Strength Study on Fly Ash Based Geopolymer Concrete with Partial Replacement of Fly Ash Using Waste Granite Powder and GGBS

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***Abstract*— This study is to investigate about strength properties of M35 grade fly-ash based geopolymer concrete by using granite powder and GGBS as a partial replacement to fly-ash. Geopolymer concrete (GPC) is 100% cement less. Laboratory tests were carried out and the conclusion was made based on the results from mechanical properties such as compressive, tensile, flexural strength, and ultrasonic pulse velocity test of geopolymer concrete.**

Index Terms: **Low calcium fly ash, GGBS, Geopolymer concrete, Granite powder, Mechanical properties.**

I.INTRODUCTION

Geopolymer Concrete in recent years has drawn serious attention of researches and investigators because of the concept of thinking "Environmentally eco friendly". It is a substitute for OPC and emit lower CO2.

Geopolymers is introduced by Davidovits. Geopolymer is a type of amorphous alumino-silicate material. Geopolymer is used as binder, instead of cement paste, to produce concrete binds the loose coarse and fine aggregate and other unreacted materials together to form geopolymer concrete.For the alkaline liquid activator, combination of sodium hydroxide NAOH) solution and sodium silicate solution was used. Geopolymer are formed when various alumina and silica containing materials react under highly alkaline conditions and forms a three dimensional network of Si-O-Al-O bonds.

II. LITERATURE REVIEW

1) Vishnu Ramesh, Annie Joy (2017) presented the investigation carried out to study of fly ash based geopolymer concrete. Large amount of CO2 emission takes place due to the increase in the production of cement. To overcome this problem, experiments were done to find out optimum strength of concrete by replacing the cement with fly ash. Geopolymer concrete were synthesized from fly ash, activated by combination of alkaline solution (sodium hydroxide and sodium silicate or potassium hydroxide and potassium silicate).

2) Sourav Kumar Das Present research is focused on the different parameters which are curing temperature, ratio of sodium silicate to sodium hydroxide, molarity of sodium hydroxide, curing type and the results have been studied and discussed. The ratio of sodium silicate solution to sodium hydroxide solution by mass was kept fixed at 2.5 and the concentration of sodium hydroxide was kept 14M. The ratio of fly ash to alkali solution was kept 0.35 & 0.40.

3) RajatSaxena, Trilok Gupta, Ravi K. Sharma & N. L. Panwar (2021)This research has focused on efficacious reutilization of granite waste in the preparation of fly ash-based geopolymer concrete. Granite waste was reutilized as fractional replacement of natural fine aggregates (sand) in varied proportions from 0 to 20% by weight in 5% incremental order.

III. GEOPOLYMERS

Geopolymer is a type of amorphous alumino-silicate material. Geopolymer can be synthesized by polycondensation of geopolymer precursor, and alkali polysilicates. Geopolymer is used as a binder, instead of cement paste, to produce concrete binds the loose coarse and fine aggregate and other

unreacted materials together to form geopolymer concrete.

Geopolymers are inorganic materials of cementitious nature. Geopolymer are formed when various alumina and silica containing materials react under highly alkaline conditions and forms a three dimensional network of Si-O-Al-O bonds. The most commonly used raw materials for geo-polymer are clay and metakaolin. The recent interest is in use of waste and by-products for Geo-polymerization from waste utilization and resource conservation points of view.

IV. MATERIALS

A.Fly ash:

Class F type-low calcium fly ash conforming to ASTM C 618 obtained from lignite burning thermal power station was collected in dry state from Mettur Thermal Power Station (MTP), Salem, Tamil Nadu and used for making concrete. Specific gravity of fly ash is about 2.27. Chemical composition of fly ash used is listed in table below

S.no.	Component	Weight%
1	SiO_2	61.30
2	Al_2O_3	29.40
3	K_2O_3	1.20
4	MgO	0.75
5	CaO	1.21
6	Fe_2O_3	3.27
7	SO_3	0.003
8	TiO_2	0.01
9	Na_2O	0.73
10	Cl	0.04
11	LOI	0.67

Chemical composition of fly ash

B.Ground Granulated Blast Furnace Slag (GGBS):

Ground Granulated Blast Furnace Slag conforming to IS 12089-1987 with specific gravity of GGBS is about 2.76 was used for the study. Chemical composition of GGBS used is listed in table below.

S.no.	Component	Weight%
1	SiO_2	33.77
2	Al_2O_3	13.24
3	Fe_2O_3	0.65
4	MgO	8.46
5	CaO	33.7
6	MnO	0.05
7	Sulphidesulphur	2.23
8	Sulphitesulphur	0.23
9	Total chlorides	0.01

Chemical composition of GGBS

C. Coarse aggregate:

Crush gravel aggregate conforming to IS 383-2016 of maximum size 20mm was used for the study. Physical properties of coarse aggregate is listed in table below.

S.No.	Parameter	Value
1	Bulk density	1480kg/m^3
2	Specific Gravity	2.94
3	Water absorption	1%
4	Crushing value	18.3%
5	Impact Value	19.69%
6	Fineness modulus	6.90

Physical properties of coarse aggregate

D. Granite Powder:

Replacement material for fly ash in geopolymer concrete. Physical properties of granite powder are listed in table below

S.No.	Parameter	Value
1	Specific gravity	2.66
2	Consistency	33%
3	Fineness	6%

Physical properties of granite powder

E. M sand:

M Sand of maximum size 4.75mm conforming to Zone II of IS 383-1970 was used as fine aggregate. Physical properties of M Sand are listed in table below.

S. No.	Parameter	Value
1	Bulk Density	1.75kg/m^3
2	Specific Gravity	2.59
3	Water Absorption	0.5
4	Fineness Modulus	2.95

Physical properties of M sand

V.MIX DESIGN

The following mix quantities are arrived for the M35 grade of geopolymer concrete.

Material	Quantity
Blinder Content	445.53kg/m^3
Fine Aggregate	629.603kg/m^3
Coarse Aggregate	1216.89kg/m^3
Alkaline Solution	191.58kg/m^3
Solution to Blinder ratio	0.43

Materials

VI .EXPERIMENTAL WORK

A. Mixing:

Mixing procedure is also same as convention concrete. Initially we have to prepare the Sodium Hydroxide and mix it with sodium silicate solution a day before of casting. Initially all the materials are mixed in dry condition and then the alkaline solution was added to the dry mix and the mixing was continued until obtained the homogenous mix.

B. Casting:

Standard casting specimens such as cube size of 100mmX100mmX100mm, cylinder size of 100mm diameter and 200mm height, Prism size of 100mmX100mmX500mm were casted. After 24 hours, the specimens were demoulded.

C. Curing:

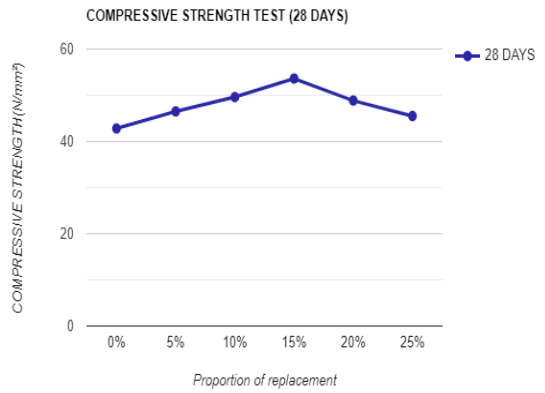
Geopolymer concrete specimens were subjected to ambient curing at a temperature of (32°C+2°C) for a period of 7 days and 28 days.

D. Testing:

Cubes casted were put for compressive strength test and cylinders casted were put for tensile strength test under Universal Testing Machine (UTM). Prisms casted were put for flexural strength test.

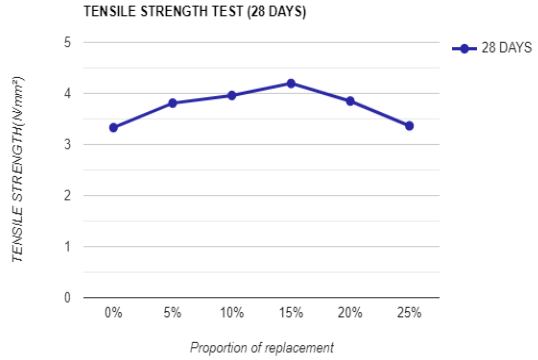
VII .RESULTS AND DISSCUSSION

A. Compressive strength test result:



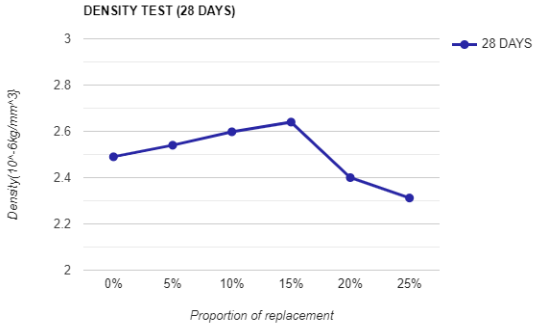
Compressive Strength of geopolymer concrete at 28 days

B. Tensile Strength Test Results:



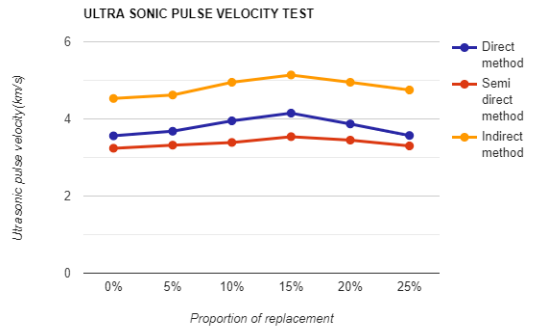
Tensile Strength ofgeopolymer concrete at 28 days

C. Density Test Results:



Density test of geopolymer Concrete at 28 Days

D. Ultra Sonic Pulse Velocity Test Results:



Ultrasonic Pulse velocity of geopolymer concrete at 28 days

VIII.CONCLUSION

This project work comprises of the study on the strength study of fly-ash based based geo-polymer concrete with partial replacement of fly ash using waste granite powder and GGBS. By concluding

from this, 15% replacement of Geopolymer concrete is more durable than 0% replacement of Geopolymer concrete without affecting the properties and strength of Geopolymer concrete.

- In the compressive strength test, 15% replacement of fly ash based geopolymerconcrete shows 25.28% increase in strength when compared to 0% replacement.
- In the tensile strength test, 15% replacement of fly ash based geopolymer concrete shows 25.97% increase in strength when compared to 0% replacement.
- In the flexural strength test, 15% replacement of fly ash based geopolymer concrete shows 42.13% increase in strength when compared to 0% replacement.
- In the density test, 15% replacement of fly ash based geopolymer concrete shows 6.06% increase in density when compared to 0% replacement.
- In ultrasonic pulse velocity test, 15% replacement shows excellent quality in indirect method and shows good quality in direct and semi-direct method.
- The slump value decreases with increase in proportion of replacement of granite powder and GGBS on fly ash based geopolymer concrete due to its fineness

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