Experimental Study of Concrete with Crumb Rubber

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***Abstract*- Aggregates are inert granular materials that are essential ingredients in a concrete. Aggregates occupy a large volume (i.e.) about 60 to 75% of the concrete, thus the selection of aggregates based on the material, shape, gradation and size is of primary concern before preparing the concrete. However many developing countries like our country face problem in acquiring the aggregates, as they are the most exploited material for the purpose of construction. And this over exploitation has led to scarcity in the availability of aggregates from the natural sources, in many parts of our country. Therefore, in order to meet the demand for aggregates, a modification be can made as partial or complete replacement of these aggregates with any new material, that would potentially induce better and additional properties to the concrete and simultaneously serve as an economical resource. With the Phenomenal growth in the Automobile industry in our country, there are so many waste and used tyres, those are getting discarded every year (i.e.) about 3 crores of used tyres are disposed in our environment. When these tyres are granulated or made into fine powder, they can be effectively used as crumb rubber. This study investigates the use of crumb rubber fragments and crumb rubber fine powder (each material of quantity of about 2%, 4%, 6% and 8%) as a partial replacement of both coarse aggregates and fine aggregates respectively. To evaluate these replacements in the OPC concrete mix, a number of laboratory tests were carried out. The tests those were conducted on the hardened concrete includes the compressive strength test, flexural strength test and Split tensile strength test on the 3rd , 7th and 28th days of curing. Finally, the results of all the above mentioned tests were compared with the conventional concrete to find the potential and the scope of this concrete modified with crumb rubber. This result shows there will be an increase in characteristic of concrete.**

***Index Terms*—granulated crumb rubber, powdered rubber, concrete, compressive strength, flexural strength, split tensile strength.**

I. INTRODUCTION

The automotive industry in India is one of the largest in the world with an annual production of 23.37 million vehicles in financial year 2014-15, following a growth of 8.68 per cent over the last year. More than 33 million vehicles have been added to Indian roads in the last three years; one can only imagine the number of tyres that will be discarded. One way to put an end to the menace would be landfills but, tyres are not disposed at landfills, due to their large volumes and 75% void space, which quickly consume valuable 2 space. Tyres can trap methane gases, causing them to become buoyant, or bubble to the surface. This 'bubbling' effect can damage landfill liners that have been installed to help keep landfill contaminants from polluting local surface and ground water. Tyre stockpiles create a great health and safety risk. Fires involving tyres can occur undoubtedly, burning for months, creating substantial pollution in the air and ground. An additional health risk, tyre piles can harbor vermin and provide a breeding ground for mosquitoes. Illegal dumping of scrap tyres pollutes ravines, woods, deserts, and empty lots. Due to heavy metals and other pollutants in tyres there is a potential risk for the leaching (leachate) of toxins into the groundwater when placed on wet soils. Surveys claims that 10% of tyres currently go to landfill, 4% are recycled and the remaining 86% are illegally grooved, dumped in the open uncultivated lands, or these tyres are stockpiled. However, when these waste automobile tyres are reduced in size or shredded into fine particles using cracker mill process, these particles are commonly called as crumb rubber. For past few years many research works and studies have been made in using this crumb rubber for the replacement of fine aggregates and also coarse aggregate. The primary objectives of these research works were to use these

tyre wastes, which are of greatest environmental concern, to be efficiently in the conventional concrete by simultaneously improving the original properties of the concrete and also induce additional properties to the concrete. It has high content of natural rubber that is present in waste tyres and insoluble sulphur thus improves lifetime of the concrete, ductility, thermal resistance and increased toughness.

In this project, we have made partial replacement of crumb rubber fragments and crumb rubber fine powder for coarse aggregates and fine aggregates. The replacement of the aggregates are done in the ratios of 2%, 4%, 6% and 8% with equal percentages of both rubber fragments and crumb rubber fine powder. Therefore, main objectives of this study is to evaluate properties of hardened concrete that has been modified by the replacement of coarse aggregates and fine aggregates with the crumb rubber fragments and crumb rubber fine powder. The mix design used for making the concrete specimens was based on IS10262-2009.

II. LITERATURE REVIEW

K.C.Panda et al. (December 2012) conducted experimental study of Scrap-Tyre-Rubber Replacement for Aggregate in Cement Concrete to identify the various properties necessary for the design of concrete mix with the coarse tyre rubber chips as aggregate in a systematic manner. In this experimental investigation, the M20 grade concrete had been chosen as the reference concrete specimen. Scrap tyre rubber chips, has been used as coarse aggregate with the replacement of conventional coarse aggregate. Study was made on the effect of partial replacement of coarse aggregate by scrap tyre rubber chips on the fresh concrete property (e.g. slump test) and hardened concrete properties like compressive strength, split tensile strength, flexural strength. A comparative study was made on the properties of M-20 Grade of concrete specimens and the concrete specimens those have been modified with partial replacement of scrap tyre as coarse aggregates. This actually resulted in reduced workability of the concrete and a decrease in slump with increase of waste tyre rubber content of total aggregate volume. The specimens were loaded at a constant strain rate until failure. The compressive strength got decreased with an increase in the percentage of the tyre rubber chips, but the concrete specimen M20 concrete with 97% coarse aggregate and 3% tyre rubber developed slightly higher compressive strength than those of without rubber. The tensile strength was reduced with the increase in percentage of rubber particles in concrete mix. The Flexural strength also did not show any progress, it also showed gradual decrease with the increase in the percentage of replacement. This paper had so many drawbacks most importantly; the main problem that was identified was lack of proper bonding between rubber particles, no admixtures were added to improve the workability of the mix, and cement paste and non-uniform distribution of rubber particles in the cement paste.

Mohammed Islamuddin Faraz et al. (April 2015) made a study Effect of Crumb Rubber Material on Concrete Mix on the effect of addition of rubber crumbs on Portland cement concrete. This study was based on studying the effects of replacement of 5% and 10% of coarse aggregates by rubber crumbs on Portland cement concrete. The addition of rubber crumb resulted in increase in workability. The increase in workability is in direct proportion to the amount of rubber crumb added. The addition of rubber crumbs resulted in increase in compressive strength of concrete at first and then it reduces gradually. The addition of rubber crumbs resulted in reduction in weight of concrete. The reduction in weight is in direct proportion to the amount of rubber crumb added. It was noticed that, the more rough the rubber used in concrete mix the better the bonding developed between the surrounding matrix and the rubber particles which results in higher compressive strength.

S.Selvakumar et al. (March 2015) conducted study on Strength Properties of Concrete Using Crumb Rubber with Partial Replacement of Fine Aggregate.This study involved the partial replacement of fine aggregates with crumb rubber. In this study the effectiveness of rubber as substitute for fine aggregates and utilization potential of the crumb rubber in concrete had been studied. The compressive strength of crumb rubber concrete with 5% replacement is 38.66 N/mm2; it is higher than the strength of normal concrete (36.73N/mm2) on 28th day. The compressive strength of crumb rubber concrete with 10% replacement, it gave an acceptable strength of 33.47 9 N/mm^2. In split tensile strength test, the strength of crumb rubber concrete was lower than the strength of normal concrete. In the flexural

strength test conducted on crumb rubber concrete it showed a decrease in strength when compared to the strength of normal concrete. From the test results, it was found that the crumb rubber possess less bonding ability which has affected on the strength of the concrete.

Yogender Antil et al. (2012) published research paper on Rubberized Concrete Made with Crumb Rubber to find alternate aggregates for construction. The proposed work presents an experimental study of effect of use of solid waste material (crumb 10 rubber) in concrete by volume variation of crumb rubber. The test results of this study indicated that there was great potential for the utilization of waste tyres in concrete mixes in several percentages, ranging from 5% to 20%.And, it was concluded that The light unit weight qualities of rubberized concrete may be suitable f or architectural application, false facades, stone baking, interior construction, in building as an earthquake shock wave absorber, where vibration damping is required such as in foundation pads f or machinery railway station, where resistance to impact or explosion is required, such as in jersey barrier, railway buffers, bunkers and f or trench filling. The compressive strength of the concrete decreases about 37% when 20% sand is replaced by crumb rubber. For large percentage of crumb rubber the compressive strength gain rate is lower than that of plain concrete.

III. MATERIALS USED

The materials used in this study are OPC 53 grade cement , fine aggregate passing through 4.75mm sieve with a specific gravity and water absorption of 2.59 and 1.21% respectively, coarse aggregate of size 20mm , CRUMB RUBBER both fragments and fine powder is used.

Fig 1: *Crumb rubber fragments and powder*

Fig 1 shows the picture of crumb rubber fragments and powder and table 1 shows its chemical properties.

Table 1 Chemical properties of crumb rubber

CONSTITUENTS	FORMULATION
Natural Rubber	80.00
Poly butadiene	20.00
Carbon black	50.00
Paraffin wax	1.00
Insoluble sulphur	2.5

IV DESIGN MIX

Mix Proportions: Design mix for M30 grade concrete as per IS 10692-2009

Cement	= 17.48 kg
Water	= 7.95 liters
Coarse aggregate (12mm)	= 21.52 kg

Table 2 Mix Proportions

% of replacement	Coarse Aggregates (20 mm) (kg)	River sand (kg)	CR fragments (kg)	CR Fine powder (kg)
0%	32.84	33.81	0	0
2 %	32.52	33.44	0.140	0.072
4 %	34.25	33.12	0.281	0.144
6%	31.86	32.81	0.422	0.217
8%	31.49	32.44	0.563	0.290

V. CASTING

Casting is one of the process in the fresh concrete is poured into a moulds that are already kept lubricated with kerosene or any other suitable nonreactive material. Casting is immediately followed by compaction for the efficient removal of air bubbles. Master Rheobuild 619 admixture is a super plasticizer is added to this mixture to enhance the workability of concrete.

Fig 2*: Specimen casting*

VI TEST ON CONCRETE

Compressive strength, Flexural strength and split tensile strength of concrete is carried out. The test results are tabulated.

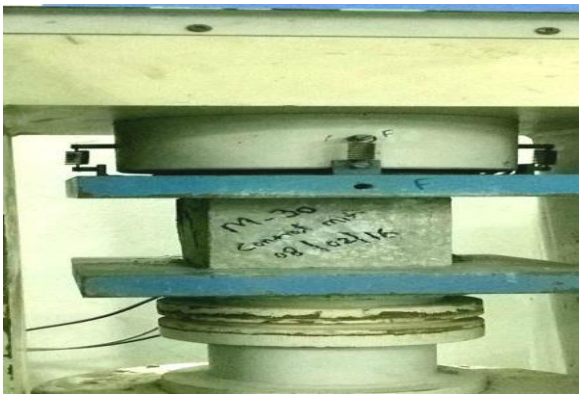

Fig 3: *Compressive strength test*

Table 3 Compressive strength test

% OF REPLACEMENT	AT 3RD DAY (N/mm2)	AT 7TH DAY (N/mm2)	AT 28TH DAY (N/mm2)
0%	29.91	31.82	34.27
2%	30.24	32.62	35.61
4%	31.32	33.45	36.72
6%	32.78	34.12	37.64
8%	33.31	35.28	38.20

Fig 4*: Flexural strength test*

The results shows that at 6% replacement the flexural strength is increased

Table 4 Test on Flexural strength of concrete

PERCENTAGE OF REPLACEMENT	AVERAGE FLEXURAL STRENGTH (N/MM²)
0%	18.03
2%	14.68
4%	16.55
6%	18.03
8%	16.70

Fig 5: *Split tensile test*

Table 5 Test on split tensile on concrete

PERCENTAGE OF REPLACEMENT	AVERAGE SPLIT TENSILE STRENGTH (N/MM²)
0%	55.75
2%	73.36
4%	75.46
6%	76.96
8%	77.18

VII CONCLUSIONS

Based on the experimental study of concrete with crumb rubber, that was partially replaced with coarse aggregates and fine aggregates respectively, the following conclusions are derived the workability of concrete was not affected by addition of crumb rubber, and this is also attributed to the addition of admixture (i.e.) a super plasticizer named Master Rheobuild 619.There was no problem in binding between the crumb rubber and the cement matrix. This showed that the crumb rubber proved to have a good absorption and binding potential in the concrete. There was a drastic increase in the compressive strength tested on 3rd, 7th and 28th days of testing. Thus the overall compressive strength proved to be greater than the conventional concrete. The flexural strength of the hardened concrete at 28th day testing showed a gradual increase up to 6% partial replacement and showed a sudden decrease at 8% partial replacement. The split tensile strength showed a progressive increase at 28th day testing, reaching a maximum at 8% partial replacement. The slump value of the concrete decreased at the maximum percentage (i.e.) 8% of partial replacement. This showed that the consistency of the concrete is greatly reduced with increase in addition of aggregates in spite of the addition of super plasticizer.

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