An art of Research on concrete -Ternary blended

R Srinivas Prabhu¹, R.Gobinath², R Anuradha³ and Bonthala Prabanjan Yadav⁴
¹Department of Civil, Sri Eshwar College of Engineering, Tamilnadu
²Department of Civil, S R Engineering College, Telanagana
³Department of civil, SNS College of Technology, Tamilnadu
⁴Sumathi Reddy Institute of Technology for Women, Warangal, India

Email id: srinivasaprabhu.r@sece.ac.in

Abstract. In this research, we experiment a ternary blended concrete, which is a concrete with silica fumes, GGBS, and Fly ash. By using sika viscocrete we achieved self compacting also, so it is a ternary blended self compacting geo polymer concrete. Three mixes were chosen namely M1, M2 and M3. The alkaline activator with different molarities were tried to get the optimum strength. The strength factors such as compressive strength and split tensile strength were carried out; similarly the fresh concrete properties such as slump test, flow table test, V-funnel test, U-Box Test & L Box test were carried out. The strength properties are did 7 days and 28 days. This research is mainly focused on fresh concrete properties of ternary blended self compacting geo polymer concrete.

1. Introduction
The world is facing the challenges to mitigate the concentration level of pollutant in the atmosphere. Many toxic contaminants are present in the atmosphere, which affects the living beings on the earth and on oceans etc[1]. It is great challenge to reduce the toxicity level in the atmosphere. Since the atmosphere was mainly contaminated due to rapid growth of industries, over population, etc[2]. Many industries have become an essential in our day to day life, so it is not possible to ban the industrial growth [3]. Only possibility is, to change the process that has been carried in the industry [4]. It is well known that the construction industry is also on rapid growth, since our country is also on rapid growth in the perspective of infrastructure also. Hence the demand for manufacturing process of cement is also increases [5]. It is well known fact that manufacturing process of cement also contaminates the atmospheric level [6]. At present we are in 2020, it is the time to rectify the wrong process. In this paper, it deals about Ternary blended self compacting geo polymer concrete, which is a concrete without cement [7].

2. Experimental

Materials
For this project, materials used are fly ash, silica fume, GGBS, M-sand, coarse aggregate, Sika viscocrete and alkaline activator [8].

Fly ash
Fly ash also known as pulverized – fuel ash is the ash precipitated electro statically / mechanically from the exhaust gases of coal – fired power stations [9]. It is the most common artificial pozzolana.
Table 1. Properties of fly ash

| S. No | Property             | Standard values       |
|-------|----------------------|-----------------------|
| 1     | Specific surface     | 250 – 600 m²/kg       |
| 2     | Diameter             | < 1µm & 100 µm        |
| 3     | Specific gravity     | 2.35                  |
| 4     | Loss on ignition     | < 12 %                |

Silica fume
Silica fume also referred to as micro silica / condensed silica fume is a by-product of the manufacture of silicon & ferro silicon alloys from high-purity quartz and coal in a submerged-arc electric furnace. It is a relatively recent arrival among cementitious material [10].

Table 2. Properties of Silica fume

| S. No | Property             | Standard values       |
|-------|----------------------|-----------------------|
| 1     | Specific surface     | 2000 m²/kg            |
| 2     | Diameter             | 0.03 µm - 0.3 µm      |
| 3     | Specific gravity     | 2.20                  |
| 4     | Bulk density         | 200-300 kg/m³         |

Ground-granulated blast-furnace slag
GGBS which is also called as GGBFS are obtained by cooling the molten iron slag from a blast furnace in water, to produce a glassy, granular product which is then dried & crushed into a fine powder[11].

Table 3. Properties of GGBS

| S. No | Property     | Standard Values        |
|-------|--------------|------------------------|
| 1     | Bulk density | 1000 – 1100 kg/m³     |
| 2     | Fineness     | >350 m²/kg             |
| 3     | Specific gravity | 2.85          |

Manufactured sand (M-sand)
M-sand is a substitute of river sand which is produced by crushing the hard granite stone [12].

Table 4. Test on M-sand

| S. No | Property             | Values obtained |
|-------|----------------------|-----------------|
| 1     | Fineness modulus     | 2.63            |
| 2     | Water absorption     | 3 %             |
| 3     | Specific gravity     | 2.72            |

Coarse aggregate
Coarse aggregate is the portion of concrete which is made up of the larger stones embedded in the mix. In this project 20mm aggregate is used [13].

Table 5. Test on CA

| S. No | Property             | Values obtained |
|-------|----------------------|-----------------|
| 1     | Fineness modulus     | 6.6             |
| 2     | Water absorption     | 2 %             |
| 3     | Specific gravity     | 2.82            |
Sika viscocrete
Sika viscocrete is a super plasticizing & accelerating admixture based on polycarboxylate polymers. It substantially increases workability & strength of concrete. 6% of Sika viscocrete by the mass of binder is used in this project [14].

Table 6. Properties of Sika viscocrete

| S. No | Property  | Standard Values |
|-------|-----------|-----------------|
| 1     | Relative density | 1.08 |
| 2     | Form       | Liquid          |
| 3     | pH value   | 4.3             |

Alkaline activators
Sodium hydroxide of pellets form & sodium silicate of powder form are used as alkaline activators. Alkaline activators with different Molarities (8M, 10M & 12M) were chosen.

Mix proportion
As there is no code provisions for the mix design of geopolymer concrete, density of geopolymer concrete is assumed as 2400 kg/m$^3$. The alkaline liquid to cementitious material is kept as 0.35 and the ratio of sodium hydroxide to sodium silicate is kept as 2. The mix design is adopted for M55 grade.

Table 7. Mix design for 1m$^3$

| Mix | Fly ash (kg/m$^3$) | GGBS (kg/m$^3$) | Silica fume (kg/m$^3$) | FA (kg/m$^3$) | CA (kg/m$^3$) |
|-----|--------------------|-----------------|------------------------|---------------|---------------|
| 1   | 113.19             | 245.25          | 18.87                  | 744.74        | 1314.68       |
| 2   | 113.19             | 226.39          | 37.73                  | 744.74        | 1314.68       |
| 3   | 113.19             | 207.52          | 56.6                   | 744.74        | 1314.68       |

Casting and curing
For the production of this concrete, material like fly ash, GGBS, silica fume are taken and mixed thoroughly until uniform colour appears. Then these finer materials are mixed with the coarse aggregate for 3 to 4 minutes. Once the dry mix is done, a premixed alkaline solution which is prepared 24 hours prior are added to the mix along with the super plasticizer and mixed for about 6 to 8 minutes. This freshly prepared concrete was then assessed for the required workability tests for characterizing the made concrete.

After testing the fresh state of concrete, hardened concrete is prepared by mixing the fresh concrete thoroughly and pouring it into the moulds like cube, cylinder and prism. Cube specimens were used for compressive strength test, cylinder specimens for split tensile strength and prism specimens for flexural strength. After 24 hours of casting, the moulds are de-moulded and the specimens are allowed for curing.
3. Tests on Fresh Concrete

Slump Cone Test Results

Table 8. Slump Test

| Specimen | Slump Value (mm) For Molarity 8m | Slump Value (mm) For Molarity 10m | Slump Value (mm) For Molarity 12m |
|----------|----------------------------------|-----------------------------------|-----------------------------------|
| M1       | 65                               | 66                                | 75                                |
| M2       | 62                               | 63                                | 76                                |
| M3       | 63                               | 65                                | 78                                |

Figure 1. slump value of different mix ratio

Here the slump values tested for different molarities, 8M, 10M and 12M. For 12M, we are getting maximum slump value in the mix of M3.

Flow table test result

The flow of the concrete is the percentage increase in diameter of spread concrete over the base diameter of the moulded concrete, calculated from the following formula.

Flow (%) = ((Spread dia. (cm) – 25)/25) ×100

Table 9. Flow table test

| Mix | Flow value in % for Molarity-8 | Flow value in % for Molarity-10 | Flow value in % for Molarity-12 |
|-----|--------------------------------|--------------------------------|--------------------------------|
| M1  | 16                             | 17                             | 20                             |
| M2  | 20                             | 21                             | 22                             |
Here the flow table test was conducted for different molarities, 8M, 10M and 12M. For 12M, we are getting maximum value in the mix of M3.

**Workability Tests - V-Funnel, U-Box & L-Box Test**

*V-Funnel Test:* The V-funnel test was done as per EFNARC procedure. A V-shaped funnel with a height of 425 mm, a top width of 490 mm, a bottom width of 65 mm, and a thickness of 75 mm. At the bottom of the V-shape, a rectangular section extends downward 150 mm.

*V-Funnel Test T5 minutes:* Open the trap door 5 minutes after the second fill of the funnel and allow the concrete to flow out under gravity. Simultaneously start the stopwatch when the trap door is opened, and record the time for the discharge to complete.

*U-Box Test:* This is a simple test to conduct, but the equipment may be difficult to construct. It provides a good direct assessment of filling ability – this is literally what the concrete has to do – modify by an un-measured requirement for passing ability. The 35mm gap between the sections of reinforcement may be considered too close. The question remains open of what filling height less than 30 cm is still acceptable.

*L-Box Test:* This test measures the filling and passing abilities of SCC. This method uses a test apparatus shown in Fig. which comprises of a vertical column and a horizontal trough with a gate between these two sections. The concrete is allowed to flow on the release of the gate from the vertical column passing through the bar obstructions placed just outside the gate. The test procedure consists in placing the L-box with the gate closed on a level horizontal base. The concrete is poured from a container into the filling hopper of the L-box and the vertical column is filled in one lift without rodding or any other consolidation. The concrete in the vertical column
is allowed to stand for \((60 \pm 10)\)s. Any segregation is recorded and the gate is raised to allow the SCC to flow into the horizontal trough.

When movement has ceased, the height of the concrete fill at beginning and at the end of the horizontal trough (H1 and H2) are measured as the average of heights at three positions equally spaced across the width of the box. The time taken by the concrete to flow distances of 200-mm (T200) and 400-mm (T400) into the horizontal trough are also measured. The passing ability (PA) typically expressed as \(H2/H1\) generally lies in the range of 0.8 to 0.85. However, a passing ability of greater than 0.9 is preferable. Passing ability is indicated by visual inspection of the area around the bar obstructions, even distribution of aggregate indicates good passing ability.

Dimensions and typical design of L-box.

![Figure 4. L box test](image)

Table 10. Workability Tests

| Test Methods / Mix                      | For Molarity-8 | For Molarity-10 | For Molarity-12 |
|----------------------------------------|---------------|---------------|---------------|
| T50 cm Slump flow Sec                  | 3.2           | 3.6           | 4.4           |
| V – funnel test Sec                    | 6             | 6.2           | 6.4           |
| V – funnel test at T5 min Sec          | 2.2           | 2.3           | 2.4           |
| U – box test mm                        | 20            | 25            | 25            |
| L – box test mm                        | 0.92          | 0.9           | 0.91          |
Figure 5. Graph showing the T50 cm Slump flow.

Figure 6. Graph showing the V – funnel test.
Figure 7. Graph showing the $V$ – funnel test at T5 min

Figure 8. Graph showing $U$ – box test

Figure 9. Graph showing $L$ – box test
4. Tests On Hardened Concrete

Compressive Strength Tests

Table 11. Compressive Strength Test

| S.NO | MIX  | FOR MOLARITY-8 (N/mm²) | FOR MOLARITY-10 (N/mm²) | FOR MOLARITY-12 (N/mm²) |
|------|------|------------------------|-------------------------|-------------------------|
| 1    | M1   | 20.34                  | 20.6                     | 21                      |
| 2    | M2   | 18.75                  | 20                       | 21.2                    |
| 3    | M3   | 17.65                  | 21                       | 21.2                    |

Figure 11. compressive strength of different mix ratio at 7 day

Table 12. 28 Days Strength Test in N/mm²

| S.NO | MIX  | For Molarity 8 | For Molarity 10 | For Molarity 12 |
|------|------|----------------|-----------------|-----------------|
| 1    | M1   | 46.3           | 46.5            | 50.3            |
| 2    | M2   | 46             | 46.6            | 50.84           |
| 3    | M3   | 45.9           | 46.9            | 49.6            |
Figure 12. Compressive strength of different mix ratio at 28 days

Split Tensile Strength of Concrete

Table 13. Split Tensile Strength Test 28 days (N/mm²)

| S.NO | SPECIMEN | For Molarity 8 | For Molarity 10 | For Molarity 12 |
|------|----------|---------------|----------------|---------------|
| 1    | M1       | 7.3           | 7.5            | 8.12          |
| 2    | M2       | 7.5           | 7.4            | 8             |
| 3    | M3       | 7.4           | 7.36           | 7.98          |

Figure 13. Split tensile strength of different mix ratio at 28 days

Flexural Strength Test

Table 14. Flexural strength test 28 Days (N/mm²)

| S.NO | MIX  | For Molarity 8 | For Molarity 10 | For Molarity 12 |
|------|------|---------------|----------------|---------------|
| 1    | M1   | 4.6           | 4.8            | 5.3           |
| 2    | M2   | 4.5           | 4.6            | 5.19          |
| 3    | M3   | 4.3           | 4.7            | 5.23          |
Figure 14. Flexural strength of different mix ratio at 28 days

5. Conclusion
In slump test, for mix M2 with a Molarity 10, the slump value was increased. Similarly, for flow table test, the Mix M2 with a Molarity 10, the workability was better. Similarly, for V-funnel test, U-box Test, L-box Test and slump Test, the Mix M3 with Molarity 12, the workability results are better. In strength tests also, for compressive strength, split tensile strength and flexural strength the Mix M3 with a Molarity 12 gives better strength. Hence it is concluded that the Mix M3 has better result for the concentration of molarity of 12M.

6. References
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