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Experimental Investigation on Self-Curing Self-Compacting Concrete

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ABSTRACT: Self Compacting Concrete (SCC) is new type of concrete that posse's property of high flow ability, passing ability and stability. To achieve SCC, many factors must be investigated. The mix design for SCC was arrived according to the suggested method. In the present investigation, SCC was made by usual ingredients such as cement, fine aggregate, coarse aggregate, water and mineral admixture silica fume but the fine aggregate was replaced by M-sand (JSW) at different replacement levels (10%, 20%, 30% and 40%). Then, for the purpose of internal curing, 10% and 15% of normal weight coarse aggregate was replaced with saturated Lightweight Aggregate (LWA) of the same size. The super plasticizer used was Glenium B233. The experiments are carried out by adopting a water-powder ratio of 0.5. Workability of the fresh concrete is determined by using tests such as: slump flow, j-ring, T50, V-funnel, L-Box and U-box tests. Cube and cylinder specimen were casted to determine the strength properties which were tested at the age of 7, 28 and 56 days. The compressive and split tensile strength was measured. It was noticed that concrete mixes prepared with M-sand and LWA showed higher strengths than normal self compacting concrete up to 30% replacement level of natural sand by M-sand. It was concluded the mechanical properties such as compressive strength and split tensile strength in hardened state were found satisfactorily for self compacting self cured concrete.

Keywords: SCC, Silica Fume, Light Weight Aggregate, Manufactured sand (JSW).

I. INTRODUCTION

Self-Compacting Concrete (SCC) is considered as a concrete with high workability that is able to flow under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without vibration, whilst maintaining homogeneity. In SCC, the aggregates generally contribute approximately 60-70% of the total volume. Proper choice of aggregates has significant effect on the fresh and hardened properties of SCC concrete. Aggregate characteristics such as shape, texture and grading influence workability, finish ability, bleeding, pump ability, segregation of fresh concrete and strength, stiffness, shrinkage, creep, density, permeability and durability of hardened concrete. In general it is observed that the effects of shape and texture of fine aggregate are much more important than the effects of coarse aggregate. The advantages of SCC are: Increases construction speed due to fewer construction tasks; Improves ability of concrete to flow into intricate spaces and between congested reinforcement; Improves form surface finish and reduced need to repair defects such as bug holes and honeycombing; reduces construction costs due to reduced labor costs and equipment purchase and maintenance costs: Improves the working conditions with fewer accidents due to elimination of vibrators. Many investigators [1-8] have studied about the manufacture sand. Strength characteristics of SCC and use of waste products such as silica fume and introduction of fibers in improving strength characteristics of SCC have been studied and reported in the literature.

Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. There are two major methods available for internal curing of concrete. The first method uses saturated porous Lightweight Aggregate (LWA) in order to supply an internal source of water, which can replace the water consumed by chemical shrinkage during cement hydration. The second method uses Poly-Ethylene Glycol (PEG) which reduces the evaporation of water from the surface of concrete and also helps in water retention. In the present study the first method is being adopted.

The use of fly ash, blast furnace slag and silica fume in SCC reduces the dosage of Super Plasticizer needed to obtain similar slump flow compared to concrete mixes made with only Portland cement.

II. OBJECTIVES OF THE STUDY

The main objective of this investigation is to determine the suitable percentage of manufacture sand (JSW), light weight aggregate replacement and influence of different proportioning of super plasticizers in SCC that gives the highest value of concrete compressive strength.

III. EXPERIMENTAL PROGRAM

In this investigation 99-cube, 99-cylinders are tested to investigate concrete compressive strength and split tensile strength of SCC with the combination of Manufactured sand, silica fume and light weight aggregate. All test specimens of cube with 150mm size and cylinders with diameter 150mm and 300mm in length.

A. Materials used in this experiment

1) Cement (C)

In this experimental study, Ordinary Portland Cement conforming to IS: 8112-1989 was used. The physical and mechanical properties of the cement used are shown in Table 1.

Table 1: Properties of cement

Physical properties	Results
Fineness	2%
Normal consistency	30%
Vicat initial setting time(minutes)	30
Vicat final setting time (minutes)	205
Specific gravity	3.1

2) Light Weight Aggregate (LWA)

It is highly porous light weight aggregate. Its density is approximately 0.25g/cm^3. It is typically light colored and translucent bubble walls.

3) Silica Fume (SF)

Silica fume is a waste by-product of the production of silicon and silicon alloys. Silica fume is available in different forms, of which the most commonly used now is in a densified form. In developed countries it is already available readily blended with cement. The details of silica fume used in this experiment are in the Table.

Table-2: Details of Silica fume

Code	**920-D**
Type	Densified (Non-Combustible)
Main content	Amorphous Sio_2

4) Aggregates

Locally available natural sand with 4.75 mm maximum size was used as fine aggregate (FA). Coarse aggregate (CA) of maximum 12.5 mm was used. Table-3 gives the Physical properties of fine & coarse aggregate.

5) Super Plasticizer (SP)

Master Glenium-Ace 30(JP) from BASF Bangalore was used.

Table-3: Physical properties of fine & coarse aggregate

Property	Fine(FA)	Coarse(CA)
Specific gravity	2.5	2.84
Fineness modulus	3.37	7.1
Surface texture	Smooth	--
Particle shape	Rounded	Angular
Crushing value	--	17.4
Impact value	--	12.5

6) Manufactured sand (JSW)

It's also one type of manufactured fine aggregate sand. Manufacture of SCC and conventional concrete is done using river sand. JSW slag is a by-product of metal smelting process that has been found to be suitable for producing M-sand as well as coarse aggregate. It has been used to replace River Sand during the manufacture of SCC.

Table-4: Properties of manufactured sand.

Physical properties	Test results
Specific gravity	2.58
Fineness modulus	3.37 (zone)

7) Water

Ordinary portable water is used.

B. SCC Mix Design

Several methods exist for the mix design of SCC. We have adopted Nan-su method.

1) Mixing procedure for SCC

- Mixing procedure for SCC is described as follows:
- Aggregates and binder are mixed for one minute.
- The 1st part (70%) of water was added and mixed for two minute.
- SP and VMA along with 2nd part (30%) of water was added and mixed for two minutes.
- The mix was stopped and discharged for SCC tests.

1SCLC1, 1SCLC2, 1SCLC3, 1SCLC4, 1SCLC5 are constant 10% LWA and 10%, 20%, 30%, 40% replacement of MS respectively. 2SCLC6, 2SCLC7, 2SCLC8, 2SCLC9, 2SCLC10 are constant 15%LWA and 10%, 20%, 30% and 40% replacement of MS respectively.

Table-5: Mix Proportions.

S.N	C	S F	FA	MS	CA	LWA
NC	360.71	147.44	821.02	0	638	0
1SCLC 1	360.71	147.44	821.02	0	638	63.8
1SCLC 2	360.71	147.44	738.91	82.1	574.2	63.8
1SCLC 3	360.71	147.44	658.81	164.2	574.2	63.8
1SCLC 4	360.71	147.44	574.71	246.3	574.2	63.8
1SCLC 5	360.71	147.44	492.61	328.4	574.2	63.8
2SCLC 1	360.71	147.44	821.02	0	638	95.7
2SCLC 2	360.71	147.44	738.91	82.1	542.3	95.7
2SCLC 3	360.71	147.44	658.81	164.2	542.3	95.7
2SCLC 4	360.71	147.44	574.71	246.3	542.3	95.7
2SCLC 10	360.71	147.44	492.61	328.4	542.3	95.7

IV. RESULT AND DISCUSSION

This paper consists of test results and discussions on workability, compressive strength, split tensile strength Self compacting Self Curing Concrete (SCLC) for different fine Aggregate (Natural Sand) and Coarse Aggregate (LWA) replacement levels. The test results are compared with Normal Self compacting Concrete (NC).

A) Properties of Fresh state SCC

The workability is measured by flow properties as per EFNARC. The values of flow properties with constant water/binder ratio for Self compacting self curing concrete for different mixes were measured.

B) Properties of hardened SCC

The properties of hardened SCC were measured in terms of Compressive Strength obtained from Compression test confirming to IS 516-1959.

Tests were conducted at different curing periods of 7, 28 and 56 days. The tensile strength is one of the basic and important properties of concrete. Hence, the tensile strength of concrete is obtained indirectly by subjecting concrete cylinders to the action of compressive force along two opposite generators of a concrete cylinder placed with its axis horizontal between the compressive platens. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from the elastic analysis. The split tensile test is carried out as per IS: 5816-1970. The magnitude of tensile stress was evaluated using the relation $\sigma SP = 2P/ \pi DL = 0.637P/DL$. The results of variation in compressive strength and tensile strength with various curing periods are as shown in table and figure.

Table 6: Compressive strength.

SI NO	Parameter	Compressive Strength N/mm^2		
		7 days	28 days	56 days
1	NC	16.33	26.02	32
2	1SCLC 1	16.89	26.77	33
3	1SCLC 2	17	28.11	34.78
4	1SCLC 3	18.88	32.22	36.67
5	1SCLC 4	19.33	34.16	39
6	1SCLC 5	19	22.89	30
7	2SCLC 1	17.75	27.29	33
8	2SCLC 2	20.56	30.11	34.89
9	2SCLC 3	22.44	31	36.12
10	2SCLC 4	23	33.22	37
11	2SCLC 5	15.77	25.33	28.87

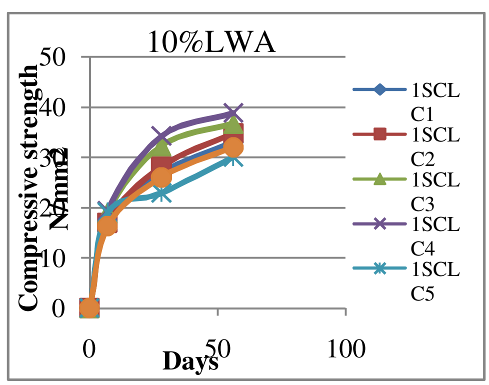

Fig. 1: Compressive strength of 10% LWA.

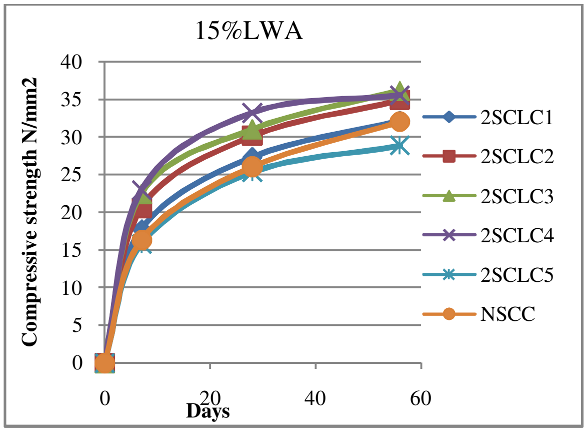

Fig. 2: Compressive strength 15% LWA.

From the results obtained it can be observed that the compressive strength for internally cured at ambient temperature by replacing coarse aggregate by LWA as compared to that of NC increased strength reasonably. From the results obtained the cube compressive strength of the mixes. It can be seen that strength increases with constant replacement of silica and increasing percentage of JSW sand content 30%. The strength 1SCLC1 to 1SCLC4 ranges from 32MPa to 39MPa and 2SCLC2 to 2SCLC5 ranges from 33MPa to 36MPa.

From the results obtained compressive strength of 1SCLC4 having silica fume compared to NC was increased by 6%, 10% and 8% at 7 days, 28 days and 56 days respectively for 30% replacement of M-sand.

From the results obtained compressive strength of 2SCLC4 having silica fume compared to NC was increased by 8%, 12% and 9% at 7 days, 28 days and 56 days respectively for 30% replacement of M-sand.

In this study an attempt for improving the harden characteristics of concrete by internally at ambient room temperature curing of concrete by partial replacement of coarse aggregate by LWA was studied. From the results obtained it shows that the compressive strength of concrete increased reasonably for all ages for SCLC1 – 2SCLC5 mixes.

The compressive strength of 1SCLC4 increases by 2% than 2SCLC4 at 28 days and 1SCLC4 increases by 3% than 2SCLC4 at 56 days. This study shows that the addition of M-sand beyond 30% compare to NC at ages reduce compressive strength.

Table 7: Split tensile strength.

SI NO.	Parameter	Tensile strength N/mm^2		
		7 days	28 days	56 days
1	NC	1.76	3.14	3.89
2	1SCLC1	1.8	3.16	3.92
3	1SCLC2	1.83	3.26	3.96
4	1SCLC3	1.88	3.35	4.0
5	1SCLC4	1.98	3.61	4.12
6	1SCLC5	1.23	3.14	3.0
7	2SCLC1	1.88	3.18	4.06
8	2SCLC2	1.79	3.54	4.12
9	2SCLC3	1.81	3.57	4.16
10	2SCLC4	1.83	3.64	4.2
11	2SCLC5	1.93	3.32	3.11

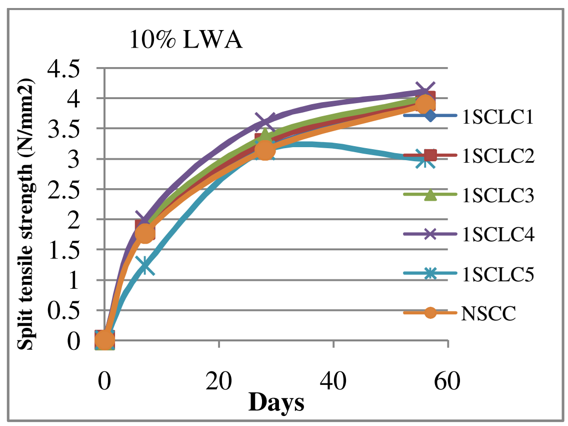

Fig. 3. Split tensile strength 10% LWA.

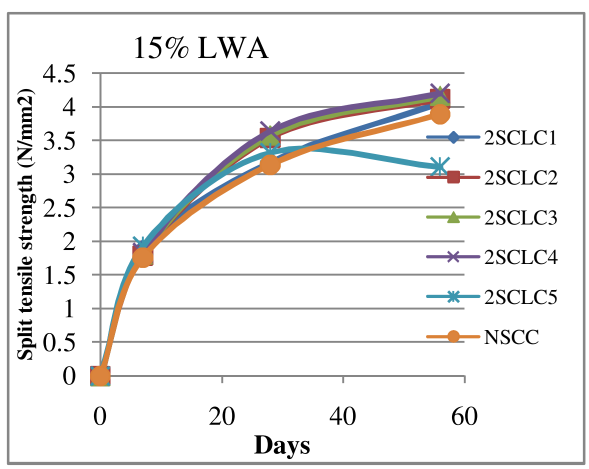

Fig. 4. Split tensile strength 15% LWA.

The strength 1SCLC1 to 1SCLC4 ranges from 3.89 MPa to 4.12 MPa and 2SCLC1 to 2SCLC5 ranges from 4.06 MPa to 4.2 MPa.

From the results obtained tensile strength of 1SCLC4 having silica fume compared to NC was increased by 20%, 8% and 11% at 7 days, 28 days and 56 days respectively for 30% replacement of M-sand.

From the results obtained split tensile strength of 2SCLC4 having silica fume compared to NC was increased by 20%, 9% and 13% at 7 days, 28 days and 56 days respectively for 30% replacement of M-sand.

In this study an attempt for improving the harden characteristics of concrete by internally at ambient room temperature curing of concrete by partial replacement of coarse aggregate by LWA was studied. From the results obtained it shows that the split tensile strength of concrete increased reasonably for all ages for 1SCLC1 – 2SCLC5 mixes.

The tensile strength of 2SCLC4 increases by 2% than 1SCLC4 at 28 days and M9 increases by 3% than 1SCLC4 at 56 days.

V. CONCLUSION

1. After designing the parameters of mix proportion of SCC mixes containing M-sand and LWA. A SCC with good workability and improved time dependent properties has been achieved and flow characteristics of SCC mixes for various proportions of M-sand and LWA were within prescribed limits as per EFNARC standards.
2. The result showed that both the flow ability and possibility measurement indicated that SCC mixes with replacement of material by M-sand and LWA was better as compared to that of control mix.
3. The compressive strength of SCC mixes containing M-sand, internally cured by replacement of coarse aggregate by LWA at ambient room temperature by replacement of coarse aggregate by LWA up to 30% replacement of M sand and later significantly decreased the strength as the percentage of M sand increased by beyond 30%.
4. The mechanical behavior of the SCC (1SCLC1-2SCLC5) mixes was attractive by internally curing compressive strength for 2SCLC4 mixes was found to be 8%, 12% and 9% for 7days 28days and 58days respectively for 15% replacement of LWA.
5. Research result demonstrated that application with SCC mixes containing M-sand and LWA can be economical due to increase in the price of natural sand and scenario has risen which offer the final concrete products with interesting characteristics by using JSW M-sand a waste product and also can introduce innovative solution for specific application of using method.

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