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Geopolymer Concrete Preparation Methodology

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Abstract: ***As a construction material, most commonly used material all over the world is concrete which is produced by Ordinary Portland cement and aggregates mixed with water. OPC is the most widely used binder material in concrete. The amount of OPC approximately present in concrete is 10% - 20% by mass of concrete. Production of OPC is creating the environmental problems over the decades.***

The production of Portland cement worldwide is increasing 9% annually. Portland cement produces almost 1.5 billion tones of greenhouse gas annually or about 7% of total greenhouse gas emissions to the earth's atmosphere. Approximately to produce 1 ton of OPC 1 ton of CO_2 is released to the environment. Due to this environmental issue, research on alternative binder material evolved.

It is important to find an alternative material which will liberate less carbon to atmosphere than cement. Industrial waste products like Fly ash and GGBS can be converted in to concrete through Geopolymer.

Keywords: Geopolymer, Ultrafine GGBS, Flyash

I. INGREDIENTS OF GEOPOLYMER CONCRETE (GPC)

Ingredients required for production of Geopolymer concrete are:

1) Binding source materials
2) Aggregates consisting both fine and coarse aggregates
3) Alkaline Activator solution

A. Binding Materials

Cementatious materials used in this Geopolymer concrete are

1) *Ultra-fine GGBS:* During the production of iron in blast furnace by heating iron ore, limestone and coke up to 1500^{o}C two materials are evolved. These are molten iron and molten slag. Molten iron is lighter in mass and hence molten iron floats on top surface. The molten slag mainly consists of silicates and alumina along with some oxides from limestone. The slag obtained in blast furnace is in molten state. It is first cooled through high pressure water jets if not large crystals may be formed. The final granulated material obtained almost contains 95% non-crystalline calcium-aluminosilicates. These granulated particles are further processed by drying and grinding to very fine powder which is called Ultra-fine GGBS or Alcofine.
2) *GGBS:* GGBS is a slag obtained during the manufacture of iron in blast furnace. Slag obtained is processed to form fine material which is called GGBS. Usually fineness varies from 300 to 350 m^2/kg.
3) *Fly Ash:* Fly ash is a binding material used as replacement with cement. Fly ash is obtained from thermal power plants during burning of coal. Fly ash as lighter in weight as hence it is carried out with flue gases which is later collected and stored in silos. Fineness varies from 450 to 550 m^2/kg.

B. Alkali Activators

Alkali activators are the combination of alkaline silicate solution and alkaline hydroxide solution. Sodium-based solutions were used in the present work because it is very less expensive compared to Potassium-based solutions.

1) Sodium Hydroxide (NaOH)
2) Sodium Silicate (Na_2SiO_3)

C. Superplasticizer

Superplasticizer is used to increase the workability of the Geopolymer concrete. Superplasticizer used in this project work was AURO MIX 400 Plus, which is a high range admixture. Amount of plasticizer added was 1.5% by mass of cementatious material.

II. TESTING OF SPECIMENS

A. *Compressive Strength*

Oven curing of cubes

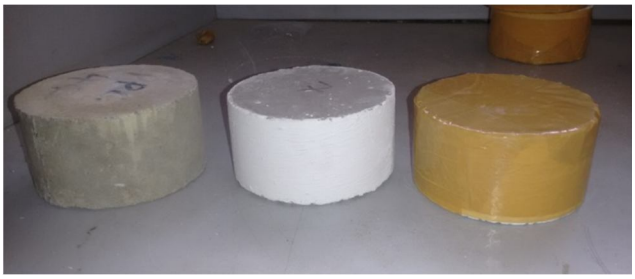
Compressive strength of geopolymer cubes are obtained for both ambient curing and oven curing. The above figure 3.8 shows the oven curing of cubes. Specimens are kept in oven for 24 hours at a temperature of 60^{o}C later specimens are removed from the oven and cured under room temperature. Compressive strength is tested on CTM of 2000KN capacity load. Compressive strength is tested on 1, 3, 7, 28 and 56 days.

B. *Water Permeability*

Water Permeability setup

Water permeability is an experiment to know the permeability of water through only top surface under constant pressure for 3 days. Cubes of 150mm size has to place as shown in figure and tight the bolts. Water as to be passed through the pipes under 5 bar pressure continuously. After 3 days the cubes are spliced in to two half's and depth of penetration of water is marked and maximum penetration is noted.

C. *Sorptivity*



Preparation for Sorptivity test

Sorptivity Test

Sorptivity is the measure of unidirectional flow of water without any external pressure. The experiment is carried out according to ASTM. To avoid the evaporation specimen is covered with tape. Initial weight of each specimen with the cover is noted. These specimens are placed in water and water depth should not be more than 5mm as shown in figure. Weight of the samples are noted at regular intervals and absorption value is calculated as below.

$$I = M_t / (axd)$$

Where, I = Absorption
Mt= change in mass at time t
a = Exposed area of the specimen in mm^2
d = Density of water in g/mm^3

D. Abrasion Resistance

Abrasion Test

Abrasion is the calculation of wear in the concrete. This is very useful in the road designing and even in commercial building. Abrasion test is carried out according to IS 1237-1980. The specimen is cut to the dimension 7.06 x 7.06 cm so that area of specimen is 50 cm^2. Then specimens are dried in oven for 24 hours at 110^oC then initial weight is noted. Specimen is placed in abrasion testing machine as shown in figure and for every 22 revolution 20 gm of abrasive powder is added. And for every 22 revolution the specimen is rotated to 90^o clockwise and again same procedure is followed for 10 times. Latter final weight and thickness is noted and abrasion value is calculated.

$$T = \frac{(W1-W2)V}{W1\ X\ A}$$

Where,
T = Average loss in thickness mm
W1 = Initial mass in gm
W2 = Final mass in gm
V = Volume of specimen in mm^3
A = Surface area in mm^2

E. Acid and Sulphate Attack

Sample placed in H_2SO_4 and Sodium Sulphate

Oven dried cubes are used after the curing period of 28 days for both Acid and Sulphate attack. Initial weight of cubes is recorded. Specimens are immersed in 5% concentrated H_2SO_4 for Acid attack and 5% Sodium sulphate for Sulphate attack. Specimens are placed in solution for 28 days and specimens are oven dried to remove the water content and final weight is recorded. Percentage loss in weight is calculated.

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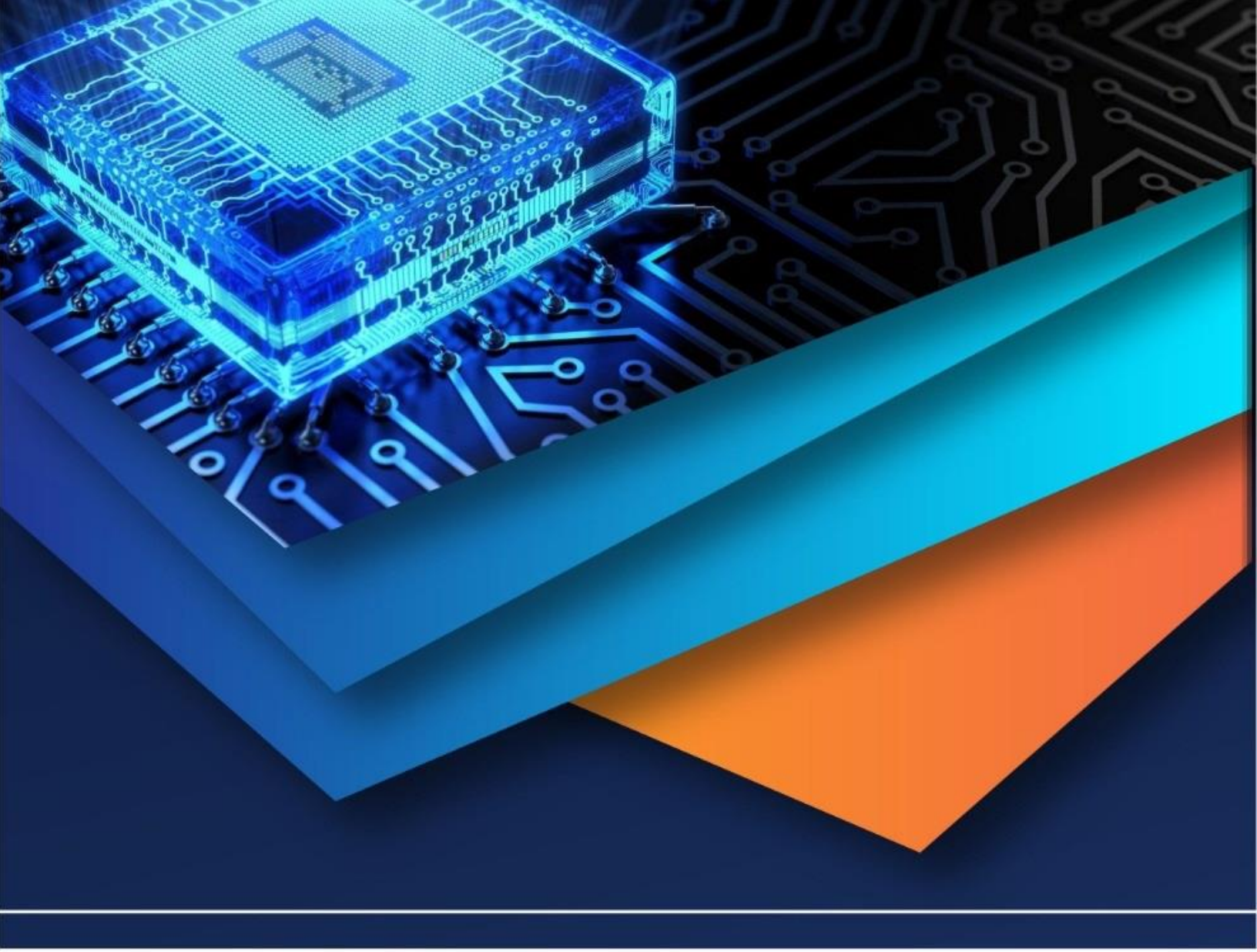

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