Experimental Investigation of Self Compacting Concrete by Partially Replacing Fine Aggregate with Quartz Sand with Use of Recron Fibre

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Abstract:- *Self Compacting Concrete is a newly developed concrete in which the ingredients of the concrete mix are proportioned in such a way that it can flow under its own weight to completely fill the formwork and passes through the packed reinforcement without any segregation and self consolidate without any mechanical vibration. Efforts for improving the performance of concrete over the past few years suggest that fine aggregate replacement materials such as Mineral admixtures can improve the strength and durability characteristics of concrete. Several studies have been done on self compacting concrete. An experimental investigation was carried out to study the performance of concrete with the inclusion of partially replacing fine aggregate with quartz sand (25%,50%,75%&100%)by the use of recron fiber (0.25%,0.50%,0.75%&1%). The fresh properties were determined through Slump Flow, J-Ring, V-Funnel and L-Box tests. The fundamental properties of concrete like compressive strength, split tensile strength and durability properties are investigated. This paper deals with the implementation of quartz sand as an effective replacement for sand. Quartz sand, which is considered as the mineral admixture, can be used for filling material. In this work, quartz sand is used as replacement for sand, which is also a major component in concrete mixture by the use of recron fiber. In the present investigation the main concentration is focused on strength behavior of self-compacting concrete.*

Keywords: self compacting concrete, Quartz sand, Recron fiber, workability, Mechanical Properties

1. INDRODUCTION

Self-Compacting Concrete (SCC) has had a remarkable impact on the concrete construction industry, especially the precast concrete industry. SCC, is defined as the concrete which can be placed into every corner of formwork, purely by means of its self-weight, by eliminating the need of external energy from vibrators or any type of compacting effort [1]. Self Compacting Concrete has been developed in Japan to improve the durability and uniformity of concrete in 1988 by Okamura and Ozawa. The mix composition is chosen to satisfy all performance for the concrete in both the fresh and hardened states [2]. SCC can be described as a high-performance material which flows under its own weight without requiring vibrators to achieve consolidation by complete filling of formworks even when access is hindered by narrow gaps between reinforcement bars. Concrete with reduced environmental impact has been produced in Denmark for some years [3]. Self-compacting concrete is a concrete which flow by its own weight. So it does not require compaction at site or concrete plants [4]. It is also referred as self-leveling concrete, super workable concrete, self-consolidating concrete, highly flow able concrete, non-vibrating concrete, etc[5]

To achieve this, mineral admixtures and super plasticizers, viscosity modifying admixture are used as a chemical admixture for design of concrete. The main difference between conventional concrete to self compacting concrete is the pores value in concrete mass i.e. highly eliminated pores[6]. In this paper, mass of fine aggregate is typically equal or more compare to coarse aggregate. And selection of coarse aggregate size also gives impact on requirement of self compacting.

There are many advantages of using SCC especially when the material cost is minimized which include, Reducing the construction time and labor cost, Eliminating the need for vibration, reducing noise pollution, Improving the filling capacity of highly congested structural member [7].

1.1 Materials

Experimental program has been designed to provide sufficient information for ascertaining the quality of quartz sand and recron fiber self compacting concrete. To evaluate the behavior of quartz, sand based self-compacting concrete with use of recron fiber, both mechanical strength and durability aspects have been studied in this investigation.

1.1.1 Cement

The ordinary Portland cement confirming to IS 4031 was used for the preparation of specimens. OPC 53 grade was used.

1.1.2 Fine aggregate

Fine aggregate is used in the experimental investigation and confirming to zone-II of IS 383-1970.Sand is used in the work which has the particle was less than 4.75mm.

1.1.3 Coarse aggregate

The coarse aggregate particles passing through 20mm and retained on 12.5 mm I.S Sieve used as the natural aggregate which met the grading requirement of IS 383-1970.

1.1.4 Water

Water is most important and least expensive ingredient of concrete. A part of mixing water is utilized in the hydration of cement to form binding matrix in which the inert aggregates are held in suspension until the matrix has harden. The remaining water serves as a lubricant between the fine and coarse aggregate and makes concrete workable.

1.1.5 Quartz Sand

Quartz, most common of all minerals is composed of silicon dioxide, or silica, SiO2. It is an essential component of igneous and metamorphic rocks. The size varies from specimens weighing a metric ton to minute particles that in rock surfaces. The crushed quartz powder used in the experiments is in a form of white powdered quartz flour, which replaces fine aggregate from the conventional concrete. The particle size used ranges from 10 to 45µm

1.1.6 Super Plasticizer

Generally super plasticizers are used to improve the workability and reduce water content. According to this the super plasticizer Complots SP 430 is a high range water reducing agent. There are difficulties and limitations to obtain high workability in the field for a given set of conditions. Specific gravity and Chloride content of super plasticizer are 1.220 to 1.225 at 300ºC and Nil as per IS: 456 respectively.

1.1.7 Recron fiber

Recron fiber is a material made from extremely fine fibers of basalt, which is composed of the mineral plagioclase, pyroxene and olivine. Recron fiber is a relative newcomer to Fiber reinforced polymers and structural composites. It has a similar chemical composition as glass fiber but has better strength characteristics, and unlike most glass fiber is highly resistant to alkaline, acidic and salt attack making it good candidate for concrete, bridge structures.

Table 1 Properties of Materials used

S.no	Name of the material	Properties of material	Result
1	OPC 53 grade	Specific gravity	3.15
		Fineness modulus	3.4%
		Consistency	32%
		Initial setting time	35 mins
		Final setting time	10 Hours
2	Fine aggregate	Specific gravity	2.5
		Fineness modulus	4.27
		Water absorption	0.85%
		Bulk density	1782.46kg/m^3
		Specific gravity	2.64%
		Fineness modulus	8.4

3	Coarse aggregate	Water absorption	0.56%
		Bulk density	1693.46kg/m^3
		Impact test	16.72%
4	Quartz Sand	Specific gravity	2.45
		Fineness modulus	4.2
		Water absorption	1.98

1.2 Mix proportion

The very first step to assure the flow requirement of SCC is to determine the optimum dosage of quartz sand and recron fiber. Various mixes were prepared and tested to satisfy the EFNARC guidelines. Finally, a mix is chosen which gave fulfilling fresh properties. The addition of different percentage of admixtures would be done in this mix. The mix proportion was done based on the EFNARC guidelines. The mix design was carried out for M30 normal grade of self compacting concrete with quartz sand as partial replacement of fine aggregate with a fraction of 25%, 50%, 75%, & 100% and recron fiber is 0.25%, 0.50%, 0.75% & 1%.

1.2.1 Mix ratio

Table 2 Grade of concrete –M30

Cement	Fine Aggregate	Coarse Aggregate	Water
594.08	793.08	843.54	189.73

Table 3 Mix proportion

Mix no	Cement	Coarse aggregate	Fine aggregate	Quartz sand
Scc 1	100%	100%	100%	0%
Scc-q1	100%	100%	75%	25%
Scc-q2	100%	100%	50%	50%
Scc-q3	100%	100%	25%	75%
Scc-q4	100%	100%	0%	100%

2. EXPERIMENTAL WORKS

2.1 Fresh properties

To study the fresh concrete properties of self-compacting concrete based on the parameters defining the fresh concrete. Many different test methods have been developed in attempt to characterize the property of Self-Compacting concrete. According to EFNARC, a slump flow diameter varies from 650 to 800mm is acceptable for SCC. In slump flow ability and segregation resistance can be also resolute. Apart from slump flow L-Box test, U-Box test and V-Funnel test are also performed to evaluate flow ability, passing ability stability of SCC. The L-Box ratio is in range of 0.8-1.0. The V-Funnel time ranges from 8 to 12 seconds.

Table 4 Fresh properties

TESTING METHODS	UNITS	WORKABILITY VALUES					
		PERMISSIBLE LIMIT	SCC	SCC-q1	Scc-q2	Scc-q3	Scc-q4
SLUMP FLOW(diameter)	mm	650-800	670	657	660	665	670
SLUMP FLOW(time)	sec	2-5	3	3.2	3	2.8	2.8
V-Funnel	sec	6-12	7	8	7.8	7.3	7
L-Box	-	0.8-1.0	0.84	0.93	0.91	0.9	0.9
J-Ring	mm	0-10	6	7	7	6.5	6.5

2.2 Mechanical properties

All the mixes were tested for various hardened properties like compressive strength, flexural strength & Split Tensile Strength test as per Indian Standards. The six different combination mixes were prepared including conventional for testing. In these investigations, Specimens prepared such as cube size is 150X150X150 mm, cylinder size is 300X150 mm and prism (500X100X100 mm) for each combinations. The testing was done on specimens after 28 days curing. All tests was repeated for three specimens and average value was taken as the mechanical strength.

2.1.1 Compressive Strength

In this investigation, the cube specimen of size 150mm x 150mm x 150mm were cast, cured and tested in accordance with BIS: 516 – 1959 (method of test for test of concrete). The testing was done on compressive testing machine of 2000kN capacity.

2.1.2 Split Tensile Strength

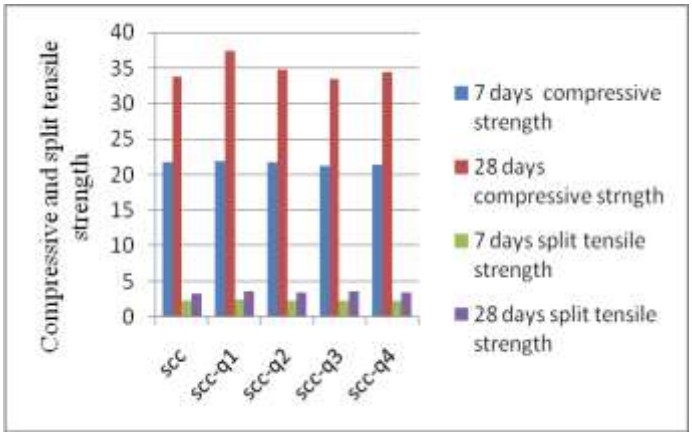
The objective of this is to find the splitting tensile strength of the concrete cylinders. This cones under indirect tension test methods. A concrete cylinder of size 150mm diameter and 300mm height was subjected to the action of the compressive forces along two opposite edges. The test was conducted using compressive testing of 200kN capacity.

Horizontal Tensile Stress = 2P/ DL

Where, P = Compressive load on the cylinder.

L = Length of cylinder. D = Diameter of cylinder.

Mix id	Compressive Strength (MPa)		Split Tensile Strength (MPa)	
	7 days	28 days	7 days	28 days
Scc	21.67	33.67	2.28	3.26
Scc-q1	21.88	37.33	2.47	3.62
Scc-q2	21.77	34.78	2.35	3.39
Scc-q3	21.22	33.34	2.36	3.58
Scc-q4	21.44	34.45	2.30	3.49



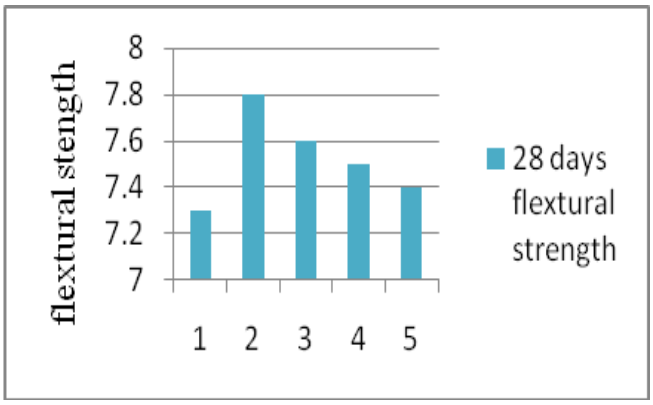
2.1.3 Flexural Strength

Flexural tests were conducted on beams of size of 100 mm x 100mm X 500 mm subjected to two point loading at 28 days in UTM. The maximum load applied to the specimen shall be recorded and the flexural strength of concrete expressed as the modulus of rupture (fb) is calculated.

Modulus of rupture fb = $3Pl / 2bd^2$

Table 6 : **Flexural strength of Self Compacting Concrete**

S.No	Mix id	Flexural strength at 28 days (MPa)
1	Scc	7.3
2	Scc-q1	7.8
3	Scc-q2	7.6
4	Scc-q3	7.5
5	Scc-q4	7.4



RESULT AND DISCUSSION

The following conclusions are drawn for feasibility study conducted on self compacting concrete with quartz sand as partial replacement of fine aggregate includes, the conclusion based on the limited observations from the present investigation on study of compressive, split tensile, flexural strength, water absorption and acid resistance of the concrete made using quartz sand as partial replacement of fine aggregate with recron fiber (0.25%). The replacement level of quartz sand ranging from

25% yields higher compressive strength than the conventional concrete mix. Beyond that there is a decrease in the compressive strength of concrete by replacing 100% of quartz sand and recron fiber.

- The present investigation has shown that it is possible to achieve self compaction with different percentage of quartz sand with use of recron fiber by the results of slump flow, J – ring, U - box, L – box and V – funnel. Although results obtained from all of the mixes satisfy the lower suggested by EFNARC, all mixes had good flow ability and possessed self-compaction characteristics.
- The compressive strength had achieved in scc-q1 mix is high. That compressive strength result 21.88N/mm^2 for 7 days and 28 days strength is 37.33 N/mm^2.
- The split tensile strength had achieved in scc-q1 mix is high. That Split tensile strength maximum result 2.47N/mm^2 for 7 days and 3.62 for 28 days.
- The flexural strength has achieved in scc-q1 mix is high. That flexural strength maximum result is 7.8 Mpa.

REFERENCE

[1] Shahul Hameed, M., and Sekar, V. et., al., "Self Compacting Concrete using Marble Sludge Powder and Crushed Rock Dust", KSCE Journal of Civil Engineering (2012)16 (6): 980-988.

[2] Raman than P, I Baskar, P Muthupriya, R Venkatasubramani. Performance of Self-Compacting Concrete Containing Different Mineral Admixtures. KSCE Journal of Civil Engineering (2013) 17(2):465-472.

[3] Shahul Hameed, M., Saraswathy, V. and Sekar, A.S.S., "Chloride Penetration Study on Self-Compacting Green Concrete Using Crusher Rock Dust and Marble Sludge Powder as Fine Aggregate", e- journal of Non-Destructive Testing', (eJNDT), ISSN. No.1435-4934, Vol.15, No.2, 2010.

[4] Shriram H, Mahure, Moniker VM. Effect of *Mineral Admixture* on Fresh and Hardened Properties of Self Compacting Concrete. ISSN: 2319-8753, Vol. 2, Issue 10, October 2013.

[5] Dhanalakshmi A, and Shahul Hameed, M., "Review Study on High Strength Self Compacting Concrete" Volume 4 Issue 12 June 2018 ISSN (online): 2349-784X.

[6] Dhiyaneshwaran S, Ramanathan P, Baskar I, Venkatasubramani R. Study on *Durability* Characteristics of Self Compacting Concrete with Fly Ash. Jordan Journal of Civil Engineering, Volume 7, No. 3, 2013.

[7] Purumani Supriya. Experimental Investigation of M40 Grade on Self Compacting Concrete UsingMineral Admixtures. International Journal of Advanced Research Foundation, Volume 3, Issue 2, February 2016.

BIOGRAPHIES

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