Experimental Investigation on Behaviour of Tire Rubber Concrete

[1]Snehal D. Jamdar, [2]Ansari U.S.

[1]PG Student, [2]Assistant Professor,
Department of Civil Engineering,
SND College of Engineering & Research Centre,
Yeola, Dist, Nashik, Maharashtra, India

Abstract : **Concrete is the building construction material which is the mixture of sand ,water aggregate and cement this lead to increasing continues the demand of natural material and alternative material for construction work. Added to this, at present environmental issues also increases due to the excess production of solid waste material like fly ash ,silica fume ,fiber glass plastic waste etc., which is difficult to manage and disposed. Many researcher, try this material as a alternative and additional concrete ingredients. Also there is huge amount of tire rubber waste is also produced due to the increasing in automobile production and depletion in site for disposal. Many countries banned landfill disposal of used tire rubber waste for avoiding land pollution. Due to which disposal of waste tire rubber becomes tough task. Therefore, in this paper, our present aim is to investigate the effect of crumb rubber on strength of concrete. For this experimental study fine aggregate is replaced by crumb rubber to produced rubberized concrete of M35 grade. During investigation tire rubber is replaced by using sieve analysis, with their volume consideration. These experimental studies were carried out to determine the effect of crumb rubber on mechanical properties and modulus of elasticity for 7, 28 and 56 days curing. Test result indicate that replacement of fine aggregate with crumb rubber by using sieve analysis gives good result as compared to the fine aggregate replace by their weight or volume in concrete.**

***Keywords*— Solid waste management, Rubberized concrete, Sieve analysis, Steel fiber, Mechanical properties.**

I. INTRODUCTION

Due to rapid urbanization, industrializations and new technical innovation large amount of solid waste is generated from various domestic, industrial, agricultural and mining activities.According to 2002 year estimation 12 billion tonne solid waste generated annually. From this 11 billion tonne waste could obtained from industry and 1.6 billion waste from municipal solid waste. From this some waste is transferred to the solid waste treatment plant and remaining waste is disposed by landfill method. Due to this reason requirement of land for disposal solid waste material is a challenge for civil and environmental engineer.

From various type of solid waste used tire rubber waste is one of the major waste which is created by automobile industry and also due to the modern lifestyle of people. Every year million of tire rubber ends their useful life due to which it is thrown or buried in land and if disposal by land filling method is not possible then it is burn in open atmosphere. Burning of used tire rubber waste it is the most simplest and cheapest way for disposal of tire rubber waste ,but this process create smoke which is dangerous to human health therefore, in many country it is prohibited by law. Like burning method, land filling technique is also easiest way for disposal of used tire rubber waste but, it pollute land. Therefore, it is necessary to find ideal solution for disposal of tyre rubber waste to protect our environment.XieJian-he et.al [1] compared the effect of recycled coarsed aggregate (RCA) and normal coarse aggregate (NCA) on rubber. Their results indicate that recycled coarsed aggregate gives good compressive strength compared to the normal concrete with steel fiber and crumb rubber. From this they conclude that recycled steel fiber rubber aggregate concrete also environment friendly alternative to normal rubber concrete .Blessen Thomas et.al [2] experimented with high strength rubberized concrete to study the behaviour of rubber concrete in aggressive environment. For this work different variation were used to replace crumb rubber with fine aggregate from 0% to 20% with 2.5% difference. Test were carried to determine the depth of carbonation, compressive strength, weight loss in acid attacked specimen and chloride penetration in rubber concrete .From this experimental work it was concluded that high rubberized concrete gives good performance in aggressive environment. ObinnaOnuaguluchi and Daman [3]was examined the effect of pre-coating crumb rubber with limestone powder on concrete properties. Concrete mix designs containing 0%, 5%, 10% and 15%volume replacement of fine aggregate with crumb rubber and 0%, 5%, 10% and 15%volume replacement of cement with silica fume are investigated. The various test were conducted to evaluate the performance of rubber concrete such as compressive strength, splitting tensile strength, static elastic modulus, water absorption, porosity, surface resistivity, and rapid chloride permeability. Test results showed that crumb rubber increased the porosity of concrete and this contributed to the decreases in mechanical properties. But there is improvement in compressive and tensile strengths was recorded in mixtures containing coated crumb rubber and silica fume. Camille Issa and George Salem [4] carried out to investigate the optimal use of waste tire aggregates in concrete mix design with 0% to 100% in replacement of crushed sand in fine aggregates. The studies show that not much increase in slump value with the addition of rubber aggregate. Therefore they were suitable for rigid pavement constructions. F. Pacheco Torgal et .al [5] examined the performance of concrete containing tire rubber and polyethylene terephthalate bottles wastes study in two subgroup first group consists rubber and second group contain concrete with recycled PET waste on which different test were conducted to asses different properties of freshen and hardened concrete. The results showed that concrete with rubber aggregate contents higher

than 10% by mass would be unacceptable for primary structural elements because there is loss in compressive and tensile strength.

The main aim of this experimental study is to find out ideal disposal method for used tire rubber waste by using it as an alternative ingredient in concrete to protect our environment. For this experimental study various mechanical test are conducted like compressive strength, spilt tensile strength, flexural strength ,and modulus of elasticity test with used of sieve analysis for aggregate replacement with crumb rubber.

II. EXPERIMENTAL DETAILS

2.1Concrete ingredients properties

For this experimental study, concrete is obtained from aggregate, sand, cement, steel fibers and water with waste tire rubber. Therefore, this concrete is also called as a rubberized concrete. The cement used was ordinary Portland cement of 53 grades. Fine aggregate and coarse aggregate are collected from local crushing plant.

2.2Tire rubber waste

Tire rubber waste is divided into various type according to their size which are as follows.

1. Chipped tire rubber has length 300-430 mm length and width 100-230 mm wide. To produce rubberized concrete it is replaced by coarse aggregate.
2. Crumb tire rubber use to replace sand for obtaining rubberized concrete. The size of this type of rubber waste is 0.425-4.75mm .In crumb rubber waste irregularity of particle is more compared to the other type of waste. Because, this crumb rubber is obtained from large size of tire rubber pieces which is torn into smaller particle in mill.
3. Ground tire rubber is obtained by micro milling process. The processed used to obtained ground rubber consists two stages which is magnetic separation and screening. Ground rubber is used for replacing cement in rubberized concrete. Because, the particle range of this waste is 0.075-0.475mm.

2.3Concrete mix design

It is the process selecting suitable ingredient with their determining proportion to achieve strength, durability and economy. The ingredients used for concrete mix design is cement, sand, coarse aggregate, water, steel fiber and tire rubber with water. Many researchers have been reported that effect of crumb rubber particle on properties of concrete with waste tire rubber. Their results indicate that strength of rubberized concrete is greatly affected by tire rubber size, proportion and surface texture of the particle. According to different literature review, there is possibility of rubberized concrete increases their strength, if we used same size particle for replacement. Crumb rubber is torn particle of large rubber pieces due to this reason surface area also increases. In this experimental work, crumb rubber is not replaced by percentage of fine aggregate and coarse aggregate weight. It is replaced by volume with their grade variation of fine aggregate for which sieve analysis is used.

The plan for this study is to carry sieve analysis for fine aggregate and crumb rubber. From this we get actual gradation of crumb rubber and fine aggregate after that replace any one grade of crumb rubber in fine aggregate and which grade of crumb rubber is used for replace fine aggregate firstly, remove this grade from fine aggregate. Crumb rubber is replaced with the volume of fine aggregate of that grade.

2.4Preparation of specimen

For this experimental work, there are six combination of mixes are used. From this one is controlled concrete mix. Another one is with addition of steel fiber to study their effect on properties of concrete. Remaining four mixes for rubberized concrete that is with crumb rubber replacement for 4.75 mm, 2.36 mm, 1.18mm retained and 1.18mm passed in fine aggregate with their volume consideration of fine aggregate for that grade. For each concrete mix proportion 9 cube, 9 beams and 15 cylinders are casted with W/C ratio 0.43 to investigate rubber concrete mechanical properties for 7, 28 and 56 day curing age. Cube specimens were casted for the purpose of compressive strength test of rubber concrete. For determining flexural strength of rubber concrete beam were casted .Similarly, cylinder specimens were casted for finding spilt tensile strength and modulus of elasticity

Table 1: Details of different type of mix

Sr.No.	Mix Identification	Description of Identification of mix
1.	PS	M35 Concrete
2.	CS	M35 Concrete with Steel Fiber
3.	CSCR-I	M35 concrete with steel fiber and crumb rubber. (Retained on 4.75 mm sieve)
4.	CSCR-II	M35 concrete with steel fiber and crumb rubber. (Retained on 2.36 mm sieve)
5.	CSCR-III	M35 concrete with steel fiber and crumb rubber. (Retained on 1.18 mm sieve)
6.	CSCR-IV	M35 concrete with steel fiber and crumb rubber.(Passing through 1.18mm sieve)

2.5Test method

To determine the properties of fresh concrete and hardened concrete slump cone test, compression strength test, spilt tensile strength test, flexural strength test and modulus of elasticity test are carried for all mixes at the age of 7,28 and 56 days.

III. EXPERIMENTAL RESULTS AND DISCUSSION

3.1Fresh concrete properties

Properties of fresh concrete are presented in Figure 1. As shown in Figure 1.the slump of concrete is slightly a decrease with rubber content addition by total aggregate volume for every grade according to sieve analysis as compared to the rubber content replaced by varying percentage of their total aggregate. When rubber content is replaced by the percentage of total weight or volume of aggregate there is great reduction in workability of concrete therefore it is replaced by using sieve analysis for crumb rubber and fine aggregate it is more beneficial. From, the graph of workability of concrete it is observed that slump value increases with finer rubber particle in rubberized concrete.

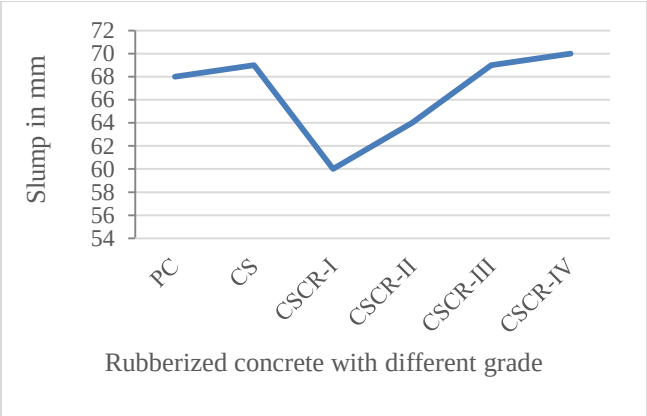

Fig.1Workability of concrete for different mix

3.2 Hardened concrete properties

3.2.1Compressive strength

Figure 2.Shows the results of compressive strength test. Compressive strength given by addition of 4.75mm retained crumb rubber in concrete with steel fiber which is more than compressive strength of controlled concrete and also, compressive strength given by concrete with steel fiber and crumb rubber Passing through 1.18mm sieve gives good result. But, for other grade replacement of crumb rubber according to sieve analysis compressive strength is slightly reduced with addition of Rubber content. The strength reduction in concrete in rubberized concrete is generally occurred due to the two reasons as reported by Khatip and Bayomy. First, is rubber particle is softer due to which bonding between concrete and rubber particle is weak. Secondly, due to this softer texture of rubber particle when load is applied on concrete immediately cracks are formed around the rubber particle.

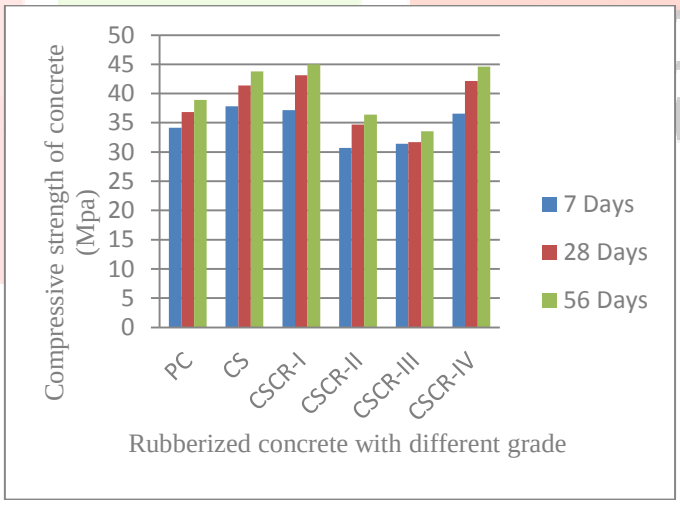

Fig.2 Compressive strength of concrete

3.2.2Spilt tensile strength test

Figure.3.shows schematic presentation of results for spilt tensile strength test from this it is observed that there is reduction occurred in gradual pattern for spilt tensile strength test. Concrete with retained crumb rubber on 4.75mm sieves and concrete with crumb rubber of 1.18mm passing through sieve gives good result as compared to the other grade rubberized concrete.

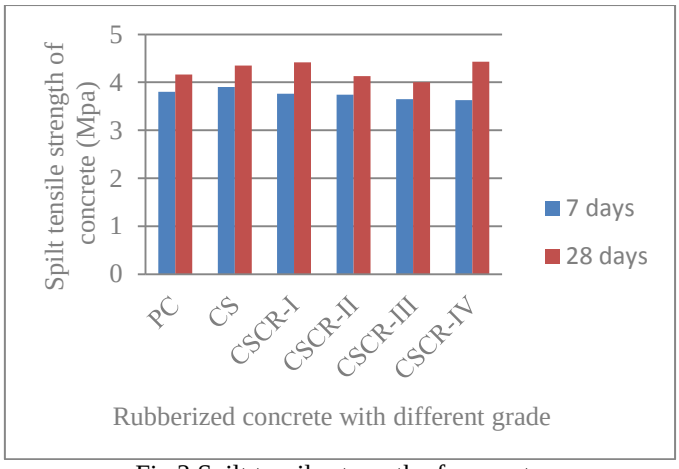

Fig.3 Spilt tensile strength of concrete

3.2.3Flexural strength test

Flexural strength result is shown on graph in Figure 4.the result shows that the addition of rubber content in concrete flexural strength is affected. But crumb rubber retained on 4.75 mmand 1.18 mm passing gives good result, there are two reason for this result.First,4.75 mm retained crumb rubber act as a fiber and secondly,1.18 mm passing crumb rubber is fine powder due to which bonding between concrete and crumb rubber improved.

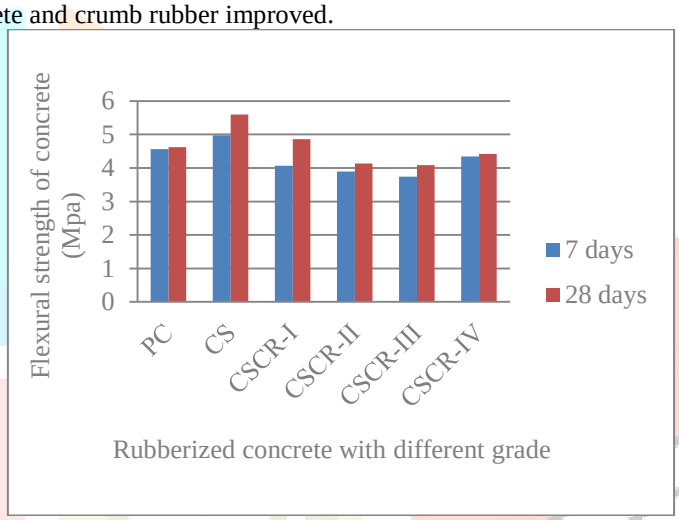

Fig.4 Flexural strength of concrete

3.2.4Modulus of elasticity

Modulus of elasticity of concrete is decreases when different grade of tyre rubber waste particle is replace with different grade of fine aggregate. But,4.75 mm retained tire rubber waste particle gives good modulus of elasticity which is shown in Figure.5.

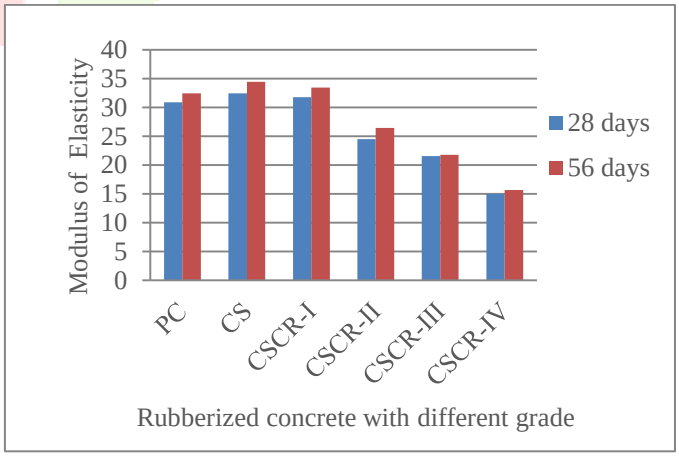

Fig.5 Modulus of Elasticity of concrete

IV.CONCLUSION

Based on the experimental work in rubberized concrete following conclusion is drawn.

1. Workability of rubberized concrete is decreases with addition of rubber by percentage of weight or volume of aggregate in concrete. But due to the used of sieve analysis for crumb rubber increases the slump with finer particle of crumb rubber.
2. However, the used of 4.75mm retained grade of crumb rubber gives compressive strength which is more than compressive strength of M35 grade concrete. This is beneficial effect of sieve analysis for fine aggregate and crumb rubber because, from the literature study it is observed that when crumb rubber is replaced 50% of aggregate general reduction is occurred up to 86% in compressive strength. For other grade of sieve analysis compressive strength is gradually decreases. From, this it is observed that crumb retained on sieve 4.75 mm act as a fiber due to which it gives better performance than chips particle.
3. The test results indicate that there is no quantitative reduction in spilt tensile strength when same chip gradation of crumb rubber is replaced by using sieve analysis in concrete as compared to controlled concrete strength.
4. Flexural strength is greatly affected by addition of crumb rubber of 2.36 mm and 1.18 mm retained on sieve with steel fiber in concrete.
5. For CSCR – I mix modulus of elasticity is increase by 2.8 % and 3.2 % for 28 days and 56 days curing.

This study is exclusively focused on the work ability and mechanical properties of the rubberized concrete with steel fiber by using sieve analysis for aggregate replacement with crumb rubber. It should be pointed out that further research should be carried out on durability of concrete under aggressive environment and also this investigation can be extended to higher strength of concrete .i.e., M40 and above grades.

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