Optimizing the Strength of Rigid Pavement by Replacing Class F Flyash in Geopolymer Concrete by Coconut Fiber Ash

[1]Gaurav Bhavsar, [2]Prof. S S Goliya, [3]O.S. Dhakre
[1]ME Student, [2]Asst. Professor, [3]Lecturer
[1, 2] Department of Civil Engineering SATI Engg. Vidisha (M.P.)
[3]Department of Civil Engineering SATI (poly) Vidisha (M.P.)

Abstract- Fly ash based Geopolymer concrete is introduced in 1979 by Davidovits to reduce the use of OPC in concrete. Geopolymer is an inorganic alumino-hydroxide polymer synthesized form predominantly silicon and aluminum materials of geological origin and by product materials such as flyash (with low calcium) and coconut fiber fly ash . In this paper an attempt is made to study strength properties of Geopolymer concrete using low calcium fly ash and coconut fiber fly ash with combination NaOH & Na2SiO3 solutions as activators with molarities 14M. The specimen is cured at ambient temperature.

Index Terms: **Geopolymer concrete (GPC), Morality(M), Flyash(FL), or coconut fiber fly ash(CFA)**

I. INTRODUCTION

1.1 GEOPOLYMER CONCRETE

The geopolymer technology is proposed by Davidovits and gives considerable promise for application in concrete Industry as an alternative binder to the Portland cement. In terms of reducing the global warming, the geopolymer technology could reduce the CO2 emission in to the atmosphere, caused by cement and aggregate industries about 80%. In this technology, the source material that is rich in silicon (Si) and Aluminum (Al) is reacted with a highly alkaline solution through the process of geopolymerisation to produce the binding material. The term „geopolymer" describes a family of mineral binders that have a polymeric silicon-oxygen-aluminum framework structure, similar to that found in zeolites, but without the crystal structure.. Geopolymer concrete is emerging as anew environmentally friendly construction material for sustainable development, using fly ash and coconut fiber fly ash in place of OPC as the binding agent. This attempt results in two benefits. i.e. reducing CO2 releases from production of OPC and effective utilization of industrial waste by products such as fly ash, coconut fiber fly ash etc by decreasing the use of OPC.

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'.coconut fiber is collected from local available temple of vidisha and it is burnt in open air & the residue is passed through **150 micron** sieve . 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.**

1.2.1 Classification of Fly Ash

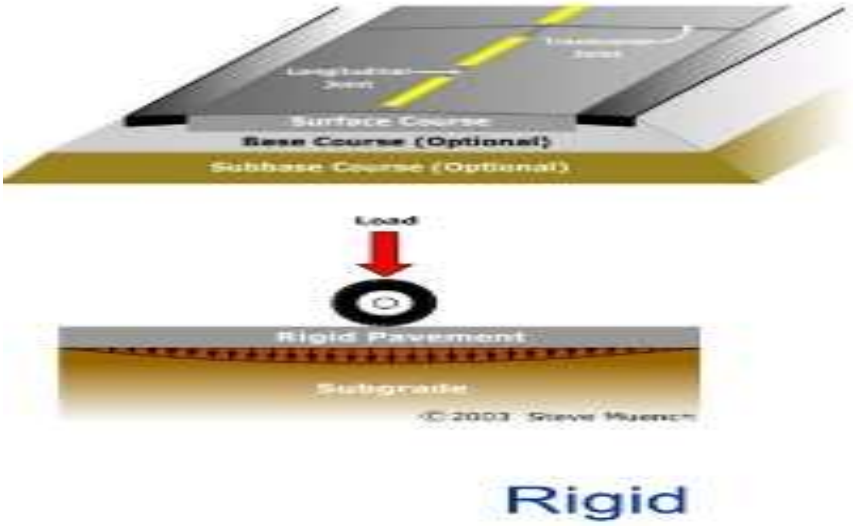
- **Class F or Siliceous Fly Ash or Low calcium Fly Ash: -** fly ash from the bituminous and anthracite coals is referred as ASTM Class F fly ash or low calcium fly ash. It consists of alumina silicate glass, and has less than 10 percent of calcium oxide.
- **Class C or Calcareous Fly Ash or High calcium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

1.3 RIGID PAVEMENT:-

- One coarse Portland cement of relatively high bending strength
- Slab to slab action
- IRC code 58-2002
- There is an expansion & contraction
- It is due to elastic theory

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 increase considerably and works out more economical in the long run.

Rigid pavement structure mainly consists of the following component parts



Rigid pavement

1.4 DETAIL OF CONSTRUCTION TECHNIQUES OF RIGID PAVEMENT

Rigid pavements construction techniques are as follow:-

- **Cement grout method**
- **Rolled concrete layer method**
- **Cement concrete 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. This method has certain advantages and disadvantages.
Advantages:-
1. Construction joint is provided easily.
2. It provides ease in working.
Disadvantage:-
1. Large number of transverse joints have to be provided. By which smooth riding qualities of the surface and increase the cost of construction.
2. Construction is spread over the full width of road, hence the traffic has to be diverted, which entails further expenditure.

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	1824 kg/m^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	

PERCENTAGE OF COCONUT FIBER FLY ASH

Replacement Percentage of coconut fiber fly ash	Amount of coconut fiber fly ash in Kg/m^3
0.5 %	2.055
1 %	4.11
1.5 %	6.165
2%	8.22

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 aggregates**
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 48 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 consider 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 Activator at 7, 14, 21 and 28 days

Table 4.1 show the average compressive strength of gpc Average compressive strength of concrete at 0.5 %

Compressive strength					
Days	**S.No.**	**Weight of cube in kg**	**Load in KN**	**Strength in MPa**	**Average strength in MPa**
7 days	1	8.2	820	36.44	33.33
	2	7.93	700	31.11	
	3	8.4	730	32.44	
14 days	1	7.83	900	40	36
	2	7.90	850	37.77	
	3	8.1	700	31.11	
21 days	1	7.8	1000	44.44	42.81
	2	8.0	850	37.77	
	3	8.3	1040	46.22	
28 days	1	8.1	1100	48.88	44.14
	2	7.8	980	43.55	
	3	8.0	900	40	

Average compressive strength of concrete at 1%

Compressive strength					
Days	S.No.	Weight of cube in kg	Load in KN	Strength in MPa	Average strength in MPa
7 days	1	8.1	810	36	33.03
	2	8.3	730	32.44	
	3	8.0	690	30.66	
14 days	1	7.9	960	42.66	37.32
	2	7.88	830	36.88	
	3	8.3	730	32.44	
21 days	1	8.23	1030	45.77	42.95
	2	8.20	910	40.44	
	3	8.0	960	42.60	
28 days	1	8.1	1080	48	45.58
	2	8.3	1010	44.88	
	3	8.1	980	43.88	

Average compressive strength of concrete at 1.5%

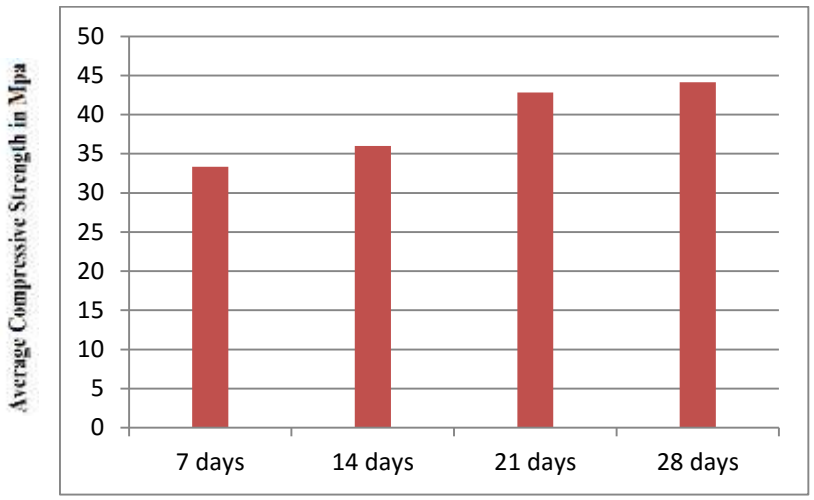
Compressive strength					
Days	**S.No.**	**Weight of cube in kg**	**Load in KN**	**Strength in MPa**	**Average strength in MPa**
7 days	1	7.9	840	37.33	34.36
	2	8.1	760	33.77	
	3	8.0	720	32.00	
14 days	1	8.3	1000	44.44	38.51
	2	8.2	850	37.77	
	3	8.1	750	33.33	
21 days	1	8.2	1080	48	44.29
	2	8.3	940	41.77	
	3	8.1	970	43.11	
28 days	1	7.9	1120	49.77	46.29
	2	8.0	1030	45.77	
	3	7.9	990	44.11	

Average compressive strength of concrete at 2%

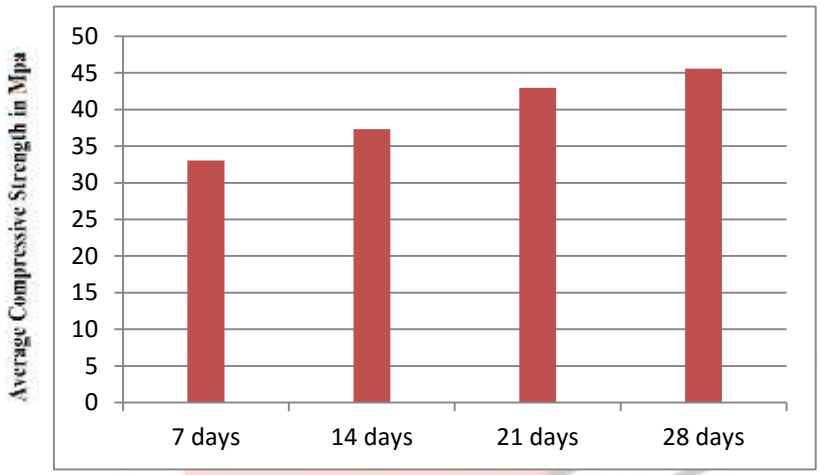
Compressive strength					
Days	**S. No.**	**Weight of cube in kg**	**Load in KN**	**Strength in MPa**	**Average strength in MPa**
7 days	1	8.1	750	33.33	30.81
	2	8.2	680	30.22	
	3	8.0	650	28.88	
14 days	1	7.88	840	37.88	31.44
	2	8.0	680	30.22	
	3	8.23	590	26.44	
21 days	1	7.9	920	40.88	37.44
	2	8.0	790	35.11	
	3	7.9	840	37.33	
28 days	1	8.1	1020	45.33	41.62
	2	7.88	910	40.44	
	3	8.0	880	39.41	

Casted cube

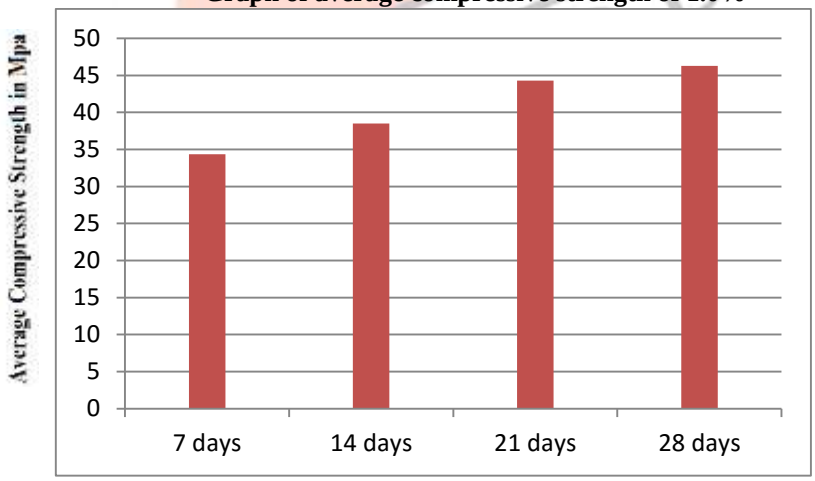
Geopolymer cubes being testing on compressive strength testing



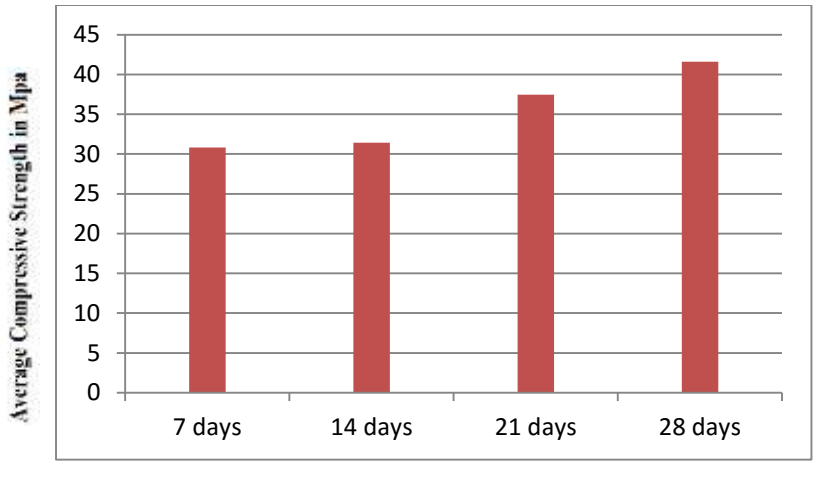
Graph of average compressive strength of 0.5%



Graph of average compressive strength of 1.0%



Graph of average compressive strength of 1.5%



Graph of average compressive strength of 2.0%

V. DISCUSSION

- The Fly Ash has been used in this dissertation is Class F Fly Ash.
- Coconut fiber fly ash should be obtained by burning coconut fiber and passed through 150 micron sieve
- The Object of this dissertation was to Role of Geopolymer concrete for the construction of RIGID PAVEMENT BY USING COCUNUT FIBER FLYASH.
- The fly ah which is used in experiment work that is obtain from the SATI college laboratory. and coconut fiber is obtained from locally available temple and shops of vidisha.
- The Alkaline activator solution of morality 14 i.e. M14 is prepared.
- The Geopolymer Concrete was made of Additive Activator, Fly Ash, Coarse and Fine aggregate and coconut fiber fly ash with different proportion.
- 48 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

VI. CONCLUSION

- Geopolymer concrete is activated by sodium silicate and sodium hydroxide , Since the morality of NAOH is increases then the compressive strength is also increases, but if percentage of coconut fiber increases up to 1.5% decreases after 2% compressive strength decreases.
- Curing should be done in two format i.e. an in ambient curing and oven drying curing ,we should done oven drying curing at 60C
- Among all fiber coconut fiber should have strain of 4-6 % more than other fiber.
- With the increase in moisture content the workability also enhances.
- The rest period for the fresh fly ash based geopolymer concrete is between 2 to 3 days. Also improves the compressive strength.
- Coconut fiber should have good durability and abrasion resistance characteristics
- If cellulose content of coconut fiber increases then compressive strength decreases.
- High lignin content as it has high resistance to different weather and therefore coconut fiber is suitable material for construction of road.
- The handling time of fresh geopolymer concrete is unto 2 hours.
- The age of concrete has no effect on the compressive strength of geopolymer concrete.
- Morality also affects the viscosity. The viscosity increases with increases morality.

VII. REFERENCES

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