Influence of Silica Fume on Mechanical Properties of Crumb Rubber Aggregate Concrete

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Abstract:- **Several studies related to sustainable concrete construction have encouraged development of composite binders, involving Portland cement, industrial by-products, and the concrete mixes with partial replacement of natural aggregate with crumb rubber aggregate concrete. In this paper, the effects of incorporating the silica fume (SF) in the concrete mix design to improve the quality of crumb rubber aggregate concrete are presented. Experimental studies for determining the physical, mechanical and durability properties of the crumb rubber aggregate concrete with silica fume compared with conventional concrete. Portland cement was replaced with SF at 5%, 10% and 15% specimens were manufactured by replacing natural aggregates with crumb rubber aggregate concrete. In all concrete mixtures a constant water/ cement ratio at 0.50 was used. Mechanical properties of the concrete specimens such as compressive strength, tensile splitting strength and flexure strength test were determined and it was found that, using the optimum value of 10% SF as a cement replacement for crumb rubber (10%) aggregate concretes enhanced the mechanical properties of concrete**

Keywords— Silica fume, crumb rubber, flexural strength.

I. INTRODUCTION

Silica fume is the byproduct of the combustion of pulverized coal and is collected by mechanical and electrostatic separators from the fuel gases of power plants where coal is used as a fuel. It is estimated that approximately 600 million tonnes of fly ash is available worldwide, but at present the current worldwide utilization rate of fly ash in concrete is about 10 per cent indicating that there is a potential for the use of much larger amounts of silica fume in concrete.

Rubber product is increasing every year in worldwide. India is also one the largest country in population exceeds 100cr. So the use of vehicles also increased, according to that the tyres for the vehicles also very much used and the amount of waste of tyre rubber is increasing. This creates a major problem for the earth and their livings. For this issue, the easiest and cheapest way of decomposing of the rubber is by burning it. This creates smoke pollution and other toxic emission and it create global warming. Currently 75-80% of scrap tyres are buried in landfills. Only 25% or fewer are utilized as a fuel substitute or as raw material for the manufacture of a number of miscellaneous rubber goods. Burying scrap tyres in landfills is not only wasteful, but also costly. Disposal of whole tyre has been banned in the majority of landfill operations because of the bulkiness of the fires and their tendency to float to the surface with time. Thus, tyres must be shredded before they are accepted in most landfills. So many recycling methods for the rubber tyre are carried according to the need. From this one of the processes is to making the tyre rubber in to crumb rubber. It is used in many works such as Road construction, Mould making etc.

FabianaMaria da Silva et al (2015), showed the flexural strength obtained to all concrete mixes studied were higher than 6.5 Mpa . It was found that concrete containing rubber showed a better abrasion resistant.

Angel Sanjuan et al (2015), this paper was presented the replacement of Portland cement with 25% of silica fume produces high-strength mortar and such fineness gives the highest compressive strength.

II. MATERIALS AND PROPERTIES

A. CEMENT

Type of cement is ordinary Portland cement, 53 grade used. Specific gravity of cement was 3.10in compliance with Indianstandard code IS 8122 -1995

B. SILICA FUME

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength durable.

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Figure no: 1 Silica fume

C. CRUMB RUBBER

Crumb rubber is a term usually applied to recycled rubber from automotive and truck scrap tires. There are two major technologies for producing crumb rubber – ambient mechanical grinding and cryogenic grinding. Of the two processes, cryogenic process is more expensive but it produces smoother and smaller crumbs

Figure no: 2 Crumb rubber

D. FINE AGGREGATE

Local clean river sand conforming to grading zone was used. The sand is sieved using 4.75 mm sieve to remove all the pebbles. Fine aggregate having a specific gravity of2.56 and fineness modulus of 2.75 and bulk density 1693Kg/m^3 was used.

E. COARSE AGGREGATE

Locally available well graded aggregates of normal size greater than 4.75 mm and less than 20 mm.Coarse aggregates having a specific gravity of 2.73, fineness modulus of 6.64 and bulk density 1527 Kg/m^3 were used.

F. SUPERPLASTICIZER

Super plasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. Conplast SP430 is supplied as a brown liquid instantly dispersible in water. Conplast SP430 has been specially formulated to give high water reductions up to 25% without loss of workability or to produce high quality concrete of reduced permeability. Improved workability - Easier, quicker placing and compaction. Improved quality - Denser, close textured concrete with reduced porosity and hence more durable.

G. PHYSICAL PROPERTIES OF MATERIALS

Particle size allocation of cement, silica fume and crumb rubber powder was decided. Physical properties such as specific gravity, bulk density and fineness of were calculated. Shown in table no 1

Table 1 - Physical Properties

Property	**Silica fume**	**Crumb rubber**	**Cement**	**Fine agg.**	**Coarse agg.**
Specific gravity	2.17	1.3	3.1	2.63	2.7
Fineness modules	-	-	-	2.75	6.64
Bulk density (kg/m^3)	580	1967	-	1693	1527

H. CHEMICAL CHARATERISTICS

Chemical compositiondata for OPC and silica fume material arecontrasted in Table 2.

Table 2 -Chemical Characteristics

	Sio_2	**Fe_2o_3**	**Al_2o_3**	**Cao**	**Mgo**	**So_3**
Cement (%)	20.25	3.16	5.04	63.61	4.56	0.56
Silica fume %)	95.4	0.16	0.1	0.15	0.2	-

I. MIX DESIGNATION

OPC (53 Grade) is partly substituted with silica fume at the dosage of 0–15% by weight ofcementitious materials. The Crumb Rubber(CR) powder of 10% constant replacement of fine aggregate at eachsubstitution along with the control mix wereorganized with a water to binder W/(C + SF + CR) ratio of 0.5 for a design cubecompressive strength of 25 MPa. These mixes were represented as M for control and M1 – M3 for CR concretes. The blend mix propositions symbol are furnished in table no.3

Guo Y C et al (2014) presented a full replacement of natural coarse aggregate by recycled coarse aggregate leads to a significant increase in the fracture toughness.

Appropriate rubber content increases the ductility of the concrete mixes but too much rubber may have a negative effect on the ductility of the concrete mixes

Table 3 – Mix Designation

Mix	Cement Kg/m^3	Fine agg. Kg/m^3	Coarse agg. Kg/m^3	Silica fume Kg/m^3	Crumb Rubber Kg/m^3	Remark
M	394	639.06	1186.38			control concrete
M1	374.3	575.15	1186.38	19.7	63.906	5% of S.F with 10% of C.R
M2	354.6	575.15	1186.38	39.4	63.906	10% of S.F with 10% of C.R
M3	334.9	575.15	1186.38	59.1	63.906	15% of S.F with 10% of C.R

III. METHODSOFTESTING

A.PH Value Mix Proportions

PH value of cement and different mix designation of M to M3 (Figure no and Table no.4) are estimated by means of PH meter. PH meter is calibrated by immersing it in distilled water for 24 hrs. 100 grams of cement and 100 ml of water mixed in a beaker for about 5 minutes and Ph meter is dipped completely in the mixed slurry and the value is recorded. These processes were done again and again as M for standard and M1- M3 for concrete

A. COMPRESSIVE STRENGTH OF CONCRETE

Compressive strength of Crumb Rubber (CR) cement concrete cube with diverse blend designation of M to M3 was calculated in accordance with provisions of IS 9013-1997 after 28 and 56 days of immersed water curing, and these cubes were experimented on digital compression testing machine according to I.S. 516-1959

C. SPLITTING TENSILE AND FLEXURAL STRENGTH OFCONCRETE

Vide IS 5816-1999and IS 516-1959, Splitting tensile strength(cylinder) and flexural strength(beam) was executed on CR concrete of blend designation of M to M3 after 28 and 56 days of curing.

IV. RESULT AND DISCUSSION

A. PH VALUE MIX PROPORTIONS

The quantity of chloride needed for stimulatingcorrosion is partially based on the pH value of thepore water in concrete. At a pH value within 11.5,corrosion happens in the absence of chloride. At Ph exceeding 11.5 a significant quantity of chloride isessential. Table.4 illustrate that thepH value of blend ratio of M to M3 is at least 11.5 it is desirable for decomposition inhabitingconcrete.

Table: 4 PH Test for different (M–M3) Mix Proportions

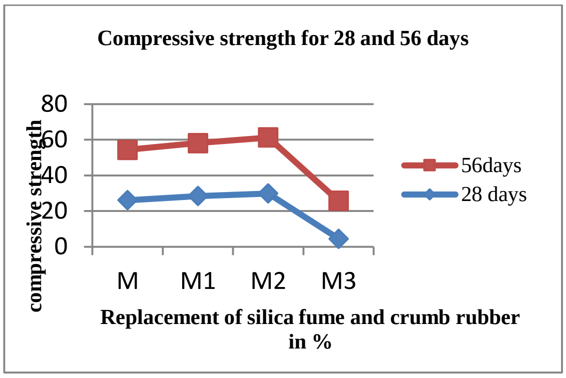
Mix designation	pH value
Water	7.2
M	12
M1	11.76
M2	11.4
M3	11.51

B. COMPRESSIVE STRENGTH OF CR CONCRETE

The compressive strengths of CR concrete are exhibited in Table 7. Assessment of the data for 28 and 56 days of curing time reveals thefact that the compressive strength goes up to M2. Anyhow, at M3, thecompressive strength comes down to a value belowthat of control concrete. Hence, M2 is taken as an enhancement instrength as depicted in Table.5

Table: 5 Mix Proportion And Compressive Strength of CR Concrete

Mix Designation	28 days(N/mm^2)	56 days(N/mm^2)
M	26.1	28.3
M1	28.4	30.0
M2	29.9	31.4
M3	20.5	26.2



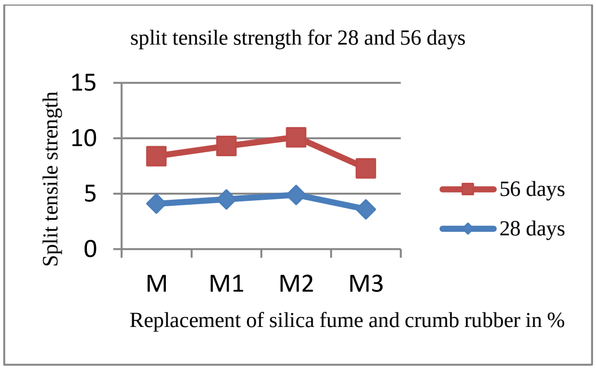
Graph: 1 Mix Proportion And Compressive Strength of CR Concrete

C. SPLITTING TENSILE AND FLEXURAL STRENGTH OF CR CONCRETE

The splitting tensile strengths of CR concretes after 28 and 56 days of curing are pictured inTable.9 and Fig. 8. It is evident that the splittingtensile strength value boosts M1 to M2 and thenat M3, the splitting tensile strength is roughly equalto that of OPC concrete.

Table: 6 Mix Proportion And Splitting Tensile Strength of CR Concrete

Mix Designation	28 days(N/mm^2)	56 days(N/mm^2)
M	3.8	4.0
M1	4.1	4.5
M2	4.6	5.2
M3	3.4	3.8



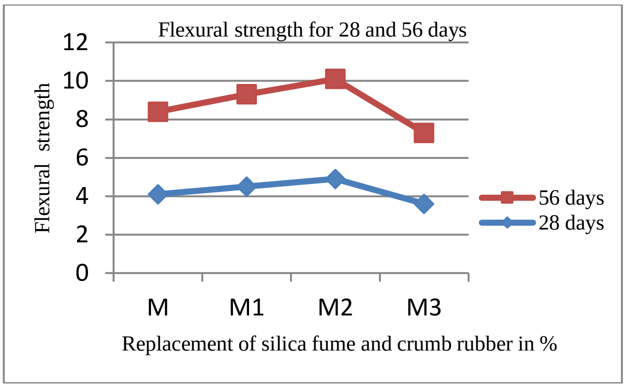
Graph:2 Mix proportion and split-tensilestrength of CR Concrete

D. FLEXURAL STRENGTH OF CONCRETE

Graph.3 and Table.7 illustrate the contrasts of outcomes of flexural tensile strength by means of beam specimens of CR concrete. Beams were investigated after 28 and 56 days of curing for Flexural Strength. It was seen that highest flexural strength was attained at M2 (10% of S.F with 10% of C.R) and thereafter at M3, the flexural strength is roughly identical to that of OPC concrete.

Table: 7 Mix Proportion And Flexural Strength of CR Concrete

Mix Designation	28 days(N/mm^2)	56 days(N/mm^2)
M	4.1	4.3
M1	4.5	4.6
M2	4.9	5.2
M3	3.6	3.7



Graph:3 Mix Proportion And Compressive Strength of CR Concrete

V. CONCLUSION

Use of crumb rubber as replacement for sand helps to conserve our natural resource.

Based on the experimental investigation concerning the mechanical properties of concrete, the following conclusions are drawn, compressive, flexural & split tensile strength of concrete were determined and the optimum value of 10% SF as a cement replacement for crumb rubber M2 (10%) in concrete enhanced the mechanical and durability properties of concrete.

The experimental observations indicated that both of silica fume and crumb rubber in concrete mix which ultimately helps in improving the durability resistance of the concrete.

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