Effects of variation of temperature on strength of geopolymer concrete having stone dust replaced with foundry sand

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Abstract - *Construction is very important part of our life. Concrete is likely to use for construction. The production of OPC not only consumes significant amount of natural resources & energy but also releases large amount of CO_2 to the atmosphere. The CO_2 produced one tone for every tone of OPC produced. Therefore to make concrete environment friendly we have to find its alternative. This has led to the innovation of geopolymer concrete which is cement less concrete in which cement is totally replaced by pozzolanic material that is rich in silica & alumina and activated by alkaline solution to act as a binder.*

The main ingredients of geopolymer concrete are fly ash, foundry sand & alkaline solution. Fly ash is byproduct obtained from burning of coal in thermal power plants. The foundry sand is also a waste by product of metal foundries. When the sand can no longer be reused in the foundry, it is removed from foundry and is termed as "Foundry Waste Sand". We have partially replaced the stone dust with foundry sand. Both fly ash and foundry sand are waste materials that are available in bulk and are not easily disposed and require more land to dispose. Hence it is require that we have to make the efforts to utilize these waste materials in concrete manufacturing in order to make the concrete more environment friendly. In present research the effort made to see the effect of different temperature on various parameters of geopolymer concrete using foundry sand

Key words: Fly ash, foundry sand, stone dust, polymerization, compressive strength and alkaline solution.

1. INTRODUCTION

Concrete is normally used as structural material for all construction. Cement is the main ingredient in concrete that binds the component together and produced concrete. The environmental issues created with the production of OPC are well known. The CO_2 produced due to the calcination of limestone and combustion of fossil fuel which is dangerous for environment so this has led to the innovation of geopolymer concrete in which the cement is totally replaced with pozzolanic material which is activated by the alkaline solution to act as a binder. In addition, it consumes natural resources like limestone, shale, sandstone and requires more energy during production. After the production of steel and aluminium OPC is next most energy intensive material.
On the other hand, the abundant available fly ash is utilized (by-product of coal burning comes from thermal power plants) as a substitute for cement to develop concrete. The Davidovits develop binder in 1978, the binder produced by polymeric reaction between alkaline liquids like sodium silicate and sodium hydroxide with the geological origin (volcanic ash) or by-product materials those material contain silicon and aluminium.

1.1 GEOPOLYMER CONCRETE

In 1978, Davidovits proposed that an alkaline solution could be used to react with fly ash and rice husk ash that contain silicon and aluminium to produce binders. These binders are formed by polymerisation process. The alkaline solutions are sodium silicate, sodium hydroxide or potassium hydroxide and potassium silicate may be used. Davidots later in 1994, coined the term 'Geopolymer' to represent these binders. Geopolymer concrete is cement-less concrete gaining popularity globally towards the sustainable development. From the last years the OPC is being replaced with fly-ash.

1.2 FLY ASH BASED GEOPOLYMER CONCRETE

The fly ash is used instead of cement to produce geopolymer concrete (fig no. 1). Fly ash and alkaline solution is used to make binder which binds the coarse & fine aggregate. It's a new technology that reduces carbon dioxide emission to the atmosphere. Inspired by this new technology an attempt has been made to develop an alternative concrete binder or a substitute for cement by using the geopolymer technology and utilizing the fly ash as main ingredient to produce geopolymer concrete. Geopolymer concrete is designed same as cement, concrete design methods.
The main contents in fly ash those would be activated are silicon and aluminium. The fly ash mixed with an alkaline solution (the alkaline solution prepared by mixing sodium silicate and sodium hydroxide) and the binders are produced by polymerization. The aggregates are one of the important constituents which are responsible for strength development. Fine aggregates are those particles which pass through 4.75mm sieve eg: crushed stone and natural sand. From the crusher, stone dust and natural sand the river sand

is most commonly used as aggregate in concrete, which is becoming scarce and expensive due to the cost of transportation from their resources. So the foundry sand can be used and it is free of cost available and having an alternate to stone dust. Foundry sand is a byproduct of Metal foundries. Foundry sand is a waste material not easily disposed; it requires more land to dispose it. So we reuse foundry sand to make environmentally friendly concrete. It also reduces the demand of natural river sand and stone dust. This research was carried out to see the effect on properties of geopolymer concrete with partial replacement of foundry sand at different temperature.

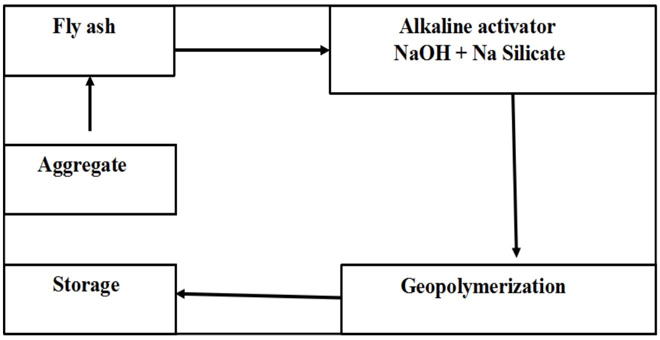

Figure-1 Process of making geopolymer concrete

1.3 APPLICATIONS

Geopolymer finds application in several structure and construction material as use pre-cast concrete products like railway sleepers, electric power poles, parking tiles, marine structures. Its property of resistance to chemical attack makes it useful for marine structures. The geopolymer concrete has better control on site as compared to OPC concrete.

2. LITRETURE SURVEY

[1] Djwantoro Hardjito et.al. (2004) concluded that increasing the concentration of NaOH solution resulting increase in strength and also increase in curing time, the curing time range is 6 to 96 hrs achieve higher strength of GPC.
[2] Djwantoro Hardjito et.al. (2004) concluded that the strength of concrete doesn't vary with age, and the strength increase with increasing curing time and curing temperature.
[3] Steenie Edward Wallah (2009) concluded that the heat-cured sample of geopolymer concrete undergo very low shrinkage
[4] N A Lloyd and B V Rangan et.al. (2010) conducted that geopolymer concrete has excellent properties. The economic benefits and contributions of geopolymer concrete to sustainable development have also outlined.
[5] K.A Anuar et.al. (2011) concluded that strength of geoploymer concrete based on waste paper sludge ash (WPSA) incorporating with recycle concrete aggregate increase by increasing the molarities of NaOH.
[6] M.A. Bhosale et.al. (2012) concluded that the geopolymer paste with NaOH concentration, compressive strength increase with molarities increases.

3. MATERIAL USED

a. **Fine aggregate**: Zone -II locally available sand is used to confirm to IS: 383-1970 having specific gravity 2.6 and fineness modulus of 2.95.
b. **Foundry sand**: foundry sand was used as a partial replacement of natural sand, 10%, 20%, and 30% having specific gravity 2.65 and fineness modulus 3.50. The foundry sand was obtained from DCM (Delhi Cloth Mills) Engineering Limited Ropar.
c. **Coarse aggregate**: locally available angular 20mm graded aggregates are used to confirm to IS:383-1970 having specific gravity 2.74.
d. **Water**: distilled water is used.
e. **Alkaline solution**: In this research Analytical Grade Sodium Hydroxide pellets and sodium silicate solution were used with 98% purity. The alkaline liquid is prepared by mixing both the solutions together. 1st of all sodium hydroxide pellets dissolved in distilled water. Sodium hydroxide and sodium silicate mixed together. The mass of NaOH solids in a solution varied depending on the concentration.
f. **Concentration of Sodium Hydroxide:** The mass of NaOH solids depend upon the concentration of the solution expressed in terms of molar, M. For 8M the concentration of solution is 8x40 = 320 grams of NaOH solid pellet per liter of the solution, where the molecular weight of NaOH = 40, similar as for other morality. Increasing molar concentration increase in the strength.

Table -1: Properties of coarse aggregates

Characteristics	Value
Shape	Angular
Maximum Size	20 mm
Specific Gravity	2.74
Grading ratio of 10mm to 20mm aggregate	1:1.5

4. DESIGN MIX FOR M40

Assume density of aggregate as unit weight of concrete = 2400 kg/m^3.
Mass of Combined aggregate = 75-80 %
Let we take 77% aggregate
2400 x 0.77% = 1848 kg/m^3
Mass of combined aggregate = 1848 kg/m^3
Mass of coarse aggregate = 1201.2kg/m^3 and mass of fine aggregate = 646.8kg/m^3
(As ratio of fine aggregate to total aggregate = .35)

Mass of Fly ash and alkaline Liquid = 2400 - 1848 = 552 kg/m^3
Let us take alkaline liquid to fly ash ratio as 0.4.
Now the mass of fly ash = (552)/ (1.4) = 394.28 kg/m^3
Mass of alkaline liquid = 552-394.28 = 157.21 kg/m^3
Let us consider the ratio of NaOH to Na_2SiO_3 as 2.5.
Now mass of NaOH solution = (157.21)/ (3.5) = 45.06 kg/m^3
Mass of Na_2SiO_3 solution = 157.21-45.06 = 112.64 kg/m^3

Table -2: Mixture proportion

Fly ash based geopolymer concrete for M 40					
Sr. No.	**material**	**0% replacement of foun. Sand**	**10% replacement of foun. Sand**	**20% replacement of foun. Sand**	**30% replacement of foun. Sand**
1	Fly ash	394.3	394.3	394.3	394.3
2	Stone Dust	646.8	582.12	517.44	452.76
3	Foundry sand	000	64.68	129.36	194.04
5	Coarse aggt.	1201.2	1201.2	1201.2	1201.2
6	NaOH	45.06	45.06	45.06	45.06
7	Na_2SiO_3	112.64	112.64	112.64	112.64
8	Molarity	16	16	16	16
	Ratio of mix. Prop.	1:1.64: 3.04	1:1.64: 3.04	1:1.64: 3.04	1:1.64: 3.04
	Liquid/binder Ratio	.40	.40	.40	.40

5. RESULTS

It can be concluded from this study that the curing temperature affects the strength of geopolymer concrete.

- The geopolymer concrete gives 90% strength at 7 days curing.
- In fly ash based concrete using foundry sand, the strength increased with increase in temperature up to a certain temperature (90°C).
- The compressive strength of fly ash based GPC concrete not gives good results in ambient curing. So heat curing is the better option than the ambient curing.
- The compressive strength of GPC using fly ash was found to be increasing with replacement of foundry sand. It was found that 10% replacement of foundry sand by stone dust gives more strength as compare to without replacement. Geopolymer concrete holds great promise as on eco-friendly.

Hence it could be summarized that the fly ash based concrete geopolymer concrete with partial replacement of foundry sand by stone dust could be effectively used in geopolymer concrete.

6. CONCLUSION

Geopolymer concrete is an eco-friendly concrete. This will reduce the percentage of CO_2 in atmosphere. Geopolymer concrete is environment friendly as compare to ordinary or conventional concrete in which ordinary Portland cement (OPC) is main ingredient. Based on review of literature on geopolymer concrete it can be concluded that research has been conducted to develop environment friendly concrete, to reduce greenhouse emissions. In this paper our main focus also on to utilize waste product like foundry sand in geopolymer concrete. However, there is scope for future research to overcome the current limitations associated with wider application of material.

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BIOGRAPHICS

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