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RESEARCH ARTICLE

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COMPARATIVE STUDY OF RUBBERIZED SELF COMPACTING CONCRETE USING CRUMBED RUBBER AND MARBLE POWDER WITH NORMAL SELF COMPACTING CONCRETE

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ABSTRACT

Reutilization of waste materials in the building industry helps to prevent environmental pollution whilst contributing to the design of more economical buildings. Over the years, there has been increase in the accumulation of tyre rubber due to the increase in the production of vehicles. Sometimes this waste tyre rubber is burned which leads to environmental pollution. So the use of this type waste tyre rubber for the replacement of aggregates in concrete leads to the decrease in the accumulation of waste tyre rubber and also reduces pollution. Another problem that we are facing is the durability of concrete structures. In order to get durable structures adequate compaction by skilled workers is required. Now a day there is a reduction in skilled workers. This leads to a new type of concrete that is self compacting concrete which can be consolidate under its own weight. In this thesis work, crumb rubber and marble powder is added as a partial replacement for fine aggregate and cement supplementary to make self compacting concrete.

Keywords: Fine Aggregate, Crumb Rubber, Marble Powder

I. INTRODUCTION

Self Compacting Concrete (SCC) is a new type of concrete that attains higher compressive strength and durability in comparison with ordinary Portland cement due to the addition of fine filler and proper admixtures such as super plasticizers and viscosity modifying agents. The combination of these components leads to a mixture that does not require vibration on placing, with time and cost saving. This promotes the formation of very compact microstructure and allowing high values for compressive strength. The making of tough concrete has been generally pursued by introducing rubber phases among the traditional components (cement, water and aggregates). Different kinds of tyres have been employed as partial substitute of natural aggregates in concrete: scrap tyres obtained by simple grinding without further purifications thus including steel and textile fibers in their composition, crumb rubber obtained by cryogenic process, milled tyre rubbers treated with sodium hydroxide solution to achieve a better adhesion with the cement paste, scrap truck tyre rubber, tyres tread etc.

The possibility to design rubberized self-compacting concrete (RSCC) appears particularly attractive because this new material might join the characteristics of self compacting concrete such as high flow ability, high mechanical strength, low porosity etc thus leading to a building material with more versatile performances. The best results were obtained for workability and mechanical strength when sand fraction was replaced by tyre waste of similar grain size. The use of wastes or byproducts as filler material, aggregate, mineral admixture etc also makes it possible to produce durable, economical and environmental friendly concrete structures. Rubberized self compacting concrete with fine aggregate filler material satisfying the regular fresh and hardened concrete properties could be more economical, durable and environmental friendly than any other concrete types. It has regular, homogeneous compressive–tensile strength distribution, better elastic properties as greater ductility, lower toughness and higher deflection compared to ordinary concrete.

II. EXPERIMENTAL INVESTIGATION

First of all, several journals were studied about the self compacting concrete with and without replacement of rubber. Then made a literature review of about 10 journals. From this literature review, materials for doing this thesis are selected by knowing the impact of these materials to the environment. After this, the selected materials are characterized that is these materials have to satisfy the material properties of self compacting concrete which is provided by the European guidelines for self compacting concrete(EFNARC). Then develop a trial mix by trial and error method which satisfies the properties of self compacting concrete that is flow ability, passing ability etc. Trial and error method is used for the mix design since there is no appropriate mix design for self compacting concrete. Using this mix design, specimens are casted by the partial replacement of fine aggregate and cement with crumb rubber and marble powder. Then the specimens are subjected to fresh state tests such as slump flow test, V-funnel test, L-box test, U-box test and hardened state tests such as compressive strength test, split tensile strength test, flexural strength test and water absorption test. After that the cost analysis were made in terms of material for various mixes. The results of these tests are compared with that of normal self compacting concrete. Then a conclusion is made from the results and observation of fresh and hardened tests of self compacting concrete. At last, a report is made by summarizing all the above details.

1. Fresh Properties of SCC

Slump-flow and T_{500} time for SCC

Slump flow is one of the most commonly used SCC tests at the current time. This test involves the use of slump cone used with conventional concretes as described in ASTM C 143(2002).The main difference between the slump flow test and ASTM C 143 is that the slump flow test measures the “spread” or “flow” of the concrete sample once the cone is lifted rather than the traditional “slump” (drop in height) of the concrete sample. The T_{500} test is determined during the slump flow test. It is simply the amount of time the concrete takes to flow to a diameter of 500 millimeters .Typically, slump flow values of approximately 600mm to 750mm are within the acceptable range; acceptable T_{500} times range from 2 to 5sec.

Fig. 1 Slump flow test

V-funnel test

In this test, the flow of SCC per unit time is determined. It includes the discharge time measurement of fresh SCC with its self-weight from the narrow mouth of funnel designed specially. This funnel is called as V-funnel. This test is a self-compatibility test to measure the capacity of concrete to pass into the spaces. This test determines the viscosity and passing capacity of SCC. Fresh SCC is filled to the funnel without any compaction or vibration and then the sliding cover under the funnel is opened and the filling time of all concrete in the funnel to the pail is recorded.

Fig. 2 V-funnel test

L-box test

L-box test is used to assess the passing ability of SCC to flow through tight openings including spaces between reinforcing bars and other obstructions without segregation or blocking. The principle behind this test is to measure the volume of fresh concrete which is allowed to flow horizontally through the gaps between vertical, smooth reinforcing bars and the height of the concrete beyond the reinforcement is measured. Height of the horizontal section of the box measured as H_2 mm. The depth of concrete immediately behind the gate measured as H_1 mm.

Fig. 3 L-box test

U-Box test

This test is used to measure the filling ability of self-compacting concrete. The apparatus consists of a vessel that is divided by a middle wall in to two compartments .An opening with a sliding gate is fitted between the two sections. Reinforcing bars with normal diameter of 13mm are installed at the gate with centre-to-centre spacing of 50mm. This creates a clear spacing of 35mm between the bars. The left hand section is filled with 20 liter of concrete then the gate lifted and concrete flows upwards in to the section. The height of the concrete in both the sections is measured.

2. Hardened Properties

Compressive Strength Test

150mm x 150mm x 150mm moulds were used to cast cubes to determine the compressive strength of the concrete.

Fig. 4 Compression Test

Flexural Strength Test

100mm x 100mm x 500mm moulds were used to cast beams to determine the flexural strength of concrete.

Fig. 5 Flexural Strength test

Split Tensile Strength Test

150mm x 300mm moulds were used to cast cylinders to determine split tensile strength and of the concrete.

Fig. 6 Split Tensile Strength test

III. RESULTS AND DISCUSIONS

1. Fresh Properties of SCC

Table I Fresh Property Details

		T_{500} Slump	V Funnel		U Box
	Slump	(s)	(s)	L Box	(mm)
Mix ID	(mm)				
NSCC	710	4	8.2	0.92	17
CR10	660	4.8	10	0.84	23
CR20	655	5	10.2	0.82	25
CR30	650	5	10.8	0.8	26
CR20MP10	665	4.6	9.6	0.85	21
CR20MP20	675	4.4	9.4	0.88	20
CR20MP30	680	4.3	9.3	0.9	19

2. Hardened Properties

Compressive Strength Test

Table II Compressive strength (N/mm^2)

Cube designation	Compressive strength (N/mm^2)		
	7 day	14 day	28 day
NSCC	14	25.64	36.8
CR10	12.89	23.78	32.75
CR20	13.56	26.54	34.56
CR30	12.55	22.56	30.82
CR20MP10	15.46	28.68	37.44
CR20MP20	14.34	27.45	35.43
CR20MP30	13.92	26.89	34.89

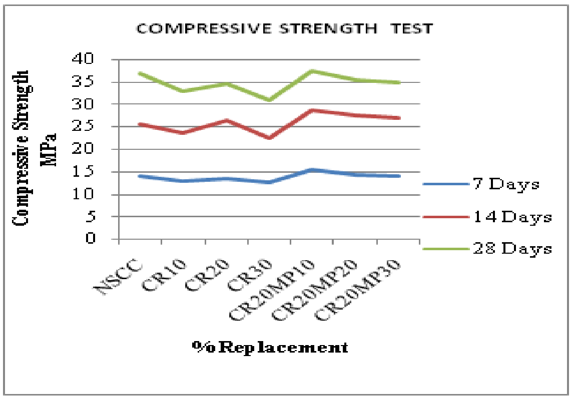

Fig. 7 Graphical representation of compressive strength at 7day, 14 day and 28day

Flexural Strength Test

Table III Flexural strength (N/mm^2)

Prism designation	Flexural strength (N/mm^2)		
	7 day	14 day	28 day
NSCC	3.12	4.85	6.25
CR10	2.67	3.98	5.86
CR20	2.84	4.45	5.57
CR30	2.56	3.42	4.95
CR20MP10	2.95	4.65	5.96
CR20MP20	2.84	4.59	5.73
CR20MP30	2.77	4.34	5.45

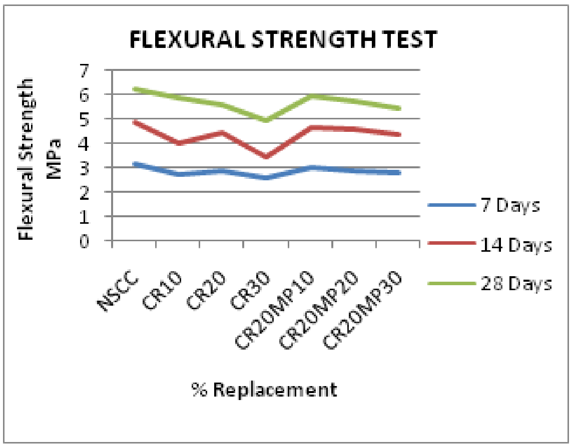

Fig. 8 Graphical representation of flexural strength test at 7day 14 day and 28day

Split Tensile Strength Test

Table IV. Split tensile strength (N/mm^2)

Cylinder designation	Split tensile strength (N/mm^2)		
	7 day	14 day	28 day
NSCC	2.08	2.4	3.12
CR10	1.78	2.15	2.64
CR20	1.82	2.35	2.66
CR30	1.69	2.27	2.55
CR20MP10	1.95	2.38	2.96
CR20MP20	1.88	2.27	2.72
CR20MP30	1.82	2.19	2.68

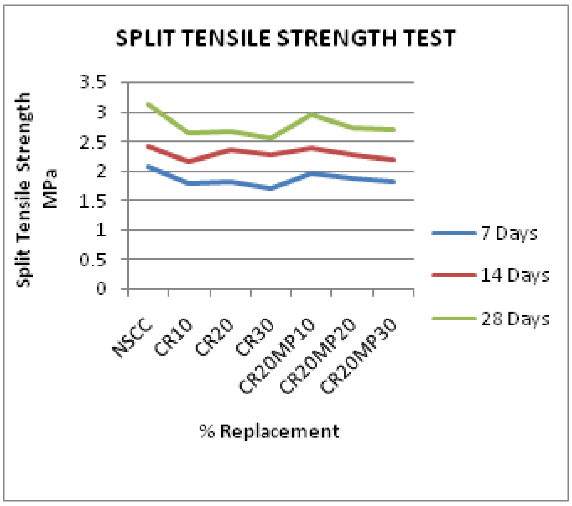

Fig. 9 Graphical representation of split tensile strength at 7day, 14day and 28day

IV. CONCLUSION

The above thesis summarizes that the self compacting concrete using rubber phase as a replacement material seems to be suitable for preparing concrete with more versatile mechanical behavior. There is a decrease in the compressive strength and stiffness by the increase in the amount of rubber content in the concrete mixes. Addition of fillers such as waste fillers from marbles, tiles etc in the self compacting concrete increases the mechanical properties of the self compacting concrete. Compactness also increases due to the addition of fillers which leads to produce economical and environmental waste concrete structures. Increased amount of rubber content leads to chloride penetration in the self compacting concrete. So the addition of fly ash in the mix reduces the chloride penetration of self compacting concrete. The dosage of super plasticizer depends on the fineness of the aggregates.Addition of viscosity modifying admixture influences the properties such as viscosity and segregation resistance. Increase in the percentage of crumb rubber reduces the flow ability, passing ability, stability and compressive strength of self compacting rubberized concrete. Replacement of rubber by 20% seems to be the best level of replacement whereas the replacement level increases there occurs a decrease in the compressive strength and stability. The use of marble powder content enhances the rheological properties of self compacting concrete. The presence of marble powder in the formulation of self compacting concrete increases the compressive strength of the concrete. The incorporation of industrial wastes increases the tensile strength and flexural strength of self compacting concrete. This also increases the compactness of the concrete. The Filling capability and passing ability are between acceptable values of self compacting concrete. In the case of using high volume of marble powder, filling capability and passing ability decreases due to the decrease in the segregation resistance. Incorporation of marble powder which is freely or cheaply in the formulation of self compacting concrete allows producing an economic self compacting concretes and environmental waste management. This thesis shows that the replacement of cement by 10% of marble powder increases the mechanical properties of self compacting concrete. Also in the case of cost analysis, the mix with 20 and 10% replacement of crumb rubber and marble powder has lower cost as compared to normal concrete. Where as the mix with 20 and 10% replacement of crumb rubber and marble powder has slightly higher cost than that of normal self compacting concrete.

From this thesis work it can be shown that the addition of more percentage of crumb rubber and marble powder will reduces the fresh and hardened properties of self compacting concrete. So the optimum percentage for replacing crumb rubber as fine aggregate is 20% where as the replacing of marble powder with cement is 10%.

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