EXPERIMENTAL INVESTIGATION ON GEOPOLYMER CONCRETE WITH PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH RECYCLED COARSE AGGREGATE

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Abstract- Geopolymer concrete is ecofriendly and it does not emit Co_2 (carbon dioxide) into the atmosphere. In this respect the geopolymer concrete with much lower environmental foot print shows considerable promise for application in the construction Industry. And the application of geopolymer technology could significantly reduce the CO_2 emission to the atmosphere caused b7y the cement industries. In this study the coarse aggregate is replaced with Recycled Coarse Aggregate (RCA) which is obtained from construction waste. In this paper molarity of 3M, 4M and 5M were used and the concrete is cast and the resulting strength characteristics and failure pattern were studied The compressive strength of concrete containing 50% RCA has strength in close proximity to that of normal concrete. This replacement of coarse aggregate with RCA reduces the cost, also tends to alter the characteristics of the Geopolymer concrete. The geopolymer is prepared by combining the mixture of flyash, sodium hydroxide (NaoH) and sodium silicate (Na_2Sio_3) with the use of alkaline liquid. The altered characteristics of the geopolymer concrete with recycled coarse aggregats are studied and tested comparing with the geopolymer concrete prepared with Natural coarse aggregates. As a result of this project investigation on the optimum percentage of molarity required for the preparation of geopolymer concrete with 50% replacement of natural coarse aggregate with recycled coarse aggregates. Strength of the geopolymer concrete mix with M60 attains the same strength of lean concrete mix when compared to 3M, 4M and 5M (molar) so in this study the failure pattern of geopolymer concrete and "M60" concrete mix design are conducted.

Keywords— Geopolymer Concrete, Alkaline liquid, Recycled coarse aggregate, Partial replacement

I. Introduction

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 Aluminium (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 - aluminium framework structure, similar to that found in zeolites, but without the crystal structure. The polymerisation process involves a substantially fast chemical reaction under highly alkaline condition on Si-Al minerals that result in a three-dimensional polymeric chain and ring structure consisting of Si-O-Al-O bonds. Geopolymer concrete is emerging as a new environmentally friendly construction material for sustainable development, using flyash and alkali 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 utilisation of industrial waste by products such as flyash, slag etc by decreasing the use of OPC

A. Advantages

- High strength
- Very low creep and shrinkage
- Chemical Resistance
- Resistance to heat and cold

B. Disadvantages

- Difficult to create
- Prepolymerization is sensitive

II. Future Trends in Geopolymer concrete

- One current producer has said that it is easy to make geopolymer and almost anyone can do it
- However to make larger quantities of GPC,with acceptable properties ata considerable price it is very different manner

- But to make cost effective GPC needs to reach full industrial scale
- Mix design is shifting from grading curves to nano technology and natural sand is becoming unavailable in many areas

II. Materials Used

Fly ash used in this study is low calcium class F Fly ash from Dirk India private limited under the name of the product POZZOCRETE 60. Ground granulated blast furnace slag used is obtained from JSW cements. The chemical and physical properties of GGBFS and Fly Ash used. The most commonly used alkaline activators are a mixture of sodium hydroxide (NaOH) with sodium silicate (Na2SiO3). For preparation of alkaline liquids. Locally available 10 mm and 20 mm crushed aggregates have been used as coarse aggregates and also using Recycled Coarse Aggregate. The specimens were cast and kept in steel moulds for 1 day as the rest period, and then kept in oven at 900 C for two different period of time viz. 24 h and 48h. And the properties of recycled coarse aggregates are greatly influenced by aggregate grading, shape and texture of aggregate particles, water absorption, and bulk density of aggregates, crushing and abrasion resistance, presence of harmful substance.

III. Mix Design

Mix design is arrived from the previous study on Geopolymer concrete by Van Chanh Bui et al. The proportion of flyash, fine aggregate and coarse aggregate are 1:1.3:3 with a solution (NaoH &Na_2Sio_3 combined together) to flyash ratio of .35. The flyash, fine aggregates and coarse aggregates were mixed manually in a container and then the alkaline solution was added to prepare the geopolymer concrete. The geopolymer concrete was placed in 150mm cube moulds in three layers and each layer was compacted by giving 25 blows with a 25mm tamping rod. Totally 3 molar design mix were used in this project. Molarity for 3M, 4M and 5M

Molarity = (Molecular weightof Naoh*No of Moles)/Volume of water

Table 1 Material Quantity

Materials	Molarity		
	3M	4M	5M
Fly ash	2.5Kg	2.5Kg	2.5Kg
Fine aggregate	3.25 Kg	3.25 Kg	3.25 Kg
Coarse aggregate			
a. Natural Gravel	3.875kg	3.875kg	3.875kg
b. Recycled Coarse aggregate	3.875kg	3.875kg	3.875kg
Alkaline liquid			
a. Sodium Hydroxide	0.42l	0.42l	0.42l
b. Sodium Silicate	0.83l	0.83l	0.83l

IV. Material Testing Results

A. Sieve Analysis

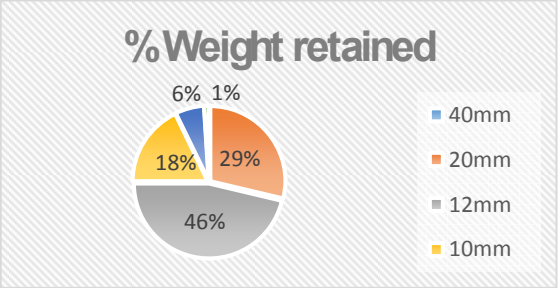

Fig.1 Sieve analysis Result

Specific gravity of coarse aggregate is found to be 2.8 and as per IS2386 (part 3):1963, the specific gravity of coarse aggregate should be 2.6 to 2.9. Percentage of water absorption coarse aggregate is found to be 3.5%, specific gravity of cement obtained is 3.08, fineness of cement is found to be 1%. And the percentage of water required for obtaining cement paste of standarad consistency is 22.5%.

V. Test Results

A. Comparative result for compression

Comparing the result of compression from the three types of specimen it is typically found that the mix containing alkaline liquid with partial replacement of recycled coarse aggregate has relatively high strength compared with that of the conventional one. It is clearly observed that even though there is a failure in three molar concentration but the cubes underwent partial failure rather than complete failure

Table 2 Compressive strength

Compressive strength (N/mm^2)		
Molarity	7 days	28 days
3M	12	15
4M	13.5	17
5M	15	18

VI. Failure Study

A.Crazng Crazing is a web like series of fine cracks, which is usually formed at the surface of the concrete. These can be caused by surface shrinkage, which can occur in low humidity, hot air or sun and wind. Since these cracks occur on the surface and do not penetrate deeper into the concrete, they do not indicate deeper structural issue

VII. Conclusion

The geopolymer concrete showed high performance with respect to the strength characteristics. The workability of the geopolymer mix is also good. High early strength was obtained in the geopolymer mix. The increase in percentage of fine aggregates and coarse aggregates increased the compressive strength upto optimum level. This may be due to the high bonding between the aggregates and the alkaline solution. The compressive strength was found reduced beyond the optimum mix. This may be due to the increase in the voulume of voids between the aggregates. The optimum mix is found to be flyash: fine aggregate: coarse aggregate are 1:1.3:3.10 with NaoH & Na_2Sio_3 solution combined together. The geopolymer concrete shows high bond strength. The bond strength of GPC is in the order of about one third of corresponding compressive strength. The bond strength of GPC is about four times higher than the corresponding standard concrete.

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