

Experimental Investigation on Strength Characteristics of 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 Co₂ (carbon dioxide) into the atmosphere. In this study the coarse aggregate is replaced with Recycled Coarse Aggregate (RCA) which is obtained from construction waste. 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 a combined mixture of sodium hydroxide (NaOH) and sodium silicate (Na₂SiO₃) with the use of alkaline liquid. The characteristic changes are observed and tested. As a result of this project investigation on the optimum percentage of strength, the geopolymer concrete mix with 3M, 4M and 5M (molar) so in this we study the failure pattern of geopolymer concrete mix design are to be 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 into 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.

ADVANTAGES OF GEOPOLYMER

- high strength
- very low creep and shrinkage
- chemical resistance
- resistant to heat and cold

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FIG 1.1 GEOPOLYMER CONCRETE

II.DISADVANTAGE OF GEOPOLYMER

- difficult to create
- pre-mix only
- geopolymerisation process is sensitive

III. 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 large quantities of GPC ,with acceptable properties, at a competitive price, is a very different matter,
- However such GPC needs to reach full industrial scale to be fully cost competitive
- A large variety of cement replacement materials and chemical admixtures are already in use
- Mix design is shifting from grading curves to nano-technology and natural sand is becoming unavailable in many areas.

V.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 (Na_2SiO_3). 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.

VI. PROPERTIES OF RECYCLED COARSE AGGREGATE

- Aggregate grading
- Shape and surface texture of aggregate particles
- Water absorption
- Bulk density of aggregate

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- Crushing and abrasion resistance
- Presence of harmful substance

VII. MIX DESIGN

The previous studies on Geopolymer concrete ((Van Chanh Bui et al., 2008; Wallah & Rangan, 2006)) The mix proportion of fly ash: Fine Aggregate: Coarse Aggregate are 1:1.3:3.10 with a solution (NaOH& Na₂SiO₃ combined together) to fly ash ratio of 0.35. The fly ash, 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 150 mm 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 such as

- Molarity for 3M
- Molarity for 4M
- Molarity for 5M

Manual calculation for molarity

$$\text{MOLARITY} = \frac{\text{(molecular wt. of NaOH * number of moles)}}{\text{Vol of water}}$$

MATERIALS	3M	4M	5M
FLY ASH	2.5KG	2.5KG	2.5KG
FINE AGGREGATE	3.25Kg	3.25Kg	3.25Kg
COARSE AGGREGATE			
➤ NATURAL GRAVEL	3.875KG	3.875KG	3.875KG
➤ RECYCLED COARSE AGGREGATE			
ALKALINE LIQUID			
➤ SODIUM HYDROXIDE	0.42L	0.42L	0.42L
➤ SODIUM SILICATE	0.83L	0.83L	0.83L

TABLE 1.1 MIX DESIGN

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VIII. MATERIAL TESTING RESULTS

SIEVE ANALYSIS

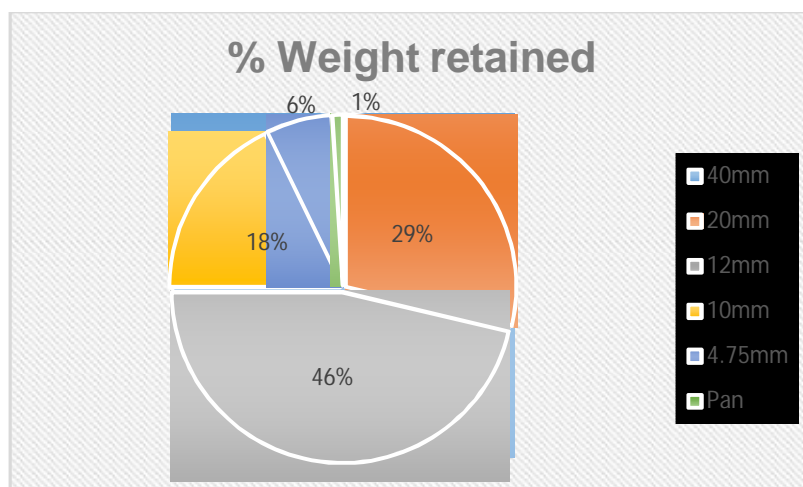


FIG 1.2 SIEVE ANALYSIS

Specific gravity of coarse aggregate is found to be 2.8 and as per IS 2386 (part3):1963, the specific gravity of coarse aggregate should be 2.6 to 2.9.

% of water absorption of coarse aggregate= 3.5 %

The specific gravity of cement obtained is 3.08.

Fineness of cement = 1%

The percentage of water required for obtaining cement paste of standard consistency = 22.5%

IX. TESTING RESULTS

Comparative results for Compression

Comparing the results of compression from the 3 type of specimens 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 the three molar concentration but the cubes underwent partial failure rather than complete failure.

COMPRESSIVE STRENGTH (N/mm ²)		
Mix type	7days	28days
3M	12	15
4M	13.5	17
5M	15	18

TABLE 1.2 COMPRESSIVE STRENGTH

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X.FAILURE STUDY CRAZING

Crazing is a web like series of fine cracks, usually 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 crack occur on the surface and do not penetrate deeper into the concrete, they do not indicate deeper structural issue.

X.CONCLUSION

The Geopolymer concrete showed high performance with respect to the strength. The Geopolymer concrete was a good workable mix. High early strength was obtained in the Geopolymer concrete mix. The increase in percentage of fine aggregates and coarse aggregates increased the compressive strength up to the optimum level. This may be due to the high bonding between the aggregates and alkaline solution. The compressive strength was found reduced beyond the optimum mix. This may be due to the increase in volume of voids between the aggregates. The optimum mix is- Fly ash: Fine aggregate: Coarse aggregate are 1:1.3:3.10 with asolution (NaOH& Na₂SiO₃ combined together) to fly ash ratio of 0.50. The Geopolymer concrete exhibited high bond strength. The Bond strength of GPC is in the order of about one third of the corresponding compressive strength. The bond strength of GPC is about four times higher than the corresponding standard concrete.

ADVANTAGE

- This project is ecofriendly and it does not emit CO₂ (carbon dioxide) into the atmosphere.
- It will give more strength when compared to normal concrete.

DISADVANTAGE

- Manuel preparation of sodium hydroxide it will affect the human beings
- When compared to normal concrete geopolymer will need more skills person to handle the preparation.

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