Compare the Strength of Fly Ash Based Geopolymer Concrete with Demolition Waste

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Abstract

About 530 million tonnes of construction and demolition waste are generated every year in India. The disposal of this waste product is a very serious and hazardous problem as not only it requires huge space for its disposal but very little demolished waste is recycled or reused. On the other hand production of 1 ton of Ordinary Portland Cement emits 1 ton of CO_2 which being a greenhouse gas induces the global warming. In this study experimental investigations have been carried out to access the effect of Geopolymer Concrete(GPC) which comprises of fly ash, demolition waste and activators i.e. sodium silicate (53% concentration) and sodium hydroxide(96% Purity & Molarity -14) to enhance the binding property with a heat curing at temperature of 80°C. The study was carried out to check the suitability of this Geopolymer concrete in construction by replacing 100% aggregate. Geopolymer concrete mixes of ratios 1:1.75:3.25, 1:1:1.85, 1:1.35:2.85 were prepared. A different characteristic of GPC with demolished waste were studied such as compressive strength, split tensile strength, slump value and compared with that of conventional concrete. It has been shown that the 7 days compressive and split tensile strength of demolition waste and fly ash based Geopolymer concrete is comparatively 6 to 15 % lesser than conventional concrete. The study thus shows that demolition waste can be utilized by replacing aggregate 100% in GPC which simultaneously solves the disposal problem of these waste products.

Keywords —*GPC, alkaline solution, demolition waste, compressive strength, split tensile strength*

I. INTRODUCTION

A. General

The cost of construction materials is increasing day by day because of high demand, scarcity of raw materials, and the high price of energy. From the point of energy saving and conservation of natural resources, the use of alternative constituents in construction materials are now a global concern. For this, the extensive research and development work towards exploring new ingredients is required for producing sustainable and environmentally friendly construction materials. The present study investigates the potential use of various solid wastes in the production of construction materials. The traditional construction materials are being produced from the existing natural resources. This is damaging the environment due to continuous exploration and depletion of natural resources. Moreover, various toxic substances such as high concentration of carbon monoxide, oxides of sulphur, oxides of nitrogen, and suspended particulate matters are invariably emitted to the atmosphere during the manufacturing process of construction materials. The emission of toxic matter contaminates air, water, soil, flora, fauna and aquatic life and thus effects all form of life on earth. Therefore, the issues related to environmental conservation have gained great importance in our society in recent years (Xue et al., 2009). The decision-makers in various fields of politics, economics, and social sectors are now seriously offering more attention to the environmental issues. Consequently, major changes regarding the conservation of resources and recycling of wastes by proper management are taking place in our day to day life. Many authorities and investigators are lately working to have the privilege of reusing the wastes again in environmentally and economically sustainable ways (Aubert et al., 2006). The utilization of this solid waste product in construction materials is one of such innovative efforts and a subject under research.

B. Objective

The main objective of this study was:

- To determine the strength, properties of a fly ash based GPC.
- To investigate the potential use of demolition waste for producing construction materials.

- To replace 100% aggregates by demolition waste in the casting of a different grade of fly ash based GPC.

II. LITERATURE REVIEW

B. Vijaya Rangan (2014)[2] studied fly ash-based geopolymer and the paper describes the result of the tests conducted on large scale reinforced geopolymer concrete members and application of the geopolymer concrete in the construction industry. Shriram Marathe(2016)[3] in his paper briefly reviewed the constituents of geopolymer concrete, its strength, and potential applications. The test results indicate the excellent potential of geopolymer concrete to be a material of engineer's choice for the future. Tarun R Naik(2010)[4] in his paper has critically discussed the opportunities, limitations and future needs to develop GPC for producing a sustainable concrete. Jindal Bharat Bhushan(2013)[5] in his paper concluded that Geopolymer concrete shows a greener substitute over Ordinary Portland cement concrete in some applications. Robina Kouser Tabassum(2015)[6] in her paper presented a brief history and review of geopolymer technology with the aim of introducing the technology and the vast categories of materials that may be synthesized by alkali activation of aluminosilicates. J. S. Jayalakshmi(2016)[7] studied the potential of using demolition waste to produce lean-mix of cement concrete and geopolymer concrete. In this study, the lean concrete mixes were prepared in the ratio 1:6:8 with the cement content of 175 and 200 kg/m³, and geopolymer mix with 3M, 4M, 5M and 6M molar concentration. Preethy K Thomas(2015)[8] concludes that the use of demolished waste in Geopolymer concrete helps in reduction of environmental pollution, valuable landfill space and saving of natural resources. Alexander Vásquez(2016)[9] studied the synthesis of geopolymer based on alkaline activation of concrete demolition waste (CDW) and using sodium hydroxide and sodium silicate as alkaline activators. The result obtained in this study demonstrates the feasibility of using concrete demolition waste as precursors to obtain geopolymer cement.

III. MIX- PROPORTION

Based on the study, eight different mix proportions were formulated for making Geopolymer concrete specimen (Reference- Journal of Indian Road Congress, vol 76-2, paper no. 640, By H.S. Goliya, Jeetendra Ahirwar & Umesh Tiwari)[10] of which three mix proportions were adopted that yielded a satisfactory result. The ratios are shown in Table 3.1 given below

Table 3.1

For Fly Ash Based Concrete	Ratios(FA:Sand:CA)	Alkaline to Fly Ash Ratio	Sodium Hydroxide to Sodium Silicate Ratio
Mix-1	1:1.75:3.25	0.6	2.5
Mix-1	1:1.00:1.85	0.6	2.5
Mix-3	1:1.35:3.00	0.6	2.5

Fig 1. Mixture

IV. CURING OF SPECIMEN

After casting, the test specimens were kept for heat-curing at 80°C for 24 hours. For at least six hours, the test specimens were left in the moulds after curing in order to avoid drastic changes in the environmental condition. After remolding, the specimens were left to air-dry until the day of the test.

V. RESULT

A. Sieve Analysis and Grading of demolition aggregates

Table 5.1: Demolition waste Aggregate Grading

Sieve Size	All In Aggregate Passing (%)
80 mm	100
40 mm	92.59
20 mm	85.73
4.75 mm	49.29
0.60 mm	30..19
0.15 mm	8.54

B. Specific gravity of Demolition waste

The specific gravity of coarse aggregates at 27^0C = 2.8
The specific gravity of fine aggregates at 27^0C = 2.6.

C. Impact value test

Impact Value of Demolition Aggregate =12.26%

D. Slump Test Values

Table 5.2. Slump Value

1:1.75:3.25	SAMPLE 1	MEDIUM
	SAMPLE 2	LOW
	SAMPLE 3	MEDIUM
	SAMPLE 4	MEDIUM
1:1:1.85	SAMPLE 1	LOW

	SAMPLE 2	MEDIUM
	SAMPLE 3	MEDIUM
	SAMPLE 4	MEDIUM
1:1.35:3	SAMPLE 1	LOW
	SAMPLE 2	MEDIUM
	SAMPLE 3	LOW
	SAMPLE 4	MEDIUM

Table 5.3. Specifications for slump of concrete sample by IS:1199-1959

Workability	Slump(in mm)
Very low	0-25
Low	25-50
Medium	50-100
High	100-175

E. Compressive Strength of Concrete

The compressive strength test was conducted on the 2000 KN capacity compressive testing machine according to IS: 516-1959. The specimens used for this test were 150 X 150 X 150 mm cubes. Compressive strength test was carried out on the various mixes and keeping all other parameters constant after 7 days and 28 days of curing in case of cement concrete and 3 days and 7 days of curing in case of geopolymer concrete because as per past study after 7 Days the increase in compressive strength is negligible in GPC. Three grade of different concrete cubes i.e. (1:1.75:3.25), (1:1:1.85) and (1:1.35:3) were prepared. The compressive strength of conventional cement concrete is given in table 5.4 and shown in graph 1. The compressive strength of Geopolymer concrete with fresh aggregate is given in table 5.5 and shown in graph 2. The compressive strength of Geopolymer concrete with demolition waste aggregate is given in table 5.6 and shown in graph 3.Compressive strength of Geopolymer concrete with mix aggregate is given in table 5.7 and shown in graph 4.

Table 5.4: Compressive strength of Cement concrete cubes (strength in N/mm²)

Ratio	7 days	28 days
1:1.75:3.25	29.78	42.22
1:1:1.85	37.44	48
1:1.35:3	39.11	55.55

Graph No. 1 Compressive strength of OPC based Concrete

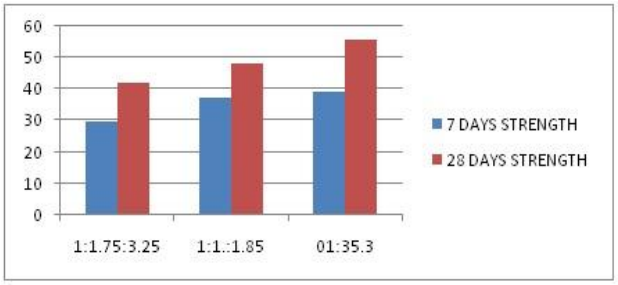


Table 5.5: Compressive strength of Geopolymer concrete with fresh aggregate cubes (strength in N/mm²)

Ratio	3 days	7 days
1:1.75:3.25	22.88	27.77
1:1:1.85	26.44	35.11
1:1.35:3	29.55	36.88

Graph No. 2 Compressive strength of Geopolymer concrete with fresh aggregate cubes (strength in N/mm²)

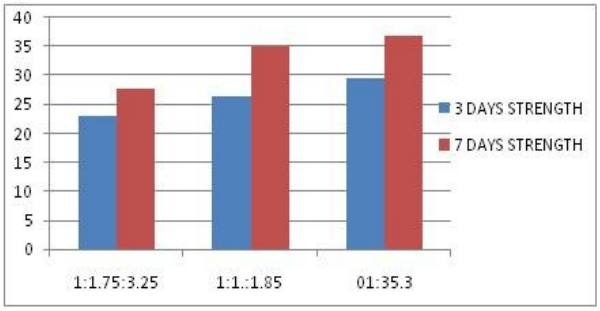


Table 5.6: Compressive strength of Geopolymer concrete with demolition waste aggregate cubes(strength in N/mm²)

Ratio	3 days	7 days
1:1.75:3.25	19.44	23.44
1:1:1.85	24.22	30.33
1:1.35:3	26.11	32.22

Graph No. 3 Compressive strength of Geopolymer concrete with demolition waste aggregate cubes(strength in N/mm²)

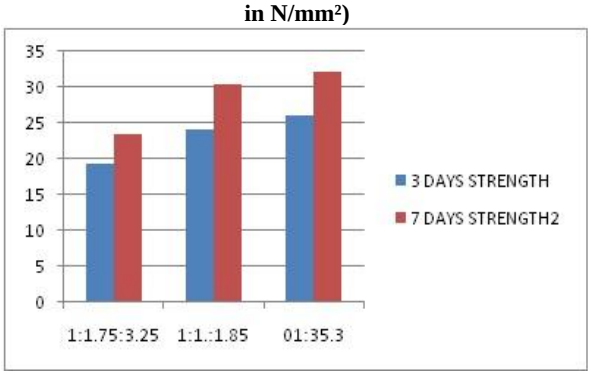


Table 5.7: Compressive strength of Geopolymer concrete with mixed aggregate (FA+DM) cubes (strength in N/mm²)

Ratio	3 days	7 days
1:1.75:3.25	18.22	25.11
1:1:1.85	26.11	33.33
1:1.35:3	29.88	34.66

Graph No. 4 Compressive strength of Geopolymer concrete with mixed aggregate (FA+DM) cubes (strength in N/mm²)

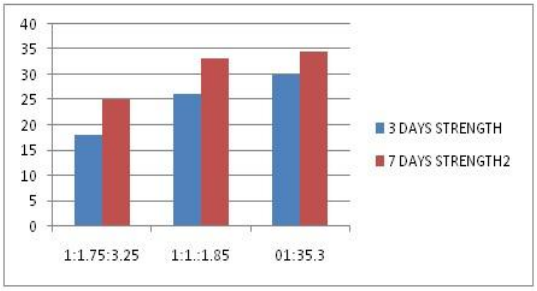


Table 5.8: Comparison of Compressive Strength (7days)

1:1.75:3.25	7 DAYS	REMARK
CCT	29.78	7.23% more
GEO. + FA	27.77	-
GEO. + DM	23.44	15.6%less
GEO. + MIX	25.11	9.58%less
1:1:1.85	7 DAYS	REMARK
CCT	37.44	6.63% more
GEO. + FA	35.11	-
GEO. + DM	30.33	13.62%less
GEO. + MIX	33.33	5.07%less
01:1.35:3	7 DAYS	REMARK
CCT	39.11	6.04% more
GEO. + FA	36.88	-
GEO. + DM	32.22	12.63%less
GEO. + MIX	34.66	6.02%less

Table 5.9: Split Tensile strength of Cement concrete cylinder (strength in N/mm²)

Ratio	7 days
1:1.75:3.25	3.17
01:01.8	3.49
01:35.3	3.68

Table 5.10: Split Tensile strength for Geopolymer concrete with fresh aggregate cylinder (strength in N/mm²)

Ratio	7 days
1:1.75:3.25	3.1
01:01.8	2.89
01:35.3	2.97

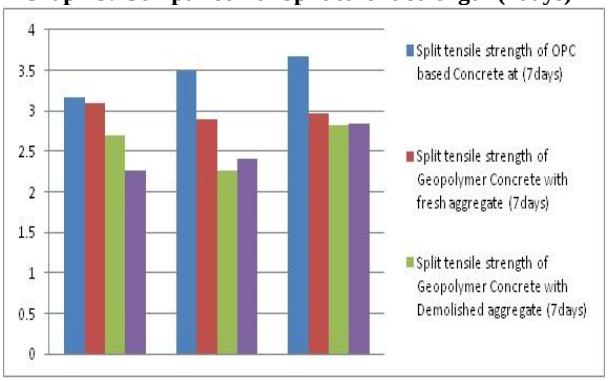
Table 5.11: Split Tensile strength for Geopolymer concrete with demolition waste aggregate cylinder (strength in N/mm²)

Ratio	7 days
1:1.75:3.25	2.7
01:01.8	2.26
01:35.3	2.83

Table 5.12: Split Tensile strength for Geopolymer concrete with mixed aggregate (FA+DM) cylinder (strength in N/mm²)

Ratio	7 days
1:1.75:3.25	2.27
01:01.8	2.41
01:35.3	2.84

Graph 5: Comparison of Split tensile strength (7days)



VI. CONCLUSION

From the above test results, it is observed that the slump value of geopolymer concrete decreases with use of demolition aggregate as a fresh aggregate. Impact value of demolished aggregate is 12.26%. The compressive strength of fly ash based geopolymer concrete decreases with 100% replacement of fresh aggregate with demolished aggregate about 12-15% whereas if the combination of both fresh and demolished aggregate is used, then there is the decrease in strength of about 5-10%. The split tensile strength also decreases with the use of demolished waste

aggregate as shown in graph 5. Thus flyash based geopolymer concrete can be used with demolished waste aggregate as a construction material with a 100% replacement of materials used in conventional concrete and thus provide the solution for the disposal problem of waste products.

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