EXPERIMENTAL BEHAVIOR OF SELF COMPACTING GEOPOLYMER CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY FLY ASH AND SILICA FUME

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***Abstract*: The Experimental Behavior of Self Compacting Geopolymer Concrete (SCGC) by partial replacement of Fly ash with Silica Fume was investigated in this paper. The workability related fresh properties for SCGC were assessed through Slumpcone, V-bee consistency test methods. Hardened concrete tests were limited to compressive, splitting tensile and flexural strengths, for the age of 7, 14 and 28 days. After casting the specimens along with steel moulds were placed in the oven for 48 hours after that the specimen are maintained in Ambient curing until the test day. The results indicate that the addition of silica fume as a partial replacement of fly ash results in the loss of workability; nevertheless, the mechanical properties of hardened SCGC are significantly improved by incorporating silica fume.Self-compacting geopolymer concrete is prepared from source materials of Fly ash and Silica Fume mixed with alkali activators such as Sodium Hydroxide and sodium silicate. Super Plasticizer is added to achieve the properties of self compacting concrete. The experimental investigation is carried out in one phase, the phase M25 grade of concrete is produced by replacing 25%, 35%, 45% of SCGC with 5% of silica fume at each mix as of sand.**

***Keywords*: SCGC - self compacting geopolymer concrete. Fly ash,Silica Fume.**

1. INTRODUCTION

1.1 GENERAL

The Geopolymer concrete (GC) is one of the revolutionary developments related to novel materials resulting in low-cost and environment friendly material as an alternative to the PC. GC is an innovative binder material and is produced by partially replacing the PC. It is demonstrated that the geopolymeric cement generates 5–6times less CO2than PC. Most of the research study was focused on geopolymer synthesis from metakaolin, however since last decade; much research has been done on Fly Ash (FA) to investigate the possibilities of using coal FA as an alumina-silicate source material. Fly ash which is rich in silica and alumina, has full potential to use as one of the source material for Geopolymer binder. Placement of the fresh concrete requires skilled operatives to ensure adequate compaction to attain the full strength and durability of the hardened concrete. One of the solutions to overcome these difficulties is the employment of Self- Compacting Concrete (SCC).
SCC is a type of concrete which can be compressed into every corner of the form work purely by means of its own weight. SCC has been developed to ensure adequate compaction and facilitate placement of concrete in structures with congested reinforcement and in restricted areas. SCC offers many benefits and advantages over traditional concrete.

1.2 OBJECTIVE

- To enhance the behaviour of Self Compacting Geo polymer Concrete.
- Partially replacement of cement by Fly ash and Silicafume.
- To investigate the Mechanical properties of Self Compacting Geo polymer Concrete (SCGC) by partially replacing Fly ash with Silica Fume.
- To replace the river sand by manufactured sand as a filler material.

1.3 MATERIAL USED

1.3.1 CEMENT

Ordinary Portland cement (43 Grade) was used for casting all the specimens. To produce high performance concrete, the utilization of high strength cements is necessary. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rates of strength development.

The physical properties of cement

1) Setting time
2) Soundness
3) Fineness
4) Strength

1.3.2 ORDINARY PORTLAND CEMENT (OPC)

Portland cement may be defined as a product obtained by finely pulverizing the clinker produced by calcining to fusion, an intimate & properly proportioned mixture of argillaceous & calcareous materials. The ordinary Portland cement has been classified as.

1) 33Grade (IS 269:1989)
2) 43 Grade (IS 8112:1989)
3) 53 Grade (IS 12669:1987)

We have to use 53 grade ordinary Portland cement (OPC) for this study program.

Chemical composition of (OPC)

Cao = 60-65%, Sio2 = 17-25%, Al2O3 = 3-8%, Fe2o3 = 0.5-6%, Mgo = 0.5-4%

1.3.3 COARSE AGGREGATE

1) Crushed granite coarse aggregate conforming to IS:383 1970 was used
2) Coarse aggregate passing through 20mm, having the specific gravity and fines modulus values 2.74 and 7.20 respectively were used.
3) Aggregate retained on 4.75mm sieve are identified as course. They are obtained by natural disintegration or by artificial crushing of rocks.
4) Coarse aggregate are obtained by crushing various types of granites, schist and gneiss, crystalline and lime stone and good quality sandstones.

1.3.4 FINE AGGREGATE

1) The fine aggregate conforming to zone-II as per IS: 383-1970 was used. Fine aggregate is smaller filler made of sand. A fineness modulus in the range 2.5-3.2 is recommended for concrete, to facilitate workability.

2) It may be obtained from bits, rivers, lake or sea shore, but it should free from clay and silt. The material passing through 4.75mm sieve are called fine aggregate. Natural sands are generally used as fine aggregate.

1.3.5 FLY ASH

In this investigation, class F type of fly ash is obtained from mettur power plant, and their Physical and Chemical properties are given below.

Figure 1.1 Fly ash

CHEMICAL PROPERTISE

Chemical properties Min% by mass	IS:3812-1981	Fly ash MTTP
$Sio_2+Al_2O_3+Fe_2O_3$	70	90.5
SiO_2	35	58
CaO	5	3.6
SO_3	2.75	1.8
Na_2O	1.5	2
L.O.I	12	2
MgO	5	1.91

Table 1.1

PHYSICAL PROPERTIES

Properties	Values
Finesses modulus (passing through 45 micro meter)	7.86
Specific gravity	2.21

Table 1.2

1.3.6 SILICA FUME (SF)

The silica fume is the another type of pozzolana and its merit being the 'Silica Fume Concrete' produced high compressive strength which is 2 to 3 times the strength of Portland Cement Concrete (PCC). This result in reduction in weight and size of structure, lower its permeability and makes it as a very durable material.The fresh SFC mix is cohesive and there is no risk of segregation during handling of concrete and desired finish can be achieved. SF increases the electrical resistivity of concrete because it reduces the rate of carbonation of concrete. For instance PCC has electrical resistivity of 4200 ohms-cm and SFC produced with 20% SF in cements has 110,000 ohms cm.

Figure 1.2 Silica Fume

CHEMICAL PROPERTISE

Chemical parameter	Silica fume (%)
SiO_2	97.1
Al_2O_3	0.4
Fe_2O_3	0.3
CaO	0.3
MgO	0.0
SO_3	0.2
Total alkalis (Na_2O)	0.0
LOI	1.7

Table 1.3

PHYSICAL PROPERTIES

Physical parameters	Values
Particle Size	0.1 - 0.2 micron
Fineness	22 sq.m/g
Colour	Weight
Specific Gravity	2.2 - 2.3

Table 1.4

1.3.7 MANUFACTURED SAND

General Requirements:

1. All the sand particles should have higher crushing strength.

2. The surface texture of the particles should be smooth.

3. The edges of the particles should be grounded.

4. The ratio of fines below 600 microns in sand should not be less than 30%.

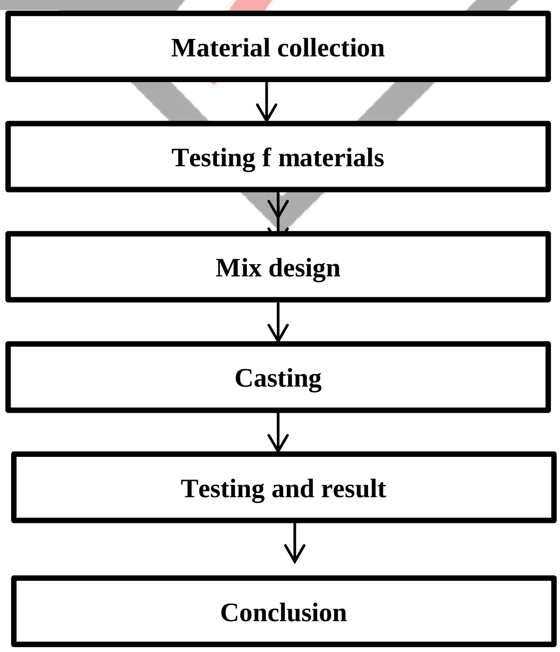
MSAND:
Manufactured sand is popularly known by several names such as Crushed sand, Rock sand, Green sand, Ultra Mod Sand, Robo sand, Poabs sand, Barmac sand, Pozzolan sand etc. recognizes manufacture sand as Crushed Stone Sand.

M sand
1)100% replacement to Natural sand &it is one of the bi-product of aggregates.
2) No scarcity, as the Govt. is encouraging thebusiness to garner un-tapped revenue.
3) Govt. has identified the places and accorded the sanction for carrying out quarrying and crushing activities without compromising on any environmental issues.
4) Sand washing machine to ensure 0% silt content, benefiting best economized concrete with possibilities of reduction in cement content.
5) Uninterrupted supply even during rainy season, which in turn facilitating timely completion of the project.
6) No adulteration.
7) World class Machine is employed to get the Top-Quality-Graded aggregates meeting both BIS and Customer requirement, the Consistency on the required gradation is guaranteed.
8) No fear, the quality is the main focus.
9) No additional manpower is required to remove boulders or pebbles, which is again cost saving.
10) Transparency in pricing, as the manufacturing facility is legal and ethical.

1.3.8 WATER

1) Water used for mixing and curing shall be clean and free from injurious amounts of oils alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.
2) If should free from organic matter and the pH value should be between 6 to7.
Portable water is generally considered satisfactory for mixing concrete.
3) Water found satisfactory for mixing is also suitable for curing concrete.
4) The amount of water must be limited to produce concrete of the quality required for job. Water also used for washing aggregates and curing.

2. METHODOLOGY



3. TEST OF MATERIALS

3.1 MATERIAL TESTING

To investigate the properties of the materials that were used for casting the specimens, various laboratory tests were performed; following the IS codes 2386:1963 and IS 383:1970.

3.1.1 CEMENT

Standard consistency test

For finding out initial setting time, final setting time and soundness of cement and strength parameter known as standard consistency has to be used,the standard consistency of a cement paste is defined as that consistency which will permit a vicar plunger having 10mm diameter and 50mm length to penetrate a depth of 33-35mm from the top of the mould

Standard Consistency of cement = 30%

3.1.2Fineness of Cement Test

100gm of cement taken and sieved in a standard IS no 90µ. The air which get lump is broken down and the material was sieved continuously for 15 minutes using sieve shaker. The weight of residue left on the sieve is noted.

3.1.3Initial setting time test

Lower the needle (c) gently and bring it in contact with the surface of the test block quickly release. Allow it to penetrate into the block. But after some times when the paste starts losing its plasticity needle may penetrate only to a depth of 33-35mm from the top.

The period elapsing between the times when water is added when the water is added to the test block to a depth equal to 33-35mm form the top is takenas initial setting time.

Initial setting time of the cement used = 30 Minutes

3.1.4Final setting time of cement test

Replace the needle (c) of the Vicat apparatus (F). The cement shall be considered as finally set when , upon , lowering the attachment gently cover the surface of the test block, the center needle makes an impression, while the circular cutting edge of the attachment fails to do so . In other words the paste more than 0.5mm. Replace the needle of the vicat apparatus by a circular attachment. The cement shall be considered as finally set when , upon lowering the attachment gently cover the surface of the test block , the center needle makes an impression , while the circular edge of the attachment fails to do so.

Final setting time of cement = 540 min

3.2 PROPERTIES OF CEMENT

S.NO	Characteristics	Relevant code	Result
1	Type	-	OPC
2	Specific gravity	IS : 4031-1988 Part 2	3.16
3	Fineness modulus	IS : 4031- 1996 Part 1	10%
4	Initial setting time	IS : 4031- 1988 Part 5	30 minutes
5	Final setting time	IS : 4031-1988 Part 5	540 minutes

3.3 FINE AGGREGATE

The following experiment were conducted to fine out properties of fine aggregate as per IS-2386, **Table**

3.3.1 Specific gravity test

The specific gravity of aggregate is made use of in design calculation of concrete mixes. Specific gravity of aggregate is also required calculating the compaction factor in connection with the workability measurement. The specific gravity is determined by pycnometer method.

Specific gravity of sand =dry weight of sand / weight of equal volume of water.

The above table represented in specific gravity of fine aggregate results is 2.7. This test are mentioned above table. Average specific gravity of the fine aggregate various from 2.6 to 2.8.

The results of tests done on fine aggregate are presented in table and all the parameters were within the permissible limits.

3.4 COARSE AGGREGATE

3.4.1Water absorption test

The coarse aggregate for the work should be river gravel or stone. The maximum size of aggregate is generally limited to 20mm. aggregate of 10 to 20mm is desirable for structures having congested reinforcement. Well graded cubical or rounded aggregates are desirable aggregates should be of uniform in size for this project 20mm size aggregate were used.

3.4.2Specific gravity test for coarse aggregate

The specific gravity of aggregate is made use in design calculation of concrete mixes. Within the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Similarly specific gravity of aggregate is required to be considered when we deal with light and heavy weight concrete.

4. MIX DESIGN

a. Characteristics compressive strength required in the field at 28 days grade designation - M_{25}

b. Nominal mix size of aggregate = 20mm

c. Shape of coarse aggregate = Angular

d. Degree of workability required at site = 75 mm

e. Degree of workability require at = As per IS: 456

f. Type of cement = Ordinary Portland cement

Test data of material (to be determined in the laboratory)

a. Specific gravity of cement = 3.16

b. Specific gravity of fine aggregate = 2.7

c. Specific gravity of coarse aggregate = 2.71

d. Fine aggregate confirm to Zone II of IS - 383

Procedure for concrete Mix design of M25 Concrete

Step - 1 Determination of Target strength

$f_{target} = f_{ck} + 1.65 \times S$

$= 25 + 1.65 \times 4$

$= 31.6 \text{ N/ mm}^2$

Where,

S = Standard deviation in N/mm^2 = 4 (as per table -1 of IS 10262 - 2009)

Step - 2 Selection of water content

From Table 5 of IS: 456, (Page no20)

Maximum water cement ratio of Mild exposure condition = 0.55

Based on experience, adopt water - cement ratio as 0.45

0.45 < 0.55, hence Ok.

Step - 3 Selection of water content

From Table 2 of IS 10262 - 2009,

Maximum water content = 186 Kg (for nominal maximum size of aggregate - 20 mm)

Estimate water content = 186 + (3/100) × 186 = 191.6 Kg/ m^3

Step - 4 Selection of cement content

Water cement ratio = 0.45

Corrected water content = 191.6 Kg/m^3

Cement content - From Table 5 IS: 456,

Minimum cement content for mild exposure condition = 300 Kg/m^3

383.2 Kg/m^3> 300 Kg/m^3, hence Ok.

This value is to be checked for durability requirement from IS: 456

As per clause 8.2.4.2 of IS: 456

Maximum cement content = 450 Kg/m^3.

Step - 5 Estimation of coarse aggregate proportion

For Table 3 of IS: 10262- 2009,

For nominal maximum size of aggregate = 20mm,

Zone of fine aggregate = Zone II

And for water content = 0.45

Volume of coarse aggregate per unit volume of total aggregate = 0.62

NOTE 1: For every ±0.05 change in w/c, the coarse aggregate proportion is to be changed by 0.01. If the w/c ratio less than 0.5 (standard value), volume of coarse aggregate is required to be increased to reduce the fine aggregate content.

NOTE 2: For pump able concrete or congested reinforcement the coarse aggregate proportion may be reduced up to 10%.

Hence,

Volume of coarse aggregate per unit volume of total aggregate

= 0.62× 90% = 0.558

Volume of fine aggregate = 1- 0.558 = 0.442

Step- 6 Estimation of the mix ingredients

a. Volume of concrete = $1m^3$

b. Volume of cement = (Mass of cement/Specific gravity of cement) × (1/1000)

= (425.7 / 3.15) × (1 / 1000)

= $0.1352m^3$

c. Volume of water = (Mass of water / Specific gravity of water)× (1/1000)

= (191.6 / 1) × (1 / 1000)

= $0.1916m^3$

d. Volume of aggregate = Volume of concrete−(Volume of cement + Volume of water)

= 1−(0.1352 + 0.1916)

= $0.6732m^3$

e. Mass of coarse aggregate = 0.6732 × 0.558 × 2.84 × 1000

= 1066.8 Kg $/m^3$

f. Mass of fine aggregate = 0.6732 × 0.442 × 2.64 × 1000

= 746.4Kg $/m^3$

Concrete mix proportion

Cement = 425.7 Kg /m^3

Water = 191.6 Kg /m^3

Fine aggregate = 746.4 Kg /m^3

Coarse aggregate = 1066.4 Kg /m^3

For casting Mass of ingredients required will be calculated for 3 numbers cube assuming 5% waste.

Volume of concrete required for 3 cubes = $3 \times (0.15^3 \times 1.05)$

= 0.010631m^3

Cement = (425.7×0.10631)

= 4.5 Kg

Water = (191.6×0.010631)

= 2Kg

Fine aggregate = (746.4×0.010631)

= 7.9 Kg

Coarse aggregate = (1066.4×0.010631)

= 11.3 Kg

Table

Water Content Kg /m^3	Cement Kg /m^3	Fine aggregate Kg /m^3	Coarse aggregate Kg /m^3
191.6	425.7	746.4	1066.4
0.45	1	1.7	2.5

5. PREPARATION OF SELFCOMPACTING GEOPOLYMER CONCRETE

5.1 SODIUM HYDROXIDE

Sodium hydroxide pellets are taken and dissolved in water at various molar concentrations. Sodium hydroxide should be prepared 24 hours prior to use and also if it exceeds 36 hours it terminate to semi solid liquid state. So the prepared solution should be used with in this time. To find the best molarity various calculations where done.The mass of NaOH solids in solution varied depending on the concentration of the solution expressed in terms of molarity (M).

NaOH	% of solids	% of water
8M	26.23	73.77
10M	31.37	68.63
12M	36.09	63.91
14M	40.43	59.57

Table 5.1 Mass of NaOH per Litre

5.2 MOLARITY CALCULATION

The solids must be dissolved in water to make a solution with the required concentration. The concentration of sodium hydroxide solution can vary in different molar. The mass of NaOH solids in a solution varies depending on the concentration of the solution.For instance, NaOH solution with a concentration of 12 molar consist of 12x40 = 480grams of NaOH solids per litre of water, were 40 is the molecular weight of NaOH. This amount of NaOH solids in one litre of water will be large of its volume so it reduces to 361 grams for 12 molar concentrations.

Molarity	Solids(grams)
8M	262
10M	314
12M	361
14M	404

Table 5.2 Solids for Various Molarities

5.2 ALKALINE LIQUID

Generally alkaline liquids are prepared by mixing of sodium hydroxide solution and sodium silicate at the room temperature. When the solutions mixed together the both solution start to react with each other there polymerization process take place. It liberate large amount of heat so it is recommended to leave it for about 20 minutes thus the alkaline liquid is reaas binding agent.

6 FRESH PROPERTIES AND TEST RESULTS

6.1 GENERAL

Fresh properties of SCGC mixes were evaluated basedon three key characteristics of SCC: filling ability, passing ability, and resistance to segregation. These characteristics were measured using,

- ✓ Slump Flow Test
- ✓ T_{50cm} Slump Flow
- ✓ V-Funnel Test
- ✓ L-Box Test
- ✓ U-Box Test

Following the European Federation of Specialist Construction Chemicals and Concrete Systems (EFNARC) guidelines.

6.2 SLUMP FLOW TEST

This is the simplest and most widely used test method for evaluating the flow ability of SCC. The basic equipment usedin this test is the traditional slump cone used for the conventional slump test; however, the concrete placed into the mould is not compacted. To perform the test, slump cone is placedon a rigid and non-absorbent leveled plate and filled with concrete without tamping. After filling the slump cone, it israised vertically and concrete is allowed to flow out freely. The diameter of the concrete in two perpendicular directions is measured and the average of the two measured diameters is recorded.

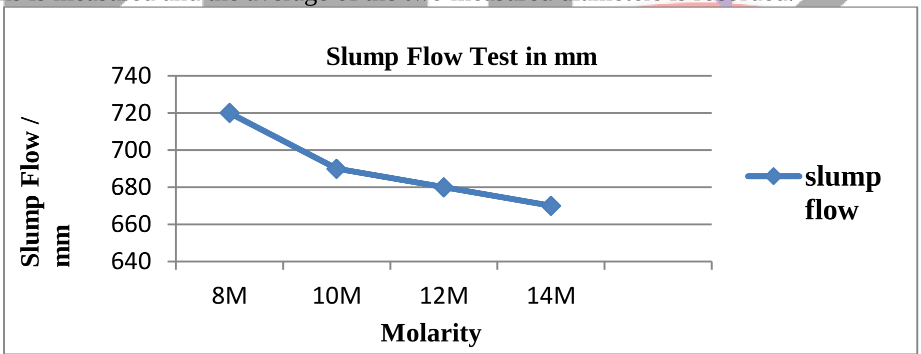


Figure 6.1 Slump Flow Test for Various Molarity

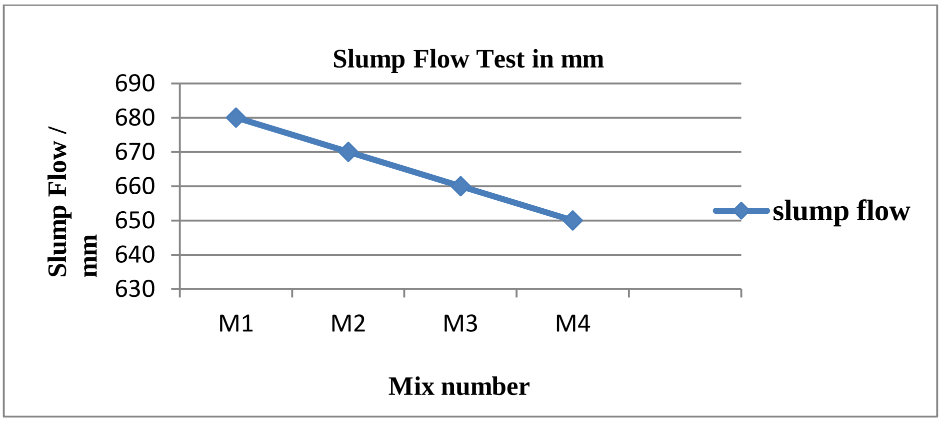


Figure 6.2 Slump Flow Test for Various Mix

6.3 T_{50cm}SLUMP FLOW

At the time of performing the slump flow test, the time taken in seconds from the instant the cone is lifted to the instant when the flow spread reaches a 500 mm circle is recorded. This flow time, termed as T50 cm Slump flow, gives an indication of the relative viscosity and provides a relative assessment of the unconfined flow rate of the SCC mixture. Alower time indicates greater flow ability. It should be noted that T50 times will be less meaningful and perhaps more variable for highly viscous mixes than for mixes with lower T50 times. This test generally not be used as a factor in rejection of a batch of SCC but rather as a quality control diagnostic test.

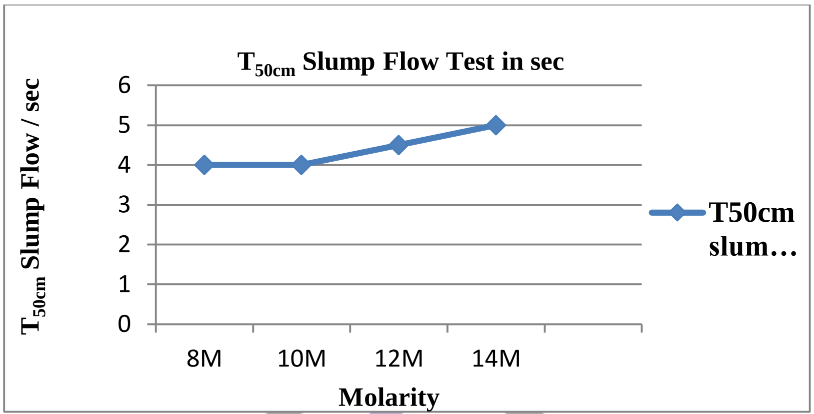


Figure 6.3 T_{50cm} Slump Flow Tests for Various Molarity

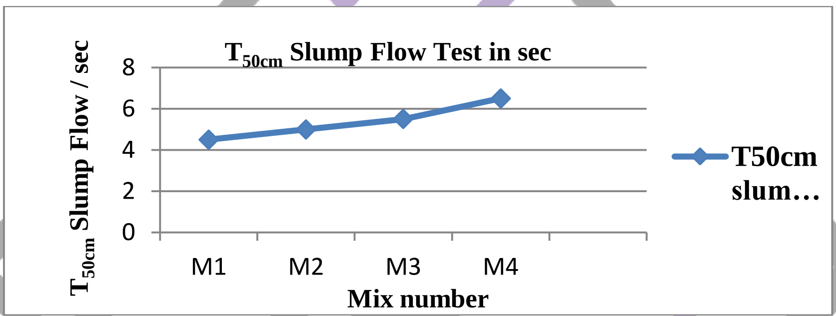


Figure 6.4 T_{50cm} Slump Flow Test for Various Mix

6.4 V-FUNNEL TEST

This test is primarily used to measure the filling ability (flow ability) of SCC and can also be used to evaluate segregation resistance. The equipment used in this test consists of a V-shaped funnel. To perform this test about 12 liters (0.4 ft^3) of concrete is needed and the funnel is completely filled with concrete without tapping or compaction. After filling the funnel with concrete, the trap door at the bottom is opened and concrete is allowed to flow out under gravity and the time taken for the concrete to flow out completely through the orifice is recorded as the V-funnel flow time. The funnel flow time between 6-12 seconds is generally desired for SCC.

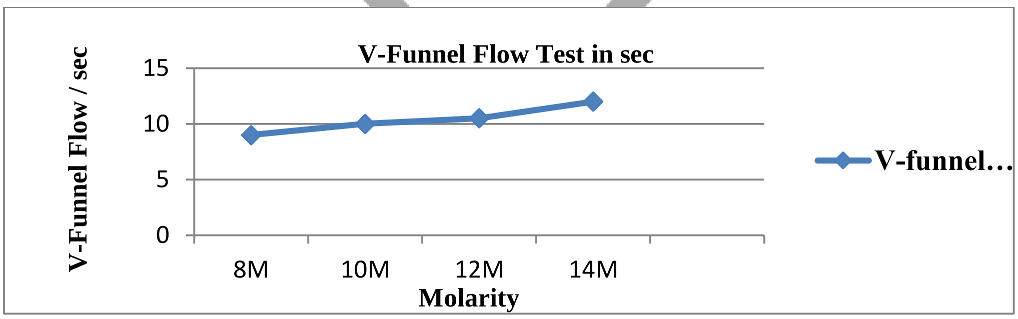


Figure 6.5 V-Funnel Tests for Various Molarity

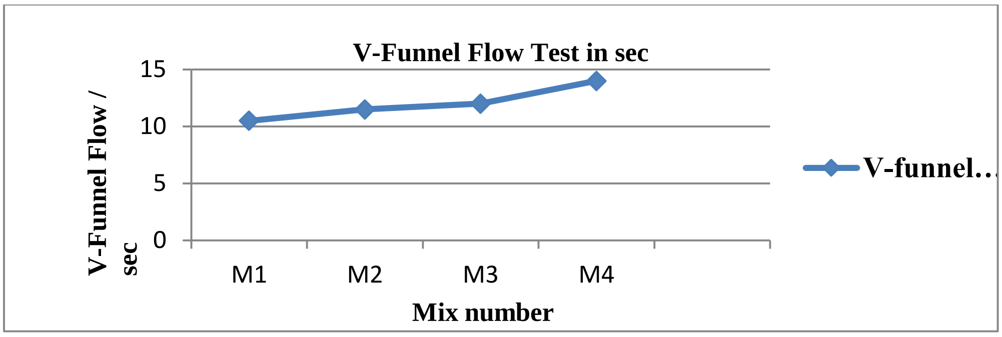


Figure 6.6 V-Funnel Tests for Various Mix

6.5 L-BOX TEST

The L-box test is used to assess the filling and passing ability of SCC. The L-box test apparatus consists of a rectangular-section box in the shape of L, with avertical and horizontal section, separated by a moveable gate, in front of which vertical reinforcement bars are fitted. The L-box is set on a firm leveled ground and inside surfaces of the box are moistened. After that, the vertical section of the box is filled with concreteand the gate separating the vertical and horizontal compartments is then lifted and the concrete is allowed to flow through closely spaced reinforcing bars at the bottom into the horizontal section of the box. When the concrete stops flowing, the heights of the concrete at the end of the horizontal section (H2) and in the vertical section (H1) are measured to compute the blocking ratio (H2/H1).Various sources set different values for H2/H1 ratio but values between 0.8-1.0 are generally recommended.

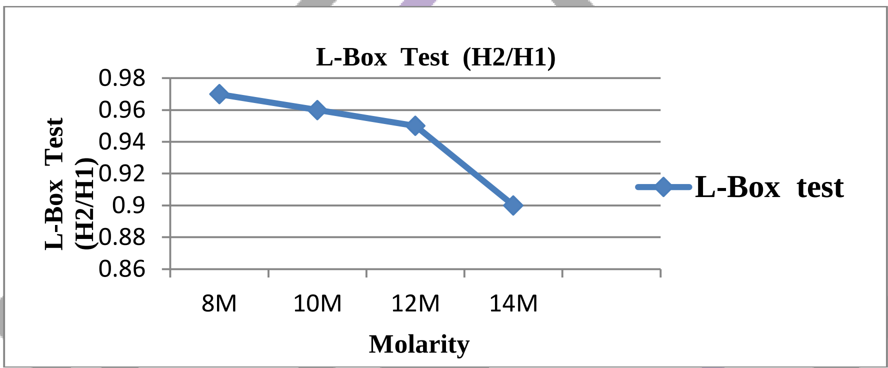


Figure 6.7 L- Box Tests for Various Molarity

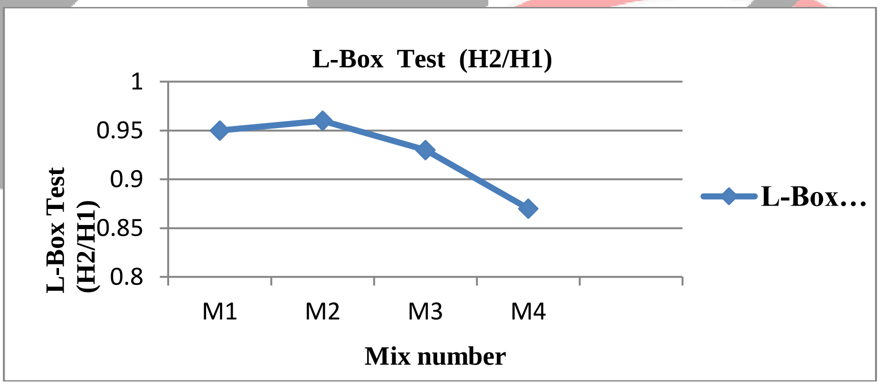


Figure 6.8 L- Box Tests for Various Mix

6.6 U-BOX TEST

The U-Box test is used to measure the filling ability of self-compacting concrete. The apparatus consists of a vessel that is divided by a middle wall into two compartments. An opening with a sliding gate is fitted between the two sections. Reinforcing bars with nominal diameters of 13mm are installed at the gate with centre-to-centre spacing of 50 mm. This creates aclear spacing of 35 mm between the bars. Set the apparatus level on firm ground, ensure that the sliding gate can open freely and then close it. Moisten the inside surfaces of the apparatus, remove any surplus water Fill the one compartment of the apparatus with the concrete sample. Leave it to stand for 1 minute. Lift the sliding gate and allow the concrete to flow out into the other compartment. After the concrete has come to rest, measure the height of the concrete in the compartment that hasbeen filled, in two places and calculate the mean (H1). Measure also the height in the other compartment (H2).

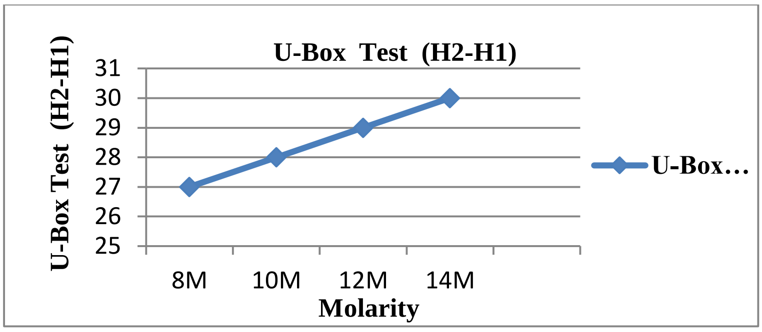


Figure 6.9 U- Box Tests for Various Molarity

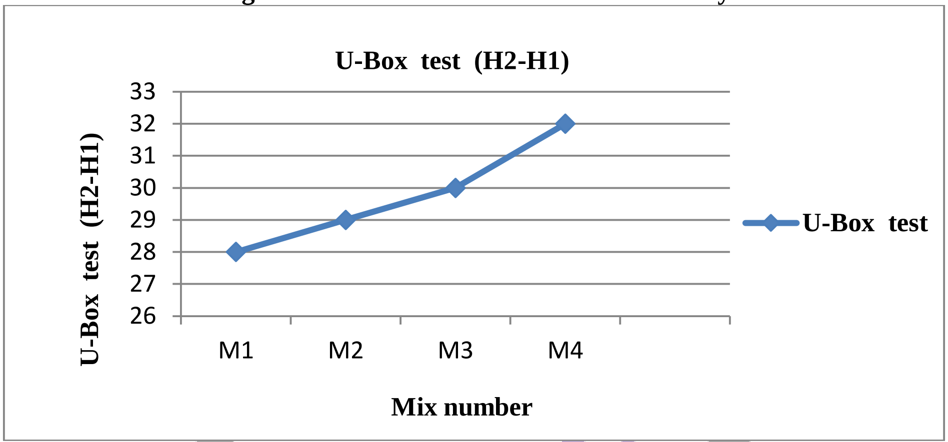


Figure 6.10 U- Box Tests for Various Mix

6.7 Workability

Molarity	Slump flow test in mm	T_{50cm} slump flow test in sec	V-Funnel Test in sec	L-Box Test(H2/H1)	U-Box Test(H2-H1) in mm
8M	720	4	9	0.97	27
10M	690	4	10	0.96	28
12M	680	4.5	10.5	0.95	29
14M	670	5	12	0.9	30

Table 6.11 Workability Test for Various Molarities

Mix	Slump flow test in mm	T_{50cm} slump flow test in sec	V-Funnel Test in sec	L-Box Test(H2/H1)	U-Box Test (H2-H1)in mm
M1	680	4.5	10.5	0.95	28
M2	670	5	11.5	0.96	29
M3	660	5.5	12	0.93	30
M4	650	6.5	14	0.87	32

Table 6.12 Workability Test for Various Percentage of Fly ash and Silica fume

7 SPECIMEN CASTING AND TEST RESULTS

7.1CASTING OF TEST SPECIMEN

The test moulds were all set and oil is applied inside, before mixing. The ingredients for SCGC were weigh batched. The concrete mixing were done using mixer machine. The concrete is taken in buckets and then poured into the moulds without any tamping or compaction. The top surface is kept smooth.

7.2 CURING OF SPECIMENS

In this project the heat curing was done for 48 hours and maintained at a temperature of 60^0C then the specimens were kept at ambient curing of 7, 14 & 28 days. The specimens were not allowed to become dry and they have been tested.

7.3 COMPRESSION TEST

Compression test is the most common test conducted on hardened concrete, because it is an easy test to perform and most desirable characteristic properties of concrete are qualitatively related to its compressive strength. The compression test is carried out on specimen in cubical or in cylindrical shape.

Mix	COMPRESSIVE STRENGTH in Mpa		
	7 days	14 days	28 days
M1	32	32.89	34.67
M2	32.89	33.33	36
M3	34.67	35.56	37.38
M4	32.89	33.78	35.56

Table 7.1 Compressive Strength for various Mix Proportions

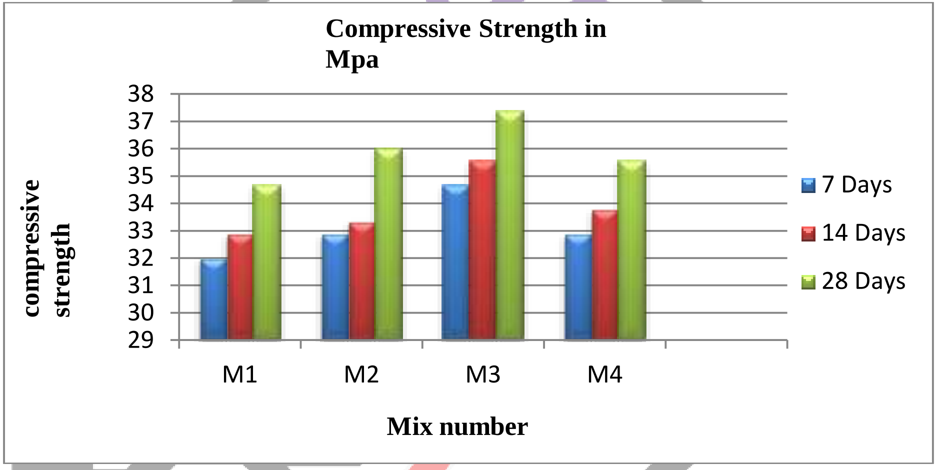


Figure7.1 Compressive Strength for Various Mix

7.4 SPLIT TENSILE STRENGTH

The test was carried out on diameter of 150mm and length 300mm in size cylinder. The test results were tabulated

Split tensile strength in Mpa = $2P/\pi DL$
Where,
P = compressive load in N
L = length in mm
D = Diameter in mm

Mix	SPLIT TENSILE STRENGTH in MPa	
	14 days	28 days
M1	3.33	3.92
M2	3.51	4.2
M3	3.88	4.4
M4	3.62	4.38

Table 7.2 Split Tensile Strength

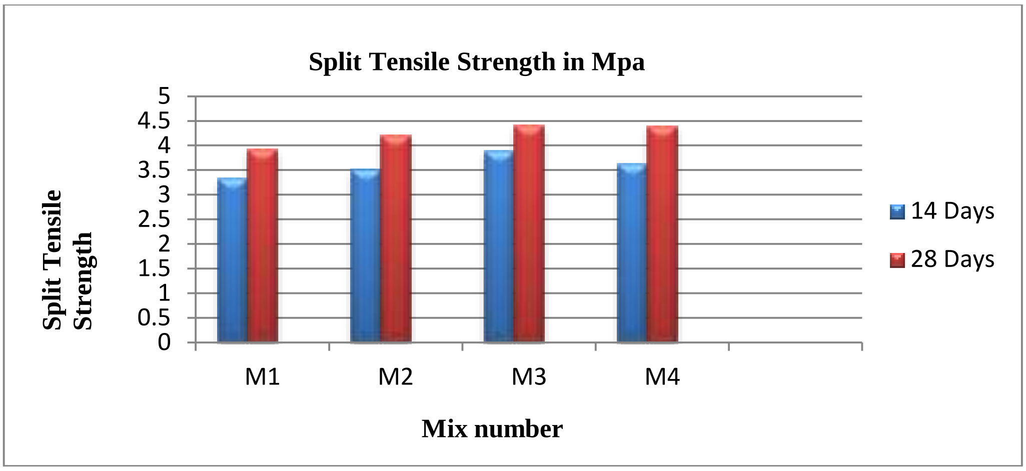


Figure7.3 Split Tensile Strength for Various Mix

7.5 FLEXURAL TEST

Concrete as we know is relatively strong in compression and weak in tension. Tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradients and many other results. Direct measurement of tensile strength of concrete is difficult. Neither specimens nor testing apparatus have been designed which assure uniform distribution of the "pull" applied to the concrete beam rest are found to be measure the flexural strength property of concrete.

Table 7.3 Flexural Strength

Mix	FLEXURAL STRENGTH in Mpa	
	14 days	28 days
M1	3.86	4.2
M2	4.1	4.28
M3	4.4	4.6
M4	4.2	4.3

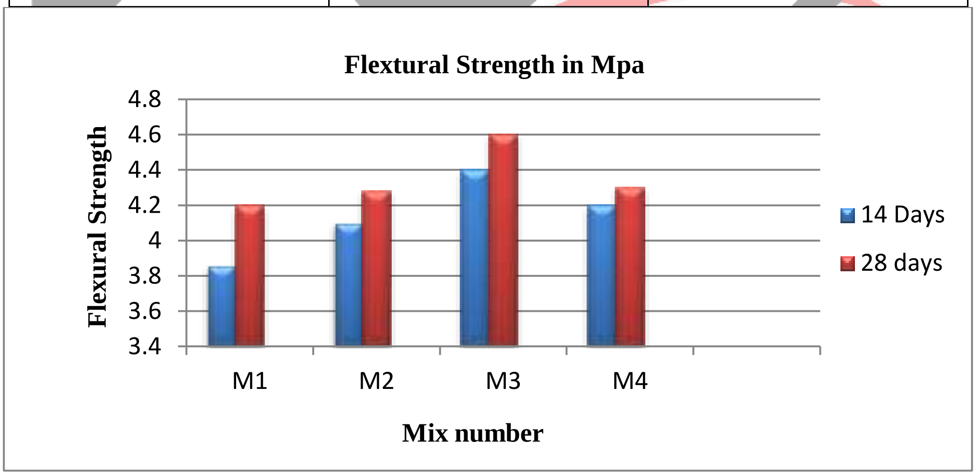


Figure7.4 Flexural Strength for Various Mix

CONCLUSION

Self-compacting Geopolymer concrete (SCGC) is relatively a new concept and can be regarded as the most revolutionary development in the field of concrete technology. SCGC is an innovative type of concrete that does not require vibration for placing it and can be produced by complete elimination of cement. SCGC can be used in prefabricated structural elements.

- The replacement of silica fume 10% (Mix 3) gives high compressive strength, split tensile strength and flexural strength then other percentage of replacement.
- Compared to control mix there is a 12% increase in compressive strength in Mix 3.
- Compared to control mix there is a 10% increase in flexural strength in Mix 3.
- Compared to control mix there is a 17% increase in split tensile strength in Mix 3.

➢ According to the workability test results the sodium hydroxide (pellet) molarity concentration is kept as 12M since it yield both good workability and compressive strength.

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