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Mechanical Properties of Thermal Ash Aggregate Content in Geopolymer Concrete

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Abstract*: *Elimination of cement in concrete was found to get increased with the introduction of geopolymer concrete. In that geopolymer concrete, natural aggregate was replaced by artificial thermal ash aggregate. The mix design was arrived by trail. The replacement level of artificial aggregate was 20, 40, 60, 80 and 100 percentages by weight of natural aggregate. The results of workability and mechanical properties of the mixes are find to be good. About 135% in compressive strength, 15% in split tensile strength and 987% in flexural strength was find to be increased.

Keywords*: *Geopolymer concrete, Thermal ash aggregate, Artificial aggregate, Mechanical properties.

I. INTRODUCTION

The cementless silica based concrete was manufactured using the natural stone as coarse aggregate in recent years. Increase in cost of natural stone and destroying nature to obtain coarse aggregates become a huge disadvantage in concrete industry. It was found to have a low cost man made aggregate named thermal ash aggregate manufactured from thermal ash powder. About 600 million tones of flyash was considered as waste in worldwide annually. Utilizing thermal ash aggregate in concrete also reduces the environmental pollution due to thermal ash.

The production of one ton of cement emits approximately one ton of carbon dioxide to the atmosphere. [1] Geo polymer concrete based on industrial by-product material such as fly ash and GGBS (Ground Granulated Blast Furnace Slag) can play a vital role in the context of sustainability environmental issues. [2] The replacement of Portland cement with GGBS will lead to significant reduction of carbon dioxide gas emission. [3]There are two main constituents of geo polymers, namely the source materials and the alkaline liquid. By-product materials such as fly ash, slag could be used as a source materials . And the alkaline liquid used in geo polymerization is a combination of sodium hydroxide and sodium silicate. [4] In fly ash based geo polymer concrete, the silica and the alumina present in the source materials are first induced by alkaline activators to form a gel known as alumina silicate. This gel binds the loose aggregates and other unreacted materials in the mixture to form the geo polymer concrete. [5] Curing conditions had a significant effect on the mechanical behaviour in the hardened state of alkali activated slag paste. [6]

Thermal ash aggregate with uniform size, surface roughness and light weight are considered to be advantages in utilizing it in concrete. The cement binded thermal ash aggregate performed good in mechanical property. This work gives the performance of geopolymer material, thermal ash aggregate, M-sand combination in fresh and hardened state..

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II. PROPERTIES OF MATERIALS USED

A. Flyash

Thoothukudi thermal power plant flyash with specific gravity 2.34 and fineness modulus 2.73 is used.

B. GGBS

Well ground GGBS with specific gravity 2.9 and fineness modulus 3.75 was purchased from salem steel industries.

C. Sodium Silicate

Glass silicate from covai seenu industries was purchased with the specific gravity of about 1.3. Water of 55%, silicon di oxide of 55% and 15% for sodium oxide occupies their positions in sodium silicate solution respectively.

D. Sodium Hydroxide

Medium pure pellets are purchased and diluted in water to get 10 M solution.

E. Fine Aggregate

Specific gravity of fine aggregate is 2.67 and fineness modulus is 2.73. Bulk density is 1668 kg /m^3

F. Coarse Aggregate

The coarse aggregate 20 mm size is used .The specific gravity and fineness modulus are respectively 2.62 & 6.45.The bulk density is 1765 kg /m^3

G. Thermal Ash Aggregate

Purchased from TAA Manufacturers, Andhra. 20 mm size with a bulk density of 800kg/m3 is used.

H. Superplasticizer

High range superplasticizer namely Glenium sp 430G, a product of BASF was used

III. EXPERIMENTAL INVESTIGATION

A. Mix Proportioning

Hardjito and Rangan (2005) have noted that unlike conventional cement concrete geopolymer concrete are a new class of construction materials and therefore no standard mix design approaches are yet available for GPC. Therefore the trial mix design was adopted .The unit weight of concrete is 2400 kg/m3. Take the mass of combined aggregate is 75% of mass of the concrete (i.e) 0.75x2400 = 1800kg/m3. The mass of 20mm coarse aggregates (65%) may comprise 1170 kg/m3 and the mass of fine aggregate 630kg/m3 are to be taken. For the trial mixture, the ratio of sodium silicate to sodium hydroxide and liquid to fly ash are respectively 2.5 & 0.5.

Table 1 Materials required (kg/m3)

Mix No	Flyash	Na2Sio3	Na2oH	Fine Aggregate	Coarse Aggregate	GGBS	TMA	Superplast (%)	Water
1	400	140	60	850	1050	0	0	4	20
2	240	140	60	850	1050	160	0	4	10
3	240	140	60	850	840	160	210	4	10
4	240	140	60	850	630	160	420	4	10
5	240	140	60	850	420	160	630	4	8
6	240	140	60	850	210	160	840	4	8
7	240	140	60	850	0	160	1050	4	8

Note : Water is added accordingly to have 100mm slump value.

Here in this mix design GGBS was added to alter the setting time and to increase the strength. About 40% of GGBS was replaced for flyash to have the setting time as similar to cement concrete. Also the coarse aggregate was replaced by thermal ash aggregate as 20, 40, 60, 80 and 100% respectively by its weight. The table shows the mixes and the proportion of materials per cubic meter.

B. Fresh Concrete Property

Slump test is conducted to access the fresh concrete property. A slump value of 100mm was kept as fixed. Initially, to achieve the fixed slump, the quantity of water required was high (20kg/m3). But by introducing GGBS and thermal ash in concrete reduces the water requirement in getting the specified slump value. This may happens due to the low water absorption capacity of artificial aggregate. Anyhow the quality of concrete is fresh state never met any segregation or fast setting.

C. Preparation of test specimens

Concrete cubes of size150mm x150mmx150mm were prepared to analyse their compressive strength. Cylinders of 150 x 300 mm size was cast to know the split tensile strength of each mix. Prism of size 100 x 100 x 500 mm was prepared to obtain the flexural strengths of each mixes. The cast specimens are demoulded on the next day of casting. It is observed that the geopolymer concrete specimens without GGBS was not achieved its setting properly. It was checked by making a small tear over the specimens surface with a nail. But the other mixes attained the setting as similar to cement concrete. The specimens were kept in open air till 7, 14 and 28 days respectively from the date of casting for testing.

D. Hardened concrete properties

Compression strength, split tensile strength and flexural strength tests are carried out to find the mechanical properties of the concrete. A minimum of three samples are tested for each mix while considering a test. The compression and split tensile test are carried out using a compression testing machine of 2000kN. Flexural strength test was carried out using a Universal testing machine of 400 kN capacity.

IV. EXPERIMENTAL OUTPUTS

The obtained results are in table 2. The average stress value of three samples per mix is taken, tabulated, and plotted.

Table 1 Compressive Strength (N/mm^2)

Mix No	Compressive Strength (N/mm^2)		
	7 Days	14 Days	28 Days
1	11.70	14.94	18
2	23.40	29.88	36
3	23.70	30.20	36.50
4	23.70	30.20	36.50
5	24.80	31.70	38.30
6	25.60	32.70	39.45
7	27.10	34.60	41.70

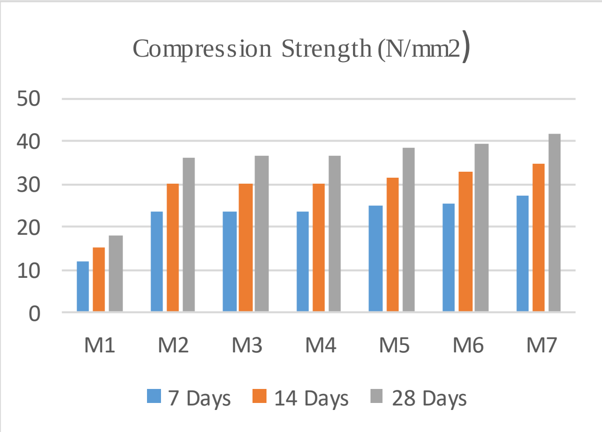

Fig 1 Compressive Strength results

Table 2 Split Tensile Strength (N/mm^2)

Mix No	Split Tensile Strength (N/mm^2)		
	7 Days	14 Days	28 Days
1	0.75	0.95	1.20
2	2.00	2.65	3.20
3	2.20	2.75	3.33
4	2.3075	2.95	3.55
5	2.34	2.95	3.60
6	2.34	3.00	3.60
7	2.3725	3.05	3.65

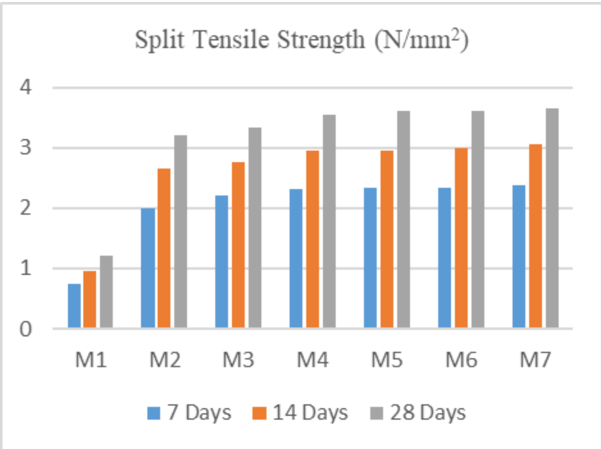

Fig 2 Split Tensile strength test results

Table 3 Flexural Strength (N/mm^2)

Mix No	Flexural Strength (N/mm^2)		
	7 Days	14 Days	28 Days
1	0.60	0.80	1.0
2	2.10	2.80	3.50
3	2.35	3.10	3.90
4	2.40	3.15	3.90
5	2.46	3.30	4.10
6	2.50	3.35	4.15
7	2.60	3.45	4.30

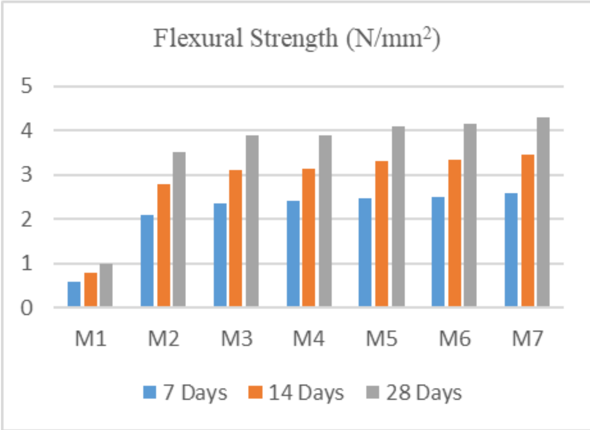

Fig 3 Flexural strength test results

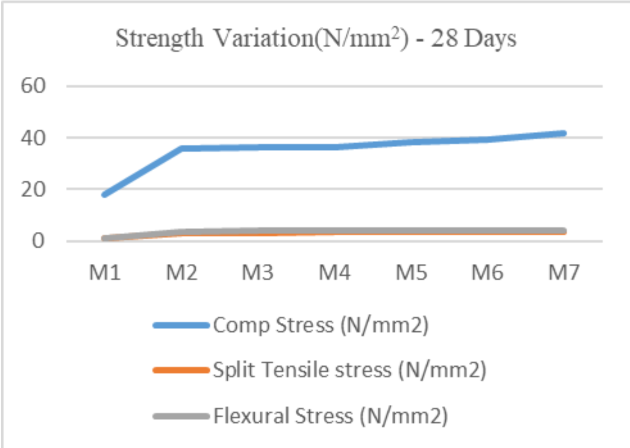

Fig 4 Compression of strength results

V. RESULT AND DISCUSSION

The contents of the journal are peer-reviewed and archival. The journal publishes scholarly articles of archival value as well as tutorial expositions and critical reviews of classical subjects and topics of current interest.

Authors should consider the following points:

A. *Compression Test*

Mix 1 given very low strength of 18 N/mm2 when compare to the other mixes. The addition of GGBS of 40 % in second mix for flyash improved the strength of about 150%. At the same time the involvement of artificial thermal aggregate fully in concrete increased the strength of about 25% when compared to mix 1 and 161% when compared to mix 2. The compression test results are given in table 2 and the variation of compression strength for the mixes are shown in fig 1.

B. *Split Tensile Strength Test*

Mix 1 given very low strength of 18 N/mm2 when compare to the other mixes. The addition of GGBS of 40 % in second mix for flyash improved the strength of about 150%. At the same time the involvement of artificial thermal aggregate fully in concrete increased the strength of about 25% when compared to mix 1 and 161% when compared to mix 2.

The compression test results are given in table 2 and the variation of compression strength for the mixes are shown in fig 1.

C. *Flexural Strength Test*

Mix 1 given very low strength of 18 N/mm2 when compare to the other mixes. The addition of GGBS of 40 % in second mix for flyash improved the strength of about 150%. At the same time the involvement of artificial thermal aggregate fully in concrete increased the strength of about 25% when compared to mix 1 and 161% when compared to mix 2. The compression test results are given in table 2 and the variation of compression strength for the mixes are shown in fig 1.

D. *Comparison of strengths*

VI. CONCLUSION

1. Flyash content in geopolymer concrete does not gives good strength.
2. GGBS in geopolymer concrete with 40% replacement of flyash increases compressive strength upto 125%. Similarly the split tensile strength and flexural strength of concrete are found to get increase upto 1651% and 164% respectively.
3. The thermal ash aggregate in geopolymer concrete also enhances its compressive strength upto 154% with 100% replacement of natural coarse aggregate. Similarly the split tensile strength and flexural strength of concrete are found to get increase upto 1651% and 164% respectively.
4. It is concluded from this work, that introducing the artificial thermal ash aggregate will increases the strength of geopolymer concrete.

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