

Experimental Investigation on Mechanical Properties of Self Compacting Geo Polymer Concrete

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Abstract— Self Compacting Geo polymer Concrete (SCGC) is an innovative concrete. It is an environment friendly concrete which reduces emission of CO₂ compared to that conventional concrete. Just like self compacting concrete, Self Compacting Geo polymer Concrete also does not require vibration for placing and compaction. It can be mainly used in prefabricated structure which is now becoming the advance method for construction. This paper presents an experimental investigation on mechanical properties of Self Compacting Geo polymer Concrete. Mechanical properties of Self Compacting Geo polymer Concrete especially Compressive Strength Test, Split Tensile Test and Flexural Strength Test are discussed in this paper. Each test was carried out at the ages of 7, 21, 28 days. It is found that Autoclaved Self Compacting Geo polymer Concrete has high strength and very low drying shrinkage. Self Compacting Geo polymer Concrete test results were compared with the conventional Self Compacting Concrete (SCC) also.

I. INTRODUCTION

Concrete is a composite material and it is the essential building element for modern developing society. Cement is actually just a part of concrete. Cement is mainly used as a binder in concrete but is not an environmentally friendly material. SiO₂, Al₂O₃, Fe₂O₃ and occasionally CaO₂ are the main chemical components present in fly ash. Fly ash is a by product of combustion of coal and disposed in an environmentally friendly manner. Fly ash generated each year were used in producing concrete because the reduction of CO₂ emission. Proper thermal curing of Geo polymer concrete reduces the porosity and sorptivity coefficient [3]. Geo polymer is an inorganic material. Geo polymer was formed by alkaline activity of silica and alumina by the process called poly condensation.

Self Compacting Geo polymer Concrete can be considered as an advanced and innovative concrete and it can be useful for prefabricated structures. Fly ash with alkaline solution and super plasticizer (SP) provides binder for matrix formation and strength. Self Compacting Concrete does not need any compaction and it is a non segregating concrete that placed by means of its own weight. Self Compacting Concrete produces a uniform surface and fast placement without vibration or mechanical compaction. According to Dhiyaneshwaran, S [6] the mechanical properties (Compressive, split tensile and flexural strength) of SCC have higher Compressive strength has been obtained by fly ash

replacement compressive strength loss decreases with the increase in fly ash in concrete.

Self Compacting Geo polymer Concrete has been used for construction of pavements, retaining wall, water tanks and precast bridge decks. Self Compacting Geo polymer Concrete has rapid strength gain in short period. It also cures very quickly, making it an excellent option for quick builds. According to Ashraf Mohamad Henigal [1] Use of fly ash based Self Compacting Geo polymer Concrete as an alternative binder can help to reduce CO₂ emission of concretes compared to Ordinary Portland Cement.

Larger curing time between 24 to 72 hours at a temperature of 70°C enhances the geo polymerization procedure bringing about higher compressive strength at early ages. Heat cured SCGC undergoes very low drying shrinkage compared to that of SCC with OPC. The permeability and water absorption of the hardened SCGC decrease with the increase in Compressive Strength of the SCGC.

II. METHODOLOGY

2.1-Materials:

Materials that is required for this experiment was selected according to the specifications. River sand of grading zone II was chosen as specified by IS: 383-1970. The specific gravity of fine aggregate was 2.6. The nominal size of coarse aggregate was 12.5mm. The specific gravity of coarse aggregate was 2.66. The size of coarse aggregate used in Self Compacting Concrete (SCC) should be lower than conventional concrete to facilitate the easy flow ability in congested in congested reinforcement OPC was used for conventional SCC with specific gravity 3.15. The fly ash required for this experiment is obtained from thermal power plant. Class F fly ash with specific gravity 2.3. To reduce the water content super plasticizer (high range water reducer) was used. Sika viscocrete of dosage as prescribed in the container was chosen. Alkali activating solution for Geo polymer Concrete was prepared by mixing Sodium Silicate solution (Na₂SiO₃) and Sodium Hydroxide (NaOH). Sodium Hydroxide solution was prepared at molarity 12M and it was prepared by mixing Sodium Hydroxide pellets with distilled water. This solution is kept for 24 hours before casting to eliminate the effect of heat liberated during mixing.

2.2-Mix proportion:

For casting Self Compacting Concrete the minimum cement content was 320kg/m³ and water cement ratio was chosen as 0.36. For good workability 30/- of fly ash was replaced for cement. These are designed to obtain M40 grade concrete. To make a required concentrated solution, the solid should be dissolved in water. These are different molarity in preparing Sodium Hydroxide solution such as 8M, 10M, 12M and 14M. For 1M solution 40grams of NaOH solid is dissolved in distilled water. Here, 12M solution 480grams of NaOH solids per one litre was dissolved.

2.3-Mixing:

2.3.1-Self Compacting Concrete:

The materials such as cement, fine aggregate, coarse aggregate, fly ash was measured and placed in mixing pan. The materials were dry mixed. Then the mixture of super plasticizer and water was added to dry mix and mixed manually. The mixing was done equally.

2.3.2-Self Compacting Geo polymer Concrete:

The powdered materials such as fly ash and fine aggregate were first mixed manually in mixing pan. Then, the coarse aggregate was placed and whole mixture was mixed for about 2 to 3 minutes. After finishing dry mix the prepared solution containing alkaline solution, super plasticizer and extra water was added to the dry mix. This mixer was mixed for three minutes continuously to mix equally. Then the freshly mixed concrete was assessed for workability tests like L-box, U-funnel, slump cone test.

2.4-Casting:

Harden concrete test such as Compressive test, Split tensile test, Flexural test was carried out. For Compressive strength test, cubes of sizes 150mm x 150mm x 150mm were casted. To carry out Split tensile strength test, cylinder of sizes 150mm x 300mm was casted. The prisms of sizes 100mm x 100mm x 750mm was used to carry out the flexural strength. For each test 3 specimens were casted to test the specimen in 7days, 21days and 28days. Before casting the fresh concrete test, to calculate the workability and flow ability was done. To find flow ability and workability of fresh concrete, L-box, Slump cone, V-funnel, J-ring, flow table, vee bee consistometer test was carried out. These fresh concrete tests were carried out to find the filling ability and passing ability of freshly prepared concrete. During Slump cone test, Slump flow time (T50) was measured. The time taken by the concrete to reach 50cm of flow was noted. After all tests had been completed the concrete was casted.

2.5-Test on fresh concrete

2.5.1-Slump cone test

The slump cone apparatus is a cone shaped mould. The mould should be cleaned. The mould is placed smoothly at a levelled surface and concrete is poured into the mould. After the mould was filled with concrete the mould is removed from the concrete immediately by raising it in a vertical direction. The concrete starts to slide down. For SSC concrete the slump value is zero in vertical direction. So for SCC diameter was measured.



Fig 1: Slump cone apparatus

2.5.2-Flow table test

The apparatus consists of flow table of 76 cm diameter having concentric circles on it. It consists of a mould of frustum in shape open at top and bottom having base diameter as 25 cm and bottom diameter as 17 cm. The table and mould is cleaned and the mould is placed at the centre of the table. Then, the concrete is filled firmly into the mould. After the mould is filled with concrete the mould is removed in a vertical manner. Then table is lifted up and down for 15 seconds. The diameter of spreading of concrete is measured in 6 directions. The flow percentage is calculated according to the suitable formula.



Fig 2: Flow table apparatus

2.5.3-Vee Bee consistometer

The apparatus consists of vibrator table, steel cylinder, slump cone, stop watch to note the time and a glass disc. First the apparatus are cleaned well. Then the slump cone is placed into the steel cylinder. The slump cone is filled with concrete and the mould is raised vertically and removed. The arm consisting of glass disc is turned and placed on the top surface of the concrete. The vibrator is switched on and the stop clock is switched simultaneously. The vibration is continued till the concrete in the cylinder disappears and the concrete resembles the cylindrical shape. After the concrete obtained the cylindrical shape the vibrator and the stop watch is stopped simultaneously. The average time taken was calculated.



Fig 3: Vee Bee consistometer

2.5.4-J- ring test

The test apparatus consists of J-ring, slump cone. This should be performed in a flat surface. The bottom base is placed in the flat surface and J ring is rested at the centre of the base plate. Then the slump cone mould is placed on the base plate with small diameter opening at bottom. The concrete is filled in the slump cone and after filling it is raised in vertical manner. Then wait until the concrete reaches larger diameter which is d_1 . Measure the diameter d_2 at the direction perpendicular to d_1 . Then the J-ring flow is calculated by necessary formula.



Fig 4: J-ring apparatus

2.5.5-L box test

The procedure is as follows. The L-box is placed in a levelled surface. Then, fill the concrete in the upper portion of the box and leave the concrete to become stable for 1 minute. After the completion of time, slide gate is lifted to allow the concrete to flow. The average distance between the edges of the box is measured after the concrete stops it flow. The passing ratio is calculated by suitable formula.



Fig 5: L box apparatus

2.5.6 V- funnel test

The v-funnel experiment consists of following apparatus, V-funnel, bucket, stop clock. The V-funnel is cleaned and placed in a vertical manner. The gate is closed and the concrete is filled in the V-funnel. Then a bucket is placed. After placing the bucket the gate is opened. At the same time the stop watch is started. The stop watch is stopped until the concrete in the V-funnel drops full down to bucket.



Fig 6: V-funnel test apparatus

The above test is done for both self compacting concrete and self compacting geo polymer concrete. The results are compared and they are as follows.

Table 1: Comparison of fresh property of SCC and SGCG

S N O	Type of con crete	Slu mp cone test (mm)	T ₅₀ slu mp test (se c)	L box (H ₂ /H ₁) ratio	J- rin g (m m)	V- fun nel (sec)	Flo w tabl e %	Vee bee cons isto met er(s ec)
1	SCC	740	4	0.95	6	5	98	12
2	SCG C	765	2	0.9	5	4	100	10

2.6-Curing:

After casting the concrete specimens are cured according to their conditions. The mould was removed after 24 hours and curing was done. Conventional Self Compacting Concrete was immersed into water after removal of mould until harden concrete tests was carried out. For Self Compacting Geo polymer Concrete, the curing was done as autoclaving. The casted specimen was subjected to high temperature of about 70°C for required days. After curing, the specimen was tested for Compressive strength test, Split tensile test and Flexural strength test.

III. RESULT DISCUSSION

3.1-Compressive Strength Test:

Compressive Strength Test is the most important property which appraised the strength of concrete. Compressive Strength Test was carried out for 150mm x 150mm x 150mm specimen. This test was conducted for

7days, 21days, 28days cured concrete. Compressive Strength increases in curing period. The compressive strength of the Geo polymer was quite larger than the conventional Self Compacting Concrete. At 7days curing period Self Compacting Geo polymer Concrete attained 19.9N/mm² strength and Self Compacting Concrete attained 18.2N/mm². SCGC achieves 32.8N/mm² of strength while SCC reaches 30.4N/mm². For 28days curing period SCC accomplish 36.9N/mm². SCGC produced 37.1 N/mm² of Compressive strength. So, from this it was noted that SCGC possess Compressive strength slightly greater than SCC.

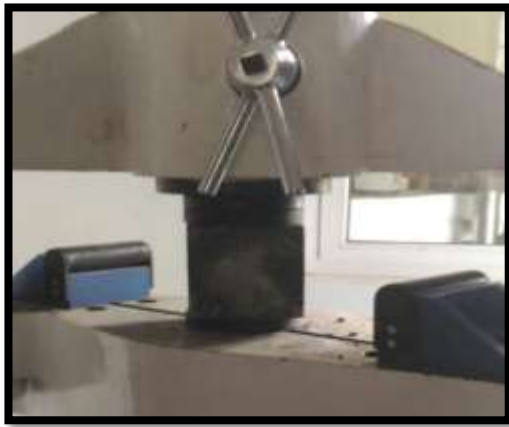


Fig 7: Compression strength test

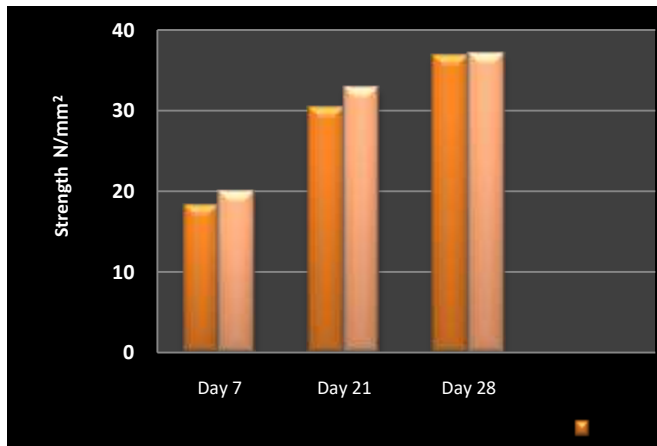


Fig 8: Graph for compression strength test

3.2-Split Tensile Test:

Split Tensile Test was carried out to test the concrete in tension. Generally concrete is strong in compression and weak in tension. It is the essential mechanical properties which defines the crack formation. The cylindrical specimen with dimension 150mm x 300mm was used for this experiment. It is also carried out at 7days, 21days and 28days curing period. In this test also SCGC has greater strength compared to SCC. At the age of 7days of concrete SCGC attained 2.9N/mm² since SCC produced 2.9N/mm² tensile strength in cylindrical specimen. SCGC gave

3.01N/mm² and SCC gave 3.1N/mm² strength at the age of 21days curing. At 28days curing, SCGC gained 3.2N/mm² and SCC gained 3.16N/mm². Above information delivered that the SCGC was greater resistance to tensile strength compared to SCC.



Fig 9: Split tensile test

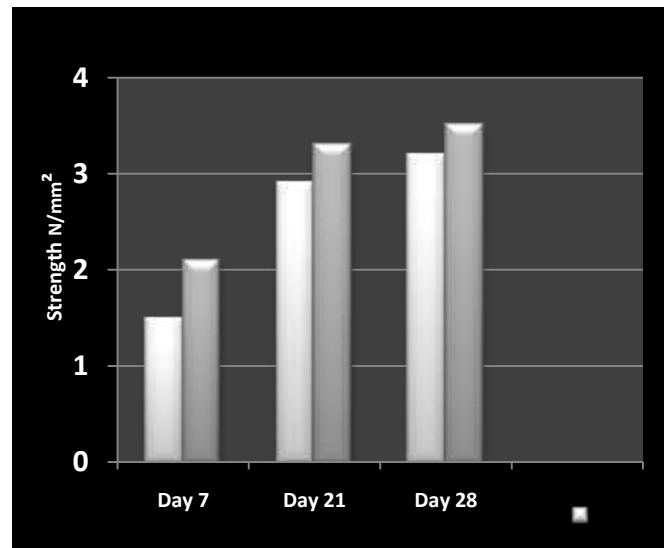


Fig 10: Graph for split tensile test

3.3-Flexural Strength Test:

Flexural Strength Test was implemented to prism specimen having 100mm x 100mm x750mm size. As same, it was tested at 7days, 21days, 28days curing. At the end of 7days curing SCGC prism attained 4.148N/mm² strength while SCC obtained 3.9N/mm². Then the SCGC prism attained 4.29N/mm² and SCC attained 4.17N/mm² strength at the end of 21days curing. SCGC provide 4.4N/mm² although SCC produced 4.38N/mm² strength. In flexural strength also the SCGC provide greater strength than SCC.



Fig 11: Flexural strength test

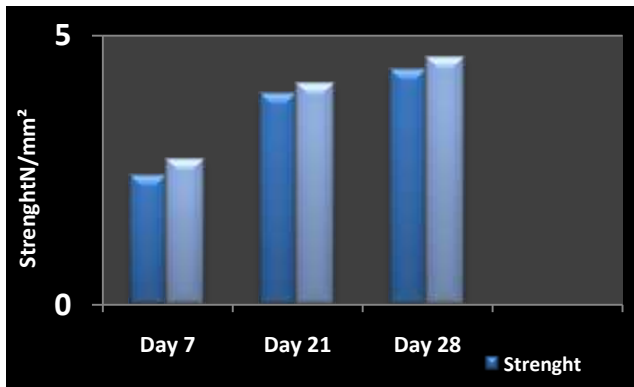


Fig 12: Graph for flexural strength test

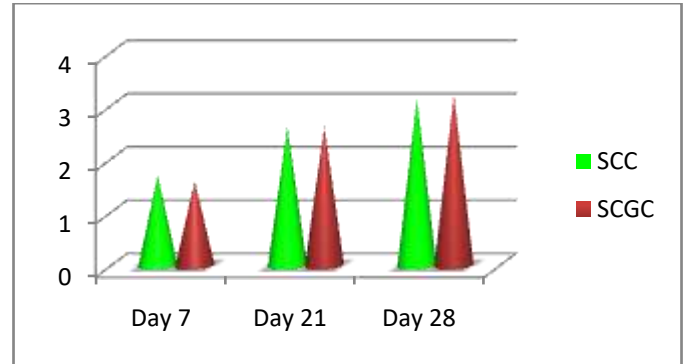


Figure11: Split Tensile Test Result (SCC vs SCGC)

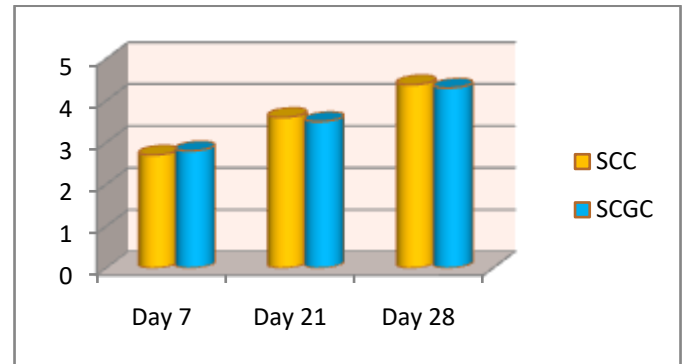


Figure 12: Flexural Strength Test Results (SCC vs SCGC)

S.N O	DAY S	Compressive strength test N/mm²		Split tensile test N/mm²		Flexural strength test N/mm²	
		SCC	SCGC	SCC	SCGC	SCC	SCGC
1	7	27.4	26.7	1.7	1.58	2.7	2.8
2	21	33.5	33.2	2.6	2.6	3.6	3.5
3	28	37.1	40.1	3.14	3.2	4.38	4.3

Table2 - SCC vs SCGC test results

COMPARISION CHART

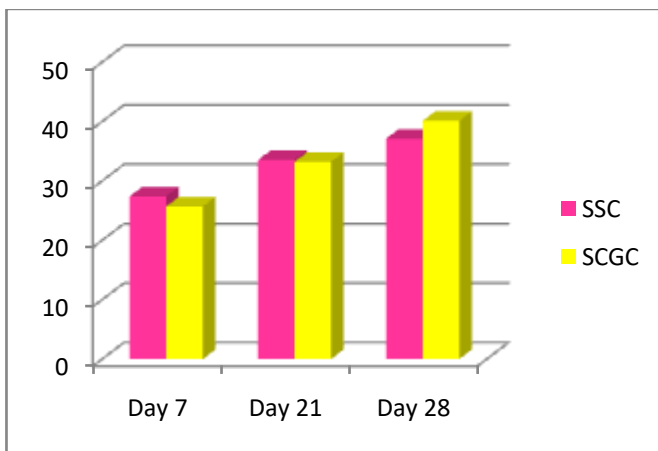


Figure 10: Compressive Strength Test Result (SCC vs SCGC)

IV. CONCLUSION

1. The mechanical property of the Self Compacting Geo polymer Concrete was determined from the above test conducted. The conclusion for this investigation is as follows:
2. Compressive strength of Self Compacting Concrete was increased due to replacement of cement by fly ash in 30/-. The workability of freshly Prepared SCC was increased by the inclusion of fly ash.
3. As cement is not required for preparation of SCGC, the use of fly ash which is a by product from thermal industry was economical and eco friendly as it does not liberate CO₂.
4. By comparing the SCC and SCGC, the strength attained in split tensile test was more or less equal.
5. The result obtained in flexural strength test by comparing both SCC and SCGC has little variation.
6. SCC requires water curing for 28days which is not required in SCGC. So the strength of SCGC was attained in short period due to autoclaving.
7. In Self Compacting Geo polymer Concrete, the combined use of Sodium Hydroxide and Sodium Silicate gives a pores free solid concrete and it has strong binding between aggregates.
8. Compressive strength of Self Compacting Geo polymer Concrete was increased due to the use of Alkaline solution.

9. In this investigation, the Self Compacting Concrete and Self Compacting Geo polymer Concrete was compared and it was concluded that Self Compacting Geo polymer Concrete was better than conventional Self Compacting Concrete.

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