Numerical Study on Geopolymer Concrete with Partial Replacement of Coarse Aggregate Using Steel Furnace SLAG

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***Abstract*-Geopolymer concrete is a type of concrete that is produced using a geopolymer binder instead of traditional Portland cement. The geopolymer binder is typically derived from the reaction of an alum inosilicate material such as fly ash or slag, with an alkaline solution. Geopolymer concrete consists of a mixture of aggregates, the geopolymer binder, and water. The geopolymer binder is responsible for binding the aggregates together. Geopolymer concrete can be used in various applications similar to conventional concrete. These include residential and commercial buildings, infrastructure projects such as bridges and roads and precast concrete elements. After ordinary Portland cement (OPC)concrete, geopolymer concrete (GPC)is the most advanced form of concrete. GPC has many advantages including improved strength and durability properties. High early age strength and ambient curing of OPC helps to reduce the construction time.**

Keywords: Geopolymer concrete, Steel slag, Fly ash, GGBS, Sodium silicate, Sodium hydroxide.

I.INTRODUCTION

Concrete is a composite material commonly used in construction for its strength, durability and versatility. Concrete is the most adaptable, long lasting, and dependable building material in the world. Concrete requires a lot of Portland cement in large quantities. Due to the emission of CO2, the use of Ordinary Portland Cement (OPC) pollutes the environment. Geopolymer concrete was introduced to reduce Portland cement related environmental pollution. Fly ash. The mineral polymers produced by geochemistry were given the name Geopolymers, mineral binders with an amorphous structure, were first developed by Professor Joseph Davidovits in 1978. The Davidovits 1994) suggested that an alkaline liquid could be used to produce binders by reacting with the silicon (Si) and aluminum (Al) in a source material of geological origin or in by-product materials like fly ash and rice husk ash. He coined the term "Geopolymer" to describe these binders because the chemical reaction in question is a polymerization process. The combination of an alkaline liquid and an alumino silicate powder produced this group of solid materials. Due to the high number of fires in Europe at the time, the initial objective of the research on these geopolymers was to find a more fire-resistant binder material. Because of this research, the material is now used as coatings to protect cruise ships from fire, and thermal protect has a low flexural strength. The use of conventional steel reinforcement alleviates the brittleness of both types of concrete. Geopolymer concrete is a novel building material that will be made by reacting chemically with inorganic molecules. Otherwise, geopolymer is an inorganic Alumino hydroxide polymer made primarily of geologically derived silicon (Si) and aluminum (Al) or byproduct materials like "Geopolymer" in the beginning. A chemical reaction on Si-Al minerals occurs under highly alkaline conditions, resulting in amorphous polymeric Si-O-Al-O bonds. It is a superior building material for the future due to its superior mechanical properties, significant chemical resistance (such as against magnesium or sulphate attack), low shrinkage and creep, and environment-friendly nature (it produces significantly less CO2 than OPC). It is common knowledge that RHA can contain non-crystalline silica and that when the rice husk is burned under controlled conditions, a highly reactive pozzolana is produced. A "residual RHA" of lower quality is produced under other conditions, typically, with residual carbon (which raises water demand) and crystalline silica. However, grinding the residual RHA to an appropriate particle size can improve it, albeit at a cost that is expected to be

substantial. Energy costs and selection and disposition strategies are associated with both processes. Composition of Geopolymer Concrete for this concrete to be made, the following materials are required:

- Fly ash, which is a byproduct of a thermal power plant.
- GGBS, which is a byproduct of a steel plant.

The fine and coarse aggregates that are necessary for normal concrete. As previously stated, an alkaline activator solution for GPCC. As an alkaline activator solution, the catalytic liquid system is utilized. In addition to distilled water, it is a solution of hydroxides and alkali silicates. The alkaline activator solution's function is to activate Si and Al containing geopolymeric source materials like GGBS and fly ash.

STEEL SLAG:

Steel slag is a byproduct generated during the production of steel. It is formed when iron ore is smelted in a blast furnace to produce pig iron, and then further processed to remove impurities and create steel. Steel slag consists mainly of calcium silicates, calcium aluminosilicates, and traces of other elements such as iron, manganese, and magnesium.

The composition of steel slag varies depending on the production process and the specific steelmaking furnace used. Generally, it is similar to natural rock or crushed stone aggregates but with some unique properties.

2.RESEARCH SIGNIFICANCE

No research data on the flexural behaviour of fly ash based geopolymer with partial replacement of coarse aggregate by Steel slag is cited at present. Geopolymer concrete with Steel slag at optimum replacement was found be effective. This Research work provided satisfactory test results regarding the numerical investigation on reinforced geopolymer concrete.

3.METHODOLOGY

- To carry out a literature survey on geopolymer concrete and Steel slag properties that can be feasible to use in concrete.
- To compare the result of the ANSYS model without Steel slag and with Steel slag.

4.TEST RESULT AND DISCUSSION

The specimen of size 1000*150*150 mm is modeled and analyzed using ANSYS software with simply supported. Software used is ANSYS SOFTWARE. Using ANSYS structural analysis software, engineers of all levels and backgrounds can solve challenging engineering issues more quickly and effectively. Engineers can use the suite of tools to conduct finite element analyses (FEA), customize and automate solutions to problems with structural mechanics, and examine a variety of design scenarios. Business can cut costs, speed up product introduction, and shorten design cycles by utilizing the software early in the process.

ANSYS is a structural analysis software can simulate every structural aspect of a product, from basic linear static analysis, which only gives stresses or deformations, to advanced transient nonlinear phenomena, which involve dynamic effects and complex behaviors, via modal analysis, which only gives vibration characteristics. Single load cases, vibration, and transient analysis can all be examined using a comprehensive set of analysis tools. Materials, joints, and geometry's linear and nonlinear behavior can also be studied.

Table 1: Properties used in ANSYS

S.no	Property	Values of steel(Fe500)	Values of Reinforced GPC Beam with 0% Steel slag	Values of Reinforced GPC Beam with 45% Steel slag
1	Young’s modulus	2E+05MPa	22360MPa	31040MPa
2	Poisson’s ratio	0.3	0.2	0.21
3	Bulk Modulus	1.6667E+11Pa	1.2422E+10Pa	1.8702E+10Pa
4	Shear modulus	7.6923E+10Pa	9.3167E+09Pa	1.2602E+10Pa

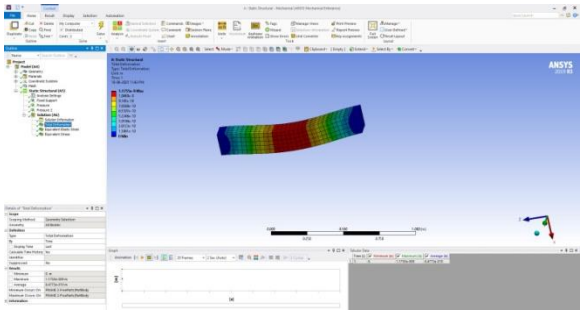

Fig 1: Total deformation of GPC beam

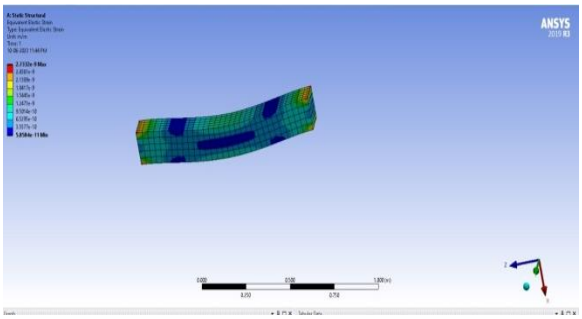

Fig 2: Total stress of GPC beam

Table 2: Result reinforced for steel slag geopolymer concrete

S. No	Load (KN)	Deformation (mm)	Stress (MPa)	Strain
1	10	0.010012	3.0241	0.0000982
2	20	0.020061	6.0222	0.0001970
3	30	0.030007	9.1013	0.0002952
4	40	0.040120	12.102	0.0003936
5	50	0.050075	15.112	0.0004925
6	60	0.060124	18.205	0.0005915
7	70	0.070150	21.153	0.0006909
8	80	0.080216	27.307	0.0007891
9	90	0.090231	24.203	0.0008877
10	100	0.10016	30.351	0.0009864
11	110	0.12078	31.226	0.0009882
12	120	0.15152	29.426	0.0009887
13	130	0.21452	27.521	0.0009932

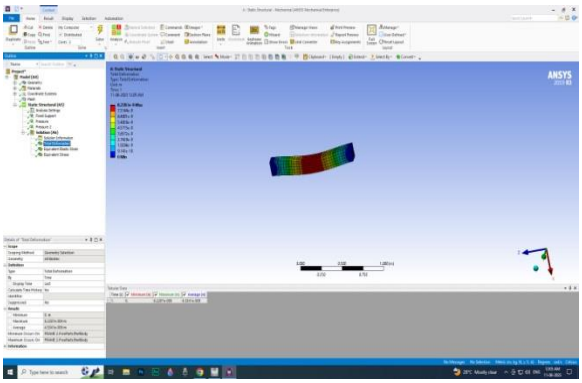

Fig 3: Deformation for 45% Steel Slag

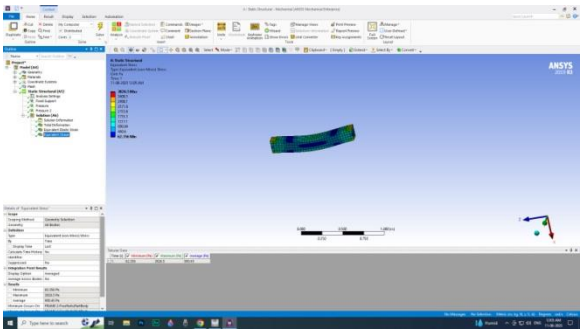

Fig 4: Strain for 45% steel slag

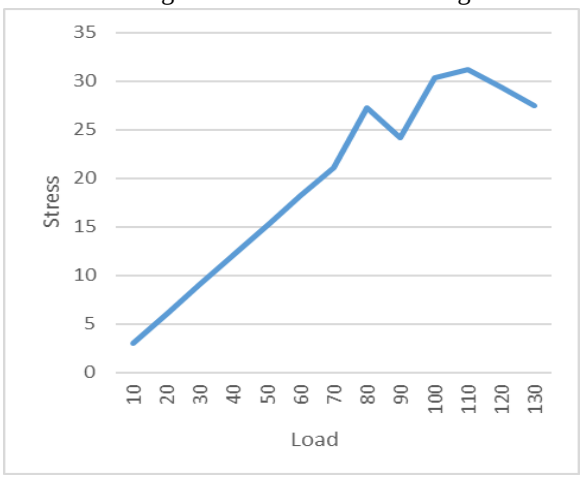

Fig 5: Load-stress graph

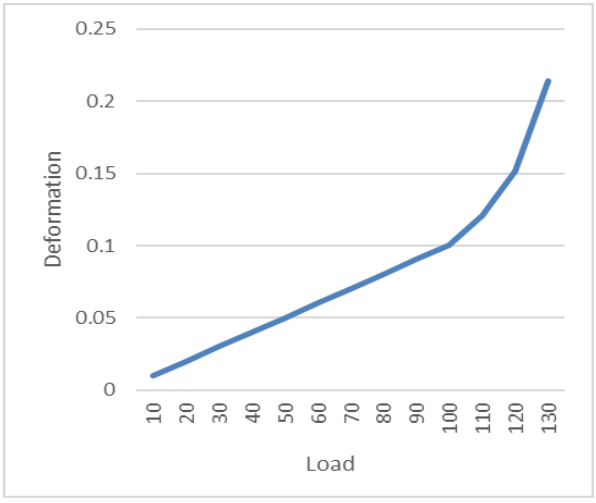

Fig 6: Load-deformation graph

5.CONCLUSION

- Load applied on the beam varies from 10KN to 130KN.
- Geopolymer steel slag concrete has less deformation 5.02% than geopolymer concrete without steel slag.

- The strength of steel slag geopolymer concrete is increased by 20% to 35% than GPC without steel slag.
- The strain of geopolymer concrete is increased by 15% than geopolymer concrete without steel slag.
- Thus compared to GPC without steel slag, steel slag geopolymer concrete withstands more stress, less deformation and improved strength.

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