STRENGTH STUDIES BY USING FLY ASH AND QUARRY DUST BY GEO-POLYMER CONCRETE

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Abstract:
Ordinary Portland cement is the primary source of binder used in the production of normal strength concrete. The production of Portland cement releases co_2 which causes many environment issues like global warming etc. To overcome this problem an alternative source of binding material fly ash is used to making polymer concrete .In this experimental study , we have used two alkaline liquids as binders, sodium hydroxide(12.5 M) and sodium silicate. A mix proportion of geo-polymer concrete is design as M30 grade. The strength parameters like compressive strength, split tensile strength, were found and compare the result with M30 grade of cement concrete.

Keywords: geo-polymer, fly ash, quarry dust, alkaline activators, ambient curing.

1. INTRODUCTION

Several research and investigations are in progress to reduce the use of Portland cement in normal strength concrete. Because the use of ordinary Portland cement in the construction industry is the major suppliers of co_2 emission in to the atmosphere which causes some environment issues.

In 1978, Joseph Davidovits a French material scientist coined the word “geo-polymer” Geo-polymer “in-organic polymer”. He suggested that an alkaline liquid can be used to react with the silicon (Si) and the aluminium (Al) in a source material by product materials such as fly ash to produce binders. In this experimental study the quarry dust are used to study the effect of different percentage of fibres on the strength of Geo-polymer concrete. As it is the waste material hence this is the way by which we can reduce the waste material in the environment. In this study low calcium (ASTM class F) fly ash is preferred as source material than high- calcium (ASTM class c) fly ash. Because the presence of calcium in high amount may interfere with polymerization process and prolonged the strength of Geo-polymer concrete. The aim of this study is to find the mechanical properties of Geo-polymer concrete developed under ambient curing .

2. OBJECTIVE OF STUDY

* To evaluate the optimum fly ash, quarry dust, percentage of geo-polymer concrete
* TO find compressive strength, split tensile, of geo-polymer concrete.

3. MATERIALS

3.1 FLY ASH

Fly ash is removed from the combustion gases by the dust collection system, either mechanically or by using electrostatic precipitators, before they are discharged to the atmosphere. The relative amounts of incombustible matter in the coal determine the chemical composition of fly ash. The chemical composition which presents mainly are oxides of silicon (Sio2), alumina (Al2o3), iron (fe2o3), and calcium (CaO), whereas magnesium, potassium, sodium, titanium, and sulphur are also present in a lesser amount .In the present experimental work, low calcium, fly ash (ASTM CLASS F) were collected from the Electrostatic precipitators of the SARNI THERMAL POWER PLANT IN M.P. (India), was used as the base material. It has a specific gravity of 2.15 with a particle size of 5-10um.

Figure 1. Fly Ash

Table 1 Chemical properties of Fly ash

S. No.	Particular	Proportion (%)
1	Silicon dioxide(SiO2)	67.35
2	Aluminium oxide (Al2O3)	22.80
3	Iron oxide(Fe2O3)	5.55
4	Calcium oxide (CaO)	1.21
5	Magnesium oxide(MgO)	0.07
6	Potassium oxide(K2O)	1.29
7	Sodium oxide(Na2O3)	0.0001
8	Titanium dioxide(TiO2)	1.38
9	Loss on ignition (LOI)	3.30

3.2 QUARRY DUST

Quarry dusts are also one of the main ingredients of the Geo-polymer concrete which helps in bonding between aggregate and fly ash properly. The size of Quarry dust is used in work is lower than 4.75mm sieve. IS:383 1963 defined the Quarry dust which will passes through 4.75mm IS sieve and retained over 75µM IS sieve is known as Quarry dust. Now-a-days the natural river sand has become scarce and very costly. Hence we are forced to think of alternative materials. The Quarry dust may be used in the place of river sand fully. The world wide consumption of fine aggregate in concrete production is very high, and several developing countries have encountered difficulties in meeting the supply of natural fine aggregate in order to satisfy the increase of infrastructural development in recent years. To overcome the stress and demand for river fine aggregate, researchers and practitioners in the construction industries have identified some alternative materials such as fly ash, slag, limestone powder and siliceous stone powder.

Figure 2 : Quarry Dust

Table2 Physical properties of quarry dust (IS: 2386-1963)

S. No.	Properties	Results
1	Type	Natural
2	Shape	Rounded
3	Size	4.75 mm
4	Specific gravity	2.60
5	Bulk Density (Kg/m^3)	1570
6	Moisture content	1.0%

3.3 Coarse Aggregate

Aggregate are the main ingredient of the concrete which gives the ultimate strength to the building.IS:383-1970 defined the Aggregate which is retained on 4.75mm IS sieve and containing only so much finer material as is permitted by is termed as coarse aggregate.20mm Sizes of coarse aggregate are chosen for the experimental work.

Figure 3 : Coarse Aggregate

Table 3 Physical properties of Coarse aggregate

S. No.	Properties of Material	Coarse Aggregates
1	Type	Crushed
2	Shape	Angular
3	Size	20 mm
4	Specific gravity	2.90
5	Fineness modulus	7.22
6	Bulk density (kg /m^3)	1681
7	Water absorption	0.5%

3.4 Alkaline activators

Combination of sodium silicate solution and sodium hydroxide solution was chosen as the alkaline activators. Sodium-based solutions were preferred because they were cheaper than potassium-based solutions.

A. Sodium Hydroxide (NAOH)

Generally the sodium hydroxides are available in solid state by means of pellets and flakes. The cost of the sodium hydroxide is mainly varied according to the purity of the substance. The sodium hydroxide (NAOH) solution was prepared by dissolving the flakes in water. The mass of NAOH solids in a solution varied depending on the concentration of the solution expressed in terms of molar(M). For example: 12.5 M = (12.5X40) = 500 gm of NAOH flakes/lit water.

Table.4 Properties of sodium hydroxide (NAOH)

Parameters	Properties
Chemical Formula	NAOH
Molecular weight	40 gms
Specific gravity	2.12

B. Sodium Silicate (Na2Sio3)

Sodium silicate also known as water glass or liquid glass, available in liquid (gel) and solid both form. In this study sodium silicate is used for the making of fiber reinforcedgeo-polymerconcrete.

Table.5. Chemical and Physical properties of sodium silicate(Na2S)

Parameters	Properties
Na2o	15.9%
Sio2	31.4%
H2o	52.7%
Specific gravity	1.6
Molar mass	122.06 g/mol

Fig4. Sodium hydroxide

Fig.5 sodium silicate

4.1 GENERAL

The aim of this research work is to develop fly ash based geo-polymer concrete of M-30 grade and study the effects of geo-polymer concrete . In this investigation the cement is replaced by 100 percent with fly ash .With concentrated sodium hydroxide solution of molarity 12.5M and keeping the solution to fly ash ratio by mass is 0.40 .Quarry dust are added in geo-polymer concrete. The entire specimen will be split tensile strength, of geo-polymer concrete have tested.

Quantity of material required per m^3 of geo-polymer concrete mix;

Table 6 Mix Proportion

Ingredients of GPC	Fly Ash	NAOH	Na2Sio3	Quarry Dust	Coarse Aggregates	Water
Quantity (kg/m^3)	405	81	81	670.92	1273.78	129.94

Solution to fly ash ratio by mass = 0.40

Fly ash: Quarry dust : Coarse aggregates Ratio = 1 : 1.65 : 3.15

4.2 Mix Proportion, Mixing, Casting, and Curing

Geo-polymer concrete was mixed along with fly ash and quarry dust. geo-polymer concrete was placed in to the standard mould in layer and compacted. Demoulding was done after 24 hours of casting and the specimens were cured under ambient heat curing at 28 days. After 28 days of ambient curing, the specimens were taken and testing is done.

Figure 6 Preparation of Material

Figure 7 Vibration of Cubes

5 RESULTS AND DISCUSSION

4.1.1COMPRESSIVE STRENGTH

Concrete cubes of size 150mmx150mmx150mm were casted for different percentage of waste steel scrap fibres contents from 0% to 2% and 3 cubes were used for each percentage. After 24 hours, the specimens were demoulded and subjected to ambient heat curing. After 28 days of ambient curing specimens were taken and tested in compressive strength testing machine.

Compressive strength (N/mm^2) = P/A where, P = Avg. load at failure (N), A= Cross-sectional area of specimen(mm^2).

From the test results it was observed that

GENERAL

The results of the tests which are specified in chapter 4 are given in the following tables with their corresponding graphs

RESULTS OF STRENGTH TESTS

4.1.1COMPRESSIVE STRENGTH

Table 7 Compressive Strength

Name of the mix	Compressive strength in N/mm^2 of specimens Cured By		
	7days	14days	28days
CC	18.6	23.4	27
GP1	19.23	23.6	27.5
GP2	20.26	24.2	28.2
GP3	21	25.2	29.4

5.2 Split tensile strength

For split tensile strength, the cylinder specimens of dimension 150mm diameter and 300mm length were cast. The specimens were remoulded after 24 hours of casting and were kept for ambient curing and that were allowed to cure for 28 days .these specimens were tested under compression testing machine.

Split tensile strength=2P/πDL

Where P = Applied load
D = Dia. of cylinder specimen
L = Length of specimens

Table 8 Split Tensile Test

Name of the mix	Split Tensile Test in N/mm^2 of specimens Cured By		
	7days	14days	28days
CC	1.7	2.25	2.87
GP1	1.9	2.34	2.74
GP2	2.2	2.47	2.85
GP3	2.3	2.52	2.96

5.3 Slump Test for Workability

Slump cone test was performed to determine the workability of geo-polymer concrete using standard size of slump cone apparatus as per IS :1199-1959

Table 9 Slump Test for Workability

S. No.	Name of the Mix	Workability in mm
1	Cc	65
2	Gp1	75
3	Gp1	82
4	Gp1	92

6. CONCLUSION

Based on the experimental work reported in this study, the following conclusions are drawn.

- Higher concentration (in terms of molar) of sodium hydroxide solution results in higher compressive strength of fly ash & quarry dust based Geo-polymer concrete.
- Longer curing time, in the range of 4 to 96 hours (4 days), produces higher compressive strength of fly ash & quarry dust based Geo-polymer concrete. However, the increase in strength beyond 24 hours is not significant.
- The fresh fly ash-based Geo-polymer concrete is easily handled up to 120 minutes without any sign of setting and without any degradation in the compressive strength.
- The mix GP3 gives higher compressive strength, as it has high morality of NaOH
- We Observe that the compressive strength is increased with the increase in the morality of the sodium hydroxide

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