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EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF GEOPOLYMER CONCRETE

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ABSTRACT:

The Ordinary Portland Cement (OPC), which is widely used material not only consumes significant amount of natural resources and energy but also pollutes the atmosphere by the emission of CO_2, So reduce this ill effect, the search for alternative result is geopolymer concrete. In this work, low calcium class F fly ash is used as the base material. This paper presents the results of an experimental investigation to determine the performance characteristics of geopolymer reinforced concrete. Two kinds of systems are considered in this study using 100% replacement of cement by ASTM class Fly ash.

1.1INTRODUCTION

After wood, concrete is the most often used material by the community. Concrete is conventionally produced by using the Ordinary Portland cement (OPC) as the primary binder. The environmental issues associated with the production of OPC are well known. The amount of the carbon dioxide released during the manufacture of OPC due to the calcination of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the amount of energy required to produce OPC is only next to steel and aluminium.

On the other side, the abundance and availability of fly ash worldwide create opportunity to utilise this by-product of burning coal, as partial replacement or as performance enhancer for OPC. Fly ash is itself does not possess the binding properties, except for the high calcium or ASTM Class C fly ash. However, in the presence of water and in ambient temperature, fly ash reacts with the calcium hydroxide during the hydration process of OPC to form the calcium silicate hydrate (C-S-H) gel. This pozzolanic action happens when fly ash is added to OPC as a partial replacement or as an admixture.

1.2 FLY ASH-BASED GEOPOLYMER CONCRETE

In this work, fly ash-based geopolymer is used as the binder, instead of Portland or any other hydraulic cement paste, to produce concrete. The fly ash-based geopolymer paste binds the loose coarse aggregates, fine aggregates and other un-reacted materials together to form the geopolymer concrete, with or without the presence of admixtures. The manufacture of geopolymer concrete is carried out using the usual concrete technology methods.

As in the OPC concrete, the aggregates occupy the largest volume, i.e. about 75- 80 % by mass, in geopolymer concrete. The silicon and the aluminium in the low calcium (ASTM Class F) fly ash are activated by a combination of sodium hydroxide and sodium silicate solutions to form the geopolymer paste that binds the aggregates and other un-reacted materials.

2.1 USE OF FLY ASH IN CONCRETE

One of the efforts to produce more environmentally friendly concrete is to reduce the use of OPC by partially replacing the amount of cement in concrete with by-products materials such as fly ash. As a cement replacement, fly ash plays the role of an artificial pozzolan, where its silicon dioxide content reacts with the calcium hydroxide from the cement hydration process to form the calcium silicate hydrate (C- S-H) gel. The spherical shape of fly ash often helps to improve the workability of the fresh concrete, while its small particle size also plays as filler of voids in the concrete, hence to produce dense and durable concrete.

2.2 GEOPOLYMERS

Polymer is a class of materials made from large molecules that are composed of a large number of repeating units (monomers). The molecular structure of the unit that makes up the large molecules controls the properties of the material. The non- crystalline or amorphous state is the state when the regularity of atomic packing is completely absent. The most familiar kind of an amorphous solid is glass. Geopolymers are a member of the family of inorganic polymers, and are a chain structures formed on a backbone of Al and Si ions. The chemical composition of this geopolymer material is similar to natural zeolitic materials, but they have amorphous microstructure instead of crystalline.

2.3 Alkaline Activators

The most common alkaline activator used in geopolymerisation is a combination ofsodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate (Davidovits 1999; Palomo, Grutzeck et al. 1999; Barbosa, MacKenzie et al. 2000; Xu and van Deventer 2000; Swanepoel and Strydom 2002; Xu and van Deventer 2002). The use of a single alkaline activator has been reported (Palomo, Grutzeck et al. 1999; Teixeira-Pinto, Fernandes et al. 2002), Palomo et al (1999) concluded that the type of activator plays an important role in the polymerisation process.

2.4 Factors Affecting the Properties of Geopolymers

Several factors have been identified as important parameters affecting the properties of geopolymers. Palomo et al (1999) concluded that the curing temperature was are action accelerator in fly ash-based geopolymers, and significantly affected the mechanical strength, together with the curing time and the type of alkaline activator.

Higher curing temperature and longer curing time were proved to result in higher compressive strength. Alkaline activator that contained soluble silicates was proved to increase the rate of reaction compared to alkaline solutions that contained only hydroxide.

2.5 THE AIM OF THE RESEARCH ARE

1. Finding the compressive strength of geopolymer concrete.
2. Finding the flexural strength of geopolymer concrete.
3. Finding the young's modulus of geopolymer concrete.
4. Finding the deflection behavior of beam.

2.6 Sodium hydroxide (NaOH)

Generally the sodium hydroxides are available in solid state by means of pellets and flakes. The cost of the sodium hydroxide varied according to the purity of the substance. Since our geopolymer concrete is homogeneous material and its main process to activate the sodium silicate Pellet Sodium Hydroxide is recommended to use the lowest cost i.e. up to 94% to 96 % purity.

Figure 2.1 NaOH

2.7 Sodium silicate

Sodium Silicate is also known as water glass or liquid glass, available in liquid (gel) form. In present investigation sodium silicate 2.0 (ratio between Na_2O to Sio_2) is used. A per the manufactured, silicate were supplied to the detergent company and textile industry as bonding agent. Same sodium silicate is used for the making of geopolymer concrete. The chemical properties and the physical of the sodium silicates were given below.

Fig. 2.2 - GEOPOLYMER MIXER

Test Results and Discussions

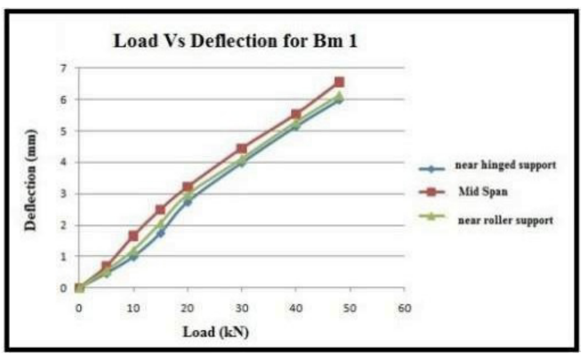

Fig 1 Load Vs deflection (a) M20

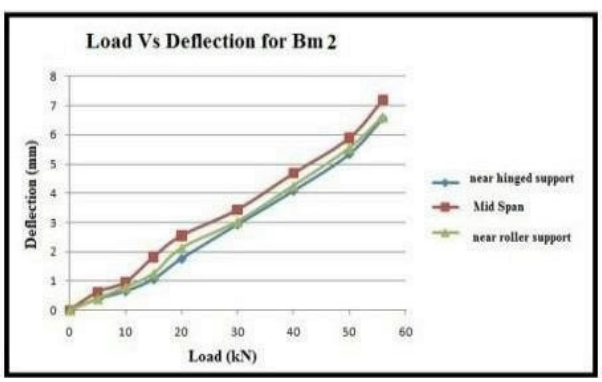

Fig 2 Load Vs deflection (b) M25

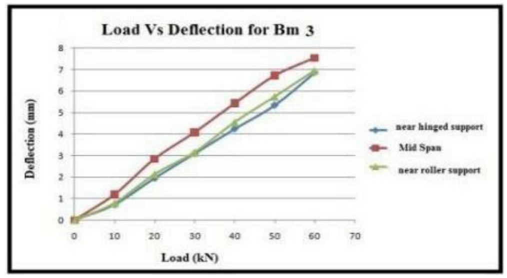

Fig 3 Load Vs deflection (c) M30

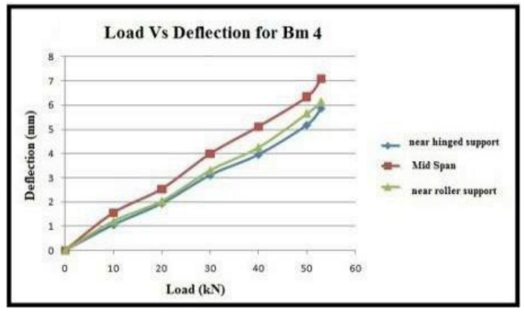

Fig 4 Load Vs deflection (d) M35

3.1 CONCLUSIONS

1. For all the mixes considered in this investigation, there was increase in load carrying capacity of beam for increase in grades.

2. The measured values of the modulus elasticity of fly ash-based geopolymer concrete with compressive strength in the range of 20 to 35 MPa were similar to those of OPC concrete. The measured values are at the lower end of the values calculated using the current design Standards due to the type of coarse aggregate used in the manufacture of the geopolymer concrete.

3. The Poisson's ratio of fly ash-based geopolymer concrete with compressive strength in the range of 20 to

35 MPa falls between 0.19 and 0.22 . These values are similar to those of OPC concrete.

4. The stress-strain relations of fly ash-based geopolymer concrete in compression fits well with the expression developed for OPC concrete as per IS 456 – 2000.

5. The compressive strength of fly ash-based geopolymer concrete is high, as in the case of Portland cement concrete. The measured values are higher than those recommended by the relevant Indian Standard.

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