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INVESTIGATION ON STRENGTH PROPERTIES OF FLYASH BASED GEOPOLYMER CONCRETE AND PARTIAL REPLACEMENT OF FINE AGGREGATE WITH M-SAND

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ABSTRACT

Concrete is one of the most vital building materials subsequent to the water. Day by day demand of concrete is escalating with rising demand on infrastructural development, but due to the emission of a considerable quantity of CO2 throughout the course of the production of cement is the principal issue concern with environmental pollution. The output of ordinary Portland cement adds about 5 to 7% of total greenhouse gas emission. As a result, it is essential to discover a substitute for cement. Fly ash is a waste material which is comprised of a great volume of silica and alumina. Fly ash is also a by-product of coal received from the thermal power station. In this research work, fly ash is employed to produce geopolymer concrete. Geopolymer is a cement-free concrete which is produced when silica and alumina react chemically with the alkaline solution. In geopolymer, fly ash function as a binder and alkaline solution function as an activator. The natural river sand has a huge demand in the developing countries to meet the active infrastructure growth. In this circumstance, emerging country like India facing a deficit in the sound quality natural sand. To minimize these difficulties, recently Manufactured sand is employed as a partial replacement with natural river sand. Fly ash and alkaline chemical activator undergo geopolymerization process to make aluminosilicate gel. In this study, fly ash based geopolymer concrete is developed with partial replacement of river sand with M-sand at various percentage replacements from 0 to 100%. An alkaline solution with 2:5 ratio of sodium silicate and sodium hydroxide was used in this research work. The strength behaviors of the geopolymer concrete enhance with rising the percentage replacement of M-Sand.

Keywords: *M-Sand, Alkaline Liquids, Geopolymer, Fly Ash*

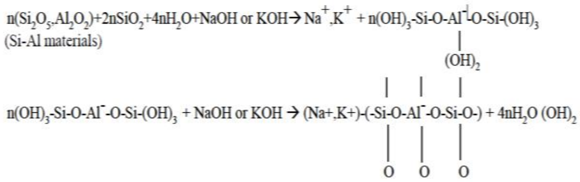
INTRODUCTION

Production of cement releases about one ton of carbon dioxide in the course of the production of one ton of cement. Alongside, coal-burning power production plants deliver a tremendous volume of fly ash. Most of the fly ash is perceived as waste and discarded as landfills (Amnon and Hadassa 2006). The growth of fly ash based geopolymer concrete is in response to the need for greener concrete. The overflowing availability of fly ash worldwide designate a chance to employ this by-product of burnt coal as a replacement for Portland cement. (Abdul Aleem and Arumairaj 2012)

In developing nations, the necessity of natural sand is very high. Specifically, in India, natural sand sediments are getting depleted and causing a severe threat to the society. Increasing extraction of natural sand from river beds generating many environmental issues (Jaarsveld, 2003). Nowada y's sand is becoming an extremely scarce material, in this scenario research began for affordable and readily obtainable alternative material (Wallah and Rangan 2006). Manufactured sand tenders a sustainable substitute to river sand, and it is developed by crushing, screening and washing process. (Hardjito and Wallah 2004, Abdul Aleem and Arumairaj 2012, Hardjito et al., 2002, Monita and Nikraz 2011, Wallah and Rangan 2006).

POLYMERISATION PROCESS

The development of geopolymer process in concrete can be shown as



MATERIALS USED

The material utilised in this present study was fly ash as source material, alkaline liquids, course & fine aggregates & water. M30 grade concrete was deemed in this study.

a) Fly ash: Table 1 shows the chemical composition of the flyash used.

Table 1: Chemical Compositions of Flyash

Component	% Composition
SiO_2	57.3
Al_2O_3	27.13
Fe_2O_3	8.06
MgO	2.13
SO_3	1.06
Na_2O	0.73
CaO	0.03
LOI	1.60

b) Alkaline liquids: A mixture of Sodium hydroxide solution & Sodium silicate solution was used as alkaline activators for geopolymerization. For this test program Sodium hydroxide solution was made by dissolving 98% pure NaOH in distilled water.

c) M Sand: M-sand having a specific gravity of 2.85 and fineness modulus of 2.79 was used in this study.

d) Coarse Aggregates and Sand: Locally available 20 millimetre size nicely graded coarse aggregate were chosen for current work. The numerous attributes of coarse aggregate were determined and tabulated in Table 2 and 3

Table 2: Properties of Coarse Aggregate

Prop.	Specific Gravity	Fineness Modulus	Bulk Density	Absorption	Surface moisture
Value	2.72	6.42	1602 kg/ m^3	1.20%	0.12%

Locally available sand in the kind of natural sand from the reference was used as the fine aggregate (FA). The sand has been analyzed for its passing ability in the 4.75-millimetre sieve. The evaluation results for the physical properties of are exhibited in Table 3

Table 3: Properties of Sand or fine aggregates

Prop.	**Specific Gravity**	**Fineness Modulus**	**Bulk Density**	**Absorption**	**Surface moisture**
Value	2.64	3.29	1782 kg/m^3	1.72%	0.10%

e) Mix proportion

Table 4: Mix proportion for M30 grade concrete

Material description	**Quantity (kg/m^3)**	**Proportion**
Flyash	408	1
NaOH	70.75	0.35
Na_2SiO_3	70.75	
Fine aggregate	658.12	1.61
Coarse aggregate	1256.42	3.08
Water	65.82	0.16

I. MIXING AND CURING

Mixing of the geo polymer concrete was performed in the lab at room temperature level. The fly ash and aggregates are first blended together and then the alkaline solutions which have been made one day before and super plasticizer were added to the mix of fly ash and aggregates. The blending of the overall concrete mass was continued till the binding paste covered all the aggregates and the mix end up being uniform in colour. The samples were prepared in accordance with the system suggested by Hardjito et al., (2002).

STRENGTH PROPERTIES: In this research work the strength properties of the geo polymer concrete are investigated with oven drying curing at 60 degrees Celsius up to 90 days curing. The value of NaOH/Na_2Sio_3 is preserved at 2.5. The test results were shown in the following tables.

Table 5: Average compressive strength of geopolymer concrete

Specimen description	**Average Compressive strength (N/mm^2)**				
	3 days	**14 days**	**28 days**	**56 days**	**90 days**
GC0MS	16.21	34.15	38.81	45.51	47.86
GC20MS	15.98	35.22	39.94	47.93	49.91
GC40MS	16.84	37.06	42.11	49.83	52.62
GC60MS	17.22	37.81	42.85	51.42	53.75
GC80MS	17.41	38.23	43.44	52.11	54.31
GC100MS	17.85	39.22	44.63	53.55	56.04

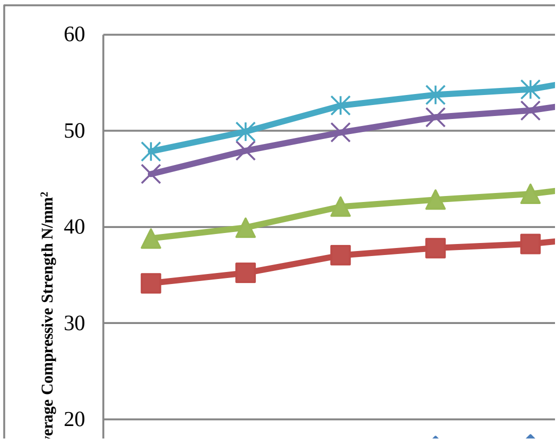


Fig. 2: Average Compressive Strength results

Table 3: Average Split Tensile Strength of geopolymer concrete

Specimen description	**Average Split tensile strength (N/mm^2)**				
	3 days	**14 days**	**28 days**	**56 days**	**90 days**
GC0MS	1.62	2.89	3.55	3.83	3.92
GC20MS	1.59	2.93	3.61	3.91	4.06
GC40MS	1.64	3.01	3.76	4.04	4.21
GC60MS	1.67	3.14	3.81	4.11	4.28
GC80MS	1.75	3.23	3.98	4.21	4.49
GC100MS	1.82	3.41	4.19	4.28	4.71

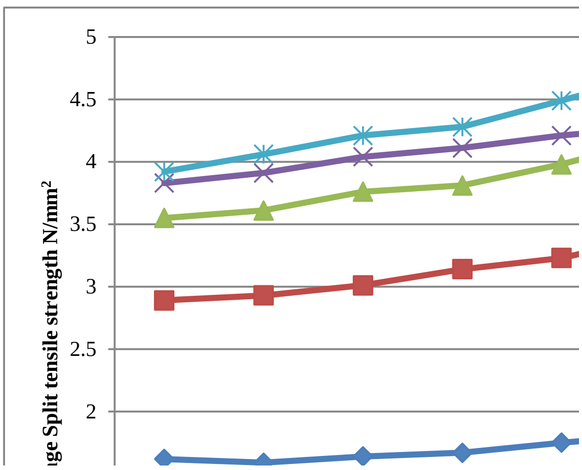


Fig. 3: Average Split tensile strength results

Table 4: Average flexural strength of geopolymer concrete

Specimen description	Flexural strength (N/mm^2)				
	3 days	14 days	28 days	56 days	90 days
GC0MS	2.71	5.76	6.54	6.98	7.22
GC20MS	2.82	6.04	6.81	7.32	7.56
GC40MS	2.88	6.21	7.05	7.75	7.83
GC60MS	2.96	6.48	7.35	8.08	8.19
GC80MS	3.11	6.77	7.69	8.29	8.58
GC100MS	3.29	6.92	7.85	8.61	8.73

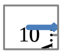


Fig. 3: Average flexural strength results

DISCUSSIONS AND CONCLUSIONS

From the experimental investigations, the following conclusions are drawn:

- Geopolymer concrete made with fly ash could be successfully utilized rather than traditional concrete to reduce the cement usage without endangering the strength specifications which undoubtedly only lower numerous environmental concerns.
- Geopolymer concrete made with M-sand reveals far better results compared to the geopolymer mix made with natural river sand. 100% substitute of M-sand with natural river sand was additionally viable without decrease a in strength qualities.
- The GC100MS compressive strength was 14.99% greater compared to that of the conventional geopolymer concrete.
- The GC100MS split tensile strength was 18.02 % higher than the traditional geopolymer concrete.
- The GC100MS flexural strength was 20.03% higher than the standard geopolymer concrete.

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