Investigation Study on Structural Properties and Behavior of WTRC in Structural Components

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Abstract - *Generally, waste tyre rubber is created around the world. In this investigation study that had been seen behavior of waste tyred rubber concrete (WTRC) in structural components. In this manner, it is important to have a significant utilization of these wastages. The point of this exploration is to ponder the likelihood of utilizing waste tyre rubber in cement concrete to supplant coarse aggregate. The test program wasdone to create data about the mechanical properties of rubberised cement concrete. The samples were set up with rate substitutions of the coarse aggregate by 4, 8, 12 and 15 per cent waste tyre rubber aggregate. The readied tests comprise of cubes, cylinders, and beams. Material properties were considered before making concrete. Slump test was directed on fresh cement concrete to consider workability. The samples were tried for compressive strength, split tensile strength, flexural strength, modulus of elasticity and impact strength. The Column-Beam joint is a basic part in a structure as it is basic in building up a definitive limit of all individuals that meet at the joint. The joints are required to have adequate quality and solidness to oppose the interior powers incited by the encircling individuals. The joint is planned according to the arrangements of IS 456:2000 and SP-34. Column-Beam joint samples of the concrete with various rates of coarse aggregate substitution were thrown and tested. The examined parameters are the malleability, joint contortion and load versus displacement curve. The discussion as gone through structural properties of column beam joint and railway sleepers.*

Key Words: Slump Test, Compressive Strength Test, Split Tensile Strength Test, Flexural Strength Test, Young's Modulus Test, Railway Sleepers, Column-Beam Joint.

1.INTRODUCTION

Plain cement concrete, usually known as concrete, is a mixture of concrete, fine aggregate, coarse aggregate and water. This can be effectively formed to wanted shape and size before it loses plasticity and hardens [1]. Plain concrete is strong in compression yet frail in tension. Parallel to the requirement for the use of the natural resources and rises a developing worry for ensuring the protection of the environment and a need to protect natural resources, for example, aggregates, by utilizing alternative materials that are either reused or disposed of as waste. It is conceivable to decide the extent of the elements for a specific quality by mix design. Coarse aggregate is less expensive than cement and it is, in this manner, affordable to put in with the concrete a significant part of the previousand as meager of the last as could be expected under the circumstances. By and by, an economy isn't the main explanation behind utilizing aggregate: it presents impressive specialized preferences on concrete, which has highervolume stability and preferred durability over hydrated cement paste alone. The wastages are separated assolid waste, fluid waste and vaporous squanders[2]. There are numerous transfer routes for fluid and vaporous waste materials. Some solid waste materials, for example, plastic bottles, papers, steel, and so on can be reused without influencing the earth. The total number of waste disposable tyres will be in the order of 112 million every year in India[12]. These emanations are considered as very undermining squanders to the universe.

1.1 Waste Tyred Concrete

The utilization of reused tyre rubber as partial replacement of aggregates in concrete has the best potential to emphatically influence the properties of concrete in a wide range. Concrete is a standout amongst the most well-known development materials. Because of this reality, the development business is continually end to expand its uses and applications and enhancing its properties, while decreasing expense [3]. When all is said and done, concrete has low tensile strength, low ductility and low energy absorption. Concrete additionally will in general reduce in size and break amid the solidifying and relieving process. These restrictions are always being tried keeping in mind the desire of enhancement by the presentation of the new admixtures and aggregates utilized in the mix. In our cutting edge time mixing of piece rubber can decrease the measure of waste dumped into mother earth and furthermore go about as a standout amongst the most prudent approaches to moderate nature by diminishing the utilization of coarse aggregate.

1.2 Objective of the Study

The point of this examination is to use the tyre elastic into concrete and spare the abuse of nature. The exploration is centered explicitly around

1. Finding out an ideal substitution level.
2. Cyclic behaviour of column-beam joint.
3. Feasibility of utilizing waste tyre rubber as aggregate in theprestressed concrete sleeper.

2. LITERATURE REVIEW

The expression "rubber concrete" is utilized as a nonexclusive name for a mix of ordinary portland cement concrete with rubber crumbs. The utilization of resonant frequency method to measure the dynamic modulus of elasticity and Poisson‟s ratio. They found that utilizing rubber particles would enhance the designing attributes of concrete. The investigation centered around supplanting mineral coarse aggregate with rubber tyre chips. Proposed a work of compressive quality decrease model of concrete mixes with included rubber substance and the mechanical behaviour of crumb rubber cement mortar.

2.1 Strength properties of waste tyre aggregate in concrete

This investigation details with the impact on properties of concrete by partially replacing the rubber aggregates by coarse aggregates in concrete. A modified concrete is prepared by replacing coarse aggregates in concrete with rubber aggregates by varying the replacement proportion from 0% to 20% with an increment of 5%. 3 cubes for each percentage of replacement were cast and tested after 28 days of curing. The physio-mechanical properties like density, compressive strength and elastic properties of modified concrete are determined from concrete cubes experimentally and further stresses and displacement at every 50 mm depth of beams are determined analytically by a Method of Initial Functions (MIF). The analytical results by MIF are compared with bending theory. It is observed that the specific gravity and bulk density of rubber aggregates are less as compared to natural coarse aggregates[4]. The density of concrete decreases when the use of rubber aggregates in concrete increases. Due to this, the lightweight concrete is obtained which helps to reduce the weight of thestructure. But the compressive strength decreases and toughness of concrete increases if the use of rubber aggregates increases. High rubber content so as to fully utilise the mechanical properties of vulcanised rubber. The fresh properties and short-term uniaxial compressive strength of 40 rubberised concrete mixes were assessed. The parameters examined included the volume (0 to 100%) and type of mineral aggregate replacement (fine or coarse), water or admixture contents, type of binder, rubber particle properties, and rubber surface pre-treatments[5]. This initial study led to the development of an “optimum” RuC mix, comprising mix parameters leading to the highest workability and strength at all rubber contents. The properties of rubber aggregates mixed in concrete where sand and coarse aggregate are replaced by rubber chips. Test results indicate that while the tensile strength is increased, compressive strength is reduced when the proportion of rubber aggregates is increased beyond 50%. However, rubber concrete did not allow cracks to propagate immediately while plain concrete allowed cracks to progress very quickly[6]. Natural sand in the concrete mixes was partially replaced by 5%, 10%, 15%, and 20%. Physical properties such as the density, the compressive strength, the fresh concrete properties, the split-tension, and the impact load capacity are examined. The results revealed a decrease in the compressive strength of concrete cylinders containing rubber[7]. The dynamic performance of the rubber concrete is of high importance because of its high resilient nature, as the rubber particles that are included in the concrete have a positive effect on the dynamic performance. The conclusions that were derived from this research implicate potential applications where rubberised concrete can be efficiently used. Even though rubberised concrete mixture generally has a reduced compressive strength that may limit its use in certain structural applications, it possesses a number of desirable properties, such as lower density, higher toughness, and higher impact resistance compared to conventional concrete.

3. MATERIALS

3.1 Cement

Cement is the most important ingredient utilized. Cement goes about as a coupling material utilized in the arrangement of concrete. It ties the coarse aggregate and fine aggregate with assistance of water, to a solid issue and furthermore it fills the voids in the solid. Normal Portland Cement of 53 grade incompliance to IS 8112-1989 and like ASTM type III (C150-95) were utilized.

Table -1: Physical properties of cement

Sl.No	Properties	Value	Standard values
1	Specific gravity	3.17	3.10 - 3.20
2	Standard consistency	28%	25 - 35%
3	Initial setting time	45 minutes	>30 min
4	Final setting time	512 minutes	<600 min
5	Compressive strength of mortar cubes at 28 days	53.80 MPa	53 MPa

3.2 Fine Aggregate

Fine aggregate assumes a vital job in concrete in the two stages, its plastic and solidified state. Fine aggregates by and large comprise of normal sand or pounded stone with most particles going through a 3/8-inch(9.5 mm) sieve. Fine aggregate ought to be legitimately evaluated to give least void proportion and be free from harmful materials like clay, sediment substance and chloride pollution and so forth.

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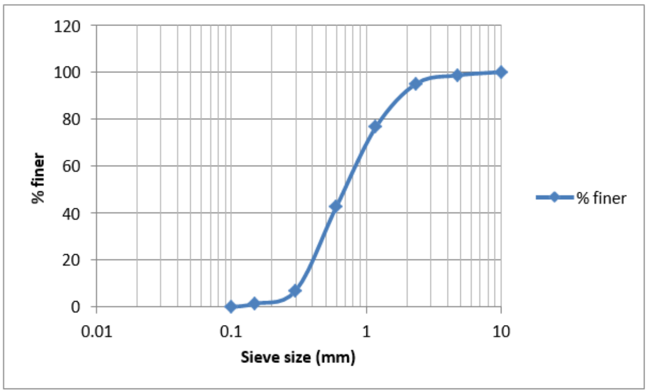
Table -2: Physical properties of fine aggregate

S.No	Properties	Value
1	Specific gravity	2.52
2	Percentage of voids	24.50%
3	Fineness modulus	2.786
4	Bulk density	1650 kg/m³
5	Water absorption	1.20%

Figure-1: Sieve analysis chart for fine aggregate



3.3 Coarse Aggregate

Coarse aggregates make up about 75% of the volume of concrete, so their properties impact the properties of the concrete. Aggregates are granular materials, most usually regular rock and sands or pounded stone, albeit every so often manufactured materials, for example, slags or extended clays or shales are utilized.

Table -3: Physical properties of coarse aggregate

S.No	Properties	Value
1	Specific gravity	2.74
2	Fineness modulus	5.67
3	Bulk density	1507.5 kg/m³
4	Water absorption	0.80%

3.4 Tyre Rubber Aggregate

Tyre rubber was made by cutting the piece truck tires into sizes of16mm and 20mm and utilized by mixing them in an extent of 2:3. The cutting of tyre was finished by hand with etches and cutters. The most extreme and least size of rubber aggregate was 20mm and 16mm separately were utilized for supplanting coarse aggregate in Rubberised Concrete.

Table -4: Physical properties of coarse aggregate

S.No	Properties	Value
1	Specific gravity	1.07
2	Bulk density	1013kg/m³
3	Water absorption	0.33%

Table -5: Mix Proportion

Cement	413.33 kg/m³
Water	186 kg/m³ Fine
aggregate	671.84 kg/m³
Coarse aggregate	1142.6 kg/m³W/C
ratio	0.45

3.5 Mix Ratio

The mix ratio of the conventional M30 grade concrete by weight is arrived from IS code method (As per IS 10262:2009)

Table -6: Mix Ratio M30 Concrete

Cement	Fine aggregate	Coarse aggregate
1	**1.62**	**2.764**

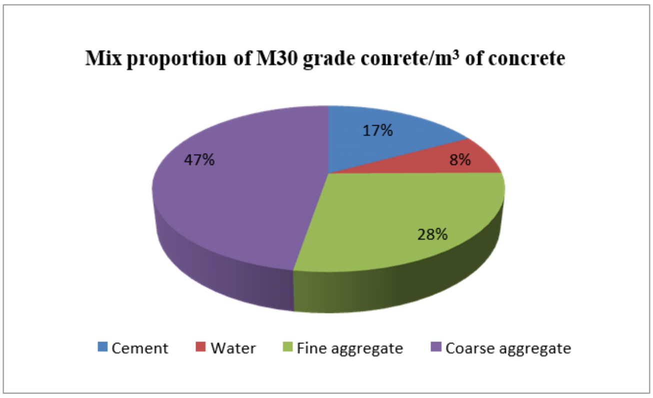


Figure-2: Mix proportion per m³ of M30 grade concrete

4. METHODOLOGY

Present investigation comprises of deciding the mechanical properties and cyclic stacking conduct of Rubberised Concrete (RC) in columnbeam joint and contrasting it with Conventional M30 grade concrete[8]. M30 review having mix proportion of 1:1.62:2.764 with water-cement proportion of 0.45 is touched base by the strategy of IS-10262:2009. The level of replacement of rubber utilized is 0%, 4%, 8%, 12% and 15% for the coarse aggregate by volume of coarse aggregate. The separate concrete are assigned as CC, RC4, RC8, RC12 and RC15. In M55 concrete utilized for railway sleeper compressive quality of the concrete with 0%, 6%, 8% and 12% rubber substance as coarse aggregate were discovered. The individual concrete was assigned as CC, R6, R8 and R12.

4.1 SLUMP TEST

Slump test is the most usually utilized technique for estimating workability of concrete[9]. The mechanical assembly to lead the slump test comprises of a metallic shape as a frustum of a cone having 200 mm base diameter, 100 mm diameter at top and 300 mm height. The shape is loaded up with concrete in three layers. Each layer is tamped 25 times by the tamping rod taking consideration to convey the strokesuniformly over the cross-area.

4.1 COMPRESSIVE STRENGTH TEST

The compression test is utilized to decide the compressive quality of cubical samples of size 150mm x 150mm x 150mm[10]. It is tried by utilizing Compression Test Machine (CTM). The shapes are set in the pressure testing machine in such way that the load is connected to the adjoining sides of the block as cast. The load is connected at the rate of 140 $kg/cm^2/min$ (around) until the failure of the sample. Samples are tried for 28th day compressive quality in Compression Test .

Table -7: Details of specimens to determine the mechanical propertiesof M30 Concrete

Specimens	Size of the specimen (mm)	Designation	% replacement of rubber	No. of specimens
Cube (compressive strength)	150 mm x150mm x150 mm	CC	0	15
		RC4	4	15
		RC8	8	15
		RC12	12	15
		RC15	15	15
Cylinder (split tensile strength)	150 mm diameter and 300 mm height	CC	0	15
		RC4	4	15
		RC8	8	15
		RC12	12	15
		RC15	15	15
Prism (flexural strength)	100 mm x 100mm x 500 mm	CC	0	15
		RC4	4	15
		RC8	8	15
		RC12	12	15
		RC15	15	15
Cylinder (young"s modulus)	150 mm diameter and 300 mm height	CC	0	5
		RC4	4	5
		RC8	8	5
		RC12	12	5
		RC15	15	5

4.2 SPLIT TENSILE STRENGTH TEST

This test is done by setting cylindrical samples (150 mm x 300 mm) on a level plane between the stacking surfaces of a compression testing machine and the load applied until failure[13]. The load will be connected without shock and expanded constantly at an ostensible rate inside the range 1.2 $N/mm^2/min$ to 2.4 $N/mm^2/min$.

4.3 FLEXURAL STRENGTH TEST

Flexural strength test is utilized to decide the modulus of rupture of concrete. In this test, the prism samples (100 mm x 100 mm x 500 mm) are utilized. The bearing surfaces of the supporting and stacking rollers are cleaned off, and any free sand or other material expelled from the surfaces of the sample where they are to reach the rollers. The samples are set in the machine in such a way, to the point that the load will be concentrated to the highest surface as cast in the form[11]. The effective span of a sample is 450mm. the separation between the roller support and the middle point load is 225mm. The load will be concentrated without shock and increasing constantly at a rateof 180 kg/min.

Sl.No	% of Rubber variation	Slump value (mm)
1	0	60
2	4	66
3	8	79
4	12	89
5	15	96

Table -8: Slump Test Values

5. RESULTS AND DISCUSSION

The Compressive strength test is completed for the cubical samples. The test outcomes are arranged in demonstrates the examination of compressive strength of Rubberised concrete.

Table -9: Results of Compressive Strength Test for Cubical Specimens

Sl. No	Designation	Average Ultimate load (kN)	Average value of compressive strength(N/mm^2)
1	CC	847.66	37.67
2	RC4	781.33	34.76
3	RC8	709.66	31.54
4	RC12	671.66	29.85
5	RC15	623.33	27.70

Table -10: Results of Split Tensile Test for Cubical Specimens

Sl.No	Designation	Average Ultimate load (kN)	Tensile strength (N/mm²)
1	CC	222.33	3.14
2	RC4	208.33	2.94
3	RC8	185.66	2.62
4	RC12	148.33	2.09
5	RC15	139	1.97

Table -11: Results of Flexural Strength Test for Cubical Specimens

Sl.No	Designation	Average ultimate load (kN)	Flexural strength (N/mm²)
1	CC	15.33	6.37
2	RC4	14	5.6
3	RC8	12.33	4.95
4	RC12	10	4.0
5	RC15	8.67	3.27

Table -12: Results of Modulus of elasticity Test for Cubical Specimens

Sl.No	Designation	Modulus of elasticity (N/mm²)
1	CC	28570
2	RC4	23960
3	RC8	21860
4	RC12	19540
5	RC15	18720

6. CONCLUSIONS

The main aim of this study is to evaluate the effect of characteristics of materials, especially crumb rubber in coarse form, in concrete. The following conclusions were derived from the investigation[15].

- ❖ The Impact strength of crumb rubber is very high.
- ❖ The specific gravity of crumb rubber is lesser than the natural coarseaggregate.
- ❖ Water absorption of crumb rubber is very less.

Fresh and hardened concrete properties of rubberised concrete with percentage of rubber 4, 8, 12 and 15 as coarse aggregate were studied andthe results were compared with conventional concrete. The following conclusions were drawn from the investigation.

- ❖ For all rubberised concretes, slump value was higher than conventional concrete hence the concrete can be used in all types of concrete especially R.C.C.
- ❖ Because of the low density of crumb rubber, the mass of concrete is reduced. Waste tyre rubber can be utilized to produce lightweightconcrete.
- ❖ In the case of M30 grade concrete 8% replacement of rubber aggregate, gives optimum result.
- ❖ In case of M55 grade concrete, designed for a sleeper, up to 12% replacement of coarse aggregate[16] by rubber aggregates were giving satisfactory results. This is due to the addition of silica fume and super plasticisers.
- ❖ Mechanical properties of concrete were decreasing with the addition of rubber aggregate. This is due to the low specific gravity of rubber aggregates.

From the various test results like acid attack, chloride attack, rapid chloride penetration and sorptivity, it can be concluded that rubberised concrete is more durable than conventional concrete.

- ❖ The loss in weight in both acid attack and chloride attack of rubberised concrete was lesser than that of conventional concrete.
- ❖ Reduction in strength also was insignificant in case of rubberised concrete compared to conventional concrete.
- ❖ Chloride ion penetrability and permeability of rubberised concrete were found to be lesser than that of conventional concrete. In such cases, reinforcement bars will not corrode in the same rate as that of conventional concrete[14].

The structural performance of column beam joint with 8% and 12% rubber aggregate was analysed and the conclusions drawn are

- ❖ The structural performance of rubberised concrete column beam joint is better than that of their conventional concrete column beam joint.
- ❖ Ductility characteristics, energy absorption capacity and toughness indices of rubberised concrete column beam joint under cyclic loading were observed to be superior to that of conventionalconcrete column beam joint.
- ❖ Hence it can be concluded that rubberised concrete can be used in the structural elements which require more energy absorption and ductility characteristics.

The tests prescribed by Indian Railway Standard specification for accepting the sleeper for Broad gauge and Meter gauge rails are conducted for sleepers made using 6%, 8% and 12% rubber in concrete and drawn the following conclusions.

- The loads required for static bending test and rail seat test are satisfied by the rubberised concrete sleeper.
- Hence it can be concluded that rubberised concrete can be used in the structures subjected to impact loading[18].

In general, it can be concluded that rubberised concrete can be used as partially replaced aggregate to make concrete.

- Rubberised concrete can be used with the addition of admixtures for the construction of structural members subjected to cyclic and impact loading.
- The usage of waste tyre rubber to make coarse aggregate in concrete will reduce the menace of waste tyre dumping into the environment[17].
- Exploitation of nature for making aggregate in concrete can be drastically reduced by the use of the waste tyre to make aggregate.

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