ISSN: 2455 – 4200
International Journal of Engineering Research and Modern Education
Impact Factor 6.525, Special Issue, April - 2017
6th National Conference on Innovative Practices in Construction and Waste Management
On 25th April 2017 Organized By
Department of Civil Engineering, Sri Ramakrishna Institute of Technology, Coimbatore, Tamilnadu

PARAMETRIC STUDY ON TESTING, DEVELOPMENT AND EVALUATION OF FIBRE REINFORCED GEOPOLYMER CONCRETE

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Cite This Article: D. Shanthini, R. V. Dhivya Shree, A. Jayasuriya, K. Jimreeves Donald & M. Madhan Kumar, "Parametric Study on Testing, Development and Evaluation of Fibre Reinforced Geopolymer Concrete", International Journal of Engineering Research and Modern Education, Special Issue, April, Page Number 109-115, 2017.

Abstract:

With the growth in infrastructure development in the housing sector the demand for cement is bound to increase. Due to environmental concerns of cement industry these arises a strong need to make a use of alternate technology. In this view the geopolymer shows considerable application in concrete industry as an alternative binder to the portland cement. An important focus of our vision should be in increasing the durability and longevity of structures .In this result the appropriate fibre has to be used in order to the requirements of the structure and achieve maximum effectiveness. In this project, an attempt is made to study the fibre reinforced geopolymer concrete. The concrete consists of flyash, ground granulated blast furnace slag, alkaline solution, coarse aggregate and nylon fibre. Nylon Fibre is added to the mix is 0.01% by volume of concrete. The cement is fully replaced by flyash and GGBS. In the part of the project, an experimental research to determine the mechanical properties of geopolymer concrete and compare the result by the FEM Software.

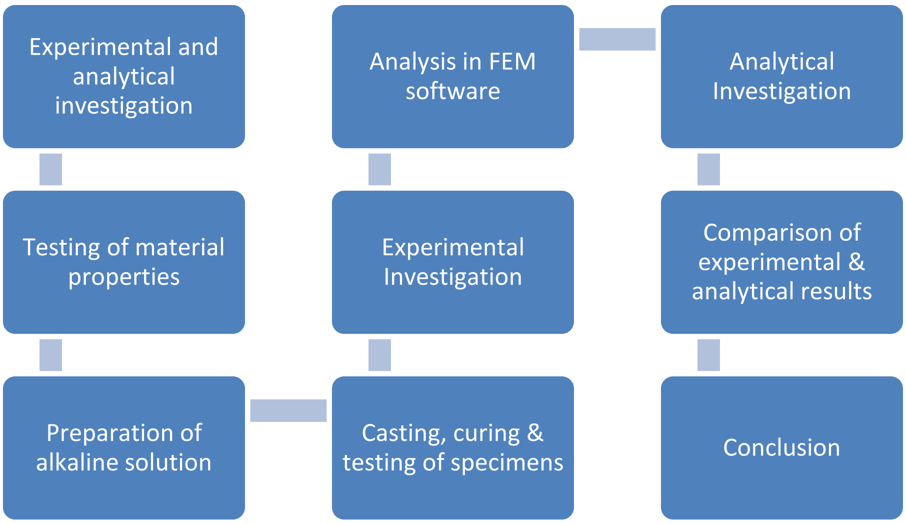
Key Words: Geopolymer, Nylon Fibre, GGBS, Flyash & FEM

1. Introduction:

The objective of the present work is to develop concrete with high strength, less porous and capillarity. So that durability of concrete will be increased. The experimental works to be undertaken are,

- ✓ To determine the compressive strength of cubes, flexural strength of beams and split tensile strength of cylinders.
- ✓ To compare the mechanical properties of fiber reinforced geopolymer concrete with finite element analysis using ABAQUS software.

2. Methodology:



3. Material Used:

Flyash: Flyash usually refers to ash produced during combustion of coal. The components of the fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide and calcium oxide, both being endemic ingredients in many coal-bearing rock strata. The general chemical composition of fly ash is as follows:

Fine Aggregate: The sand used for experimental programmed was locally procured and confirmed to grading zone III as per IS: 383-1970. Fine aggregates passing 2.36 mm sieve is used. Tests were conducted on the fine aggregate like Specific gravity, Bulk density & fineness modulus.

Coarse Aggregate: Local aggregates comprising 20 mm coarse aggregates, in saturated surface dry condition were used. The coarse aggregate were crushed granite-type aggregates and the fine aggregate used was clean dry river sand. The fineness modulus of combined aggregates was 5.0.

Recron 3S Fiber: In order to increase the strength of Geopolymer concrete, recron 3s was used. This was purchased from L & T Construction, Edapalli, Kerala. Recron 3S acts as "secondary reinforcement" in concrete which arrests cracks, increases resistance to impact / abrasion & greatly improves quality of constructions.

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Alkaline Solution: As per the recommendation of Prof. Davidovits, (Geopolymer institute, France in 1978), the alkaline solutions were mixed together one day prior to the use to prepare the Geopolymer concrete. The ratio of sodium silicate solution to sodium hydroxide solution was fixed as 2.5%.

Ground Granulated Blast Furnace: The chemical composition of a slag varies considerably depending on the composition of the raw materials in the iron production process. The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18)

Preparation of Alkaline Solution: The Geopolymer concrete was prepared, placed and compacted in 150mm cube moulds. The cubes were cured by using ambient curing. Generally alkaline liquids are prepared by mixing of the sodium hydroxide and sodium silicate solution at room temperature. When the solution mixed together, they react i.e. (polymerization takes place) it liberate large amount of heat so it is recommended to leave it for 24 hours thus the alkaline solution is get ready as binding agent. Sodium hydroxide pellets are taken and dissolved in the water at the rate of 10 molar concentrations. It is strongly recommended that the sodium hydroxide solution must prepared 24 hours prior use and also if it exceeds 36 hours it terminate to semi solid liquid state. So the prepared solution should be used within this time. Sodium hydroxide solution with a concentration of 8 molarity consists of 8 x 40 =320 grams of NaOH solids per litre of water, where 40 is the molecular weight of NaOH. The sodium silicate is obtained in solution from and hence it is used. The ratio of sodium silicate to sodium hydroxide solution is kept as 2.5.

4. Mix Proportion:

Coarse aggregate	= 1294 kg/m^3
Fine aggregate	= 554 kg/m^3
Flyash	= 409 kg/m^3
Sodium silicate	= 102 kg/m^3
Sodium hydroxide	= 41 kg/m^3

A. Test on Concrete:

Compressive Strength Test: The compressive strength of concrete is the most commom performance measured by the engineer. The compressive strength of cube was tested at 7, 14 and 28 days.

Table 4.1: Compressive strength for cube

Combination	Fibre Percentage (%)	Average compressive strength in (N/mm²)		
		7 days	14 days	28 days
With fibre	0.01	17.13	26.76	48.83
Without fibre	0	13.4	19.6	41.86

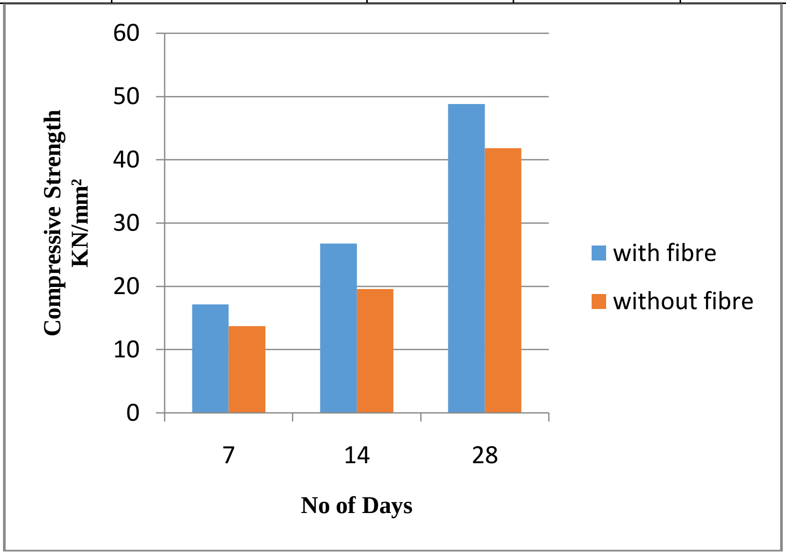

Figure 1: Compressive strength for cube

Split Tension Strength Test: The load is applied tensile stress. Record the maximum load note the appearance of concrete and usually feature type of failure. The split tensile strength was tested at 7, 14 and 28 days.

Table 4.2: Split tensile strength for cube

Combination	Fibre percentage (%)	Average split tensile strength in (N/mm²)		
		7 days	14 days	28 days
With fibre	0.01	1.69	2.26	3.69
Without fibre	0	1.59	2.05	3.22

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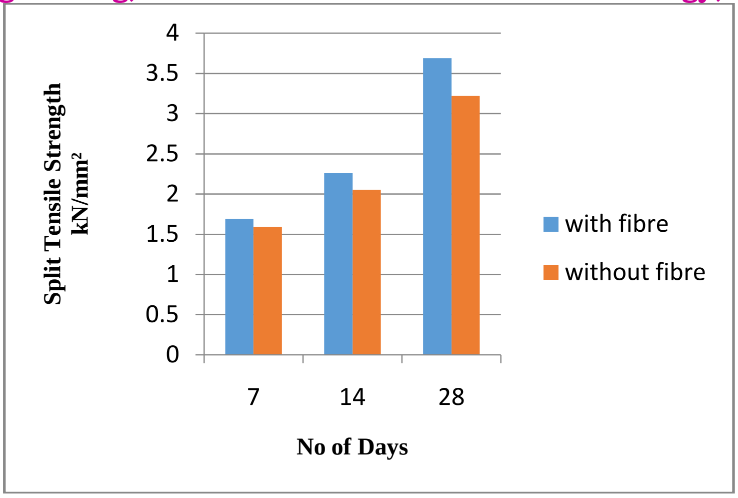

Figure 2: Split tensile strength for cylinder

Flexural Strength Test: The load is applied without shock and increasing continuously at a rate of the specimen. The load is increased until the specimen fails and the maximum load applied to the specimen the test is recorded. The flexural strength was tested at 7, 14 and 28 days

Table 4.3: flexural strength for prism

Combination	Fibre percentage (%)	Average flexural strength in (N/mm²)		
		7 days	14 days	28 days
With fibre	0.01	4.82	5.49	6.13
Without fibre	0	2.6	4.29	4.44

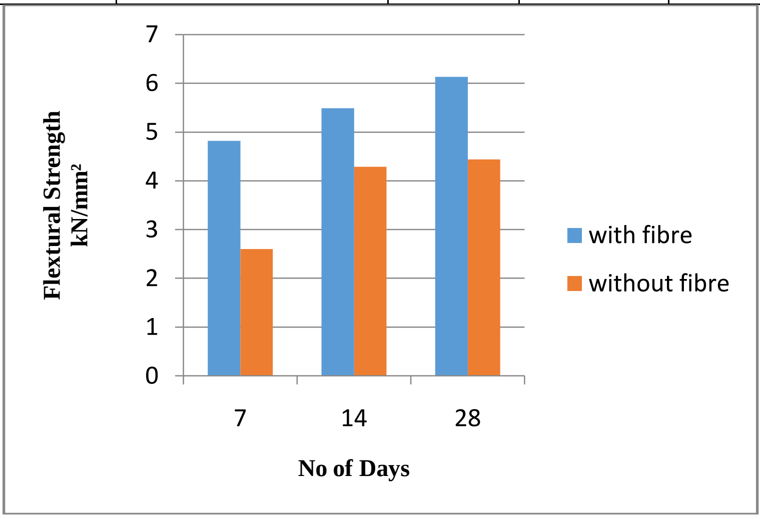

Figure.3: Flexural strength for prism

B. Analytical Results:

Abaqus Software: A 3D finite element model was developed to stimulate the bond behaviour that exist between concrete and steel in reinforced concrete material using ABAQUS software.

Material Modeling: Concrete has relatively high compressive strength, but significantly lower tensile strength, and is usually reinforced with materials that are strong in tension (often steel). Concrete is a heterogeneous, non-linear and orthotropic material. All concrete structure will crack to some extent, due to shrinkage and tension. The elastic parameters required to establish the relation are elastic modulus and tensile strength. The density of concrete is taken as 22 kN/m³ for plain cement concrete and reinforced concrete beam. The Young's modulus of concrete is taken as 25 x 10^3 N/mm^2. Poisson ratio of 0.18 is used for plain cement concrete beam and reinforced concrete beam. The plasticity of model also considers 34 degree for dilation angle and 1.16 for the ratio between equi biaxial compressive stresses to uniaxial compressive stress. The ratio of the second stress invariant on the tensile meridian to that on the compressive meridian, K is taken as 0.667. The Viscosity Parameter, μ, used for the visco plastic regularization of the concrete constitutive equations is taken as 0.The concrete material of the model was simulated by concrete damaged plasticity. In this study, the finite element model is approached by Concrete Damaged Plasticity model.

Table 5.1: Compressive Behavior for Concrete damaged plasticity

Yield Stress (σ)	7.52	18	25	27	28	20
Inelastic Strain (e)	0	0.0008	0.0015	0.0018	0.0023	0.003

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Table 5.2: Tensile Behaviour for Concrete damaged plasticity model

Yield Stress	2.5	0
Cracking strain	0	0.0031

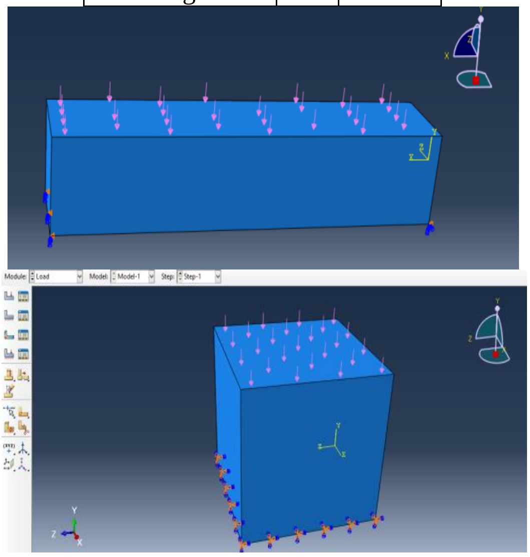
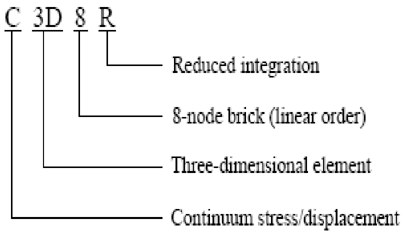


Figure 4: Loading and boundary condition for Prism &Cube

Meshing: To apply a pressure load on the top of the shell model is meshed with 8 nodel linear hexahedron elements. The shell part of the model is divided into so called brick elements to obtain a proper stress distribution in the 3D analysis. There are several types of brick elements available in ABAQUS. For the analysis, C3D8R elements have been used and the abbreviation stands for:



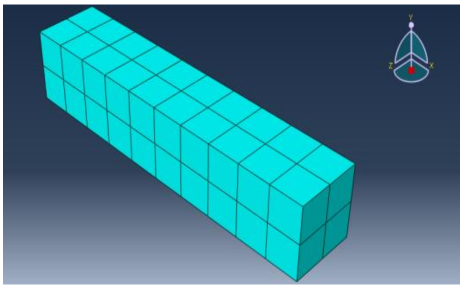


Figure 5: Meshing of Prism

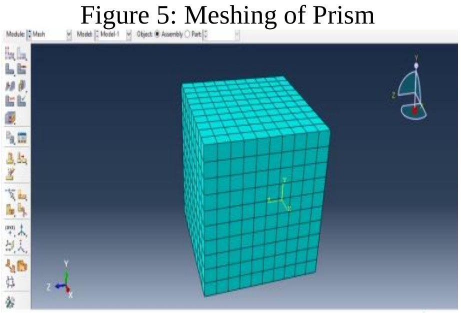


Figure 6: Meshing of cube

Job: The Job module allows us to create a job, to submit it to ABAQUS/Standard or ABAQUS explicit for analysis, and to monitor its progress. If desired, we can create multiple models and jobs and run and monitor the jobs simultaneously. In addition, we have the option of creating only the analysis input file for model. This option allows us to view and edit the input file before submitting it for analysis.

Maximum Principal Stress: The maximum principal stress occurred on the centre of the specimen. The stress occur shown in figure.

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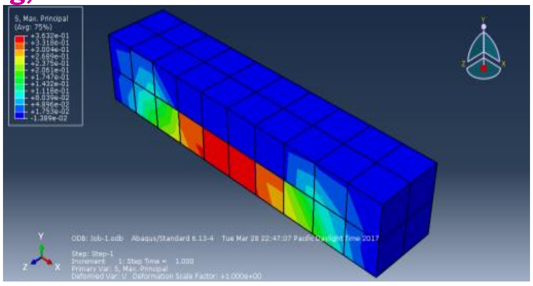

Figure 7: Maximum principle stress for Prism

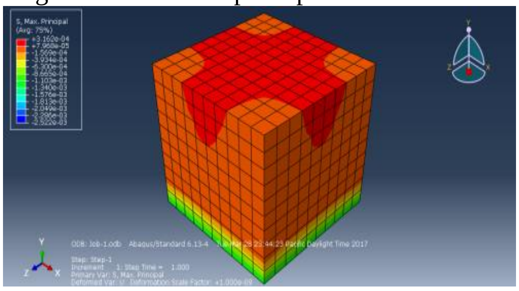

Figure 8: Maximum principle stress for cube

Minimum Principal Stress: The minimum principal stress for the specimen is shown in figure

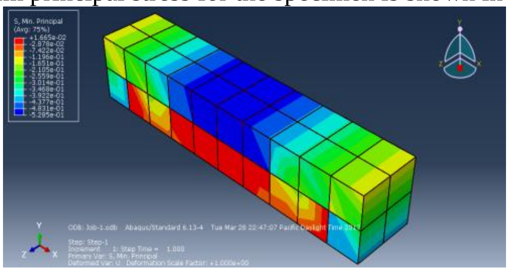

Figure 9: Minimum principal stress for Prism

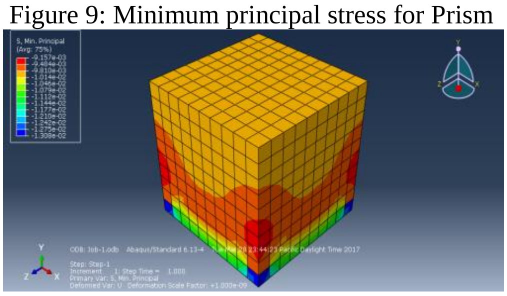

Figure 10: Minimum principal stress for Cube

Force Vs Deflection:

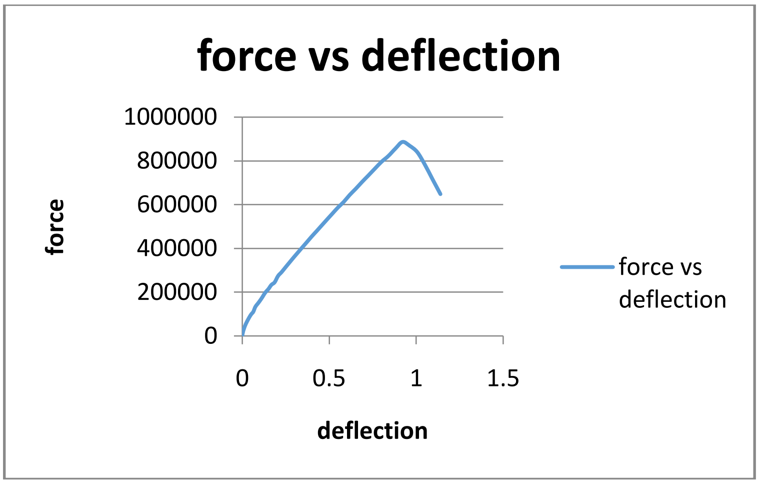

Figure 9: Force vs Deflection for cube

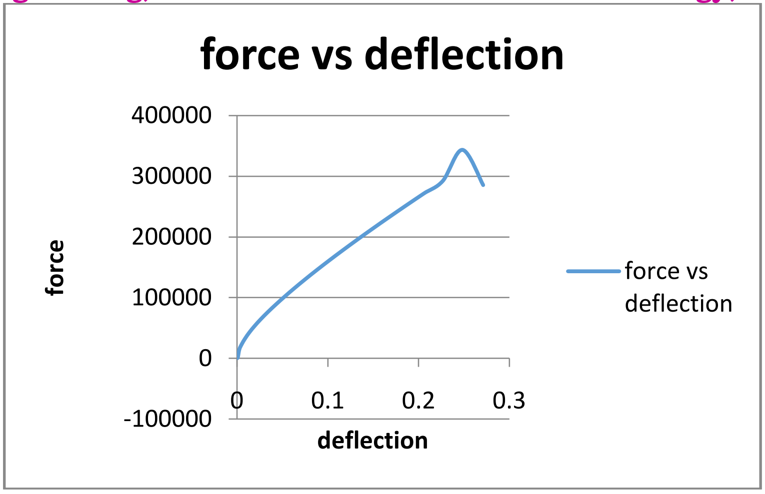

Figure 10: Force vs Deflection for cylinder

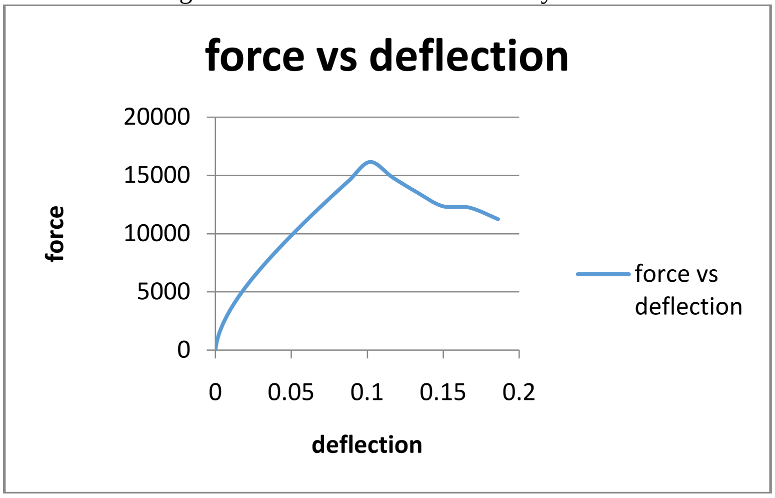

Figure 11: Force vs Deflection for Prism

5. Conclusion:

- ✓ The results from the experimental study the fibre reinforced geopolymer concrete gives better strength compared to the normal geopolymer concrete
- ✓ The compressive strength, split tensile strength, flexural strength for fibre reinforced geopolymer concrete has more strength than geopolymer concrete.
- ✓ The compressive strength of geopolymer concrete in experimental results is higher than analytical results.
- ✓ The split tensile and flexural strength in analytical result is higher than experimental results.
- ✓ The analytical and experimental results are varying because the material properties and load changes.

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