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Abrasion Resistance of Geopolymer Concrete at Varying Temperature

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Abstract: *India is developing and progressing rapidly in the field of construction .With the increase in construction at a fast pace, usage of concrete is increasing .Cement is one of the main ingredients of concrete. The increase in environment pollution due to the release of CO_2 in the atmosphere by the production of cement has been alarming. To develop clean environment the use of cement should be limited and should be replaced by an eco friendly material, Geopolymer ,which results from the reaction of a source material that is rich in silica and alumina along with alkaline liquid. This material is being studied extensively and can be used as a substitute for ordinary Portland cement concrete. In this research paper, abrasion resistance of geopolymer concrete will be observed which has not been explored in detail. Alkaline liquids used in preparing geopolymer concrete is 12 M sodium hydroxide (NaOH) solution and sodium silicate (Na_2SiO_3) solution while source material is fly ash and abrasion resistance will be tested at varying temperature.*

Keywords: *abrasion resistance, alkaline liquids, eco friendly ,geopolymer concrete, fly ash.*

I. Introduction

Portland cement (PC) concrete is the most popular and widely used building materials, as the raw materials are easily available and it can be easily prepared and casted in all sorts of shapes[1]. However, there are some disadvantages of Portland cement which are difficult to overcome. About 1.5 tons of raw materials is required in the production of every ton of Portland cement, at the same time about one ton of carbon dioxide (CO2) is released into the environment during the production [2]. On the other hand, the global warming also can occur because of the greenhouse gases such as carbon dioxide to the atmosphere. Several studies have been carried out to reduce the use of Portland cement in concrete by the use of alternative material. These include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaoline and the development of alternative binders to Portland cement [7]. Davidovits [1988] proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminium (Al) in a source material of geological origin or in by-product materials such as fly ash and rice husk ash to produce binders and the chemical reaction that takes place is a polymerization process, he named the term, Geopolymer to represent these binders. Geopolymer concrete is concrete which does not utilize any Portland cement in its production. There are two main constituents of geopolymers, namely the source materials and the alkaline liquids. The source materials for geopolymers based on alumina-silicate should be rich in silicon (Si) and aluminium (Al). These could be natural minerals such as kaolinite, clays, etc or by-product materials such as fly ash, silica fume, slag, rice-husk ash, red mud, etc[3] . The most common alkaline liquid used in geopolymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate.

Lot of research has been carried on the strength parameters of geopolymer concrete but the abrasion resistance has not been studied in detail. The abrasion resistance is the ability to resist being worn away by rubbing .The previous work has been carried out by few authors like Kolli Ramujee .He has compared the abrasion resistance of geopolynmer concrete with the standard conventional OPC Concrete. He observed that the depth of wear decreases with the increase in duration. Geopolymer concrete has better abrasion resistance than conventional concrete[8].

Shuguang Hu, Hongxi Wong, Gauzhan Zhang, Qingjing Ding have calculated abrasion resistance of geopolymer concrete by deriving formula[4].

$$I_a = (R/P)^{1/2}$$

where I_a is the grade of abrasion resistance , R is the number of revolutions of grinding machine in ppm ,P is the depth of grinding trace in mm

In this research paper the abrasion resistance of geopolymer concrete is studied at different temperature .i.e.25 ^{0} C, 60 ^{0}C and 80 ^{0}C and at different curing time.

II. Preparation Of Geopolymer Concrete

The manufacturing of geopolymer concrete is similar to cement concrete. The process involves the preparation of alkaline solution, dry mixing, wet mixing, curing & testing of samples. To prepare sodium hydroxide solution of 12 molarity, 480 g (12 x 40) i.e. (molarity x molecular weight) of sodium hydroxide pellets were dissolved in one liter of water. The mass of sodium hydroxide solids in the solution varies depending on the concentration of the solution expressed in terms of molar M[5]. Then the required amount was mixed with the alkaline solution The ratio of sodium hydroxide to sodium silicate is 1.5. The prepared NaOH solution was added with sodium silicate solution proportionately according to the mix, 24 hours before casting. The coarse aggregate(20 mm), fine aggregate, flyash were taken in the ratio(2:1:1) in a mixing tray and dry mixed manually for about two minutes, then the required amount was mixed with the alkaline solution and was added to the dry mix, addition of solution was done in small quantities. The mixing of total mass continued until the mixture became homogeneous and uniform in color. The fresh geopolymer concrete was casted in cubes of size 100 X 100 X 100 mm to three layers and was compacted by using the standard compaction rod so that each layer receives 25 strokes followed by further compaction on the vibrating table. The casted specimens were kept in oven for 25ºC for the curing period of 120 hours and another specimens were kept in an oven at 60 ^{0} C, 80 ^{0}C for 72 hours and after the required curing period the specimens were removed from the oven and were kept open at room temperature until testing. The alkaline solution-to-Fly ash ratio was kept 0.4. A low calcium processed fly ash was obtained from Ropar Thermal Power Plant .Coarse aggregate of size 20mm having the specific gravity of 2.78 and fineness modulus of 7.21 (IS:2386) was used. The fineness modulus of fine sand used was 2.41 with a specific gravity of 2.6. The ratio of sodium hydroxide to Sodium silicate was 1.5.

Table 1: The chemical composition of dry processed fly ash sample as obtained from XRF Analysis.

SiO2	P_2O_5	Cr_2O_3	Rb_2O
59,09 %	3,0 KCps	1,3 KCps	9,0 KCps
Al_2O_3	0,50 %	0,02 %	74 PPM
229,8 KCps	MgO	SeO_2	Ga_2O_3
30,77 %	3,9 KCps	5,7 KCps	2,5 KCps
Fe_2O_3	0,43 %	0,02 %	59 PPM
470,8 KCps	SO_3	La2O3	Nb_2O_5
3,85 %	1,7 KCps	0,1 KCps	8,4 KCps
TiO_2	0,16 %	0,01 %	58 PPM
45,2 KCps	Na_2O	CuO	PbO
2,06 %	0,3 KCps	3,7 KCps	1,7 KCps
CaO	0,07 %	0,01 %	46 PPM
31,3 KCps	BaO	Cl	As_2O_3
1,65 %	0,8 KCps	0,2 KCps	1,8 KCps
K 2O	0,06 %	0,01 %	9 PPM
21,0 KCps	ZrO2	Y 2O 3	ZnO
1,06 %	80,4 KCps	11,9 KCps	3,5 KCps
MnO	0,06 %	85 PPM	3 PPM
3,7 KCps	V 2O5	NiO	Intensity Scal
0,04 %	1,7 KCps	1,9 KCps	0,9803
Re	0,05 %	81 PPM	
3,5 KCps	SrO		
0,02 %	25,9 KCps		
	0,02 %		

Fig: 1 sample casted into moulds.

2.1 Abrasion Resistance Of Geopolymer Concrete

Tile Abrasion Testing Machine, helps in determining the wear resistance of geopolymer concrete tiles of size 7. 06 cm x 7. 06 cm. The wear of the tile is measured on a thickness gauge, which is specifically made for the purpose. The tile is pressed under certain load on a grinding path and abrasive powder is evenly spread on the rotating grinding path. Further, the second parallel side of the tile is also subjected to wear for similar number of rotations, after specific number of revolution are completed of the grinding disc

In this research paper the abrasion resistance of geopolymer concrete is studied at different temperature .i.e. 25 ^{0} C, 60 ^{0}C and 80 ^{0}C

Fig 2 samples are cut into required size by the cutting machine

Fig 3 the samples are made of the required shape that can be fitted into the abrasion testing machine

Fig 4 samples are fixed into the abrasion testing machine

III. Results

The tests were conducted on samples of geopolymer concrete at 25^0 C, 60^0 C and 80^0 C at 28 days. The sample of geopolymer concrete was given curing time of 120 hours cured at curing temperature of 25^0 C and the sample of geopolymer concrete which was cured for 72 hours was kept in the oven at 60^0 C and 80^0C.

Table 2

S. No	TEMPERATURE	INITIAL WEIGHTkg	FINAL WEIGHTkg	DEPTH OF WEAR(mm)at 5 min	DEPTH OF WEAR(mm)at 10 min	DEPTH OF WEAR(mm) at 15 min	DEPTH OF WEAR mm At 20 min	DEPTH OF WEAR(mm) at 25 min
1	25^0 C	2.344	2.140	1.0	1.15	1.29	1.45	1.62
2	60^0 C	2.245	2.004	1.6	1.75	1.90	2.10	2.17
3	80^0 C	2.344	2.112	1.8	1.96	2.05	2.15	2.30

IV. Conclusion

The paper presented brief details of abrasion resistance of fly ash-based geopolymer concrete. Geopolymer concrete sample cured at 25^0 C requires 120 hours of curing whereas geopolymer concrete at high temperatures can be cured at 72 hours. Abrasion resistance increases with the increase in temperature**.**

A simple method to design geopolymer concrete mixtures has been described. Geopolymer concrete has excellent properties. To ensure future intake of geopolymer technology within the concrete industry, research is needed in the critical area of abrasion resistance with the increase in the ratio of alkaline liquids. Current research is focusing on the abrasion resistance of geopolymer concrete with NaOH to $Na_2Si O_3$ as 2.

The limitations of geopolymer Concrete are as follows[6]:

Bringing the fly ash to the required location.

High cost of alkaline solution

Risk due to high alkalinity of the solution , safety measures to be taken.

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