 30 percentages (by weight) of tyre rubber particles in epoxy resin.

(1)

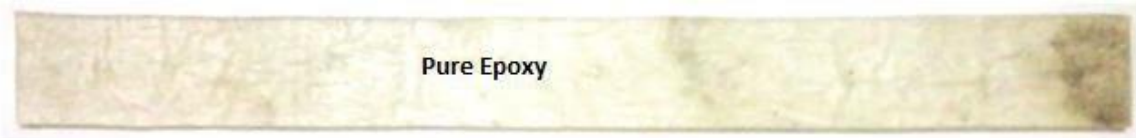
(2)

(3)

Figure 3.4: Specimens for Flexural Test

G. Damping Test Specimens

Here a control specimen i.e. pure epoxy specimen, along with 10, 20 and 30 wt. percentage of reinforcement of tyre rubber particles, is also prepared. Following figure shows these specimens.



(1)

(2)

(3)

(4)

Figure 3.5: Specimens for Damping Test

H. Single Point Laser Sensor Setup

Tire rubber particulate reinforcement using single point laser sensor is used for analyzing the damping characteristics of various weight percentages of epoxy matrix composite. The use of single point laser sensor is often used in monitoring and closing loop feedback control sys-tems. The laser sensor has a solid-state laser light source and a detector. Figure 3.5 shows the setup of a single point laser sensor. A laser beam is placed on target. A part of the laser beam is reflected through the focus on the detector focus. When the target moves, then the laser beam proportionally moves on the detector. The signal from the detector is used to determine the relative distance of the sample. The laser sensor used here is a non-contact type sensor. Therefore, this sensor can measure the displacement of any target without touching it. As a result, the target is not damaged.

The sample prepared is kept in the form of cantilever beam on stability. For the method of soaking the effect of the test, an effect or some displacement is given to the sample from its mid- poseon. For compulsive vibration testing, a type of vessel is shown in Figure 3.8. Shaker is given a wave signal by the function generator. Shaker stimulates the sample from its middle position. To avoid errors, the sample should be placed in the normal position on the laser head. Otherwise this surface will affect reflective properties. The single laser records transverse displacement of a particular point centered by the laser on the sample. An excel data sheet is generated by con- displacement and at the same time.

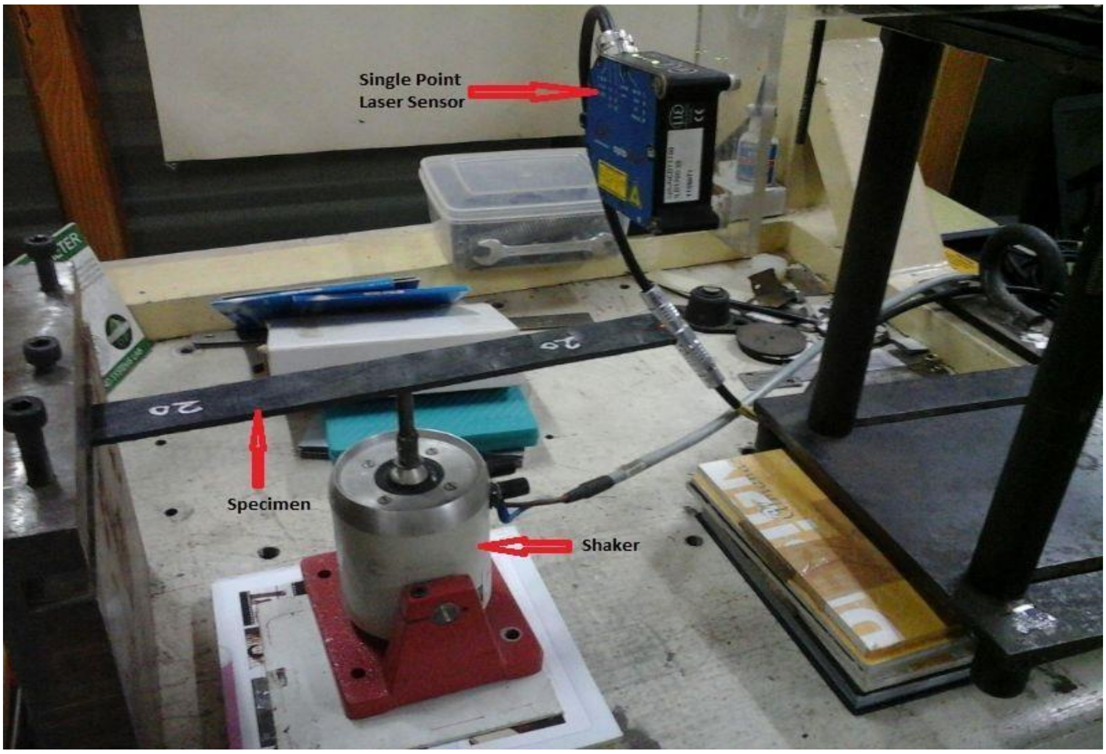


Figure 3.6: Single Point Laser Sensor Setup

IV. RESULTS AND DISCUSSION

A. Tensile Test

Type-I tensile times with dimensions of 165mm × 19mm × 6mm, the samples are cut and made from mixed plates. According to ASTM D3039, using a standard material testing system at 5 mm / minute crosshead speed, the tensile test is done on the Universal Testing Machine. The result of the load and the corresponding displacement (elongation) is the repetition of the samples. Three samples are tested for each composition of the composite. In the square meter, the tensile strength was calculated by dividing the maximum weight in Newton by the original minimum cross-sectional area of the sample.

Table 4.1: Experimental Values of Displacement/Load in tensile test with variation of tyre rubber particles percentage

Sr. No.	Displacement (mm) (10% Reinforcement)	Displacement (mm) (20% Reinforcement)	Displacement (mm) (30% Reinforcement)	Load (N) (10% Reinforcement)	Load (N) (20% Reinforcement)	Load (N) (30% Reinforcement)
1	0	0	0	0	0	0
2	0.1	0.1	0.1	9.81	19.62	39.24
3	0.2	0.2	0.2	19.62	39.24	68.67
4	0.3	0.4	0.3	29.43	88.29	98.10
5	0.5	0.7	0.5	49.05	117.72	137.34
6	0.7	1.0	0.7	68.67	137.34	196.20
7	0.9	1.2	0.8	117.72	156.96	215.82
8	1	1.4	1.0	137.34	186.39	274.68
9	1.2	1.6	1.2	176.58	235.44	284.49
10	1.4	1.8	1.5	206.01	294.30	353.16
11	1.6	2	1.8	255.06	362.97	382.59
12	1.8	2.2	2.0	313.92	441.45	441.45
13	2	2.4	2.2	412.02	529.74	480.69
14	2.3	2.6	2.4	549.36	568.98	559.17
15	2.5	2.8	2.6	618.03	667.08	598.41
16	2.8	3.0	2.8	765.18	784.80	657.27
17	3	3.3	3.0	873.09	917.19	765.18
18	3.3	3.5	3.2	1079.1	1108.53	833.85
19	3.6	3.7	3.4	1294.92	1275.30	882.90
20	3.7	3.9	3.7	1343.97	1363.59	961.38
21	4			1393.02		

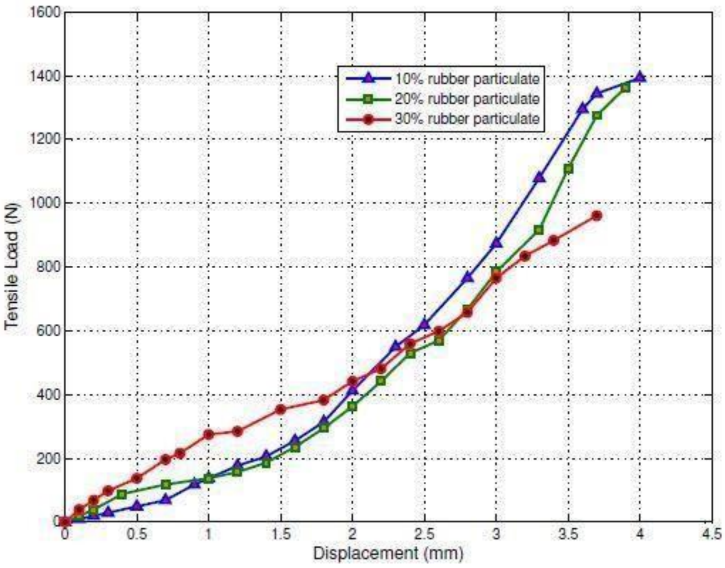


Figure 4.1: Load/Displacement curves for tensile test with variation of tyre rubber particles wt. percentage

The load/displacement graph shows that initially load is more for the 30 wt% rubber particulate composite but 30% rubber particulate composite breaks at lowest of the three loads i.e. at 961.38 N. 10% rubber particulate composite breaks at maximum load. Hence increasing the particulate decreases the load at fracture.

Table 4.2: Experimental value of stress and strain in tensile testing with variation of percentage of tire rubber particles

Sr. No.	**Strain (10% Reinforcement)**	**Strain (20% Reinforcement)**	**Strain (30% Reinforcement)**	**Stress (MPa) (10% Reinforcement)**	**Stress (MPa) (20% Reinforcement)**	**Stress(MPa) (30% Reinforcement)**
1	0	0	0	0	0	0
2	0.061	0.061	0.061	0.0861	0.1721	0.3442
3	0.121	0.121	0.121	0.1721	0.3442	0.6024
4	0.182	0.242	0.182	0.2582	0.7745	0.8605
5	0.303	0.424	0.303	0.4303	1.0326	1.2047
6	0.424	0.606	0.424	0.6024	1.2047	1.7211
7	0.545	0.727	0.485	1.0326	1.3768	1.8932
8	0.606	0.848	0.606	1.2047	1.6350	2.4095
9	0.727	0.970	0.727	1.5489	2.0653	2.4955
10	0.848	1.091	0.909	1.8071	2.5816	3.0979
11	0.97	1.212	1.091	2.2374	3.1839	3.3561
12	1.091	1.333	1.212	2.7537	3.8724	3.8724
13	1.212	1.455	1.333	3.6142	4.6468	4.2166
14	1.394	1.576	1.455	4.8189	4.9911	4.9050
15	1.515	1.697	1.576	5.4213	5.8516	5.2492
16	1.697	1.818	1.697	6.7121	6.8842	5.7655
17	1.818	2.000	1.818	7.6587	8.0455	6.7121
18	2	2.121	1.939	9.4658	9.7239	7.3145
19	2.182	2.242	2.061	11.359	11.187	7.7447
20	2.242	2.364	2.242	11.789	11.961	8.4332
21	2.424			12.219		

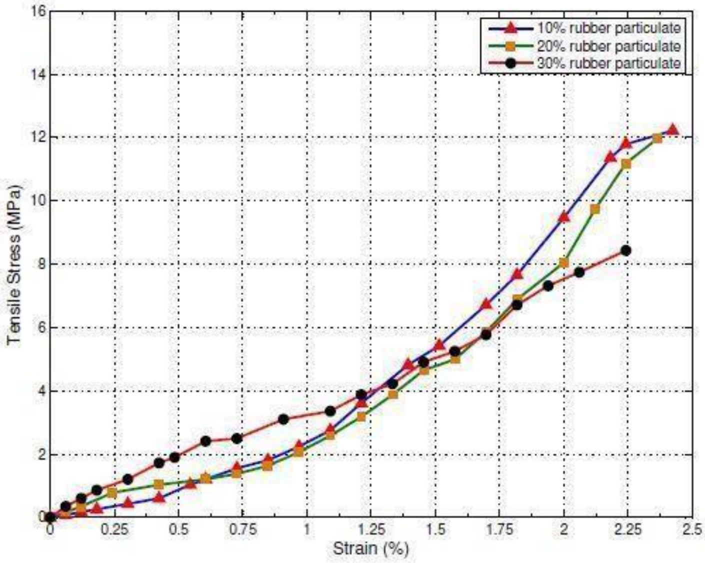


Figure 4.2: Stress/Strain curves for tensile test with variation of tyre rubber particles wt. percentage

Here the tensile stress is decreasing on increasing the particulate wt. percentages. Tensile stress for 10 wt % rubber particulate composite decreases by about 85% of the pure epoxy. The decrease in 20% and 30% rubber particulate composite is recorded as 86% and 90%.

B. Compressive Test

The compressive property is measured in accordance with ASTM D695. Two 50 mm diameter hardened-steel compression plates mounted on a universal testing machine. The specimen is placed between the compression plates parallel to the surface. The specimen size for compressive test is 25.4mm×25.4mm×63.5mm. The specimen is then compressed at the rate of 1.3 mm/min. until fracture. Three replicates of each composite formulation are tested. The maximum load at fracture is recorded. This load is divided by original cross sectional area to find compressive strength of the composite.

Table 4.3: Experimental valuesof Load and Strength in compressive test withvariation of tyre rubber par ticlespercentage

Sr. No.	**Tyre Rubber Particles Reinforcement(wt%)**	**Compressive Load at Break**	**Compressive Strength (MPa)**
1	10	30685.7	47.6
2	20	29069.7	45.0
3	30	19629.4	30.7

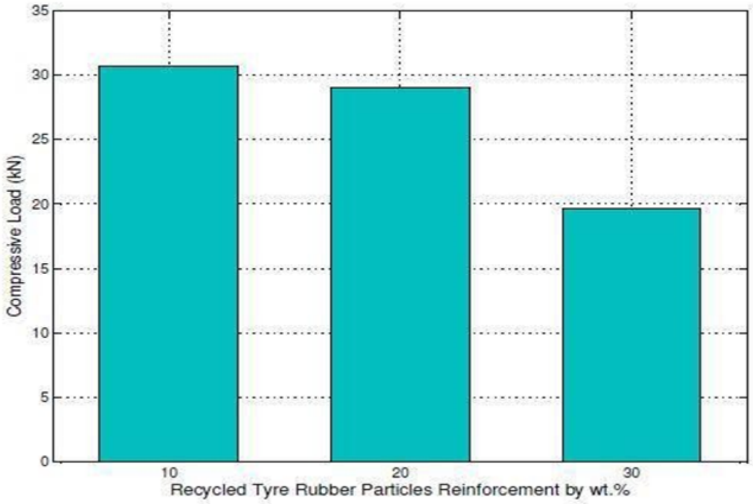


Figure 4.3: Compressive Load at break with variation of tyre rubber particles reinforcement by wt. percentage

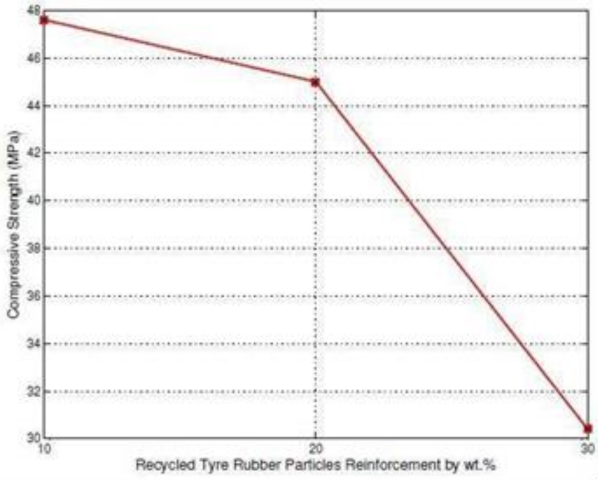


Figure 4.4: Compressive Strength with variation of tyre rubber particles reinforcement by wt. percentage

Compressive strength is also decreasing on increasing the reinforcement of rubber particulates. It has been seen that 75%, 76% and 83% decrease in compressive strength are occurred for 10%, 20% and 30% rubber particulate composites respectively as compared to that of pure epoxy (compressive strength 190 MPa). 10 wt% rubber particulate composite have high value of compressive strength (47.6 MPa) of these three configurations.

C. Flexural Test

Flexural properties are measured at a three-point bending test according to ASTM D790 at cross speed of 2.8 mm / minute. Flexural test samples are cut from the overall plate with a dimension of 100 mm × 13 mm × 6 mm. Each mixed formula-three replication of Tion is tested. Flexural strength, S, is calculated by the following equation:

$$S = \frac{3FL}{2bt^2} \quad ......(3.23)$$

where F is Flexural Load at break and L, b and t are length breadth and thickness of the specimen respectively.

Table 4.4: Experimental valuesof Load and Strength in flexural itest with variation of tyre rubber particles ipercentage

Sr. No.	Tyre Rubber Particles Reinforcement (wt. %)	Flexural Load at Break (N)	Flexural Strength (MPa)
1	10	107.8	35.3
2	20	88.2	28.9
3	30	58.8	19.3

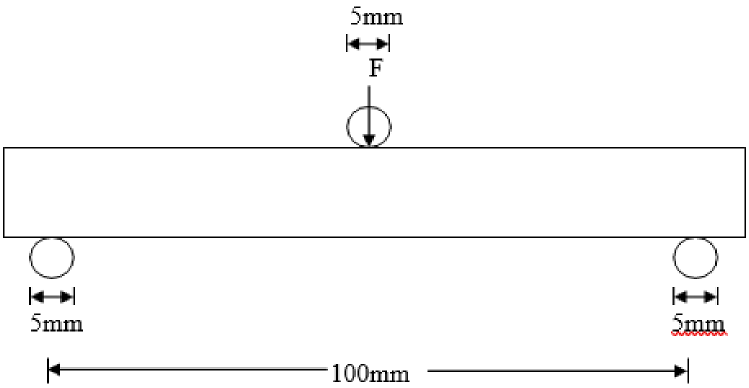


Figure 4.5: Three Point Bend Test Setup

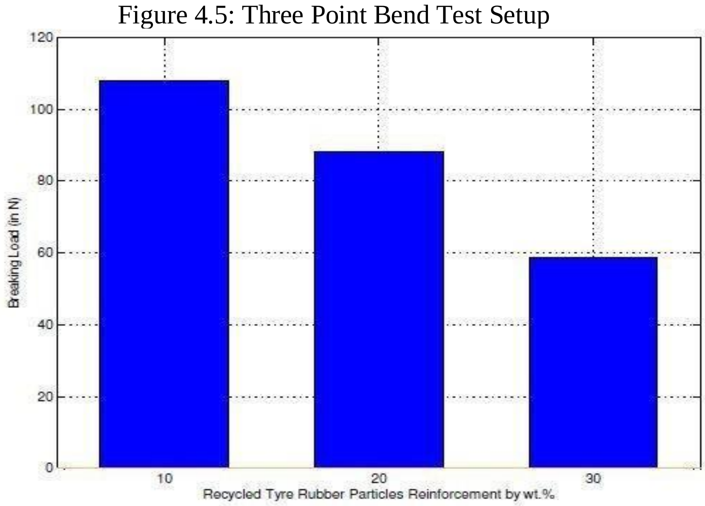


Figure 4.6: Flexural Load at break with variation of tyre rubber particles reinforcement by wt. percentage

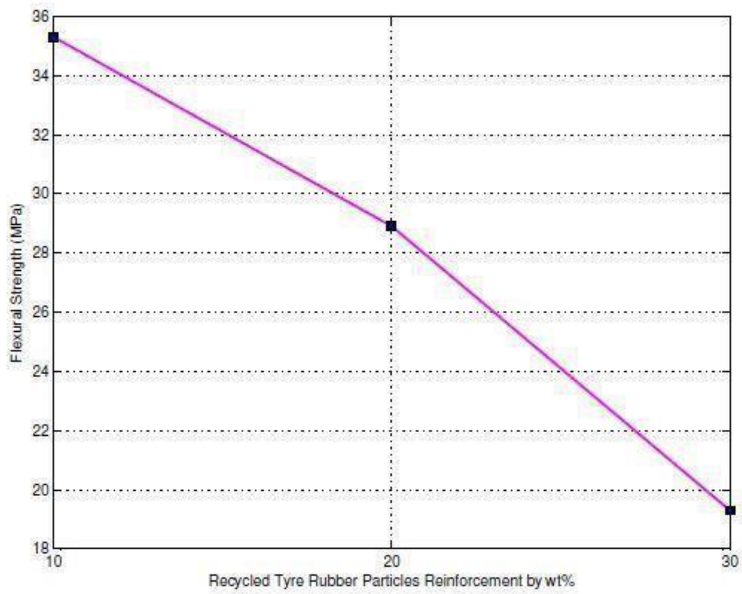


Figure 4.7: Flexural Strength at break with variation of tyre rubber particles reinforcement by wt. percent age

Here flexural strength is decreasing on increase in the tyre rubber particulate reinforcement in the composite. A decrease of 68%, 74% and 82% in flexural strength is noted as compared to that of pure epoxy (flexural strength 112 MPa).

D. Damping Test

The specimen size for the damping test is taken as 280mm×30mm×4mm. Following are of the experiments carried out by the Impact Damping method on different specimens of composite beam with varying weight percentages of recycled tyre rubber particulate in the composite. The time domain responses for different weight percentages tyre rubber particulate in the composite specimens are shown in Figures 4.8 to 4.11. The values of peak amplitude x0 and xn separated by N number of cycles are obtained from the excel sheet plots. Using equation (3.21), the logarithmic decrement, δ, is obtained for different weight percentages of tyre rubber particulate reinforcement composite specimens. The corresponding damping ratio, ξ, is obtained using equ- ation (3.20). These values are tabulated in Table 4.6. The damping ratio, ξ, in present cases is in the range of 0 to 0.3, so the loss factor, tan δ is equal to 2ξ. The values of ξ and loss factor, tan δ are tabulated in Table 4.6.

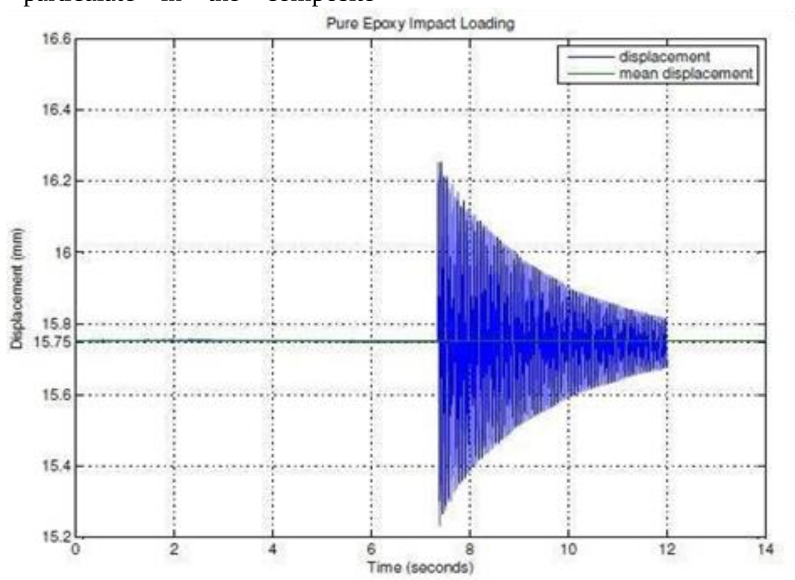


Figure 4.8: Time domain response of the Pure Epoxy beam in Impact damping imethod

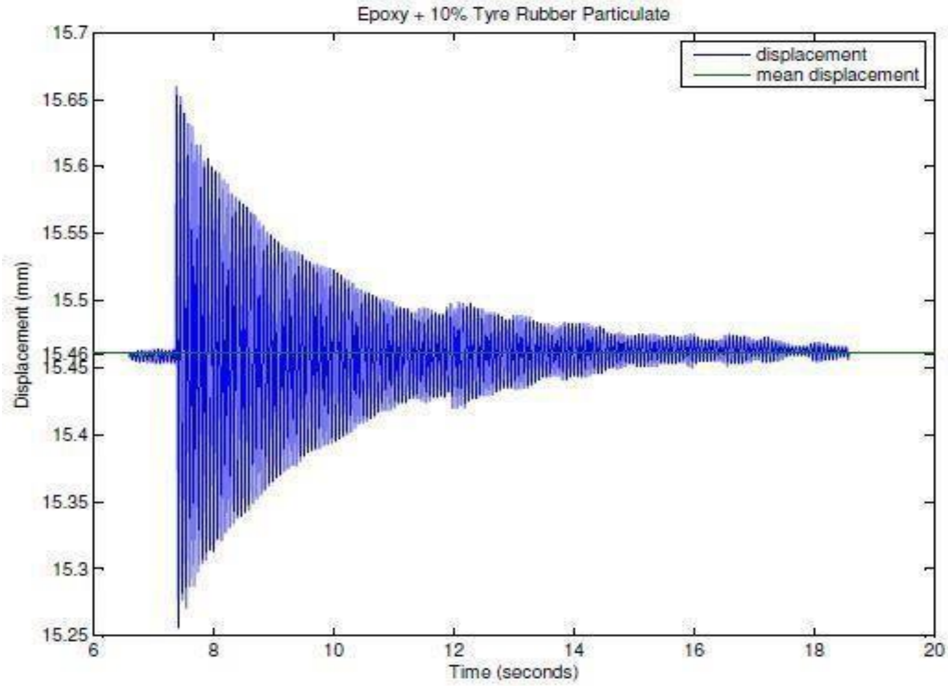


Figure 4.9: Time domain response of Epoxy + 10% (by wt.) Tyre Rubber particulate beam

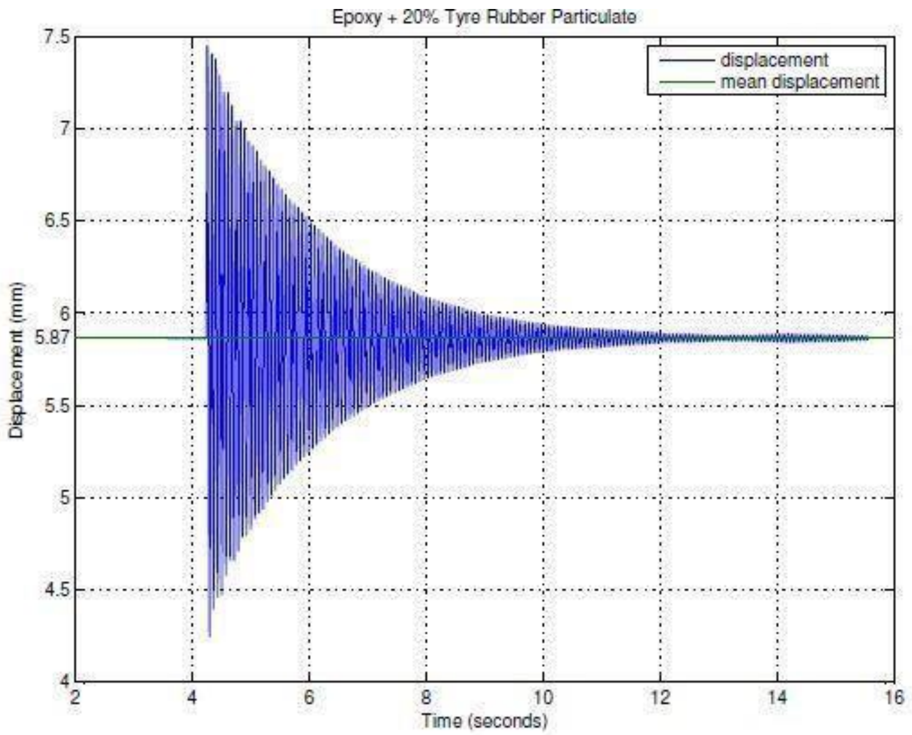


Figure 4.10: Time domain response of Epoxy + 20% (by wt.) Tyre Rubber particulate beam

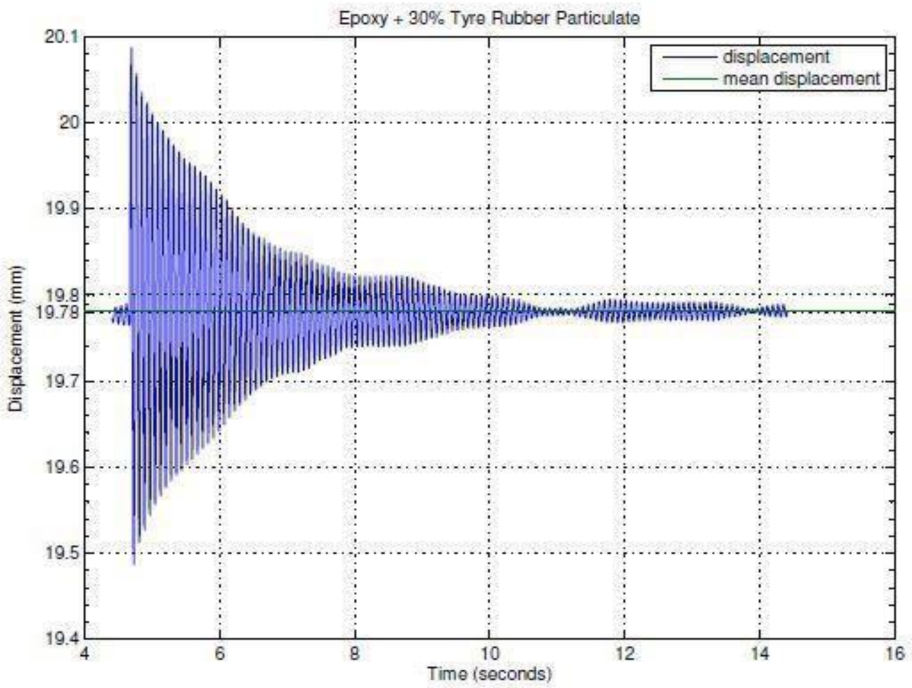


Figure 4.11: Time domain response of Epoxy + 30% (by wt.) Tyre Rubber particulate beam

Table 4.5: Peak amplitude values for N number of cycles

Sr. No.	**Specimen**	**xo(mm)**	**xn(mm)**	**Number of Cycles, N**
1	Pure Epoxy	0.34	0.09	51
2	Epoxy + 10% Tyre Rubber particulate reinforcement	0.2	0.06	38
3	Epoxy + 20% Tyre Rubber particulate reinforcement	0.624	0.073	56
4	Epoxy + 30% Tyre Rubber particulate reinforcement	0.3	0.03	53

Table 4.6: Loss Factor obtained from time domain response (Logarithmic Decrement)

Sr. No.	**Specimen**	**Logarithmic Decrement, δ**	**Damping Ratio, ξ**	**Loss Factor, tan δ**
1	Pure Epoxy	0.0261	0.0041	0.0082
2	Epoxy + 10% Tyre Rubber particulate reinforcement	0.0316	0.0050	0.0100
3	Epoxy + 20% Tyre Rubber particulate reinforcement	0.0383	0.0061	0.0122
4	Epoxy + 30% Tyre Rubber particulate reinforcement	0.0434	0.069	0.0138

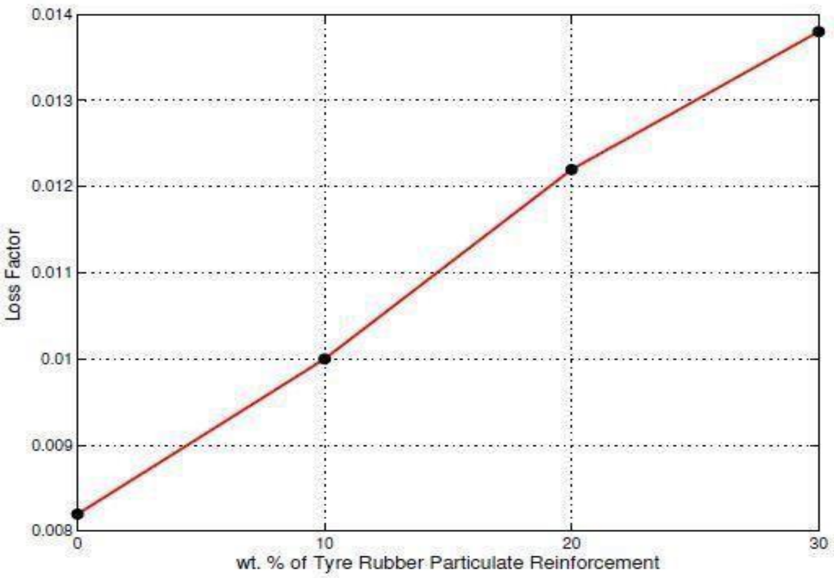


Figure 4.12: Variation in Loss Factor with varying wt. % of Tyre Rubber Particulate

V. Conclusion

The focus of this thesis is to use the waste material (tyre rubber) in preparing composite material, which can be used in many applications. This thesis focuses on the effective utilization of environmentally hazardous waste tyres. The composites are successfully prepared by reinforcing different weight percentages of tyre rubber particulates with epoxy matrix.

➢ The mechanical behavior of prepared composites is experimentally determined. Structural pro- perties such as tensile, compressive, flexural, and dynamic property such as damping chara- cteristics are determined. It has been observed that the difference in weight percentage of particle reinforcement plays an important role in influencing these properties. In the present case, with overall increase in the restructuring of tire rubber particulate, tensile, compressed and fluxural strength in nature is decreasing. Tensile, compressive and flexural strength are maximum for 10% (by weight) tyre rubber particulate reinforcement composite.

- Viscoelastic materials have good damping characteristics, which can be used for vibration supp- ression. Tyre rubber particles in particulate composite with epoxy matrix increase the loss tan- gent (loss factor). In the present case, logarithmic decrement, damping ratio, and loss factor are determined for various weight percentages of tyre rubber particulate reinforcement in the com- posite for impact damping test. Loss factor is maximum for 30% (by weight) tyre rubber rein- forcement composite.
- The prepared composite material can be used in many applications such as flooring, playground surfacing, isolation etc. Fabrication of brake pad in automotive field is an ongoing process . The prepared composite material has lower density as compared to metal particulate reinforced composites.

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