Experimental Investigation on Properties of Concrete using Scrap Tires

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Abstract:- **At present the disposal of waste tyres is becoming a major waste management problem in the world. It is estimated that 1.2 billions of waste tyre rubber produced globally per year. It is estimated that 11% of post consumer tyres are exported and 27% are sent to landfill, stockpiled or dumped illegally and only 4% is used for civil engineering projects. Hence efforts have been taken to identify the potential application of waste tyres in civil engineering projects. In this context, our present study aims to investigate the optimal use of waste tyre rubber as coarse aggregate in concrete composite**

INTRODUCTION

-Once tires are discarded, they are considered as **scrap tires**. An interesting use, developed over 30 years back but not yet universally used, is to process scrap tires as raw material for roads.
-More than 273 million scrap tires are produced in India each year. In addition to this, more than 300 million tires are currently stockpiled throughout the country. These stockpiles are dangerous not only from potential environmental threat, but also from fire hazards and provide breeding grounds for mosquitoes.
Over the years, disposal of tires has become one of the serious problems in environments, and land filling is becoming unacceptable because of the rapid depletion of available sites for waste disposal. Used tires are required to be shredded before land filling.

SOLUTIONS FOR TIRE DISPOSAL :

Innovative solutions to meet the challenge of tire disposal problem have been in development, and the promising options are;
(i) Thermal incineration of worn out tires for the production of electricity or steam, and
(ii) Reuse of ground tire rubber in number of plastic and rubber products.

OBJECTIVES

This experimental work investigates the impact of substituting the part of the conventional aggregates with scrap tire, on certain characteristics of the cement concretes. Rubber aggregates resulting from cutting worn tires is used to replace the coarse aggregates by certain percentage of volume.

Three Different Formulations of Tire Scrap in concrete	Percentage of Replacement of coarse aggregate
F1	5%
F2	10%
F3	15%

Typical Materials Used in Manufacturing Tire

1. Synthetic Rubber
2. Natural Rubber
3. Sulfur and sulfur compounds
4. Phenolic resin
5. Oil
   (i)Aromatic
   (ii)Naphthenic
   (iii) Paraffinic
6. Fabric
   (i)Polyester
   (ii) Nylon etc.
7. Petroleum waxes
8. Pigments
   (i)Zinc oxide
   (ii) Titanium dioxide etc.
9. Carbon black
10. Fatty acids
11. Inert materials
12. Steel wires

CLASSIFICATION OF SCRAP TIRES

Scrap tires

They can be managed as a whole tire, as slit tire, as shredded or chopped tire, as ground rubber or as a crumb rubber product. A typical automobile tire weighs 20 lb, whereas a truck tire weighs around 100 lb.

Slit Tires

These are produced in tire cutting machines. These machines can slit the tire into two halves or can separate the sidewalls from the tread of the tires.

Shredded or Chipped Tires

Tire shreds or chips involves primary and secondary shredding. The size of the tire shreds produced in the primary shredding process can vary from as large as 300 to 460 mm (12 to 18 inch) long by 100 to 230 mm (4 to 9 inch) wide, down to as small as 100 to 150 mm (4 to 6 inch) in length, depending on the manufacturer's model and condition of the cutting edges. Production of tire chips, normally sized from 76 mm (3 inch) to 13 mm (0.5 inch), requires both primary and secondary shredding to achieve adequate size reduction.

Ground Rubber

Ground rubber may be sized to particles as big as 19 mm (3/4 inch) to as small as 0.15 mm (No. 100 sieve). It depends upon the type of size reduction equipment and intended applications. Ground rubber particles are subjected to a dual cycle of magnetic separation, then screened and recovered in various sizes

Crumb Rubber

Crumb rubber consists of particles ranging in size from 4.75 mm (No. 4 Sieve) to less than 0.075 mm (No. 200 Sieve). Generally, these methods are used to convert scrap tires into crumb rubber.

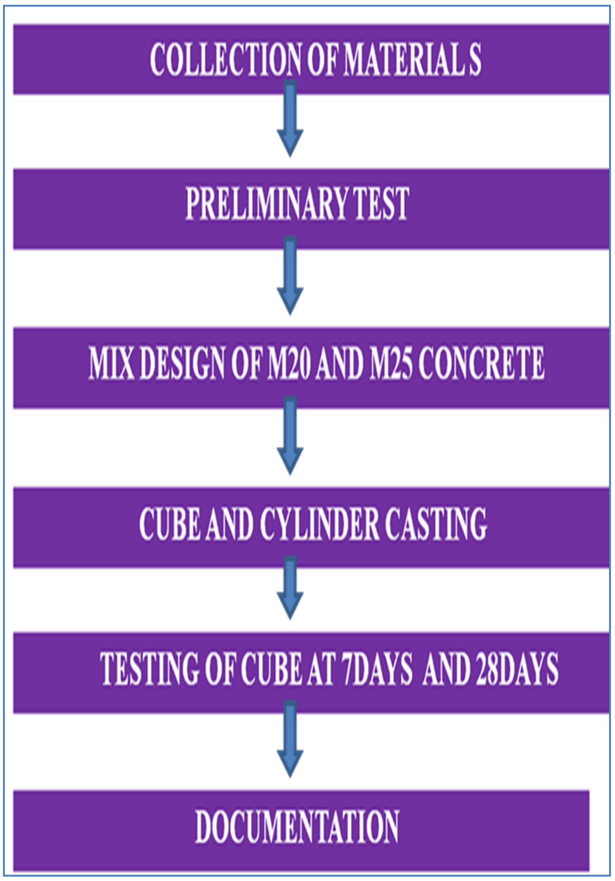
These methods are

(i) cracker mill process,

(ii) granular process, and

(iii) micro mill process.

METHODOLOGY



LITERATURE REVIEW

Early investigations on the use of worn-out tires in asphalt mixes had been very encouraging. Results showed that rubberized asphalt had better skid resistance, reduced fatigue cracking, and achieved longer pavement life than conventional asphalt.

- Raghavan, etal. have reported that mortars incorporating rubber shreds achieved workability comparable to or better than a control mortar with out rubber particles.
- Khatib and Bayomy investigated the workability of rub crete, and reported that there is a decrease in slump with increase in rubber content by total aggregate volume. They further mentioned that at rubber contents of 40% by total aggregate volume, slump was almost zero, and concrete was not workable manually.
- It was observed that mixtures made with fine crumb rubber were more workable than those with coarse tire chips were or a combination of tire chips and crumb rubber. Fedroff, et al. have reported higher air content in rubber concrete mixtures than control mixtures even without the use of air-entraining admixture (AEA). The similar observation were also made by Khatib and Bayomy . This may be due to the non polar nature of rubber particles and their tendency to entrap air in their rough surface, and when rubber is added to concrete mixture, it may attract air as it has the tendency to repel water. This way air may adhere to the rubber particles. Therefore, increasing the rubber content results in higher air contents of rubber concrete mixtures.
- Eldin and Senouci have reported that concrete mixtures with tire chips and crumb rubber aggregate exhibited lower compressive and split tensile strength than regular port land cement concrete. There was approximately 85% reduction in compressive strength and 50% reduction in split tensile strength when coarse aggregate was fully replaced by coarse rubber chips. However, there reduction of about 65% in compressive strength and up to 50% in split tensile strength when fine aggregate was fully replaced by fine crumb rubber. However, the mixes demonstrated a ductile failure and had the ability to absorb a large amount of plastic energy under compressive and tensile loads.

Topcu and Khatib and Bayomy also showed that the addition of coarse rubber chips in concrete lowered the compressive strength more than the addition of fine crumb rubber. However, results reported by Ali, et al. and Fatuhi and Clark indicate the opposite trend. Segre and Jockes have worked on the use of tire rubber particles as addition of cement paste. In their work, the surface of powdered tire rubber was modified to increase its adhesion to cement paste. Low cost procedures and reagents were used in the surface

- treatment to minimize the final cost of the material. Among the surface treatments tested to enhance the hydrophilicity of the rubber surface, a sodium hydroxide (NaOH) solution gave the best result.
- Lee, et al. developed tire-added latex concrete to incorporate recycled tire rubber as part of concrete. Crumb rubbers from tires were used in TALC as a substitute for fine aggregates. while maintaining the same water-cement ratio TALC showed higher flexural and impact strengths than those of portland cement .

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EXPERIMENTAL INVESTIGATION

PRELIMINARY TEST FOR CEMENT
SPECIFIC GRAVITY FOR CEMENT

The specific gravity of cement found to be 3.15

FINENESS OF CEMENT

The fineness of cement has an important bearing on the rate of hydration and hence the gain of strength.

PROCEDURE: -
100 grams of cement is weighed accurately and placed on IS: sieve 90µ. Any air set lumps are broken using fingers. Allow gentle sieving is done continuously for 15 minutes. The residue left is weighted. This shall not exceed 10 percent by weight of sample of cement. Repeat the procedure for two more samples. Then take the average of three samples.
The fineness of cement sample = **93%**.

CONSISTENCY OF CEMENT

The standard consistency of cement paste is defined on the consistency which will permit a Vicat plunger having 10mm diameter and 5-mm length to penetrate to a depth of 5 to 7mm from the bottle of the mould. The Vicat apparatus is used to find out the percentage of water required to produce a cement paste of standard consistency.

PROCEDURE: -Take about 250 grams of cement and paste it in the enameled tray. Mix about 25% of water by weight of dry cement thoroughly to get a cement paste. Start the stop watch as soon as the water is added to dry sample and take care that the cement paste is moulded with in the 'Gauge time'. Immediately fill the paste in the Vicat mould resting on the glass plate and bring the paste level with the top of the mould. Place the mould along with the glass plate under the rod fitted with the plunger. Adjust the indicator 0-0 when the plunger is touching the cement paste surface in the mould. Release the plunger quickly and allow it to sink in the paste. Mould the trial paste with different percentage of water starting with 25% by weight of cement. Take the reading by noting the depth of penetrating the plunger into the paste on the vertical scale of Vicat apparatus. Repeat the process of moulding and filling again by adding 2% of extra water each time. Continue till the resistance to penetration is 5mm to 7mm from the bottom o the mould. Then express the amount of water which gives 5 mm to 7 mm resistance from the bottom of the mould as percentage by weight of dry cement.

Then the normal consistency of cement paste is found to be **35%**.

INITIAL SETTING TIME

Initial setting time is the time elapsed between the moments that the water is added to the cement to the paste starts its plasticity.

PROCEDURE:-
Take about 250 grams of cement sample and mix it with 0.85 times the water required to produce cement paste of normal consistency. Start the stop watch the moment the water is added to the cement. Place the Vicat's mould filled with the paste of standard consistency with the glass plate at the bottom in the Vicat apparatus with indicator set to 0-0 when the tip of the initial set needle fix in the needle holder touches the surface of the paste in the mould. Quick release the needle to allow it to penetrate into the paste and note the resistance offered from the bottle of the mould. Repeat the process by quickly releasing the needle after every 2 minutes till the resistance to penetration offered is 5 mm to 7 mm from the bottom of the mould. Then note down the initial setting time.
Time when needle fails to penetrate 5 mm to 7 mm from bottom of the mould is noted as **32 minutes**.

TESTS ON FINE AGGREGATE

SAND

Locally available river sand is used in the experiment investigation. The river sand conformed to the limits of **IS 2368-1983-1970** when tested.

SPECIFIC GRAVITY TEST

For finding the specific gravity of the fine aggregate, Pycnometer method is adopted.

PROCEDURE:-
The Pycnometer is washed, cleaned and dried. The Pycnometer with brass cap and washer is weighed (w_1). About 200 to 400 grams of oven dried sand is taken in the Pycnometer and is weighed with its cap and washer (w_2). The Pycnometer is filled to half of its height with water and mixed thoroughly with glass rod. Add more water and stir it.

Replace the screw top and fill the Pycnometer with water through the hole in the conical cap and weight it (w_3). Empty the Pycnometer, clean it thoroughly and fill it with water to the hole of conical cap and weigh it (w_4). Then the specific gravity G is determined and repeat the procedure for two more samples. Then take the average of three samples.

The specific gravity of sand is found to be **2.7**.

SIEVE ANALYSIS FOR SAND

PROCEDURE:-

Weigh each sieve which is to be used, make sure that each sieve is clean before weighing it. Obtain 1kg of oven dry sample sand should be taken. Pass the sample through 4.75mm IS Sieve to find percent gravel, if any. Sieve the remaining soil through a rest of sieves by using mechanical shaker sieving should continue for at least 15 minutes and take care to ensure that sieving is complete. Weigh each sieve and the pan with soil retained on them, Find by subtraction the weight of soil retained on each sieve.

The cumulative weight passing each sieve shall be calculated as a percentage of the total sample weight.

Thus the given sample confirms to ZONE III

TEST ON COARSE AGGREGATE

AGGREGATE IMPACT TEST

PROCEDURE:-

Fill the measure about 1/3rd full with aggregate and using the tamping rod the aggregate with 25 strokes. Repeat the procedure twice for the remaining 2/3rd portion adding each time 1/3rd of the volume and tamping it. Note down the weight of the sample. Transfer the sample to the cylinder in three layers of 1/3rd volume and tamp it as usual. Place the cylinder in its position in the impact testing machine firmly allow the load to fall 15 times at 1 blow per second at constant rate. Take the sample out of the cylinder carefully. Sieve the sample in 2.36mm Sieve, weigh the potion passing through it. Repeat the procedure for two more samples. Then take the average of aggregate impact value

Then the aggregate impact value is found to be **23.47%**.

CRUSHING TEST

Aggregate crushing value gives a relative measure of the resistance of an aggregate sample against crushing under gradually applied compressive load.

PROCEDURE:-

Aggregates passed through 12.5mm IS Sieve and retained on 10 mm IS Sieve is filled in three layers is given in 25 blows. Using bullet end of the tamping rod in the cylindrical measure. Then transform the sample of the aggregate in three layers in aggregate crushing mould subjected each layers to 25 blows by using the tamping rod. Insert the plunger to rest horizontally on the surface of the aggregate. Place the entire setup between the plates of the compression testing machine. So that it reaches 40T in 10 minutes at a uniform rate of loading. Release the load and take entire setup from the compression testing machine. Remove the aggregate from the cylinder and Sieve it through IS Sieve 2.36mm. Weight the fraction passing through the IS Sieve 2.36mm taking care to avoid the loss of fines. Repeat the procedure for two more samples. Then take the average of crushing value.

Then the crushing value is found to be **19.6%**.

SPECIFIC GRAVITY TEST

For finding the specific gravity of fine aggregate, pycnometer method is adopted.

PROCEDURE:-

The pycnometer is washed, cleaned and dried. The pycnometer with brass cap and washer is weighed (w_1). About 200 to 400 grams of oven dried coarse aggregate is taken in the pycnometer and it washed with its cap and washer (w_2). The pycnometer is filled to half of its height with water and mixed thoroughly with glass rod. Add more water to stir it. Replace the screw top and fill the pycnometer with water through the hole in the conical cap and weigh it (w_3). Empty the pycnometer, clean it thoroughly and fill it with water to the hole of conical cap and weigh it (w_4). The specific gravity G is determined and repeat the procedure for two more samples. Then take the average of three samples.

Thus the specific gravity is found to be **2.8**.

EXPERIMENTAL INVESTIGATIONS

SI. NO.	Materials	Properties	Results
1.	Cement	Specific gravity	3.15
		Fineness	93%
		Consistency	33%
		Initial setting time	30 mins.
2.	Fine aggregate	Specific gravity	2.61
		Sieve analysis	Zone III
3.	Coarse aggregate	Specific gravity	2.8
		Aggregate impact test	23.47%
		Crushing test	19.6%

MIX DESIGN

GENERAL

The design of concrete mix involves the determinate of the most rational proportion of ingredients of concrete to achieve a cone which is workable in its plastic state and will develop the rare qualities when hardened. A properly designed concrete mix should have minimum possible cement content without sacrificing the concrete quality in order to make it concrete mix.

METHODS OF MIX DESIGN

The mix design method being used in different countries are mostly based on empirical relationships, charts and graphs developed from the extensive investigations. The various methods of proportioning are:-

1. Minimum void method
2. Maximum density method
3. Fineness modulus method
4. Talbot- Richard method
5. Kennedy's method
6. Arbitrary method
7. ACI committee method
8. IRCC 44 method
9. High strength concrete mix design
10. Design based on flexural strength
11. Indian Standard method

ASSUMPTIONS:-

The basic assumptions made in mix design are:-

The compressive strength of workable concrete is by and large, governed by the water cement ratio. The size, shape, and type and grading of aggregates; the amount of water added determines the workability of concrete.Therefore, the specific relationships that are used in proportioning concrete mixes should be considered only as a basis for trial, subject to modifications in the light of experience as well as for the particular materials used at the site in the case.

MIX DESIGN IN ACCORDANCE WITH INDIAN STANDARD RECOMMENDED GUIDE LINES FOR CONCRETE MIX DESIGN.

DATA FOR MIX DESIGN

The following basic data are required to be specified for design of concrete mix:

Characteristic compressive strength (i.e., below which only a specified proportion of test results are allowed to fall) of concrete at 28 days (fck).

1. Degree of workability desired.
2. Limitations of the water-cement ratio and the minimum cement content to ensure adequate durability.
3. Type and maximum size of aggregate to be used.
4. Standard deviation (s) of compressive strength of concrete.

MIX DESIGN PROCEDURE:-

1. The step by step procedure of mix proportioning is as follows:

The target mean strength is first determined is as follows:

$$\mathbf{Ft = Fck + t \times S}$$

Where,

Ft = Target mean compressive strength at 28 days.

F_{ck} = Characteristic compressive strength at 28 days.

S = Standard deviation, upon the accepted proportion of low results and the number of tests (see table 6.1)

t = A statistical value depending upon the accepted proportion of low results and the number of tests (see table 6.2)

Note- As per IS: 456-1978, the characteristic strength defined as that

Value below which is not more than 1 in 20 of the test results is expected to fall. In such case, t = 1.65.

ESTIMATION OF AIR CONTENT:

2. The air content (amount of entrapped air) is estimated from (table 6.3) for maximum size of aggregate used.

SELECTION OF WATER CONTENT AND FINE AGGREGATE TO TOTAL AGGREGATE RATIO:

3. The water content and percentage of sand in total aggregate by absolute volume are next selected from tables 4 and 5 for medium and high strength concretes, respectively, for the following standard reference conditions.

I. Crushed (angular) coarse aggregated.
II. Fine aggregate consisting of natural sand confirming to grading zone2 of table 4, IS: 383-1970, in saturated surface dry condition.
III. Water-cement ratio of 0.5 for medium and high strength concrete respectively, and
IV. Workability corresponding to compacting factor of 0.90.

4. For other conditions of workability, water-cement ratio, gradingof fine aggregate and for rounded aggregates, adjustments in water content and percentage of sand in total aggregate are made as per IS CODE table 6.

CALCULATION OF AGGREGATE CONTENT:-

With the quantities of water and cement per unit volume of concrete and the percentage of sand in the total aggregate already determined. The coarse and fine aggregates content per unit volume of concrete are calculated from the following equation:

Mass of coarse aggregate,

= Volume of cement and water × volume of coarse aggregates × specific gravity of coarse aggregates × 1000

Mass of fine aggregate,

= Volume of cement and water × volume of fine aggregates × specific gravity of fine aggregates × 1000

CALCULATION OF CEMENT CONTENT:-

The cement content per unit volume of concrete may be calculated from the free water cement ratio and the quantity of water per unit volume of concrete. The cement content so calculated against the minimum cement for the requirements of durability and the greater of the two values are adopted.

MIX DESIGN FOR M25

MIX DESIGN IN ACCORDANCE WITH IS: 10262-2009

Step 1

Design stipulations

- Characteristics compressive strength required in the field at 28 days = 25 N/mm^2
- Maximum size of aggregate = 20 mm
- Degree of workability = 0.9(compacting factor)

- Degree of quality control
  = good
- Type of exposure
  = Mild

Step 2

Test data for materials

- Cement used
  = Pozzolana Portland Cement
- Specific gravity of cement
  = 3.15
- Specific gravity of coarse aggregate
  = 2.8
- Specific gravity of fine aggregate
  = 2.61
- Water absorption for coarse aggregate
  = 0.50%
- Water absorption for fine aggregate
  = 1.0%
- Free surface moisture for coarse aggregate
  = Nil
- Free surface moisture for fine aggregate
  = 2%

Sieve analysis for coarse aggregate
= Conforming to grading of IS: 456-2000
Sieve analysis for fine aggregate
= Conforming zone III

Step 3

Target mean strength of concrete

$$F_t = F_{ck} + t.S$$

= 25 + (1.65×4)
= 31.6 N/mm^2

Step 4

Selection of water- cement ratio = 0.5 (From IS: 456-2000)

Step 5

Selection of water and sand content from table 6.4
Water content per m^3 = 186 kg
Sand content of total aggregate by absolute volume = 36%

Step 6

Determination of Cement content

- Water cement ratio
  = 0.5
- Water content
  = 197 lit/m^3
- Cement content
  = 197/0.5
  = 394 kg/m^3

Step 7

Determination of Coarse and Fine aggregates

Fine aggregate
= 0.678 × 0.36 × 2.61 × 1000
= 0.637 × 1000
= 637 kg/m^3

Coarse aggregate
= 0.678 × 0.64 × 2.8 × 1000
= 1.215 × 1000
= 1215 kg/m^3

W/C Ratio	Cement	Fine aggregate	Coarse aggregate
197	394	637	1215
0.5	1	1.62	3.08

The following tests were carried out to establish the mechanical properties of concrete:
(I) Compressive strength,
(II) Split Tensile Strength.

Preparation of Master Normal RCC.

RESULTS AND DISCUSSIONS

COMPRESSIVE TEST ON CONCRETE CUBES FOR 7 DAYS.

TABLE: - 01

7- DAYS COMPRESSIVE STRENGTH OF NORMAL CONCRETE CUBES.

CALCULATION:

Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)

1division = 1000kg

i) 48 x 1000 x 9.81 / 150 x 150
ii) 47 x 1000 x 9.81 / 150 x 150
= 20.92 N/mm^2
= 20.49 N/mm^2

iii) 50 x 1000 x 9.81 / 150 x 150
= 21.8 N/mm^2

Avg = 20.92+20.49+21.8 / 3 = 21.07

Compressive strength given by the specimen = 21.07 N/mm^2 @ 7 days curing.

7- DAYS COMPRESSIVE STRENGTH OF CONCRETE CUBES.

TABLE: - 0

CALCULATION:

Cube size : l x b x d = 150 x 150 x 150

Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)

1division = 1000kg

i) 40 x 1000 x 9.81 / 150 x 150
ii) 43 x 1000 x 9.81 / 150 x 150
= 17.44 N/mm^2
= 18.74 N/mm^2

iii) 41 x 1000 x 9.81 / 150 x 150
= 17.02 N/mm^2
Avg = 17.44+18.74+18.02 / 3 = 18.02

Compressive strength given by the specimen = 18.02N/mm^2 @ 7 days curing.

7- DAYS COMPRESSIVE STRENGTH OF CONCRETE CUBES.

CALCULATION:

Cube size : l x b x d = 150 x 150 x 150

Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)

1division = 1000kg

i) 38 x 1000 x 9.81 / 150 x 150
ii) 40 x 1000 x 9.81 / 150 x 150
= 16.56 N/mm^2
= 17.44 N/mm^2

iii) 39 x 1000 x 9.81 / 150 x 150
= 17.00 N/mm^2
Avg = 16.56+17.44+17.00 / 3 = 17.00 N/mm^2

Compressive strength given by the specimen = 17.02N/mm^2 @ 7 days curing.

7- DAYS COMPRESSIVE STRENGTH OF CONCRETE CUBES.
TABLE: - 04

SI.No.	Specimen no	Rubber usage 15% per cube (kg)	Weight of specimen in (kg)	C/s Area (mm^2)	Applied load (t)	Stress (N/mm^2)
1	a	0.321	7.884	22500	26	11.33
2	b	0.321	7.820	22500	24	10.46
3	c	0.321	7.770	22500	24	10.46

CALCULATION:

Cube size: l x b x d = 150 x 150 x 150

Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)

1division = 1000kg

i) 26 x 1000 x 9.81 / 150 x 150
ii) 24 x 1000 x 9.81 / 150 x 150
= 11.33 N/mm^2
= 10.46 N/mm^2

iii) 24 x 1000 x 9.81 / 150 x 150
= 10.46 N/mm^2
Avg = 11.33+10.46+10.46 / 3 = 10.74 N/mm^2

Compressive strength given by the specimen = 10.74 N/mm^2 @ 7 days curing.

CALCULATION:

Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)

1division = 1000kg

i) 62 x 1000 x 9.81 / 150 x 150
ii) 64 x 1000 x 9.81 / 150 x 150
= 27.03 N/mm^2
= 27.90 N/mm^2

iii) 50 x 1000 x 9.81 / 150 x 150
= 27.90 N/mm^2
Avg = 27.03+27.90+27.90 / 3 = 27.60 N/mm^2

Compressive strength given by the specimen = 27.60 N/mm^2 @ 28 days curing.

CALCULATION:

Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)

1division = 1000kg

i) 59 x 1000 x 9.81 / 150 x 150
ii) 58 x 1000 x 9.81 / 150 x 150
= 25.72 N/mm^2
= 25.28 N/mm^2

iii) 60 x 1000 x 9.81 / 150 x 150
= 26.16 N/mm^2
Avg = 25.72+25.28+26.16 / 3 = 25.72 N/mm^2

Compressive strength given by the specimen = 25.72 N/mm^2 @ 28 days curing.

28- DAYS COMPRESSIVE STRENGTH OF CONCRETE CUBES.
TABLE: - 10

CALCULATION:

Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)

1division = 1000kg

i) 43 x 1000 x 9.81 / 150 x 150
ii) 43 x 1000 x 9.81 / 150 x 150
= 18.74 N/mm^2
= 18.74 N/mm^2

iii) 42 x 1000 x 9.81 / 150 x 150
= 18.31 N/mm^2
Avg = 18.74+18.74+18.31 / 3 = 18.59

Compressive strength given by the specimen = 18.59 N/mm^2 @ 28 days curing.

AVERAGE COMPRESSIVE STRENGTH OF CONCRETE CUBES

NO.OF CURRING DAYS	AVERAGE COMPRESSIVE STRENGTH OF CONCRETE CUBES (N/mm^2)			
	0%-RUBBER	5%-RUBBER	10%-RUBBER	15%-RUBBER
0	0	0	0	0
7	21.07	18.02	17.00	10.74
28	33	27.61	25.72	18.59

CALCULATION:
Cube size : l x b x d = 150 x 150 x 150
Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)
1division = 1000kg

i) 45 x 1000 x 9.81 / 22500
ii) 48 x 1000 x 9.81 / 22500
= 19.62 N/mm^2
= 20.92 N/mm^2

iii) 46 x 1000 x 9.81 / 22500
= 20.05 N/mm^2
Avg = 19.62+20.92+20.05 / 3 = 20.19 N/mm^2

Compressive strength given by the specimen = 20.19 N/mm^2 @ 7 days curing.
7- DAYS COMPRESSIVE STRENGTH OF CONCRETE CUBES.

CALCULATION:
Cube size : l x b x d = 150 x 150 x 150
Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)
1division = 1000kg

i) 43 x 1000 x 9.81 / 150 x 150
ii) 45 x 1000 x 9.81 / 150 x 150
= 18.74 N/mm^2
= 19.62 N/mm^2

iii) 44 x 1000 x 9.81 / 150 x 150
= 19.18 N/mm^2
Avg = 18.74+19.62+19.18 / 3 = 19.18 N/mm^2

Compressive strength given by the specimen = 19.18 N/mm^2 @ 7 days curing.

CALCULATION:
Cube size : l x b x d = 150 x 150 x 150
Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)
1division = 1000kg

i) 31 x 1000 x 9.81 / 150 x 150
ii) 29 x 1000 x 9.81 / 150 x 150
= 13.51 N/mm^2
= 12.64 N/mm^2

iii) 29 x 1000 x 9.81 / 150 x 150
= 12.64 N/mm^2
Avg = 13.51+12.64+12.64 / 3 = 12.93 N/mm^2

Compressive strength given by the specimen = 12.93 N/mm^2 @ 7 days curing.

28- DAYS COMPRESSIVE STRENGTH OF CONCRETE CUBES

CALCULATION:
Cube size : l x b x d = 150 x 150 x 150
Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)
1division = 1000kg

i) 45 x 1000 x 9.81 / 22500
ii) 48 x 1000 x 9.81 / 22500
= 19.62 N/mm^2
= 20.92 N/mm^2

iii) 46 x 1000 x 9.81 / 22500
= 20.05 N/mm^2
Avg = 19.62+20.92+20.05 / 3 = 20.19 N/mm^2

Compressive strength given by the specimen = 20.19 N/mm^2 @ 7 days curing.

28- DAYS COMPRESSIVE STRENGTH OF CONCRETE CUBES.

CALCULATION:
Cube size : l x b x d = 150 x 150 x 150
Compressive Strength = Load of failure x 9.81/Area of compression (N/mm^2)
1division = 1000kg

i) 45 x 1000 x 9.81 / 22500
ii) 48 x 1000 x 9.81 / 22500
= 19.62 N/mm^2
= 20.92 N/mm^2

iii) 46 x 1000 x 9.81 / 22500
= 20.05 N/mm^2
Avg = 19.62+20.92+20.05 / 3 = 20.19 N/mm^2

Compressive strength given by the specimen = 20.19 N/mm² @ 7 days curing.

28- DAYS COMPRESSIVE STRENGTH OF CONCRETE CUBES.

CALCULATION:

Cube size :l x b x d = 150 x 150 x 150

Compressive Strength = Load of failure x 9.81/Area of compression (N/mm²)

1division = 1000kg

i) 45 x 1000 x 9.81 / 22500
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= 19.62 N/mm²
= 20.92 N/mm²

iii) 46 x 1000 x 9.81 / 22500
= 20.05 N/mm²
Avg = 19.62+20.92+20.05 / 3 = 20.19 N/mm²

Compressive strength given by the specimen = 20.19 N/mm² @ 7 days curing.

AVERAGE SPLIT TENSILE STRENGTH OF CONCRETE CYCLINDER

NO.OF CURRING DAYS	AVERAGE SPLIT TENSILE STRENGTH OF CONCRETE CYLINDER (N/mm²)			
	0%-RUBBER	5%-RUBBER	10%-RUBBER	15%-RUBBER
0				
7				
28				

7-DAYS SPLIT TENSILE TEST ON NORMAL CONCRETE CYLINDER

TABLE: - 14

SI No.	Specimen no	Weight of specimen in (kg)	Length of cylinder (mm)	Applied load (t)	Stress (N/mm²)
1	a	12.764	300	30	0.42
2	b	12.784	300	29	0.41
3	c	12.810	300	31	0.43

Split Tensile Strength f_{ck} = 2P/ πLD(N/mm²) (using code book IS 5816-1999)

Where,

P - maximum load in Newtons applied to the specimen

L - length of the specimen in mm

D - cross sectional dimension of the specimen in (150 mm)

CALCULATION:

i) 2 x 30 x 1000 / π x 150 x 300
ii) 2 x 29 x 1000 x / π x 150 x 300
= 0.42 N/mm²
= 0.41 N/mm²

iii) 2 x 31 x 1000 x / π x 150 x 300
= 0.43 N/mm²

Avg = 0.42+0.41+0.43 / 3 = 0.42 N/mm²

Split Tensile Strength given by the specimen = 0.42N/mm² @ 7 days curing.

7-DAYS SPLIT TENSILE TEST ON NORMAL CONCRETE CYLINDER

CALCULATION:

Split Tensile Strength = 2P/лLD(N/mm²) (using code book IS 5816-1999)

Diameter of cylinder =150 mm

i) 2 x 14 x 1000 / π x 150 x 300
ii) 2 x 18 x 1000 x / π x 150 x 300
= 0.19 N/mm²
= 0.25 N/mm²

iii) 2 x 14 x 1000 x / π x 150 x 300
= 0.19 N/mm²
Avg = 0.19+0.25+0.19 / 3 = 0.21 N/mm²

Split Tensile Strength given by the specimen = 0.21 N/mm² @ 7 days curing

7-DAYS SPLIT TENSILE TEST ON NORMAL CONCRETE CYLINDER

CALCULATION:

Split Tensile Strength = 2P/πLD(N/mm²) (using code book IS5816-1999)

Diameter of cylinder =150 mm

i) 10 x 14 x 1000 / π x 150 x 300
ii) 10 x 18 x 1000 x / π x 150 x 300
= 0.14 N/mm²
= 0.14 N/mm²

iii) 2 x 12 x 1000 x / π x 150 x 300
= 0.16 N/mm²
Avg = 0.14+0.14+0.16 / 3 = 0.14 N/mm²

Split Tensile Strength given by the specimen = 0.14 N/mm² @ 7 days curing.

7-DAYS SPLIT TENSILE TEST ON NORMAL CONCRETE CYLINDER

CALCULATION:

Split Tensile Strength = 2P/π LD(N/mm²) (using code book IS5816-1999)

Diameter of cylinder =150 mm

i) 10 x 14 x 1000 / π x 150 x 300
ii) 10 x 18 x 1000 x / π x 150 x 300

= 0.14 N/mm²
= 0.14 N/mm²

iii) 10 x 12 x 1000 x / π x 150 x 300
= 0.14 N/mm²
Avg = 0.14+0.14+0.14 / 3 = 0.14 N/mm²

Split Tensile Strength given by the specimen = 0.14 N/mm² @ 7 days curing.

28-DAYS SPLIT TENSILE TEST ON NORMAL CONCRETE CYLINDER

CALCULATION:

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Diameter of cylinder =150 mm

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= 0.19 N/mm²
= 0.25 N/mm²

iii) 2 x 14 x 1000 x / π x 150 x 300
= 0.19 N/mm²
Avg = 0.19+0.25+0.19 / 3 = 0.21 N/mm²

Split Tensile Strength given by the specimen = 0.21 N/mm² @ 7 days curing.

28-DAYS SPLIT TENSILE TEST ON NORMAL CONCRETE CYLINDER

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= 0.19 N/mm²

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Avg = 0.19+0.25+0.19 / 3 = 0.21 N/mm²

Split Tensile Strength given by the specimen = 0.21 N/mm² @ 7 days curing

AVERAGE SPLIT TENSILE STRENGTH OF CONCRETE CYCLINDER

7-DAYS SPLIT TENSILE TEST ON NORMAL CONCRETE CYLINDER

CALCULATION:

Split Tensile Strength = 2P/лLD(N/mm²) (using code book IS 5816-1999)

Diameter of cylinder =150 mm

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= 0.19 N/mm²
= 0.25 N/mm²

iii) 2 x 14 x 1000 x / π x 150 x 300
= 0.19 N/mm²

Avg = 0.19+0.25+0.19 / 3 = 0.21 N/mm²

Split Tensile Strength given by the specimen = 0.21 N/mm² @ 7 days curing.

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= 0.19 N/mm²
Avg = 0.19+0.25+0.19 / 3 = 0.21 N/mm²

Split Tensile Strength given by the specimen = 0.21 N/mm² @ 7 days curing.

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iii) 2 x 14 x 1000 x / π x 150 x 300
= 0.19 N/mm²
Avg = 0.19+0.25+0.19 / 3 = 0.21 N/mm²

Split Tensile Strength given by the specimen = 0.21 N/mm² @ 7 days curing.

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Avg = 0.19+0.25+0.19 / 3 = 0.21 N/mm²

Split Tensile Strength given by the specimen = 0.21 N/mm² @ 7 days curing.

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iii) 2 x 14 x 1000 x / π x 150 x 300
= 0.19 N/mm²
Avg = 0.19+0.25+0.19 / 3 = 0.21 N/mm²

Split Tensile Strength given by the specimen = 0.21 N/mm² @ 7 days curing.

LITERATURE REVIEW

Early investigations on the use of worn-out tires in asphalt mixes had been very encouraging. Results showed that rubberized asphalt had better skid resistance, reduced fatigue cracking, and achieved longer pavement life than conventional asphalt.

- Raghavan, etal. have reported that mortars incorporating rubber shreds achieved workability comparable to or better than a control mortar with out rubber particles.
- Khatib and Bayomy investigated the workability of rub crete, and reported that there is a decrease in slump with increase in rubber content by total aggregate volume. They further mentioned that at rubber contents of 40% by total aggregate volume, slump was almost zero, and concrete was not workable manually.
- It was observed that mixtures made with fine crumb rubber were more workable than those with coarse tire chips were or a combination of tire chips and crumb rubber.
  Fedroff, et al. have reported higher air content in rubber concrete mixtures than control mixtures even without the use of air-entraining admixture (AEA). The similar observation were also made by Khatib and Bayomy . This may be due to the non polar nature of rubber particles and their tendency to entrap air in their rough surface, and when rubber is added to concrete mixture, it may attract air as it has the tendency to repel water. This way air may adhere to the rubber particles. Therefore, increasing the rubber content results in higher air contents of rubber concrete mixtures.
- Eldin and Senouci have reported that concrete mixtures with tire chips and crumb rubber aggregate exhibited lower compressive and split tensile strength than regular port land cement concrete. There was approximately 85% reduction in compressive strength and 50% reduction in split tensile strength when coarse aggregate was fully replaced by coarse rubber chips. However, there reduction of about 65% in compressive strength and up to 50% in split tensile strength when fine aggregate was fully replaced by fine crumb rubber. However, the mixes demonstrated a ductile failure

and had the ability to absorb a large amount of plastic energy under compressive and tensile loads.

- Topcu and Khatib and Bayomy also showed that the addition of coarse rubber chips in concrete lowered the compressive strength more than the addition of fine crumb rubber. However, results reported by Ali, et al. and Fatuhi and Clark indicate the opposite trend. Segre and Jockes have worked on the use of tire rubber particles as addition of cement paste. In their work, the surface of powdered tire rubber was modified to increase its adhesion to cement paste. Low cost procedures and reagents were used in the surface treatment to minimize the final cost of the material. Among the surface treatments tested to enhance the hydrophilicity of the rubber surface, a sodium hydroxide (NaOH) solution gave the best result.
- Lee, et al. developed tire-added latex concrete to incorporate recycled tire rubber as part of concrete. Crumb rubbers from tires were used in TALC as a substitute for fine aggregates. while maintaining the same water-cement ratio TALC showed higher flexural and impact strengths than those of portland cement .

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