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EFFECT OF CHANGE IN THE PROPERTIES OF GEOPOLYMER CONCRETE BY PARTIAL REPLACEMENT OF SAND BY FOUNDRY SLAG

Arvind Thakur[1], Bhartesh[2]

[1]*Assistant Professor, Department of Civil Engineering, A.P.Goyal Shimla University, Shimla*

[2]*Assistant Professor, Department of Civil Engineering, A.P.Goyal Shimla University, Shimla*

ABSTRACT

Geopolymer concrete is cement less concrete gaining popularity globally toward the sustainable development. It is a type of amorphous alumino silicate cementitious material which can be synthetized by polycondensation reaction of geopolymeric precursor and alkali poly silicate. The design parameters alkaline liquid to fly ash ratio and water to geopolymer solid ratio were proposed to develop the geopolymer concrete in lower grades. Continued increase in the focus and restriction on global carbon dioxide emissions requires there search for a cleaner alternative to the use of Portland cement. The manufacture of this product is responsible for the release of millions of tons of carbon dioxide worldwide every year. Geopolymer concrete consists of 100% fly ash replacement of the ordinary Portland cement. The aim of this project is to study the characteristics of fly ash based geopolymer concrete and to analyze the effect of change in the properties of geopolymer concrete due to different variations in the proportion of its constituent such as partial replacement of sand by foundry slag.

Keywords: Geopolymer concrete, foundry slag.

INTRODUCTION

Structural engineer's Geopolymer were first discovered by Professor V.D. Glukhovsky of the former Soviet Union during the 1950s and was given the name ‘soil cement’. A French scientist name of “Joseph Davidovits” began similar work in the 1970s naming these materials “Geopolymer”, which refers to an amorphous inorganic polymer formed through the ionic bonding reaction between an aluminosilicate (Al-Si) material and a strong alkaline solution. Geopolymer are able to be synthesized from a variety of aluminosilicate source such as polysilicates, zeolites, kaolinite, metakaolin, calcium, rocks, silica, and fly ash.

It was in 1978 when Davidovits proposed that an Al-Si compound could polymerise with an alkaline solution. This led to the idea of cement replacement and the subsequent creation of ‘Geopolymer Concrete`. Hundreds of papers have since been published, with interest in geopolymer concrete growing exponentially. For sustainable development, the concrete industry needs an alternative binder to the Portland Cement. Such an alternative is offered by the fly ash based geopolymer

concrete, as this concrete uses no Portland Cement; instead, utilizes the fly ash from coal burning power stations to make the binder necessary to manufacture concrete .the use of fly ash based geopolymer concrete contributes through the process of carbon dioxide reduction scheme between the Power Generators, coal producers the government agencies, and other industries including the cement producers.

OBJECTIVE

The main aim of this project is to study the properties and characteristics of geopolymer concrete. Variations were carried out in the quantity of foundry slag.

Variation: Partial replacement of fine aggregates by foundry slag, initially by 10% and secondly 20%

EXPERIMENTAL PROCEDURE

General

This chapter deals with the experimental procedure that was adopted in order to produce G40 mix design geopolymer concrete and then to carry out the different variations in its proportions as per the problem formulation in order to study its characteristics. After studying different research papers, the papers which offered scope for further study were selected. The paper selected was "Development of Mix Design for Low Calcium Based Geopolymer Concrete in Low, Medium and Higher Grades – Indian Scenario" by KolliRamujee, published in 2013 in JCIET. The mix design for G40 geopolymer concrete given in the paper was taken as a reference for the project.It was decided that a fly ash based geopolymer concrete will be made which will conform to the mix design of G40 geopolymer concrete as given in the reference paper.Partial replacement of fine aggregate by foundry slag by 10% and 20% of mass of fine aggregate as in the mix design is carried out.

The concrete obtained after mixing the ingredients was cast into moulds of dimensions 150 x 150 x 150 mm and cured. As decided before 12 test samples were to be formulated so that at least 3 test results were available to derive the average strength per mix for one particular testing day. The material was estimated for 3 spare cubes to compensate for any contingencies during the opening of cubes or in case of material shortage.

The samples after curing were tested for compressive strength. The testing days were decided as 3rd, 7th, 14th and 28th day but when the 1st testing was done on the 3rd day for the first mixture, the cubes were found to be extremely dry due to the oven curing owing to loss of moisture due to burning of plastic bags inside the oven rendering them uncovered and vulnerable to moisture loss. Later when ambient curing was done for the second mix the cubes were found to be too moist inside and hence the 3rd day testing was discarded and testing on the 7th, 14th and 28th day were finalized.

When ambient curing yielded insignificant strength gain on 14th day as well then for the subsequent mixes oven curing was practiced again but with better wrapping in order to seal the moisture inside and prevent the wrapping from burning. Oven curing was done for 24 hours at 600C as mentioned in the reference paper. There were many difficulties faced in the production of geopolymer concrete some even because of the infrastructural constraints, but the most troublesome issue was that of workability. In order to deal with this issue trial mixes with different water content were formed the one which gave the best workability was selected.

Foundry slag

Foundry slag has been obtained from TIMCO Steel Plant Bharatgarh. It has been used to replace fine aggregates by some percentage in the preparation of geopolymer concrete. As this replacement fineness modulus test was conducted on the foundry slag.

Table 1. Properties of aggregates and slag.

Types of aggregates	Bulk density (kg/lit)	Specific gravity	Water absorption (%)	Fineness modulus
Coarse aggregate (20mm)	1.48	3.07	1.31	2.790
Coarse aggregate (10mm)	1.49	2.64	2.378	
Fine aggregate	1.73	1.95	16.27	
Foundry slag	__	2.38	29.34	2.8245

Table 2. Type of mix.

Casting	Mix	Type of mix
A	Mix 1	Reference mix of G40
D	Mix 4	New mix with increased water content of 150 kg/m3
F	Mix 6	Mix with 10% replacement of sand by foundry slag
G	Mix 7	Mix with 20% replacement of sand by foundry slag

RESULT

Effect of partial replacement of sand by foundry slag

The replacement of sand by foundry slag has yielded one of the best strength results in terms of variation in proportion of constituents of geopolymer concrete. It also shows maximum strength gain on the 7th testing day confirming that geopolymer concrete gains maximum strength in the early phase. It is also observed that 10% replacement of sand by slag gives better results than 20% replacement.

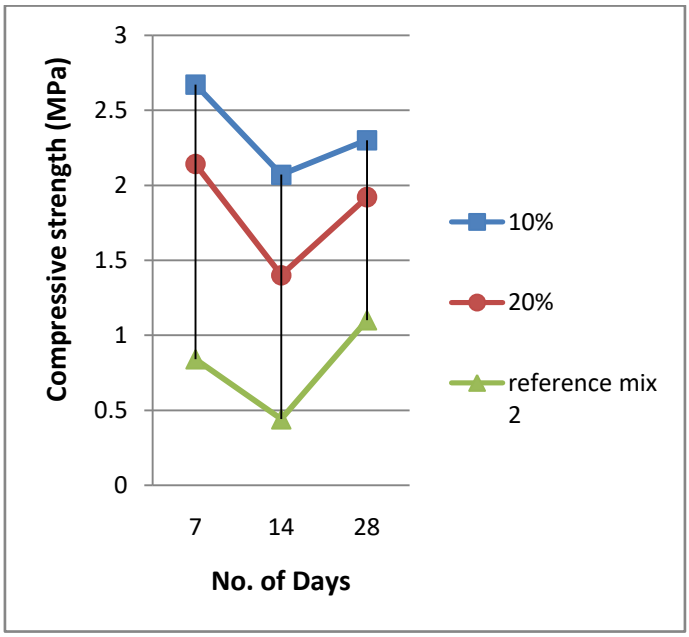

Fig.1. Effect of partial replacement of sand by foundry slag on compressive strength.

Effect of ambient curing and oven curing

Results show that oven cured mixes have yielded greater strength especially the 7th day strength of these mixes is considerable as compared to the gain in strength for the subsequent testing days. This confirms the fact that high temperature aids in the polymerization process which further yields good strength. On analyzing the cubes which were ambient cured on the 7th day it was observed that the cubes were moist from within. In oven curing it was seen that by the 28th day testing the cubes were very dry from within.

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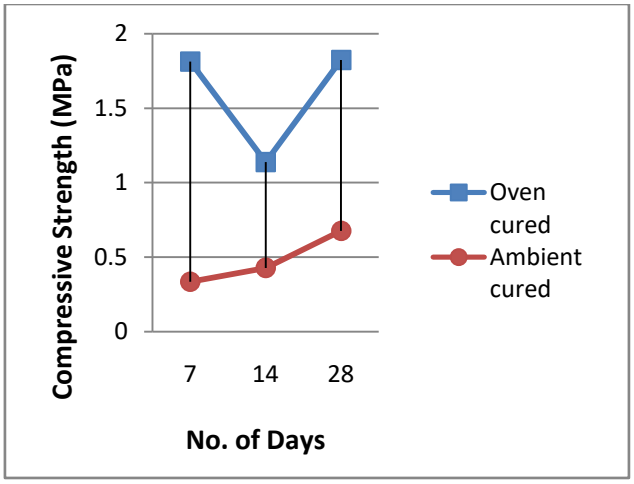

Fig.2. Effect of ambient curing and oven curing on compressive strength.

CONCLUSIONS

From the various results it can be concluded that

• Heat curing is a much better option than ambient curing. However, oven curing itself is not the best option steam curing should be adopted as it would ensure that good moisture content is maintained in the cubes even till the 28th day of testing.

• Replacement of sand by foundry slag upto 10% is good option and needs further investigations as to what is the limitation and extent of this replacement.

• The increase in molarity of NaOH yields positive results in strength gain and as suggested by previous studies, 12M gives maximum strength gain so it should be adopted for geopolymer concrete formulation.

• For further studies on the project it is recommended that studies be carried out with the addition of admixtures such as Alcophyn which are known to impart strength and workability.

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