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Experimental Study on Strength Properties of Triple Blended Self-Compacting Concrete

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Abstract

Self-compacting concrete (SCC) is a flowing concrete mixture that can self-consolidate under its own weight, and it is one of the most significant advancements in concrete technology in the recent decade. SCC's very fluid character makes it ideal for use in challenging situations and in sections with crowded reinforcing. SCC, which was initially created in the late 1980s, has since expanded around the world, with an ever-growing variety of applications. Because of its unique features, SCC has the potential to significantly improve the quality of concrete buildings while also opening up new areas for concrete use. The addition of treated and untreated industrial byproducts, raw materials, and home wastes to SCC is becoming increasingly popular as a way to make it more durable and cost effective. This not only allows waste materials to be reused, but it also results in a eco-friendly environment. The Strength Characteristics of Self-Compacting Concrete were determined by an experimental investigation (SCC). The goal of this research is to see how Fly Ash (FA), Ground Granulated Blast Furnace Slag (GGBS), and Silica Fume (SF) can be used as cement substitutes and what influence they have on the fresh and hardened qualities of concrete. The investigation involves the notion of using a triple blend of Fly ash, GGBS, and Silica Fume to produce better concrete. This triple blend takes use of the favorable properties of Pozzolanic materials.

Keywords: *Fly ash, GGBS, Silica Fume, Self-Compacting Concrete, Triple blend*

1. Introduction

Chronic Along with its self-compacting properties and added strength benefits, self-compacting concrete (SCC) is one of the most often utilized concrete varieties. The concrete should be robust and adequately compacted, regardless of the kind of building construction. Compaction improves not just the structure's strength but also the end product's polish and appearance. Self-compacting concrete is an elevated concrete that can fill the formwork entirely to its own mass and self-consolidate without mechanical vibrations. The self-compacting ability of the concrete allows it to entirely strengthen the steel structure and totally fill the voids inside the framework once it has been placed. Self-compaction of concrete is achieved without any loss of strength, stability, or property change. Cement is the most significant component in Scc. This raw material's manufacturing process emits a significant amount of carbon dioxide. Cement production produces roughly 1.35 billion tons of emissions into the atmosphere each year, according to the report. CO2 emissions from cement manufacturing are expected to increase by nearly 50% by 2020, compared to present levels. Researchers are now working to reduce CO2 emissions from industry. The most efficient strategy to reduce CO2 emissions from the cement business is to replace alternative materials for a part of the cement. Fly Ash (FA), GGBS, and Silica Fume (SF), as well as Metakaolin, are often used supplemental cementing ingredients. By products are a green way to dispose of enormous amounts of materials that might otherwise damage land, water, and air. FA, GGBS, and SF are used to make a triple blended self-compacting concrete in this study.

Scope of the study

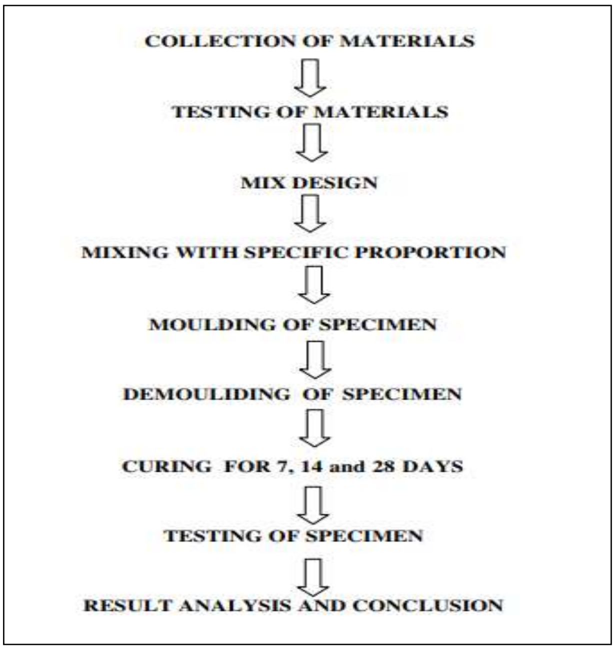
The study's major goal is to investigate the strength of SCCs made from industrial wastes such as FA, GGBS, and SF as a replacement for cement. The manufacturing of cement can be decreased, due to this cement substitution in concrete, resulting in less pollution. The SCC is a novel concrete technique beneath the bulk of its flow to entirely fill and consolidate crowded reinforcement without the use of external methods. SCC can manufacture an environmentally friendly concrete by using these industrial waste resources.

Objectives

- The major goal of this research is to look at the effects of replacing cement with FA, GGBS, and SF in a systematic way.
- Slump cone, U box test, L box test, and V funnel test were used to assess the workability of triple mixed Self Compacting Concrete.
- Compressive strength, Split Tensile strength, and Flexural strength of triple blended Self Compacting Concrete were investigated.

Fly Ash, GGBS, and Silica Fume are replaced partially by cement in 0 percent, 15 percent, 25 percent, 45 percent, and 65 percent of the research.

2. Materials And Methods



The different materials used in this investigation are

- Cement
- Fine aggregate
- Coarse aggregate
- Fly Ash
- Ground Granulated Blast Furnace Slag
- Silica Fume
- Super plasticizer (Conplast SP 430)
- Portable Water

Fly Ash:

After burning coal, fly ash is a dark grey powder. Fly ash is created when powder coal is burned in a thermal power station. Fly ash has a variety of physical and chemical characteristics.

Table .1 Chemical Characteristics of FlyAsh

S.No	Content	Percentage %
1	$SiO_2+Al_2O_3+Fe_2O_3$	90.5
2	SiO_2	58
3	CaO	3.6
4	SO_3	1.8
5	Na_2O	2
6	L.O.I	2
7	MgO	1.91

Ground Granulated Blast Furnace Slag (Ggbs)

GGBSslag, or blast furnace slag, is a nonmetals powder composed up of silicates, aluminates, calcium, and other bases. GGBS has the following physical and chemical properties:

Table .2 Chemical Characteristics of GGBS

S.No	Content	Percentage %
1	Magnesia	7.73
2	Sulphide Sulphur	0.50
3	Sulphite	0.38
4	Loss Of Ignition	0.26
5	Manganese	0.12
6	Chloride	0.009
7	Glass	91
8	Moisture Content	0.10

Silica Fume:

Another substance utilized as a Pozzolanic additive is silica fumes, also known as micro silica or condensed silica fume. The physical characteristics of silica fume are as follows:

Table .3 Chemical Characteristics of Silica Fume

S.No	Content	Percentage %
1	SiO2	90.20
2	Al_2O_3	0.82
3	Fe_2O_3	1.67
4	CaO	1.27
5	SO_3	1.40
6	K_2O	4.02
7	LOI	2.4

Design Mix:

Water	:	Cement	:	FA	:	CA	:	SP
180	:	530	:	941	:	736	:	9
0.34	:	1	:	1.77	:	1.38	:	0.016

Fresh Properties

Fresh properties tests, such as slump flow, T50 slump flow in sec, U – box test, V – funnel test, and L box test, were carried out, and the findings are listed below.

Table .4 Workability of Fresh Concrete

TEST METHODS	SCC 1	SCC 2	SCC 3	SCC 4	SCC 5
Slump flow mm	655	660	680	670	650
T_{50} cm Slump flow Sec	3.6	4.4	4	4.5	4.7
V – funnel test Sec	6	6.2	6.4	7.2	10.6
V – funnel test at T_5 min Sec	2.2	2.3	2.4	2.8	3
U – box test mm	20	25	22	26	30
L – box test mm	0.92	0.90	0.91	0.87	0.85

Fig.1 – L-box Test

Hardened Properties

Compression test with compression testing machine, split tensile test with compression testing machine, and flexural test with ultimate testing machine are some of the toughened property tests that are carried out. The findings for the different triple blended SCC mixes with 0, 15%, 25%, 45, and 65 percent cement substitution by fly ash, GGBS, and silica fume were obtained.

Compressive Strength Test

Concrete's compressive strength is one of its most essential characteristics. Compressive strength of concrete has a direct link with all other qualities, i.e., these qualities improve as compression strength improves. The goal of this experimental test is to ascertain the test specimens' maximum load bearing capability. The cube test specimens are 150x150x150mm in size. A compression testing equipment was used to put the specimens through their paces (CTM). The specimen was positioned on the machine in such a way that it was at right angles to its original position at the time of casting. The load is gradually delivered at a rate of 14 N/mm2/min (320 kN/min).

Table. 5 Compressive Strength for 7, 14 and 28 days

MIX	7 day (MPa)	14 day(MPa)	28 day(MPa)
SCC 1	19.38	22.83	30.22
SCC2	21.05	27.13	34.76
SCC3	24.54	30.11	39.17
SCC4	22.35	26.72	37.40
SCC 5	18.44	24.56	33.56

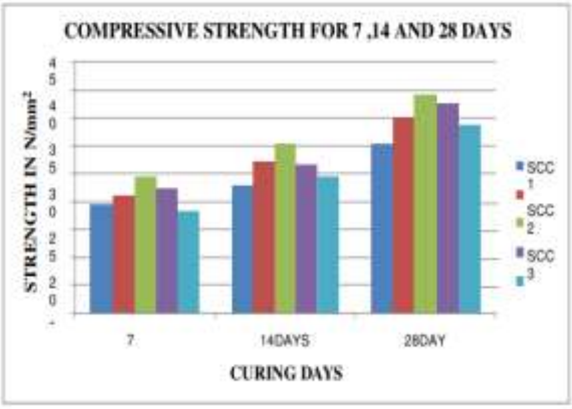


Fig 2- Compressive Strength of Concrete

The compressive strength for 7, 14, and 28 days for SCC mixes can be seen in the graph, and the strength decreases as the cement replacement increases. For SCC 3 mix, the strength grows to 39.17 MPa for 28 days, then decreases as the replacement rises.

Split Tensile Strength Test

The fundamental features of concrete are its tensile strength. Because of its fragility and poor strength properties, concrete is not normally expected to withstand direct tension. The tensile strength of concrete, must be determined in order to establish the load at which the concrete members break. Tensile failure manifests itself in the form of cracking. The purpose of this experimental test is to ascertain the test specimens' maximum load bearing capability. Split tensile tests were performed with a diameter of 150 mm and a height of 300 mm. it is an indirect method of assessing concrete tensile strength. Split tensile strength of concrete is a term that is occasionally used to describe them. The load on the specimen was raised until it failed, and the highest load applied on the specimen throughout the test was recorded. The final split tensile strength value is calculated using the mean of the three specimens of each Kind.

Table 6. Split Tensile Strength for 7, 14 and 28 days

MIX	7 day (MPa)	14 day(MPa)	28 day(MPa)
SCC 1	1.92	2.75	3.20
SCC2	2.19	2.87	3.48
SCC3	2.44	3.30	3.82
SCC4	2.16	2.71	3.37
SCC 5	1.88	2.50	3.03

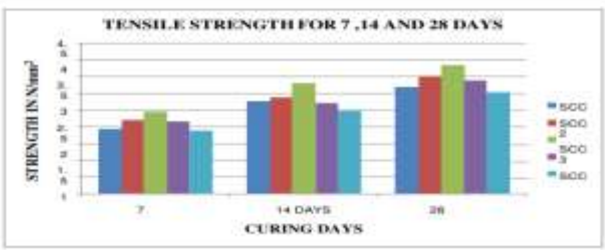
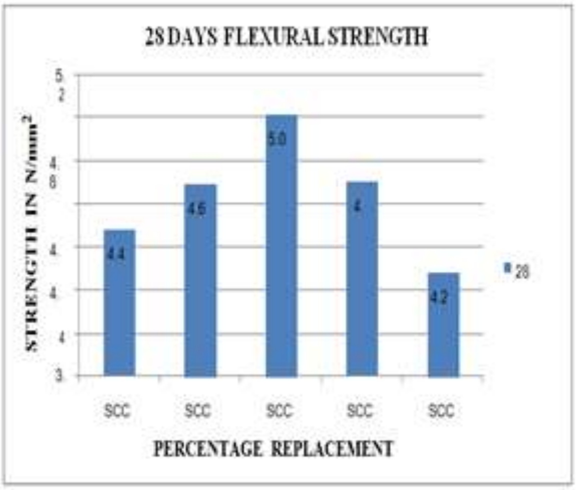


Fig 3- Split Tensile Strength of Concret

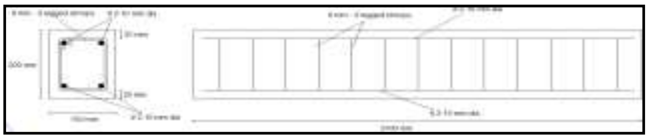
Flexural Strength Test

The primary purpose of this experiment is to determine how much weight prism specimens can support. The specimen is loaded in two spots, and the load at which the specimen fails is recorded. Prisms measuring 100 x 100 x 500 mm were produced. These specimens were put through their paces on a universal testing machine (UTM). The major value of each type's specimen is used as the final flexure value. The rupture modules are used to express the specimen's flexing strength.



Reinforcement Details of Beam

The specimens were 150mm x 200mm x 2100mm beams reinforced with two 10mm diameter HYSD bars in the bottom and two 10mm diameter HYSD bars in the top as hanger rods. Shear reinforcements in the form of 8mm diameter mild steel bar two legged stirrups at 120 mm center to center were also added to the specimen. The specifics of the reinforcement were displayed.



Load vs Delection Behaviour

All beams' load deflection history was documented. The partial replacement of cement with a mix of 10% FA, 10% GGBS, and 5% SF functioned better than any other combinations. It was discovered that replacing 25% of the cement with mineral admixtures increases the beam's performance when compared to a typical SCC beam.

Fig 5- Load –Deflection Test

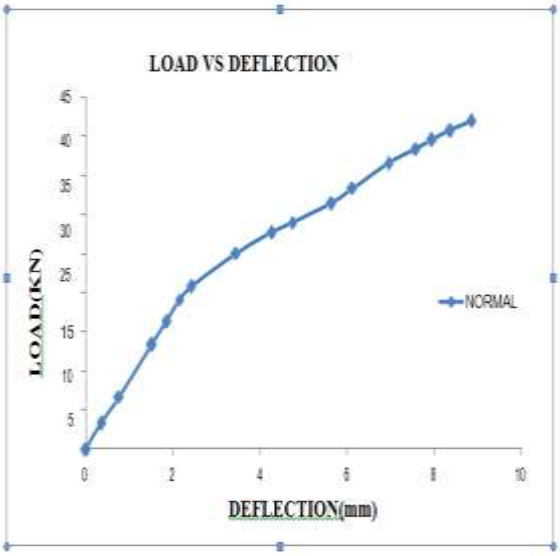


Fig 5- Load –Deflection Test for Normal Concrete

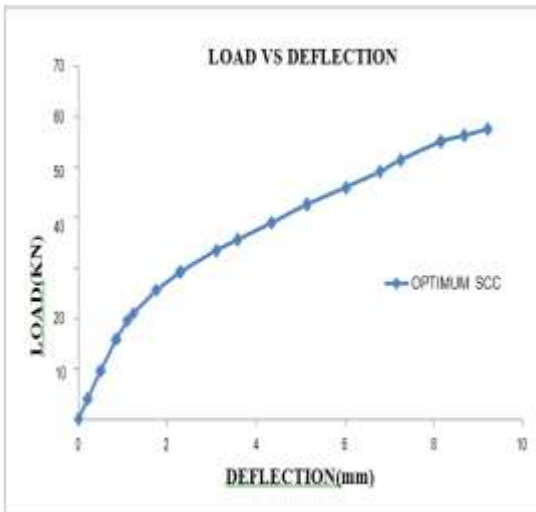


Fig 6- Load –Deflection Test for SCC

First Crack Load and Deflection

All of the beam specimens were subjected to a static load. The dial gauge was used to measure the load deflection at the midpoint. The difference between the initial crack load and the ultimate load Normal SCC and optimal SCC mix first crack loads were 20.8 KN and 33.5 KN, respectively. The influence of the Fly ash GGBS and silica fume, which raise the first crack load and prevent their propagation, causes the optimum SCC to exhibit a 61 percent increase in first crack load.

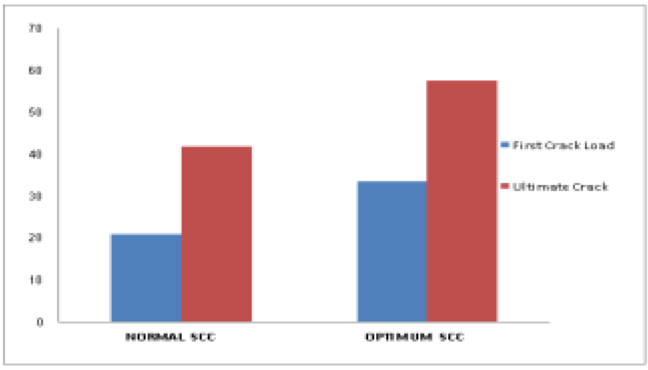


Fig 7- Comparison of Normal and Optimum SCC

The normal SCC and optimal SCC of the beams have ultimate load bearing capacities of 42 and 57.5 KN, respectively. When compared to the typical SCC, there is a 36.9% increase in ultimate load. The relevance of utilizing FA, GGBS, and SF in concrete to achieve ductile rather than brittle failure of the specimens, with all specimens failing in a ductile way. There was no shear failure in any of the beams that failed in flexural mode.

4. Conclusion

It The following conclusions were drawn based on the experimental investigation of Triple Blended Self Compacting Concrete:

The workability of concrete was increased with the addition of FA, GGBS, and SF as a replacement for cement, and it met the acceptance criteria for self-compacting concrete; also, the addition of super plasticizers made the resulting concrete more pliable.

- Compressive strength, flexural strength, and split tensile strength have all been boosted by up to 25% by replacing cement with 10% fly ash, 10% GGBS, and 5% silica fume.
- Beyond the substitution of 10% Fly Ash, GGBS, and 5% Silica Fume in cement, the strength properties and workability were reduced.
- According to studies, flyash, silica fume, and GGBS, as well as chemical admixtures, have an excellent compatibility.
- When optimal SCC beams containing 10% Fly Ash, GGBS, and 5% Silica Fume were compared to normal SCC beams, the increase in first crack load was seen.
- It was revealed that the ultimate load bearing capacity of optimal SCC beams is 1.37 times that of conventional SCC beams.
- The cement content of triple blended self-compacting concrete is reduced, and industrial byproducts are used. As a result, it decreases pollutants and maintains an environmentally friendly concrete.

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