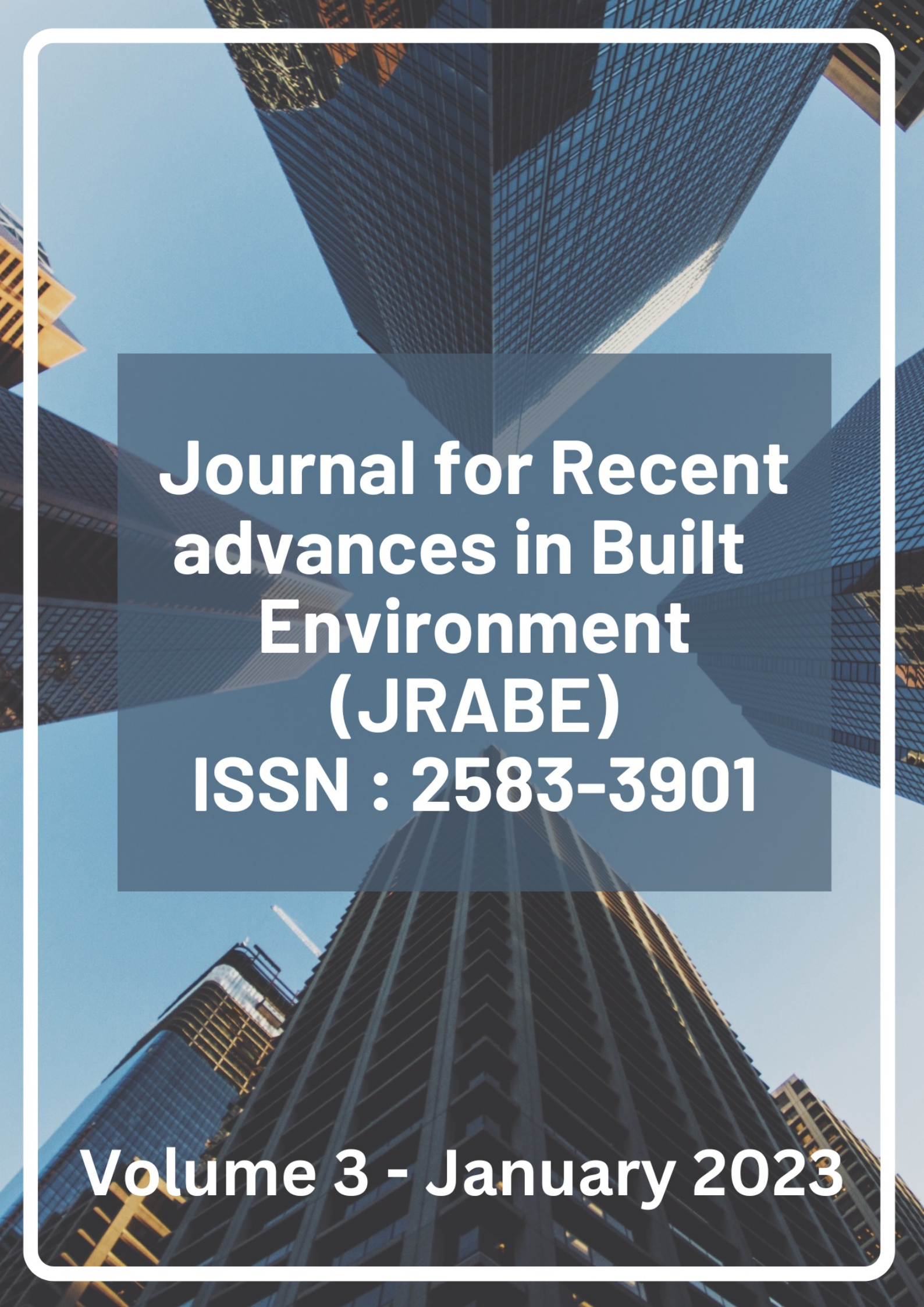

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Comparative analysis of compressive strength of masonry units with Geo-polymer Blocks and concrete blocks with and without horizontal reinforcement

Shrujana[1], Manjunath B[2], Prashanth M[3]

[1] PG Student, JSSCE, [2, 3], Assistant Professor, K S School of Engineering and Management, Bangalore
mjgowdru12@gmail.com

Abstract – Reinforced masonry combines the advantage of masonry and reinforcement. The literature review clearly shows that compressive strength of normal block masonry without horizontal reinforcement is less as compared to masonry with horizontal reinforcement. The blocks were cast of size 400mmX200mmX150mm and compressive test for Geo polymer blocks is more compared to Normal blocks, an increase of 26% for 7 days and by 30% for 28 days. Geo-polymer prisms and normal block prisms were casted with and without horizontal mesh reinforcement and were tested for compression. From the experimental results it was observed that Geo-polymer blocks with horizontal mesh gave 33% higher compressive strength than the normal blocks with horizontal mesh. It can be concluded that the geo-polymer block prisms with reinforcement yield better compressive strength than the normal block prisms without reinforcement.

Keywords:- **Geo-polymer, Horizontal Reinforcement, Compressive strength**

1.0 INTRODUCTION:

Masonry can be used to build various forms of different sizes. Strength and elastic characteristics are the factors that structural designers consider as most important. These are further broken down into compressive strength, shear and flexural strength, elastic modulus, friction coefficient, creep, moisture, thermal expansion, and many more. Prism strength, unit strength, mortar strength, bed joint thickness, prism strength, prism height to thickness ratio, contributes to the compressive strength of the brickwork.

The performance of plain masonry under gravity loading is good but is poor under lateral loads such as wind loads, and seismic loads. This can be improved by introducing reinforcement into the masonry. This improves the load carrying capacity as well as performance under lateral loading.

1.1 Geo-polymer concrete

Geo-polymer concrete is relatively a new material and has the potential to replace the conventional concrete. Geo-polymer is an inert polymer that is developed at a specific temperature by using industrial waste materials to form a binder which possess similar properties that of ordinary Portland cement. The fly ash is mixed with alkaline solution to produce binder. The Geo-polymer paste binds the fine aggregates, coarse aggregates and unreacted particles to form Geo-polymer concrete. Fly ash is used as replacement to Ordinary Portland cement and reacts with calcium hydroxide during the hydration of cement to form calcium silicate hydrate gel.

1.2 Advantages of Geo-polymer concrete

- Raw materials available easily.
- Using of geo-polymer saves energy and
- it is environmentally friendly.

*Corresponding Author: mjgowdru12@gmail.com

- Preparation of geo-polymer is easy.
- Good volume stability.
- Excellent durability.

1.3 Applications of Geo-polymer concrete

- It is used in heat resistant composites.
- It is used in manufacturing bricks and ceramics.
- Geo-polymer used in fibre glasses used for fire protection.
- Concrete road repair works.
- Mainly used in construction of wind tunnels and irrigation structures.

1.4 Durability of Geo-polymer concrete

Durability of Geo-polymer concrete is the ability to resist weathering abrasion, chemical attacks etc. The durability tests are conducted on geo-polymer concrete to know the effect of weathering on concrete.

2.0 LITERATURE REVIEW

Compressive strength and Modulus of elasticity of masonry are significant parameters when considering structural masonry design. Masonry properties were determined experimentally by Ida Ayu Made Budiwati [3]. Three types of prism specimens are made of clay brick and concrete block masonry are prepared. Prisms were tested to check the properties of structural units and the mortar. Results show that mean compressive strength of the mortar, clay brick units and concrete block units are 4.2 N/mm^2, 6.3 N/mm^2 and 12.8 N/mm^2 respectively. The characteristic compressive strength of clay brick and concrete block masonry is 11.2 N/mm^2 and 7.2 N/mm^2. It is concluded that the failure of the masonry tested in compression was due to development of tensile cracks parallel to the axis of the loading. Reinforced masonry was introduced to increase the durability and strength of free masonry to overcome the tensile strength. The prism specimens, masonry triplets and masonry wallets were casted using the hollow concrete blocks of dimension 400x200x200mm. Totally six specimens were cast , out of which three specimens were cast with unreinforced Hollow Concrete Block Masonry (UHCBM) and three specimens were cast with 8mm diameter Vertical Reinforcement in Hollow Concrete Block Masonry (RHCBM). Anusha G Krishna [1] concluded that the Compressive strength of mortar cube (1:4) with w/c ratio of 0.7 is found to be 10.23 N/mm^2 for 28 days. The average compressive strength, shear strength and Flexure strength for reinforced masonry using 8mm dia bar is 10.24 N/mm^2, 2.91 N/mm^2 and 2.31 N/mm^2 respectively. The average compressive strength, shear strength and Flexure strength for Unreinforced masonry is 8.54 N/mm^2, 1.28 N/mm^2 and 1.02 N/mm^2 respectively.

The masonry prism specimens were cast using hollow concrete blocks of dimension 400×150×200 mm for Compression and Modulus of Elasticity test. Fe-415 steel of diameter 12 mm and 8 mm reinforcement is placed in Reinforced Hollow Concrete Block Masonry (RHCBM). Totally four number of RHCBM using 12 mm diameter bar, six number of RHCBM using 8 mm diameter bar and three number of unreinforced masonry prisms were cast and tested under compression. Madan Kumar & et.al. [4] Concluded that the average compressive strength and modulus of elasticity of Hollow concrete blocks is found to be 6.08 N/mm^2 and 5898 MPa. The average Compressive Strength for Unreinforced masonry, RHCBM using 12mm dia and RHCBM using 12mm dia is found to be 6.83 N/mm^2, 11.1 N/mm^2 and 9.09 N/mm^2 respectively. The average Modulus of elasticity for unreinforced masonry and RHCBM using 12mm dia is 17265 MPa and

22072 MPa.

3.0 TESTS ON CONCRETE BLOCK

Water absorption: According to IS: 2185 part 1, the average water absorption shall not exceed 10%. Three specimens were picked at random, and their weight was determined (W2). For 24 hours, the test specimens were submerged in water. The specimen was removed from the water and allowed to drain for one minute. Surface water was removed with a towel and weighed immediately (W1).

Water Absorption = (W1-W2) / W2x 100 %

4.0 TEST ON MORTAR

Compressive strength:

According to IS 2250, the mortar used to build the prism specimens' compression strength was assessed (1981). The 70.6 mm mortar test specimens with cement sand mixture of 1:3, 1:6, and 1:8 are tested. The cubes were tested after 28 days in a compression testing machine.

4.1 Fly ash

The properties of flyash are found as per IS: 38122003 and are tabulated in Table 1

Table 1: properties of fly ash

SL. No.	Nature of the Test	Results
1.	Fineness	6%
2.	Specific Gravity	2.28

Chemical composition (%)	
Binder	Fly Ash
Fe_2O_3	1.45
MgO	0.745
SO_3	0.54
Na_2O	0.75
CaO	3.21
SiO_2	61.13
Al_2O_3	31.225
Chlorides	0.065

4.2 Ground Granulated Blast Furnace Slag

The properties of Ground Granulated Blast Furnace Slag are shown in Table 2

Table 2: properties of ground granulated blast furnace slag

SL. No.	Nature of Test	Test Results
1.	Fineness	2.45%
2.	Specific Gravity	2.786

Chemical composition (%)	
Binder	Fly Ash
Fe_2O_3	0.64
MgO	8.645
SO_3	2.22
Na_2O	0.32
CaO	37.24
SiO_2	37.2
Al_2O_3	13.235
Chlorides	0.0035

4.3 **Sodium Hydroxide**

Sodium hydroxide commercially called as caustic soda, generally available in form of pellets, flakes or granular form as shown in 3.7. It is highly soluble in water and gives raise to exothermic reaction liberating large amount of heat. The basic tests done in laboratory are tabulated in Table 3

Table 3: properties of sodium hydroxide

SL. No	Nature of Property	Value
1.	Specific Gravity	2.13
2.	Purity	97%

4.4 Sodium silicate also called as liquid glass or water glass and is available in the form of aqueous solution or in solid form. The composition of sodium silicate consists of sodium oxide, silicon dioxide and water. Sodium silicate is added to increase the rate of polymerization. The basic tests done in laboratory are tabulated in Table 4.

Table 4: properties of sodium silicate

SL. No	Nature of Property	Value
1.	Specific Gravity	1.39
2.	Composition:	Mass (%)
	a. Sodium Oxide (Na_2O)	14.7
	b. Silicon dioxide (SiO_2)	29.4
	c. Water	55.9

Table 5: geo-polymer concrete mix

Sodium Hydroxide Solution	58kg
Coarse aggregate	1069.25kg
M-Sand	575.75kg
Water	50.3kg
Molarity	10M

5.0 EXPERIMENTAL PROGRAM

The approaches and procedures adopted in the past to develop GPC mixes is reviewed and implemented in the study as standard GPC mix design is not mentioned in IS codes. The design mix has 70% of mixed aggregates, 30% alkaline solutions of the mass of concrete, the density of GPC was assumed to be 2350 kg/m^3 (a lower value was chosen because of the low bulk densities of FA and GGBS).

Geo-polymer concrete is prepared by mixing Fly ash, GGBS, M sand and coarse aggregates with alkaline solution. The alkaline solution is prepared mixing NaOH solution and sodium silicate solution as shown in table 4. NaOH pellets are dissolved in distilled water and kept for 24 hours before mixing in the concrete. Sodium silicate is thoroughly mixed with NaOH solution at the time of casting. Fly ash, GGBS, M sand and coarse aggregate are mixed in dry state for 5min. Thereafter alkaline solution is and mixed for another 5min. The mixing of concrete is done in room temperature and specimens are casted without any delay. After many trials, the following mix is adopted with a compressive strength of 40MPa. The Quantity of materials required for 1m^3 of Geo-polymer concrete as shown in Table 5. The manufactured block size is 400mmX200mmX150mm. Total number of prisms 24 were casted with without horizontal mesh.

6.0 RESULT AND DISCUSSIONS:

6.1 Water absorption:

The Water absorption values at saturation for solid and hollow blocks were found to be 2.10%, 5.51%, respectively. The test results were also found to be in the specified range i.e., below 10% as per the IS: 2185 part 1.

6.2 Compressive Strength:

The compressive strength of conventional blocks was found to be 3.08 N/mm^2 and 4.01 N/mm^2 for 7days and 28 days respectively and 3.9 N/mm^2 and 5.07 N/mm^2 respectively for GPC blocks.

6.3 Tests on Prisms:

The compressive strength test was conducted on prisms. The prisms were placed on the loading frame and the Experimental setup as shown in Fig 1. the load displacement curve is shown in Fig2. The geo- polymer blocks without horizontal mesh for a maximum Load of 55kN at a Displacement of 11mm for 28days and Normal Blocks without horizontal Mesh Maximum Load of 50kN At a Displacement of 9mm for 28days.

Fig 1 Experimental setup
Structures Laboratory,KSSEM

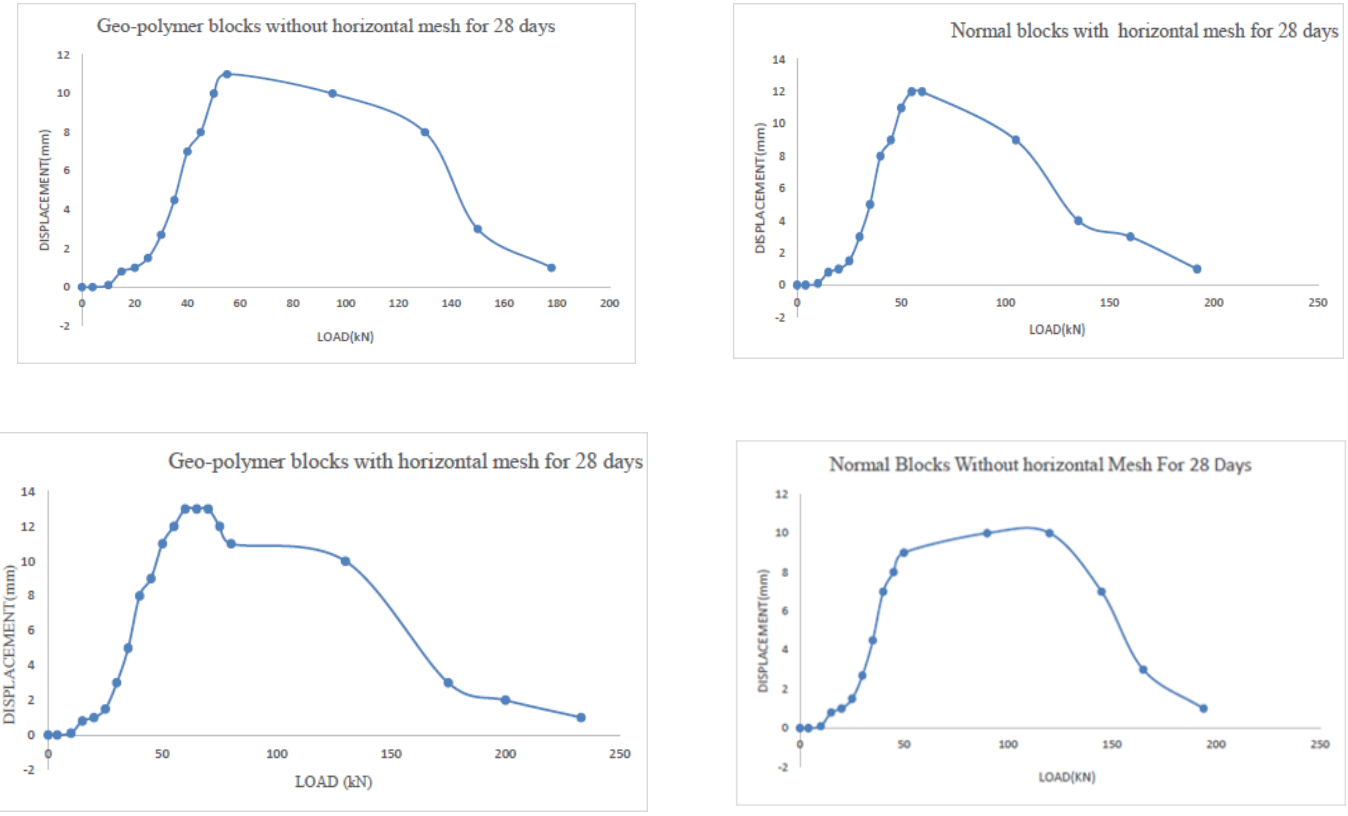

Fig 2 Load displacement curves for normal and Geo Polymer blocks

The geo-polymer blocks with horizontal mesh for a maximum load of 80kN showed a displacement of 13mm for 28days. 12mm displacement was observed for normal blocks under 60kN. The displacement for geo-polymer blocks without horizontal mesh under a maximum load of 55kN is 11mm and 9mm for Normal Blocks under 50kN load.

7.0 CONCLUSIONS

1. It is observed from the compressive strength test results for both 7 and 28 days, the compressive strength for Geo polymer blocks is 3.9 N/mm^2 and 5.07 N/mm^2 and for Normal block is 3.08 N/mm^2 and 4.01 N/mm^2 for 7days and 28days respectively.
2. The compressive strength Geo-polymer blocks (3.9 N/mm^2) is more compared to normal blocks (3.08N/mm^2) by 26% for 7 days testing and by 30% for 28 days. Geo polymer blocks showed better results when compared to the normal blocks.
3. Geo polymer block prisms have shown higher compressive load carrying capacity when compared to normal block prism.
4. From the test results it is observed that the compressive load carrying capacity of geo polymer block masonry prisms with mesh horizontal reinforcement is 80kN and 60kN for normal blocks.
5. The maximum displacement was 13mm for Geo polymer Blocks and 12mm for normal Blocks.
6. Typical compression failure was observed in prisms during testing. Vertically splitting cracks were observed in units.

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