Numerical Study on M30grade of Self Compacting Geopolymer Concrete Reinforced Beam

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Abstract— Self-compacting geopolymer concrete (SCGC) holds promise as an eco-friendly and high - performance construction material with the potential to contribute to sustainable development. Self-compacting geopolymer concrete is a type of concrete that two innovative technologies. It is designed to have high followability and the ability to fill intricate and congested reinforcement within the need for external vibration or compaction. The constituents of SCGC is Silica Fume (SF) and Metakaolin (MK), activated with various molarities of alkaline solution containing sodium hydroxide (NaOH) and sodium silicate (Na2SiO3) Ground granulated blast furnace slag, fly ash and superplasticizer. In this research M30 grade of SCGC is taken into consideration. The beam is modelled and analyzed using ANSYS software.

Indexed Terms— SGCC, GPC, sodium hydroxide (NaOH), sodium silicate (Na2SiO3), ANSYS software.

I. INTRODUCTION

Self-compacting concrete, on the other hand, is a highly fluid and workable concrete that can flow and fill in confined spaces under its own weight. It is achieved by optimizing the mix design with a combination of high-range water reducers, viscosity-modifying agents, and stabilizers. Geopolymer concrete is an eco-friendly alternative to conventional Portland cement -based concrete.it is made by activating natural or industrial by-products rich in silica and alumina with alkaline solutions, resulting in a binder that hardens and gains strength. This process produces less carbon dioxide emissions compared to traditional cement production.

Self-compacting concrete (SCC) is a type of concrete that has the ability to flow and compact itself into the desired shape without the need for mechanical vibration or excessive external forces. It is also known as self-consolidating concrete.

SCC is highly fluid and has excellent filling and passing ability, which allows it to flow through congested reinforcement and into complex melds or formwork without the need for additional consolidation methods. It can easily achieve full compaction even in areas with limited access.

Geopolymer concrete is a type of concrete that is made from a geopolymer binder instead of Portland cement. The geopolymer binder is typically made by mixing aluminosilicate material such as fly ash, slag, or rice husk ash with an alkaline solution such as sodium hydroxide or potassium hydroxide. This chemical reaction between the aluminosilicate and the alkaline solution forms a solid material that can bind together aggregate and other fillers to create a concrete-like material. Geopolymer concrete has several advantages over traditional Portland cement concrete, including higher compressive and flexural strength, lower permeability, better fire resistance, and a lower carbon footprint. Geopolymer concrete is one of the special concretes in which the cement content is fully reduced instead of source material.

It is produced by the polymerization process of silica and aluminum rich material. Sodium silicate and Sodium Hydroxide are alkaline activator which are reacted to form a gel under ambient condition. Hardened cementations paste made from fly ash, GGBS and alkaline solution.

- MATERIALS USED FOR SELF COMPACTING GEOPOLYMER CONCRETE

- Alkaline solution

An alkaline solution is a liquid or aqueous solution that has a PH value greater than 7. It contains a base or alkali that can donate hydroxide ions (OH-) when dissolved in water, resulting in the solution's alkaline properties. Alkaline solution has several applications across various industries.

- Sodium silicate

Sodium silicate also known as water glass, is a chemical compound composed of sodium oxide (NaO2) and silicon dioxide (SiO2).it is commonly available in liquid form, silicon dioxide.

- Sodium hydroxide

Sodium hydroxide, also known as caustic soda or lye, is a highly caustic and alkaline chemical compound. It is composed of sodium (Na), hydrogen (H), and oxygen (O), with the chemical formula NaOH. Sodium hydroxide is available in various forms, including solid flakes, pellets, or as a concentrated solution.

- Super plasticizer

High- range water reducer (HRWR), is a chemical admixture used in concrete mixture to improve workability and followability without sacrificing its strength. Superplasticizers are typically added during the mixing and can significantly reduce the amount of water required for achieving a desired consistency in concrete

- Silica fume

It is also known as micro silica, is a byproduct of the production of silicon and ferrosilicon alloys in the electric arc furnace. It is a highly reactive and fine grain material composed of amorphous silica particles. Silica fume is commonly used as a supplementary cementitious material (SCM) in concrete due to its beneficial properties.

- GGBS

GGBS stands for Ground Granulated Blast Furnace Slag. It is primarily composed of silicates and aluminates of calcium and other elements. It has cementitious properties and can be used as a supplementary cementitious material in the production of concrete.

BENEFITS OF SELF COMPACTING GEO POLYMER COMCRETE:

- Improved workability
- Elimination of vibration
- Enhanced durability
- Eco- friendly alternative
- Superior mechanical properties
- Heat resistance

II. METHODOLOGY

Methodology used for this project is

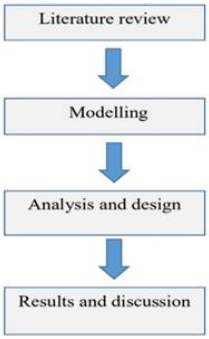


FIGURE 1: Methodology

III. MODELLING

The modelling and analysis is carried out on ANSYS software for reinforced beam.

Beam	1000mmx150 mmx150 mm
Grade of concrete	M30
Grade of steel	Fe500

TABLE1: Modelling details

IV. PROPERTY

SNO	PROPERTY	VALUES OF STEEL (Fe500)	VALUES OF REIFORCED BEAM GPC	VALUES OF REIFORCED BEAM SCGPC
1	Young's	2E+05	31040	27386.12

	modulus	MPa	MPa	MPa
2	Poisson's Ratio	0.3	0.176	0.21
3	Bulk modulus	1.6667E+11 MPa	1.5967 E+10	1.5739E+10
4	Shear modulus	7.6923 E+10 MPa	1.3197 E+10	1.1317E+10

TABLE 2: Property

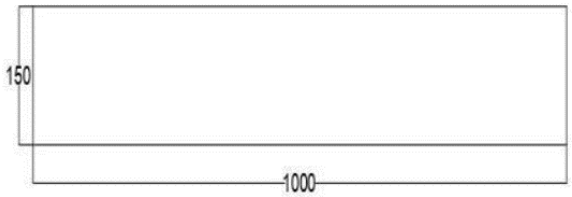


FIGURE 2: 2D view of beam

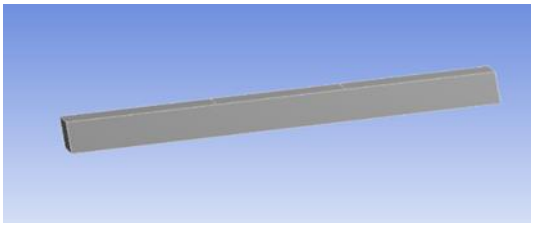


FIGURE 3: 3D view of beam

V. REINFORCEMENT DETAILS

No. of bars provided	2 bars of 10mm dia at Tension 2 bars of 8mm dia at Compression
Size of stirrups	6mm
Stirrups spacing	75mm

TABLE 3: Reinforcement details

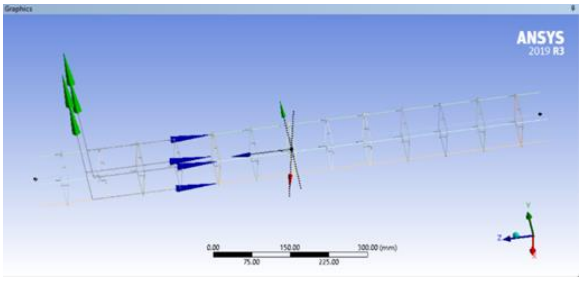


FIGURE 4: Reinforcement data

VI. MESH

Rectangular mesh is used in this project. It is commonly used in numerical methods, such as finite element analysis and finite difference methods. Rectangular mesh offers several advantages and widely utilized in various fields.

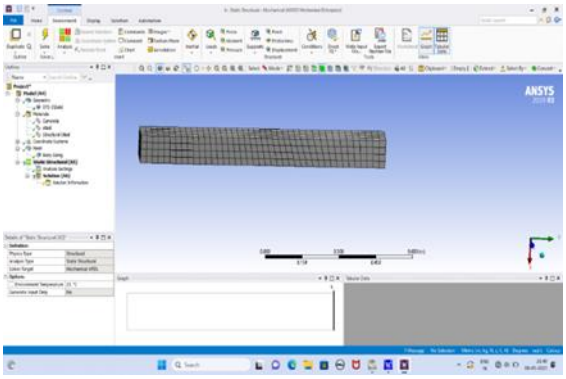
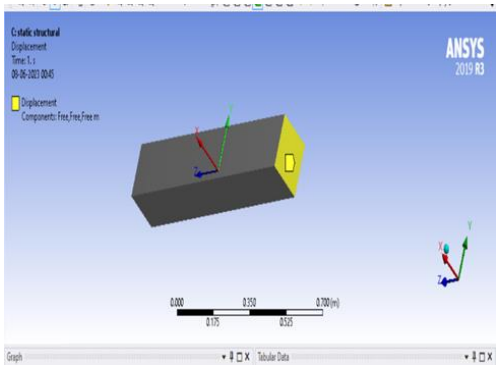


FIGURE 5: Mesh details

VII. SUPPORT

Simply supported beam is considered for both sides of the beam.



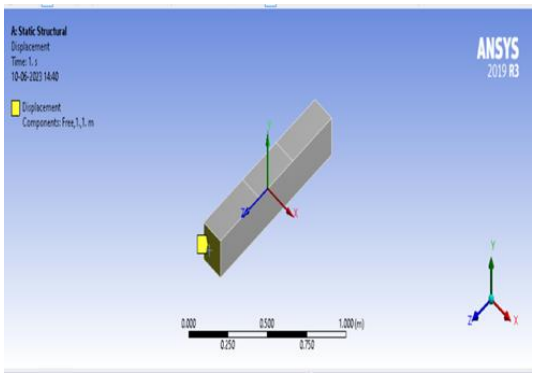


FIGURE 6: Support conditions

VIII. LOADING DETAILS

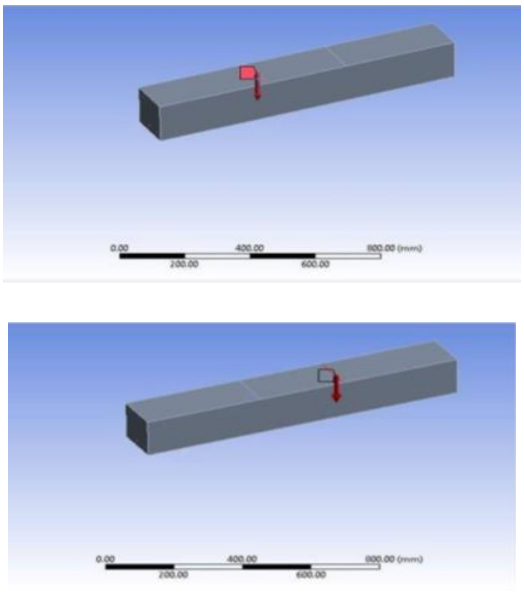


FIGURE 7: Loading details

IX. RESULT

GEOPOLYMER CONCRETE

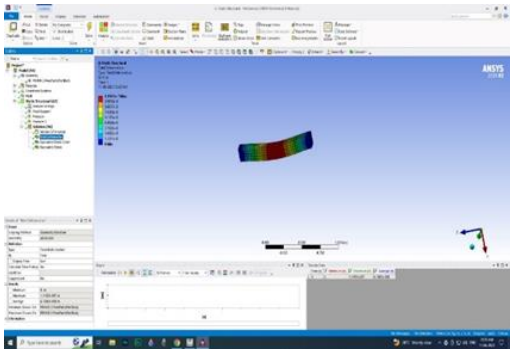


FIGURE 8: Deformation of GPC

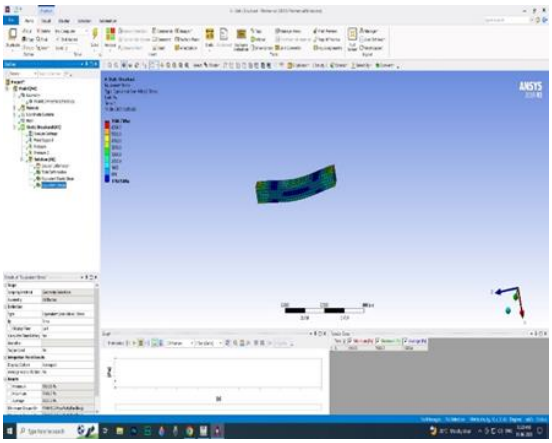


FIGURE 9: Stress for GPC

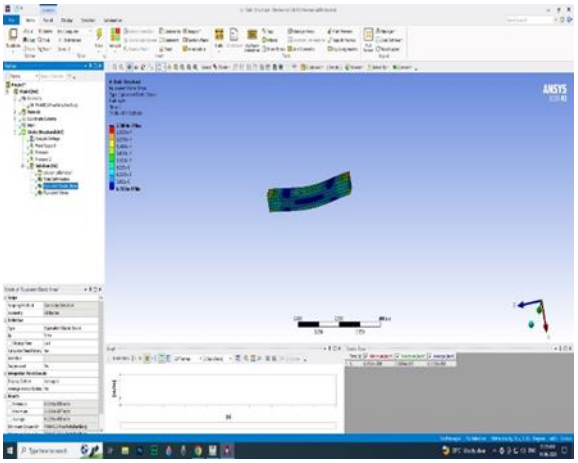


FIGURE 10: Strain for GPC

SELF-COMPACTING GEOPOLYMER CONCRETE

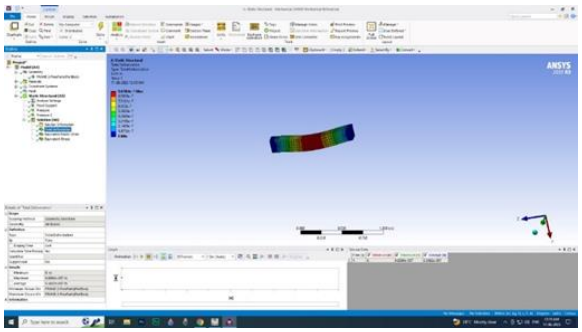


FIGURE 11: Deformation of SCGPC

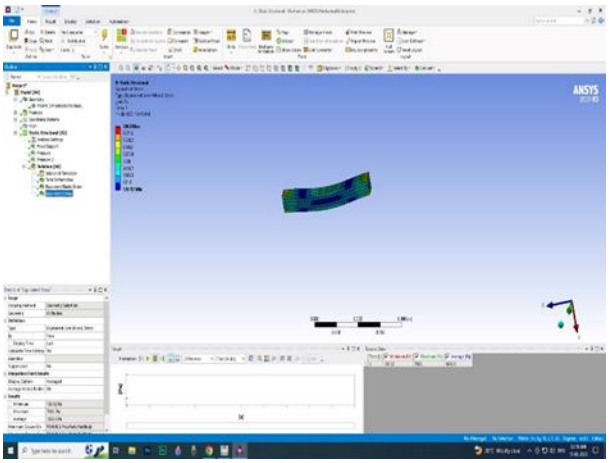


FIGURE 12: Stress for SCGPC

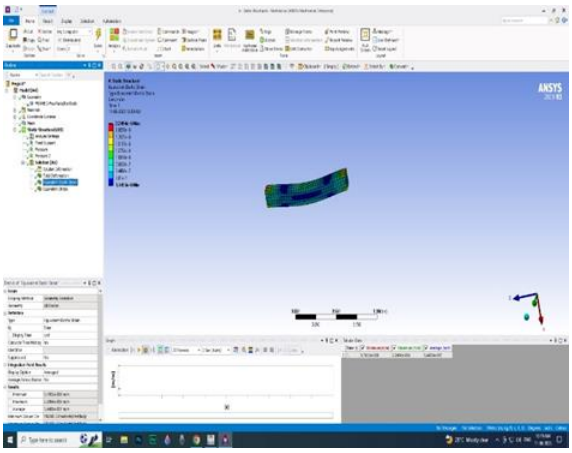


FIGURE 13: Strain for SCGPC

S.NO	LOAD (KN)	DEFORMATION (mm)	STRESS (N/mm²)	STRAIN
1	10	0.0268	4.1752	0.00354
2	20	0.0354	6.3278	0.00683
3	30	0.0423	9.1546	0.000359
4	40	0.0532	12.7855	0.000478
5	50	0.0625	16.2545	0.000543
6	60	0.0874	20.4785	0.0006855
7	70	0.0925	23.8554	0.0006923
8	80	0.1145	26.2578	0.0007124
9	90	0.1565	31.5486	0.0007546
10	100	0.2834	34.2589	0.0007752
11	110	0.3762	29.2154	0.0007946
12	120	0.4545	25.5542	0.0008756
13	130	0.4893	23.1544	0.0008925

TABLE 4 Result Reinforced Geopolymer Concrete Beam

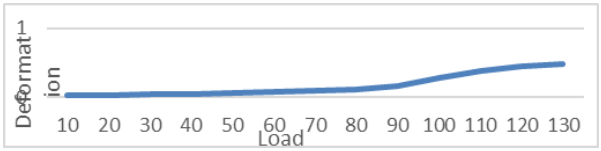


FIGURE 14 load(kN) deformation (mm) geopolymer concrete

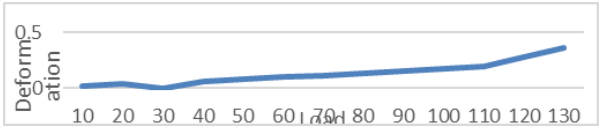


FIGURE 15 load(kN) deformation (mm) self-compacting geopolymer concrete

S.NO	LOAD (KN)	DEFORMATION (mm)	STRESS (N/mm²)	STRAIN
1	10	0.0254	5.1438	0.001238
2	20	0.0367	8.3072	0.000432
3	30	0.o454	12.8765	0.000452
4	40	0.0625	15.7325	0.000583
5	50	0.0834	19.9830	0.000643
6	60	0.1015	24.1120	0.000651
7	70	0.1125	28.3645	0.000695
8	80	0.1336	36.7546	0.000705
9	90	0.1576	42.9786	0.000712
10	100	0.1737	49.8354	0.000755
11	110	0.1943	38.1250	0.000832
12	120	0.2820	30.5432	0.000854
13	130	0.3596	28.2340	0.000893

TABLE 5 Result Reinforced Self-Geopolymer Concrete Beam

CONCLUSION

1. The properties can be enhanced by considering the self-compacting geopolymer concrete.
2. The analysis based on gradually load acting on the beam.
3. Load applied on the beam is 10 to 130 kN and deflection value is 0.02658 to o.4893 mm respectively. As well as the stress values are increased gradually up to 100kn then decrease value for geopolymer concrete.
4. Load applied on the beam is 10 to 130 kN and deflection value is 0.0254to0.3596 mm respectively. As well as the stress values are increased gradually up to 120kn then decrease value for self-compacting geopolymer concrete.
5. The strength of self-compacting geopolymer concrete is increased by 30% than geopolymer concrete.

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