Role of Geopolymer Concrete for the Construction of Rigid Pavement

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Abstract **- Geopolymer Concrete (GPCs) is a new class of concrete based on an inorganic alumina silicate binder system compared to the hydrated calcium silicate binder system of concrete are activated by alkaline liquids to produce the binder. The basic material used for the activation of the geopolimerization process is Fly ash, also to replace the use of conventional Portland cement. The binding agent is the only difference to the ordinary Portland cement concrete. To activate content in fly ash, sodium hydroxide solution and sodium silicate solution was used in combination. The geopolymer possesses the advantages of rapid strength gain, elimination of water curing, good mechanical and durability properties and are eco-friendly and sustainable alternative to Ordinary Portland Cement (OPC) based concrete. In the construction industry mainly the production of Portland cement causes the emission of air pollutants which results in environmental pollution. It reduces 80 - 90% CO_2 emissions.**

Index Terms **- Geopolymer (GPC), Fly ash, chemicals.**

I. INTRODUCTION

1.1 Geopolymer Concrete

Concrete is the second widely used man made material in the world after water. It is obtain by mixing cementing materials, sand, aggregates, and sometimes admixtures within require proportions. The mixture when placed in forms and allow cure, hardens into the rock like mass known as Concrete. The Ordinary Portland Cement is the key ingredient of production of the Ordinary Portland Cement Concrete .The demand of concrete as a construction material is increased as the demand for infrastructure development is increased. The utilization of cement pollutes the environment and reduces raw materials The manufacturing of Ordinary Portland Cement (OPC) requires large quantities of fuel for burning as well as the decomposition of limestone, resulting the significant emissions of CO_2Cement plants have been emit up to 1.5 billion tons of CO2 into the atmosphere annually.
Geopolymer Concrete has been introduced to reduce this problem. Geopolymer concrete is an inorganic polymer concrete that can be formed at room temperature by using industrial waste or by-products as source materials to form a solid binder and it is looks like OPC and performs similar function to OPC. Geopolymer binder can be used in applications to fully or partially replace OPC for environmental and technical benefits.

Properties Of Geopolymer Concrete

- Non-toxic and bleed free.
- Sets at room temperature.
- Higher resistance to heat and resist to all inorganic solvents.
- Higher compressive strength
- Light in weight.

Compressive strength of Geopolymer concrete is very high compared to the Ordinary Portland Cement Concrete. Geopolymer Concrete also showed very high early strength. The compressive strength of Geopolymer Concrete is about 1.5 times more than the compressive strength of the Ordinary Portland Cement Concrete, for the same mix.

1.2 Flyash

fly ash is defined as 'the finely divided particles that results from the combustion of ground or powdered coal and that is transported by gases from the combustion zone to the particle removal system' . Fly ash is removed from the combustion gases by the dust collection system by mechanical means or by using electrostatic precipitators, before discharging to the atmosphere. Fly ash particles are spherical in shape, finer than cement and lime, ranging in diameter **from less than 1 µm and not more than 150 µm.**

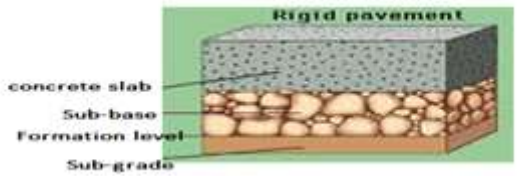
Classification of Fly Ash

- **Class F or Siliceous Fly Ash or Low calcium Fly Ash: -** fly ash from the bituminous and anthracite coals is referred as ASTM Class F fly ash or low calcium fly ash. It consists of alumina silicate glass, and has less than 10 percent of calcium oxide.
- **Class C or Calcareous Fly Ash or High calcium Fly Ash: -** Fly ash that is obtained from burning sub-bituminous coals is referred as ASTM Class Cfly ash or high calcium fly ash, contains more than 20 percent of calcium oxide.

1.3 Rigid Pavement

The rigid pavements are possessed considerable flexural strength or flexural rigidity. The rigid pavement are made of Portland cement concrete either plain, reinforced or prestressed concrete. The rigid pavement have slab action and are capable of distributing the wheel loads to larger area .The plain cement concrete slabs are expected to sustain about 40 kg/cm^2 flexural stress. The cement concrete pavement slab can very well wearing surface as well as effective base course. Therefore usually the rigid pavement structure consist of a cement concrete slab, below which a granular base or sub-base course may be provided. Through the cement concrete slab can also be laid directly over the soil sub-grade, this is not preferred specially when the sub-grade have fine grained soil. By providing a good base or sub-base course layer below the cement concrete slab, the pavement life can be increased considerably and works out more economical in the long run.

Rigid pavement structure mainly consists of the following component parts:-



Rigid Pavement

1.5 Detail Of Construction Techniques Of Rigid Pavement

Rigid pavements construction techniques are as follow:-

Slab method: - This method comprises of laying concrete in bays i.e. in small portion at a time. This can be done in two ways.

- **Alternate bay method:-**In alternate bay method of pavement construction, the pavement surface is divided into a large number of bays and concreting is done in alternate bays. The left bays are concreted after a week or so.
- **Continuous bay method: -** This method is generally preferred because in this method concreting can be completed in half width of the pavement at a time. During this time the traffic can be use the other half portion. Thus the expenditure required for diverting the traffic can be saved.

II. MIX DESIGN OF M 30

Table 2.1 show the M 30 mix design of geopolymer concrete (gpc)

Grade of GPC		**M 30**	
Fly ash		411 kg/m^3	
Aggregates	Fine aggregates	547 kg/m^3	1824m^3
	Coarse aggregates 20 mm aggregates 10mm aggregates	1277 kg/m^3 702 kg/m^3 575 kg/m^3	
Sodium hydroxide concentration		Solid = 22 kg/m^3 Water = 33 kg/m^3	
Sodium silicate		Solid = 62 kg/m^3 Water = 48 kg/m^3	
Ratio of mix proportion		1: 1.3: 3.2	
Liquid / binder ratio		.4	
Water / Geopolymer ratio		.2	

III. MATERIAL AND ITS PROPERTIES

3.1 Fly ash: - for experimental work **class f** or **siliceous fly ash** or **low calcium fly ash** is used.

3.2 Aggregates

Coarse aggregates:-10mm and 20mm Sizes of coarse aggregate are chosen for the experimental work

Fine aggregates:- Locally available river sand and which was obtained from river Narmada sand, having a lower size of about 0.07mm was used as a fine aggregate.

Physical properties of aggregates		
Properties of material	**Coarse aggregates**	**Fine aggregate**
Type	Crushed	Natural
Shape	Angular	Spherical
Size	20 mm & 10 mm	> 4.75 µ
Specific gravity	2.71	2.65
Fineness modulus	7.2	2.9
Bulk Density (Kg/m3)	1426	1570
Source	Crushed basalt stone	Narmada river sand

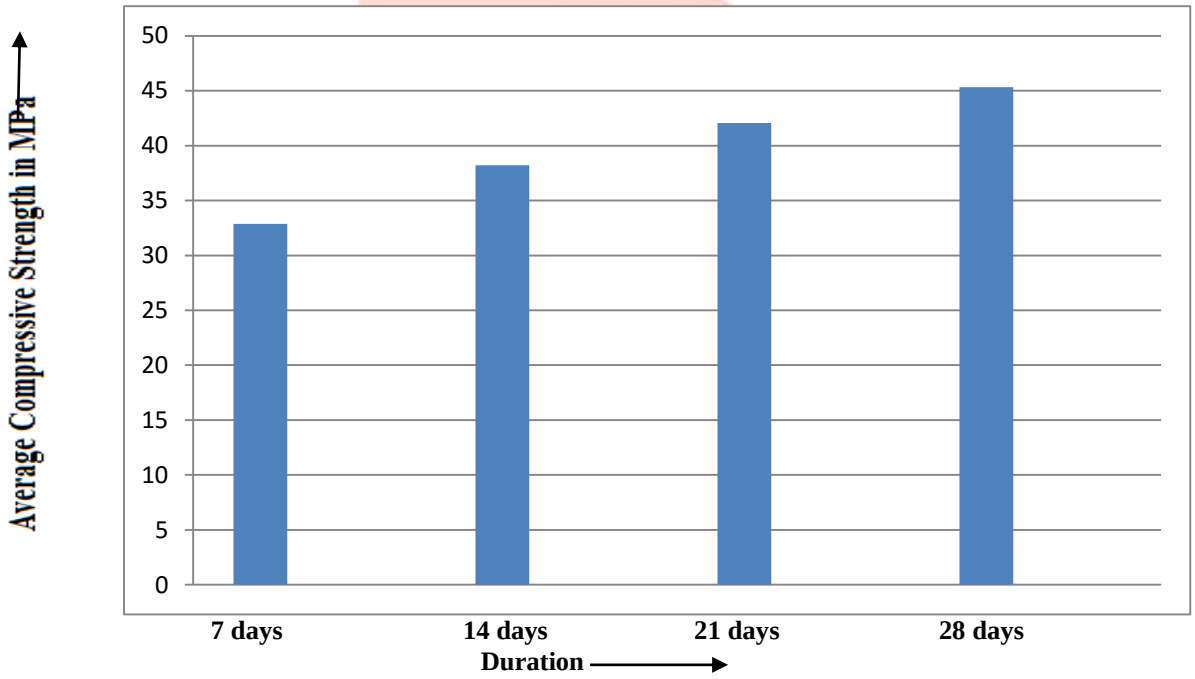
3.1.3Alkaline solution:- To activate the fly ash, a combination of sodium hydroxide solution and sodium silicate solution was chosen as the alkaline activator. The sodium hydroxide (NaOH) solution was prepared by dissolving either the flakes or the pellets in water. The mass of NaOH solids in a solution varied depending on the concentration of the solution expressed in terms of molar, M. For the experimental work we prepared the alkaline solution of molarity 14 i.e. M 14 for activating the fly ash of mix design M 30.

IV. RESULT & DISCUSSION

In one batch total 12 numbers of cubes were casted. All the cubes were thermal cured or oven cured at 60C for 24 hours. Average Compressive Strength of Geopolymer Concrete cube is considered of thermal cured at 60 C for 24 hrs. and after that left at ambient at room temperature. Geopolymer Concrete cubes of Morality 14 M of Additive Activatorat7, 14,21and28days.

Table 4.1 show the average compressive strength of gpc

Compressive strength					
Days	**S.No.**	**Weight of cube in kg**	**Load in KN**	**Strength in MPa**	**Average strength in MPa**
7 days	1	8.10	800	35.56	32.88
	2	7.98	720	32	
	3	7.95	700	31.1	
14 days	1	8.10	1030	45.77	38.22
	2	7.90	800	35.56	
	3	7.90	750	33.34	
21 days	1	8.32	1040	46.22	42.07
	2	8.18	800	35.56	
	3	8.14	1000	44.44	
28 days	1	7.91	1140	50.66	45.33
	2	8.32	940	41.78	
	3	7.90	980	43.55	



Casted cubes

Geopolymer cubes being testing on compressive Strength testing machine

V. DISCUSSION

- The Fly Ash has been used in this dissertation is Class F Fly Ash.
- The Object of this dissertation was to Role of geopolymer concrete for the construction of RIGID PAVEMENT.
- The fly ah which is used in experiment work that is obtain from the SATI college laboratory.
- The Alkaline activator solution of molarity 14 i.e. M14 is prepared.
- The Geopolymer Concrete was made of Additive Activator, Fly Ash, Coarse and Fine aggregate.
- 12 numbers of cubes were casted and after that cured in oven at 60℃ for 24 hours for thermal curing. The compressive strength was tested at, 7, 14, 21 and 28 days of thermal cured Geopolymer Concrete cubes. The results of compressive strength of Geopolymer cube is show in table no 4.1.

VI. CONCLUSION

1. As the strength of concrete is depend upon morality of the sodium hydroxide (NaOH) , Since the molarity of NAOH is increases then the compressive strength is also increases
2. The curing time has a direct effect on the compressive strength of geopolymer concrete i.e. as the curing time increases ,the compressive strength increases proportionally
3. The curing temperature helps the geopolymer concrete to gain strength and an increase in curing temperature (90°C to 100°C) increases the compressive strength.
4. With the increase in moisture content the workability also enhances.
5. The rest period for the fresh fly ash based geopolymer concrete is between 2 to 3 days. Also improves the compressive strength.
6. The handling time of fresh geopolymer concrete is unto 2 hours.
7. The age of concrete has no effect on the compressive strength of geopolymer concrete.
8. Molarity also affects the viscosity. The viscosity increases with increases the
9. Inorganic-organic hybrid alkaline activator (concentration of NaOH) that can be used in many civil Engineering applications such as building work, dry lean concrete and precast items.

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