



EXPERIMENTAL STUDY ON RISE HUSK ASH & FLY

ASH BASED GEO-POLYMER CONCRETE USING

M-SAND.

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ABSTRACT

Serious environmental problems by means of increasing the production of Ordinary Portland cement (OPC), which is conventionally used as the primary binder to produce cement concrete. An attempt has been made to reduce the use of ordinary Portland cement in cement concrete. There is no standard mix design of geo-polymer concrete, an effort has been made to know the physical, chemical properties and optimum mix of geo-polymer concrete mix design. Concrete cubes of 100 x 100 x 100 mm were prepared and cured under steam curing for about 24 hours at temperature range of 40°C to 60°C. Fly ash is replaced partially with rice husk ash at percentage of 10%, 15% and 25%. Sodium hydroxide and sodium silicate are of used as alkaline activators with 5 Molar and 10 Molar NaOH solutions. Natural sand is replaced with manufacture sand. Test results were compared with controlled concrete mix of grade M30. The results shows that as the percentage of rice husk ash and water content increases, compressive strength will be decreases and as molarity of the alkaline solution increases, strength will be increases.

Keywords: *geo polymer, fly ash, rice husk ash, alkaline solution, manufacture sand.*

I. INTRODUCTION

The applications of concrete in the field of infrastructure and transportation have greatly influenced the growth rate of economic progress and their quality of life. Though Ordinary Portland Concrete (OPC) is widely used in construction industry for many decades. About 1.5 tons of raw materials are required in the production of every tonne of Portland cement, on the other hand for about one tone of carbon dioxide is being released in to the environment, rich in green house increasing gasses like carbon dioxide (CO₂), carbon monoxide (CO) which are serious in increases the global warming.

Geopolymer cement was developed by Davidovits in the year of 1984 to 2008. Geo polymer is an alumino silicate material which binds the materials to-gether. Geopolymer technology is to reduce the use of Portland cement in cement concrete. The role of Ordinary Portland cement in geo polymer concrete is replaced by fly ash which also possesses pozzolanic properties same as of Ordinary Portland cement and rich with alumina and silicate. Fly ash is residue from the burnt coal which is widely available worldwide as a waste material and hazardous waste. The geo polymer concrete can be prepared by mixing fly ash using alkaline solution like Sodium Hydroxide (NaOH) or Potassium Hydroxide (KOH) and Sodium Silicate (Na₂SiO₃) or Potassium Silicate



(K₂SiO₃) and forms a gel which binds the fine and coarse aggregates, which produces hard compacting bonding material. This material possesses good engineering properties and durability in aggressive environments.

Polymerization is a process which takes place in geo polymer concrete mix. The geo-polymer can be characterized as three-dimensional inorganic polymer with a formula:

$M_n [-(Si-O)_z - Al-O]_n \cdot w(H_2O)$. Where n is degree of polymerization

The performance of concrete is usually determined by its strength and durability. For getting better quality of concrete, parameters like reduction of water content, fine and coarse aggregates should be well graded. Strength depends up on not only on grading of properties but also on better curing technique like, steam curing, ambient. For example, high alkaline solution content could significantly change the strength of the concrete in fly ash-based geo polymer concrete, aluminosilicate gel which is formed from sodium hydroxide and sodium silicate induces the silica and the alumina in the source materials. Physical and chemical properties of geo polymer concrete like strength, microstructure etc, differ with type of curing

To meet modern civilization requirements usage of natural sand has become high, in making concrete and mortar. Results the supply and demand of natural sand is very high. Usage of naturally occurring river sand deposits results most disaster problems like threat to environment, low laying areas during floods, vegetation, aquatic life gets disturbed, loosing of soil strata, level of water table gets reduces which seriously effects agriculture etc are some examples. Availability of natural sand with good quality is a serious problem in developing countries like India. Researcher and Engineers have come out with their own ideas to reduce partially or fully replacement of river sand and use recent bi-products, such as M-Sand (manufactured sand), robot silica or sand, stone crusher dust, filtered sand, treated and sieved silt removed from reservoirs.

An effort has been made to use rice husk ash as partial replacement of fly ash in different proportions to study the change in mechanical properties comparing to traditional Geopolymer concrete, The objective of this paper is to study about fly ash and rice husk ash geo polymer concrete

II. LITERATURE REVIEW

Optimum mix for the geo polymer concrete (M.I. Abdul Aleem and P.D. Arumairaj)⁽¹⁾. As percentage of fine and coarse aggregates increases the compressive strength increases up to optimum level. This happens due to high bonding in between the aggregates and alkaline solution at early stage of geo polymer concrete mix high strength is achieved. Sodium hydroxide (NaOH) and sodium silicate (Na₂SiO₃) are being used as alkaline solution with 0.35 ratio of alkaline solution to fly ash content.

Manufactured Sand, A Solution and an Alternative to River Sand and in Concrete Manufacturing (Dr.S.Elavenil and B.vijaya)² usage of m-sand in concrete mix improves higher flexural strength, compressive strength and lower permeability due to fillings the pores with micro fines.

III. MATERIALS AND PROPERTIES

A. Fly ash

For the development of geo polymer concrete class ASTM C fly ash collected from nuyvelli Thermal Power Station has been used. The chemical composition of fly ash as determined by XRF (weight percentage) is presented in table 1.

Table 1 chemical compositions of class c fly ash

Type of chemicals	% by weight
Silica	63.53
Alumina	27.40
Iron oxide	3.67
Calcium oxide	1.26
Magnesium oxide	0.35
Sodium oxide	0.19
Sulphur trioxide	0.01
Titanium dioxide	1.84
Potassium oxide	0.85

B. Rice husk ash

Rice husk is being collected from a latnam rice mill, Chennai, Which was burnt at uncontrolled conditions chemical and physical composition of RHA was listed in table 2.

Table 2 physical and chemical composition of RHA

Physical Properties	Values
Specific gravity	2.05
Fineness – median particle size, m	8.3
Nitrogen absorption, m ² /g	20.6
Water requirement, %	104
Pozzolanic activity index, %	99
Chemical Properties	
Silicon dioxide (SiO ₂)	90.7
Aluminium oxide (Al ₂ O ₃)	0.4
Ferric oxide (Fe ₂ O ₃)	0.4
Calcium oxide (CaO)	0.4
Magnesium oxide (MgO)	0.5
Sodium oxide (Na ₂ O)	0.1
Potassium oxide (K ₂ O)	2.2
Equivalent alkali (Na ₂ O+0.658K ₂ O)	1.5

Phosphorous oxide (P ₂ O ₅)	0.4
Titanium oxide (TiO ₂)	0.03
Sulphur trioxide (SO ₃)	0.1
Loss of ignition	4.8

C. Geo polymer liquids

Sodium hydroxide (NaOH) and sodium silicate (Na₂SiO₃) are commercially available with 97%-98% purity. Were NaOH is available in the form of pellets and Na₂SiO₃ is available in the form of liquid solution which is dark reddish in colour.

For getting a good dissolution of alkaline solution and as mixing of NaOH pellets with water produces large amount of heat which damages skin while mixing in order to overcome. Mixing of both the solution is done 24 hours before. mixing proportions of geo polymer liquids listed below in table 3

Table 3 geo polymer mixing proportions.

Materials	Mass(kg/m ³)	
Class C. Fly ash	550	550
Fine aggregates	510.2	510.2
Coarse aggregate (20 mm)	870.2	870.2
Sodium silicate solution	231.8	231.8
Sodium hydroxide	92.7	92.7
Molarity of NaOH solution	5 M	10 M
Water to solid ratio	0.20	0.20
Alkaline to fly ash	0.30	0.30
Aggregate to solid	3.50	3.50
Extra water	11	11

D. Specific gravity of materials

As standers materials are being replaced with experimental material, testing of specific gravity is required and values are listed in table no 4

Table 4 specific gravity details

S.no	Specific gravity
Fly ash	2.22
Rice husk ash	1.87
Fine aggregate (m-sand)	2.79
Coarse aggregate	2.6
NaOH pellets	1.66
Na ₂ SiO ₃ liquid	1.76

IV. EXPERIMENTAL SET UP

A. Proportions of rice husk ash and fly ash

As RHA was burnt under uncontrolled conditions partial replacement with rice husk is done which has binding properties. Proportions of RHA is listed in table 4

Table 5 proportions of RHA and fly ash

S.no	RHA%	Fly ash
1	0	100
2	10	90
3	15	85
4	25	75

B. Mixing with alkaline activaters

In mixing first fly ash, rice husk ash are mixed well and then NaOH solution is added, then it is mixed with coarse aggregates sodium silicate is added at last if required water content of 100ml is added. In mix one 10% of fly ash is replaced with rice husk ash, and same procedure is carried up to 15 and 25 %. Entire mix design is done with M 30

C. Casting

Casting of cubes is done in 100 mm cubes in 3 layers with 25 blows by tamping rod in each layer. 3 cubes are casted for each percentage as if total 24 cubes are casted.



a b

Fig 1(a and b) shows casting and mixing of geo polymer concrete in cubes.

D. Curing

Casting of cubes is done by making use of steam curing for 48 hours at 60⁰ C.

Under steam curing breaking of fly ash particles takes place which results formation of strong bond in between alkaline liquids, aggregates, fly ash. The content of silica and alumina is more in class C fly ash as compared to class F fly ash; therefore class C fly ash produces more strength because of its more fineness.

V. TEST RESULTS

A. Materials contents

Table.6 Concrete mix proportions for casting 3 cubes

Mix designation%	fly ash	RHA	F.A	C.A	H ₂ O	NaOH	NaSiO ₃
Mix 1	1.89	-	1.75	3.0	0.17	0.31	0.79
Mix 2	1.701	0.189	1.75	3.0	0.17	0.31	0.79
Mix 3	1.607	0.283	1.75	3.0	0.17	0.31	0.79
Mix 4	1.42	0.47	1.75	3.0	0.17	0.31	0.79

B. compressive strength with 5 and 10 Molar alkaline solutions

Testing has been done after 48 hours of steam curing with 2 days delay for curing.

Table 7 shows compressive strength with 5 Molarity

S.no	% RHA	Compressive strength (MPa)	
		5 Molarity	10 Molarity
1	0	27.9	30.1
2	10	26.2	28.4
3	15	22.8	24.9
4	25	15.3	19.3

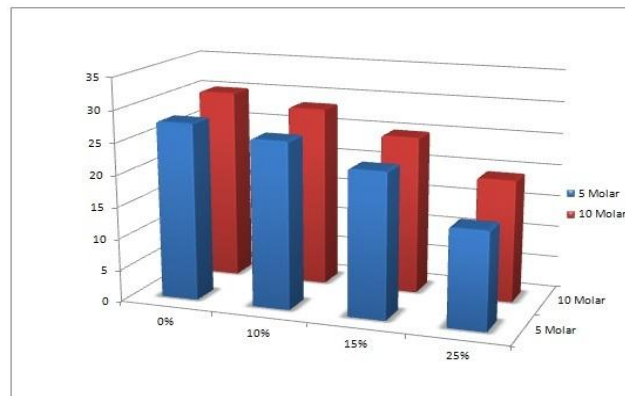


Fig 2. Above graph shows variation of compressive strength, strength along Y-axis and % of RHA along X-axis.

VI. CONCLUSIONS

Experimental results shows that as the percentages of rice husk ash increases then compressive strength decreases, Up to 10 and 15 % of fly ash can be replaced with rice husk ash, beyond that the bonding in between alkaline liquids, rice husk ash and fine aggregates is not so strong.

Strength obtained with no replacement of fly ash is nearly equal to 10% replacement with rice husk ash, that implies rice husk ash can also be used a alternate binder in geo polymer concrete

As the molarity concentration increases, compressive strength also increases, not only on molarity but also on temperature and number of days of curing. Compressive strength is directly proportional to temperature.

REFERENCES

- [1] M.I. Abdul Aleem and P.D. Arumairaj, "Optimum mix for the geo polymer concrete", 2012.
- [2] Andri Kusbiantoro a, Muhd Fadhil Nuruddin , Nasir Shafiq, Sobia Anwar Qazi, "The effect of rice husk ash on the compressive and bond strength of fly ash based geo polymer concrete", 2012.
- [3] Davidovits J "Geopolymer chemistry and applications. Institute Geopolymer, Saint-Quenti", 2008
- [4] Djwantoro Hardhat, Steenie E. Wallah, Dody M. J. Sumajouw, and B.vijaya Rangan, "On the Development of Fly Ash-Based Geopolymer Concrete", 2004.
- [5] Shankar H. Sanni, Khadiranaikar, R. B, "Performance of geo polymer concrete under severe environmental conditions", 2012.
- [6] M. M. A. Abdullah, K. Hussin, M. Bnhussain, K. N. Ismail and W. M. W. Ibrahim, "Mechanism and Chemical Reaction of Fly Ash Geopolymer Cement- A Review", 2011
- [7] Dr.S.Elavenil and B.vijaya, "Manufactured Sand, a Solution and an Alternative to River Sand and in Concrete Manufacturing", 2013.[8] Joseph DAVIDOVITS, "Application of Ca-based geo polymer with blast furnace slag, a review", 2011.