Study on Performance of Recycled Tyre Steel Fibre and Waste Granite Chip in Concrete

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Abstract— The usage of suitable waste materials in concrete can contribute not only to reduction in the cost of construction, but also solves some of the waste disposal problems. The main threat to construction industry is the fast depletion of natural resources. Granites are increasingly used for flooring now a days. But large amount of wastes are generated in the form of chips. This can be used to replace coarse aggregate in concrete. Most of the volume of concrete is aggregates. Replacing all or some portion of natural aggregates with waste granite chip aggregate would lead to considerable environmental benefits. The steel fibre reinforced concrete is also becoming predominant in the construction industry. But the cost of these steel fibres are very high. Steel fibres extracted from these tyres shows the same properties of normal steel fibre. So steel fibres are replaced with recycled tyre steel fibre. The primary aim of this study is to investigate the cyclic behavior of the beam with the addition of steel fibre extracted from tyres and also replacement of waste granite chip with coarse aggregate. Cube, cylinder and beam tests are conducted to examine the strength of concrete produced. The steel fibres are varied at 0,0.5,1,1.5,2% respectively. The waste granite chips are replaced with normal coarse aggregate at 0,25,50,75,100%. Physical properties of both tyre steel fibre and granite chips were investigated and discussed. The parameters including workability, compressive strength, tensile strength are studied and discussed.

Index Terms—- WGCA, RTSF

1 INTRODUCTION

Concrete is usually composed of fine and coarse aggregates, cement, water. Although many materials are developed, concrete is still considered to be one of the most durable building materials for the construction purpose. Concrete provides superior versatility and affordability compared to wooden and steel constructions. Structures made of concrete can have long service life. All over the world, concrete structures like are roads, houses, bridges, skyscrapers, etc. are seen. Thus most of the buildings in the world are made of concrete.

Today, a significant growth is observed in the manufacture of composite material. Several fibres have been used so far to improve the properties of conventional concrete. Recycled tyre steel fibre is one of it. It can be used as alternative to steel fibre. The idea behind this is to ensure a proper and a most effective waste management.

Coarse aggregate is one of the major constituent of concrete. It is obtained from natural source. The over consumption of it will lead to depletion of the source. So an efficient use of it is necessary. Now a day, the usage of granite as flooring materials is increasing. Granites are shaped for the purpose of flooring. But during that time large amount of cutting waste are generated. This is also a quarry product. So it can be used to replace coarse aggregates in concrete. The main aim of this paper is to find the best combination of RTSF and WGCA and use it efficiently in the concrete industry.

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2 LITERATURE REVIEW

2.1 GENERAL

Literature survey done by referring and going through articles and journals published in the related area of the studies to get detailed subject knowledge. Literature review refers to review of scholarly articles and journal papers. It helps us to evaluate and understand about previous findings in the topic of study.

2.2 LITERATURE SURVEY

Chu et al. (2019) In this research, the effect of rigid fibres on aggregate packing was studied by adding different types of steel fibres at different volumes to aggregates of different sizes and measuring the packing density of the aggregate-fibre mixture. It was found that the proportional decrease in packing density due to the addition of steel fibres increases linearly with the fibre volume but at different rates for different fibre types and different aggregate sizes. Generally, fibres with larger aspect ratios have larger effect and smaller size aggregates are less affected

Chaboki et al. (2019) This paper mainly studies the shear characteristics of reinforced concrete beams manufactured by introducing coarse recycled aggregate (RA) and steel fibres. For that purpose, 27 concrete beams were produced. Additionally, the RA obtained from building demolition waste and introduced in the concrete mixes at 0%, 50% and 100%. Furthermore, the steel fibres (SF) were introduced in the beams at 0%, 1%and 2% to improve the flexural characteristics. Specimens underwent a 4 points bending test. In this test, the maximum deflection, shear capacity, at the mid-span of the beam and tension strain were obtained. The results show that

that SF improved the specimens' maximum strain and their use enhanced the shear behavior of RA concrete beams relative to control specimens.

3 OBJECTIVE

The objective of project is to find out the best combination of RTSF and WGCA in concrete by casting cubes for different percentages of replacement and finding out their compressive strength.

4 SCOPE

The scope of the project is limited for M20 mix and the overall aim is to reduce the cost of construction by incorporating WGCA and RTSF in concrete.

5 METHODOLOGY

Literature review of available journals on the topic is studied. Then, the first process of the project is the determination of the properties of materials by carrying out preliminary tests. Then, mix design of concrete is done. Slump tests are also carried out. Casting of cubes and cylinder specimens is done. Compression and split tensile tests are carried out on the cast cubes and cylinders. The last step of the project is the analysis and discussion of results.

6 MATERIAL PROPERTIES

This chapter is an introduction to the materials and their properties, used in the study. Properties of material used in this study were obtained either by testing of the material as per relevant BIS standards or were taken from the users manuals provided by the manufacturers

6.1 CEMENT

Portland Pozzolona Cement (PPC) is used for this study. Unlike Ordinary Portland Cement, Portland Pozzolana Cement (PPC) is manufactured by combination of pozzolanic materials. Pozzolana is an artificial or natural material which has silica in it in a reactive form. Along with pozzolanic materials in specific proportions, PPC also contains OPC clinker and gypsum. These pozzolanic materials includes volcanic ash, calcined clay or silica fumes and fly ash which make around 15 percent to 35 percent of cement weight. It has low initial setting strength compared to OPC but hardens over a period of time with proper curing. Specific gravity of cement is determined. Siliceous material is added to concrete mixtures, to potentially lower the mix cost without harming the performance characteristics.

6.2 AGGREGATE

The role of the aggregate is to provide much better dimensional stability and wear resistance. Also, because they are less expensive than Portland cement, aggregates lead to the production of more economical concretes. Fine and coarse aggregates are the one of the major constituents in concrete. Manufactured sand (M-Sand) was used as fine aggregate for the test. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. M-Sand is a substitute of river sand for concrete construction and it is produced from hard granite stone by crushing. Crushed rock of 10-20 mm size is used as coarse aggregates. Specific gravity, water absorption, sieve analysis tests were conducted to determine the properties.

6.3 WASTE GRANITE CHIP AGGREGATE

Granite is immensely used in flooring now a days. The durability over other flooring materials ensure the fast usage of it. But during shaping of it large amount of waste are generated. Usually these are disposed on the land simply. They can be effectively used in concrete. These can be used to replace CA.Waste Granite Chip Aggregate (WGCA) used is shown in Figure 3.2.

Figure 1: WGCA

The properties of aggregates taken are shown in Table 3.1.

Table 1: Properties of Aggregates

Properties	Fine aggregate	Coarse aggregate	WGCA
Specific gravity	2.69	2.74	2.77
Water absorption	0.806%	0.6%	0.8%
Sieve analysis	Zone II		

6.4 RECYCLED TYRE STEEL FIBRE (RTSF)

In the modern waste management system, more importance is for reuse and recycle rather than disposal. Fibre reinforced concrete is found more common in use now a days. Steel fibre use is not economical. Tyre after use is a major waste product dumped in nature. Steel fibres are present in tyre. So once after use these steel fibre can be extracted from tyre. These recycled tyre steel fibre as shown in Figure 3.5 looks exactly similar to common steel fibres and also possess the same properties of steel fibre.

Figure 2 : RTSF

6.5 WATER

Water is an important ingredient of concrete. It chemically participates in the reactions with cement to form the hydration product, C-S-H gel. The strength of cement mortar depends mainly from the binding action of the hydrated cement paste gel. Potable drinking water having pH value ranging between 6 and 8 can be used for construction. The quantity and quality of water should be very carefully inspected and it should be free from any foreign materials. The strength of cement mortar depends mainly from the binding action of the hydrated cement paste gel. The attention is required to see that the initial hydration rate of cement should not be significantly affected. Potable water from the source was used for mixing and curing of concrete. Water used was free from any impurities and amount of acid, alkali, salt, organic materials etc. are within limit.

6.6 SUPER PLASTICIZER

Super plasticizers are admixtures for concrete, which is added in order to reduce the water content in a mixture or to slow the setting rate of the concrete while retaining the flowing properties of a concrete mixture. Figure 3.5 shows a super plasticizer.

Figure 3 : Super Plasticizer

7 MIX DESIGN

In this study, two materials were used in concrete. One is RTSF which isadded to mix. While the waste granite chips to replace the coarse aggregate. RTSF is varied as (0,0.5,1,1.5,2)%. The waste granite chips varied as (0,25,50,75,100)%.

Mix design parameters

1. WGCA (0%):

I. RTSF mix (0 %) or Control mix :

Water content, w = 210L

Cement content, c = 210/0.45 = 467kg

Super plasticizer = 0.35 %(Cement)

Volume of coarse aggregate = 0.63

Volume of fine aggregate = 0.37

1000 = W + C/SC + F.A/SFA +C.A/SCA + P.A/SPA

1000 = 210+ (467/2.92) + (FA/2.69*(1/0.37)) + (0.35X467/(1.15X100))

FA = 626kg

1000 = 210 + (467/2.92) + (CA/2.74*(1/0.63)) + (0.35X467/(1.15X100))

CA = 1085kg

Mix proportion; 0.45: 1:1.34:2.33

II. RTSF mix (0.5%):

Water content, w = 210L

Cement content, c = 210/0.45 = 467kg

Recycled tyre steel fiber = (467*0.5)/100 = 2.33kg

Super plasticizer = 0.9%(Cement)

Volume of coarse aggregate = 0.63

Volume of fine aggregate = 0.37

1000 = W + C/SC + F.A/SFA +C.A/SCA +P.A/SPA +RTSF/SRTSF

1000 = 210+ (467/2.92) + (FA/2.69*(1/0.37)) + (0.35X467/(1.15X100))+

(0.5X467/(7.85X100))

FA = 626kg

1000 = 210+ (467/2.92) + (CA/2.74*(1/0.63)) + (0.35X467/(1.15X100))+

(0.5X467/(7.85X100))

CA =1086kg

Mix proportion; 0.45: 1:1.34:2.33

2. WGCA (100%):

II. RTSF mix (0%):

Water content, w = 210L

Cement content, c = 210/0.45 = 467kg

Super plasticizer = 0.35 %(Cement)

Volume of coarse aggregate = 0.63

Volume of fine aggregate = 0.37

1000 =W+ C/SC + F.A/SFA +WGCA/SWGCA + P.A/SPA + WGCA/SWGCA

1000 = 210+ (467/2.92) + (FA/2.69*(1/0.37)) + (0.35X467/(1.15X100))

FA = 626kg

1000 = 210 + (467/2.92) + (CA/2.77*(1/0.63)) + (0.35X467/(1.15X100))

CA = 1097kg

Mix proportion; 0.45: 1:1.34:2.34

II. RTSF mix (0.5%):

Water content, w = 210L

Cement content, c = 210/0.45 = 467kg

Recycled tyre steel fiber = (467*0.5)/100 = 2.33kg

Super plasticizer = 0.35%(Cement)

Volume of coarse aggregate = 0.63

Volume of fine aggregate = 0.37

1000 = W + C/SC + F.A/SFA +C.A/SCA +P.A/SPA +RTSF/SRTSF

1000 = 210+ (467/2.92) + (FA/2.69*(1/0.37)) + (0.35X467/(1.15X100))+

(0.5X467/(7.85X100))

FA = 626kg

1000 = 210+ (467/2.92) + (CA/2.77*(1/0.63)) + (0.35X467/(1.15X100))+

(0.5X467/(7.85X100))

CA =1097kg

Mix proportion; 0.45: 1:1.34:2.34

8 WORKABILITY OF THE MIX

Workability of concrete is the property of freshly mixed concrete which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished. Workability is directly proportional to water cement ratio. An increase in water-cement ratio increases the workability of concrete. It also related compaction as well as strength of concrete.

After actually mixing concrete in the mix proportion, the workability is checked in the wet stage. For the water cement ratio 0.45 and water content of 210 litres, the slump is found to be 75 mm. The slump obtained, 75 mm, is less than 90 mm. As per IS 7320: 1974, the slump value 75 mm is taken for medium workability (60 to 90mm).

9 TESTING OF CUBES

Casting of concrete specimens is done as per Indian Standards. M20 mix is chosen and mix design is done. Mix ratio obtained is 0.45: 1: 1.34: 2.29. Compressive strength of concrete is determined by making cubes of size 150 mm x 150 mm x 150 mm as shown in Figure 3.7. Cubes are made by finding out the required amount of quantities of materials using mix proportion. Mixing of concrete is carried out manually.

First, the coarse aggregate and fine aggregate are mixed. After that, the cement is poured into the mixer. Required amount of water is added. And the resulting concrete with uniform appearance is transferred to moulds. In assembling the mould for use, the joints between the sections of mould is thinly coated with mould oil and a similar coating of mould oil is applied between the contact surfaces of the bottom of the mould and the base plate in order to ensure that no water escapes during the filling.

Figure 4: Cubes

The interior surfaces of the assembled mould are thinly coated with mould oil to prevent adhesion of the concrete. Necessary compaction is given and the specimens to be tested are stored on the site, under sacks for 24 hours from the time of adding the water to the other ingredients. After 24 hours of air curing, the specimens are transferred to the curing tank.

Figure 5: WGCA replaced cubes

Table 2: Compressive Strength Test Results of Cubes with 0% WGCA

0 % WGCA			
Percentage of RTSF	C/S Area (mm^2)	Load (N)	28 day Average compressive strength (N/mm^2)
0	150 x 150	630000	28
0.5	150 x 150	370000	16.4
1	150 x 150	392000	17.42
1.5	150 x 150	542200	24.53
2	150 x 150	520000	23.11

Figure 6 : Cube placed in CTM for loading

Table 3: Compressive Strength Test Results of Cubes with 100% WGCA

100 % WGCA			
Percentage of RTSF	C/S Area (mm^2)	Load (N)	28 day Average compressive strength (N/mm^2)
0	150 x 150	325700	14.47
0.5	150 x 150	357000	15.86
1	150 x 150	389200	17.29
1.5	150 x 150	533600	23.71
2	150 x 150	506000	22.48

Figure 2 and Figure 3 show the unmolded cubes for testing. After 28 days of curing, the compressive strength of cubes were found out. The test is done in Compressive Testing Machine (CTM). Test results are shown in Table 2 and Table 3. the compressive strength of cubes were found out. The test is done in Compressive Testing Machine (CTM). The 0% RTSF and 0% WGCA is the standard mix case which got a 28 day compressive strength of 28 N/mm². It is the standard mix. Then variation is brought in the percentage of RTSF. So from the above it is clear that maximum strength is attained for 1.5% of RTSF. So by fixing 1.5% as RTSF the composition of WGCA is varied as 0,25, 50, 75, 100 % respectively. In this 0 % and 100 %, which is the worse combination is already conducted. The results of 25%,50% and 75% are given in the tables. Figure Table 3: Compressive strength test results of standard cubes.

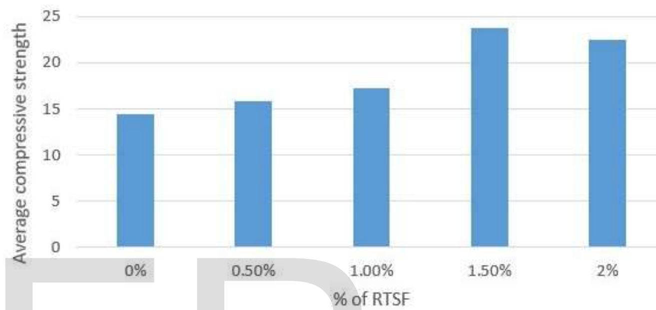

Figure 7: Average Compressive Strength with 0% WGCA

Figure 8: Average Compressive Strength with 100% WGCA

Table 4: Compressive Strength Test Results of Cubes with 1.5% RTSF

1.5 % RTSF			
Percentage of WGCA	C/S Area (mm^2)	LOAD (N)	28 day Average compressive strength (N/mm^2)
0	150 x 150	542200	24.53
25	150 x 150	64550	28.6
50	150 x 150	56065	24.9
75	150 x 150	54000	24
100	150 x 150	53360	23.71

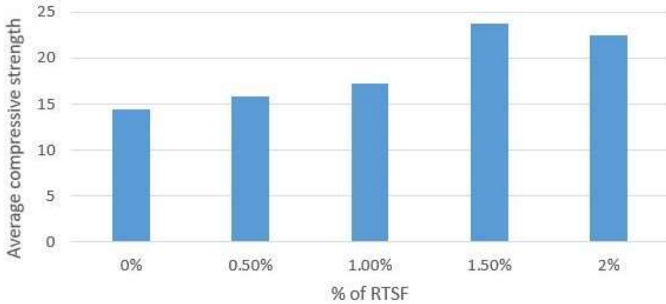

Figure 9: Average compressive strength with 1.5% RTSF

10 RESULTS OF CUBE

From the above tables the maximum characteristic compressive strength attained for control mix is 28.1 N/mm2. Maximum compressive strength obtained by varying the percentage of RTSF and WGCA is 28.6 N/mm2 which is available for 1.5% RTSF and 25% WGCA. So the best combination is of 1.5% RTSF and 25% WGCA.

11 TESTING OF CYLINDERS

Casting of concrete specimens are done as per Indian Standards. M20 mix is chosen and done mix design. Mix ratio obtained is 0.45: 1: 1.34: 2.29. Compressive strength of cylinders of 150 mm diameter and 300 mm length is determined. Cylinders are made by finding out the required amount of quantities of materials using mix proportion. Mixing of concrete is carried out manually. First the coarse aggregate and fine aggregate are mixed. After that the cement is poured into the mixer. Required amount of water is added. And the resulting concretewith uniform appearance is transferred to moulds. In assembling the mould for use, the joints between the sections of mould is thinly coated with mould oil and a similar coating of mould oil is applied between the contact surfaces of the bottom of the mould and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the assembled mould are thinly coated with mould oil to prevent adhesion of the concrete. Necessary compaction is given and the specimens to be tested are stored on the site, under sacks for 24 hour from the time of adding the water to the other ingredients. After 24 hours of air curing the specimens are transferred to the curing tank. The above table shows the split tensile strength of standard M20 mix. The strength obtained was satisfactory. In the same manner cylinder was casted using the best combination of RTSF and WGCA which is 1.5 % and 25 % for RTSF and WGCA respectively. The table below. Figure 4.9 shows the testing of cylinder. After 28 days of curing the compressive strength of cylinders were found out. The test is done in Compressive Testing machine.

Table 5: Split Tensile Strength Test Results of WGCA and RTSF Cylinder

CYLINDER NO.	LOAD (N)	SPLIT TENSILE STRENGTH FOR 28 DAYS (N/mm^2)
1	228000	3.22
2	220000	3.11
Average		3.16

Table 6: Split Tensile Strength Test Results of Control Mix

CYLINDER NO.	LOAD (N)	SPLIT TENSILE STRENGTH FOR 28 DAYS (N/mm^2)
1	202000	2.85
2	210000	2.97
Average		2.91

12 RESULTS OF CYLINDER

From the above table the split tensile strength for 1.5% RTSF and 25% WGCA is found to be 3.16 N/mm² which is much higher compared to control mix with 2.91 N/mm².

13 CONCLUSION

The mix proportion for casting specimens are found out. Compressive strengthof the standard concrete mix M20 is found after 28 days of curing. The compressivestrength of cubes and cylinders of required mix is obtained as 28.1 N/mm² and 2.91 N/mm². Also the best combination for RTSF and WGCA was found as 1.5%and 25% respectively. The compressive strength and split tensile strength for therequired mix was also found. The compressive strength of the mix was found to be 28.6 N/mm² and 3:16N/mm².

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