Assessment of Alcoffine - Blended Geopolymer Concrete Deep Beams Behaviour Under Ambient Curing Conditions

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Abstract- *The investigation of the development of strength for various classes of geopolymer concrete under ambient curing conditions is compared with M30 and M60 Ordinary Portland cement concrete. Trial mix was carried out for low calcium fly ash based GPC with various percentage of Alccofine as 10M, 12M and 14M, 16M to achieve target strength of OPCC. The alkaline solution used in this study is a combination of sodium silicate (Na2SiO3) and sodium hydroxide (NaOH) solution with the ratio of 2.5. The effect of change in mechanical properties under ambient curing conditions such as compressive strength, Stress- strain behaviour, flexural strength and micro structural properties (SEM) of GPC are studied.*

I. INTRODUCTION

Geopolymers are a sustainable alternative to Portland cement. According to (Ouellet-Plamondon and Habert 2014) showed only one part of geopolymer without sodium silicate shows carbon foot print level much lower than Portland cement based mixtures. Geopolymers have properties such as highly mechanical and durable. The emission of Carbon dioxide in Geopolymers is lower than those of Ordinary Portland Cement (OPC). It is observed that Geopolymer cement and concrete have superior properties than that of Portland cement and concrete. With the recent rapid increase in population, the need for infrastructure development increases exponentially. This augmented demand for new infrastructure in feeding the global, demand for construction resources like OPC, which forms the main binding constituent for making concrete.

At present, the demand of the OPC globally is approximately 4 billion tons (Wilson *et al.* 2015), which is the second most required substance next to water and it is predicted to increase by 8-10% in the coming years (Bambang Suhendro2014). This causes increased thrust on the industry of concrete construction. In addition, industrial wastes require large area of useful land for utilization. In order to surmount these challenges, researchers have of late developed substitute binder materials. Geopolymer Concrete (GPC) is one such material that has risen to prominence as a result of alkali activation of silica and alumina-rich compounds. The use of GPC results in low cost, CO2 emission reduction and environmentally affable materials by efficiently utilizing industrial wastes like fly ash, slag, rice husk ash etc. It is also found that GPC cured at elevated temperatures can outperform conventional concrete when it comes to strength and durability.

DATA FOR PROPORTIONING

Grade designation	M30
Type of Cement	OPC 53 Grade
Max. Nominal size of aggregate	20mm
Min. cement content	320 kg/m3
Max. Water-cement ratio	0.45
Workablity	75mm (Slump)
Exposure Condition	Severe
Type of Aggregate	Angular
Max Cement Content	450 kg/m3
Admixture	NapthaleneSulphonate

TEST DATA FOR MATERIALS

Specific gravity of cement	3.13
Specific gravity ofFine Aggregate	2.6
Specific gravity of Coarse Agg	2.8

Water absorption for Coarse Agg	0.5
Water absorption for fine Agg	1
Sieve analysis for Coarse Aggregate	Zone II IS383 :1970
Sieve analysis for fine Aggregate	Zone III IS383 :1970

MIX CALCULATIONS

The mix design for M30 concrete as follow

W/C	0.43
CEMENT	340 Kg/m³
FINE AGGREGATE	654.29 Kg/m³
COARSE AGGREGATE	1308.58 Kg/m³
WATER	162.85 Kg/m³
CHEMICAL ADMIXTURE	1.7 Kg/m³

CALCULATION OF NaOH. FOR (10M) AND WATER

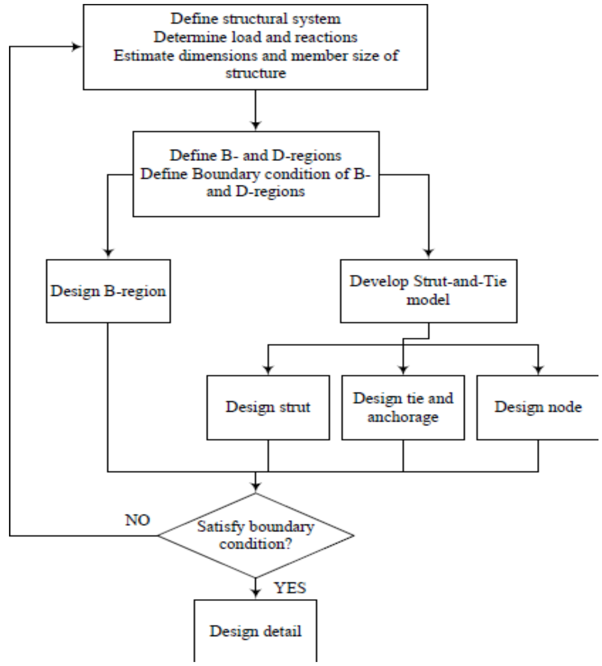
WATER	27.35 kg/m^3
SODIUM HYDROXIDE (NaOH)	18.23 kg/m^3
SODIUM SILICATE (Na_2SiO_3)	113.95 kg/m^3

CALCULATION OF NaOH. FOR (16M) AND WATER

WATER	16.98 kg/m^3
SODIUM HYDROXIDE (NaOH)	30.195 kg/m^3
SODIUM SILICATE (Na_2SiO_3)	117.28 kg/m^3

THEORITICAL ANALYSIS

STRUT AND TIE METHOD (STM) The general procedure of the strut-and- tie method as proposed by Fu (2001) is reproduced.



From Load versus Deflection Response

The deflection characteristics at mid-span and along the strut path of the GPC and OPCC beams are found to be almost similar trends. Also, the OPCC control beams showed slightly more defections when compared to GPC beams under the same loads values. It is primarily due to higher elastic modulus.

Test specimens with two different molarities, two different grades of concrete viz., M30 and M60; three different steel ratios are observed with deflections and stains at various load stages.

The load-carrying capacity of the GPC beams is slightly higher than the OPCC beams due to the higher concentration of molarity in the geopolymer concrete increases the load-carrying capacity. The material displays a linear elastic response for small strain values and nonlinear behavior begins to emerge as deformation increases.

 It can be observed from the load-deflection response, that shear deformations are more apparent than flexural deformations, resulting in a significant loss in flexural capacity and, as a result, lower deflection values in all specimens. The impact of the tensile reinforcement ratio on the flexural capacity of geopolymer concrete beams is same as conventional concrete beams.
 The GPC beams have lesser midspan deflection when compared to conventional concrete beams almost all parametric beams. The excepted and observed values of cracking and deflection of GPC beams are very similar to

OPCC. Up to ultimate load-deflection curve in all beams is almost liner and it indicates that shear deformation is the most common cause of brittle failure.

FROM THEORETICAL ANALYSIS

The shear capacity of Geopolymer concrete beams for various parametric conditions are derived theoretically using exiting theories (De Paiva and Siess 1965; Kong et al. 1973; Prakash, D 1974, CIRI Guide 1977, Schutt, H 1956, and Euro- International Concrete Committee 1990). The De Paiva and Siess 1965; Kong et al. 1973; Prakash, D 1974 gave the best prediction of shear capacity for both GPC and OPCC beams. A good correlation exists between predicted and experimental. The existing theories are more reliable to predict the behaviour of Geopolymer concrete deep beams but the predicted values always being on the safe side.

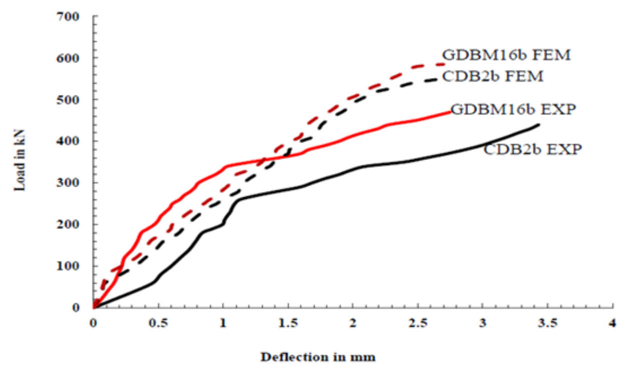
FINITE ELEMENT MODELLING AND ANALYSIS

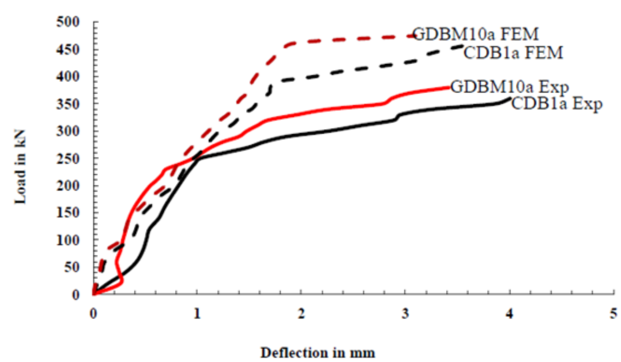
Beam	Exp. (Vu)	FEM (Vu)	$\frac{Vu(FEM)}{Vu(Exp)}$	$\frac{\Delta u\,(FEM)}{\Delta u(Exp)}$
CDB1a	360	460	1.27	0.91
GDBM10a	380	475	1.25	0.91
CDB1b	430	500	1.16	0.90
GDBM10b	450	540	1.20	0.80
CDB2b	440	550	1.25	0.80
GDBM16b	470	585	1.24	0.98
CDB2c	590	700	1.18	1.09
GDBM16c	620	740	1.19	1.25

A Three Dimensional element model is developed to simulate the performance and various failures modes of geopolymer concrete beams by using ANSYS software. In this study, an eight noded solid element is employed to model concrete beam having a dimension of 1200×125×600 mm. The material properties are assigned through an input data file. Meshing is the process of generating nodes and elements. A mesh is generated by defining nodes and connecting them to define the elements. Accuracy of analysis increases with the number of elements considered but these increases the processing time. The boundary and loading conditions are specified to simulate the experimental conditions (SaravananJagadeesan*et al.* 2012**;** Swaminathan*et al* 2021). The characteristics of deep concrete beams under static loading are complex due to various parameters. The present study covers only material non-linearity as it simulates well for various material uncertainties under monotonically increasing loading conditions.

The non- linear stress strain relationships for concrete and steel are obtained from preliminary experimental studies. These relationships are converted into piecewise linear curves in order to suit the numerical modelling and analysis. So many researchers are made attempts to predict the behaviours of the members by using ANSYS. The mesh density, properties of concrete, tolerance values, etc. is the main values, which will effect on the convergence and accuracy of the solution.

The present study, discrete modelling approach is used to simulate the geopolymer concrete deep beams. Two common types of finite elements viz. SOILD65 and LINK8 are adapted to model geopolymer concrete deep beams. The SOILD65 element takes into account translational degrees of alone. Such elements can be utilized to handle cracking and crushing phenomenon. The Link8 elements are used to model reinforcements.





II. CONCLUSION

This project provides a comprehensive review of the historical background and current state of research in the field of geopolymer concrete and Alccofine.the review covers the properties, advantages and applications of these materials as well as behavior of deep beams and shear in deep beams.

The literature review includes an analysis of existing research on Alccofine – based GPC, mix characteristics of GPC, and the behavior of concrete deep beams reinforced internally with conventional reinforcements.

The average compressive strength values are found to be higher than Conventional concrete. It is noticed that, among the various molarities tried in laboratory conditions, Molarity 10 and Molarity 16 shown optimum target strengths for M30. It is observed that the compressive strength of all the mixes increases as the molarity rises, especially when the fly ash and alccofine 1203 content are optimized.

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