

# International Journal of Innovative Research in Science, Engineering and Technology

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## Strength Behaviour of Light weight aggregate based Geopolymer Concrete

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**ABSTRACT:** Geopolymer is new apparent concrete; completely compensate cement accompanying fly ash including slags which are no more harassing to surroundings. This project is to ascertain the characteristic of geopolymer concrete when it is partially replacing with pumice stone. The foremost objective of project is to decrease the weight of concrete proving by Structural light weight aggregate. When using this aggregate increase fire resistance, ease to handling and transportation. This paper presents an examination on behaviour of pumice stone. G20 grade of concrete is prepared. The coarse aggregate is partially replaced pumice stone with various percentages such as 0%, 10%, 20%, 30%, 40%, 50%. 8 molarity of concentration of NaOH is prepared. The samples were mixed and casted in specimen such as 150mm x 150mm x 150mm for compression test and 100mm diameter and 200mm length for split tensile test and beam were designed as under reinforcement of size 1300mm x 150mm x 150mm and tested under loading frame and then compared with other geopolymer concrete. Based on performance aspect it shows that increase of pumice stone reduces the density and strength gently decreases.

**KEYWORDS:** Fly ash, GGBS, Pumice stone, Compressive strength, Split tensile strength, Flexural strength

### I. INTRODUCTION

Concrete plays a potent role in construction industry. An effort is taken to produce a concrete which are better to environment. Cement is significant causes to global pollution. Davidovits in 1998 proposed a geopolymer or inorganic polymer. In Geopolymer concrete does not utilise cement which can be furnish with fly ash, silica fume, rice husk, GGBS etc. The other important frame in geopolymer is alkaline liquid the alkaline liquid may be fusion of sodium hydroxide, sodium silicate or potassium hydroxide and potassium silicate. The other is Structural light concrete provides an achieving strength. The main principle of light weight aggregate is to impoverish dead load of structure. This can succeed in achieving strength as same as normal aggregate. The determination of this experimental is study the geopolymer when it's replaced with light weight aggregate such as pumice stone. Pumice stone is obtained as natural. In this project source substantial used are fly ash and GGBS and alkaline liquid in the combination of sodium hydroxide and sodium silicate.

### II. LITERATURE SURVEY

**T.Lakshmi Prasad, H.Sundarsana Rao, Vaishali [1]** has presented tensile properties of GGBS and Phosphogypsum blended geopolymer concrete. In this experimental GGBS and Phosphogypsum have replaced with various percentages and test was taken for 28 and 90 days. Based on result GGBS has increases strength increases with increases in percentage. Phosphogypsum has increased to certain limit and strength decreases in increases in percentage.

**S.P.Dange, S.R.Sutyawanshi [2]** This paper briefly explain about the behaviour of geopolymer concrete. From the result the geopolymer concrete gained strength and heat curing is eliminated due to including GGBS in mix. The

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strength of geopolymer concrete increases with increase in percentage of GGBS increases. It observed that M80 gave maximum strength.

**R.S.Patel, D.R.Dara [3]** In this experimental study ceramic waste is replaced in place of coarse aggregate. The waste is replaced with 5 to 30% it gives better result compressive strength and tensile strength compare to the normal aggregate. Using fly ash and Ceramic waste a source material it will good for environment and hence safe to environment. They conclude that ceramic waste is extensively used as coarse aggregate.

**Lakshmi Kumar Minapu, MKMV Ratnam, Dr.U.Ranganraju [4]** This is project is to study the mechanical properties of light weight aggregate. Coarse aggregate is replaced with pumice stone and mineral admixtures like fly ash and silica fume. Fly ash and silica fume shows good strength. When replacing pumice stone with 20% is sufficient above this percentage strength decreases.

**Nindyawati, Sri umniati, Puput Ridanareni [5]** This experimental study explain about the flexural strength of geopolymer. The data are obtained from testing of 4 pieces of reinforced geopolymer concrete beam. For the result geopolymer concrete cylinder ha higher compressive strength ordinary concrete withstand 34.8% load higher compared to geopolymer concrete beam. Reinforced ordinary concrete beam experience bending shear collapse while reinforced geopolymer concrete beam experience pure bending collapse.

**A.Suba lakshmi,S.Karthick[6]** This study is to attempt compare the conventional concrete and light weight aggregate concrete using mix M30 with poly carboxyl ether admixture. Pumice stone is replaced with various percentages and various tests were done and compared with conventional concrete. The density decrease increase in pumice stone.50% give high result compared to the other percentage.

### III. MATERIAL USED

#### Fly ash

Fly ash is obtained from the power plant. Class F type fly ash is used in this project.

#### GGBS

GGBS is also used in this project. GGBS is partially compensated with fly ash.

#### Aggregates

Aggregates are classified as fine aggregate and coarse aggregate. Fine aggregates and coarse aggregate are locally available. Aggregate are passed through the IS sieve and then used in this experimental propose.

#### Pumice stone

Pumice stone is rock from the volcanic origin. Pumice stone is a classified as natural light weight aggregate and which has low specific gravity. Pumice stone is substituted as a coarse aggregate in this project.



Fig 1: Pumice Stone

Table -1: Properties of aggregates

Properties	Fine aggregate	Coarse aggregate	Pumice Stone
Specific gravity	2.45	2.75	0.92
Fineness modulus	2.57	7.34	7.12
Water absorption	0.918%	1.23%	27.13%
Impact value	-	6.95%	33%

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## Alkaline activator

Sodium hydroxide and sodium silicate is used as an alkaline activator. Sodium hydroxide is in the form of pellet and sodium silicate is in the form of liquid. The ratio of sodium hydroxide to sodium silicate is 2.5. Mass of sodium hydroxide is  $44.5 \text{ kg/m}^3$  and mass of sodium silicate is  $104 \text{ kg/m}^3$ . The alkaline liquid are prepared before 24 hours for casting.

## IV. EXPERIMENTAL RESULTS

### Alkaline solution preparation

Alkaline solution preparation is major processes in geopolymer concrete. Sodium hydroxide and sodium silicate is mixed before 24 hours to start polymerization process. It is recommended to stay away after mix due to heat evaporation and getting ready as binding agent. Sodium hydroxide pellets are taken and liquefy in the water at the rate of 8 molar concentrations and sodium silicate in the ratio of 2.5.

### Mix proportion

G-20 mix design were prepared and 8M were used. 75% aggregate were used and various percentage of coarse aggregate replaced pumice stone with various percentage such as 0%, 10%, 20%, 30%, 40%, 50%.

Table -2: Mix proportion of G20 grade

Fly ash	428.57 $\text{Kg/m}^3$
Fine aggregate	530 $\text{Kg/m}^3$
Coarse aggregate	1270 $\text{Kg/m}^3$
Water	104.25 $\text{Kg/m}^3$
Sodium hydroxide	48.98 $\text{Kg/m}^3$
Sodium silicate	122.4 $\text{Kg/m}^3$
Molarity	8M
Water ratio to solid ratio	0.21
Alkaline to fly ash ratio	0.40
NaOH to $\text{Na}_2\text{SiO}_3$	2.5

### Preparation of concrete

Geopolymer concrete mixing is similar as same as ordinary concrete. Initially fly ash, GGBS and aggregate were mixed. Pumice aggregate is replaced with various percentages such as 0%, 10%, 20%, 30%, 40%, and 50%. Then prepared alkaline solution was mixed thoroughly thorough out the mix and then super plasticizer and additionally water is added for uniform mix. Various tests had done on the fresh and hardened concrete. The fresh concrete is used to check the workability of concrete. Hardened concrete are to find strength durability. The specimen is prepared to for the compressive strength and split tensile strength, flexural strength



Fig 2 Preparation for specimen

## TEST ON FRESH CONCRETE

### Slump test

The slump test is essentially to consistency of concrete mix. The test is carried out with a steel mould in the form of frustum cone of size top diameter is 100mm bottom 200mm and height 300mm. The surface are cleaned and

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the mould is filled. After filling the mould, the cone should be removed slowly. The height of the cone is measured and the readings are taken for various percentage.

**Table -3:** Slump value

Pumice stone %	0%	10%	20%	30%	40%	50%
Slump value (mm)	74	81	87	79	61	53

### Compaction factor test

The compaction factor test is carried out to measure the compact ability. This test is more accurate than slump test.

**Table -4:** Compaction factor

Pumice stone %	0%	10%	20%	30%	40%	50%
Compaction factor	0.89	0.90	0.95	0.85	0.83	0.79

### TEST ON HARDENED CONCRETE

#### Compression test

Compressive strength is one of the common tests in hardened concrete. The mould size 150mm x 150mm x 150mm is used in this experimental study. Coarse aggregate are partially replaced with pumice stone of various percentage such as 0%, 10%, 20%, 30%, 40%, 50%. The cube is filled with layer by layer and compacted with tamping rod. The specimens were cured and 7 days and 28 days test were recorded.



Fig 3 Compression test of cubes

**Table -5:** Compressive strength for geopolymer concrete

Percentage of pumice stone	Compressive strength for 7 days (N/mm <sup>2</sup> )	Compressive strength for 28 days (N/mm <sup>2</sup> )
0%	22.38	31.54
10%	24.16	34.77
20%	25.63	38.92
30%	23.42	33.13
40%	21.17	30.87
50%	19.57	27.42

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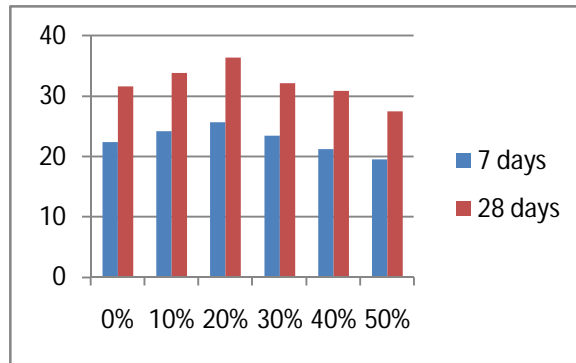


Fig 4 Comparison of compressive strength for 7 day and 28 days

**Table -6:** Unit weight of concrete

Percentage	Unit weight of cube (kg)
0%	8.90
10%	8.53
20%	7.21
30%	6.15
40%	5.66
50%	5.30

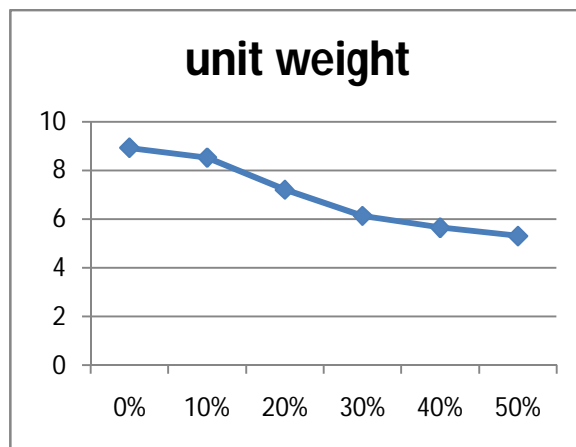


Fig 5 Unit weight of geopolymer cube by replacing pumice stone

## Split tensile test

This test is determining the tensile strength of concrete is primarily made to estimate the load under which cracking develops. The mould is filled with layer by layer the mould size 100 mm diameter and 200mm lengths. In this test cylindrical specimen is placed horizontally. The load is applied until the specimen cracks.

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Fig 6 Split tensile test of cylinder

**Table -7:** Split tensile test for geopolymer concrete

Percentage of pumice stone	Split tensile test for 7 days (N/mm <sup>2</sup> )	Split tensile test for 28 days (N/mm <sup>2</sup> )
0%	2.93	4.86
10%	3.19	5.01
20%	3.27	5.47
30%	3.07	4.52
40%	2.57	3.67
50%	2.28	3.51

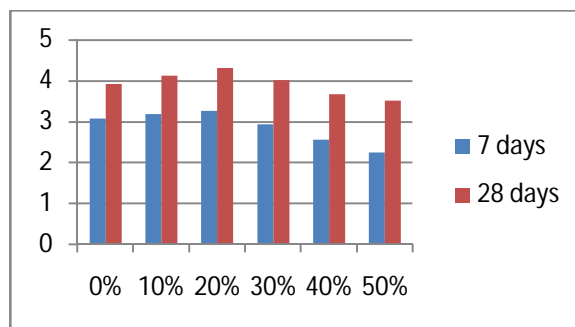


Fig 7 Comparisons for split tensile strength for 7 and 28 days test

## Flexural strength test

### Beam design

The beam is casted of size 1300 x 150 x 150 mm. It is designed for under reinforced beams. The top is with reinforcement with 12 mm diameter of 2 nos (12# - 2 nos) at top and 12mm diameter of 2 nos (12#-2nos) at bottom. Stirrups are used as 6mm diameter and placed a spacing of 120mm C/C. G 20 grade of concrete is used. Coarse aggregate is replaced with various percentages.

### Test setup

The flexural strength of geopolymer is tested in loading frame. The beam placed is over simple supported over 1000 mm and placed symmetrically. The load is applied using hydraulic jack of 50 ton. Deflections are measured by using dial gauge at various loads. Linear Variable Data Transformers were placed at mid span and under the load points of the beam. The first crack loads are obtained. Then readings are recorded.

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Fig 8: Beam setup on loading frame

Table 8: Details of beam

Section	Mix	W/C	Size of beam	Ast (mm <sup>2</sup> )
Under reinforced	1:1.3:2.8	0.41	1300 x 150 x 150	356

Table -9: Flexural strength of beam

Percent age of pumice stone	First Crack(KN)	Ultimate load(KN)	Deflection at ultimate load(mm)	Crack width on first crack (mm)
0	23.54	62.78	3.81	0.21
10	27.46	70.63	4.12	0.13
20	31.39	78.48	5.01	0.09
30	19.62	58.86	3.41	0.33
40	15.69	43.16	2.93	0.41
50	11.77	23.54	1.92	0.51

## V. CONCLUSION

Geopolymer concrete is alternate. In nowadays construction industries needs an eco friendly substantial which should strong as possible as. Using fly ash and GGBS there by reduce the pursuit of Portland cement which pollutes the environment. The pumice stone is replaced with 0%, 10%, 20%, 30%, 40%, and 50%. On basis of results for 7 days and 28 days obtained in the graph.

- The unit weight of concrete decrease when increasing in percentage of pumice stone.
- The slump test and compaction factor decrease as when increasing the percentage of pumice stone.
- The concrete replacing up to 50% considerable reduce the unit weight but not give sufficient strength cannot be used for structural purpose.
- But when the percentage 20% gives high compression and split tensile strength and flexural compared to other percentage.
- When percentage of pumice stone increase more 20% strength decreases but unit weight increases.

From these experimental investigation shows that when replaced with 50% it reduces for the self weight but it is suitable for only non bearing structures. When coarse aggregate is replaced with pumice stone for 20% it suitable for bearing structure and slightly corrosion occurs coating should be preferred for bearing structure

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## REFERENCES

- [1] Davidovits, J, "Soft Mineralogy and Geopolymer", Proceedings of the Geopolymer 88 International Conference, the University Technologies, Compiègne, France, 1988.
- [2] Davidovits J., 1991. "Geopolymer: inorganic polymeric new materials", Journal of Thermal Analysis, 37, pp. 1633–1656.
- [3] Hardjito, D. and Rangan, B. V., 2005. "Development and Properties of Low- Calcium Fly Ash-based Geopolymer Concrete." Research Report GC-1, Faculty of Engineering, Curtin University of Technology, Perth, Australia.
- [4] Malhotra.V.M., "Making concrete 'greener' with fly ash". ACI Concrete International 21,
- [5] Nindyawati "Flexural Test of Fly Ash base Geopolymer Concrete Beams" Department of Civil Engineering, Universities Nigeria.
- [6] T. Parhizkar, M. Najimi and A.R. Pourkhorshidi, "Application of pumice aggregate in structural lightweight concrete", Asian journal of civil Engineering (building and housing) VOL. 13, NO. 1 (2012) PAGES 43-54.
- [7] Raijiwala D.B., Patil H.S., 2011. "Geopolymer concrete: A concrete of next decade", Journal of Engineering Research and Studies, vol.2, pp. 19-25
- [8] Sujatha.T., Kannapiran and Nagan.S. "Strength assessment of heat cured geopolymer concrete slender column", Asian Journal of civil Engineering (Building Malhotra.V.M., "Making concrete 'greener' with fly ash". ACI Concrete International 21)
- [9] Vijaya Rangan B., 2006. "Studies on Low Calcium Fly Ash Based Geopolymer Concrete", Indian Concrete Journal, pp.9-1
- [10] Shetty M.S., (2002), 'Concrete Technology-Theory and Practice', S.Chand&co.Ltd., New Delhi.
- [11] Satish Chandra, "Light weight aggregate concrete" William Andrew publishing. USA.
- [12] Neville A.M. and Brooks J.J., (2009), Concrete Technology, 8th edition, Pearson Education Ltd., Noida.