Development of Self Compacting Concrete Using Composite Material

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Abstract - Self-compacting concrete (SCC) is an innovative and versatile material in the field of construction. SCC is a unique kind of concrete that can flow and fill form work or mould under its weight without the aid of vibration or mechanical compaction. SCC is accomplished using a specifically formulated mix that contains high-range water-reducing admixtures super-plasticizers and viscosity-modifying agents. In the environment, wastes such as Fly Ash (FA), limestone (LS) Composite material made of fly ash is used in many ways and is subject to a variety of different loading conditions, and so different types of stress develop. Optimum replacement of cement with a combination of FA (30%) and limestone (10%,15%&20%). The durability properties of the different mixes were also assessed using tests for sulphate resistance, sorptivity, water absorption, water impermeability, and porosity. Based on the results, the optimal mix proportion was identified, filling ability, passing ability. The test results for acceptance characteristics of self-compacting concrete such as slump flow; J-ring, V-funnel and L-Box are presented. Further, compressive strength at the ages of 7, 14, and 28 days was also determined and results are included

Key Words: optics, photonics, light, lasers, templates, journals

1.INTRODUCTION

This Self-compacting concrete (SCC) is an innovative and versatile material in the field of construction. Unlike traditional concrete, SCC doesn't require the use of mechanical vibration to eliminate air voids and ensure proper compaction. It possesses exceptional flow-ability, allowing it to effortlessly fill intricate formwork and reach even densely reinforced areas. SCC's self-consolidating properties not only make construction processes more efficient but also result in smoother and aesthetically pleasing surface finishes. Super-plasticizers play a crucial role in the formulation of Self-Compacting Concrete (SCC), enhancing its unique properties. These high-range water-reducing admixtures are employed to significantly improve the workability and flowability of SCC without compromising its strength or durability. Superplasticizers effectively disperse the cement particles and reduce the water content required for the mix, resulting in a more fluid and self-consolidating mixture. Hence, tests to determine strength are the most common type made to evaluate the properties of hardened concrete, because (a) the strength of concrete. in compression, tension, shear, or a combination of these, has in most cases a direct influence on the load-carrying capacity of both plain and reinforced structures; (b) of all the properties of hardened concrete, those concerning strength usually can be determined most easily; and (c) by means of correlations with other more complicated tests, the results of strength tests can be used as a qualitative indication of other important properties of hardened concrete. The materials that are used in the production of self-compacting concrete are cement, fly ash, fine and coarse aggregate, limestone and super plasticizer.

2. LITERATURE REVIEW

C Chandana Priya et, al; (2020); Has carried out an experimental investigation on replacing cement with higher percentages of fly ash, which is a no cost material and available in abundance. At the same time to achieve higher grade HVFASCC, micro silica which is otherwise condensed silica fume can also be used along with fly ash to enhance the strength properties of HVFASCC. By replacing fly ash in high volumes in the mix, high amount of pozzolanic material becomes available, majorly reactive silica, for which more calcium hydroxide is necessary for further pozzolanic reaction. As we are reducing cement quantity, the amount of calcium hydroxide available is reduced thus demanding external addition of hydrated lime which can be supplied as additive to cater to the need of calcium hydroxide required for reactive silica in fly ash. The present investigation aims to achieve strength for high volume fly ash self-compacting concrete. The replacement of cement with fly ash is made in 45%, 50%, 55%, 60%, 65% and 70% with 20% hydrated lime and 10% silica fume in one trial. In another trial, 30% hydrated lime and 10% silica fume is added with replacement of fly ash to cement varying in same percentages. The design mix is tested for workability and flowability and cubes are casted for compression strength test and tested at 28 day,, 56 day, and 90 day.

Kumar Singh et al (2011): conducted an experimental investigation to predict the flexural capacity of SCC. A constitutive model covering a wide range of concrete strengths was proposed for SCC. The equivalent rectangular stress block specified in current design codes for flexural capacity predictions was developed on the basis of experimental tests. On the basis of the proposed constitutive model for SCC, a new equivalent rectangular stress block valid for concrete strengths of up to 70 MPa is presented for analysis of flexural capacity. The flexural capacity predictions of the proposed stress block were compared with experimental data. They found that the initial tangent modulus of elasticity (E_{it}) values for SCC increased with an increase in crushing strength.

Thomas Silver et al (2003): He explains about high performance characteristic of Chemically Activated Fly Ash (CAFA). CAFA concrete is produced using conventional concrete mixing and forming techniques. He reported that CAFA requires dry curing at elevated temperature of 50 to 93 degree Celsius making it feasible for production of pre-cast concrete products. CAFA concrete has HP properties including rapid strength gain (up to 90.5) of 28 days compressive strength in 24 hours, high ultimate strength (over 124 MPa) and excellent acid resistance. CAFA concrete is resistant to chemical attack such as sulphuric, nitric and hydrochloric and organic acids. They carried out testing for alkali silica reactivity, chloride permeability, and micro structure.

3.MATERIALS AND METHODS

Fly ash: Fly ash is a fine, powdery byproduct produced during the combustion of coal in thermal power plants. It's primarily composed of silica, alumina, and small amounts of iron oxides and other trace elements. Fly ash particles are small and spherical, allowing them to be easily carried away with flue gases and collected using filtration systems like electrostatic precipitators or bag filters. Its Composition are mainly silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), iron oxide (Fe_2O_3), and calcium oxide (CaO), with smaller amounts of magnesium, sulfur, and carbon. The most common use of fly ash is in concrete, where it replaces a portion of cement. It improves workability, strength, and durability, and also reduces the concrete's water demand.

Lime: Lime is a material derived from limestone (calcium carbonate) through a heating process known as calcination. It has been used for centuries in construction, agriculture, and various industrial applications. There are different forms of lime, including quicklime, slaked lime, and hydrated lime, each with unique properties and uses. Slaked lime is used to make mortar for masonry and plaster for walls due to its

Table -1: Chemical composition of Indian fly ash

Chemical composition	Percentage %
Silica (SiO_2)	49-67
Alumina (Al_2O_3)	16-29
Iron Oxide (Fe_2O_3)	4-10
Calcium Oxide (CaO)	1-4
Magnesium Oxide (MgO)	0.2-2
Sulphur (SO_3)	0.1-2
Loss of Ignition	0.5-3.0

4.Tests:

Compressive Strength: The compressive strength test was carried using 2000kN compression testing machine in accordance with BIS (IS: 516-1959). A typical arrangement for compression testing of cubes is present in Fig below.

Fig 1. Compressive Strength Test Machine

Split Tensile Strength

The split tensile strength of concrete was determined after 7 days & 28 days of curing on cylindrical specimens. The cylindrical mould shall be of 150 mm diameter and 300 mm height conforming to BIS (IS:10086-1982), using 2000 KN compression testing machine as per the procedure given in BIS (IS:5816-1999). Therefore, the most commonly used tests for estimating the tensile strength of concrete is the splitting tension test. In the splitting tension test a 150mmx300mm concrete cylinder is subjected to compression loads along to axial lines which are diametrically opposite. The load is applied continuously at a constant rate until the specimen fails. The compression stress produces a transverse tensile stress which is uniform along the vertical diameter. The splitting tension stress is computed by the formula.

$$T=2P/\pi LD$$

Fig 1. Split Tensile Strength Test Machine

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Flexural Strength

The flexural strength test was carried out on a prism specimen of dimension 100mm×100mm×500mm as per IS specification. So, in total forty-two numbers prisms were cast to measure the flexural strength after 28-days. The flexural strength of specimen shall be calculated as:

$$PL / bd^2$$

Where P = load applied on the prism (KN), L = length of the specimen from supports (mm), b = measured width of the specimen (mm), d = measured depth of the specimen (mm).

5.RESULTS AND DISCUSSION

The below results represent the compressive strength test of 7, 14 & 28 days with different percentage of Lime and Fly ash representations in (MPa).

Table.2. Compressive Strength test results in (MPa)

Mixes	7-Day	14-Day	28-days
	compressive	compressive	compressive
Lime % + Fly ASH %	strength (MPa)	strength (MPa)	strength (MPa)
0% L+100%FA	23.45	33.25	52.45
5% L+95%FA	24.85	33.55	53.45
10% L+90%FA	24.15	33.45	54.25
15% L+85%FA	24.95	34.56	53.35
20% L+80%FA	24.25	34.12	53.45
25% L+75%FA	23.45	33.25	52.14
30% L+70%FA	22.21	33.45	51.42
35% L+ 65%FA	22.46	32.25	50.25
40% L+ 60%FA	21.68	32.84	48.67
45% L+ 55%FA	20.44	31.22	48.22

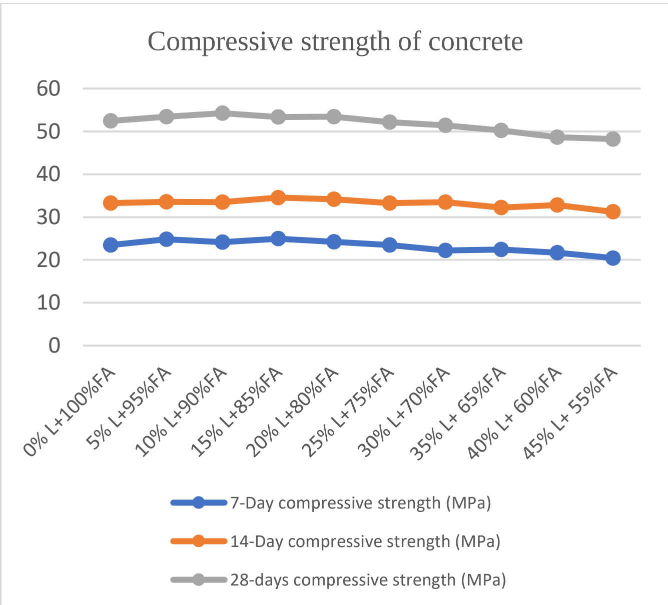
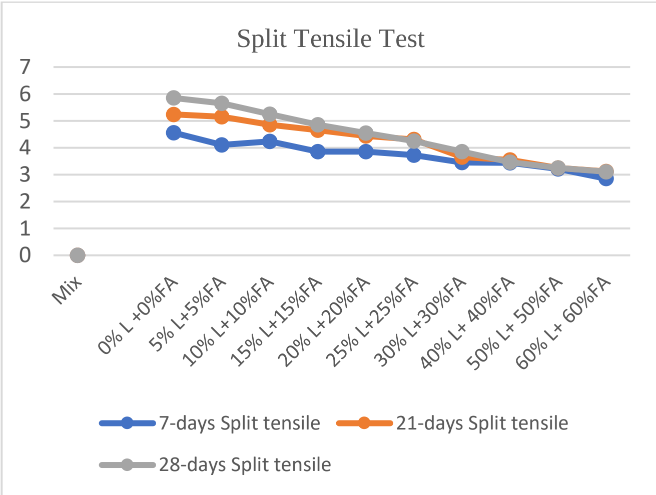


Fig -1: Compressive strength of concrete

Table.4.2 Split tensile strength test results in (MPa)

Mixes: Lime % + Fly ASH %	7-days Split tensile strength (MPa)	21-days Split tensile strength (MPa)	28-days Split tensile strength (MPa)
0% L +0%FA	4.56	5.24	5.85
5% L+5%FA	4.11	5.15	5.65
10% L+10%FA	4.24	4.85	5.25
15% L+15%FA	3.85	4.65	4.85
20% L+20%FA	3.85	4.44	4.55
25% L+25%FA	3.72	4.31	4.25
30% L+30%FA	3.45	3.65	3.85
40% L+ 40%FA	3.44	3.54	3.46
50% L+ 50%FA	3.21	3.25	3.25
60% L+ 60%FA	2.85	3.12	3.11



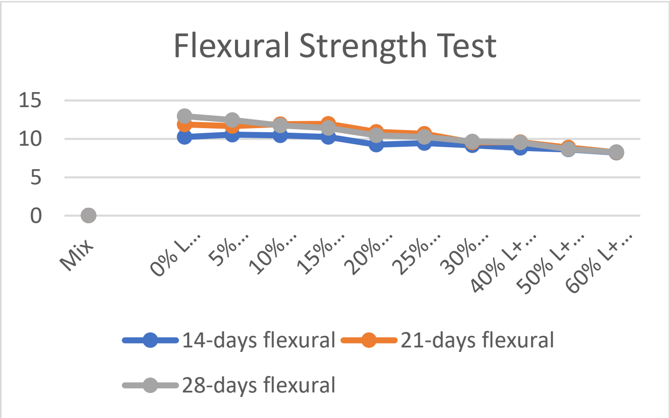
Graph 4.2 Split tensile strength test results in (MPa)

From table no 2. The results show that there is a marginal increase in strength from 7 to 28 days the compressive strength for 5% addition of L+FA, while compressive strength increases at all ages for up to 15 % addition of Lime content as compared to control specimen. However, the compressive strength start decreasing as the increment of L+FA in concrete percentage which varies from 24.95 to 20.44 at (45% L+ 55%FA) it was found the lowest strength. Similarly

The split tensile strength of concrete gets decreases with respect to control mix at 0% and 55% of L+FA content. Other percentages of fiber show a reduction in the split tensile strength with reference to control mix.

Table.4.3 Flexural Strength Test Results in (MPa)

Mixes Lime % + Fly ASH %	14-days flexural strength (MPa)	21-days flexural strength (MPa)	28-days flexural strength (MPa)
0% L +0%FA	10.24	11.85	12.95
5% L+5%FA	10.55	11.65	12.45
10% L+10%FA	10.46	11.91	11.75
15% L+15%FA	10.22	11.95	11.42
20% L+20%FA	9.25	10.92	10.45
25% L+25%FA	9.45	10.65	10.25
30% L+30%FA	9.15	9.54	9.65
40% L+ 40%FA	8.84	9.58	9.54
50% L+ 50%FA	8.63	8.86	8.65
60% L+ 60%FA	8.21	8.24	8.26



Graph 4.3 Flexural strength test results in (MPa)

6. CONCLUSIONS

The concrete specimens were made out of conventional SCC, SCC with Fly ash, lime stone and sugarcane bagasse as partial replacement to cement. And based on compressive strength for 7 days and 28 days results optimization of SCC was done It is observed that as the lime content increasing the strength is also increasing but amount of increase in strength from 3 % to 5% is more and from 10 % to 15% is less. Addition of lime in excess to fly ash may not be beneficial. As the curing period increases the strength also increases. But increase in strength from 7 days to 14 days curing is more than from 14 days to 28 days curing. Up to certain days of curing there will be no more increase in strength. Based upon data recorded, it can be concluded that specimen containing fly ash with and lime with appropriate proportion of certain additives can be proportioned to meet the strength and workability requirement for structural grade concretes and Geotechnical application.
After conducting all the experiments related to strength development of fly ash based composite materials the following are the factors that affect Strength Gain of Lime- -Fly ash composite material:
Fly ash type (classification, particle size and distribution, etc.), Types of stabilization agents, Preparation of sample, Sample size (mould size) and Curing time.

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BIOGRAPHIES

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