IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Effect of partial replacementof coarse aggrgates in concrete by waste tyre rubber aggregates in rigid pavements

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Abstract : The excessive reliance on natural aggregate in concrete production poses a severe environmental threat. The buildup and disposal of waste tyres poses a possible environmental issue. The goal of this study was to see if modified waste rubber tyre aggregate could be used in concrete manufacturing. To achieve the best results, the rubber aggregates are surface treated with NaOH solution and cement paste before being used in concrete. The concrete is of M20 quality. Coarse aggregate was replaced with modified waste tyre rubber at 0%, 5%, 10%, and 15% by volume of coarse aggregate, respectively. The slump, compacting factor, density, compressive, split tensile, and flexure strength of fresh and hardened concrete were investigated. This compressive strength is sufficient for treated-rubberized concrete to be used in a variety of applications where compressive strength is not critical, such as flooring and concrete road pavements. The flexural and split tensile strength of rubber aggregates is found to be higher than that of standard concrete, but only when they are treated before use. Workability has suffered. It has more flexibility and is lighter than regular concrete due to the reduced unit weight of the rubber particles. These improved qualities make this concrete suitable for use in flexible slabs and light weight concretes. Significant compressive strength, increased flexural and split tensile strength, light weight, increased impact and toughness resistance.

***Index Terms* – Waste tyre rubber, Coarse aggregate, Rigid pavements, Aggregate**

I.INTRODUCTION

The building industry requires cement and aggregate, which are the two most essential ingredients utilized in concrete production. This resulted in a steady and rising demand for the natural materials utilized in their manufacture. Parallel to the requirement for natural resource exploitation, there is a growing concern for environmental protection and the need to preserve natural resources like aggregate by employing alternative materials that are either recycled or disposed as trash. The disposal of waste tyres is costly. Construction is one of the most promising avenues; yet waste tyre utilization in civil engineering is extremely low.

Tyre sector in India has grown by roughly 12% in the last five fiscal years, from 2010 to 2015. This is owing to increased automotive production. This increase is regarded as beneficial to the nation's economy and industrialization, but it has been viewed as a challenge and an increasing threat from an environmental standpoint.

The mixing of rubber particles from crushed automobile tires into normal concrete, in place of coarse aggregate offers not only way to recycle and alleviate the environment harm associated with automobile waste but also improves the engineering properties of concrete, including shock resistance, fatigue resistance, corrosion resistance etc. The different applications of waste tyre rubber where it has been successfully used are:

I. Sports surfaces
II. Automotive industry
III. construction
IV. geo-technical/asphalt applications
V. adhesives and sealants
VI. shock absorption and safety products
VII. rubber and plastic products

Construction is one of the applications of waste tyre rubber to address its environmental concern. It has demonstrated considerable promise in the building business, where it can be employed with cement concrete pavements. Various studies have been carried out in order to successfully incorporate waste rubber into concrete, with positive results. Rubber's qualities, such as its flexibility and light weight, are said to be the primary cause for its increasing use in the building sector. Waste rubber has been used to substitute aggregates in cement concrete with great success. With a great environmental concern and in saving the natural rock aggregates, we have replaced a part of the conventional coarse aggregates by shredded rubber aggregates resulted from cutting worn tyres.

II.NEED OF THE STUDY

Crumb rubber, which is nearly a powdered form of rubber, has been used to replace coarse aggregates and tyre chips or shredded rubber has been used to replace fine aggregates. However, the results have been shown to be less than desirable, but still acceptable Other than compressive and tensile strength, adding rubber to concrete increases other properties. Rubberized concrete has a higher ductility than ordinary concrete. This property of rubberized concrete makes it ideal for covering worn or cracked pavements. It can also be utilised in new construction as a crack-resistant asphalt surface. Although concretes incorporating tyre rubber particles have been discovered to have lower compressive and tensile strengths than typical concretes utilising conventional aggregates, these values are within acceptable ranges.

Every year, almost 6 million tyres are abandoned in landfills. Recovering this much rubber, which would otherwise be a major source of pollution, is of national importance and a top priority. A lot of research has been done over the years on the possibility of using scrap rubber as a traditional aggregate replacement.

III.RESEARCH METHODOLOGY

For the building of stiff pavements, experiments are conducted on concrete samples with coarse particles partially replaced by waste rubber pieces. The waste rubber material was replaced, and tests were conducted with varied quantities of waste rubber material at rates of 5%, 10%, and 15% by weight due to coarse aggregate replacement. Tests were carried out to see how the effect would be if the coarse aggregate was replaced with waste rubber. To acquire the effect of both solutions, the rubber pieces of coarse aggregate gauge are dipped (treated/coated) in two distinct types of solutions such as Sodium Hydroxide (NaOH) and cement paste separately. The scheme to carry out this work is as under shown in Fig.3.1:

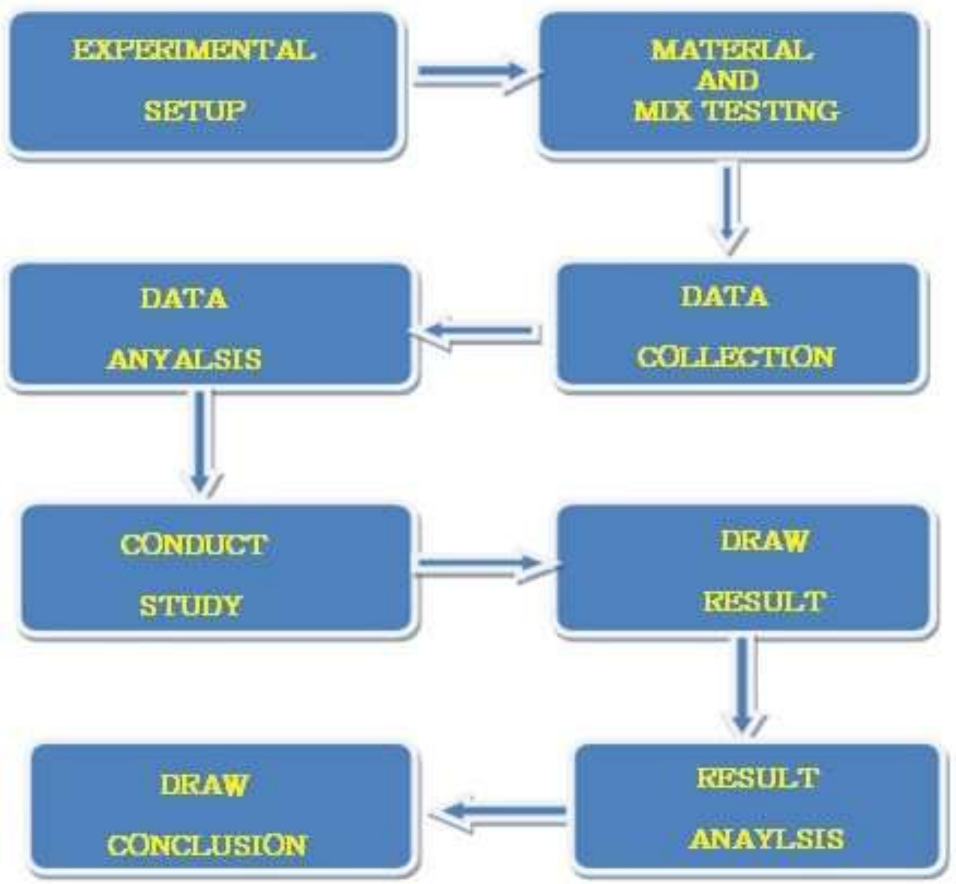


Fig. 3.1 Flow Chart of Methodology

3.1 Treatment (coating/dipping) of Waste Rubber Material

Before being used in sample casting, the rubber aggregate particles are surface treated with one molar sodium hydroxide and cement paste. One molar of NaOH solution is prepared, and the rubber particles are steeped in it for roughly 20 minutes before being used in the concrete. The same procedure is used in cement paste treatment: cement and water are mixed to produce a thick paste, and then rubber particles are soaked in it for roughly 20 minutes before being used in concrete. These treatments improve the surface characteristics of the rubber particles, allowing them to better bond with the cement in the concrete, resulting in higher strength.

Fig. 3.2 NaOH- Treated Rubber   Fig. 3.3 Cement Paste-Treated Rubber

3.2 Mix Proportion

The ratio of cement, sand, and aggregate is 1:1.5:3, and the weight analysis was used to calculate each constituent. The aggregate replacement percent age is calculated as shown in the table below for replacements. For all samples, the water/cement ratio is preserved at 0.45. OPC 53 is the grade of cement used in the mix design. To increase the percentage of rubber from 0% to 5% there is reduction in gravel accordingly and there is not any effect on water cement ratio. Again when the percentage of rubber is increased from 5% to 10% there is reduction in gravel and not any effect on water cement ratio. The mix proportions on each percentage is given on Table 3.1

Table 3.1: Mix proportions

S.No	Mix ID	Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate(Kg/m^3)		Percent replacement by Rubber	Water cement ratio
				Gravel	Rubber		
1	PC	436	654	1309	00	00	0.45
2	UTR-5	436	654	1243	66	05	0.45
3	UTR-10	436	654	1178	131	10	0.45
4	UTR-15	436	654	1112	196	15	0.45
5	NTR-5	436	654	1243	66	05	0.45
6	NTR-10	436	654	1178	131	10	0.45
7	NTR-15	436	654	1112	196	15	0.45
8	CTR-5	436	654	1243	66	05	0.45
9	CTR-10	436	654	1178	131	10	0.45
10	CTR-15	436	654	1112	196	15	0.45

where,
UTR-5 represents untreated 5% rubber.
NTR-5 represents sodium hydroxide treated rubber. CTR-5 represents cement treated rubber.
PC represents plain concrete.

3.3 Experimental Setup

For compressive strength testing, cubes of size (15cm x 15cm x 15cm), beams of size (50cm x 10cm x 10cm) for flexural testing, and cylinders of size (10cm x 20cm) for split tensile strength testing were utilised as moulds.

Surface modification of rubber wastes was done by soaking rubber particles in a 0.1 molar solution of NaOH and in cemented suspension for about 20 minutes shortly before utilising them in concrete to strengthen the connection between rubber and concrete components like cement paste and aggregates. By replacing 5, 10, and 15% of natural coarse aggregate with untreated and treated waste rubbertyre aggregate, a total of 20 cubes, 10 beams, and 10 prisms of M20 grade concrete are cast and compared to ordinary M20 grade concrete.

3.4Material Testing

Cement, fine aggregates, coarse aggregates, tyre rubber, and sodium hydroxide were utilised in the project. Waste tyre rubber is one of these commodities that is available in limited quantities and locations. The sodium hydroxide was purchased from the market and the tyre rubber was bought from a nearby garage. Cement is a distributed material with particles ranging in size from 0.1 to 250 microns. The rubber acquired in this way was reduced to a size comparable to coarse aggregate. To achieve this, the rubber was manually/mechanically sliced down to the necessary size of materials.
Various types of tests conducted on materials used are as under:

Tests for cement: Consistency test, initial and final setting time test, compressive strength test, fineness test (sieve analysis), soundness test.

3.4.1 Consistency test for cement

The standard consistency of cement past is defined as the percentage of water added in the 300gm weight of cement, which will permit a vicat plunger having 50mm length and 10mm diameter to penetrate in cement paste to a depth of 33-35mm from the top of the mold.
The objective of consistency test of cement is to find out the standard consistency of cement paste in the laboratory using vicat apparatus.
Procedure: In this project, 400 gm of cement is weighed and mixed with a weighed amount of water to achieve a water cement ratio of 0.25. The water quantity is calculated to be 100 grams. The mixing is done for 3 to 5 minutes, commonly known as the Gauging period. Fill and smooth the vicat's mould using this cement paste. The mould should be placed on a clean, dry plate. The most common and preferred plate is glass. Allow the needle to penetrate the paste in the mould by releasing it. The penetration depth is measured, and the method is repeated with the water cement ratio value changed. This value is adjusted to achieve the penetration value. The particular percentage of water at which the penetration value comes between 33- 35 mm, is known as the percentage required producing a cement paste of standard consistency. The results carried out on three different samples are given below:

Table 3.2 Consistency test results of cement

Sample number	Consistency value	Weight of water(gm)
1	28.9	115.6
2	28.5	114
3	29.3	117.2

The consideration is taken that the average of above three sample result as the consistency value of the cement.

Therefore, consistency value (P) is 28.9 %.

3.4.2 Initial and final setting time

Procedure: We take a 400 gm sample of cement and combine it with 0.85 times the amount of water required to make a paste of standard consistency, i.e. (0.85P). The measuring duration should be between 3-5 minutes, same like for determining standard consistency. By the time the paste begins to set, the measuring should be completed. The time between when the water is added and when we begin to fill the mould is kept track of. The cement paste is poured into the mould, and the top surface is levelled with the mould. To eliminate any potential cavities, a very small vibration can be applied.
Water added = 0.85 * P = 0.85 *115.6 = 98.26 gm.

Initial setting time: The time interval between when water is applied to the cement and when it begins to lose its ductility is known as the initial setting time. The needle used to calculate the first setting time has a 1 mm square area. This needle is lowered into the mould and then immediately released, allowing it to penetrate. It will totally pierce through the 40 mm of the mould in the first few minutes. We keep letting the needle pierce through the cement paste in the mould until it fails to pierce the test block to a depth of 5-7 mm from the mould's bottom. The time elapsed between the time when water is added to the cement and the time at which the needle fails to go through the paste in the mould to a depth of 5-7 mm from the bottom. The initial setting time for the ordinary Portland cement (OPC) is generally taken as 30 minutes. Initial test observed on stopwatch was 40 minutes.

Final setting time: The process is nearly identical to that for computing the initial setting time, with the exception of the needle type. The needle used for initial setting time is replaced with a needle with an angled ring at the bottom for determining final setting time. The needle is let go, leaving an imprint on the cement paste. The operation is repeated until the needle does not leave an impression on the paste. The time between when water is introduced to the cement at the beginning and when the needle fails to create an impression on it is thus determined as the final setting time. It is usually taken for four hours.
Final setting time for our sample was observed as 3 hours and 35 minutes.

3.4.3 Fine and Coarse Aggregate Tests: Crushing test, Impact test, Abrasion test, Water absorption test, Soundness test, Shape test, Specific gravity and Sieve analysis (gradation).

3.4.3.1 Crushing Tests

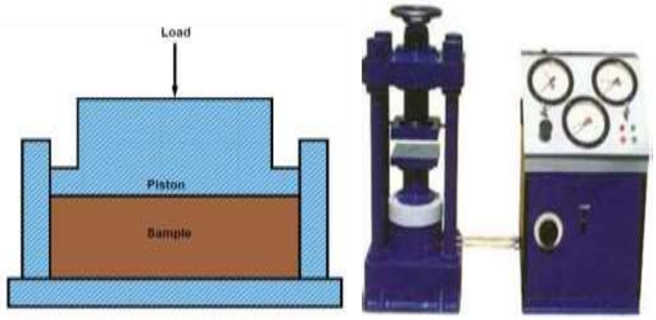


Fig. 3.4 Setup for Crushing Test

Crushing strength of aggregates is assessed by performing a crushing test to determine the load at which it fails when compressive stress is applied. IS: 2386 part-IV is the international standard for this test. This figure represents the aggregates' relative resistance to crushing when a weight is applied gradually. In other words, it's the ability to withstand crushing under extreme conditions. The aggregates used in the test range in size from 10 to 12.5 mm. A 115mm diameter and 180mm depth mould is included with the configuration. The aggregates in the mould are subjected to a 40-tonne load that is imposed for 10 minutes.

The aggregate crushing value of the aggregates is calculated as the material passing through
2.36 mm sieve expressed as the percentage of total aggregate.

Aggregate crushing value = (B/A)*100 % where,
B = weight of fraction passing through 2.36 mm sieve = 1.5 kg A = weight of surface dry sample taken in mould = 6.5 kg Crushing value = (1.5/6.5)*100 = 23.07 %

3.4.2.2 Abrasion test

Hardness feature of the aggregates is found out by performing abrasion test on them and then depending upon the test results, decision is taken if the aggregates are suitable for the various construction works. There are three types of abrasion tests:
Los Angeles abrasion test. Deval abrasion test.
Dory abrasion test.
The Los Angeles test is the preferred and most extensively utilised of the following types of abrasion testing. In India, it has also been standardised (IS: 2386 part-IV). The percentage wear is determined using an abrasion test. The relative rubbing action between steel balls utilised as an abrasive charge in the steel drum and the aggregates causes wear in the test. Aggregates are loaded into a revolving steel drum with a shelf plate affixed to the drum's outside wall. The steel drum measures 700 mm in diameter and 500 mm in length. Steel balls with a diameter of 48 mm and a weight of 390-455 gram were utilized. At the time of testing, the drum rotates at 30-33 revolutions per minute. The quantity of steel balls in the drum changes depending on the aggregate gradation. The material passing through a 1.7 mm sieve is stated as a percentage of total aggregate to calculate the Los Angeles abrasion value of the aggregates.

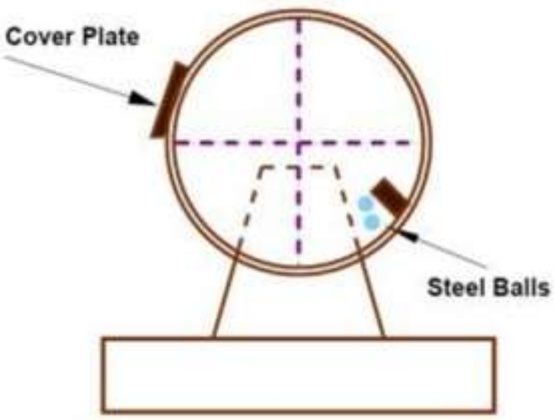


Fig. 3.5 Setup for Los Angeles Abrasion Test

Los Angeles abrasion value = (B/A)*100 % where,
B = weight of material passing through 1.7 mm sieve = 0.67 kg A = weight of total aggregates = 2.1 kg
Abrasion value = (0.67/2.1)*100 = 30.90 %.

3.4.2.3 Impact test

The aggregate impact test is used to determine the aggregates' resistance to impact or abrupt loads. The aggregates utilised in the test should be 10-12.5 mm in size. This test is carried out in a mould that is 50 mm deep and 102 mm in diameter. The hammer used to provide the impact load to the aggregates weighs 13.5-14 kg and has a 380 mm drop. The aggregates receive a total of 15 blows.

The impact value of the aggregates is calculated as the material passing through 2.36 mm sieve expressed as the percentage of total aggregate.

Aggregate Impact value = (B/A)*100 % Where,

B = weight of fraction passing through 2.36 mm sieve = 325 g A = weight of surface dry sample taken in mould = 1.55 kg Crushing value = (0.325/1.55)*100 = 21 %

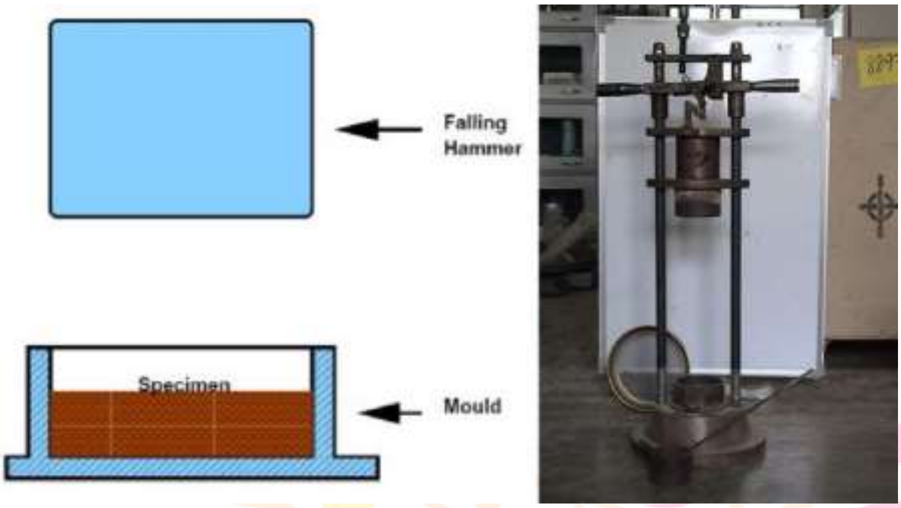


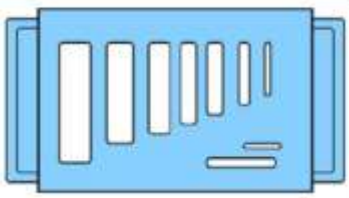
Fig. 3.6 Setup for Impact Test

3.4.2.4 Soundness test

Some aggregates disintegrate quite quickly when frozen and thawed. This test is used to determine how long such aggregates will last. The purpose of this test is to determine how resistant aggregates are to weathering. This is accomplished by repeatedly immersing the aggregate sample in chemicals. This test is specified in IS: 2386 part-V in India. We immerse the aggregate sample in a saturated sodium or magnesium sulphate solution for 16-18 hours in this test. After soaking, the sample is dried and heated to 105 degrees to maintain a steady weight. The identical method is followed once more, for a total of 5 cycles. The weight reduction for each fraction of aggregates is then calculated. The weighted average percent loss for the entire sample is used to get the soundness value. This weight decrease is achieved by sifting and weighing all undersized particles.

When sodium sulphate is employed, weight loss should be less than 12%, but in the case of magnesium, the limiting value of soundness is 18%.

3.4.2.5 Shape test



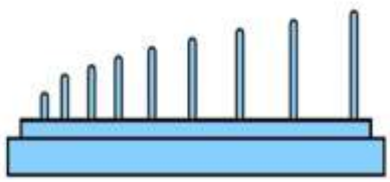


Fig. 3.7 Flakiness Gauge   Fig. 3.8 Elongation Gauge

This test is critical for compaction, PCC workability, and bituminous mix binder requirements. In terms of strength, cubic angular aggregates with a rough texture are preferred, although their workability is compromised. Rounded particles are easier to compact, but they provide the concrete less strength. When compaction is done, flat and elongated aggregates frequently break, resulting in a loss of strength. The procedure adopted for performing this test has been standardized in India (IS: 2386 part-I). Flakiness index is the percent by weight of the aggregate particles whose least dimension is less than 0.6 times the average size of the aggregate fraction. It is applicable for the sizes larger than 6.3 mm. Thickness gauge is used.

Elongation index is the percent by weight of the aggregate particles having maximum dimension greater than 1.8 times the average dimension. Length gauge is used.

3.4.2.6 Specific gravity and water absorption test

Specific gravity and water absorption, two highly essential aggregate qualities, are used in the creation of concrete and bituminous mixtures. For 24 hours, two kg of dry aggregates are submerged in water. The buoyant weight is obtained by finding the aggregate sample weight in water. The same aggregates are then baked for roughly 24 hours at a temperature of 100-110oC before being weighed. By dividing the dry weight of aggregates by the weight of an equal amount of water at a certain temperature, the specific gravity is computed. Value of specific gravity of aggregates lies between 2.6 and 2.9.

Water absorption can be expressed as the percent water absorbed in terms of oven dried weight of aggregates. The value of the water absorption should be less than 0.6 % of the weight of aggregates.

3.4.2.7 Sieve analysis

Sieve analysis is used to examine the gradation of aggregates. The aggregate sample is sieved through a standard size mesh, and the cumulative proportion of aggregates passing is displayed against sieve sizes. It's usually done on a logarithmic scale with a graph. Aggregate gradation or particle distribution curve is the result of this process. The procedure adopted is given below:
Procedure:- Take around 2.5 kilogrammes of coarse aggregates and 0.5 kilogrammes of fine aggregates as a sample for testing. Take the needed number of sieves and arrange them in descending order. This means that the sieve with the smallest aperture will be at the bottom of the stack, while the sieve with the widest opening will be at the top. The
The aggregates are poured into the top sieve and shaken or vibrated for at least two minutes. The weight of aggregates present on each sieve after vibration is then calculated and given as a percentage of passing. These values of percent passing are compared with the recommended values to check if it lies within that recommended range of gradation or not. If it lies outside that range, then necessary action is needed to fix the problem.
For reference, grading limit of both kinds of aggregates i.e. coarse aggregates and fine aggregates is given below;

Table 3.3 Grading limit of fine aggregate

IS Sieve	Equivalent BS sieve	Percentage passing for			
		Zone 1	Zone 2	Zone 3	Zone 4
10 mm	3/8 –in	100	100	100	100
4.75 mm	3/16 –in	90-100	90-100	90-100	95-100
2.36 mm	N0. 7	60-95	75-100	85-100	95-100
1.18 mm	No. 14	30-70	55-90	75-100	90-100
600 micron	No. 25	15-34	35-59	60-79	80-100
300 micron	No. 52	5-20	8-30	12-40	15-50

Table 3.4 Results for coarse aggregates

IS sieve size	Percent retained	Cumulative percent retained	Percent passing
40 mm	0.00	0.00	100
20 mm	3.55	3.55	96.45
10 mm	61.20	64.75	35.25
4.75 mm	31.25	96.00	4.00

Table 3.5 Grading limit of coarse aggregate

I.S. Sieve Designation	% passing for graded aggregate of nominal size			
	40 mm	20 mm	16 mm	12.5 mm
80 mm	100	-	-	-
63 mm	-	-	-	-
40 mm	95-100	100	-	-
20 mm	30-70	95-100	100	100
16 mm	-	-	90-100	-
12.5 mm	-	-	-	90-100

10 mm	10-35	25-55	30-70	40-85
4.75 mm	0-5	0-10	0-10	0-10
2.36 mm	-	-	-	-

IV. MATERIALS USED AND TESTS PERFORMED

The waste rubber tyres used in the construction sector are not classified in any precise or specified way. They have been divided into the following classes based on the size they are chopped down to after they retire from their primary function of supporting a vehicle in motion. This is not a particularly precise or tight classification because they are sometimes employed as a single category at the same time.

Fig. 3.9 Manual cutting of Tyre Rubber to the size of Coarse Aggregates

4.1 Different types of rubbers

4.1.1 Scrap tyres

These are whole waste tyres in their original state, with no cutting or shredding. A standard automotive tyre weighs around 9.07 kilos. Similarly, the average weight of a truck tyre is estimated to be 45.35 kg. The table below shows the normal composition of automotive and truck tyres by weight.

Table 3.6 Composition by weight

Composition by percent weight	Automobile tyre	Truck tyre
Natural rubber	14	27
Synthetic rubber	27	14
Carbon black	28	28
Steel	14-15	14-15
Fabric, filler, accelerators	16-17	16-17

Given here are different the materials used in the manufacture of tyres Synthetic Rubber Natural Rubber, Sulfur and Sulfur compounds, Phenolic resin, Oil (Aromatic, naphthenic, paraffinic), Fabric (Polyester, Nylon etc), Petroleum Waxes, Pigments (Zinc oxide, Titanium Dioxide etc), Carbon black, Fatty acids.

4.1.2 Slit tyres

When a whole tyre is chopped down into two or three halves, this is referred to as waste tyre rubber. This work is done with a variety of tyre cutting machines. These are the Tyre cutting machines manufacture it. These devices can cut these tyres into pieces as well as separate the tread from the side walls.

4.1.3 Shredded and chipped tyres

Shredded or chipped tyres are the outcome of the primary and secondary shredding processes. This simply refers to the tyre being sliced into significantly smaller pieces. These shredded or chipped rubber particles are typically 0.5- 3 inches in size.

4.1.4 Ground rubber

It's a considerably smaller rubber that varies in size depending on the application. Its size is also determined by the tool that was used to reduce it to this lesser size. These particles are initially exposed to a dual magnetic separation cycle. Following that, they are screened and recovered in various sizes.

4.1.5 Crumb rubber

When compared to other tyes, these are the rubber particles with the lowest size. These are the powdered version of rubber that can be used to substitute fine particles in concrete. They range in size from 0.075 to 4.55 mm. A discarded tyre can be transformed into crumb rubber in a variety of ways. These methods are enlisted below;
Cracker mill process, Granular process, Micro mill process.

4.2 Concrete Mix Testing

The concrete mix required as per design for the construction of rigid pavement tested in the laboratory as per the details are given below:

4.2.1 Workability Test

This test is done with a slump cone, which has a top diameter of 10cm, a bottom diameter of 20cm, and a height of 30cm. The mould is set on a smooth surface, and mixed substances such as cement, fine aggregates, rubber pieces, and water are placed in the mould to about one-fourth of its height in this test. After that, the concrete is compressed 25 times with a tamping rod uniformly all over the mold's surface. This method is continued until the mould is completely full, after which the upper surface is cleaned with a shovel and the mould is removed.
Place the mould upright and wait until the concrete settles to the desired slump value. This procedure is for plain concrete and same procedure is repeated for sodium hydroxide(NaOH) treated mixture and cement paste treated mixture as well as for untreated mixture. The rubberized concrete sample for workability test is shown in Fig. 3.10 and values of slump are shown in table 3.7.

Table 3.7 Slump values of different samples

SAMPLE	SLUMP VALUE (mm)	PERCENT REDUCTION OF SLUMP
PC	50	0
UTR-5	47	6
UTR-10	45	10
UTR-15	43	14
NTR-5	48	4
NTR-10	44	12
NTR-15	40	20
CTR-5	45	10
CTR-10	42	16
CTR-15	35	30

Fig. 3.10 Rubberized Concrete Sample for Workability Test

4.2.2 Compressive Strength Test

The compression test is carried out on a compression testing machine. This test is carried out using cubical moulds measuring 15cm x 15cm x 15cm. This test involves pouring concrete into a mould and tempering it properly to avoid voids. These moulds are removed after 24 hours, and test specimens are immersed in water to cure. The top layer should be smooth and even. After 7 or 28 days after curing, these specimens are subjected to compression testing, which involves gradually increasing load at a rate of 140kg/cm per minute until the specimen fails. Load at the point of failure The compressive strength of rubberized concrete is calculated by dividing its area by its volume. The technique is the same for plain concrete and is repeated for sodium hydroxide (NaOH) treated mixtures, cement paste treated mixtures, and untreated mixtures. The cube is compressed in figure 3.11, and table 3.8 illustrates the compressive strength of several samples.

Fig. 3.11 Cube under Compression

Table 3.8 Compressive strength of different samples

SAMPLE	7-DAY COMPRESSIVE STRENGTH-CUBE (N/mm^2)	28-DAY COMPRESSIVE STRENGTH-CUBE (N/mm^2)
PC	19.11	27.33
UTR-5	13.87	19.80
UTR-10	16.44	23.50
UTR-15	15.60	20.40
NTR-5	16.40	23.30
NTR-10	17.70	25.30
NTR-15	11.11	15.60
CTR-5	15.60	22.2
CTR-10	12.11	15.50
CTR-15	17.33	21.70

4.2.3 Flexural Strength Test

This test is carried out using equipment such as a testing machine, tamping rods, streel moulds, scoop, and trovel. Cement, sand, waste rubber aggregates, and water are well mixed before being poured into the mould in three layers and compacted with a tamping rod to produce a cube. Remove any extra concrete from the mold's top and level it down. Until the testing, the specimens are stored at room temperature. The test specimens are placed on the testing equipment after 28 days and a gradual load is given. Finally, determine average depth and height by measuring the cross-section of the tested specimen at each end and in the middle. The procedure is for plain concrete and same procedure is repeated for sodium hydroxide (NaOH) treated mixture and cement paste treated mixture as well as for untreated mixture. The flexural strength after 28 days of the tested specimen is shown in the table 3.9.

Fig. 3.12 Two Point Flexural Loading on Beam

Table 3.9 Flexural strength test results

SAMPLE	28-DAY FLEXURAL STRENGTH BEAM (N/mm^2)	ULTIMATE LOAD `(KN)	DISPLACEMENT (mm)
PC	8.10	16.20	0.96
UTR-5	7.95	15.90	1.12
UTR-10	6.90	13.80	1.10
UTR-15	6.40	14.80	0.80
NTR-5	9.30	18.60	1.30
NTR-10	8.75	17.50	1.50
NTR-15	7.51	15.02	1.38
CTR-5	9.25	18.50	1.60
CTR-10	8.51	17.02	1.45
CTR-15	8.00	16.00	1.30

4.2.4 Split Tensile Strength Test

Steel moulds, testing machines, and tamping rods are used to test the split tensile strength of concrete. To make a homogeneous mixture, components such as fine sand, cement, rubberized concrete, and water are combined together. The material is then poured into the mould in layers, with each layer crushed with a tamping rod, and the top surface of the specimen polished properly. The specimen is kept at a constant temperature for 28 days. After the specimen has been curing for a period of time, its weight and dimensions are verified, and it is placed on a testing machine, where a load of 0.7 to 1.4 MPa/min is applied progressively to the specimen, and the breaking load is calculated. The technique is the same for plain concrete, NaOH-treated mixtures, cement paste-treated mixtures, and untreated mixtures. Table 3.10 shows the test's calculations.

Fig. 3.13 Cylinder under Split Tensile load

Table 3.10 Split tensile strength of different samples

SAMPLE	28-DAY SPLIT TENSILE STRENGTH CYLINDER(N/mm^2)
PC	2.38
UTR-5	2.10
UTR-10	1.90
UTR-15	1.60
NTR-5	3.82
NTR-10	5.72
NTR-15	6.36
CTR-5	4.76
CTR-10	4.28
CTR-15	4.07

V. RESULTS AND DISCUSSION

5.1 Workability

Both treated and untreated rubberized concrete have lower workability than plain concrete, and this reduces as the percentage of particles replaced increases. Except for NTR-5, which has a tiny increase of 1mm in slump value over UTR-5, all other replacement levels and treatments exhibit a decline in workability as the percentage replacement is raised, as shown in Figure 4.1. Rubber aggregates obstruct the mobility of concrete paste and natural aggregates, and incorrect bonding results in low workability of rubberized concrete (untreated). Increased viscosity causes a loss in workability when bonding is improved by NaOH treatment. Workability is reduced when rubber is treated with cement paste because cement particles stick to rubber particles, absorbing water from the concrete and leaving less water available for workability.

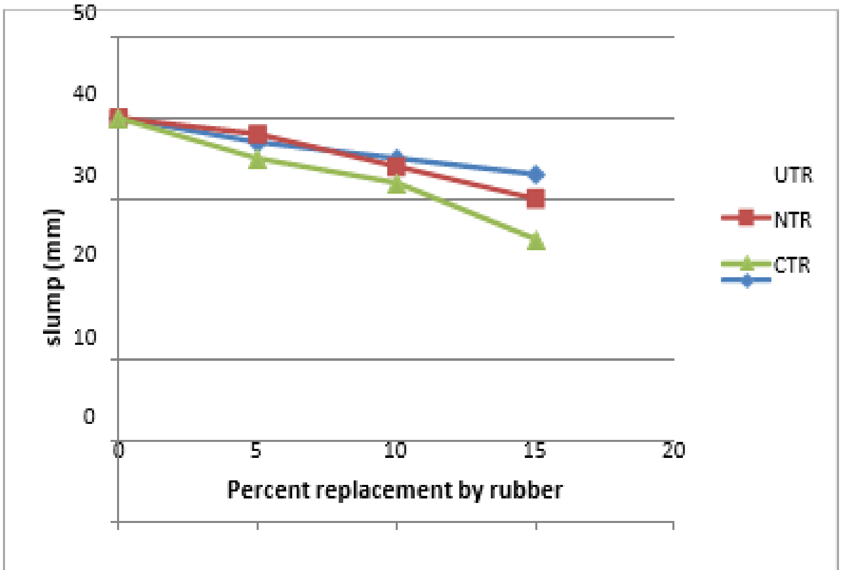


Fig. 4.1 Slump vs Percent Replacement by Rubber

5.2 Compressive Strength

NTR-10 has the highest 7-day compressive strength of all the substituted mixes, however it is lower than plain concrete. However, in this situation, the plain concrete compressive strength is restored to 92.62 percent, which is pretty excellent given the material utilised. Similarly, NTR-10 has the maximum 28-day compressive strength, however it is lower than plain concrete. It accounts for 92.57 percent of the compressive strength of ordinary concrete, which is deemed adequate. When compared to NTR-10 and plain concrete, the compressive strengths of untreated and cement treated rubberized concrete are shown to be very low. Less compressive strength may be attributed to a large variation in elastic modules, a lack of adequate bonding, and low adhesion between concrete ingredients and untreated rubber particles. It's also because rubber particles have a lower strength than the concrete matrix around them, therefore when force is applied, cracks occur first in the rubber-concrete matrix contact zone.

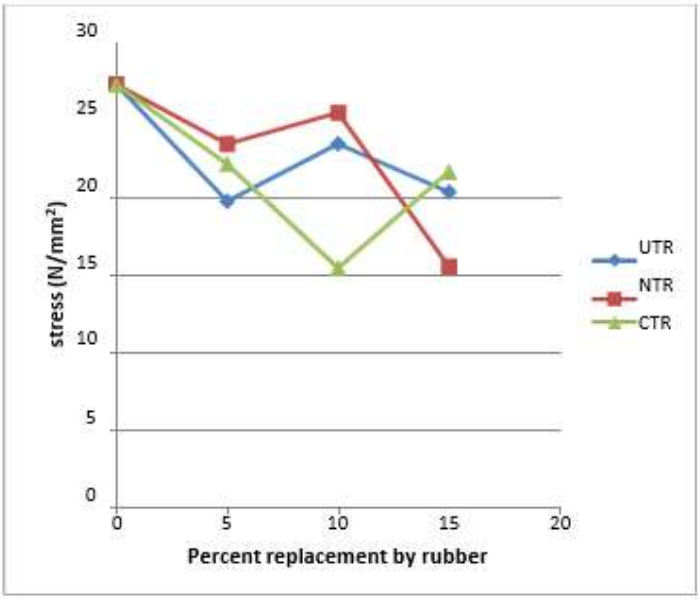


Fig.4.2 Variation of 28 Days Compressive Strength vs Percent Replacement by Rubber

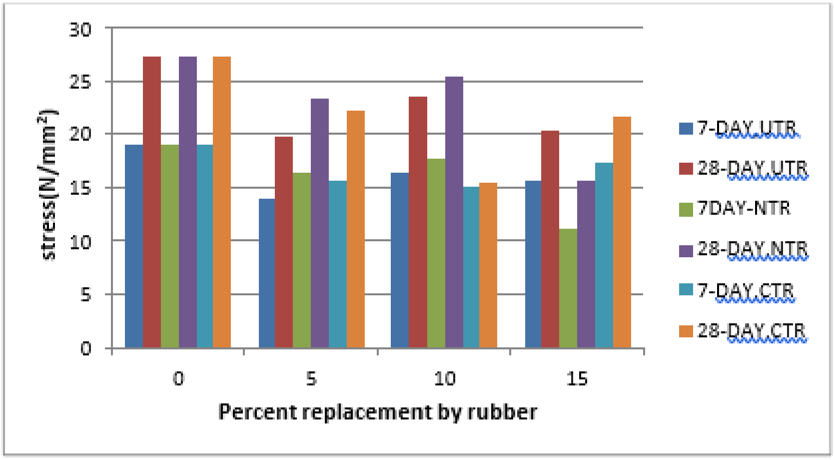


Fig. 4.3 Comparison between 7 and 28 days Compressive Strength on Varying Percentages of Rubber

5.3 Flexural Strength

In our current investigation, flexural strength displays a variable pattern. NTR-5 had the highest flexural strength of all replacement mixes and plain concrete after 28 days. The flexure strength of untreated rubber concrete decreased, but the flexure strength of treated rubber concrete varied. The maximum flexural strength of treated rubberized concretes corresponds to 5% replacement level, while the minimum flexural strength corresponds to 15% replacement level. At 5% replacement by treated rubber, the improvement in strength relative to typical conventional concrete is determined to be roughly 13%. Less cement in the mixture makes it less rigid. As the rubber aggregates can bridge cracks caused by flexural loading, the less stiff specimens with rubber aggregates can withstand additional loading after cracking. Thus increase in treated rubber aggregate content increases the flexural strength but only up to a replacement range of 5%.

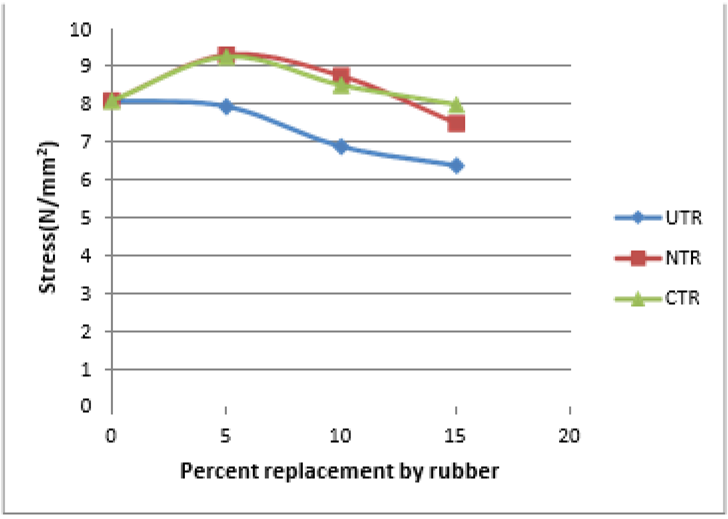


Fig. 4.4 Variation of 28 days Flexural Strength vs Percent Replacement by Rubber

5.4 Split Tensile Strength

After 28 days, split tensile strength is found to be higher in each case when treated rubber is employed, and it is highest at NTR-15 (Sodium hydroxide treated with 15 percent replacement). The split tensile strength is 2.67 times that of conventional concrete at this replacement level, which is tremendous and encouraging. This increase in split tensile strength after rubber treatment is due to a combination of increased bonding caused by the treatment and the flexible nature gained by concrete as a result of the rubber particle.

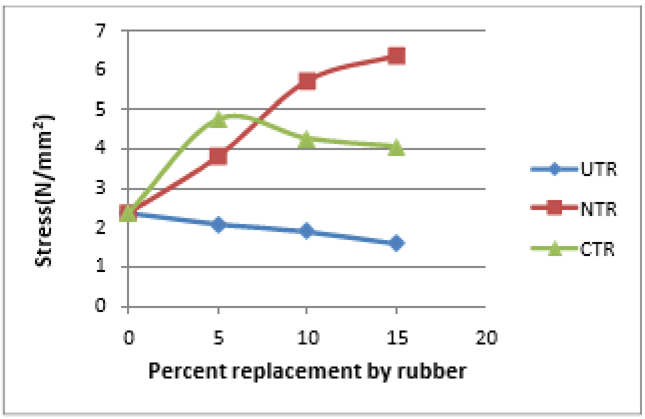


Fig. 4.5 Variation of 28 days Split Tensile Strength vs Percent Replacement by Rubber

VI. CONCLUSIONS

Following are the conclusions:

1) The best results for treated waste tyre rubber material with NaOH replaced by 5% had a small increase in slump value of 1mm over the UTR-5. As the waste tyre rubber replacement demonstrates natural resource of course aggregates, the compressive strength attained is 92.57 percent, which is considered to be a very excellent figure from a structural standpoint.

2) The flexural and split tensile strength of treated rubberized concrete replacement levels is found to be higher than that of conventional concrete. NTR-5 and NTR-15 have the highest 28-day flexural and split tensile strength, respectively.

3) The goal of this research was to see if a waste resource like old tyres could improve the basic qualities of concrete. The data presented in this study indicates that the use of tyres as aggregates has a lot of promise. Utilized tyres are thought to offer far more chances for value addition and cost recovery because they can be used to substitute more expensive materials like rock aggregate.

I. ACKNOWLEDGMENT

I would also like to expresses deep gratitude and thankfulness to my supervisors, Er AJAY BAKUL, Assistant Professor, Department of Civil Engineering, for her gracious support, dynamism, fantastic stamina, cooperation and encouragement and day-to-day monitoring of every minute detail was a constant source of inspiration to me to the completion of thesis.

I am also heartily thankful to Prof. MUKESH KUMAR , Associate Professor and HOD Civil Engineering Department, for the motivation and inspiration that triggered me for my thesis.

I would also like to thank all the faculty members at UNIVERSAL GROUP OF INSTITUTION, LALRU MANDI, CHANDIGARH, DISTRICT MOHALLI.

REFERENCES

[1] Lee, Hee Suk, et al., "Development of tire added latex concrete." Materials Journal 95.4 (1998): 356-364.

[2] Taha, MM Reda, A. S. El-Dieb, and MA Abd El-Wahab., "Fracture toughness of concrete incorporating rubber tire particles." International conference on performance of construction materials. 2003.

[3] Azmi, N. J., B. S. Mohammed, and H. M. A. Al-Mattarneh., "Engineering Properties of Concrete Containing Recycled Tyre Rubber." International Conference on Construction and Building Technology. 2008.

[4] Boudaoud, Zeineddine and MiloudBeddar., "Effects of recycled tires Rubber aggregates on the characteristics of cement concrete." (2012).

[5] Yasin, Amjad A., "Using Shredded Tires as an Aggregate in Concrete."Contemporary Engineering Sciences 5.10 (2012): 473-480.

[6] Akinwonmi, SAdemola et al., "mechanical strength of concrete with crumb and shredded tyre as aggregate replacement.",International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 2, March -April 2013, pp.1098-1101.

[7] Shah, Sunil N, Pradip D. Jadhao and S. M. Dumne., "Effect of Chipped Rubber Aggregates on Performance of Concrete."

[8] Onuaguluchi, Obinna and Daman K. Panesar., "Hardened properties of concrete mixtures containing pre-coated crumb rubber and silica fume." Journal of Cleaner Production 82 (2014): 125-131.

[9] Kranul N Patel, Prof. M.A Jamnu., "Enhancement of mechanical properties of Rubber Crumb concrete using pretreated rubber crumbs and alccofine." Journal Of International Academic Research For Multidisciplinary Impact Factor 1.393, ISSN: 2320-5083, Volume 2, Issue 2, March 2014.

[10] Alam, Ishtiaq, UmerAmmarMahmood and NoumanKhattak., "Use of Rubber as Aggregate in Concrete: A Review." International Journal of Advanced Structures and Geotechnical Engineering 4.02 (2015).

[11] More, Tushar R, Pradip D. Jadhao and S. M. Dumne., "Strength Appraisal Of Concrete Containing Waste Tyre Crumb Rubber."(2015).

[12]He, Liang, et al., "Surface modification of crumb rubber and its influence on the mechanical properties of rubber-cement concrete." Construction and Building Materials 120 (2016): 403-407.

[13]Thomas, Blessen, Skariah and Ramesh Chandra Gupta., "A comprehensive review on the applications of waste tire rubber in cement concrete." Renewable and Sustainable Energy Reviews 54 (2016): 1323-1333.

[14]Guo, Shuaicheng, et al., "Evaluation of properties and performance of rubber-modified concrete for recycling of waste scrap tire." Journal of Cleaner Production 148 (2017): 681-689.

[15]El-Gammal, A, et al., "Compressive strength of concrete utilizing waste tire rubber." Journal of Emerging Trends in Engineering and Applied Sciences 1.1 (2010): 96-99.

[16] Raghavan, Dharmaraj, H. Huynh and C. F. Ferraris., "Workability, mechanical properties, and chemical stability of a recycled tyre rubber-filled cementitious composite." Journal of Materials science 33.7 (1998): 1745-1752.

[17] Zhang Y, Sun Wei and Chen Shengxia., "Study on properties of rubber included concrete under wet-dry cycling." Measuring, Monitoring and Modeling Concrete Properties (2006): 395-401.

[18] Zhigang, Ye, Zhang Yuzhen and Kong Xianming., "Modification of bitumen with desulfurized crumb rubber in the present of reactive additives." Journal of Wuhan University of Technology--Materials Science Edition 20.1 (2005): 95-97.

[19] Yue, Li, Jin Caiyun and Xi Yunping., "The properties of sulfur rubber concrete (SRC)." Journal of Wuhan University of Technology--Materials Science Edition 21.1 (2006): 129- 133.