# An Experimental Study on Self Compacting Geopolymer Concrete

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**Abstract— Self-compacting geopolymer concrete (SCGC) holds promise as an eco-friendly and high - performance construction material with the potential to contribute to sustainable development. Self-compacting geopolymer concrete is a type of concrete that two innovative technologies. It is designed to have high followability and the ability to fill intricate and congested reinforcement within the need for external vibration or compaction. The constituents of SCGC are activated with various molarities of alkaline solution containing sodium hydroxide (NaOH) and sodium silicate (Na2SiO3) Ground granulated blast furnace slag, fly ash and superplasticizer. M30 grade concrete was prepared using trial and error process. Workability tests like slump flow, L-Box Test, U- Box Test and V- funnel tests are conducted to assess fresh properties of SCGC. Mechanical properties such as Cube compressive strength, splitting tensile strength test evaluated. The comparison was established by preparing normal SCC and to test parametrically with superior properties of SCGC towards SCC.**

**Key words: SGCC, SCC, sodium hydroxide (NaOH), sodium silicate (Na2SiO3), fine aggregate, coarse aggregate, cement, superplasticizer.**

## I. INTRODUCTION

Self-compacting geopolymer concrete (SCGC) is a type of concrete that combines the principles of self-compacting concrete (SCC) with the use of geopolymer binders. Geopolymer binders are alternative cementitious materials that can be used as a replacement for Portland cement in concrete production. Self-compacting concrete (SCC) is a type of concrete that has the ability to flow and compact itself into the desired shape without the need for mechanical vibration or excessive external forces. It is also known as self-consolidating concrete. Self-compacting concrete, on the other hand, is a highly fluid and workable concrete that can flow and fill in confined spaces under its own weight. It is achieved by optimizing the mix design with a combination of high-range water reducers, viscosity-modifying agents, and stabilizers. Geopolymer concrete is an eco-friendly alternative to conventional Portland cement - based concrete.it is made by activating natural or industrial by-products rich in silica and alumina with alkaline solutions, resulting in a binder that hardens and gains strength.

## II. MATERIALS PROPERTIES

A. FLY ASH: Low calcium fly ash (Class F) is one of the deposits produced in the burning of coal. In this work, Class F fly ash is to be used which was collected from Mettur Thermal Power Station, Salem. Generally, Class F fly ash providesgood pozzolanic activity and it contains less than 10% of lime (CaO).

Table. 1 Properties of fly ash

| DESCRIPTION | VALUE |
|---|---|
| CONSISTENCY | 28% |
| INTIALSETTING TIME | 40min |
| FINENESS | 5% |
| SPECIFIC GRAVITY | 2.36 |

B. GGBS: Ground Granulated Blast Furnace Slag which is a by-product of iron manufacturing industry is an accepted mineral admixture for use in concrete. This granulated material when further ground to less than 45micron is called Ground Granulated Blast Furnace Slag (GGBS).

Table.2 Properties of GGBS

| DESCRIPTION | VALUE |
|---|---|
| CONSISTENCY | 32% |
| INTIALSETTING TIME | 50min |
| FINENESS | 6% |
| SPECIFIC GRAVITY | 2.45 |

C. CEMENT: Ordinary Portland cement either grade cement can be used. It has great resistance to cracking

and shrinkage but has less resistance to chemical attacks. It is manufactured with excellent quality clinker, containing high percentage (56-60%) of Tri-calcium Silicate (C3S), and optimum quantity of gypsum.

Table.3 Properties of cement

| DESCRIPTION | VALUE |
|---|---|
| CONSISTENCY | 34% |
| INTIALSETTING TIME | 36min |
| FINENESS | 4% |
| SPECIFIC GRAVITY | 3.15 |
| FINAL SETTING TIME | 415min |

D.FINE AGGREGATE: The fine aggregates used in SCCcan be either natural aggregates or manufactured aggregates (M- Sand) with a uniform grade. The fine aggregates with particle size less than 0.125mm are generally employed.

Table.4 Properties of FA

| DESCRIPTION | VALUE |
|---|---|
| BULK DENSITY | 1633.5 kg/m3 |
| WATER ABSORPTION | 1.4% |
| FINENESS | 10% |
| SPECIFIC GRAVITY | 2.73 |

E. COARSE AGGREGATE: The size of the aggregates used for SCC design is limited to 20mm. If the reinforcement employed for the structure is congested, the aggregatesize used can be in the range 10 to 12mm. Well graded aggregates either round or cubical shape are a best choice. The Coarse aggregate used was 12.5 mm size crushed granite stone.

Table.5 Properties of CA

| DESCRIPTION | VALUE |
|---|---|
| BULK DENSITY | 1555.3 kg/m3 |
| WATER ABSORPTION | 0.6% |
| IMPACT VALUE | 12.5% |
| SPECIFIC GRAVITY | 2.56 |
| CRUSHING VALUE | 19.3% |

## III MIX PROPOTION

| | |
|---|---|
| CEMENT | = 520Kg /m3 |
| FINE AGGREGATE | = 960Kg/m3 |
| COARSE AGGREGATE | = 821 Kg/m3 |
| SUPERPLASTICIZER | = 8.32Kg/m3 |
| WATER | = 188Kg/m3 |
| FLY ASH | = 500Kg/m3 |
| NaOH | = 83Kg/m3 |
| Na2sio3 SOLUTION | =167Kg/m3 |

## IV WORKABILITY TEST

TESTING FOR FRESH PROPERTIES OF SCC AND SCGC

A. SLUMP FLOE TEST: The test can be done in the site with specific specifications like the level ground, the test pieces of equipment are Mold, plate, trowel, scoop, ruler, and stopwatch. The procedure of the test done by the following steps, firstly make sure about the smooth of the cone and the plate or surface then put the cone to the downside and fill it with concrete without tamping. Then remove the cone in the vertical side to allow the concrete flow as a form of a circle. Calculate the diameter of the concrete in the vertical direction by taking the measured average of two diameters, the average number will be the slump flow in mm.

Figure 1 Slump Flow Test


Table 6 Results of Slump Flow Test

| TYPE OF CONCRETE | VALUE |
|---|---|
| SCC | 700mm |
| SCGC | 690mm |

**B. V-FUNNEL TEST:** Test designed to evaluate the flowability of the concrete by use of the V-shaped funnel, test also designed to evaluate segregation to the resistance. Test pieces of equipment include the following bucket, trowel, scoop and stopwatch. The test procedure done by the following steps, fill the funnel with 12 litters of concrete without being compacted with closing the door of the funnel. Bucket must be readyand placed under the funnel door, then open the door and calculate the period of the discharge. Flow time indicates flowability and if there is segregation in the concrete, the time of flow will increase.

Figure 2 V- funnel Test

Table 7 Results of V-Funnel Test

| TYPE OF CONCRETE | VALUE |
|---|---|
| SCC | 11sec |
| SCGC | 8sec |

**C.L-BOX TEST:** The test assesses the flow of the concrete and also the extent to which it is subjected to blocking by reinforcement. The L-Box test to BS EN 12350-10 is used to assess the passing ability of self-compacting concrete to flow through tight obstructions without segregation or blocking. Used for determining the passing ratio of self- compacting concrete. The apparatus consists of a L shaped stainless steel frame, supplied complete with filling hopper.

Figure 3 L- box Test


Table 8 Results of L-box test

| TYPE OF CONCRETE | VALUE |
|---|---|
| SCC | 0.87 |
| SCGC | 0.82 |

D.U-BOX TEST: Test used for the sake of filing ability of the SCC and it can be called with another name like the box-shaped test, it is developed and created in Japan. The problem of this test is hard to construct it but there is an advantage of this test is giving a direct assessment of the filing ability. The main pieces of equipment of this test are the following, U box,and stopwatch. The test can be done by the following steps, place the machine of test on the ground and fill it with 20 litters of concrete and leave it for 1 minute. After that open the gate of the machine test and leave the concrete flowing to another box. Then calculate the height of the concrete from different two positions and measure their mean.

Figure 4 U-box Test

Table 9 Results of U-box test

| TYPE OF CONCRETE | VALUE |
|---|---|
| SCC | 26mm |
| SCGC | 18mm |

## V EXPERIMENTAL INVESTIGATION

TESTING FOR HARDENED PROPERTIES OF SCC AND SCGC

A. COMPRESSIVE STRENGTH TEST

The test specimens were cast in the steel moulds, the inside of the moulds was supplied with oil to facilitate the easy removal of specimens. The size of the cube specimen is 100mmx100mm and for the cylinder 100mm diameter 200mm height and Required amount of NaOH solution is mixed and kept separately for 24 hours. Likewise, sodium silicate solution is prepared and kept separately for 24 hours. Both sodium hydroxide and sodium silicate are mixed together and kept for 24 hours before casting the specimens. Now calculated amount of fly ash with coarse aggregate ad fine aggregate are mixed together. Now the combined solution of sodium hydroxide and sodium silicate and superplasticizer is gently poured to the mixer and mixed for 2 minutes to get self-compacting geopolymer concrete.

B. SPLIT TENSILE STRENGTH TEST

This method consists of applying a diametric compressive force along thelength of the cylindrical specimen. This loading induces tensile stresses on the plane containing the applied load. Tensile failure occurs rather than compressive failure. Plywood strips are used so that load is applied uniformly along thelength of the cylinder. The maximum load is divided by appropriate geometrical factors to obtain the splitting tensile strength.

Test has been conducted on the specimen of size 100 mm in diameter and200mm in length after the curing period of 28 days and 56 days.

## VI. RESULTS AND DISCUSSION

TABLE 10 COMPRESSIVE STRENGTH TEST RESULTS FOR SCC AND SCGC

| TYPE OF CONCRETE | COMP STRENGTH 7days | COMP STRENGTH 28 days |
|---|---|---|
| SCC | 20.6 | 31 |
| SCGC | 28.5 | 36 |

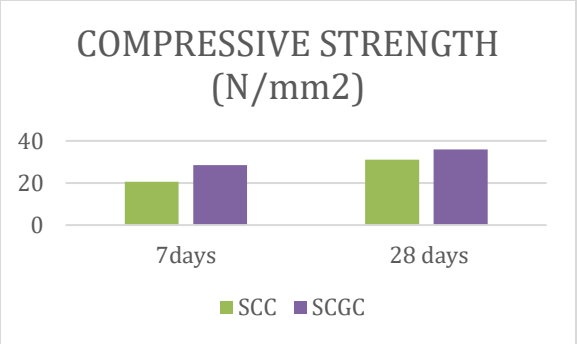


FIG 5 COMPRESSIVE STRENGTH TEST RESULTS FOR SCC AND SCGC

TABLE 11 SPLIT TENSILE STRENGTH TEST RESULTS FOR SCC AND SCGC

| TYPE OF CONCRETE | SPLIT TENSILE STRENGTH 7days | SPLIT TENSILE STRENGTH 28days |
|---|---|---|
| SCC | 2.3 | 3.4 |
| SCGC | 2.9 | 3.8 |

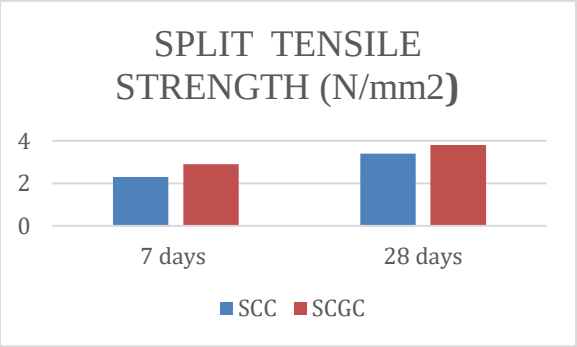


FIG 6 SPLIT STRENGTH TEST RESULTS FOR SCC AND SCGC

## VII. CONCLUSION

- The properties can be enhanced in self-compacting geopolymer concrete comparison with self-compacting concrete.
- The segregation and bleeding of self-compacting geopolymer concrete were checked using slump flow test, L- box test, U-box test, and V-funnel test are according to the guidelines of EFNARC.
- The effects of several properties, specifically compressive and split tensile strength for proposed SCGC with SCC has experimented.
- The proposed SCGC and SCC (12M) has analyzed for compressive strength (7 and 28) and split tensile strength (7 and 28 days).
- The compressive strength of SCC increased by 18% when compared to SCGC at 28 days.
- The split tensile strength of SCC increased by 12% when compared to SCGC at 28 days.
- The analyzed mechanical properties of proposed SCGC results were compared with SCC.

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