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Experimental Study on Flexural behaviour of Geocement Concrete Beam

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ABSTRACT –

Concrete, a key construction material, combines cement, aggregates, water, and additives for strength and versatility in structures like high-rises and bridges. Its energy-intensive production raises environmental concerns. Sustainability efforts involve eco-friendly additives and local materials to mitigate environmental impact. Despite resilience against weathering and seismic forces, addressing environmental issues is imperative. Achieving a sustainable future in construction requires innovation and environmentally conscious practices to minimize concrete's environmental footprint while maintaining its essential role in shaping the built environment. For M30 grade concrete, a mix design was completed, and test specimens were created to determine the concrete's water absorption, split tensile strength, flexural strength and compressive strength. This study's experimental investigation on the durability and strength of concrete using optimum value of 75% geocement in replace of cement. This thesis report examines and reports on the effect of geocement on the development of concrete strength. After finding the optimum percentage of precious slag balls in concrete then the flexural behavior of concrete is also conducted. The test specimens were tested for the Flexural Behavior at the age of 28 days. The study investigated replacing geocement in concrete, improving workability and enhancing strength through GGBS activation. Mixes with 75% geocement and 25% OPC demonstrated flexural behaviour of the beam. The study compares the flexural behavior of conventional reinforcement concrete beams with the optimum ratio of geocement reinforcement concrete beam results. Utilizing ANSYS software to analyze comparisons between geocement and conventional reinforced concrete beams.

Keywords: Geocement, Geocement Reinforcement Concrete Beam, Flexural Behavior, ANSYS Software.

1. INTRODUCTION

The building sector is seeing an increase in the use of geocement concrete, commonly referred to as geoconcrete. It serves as an alternative to conventional Portland cement-based concrete and has a number of benefits in terms of performance and sustainability. Typically manufactured from industrial waste products like fly ash, slag, or silica fume, geopolymer is the binder substance used to create geocement concrete. To create a binder that can take the place of conventional cement in the manufacturing of concrete, these waste elements

are chemically activated. The lower carbon footprint of geocement concrete is one of its key benefits. Geocement concrete reduces carbon emissions since it uses industrial waste materials rather than limestone, which is used to make Portland cement and produces a lot of them. An innovative green cement technology, free from clinker and gypsum, containing over 90% Ground Granulated Blast Furnace Slag (GGBFS) activated by proprietary additives. It meets the standards of OPC 43 grade cement for its physical properties and complies with ASTM C 1157. Contains 90% GGBFS and 10% proprietary chemicals, Confirms to OPC 43 grade cement, off white in color, Same Cost as Portland cement.

2. Objective

- To replace cement with 100%, 75%, and 50% of Geocement.
- To conduct the strength test on the geocement concrete for an optimum percentage of geocement.
- To design a reinforced concrete beam for M30 Grade.
- To cast the conventional and optimal percentage of reinforced concrete beam using geocement (75%).
- To test and compare the flexural behavior of conventional and optimum percentage of geocement reinforced concrete beam.
- To analyze and compare the conventional and geocement reinforced concrete beam using ANSYS software.

3. LITERATURE REVIEW

i. Rudy Djamaluddin [Science Direct (2013)]

The study examined external reinforced concrete beams (ERCB) versus normal beams, revealing reduced flexural capacity and stiffness in ERCB. Efforts aimed to minimize concrete volume on tension parts, showing less crack propagation in ERCB. High concrete demand impacts the environment through natural material exploitation and CO2 emissions from energy-intensive cement production.

ii. Mostafa Samadi, Mohammad Hajmohammadian Baghba, etc., [MDPI (2022)]

The study analyzed flexural behavior of concrete beams under instantaneous loading, exploring recycled ceramic's impact as cement and aggregate substitute. Chemical composition of ceramic waste and Ordinary Portland Cement (OPC) was examined, confirming ceramic powder's suitability as a pozzolanic material.

iii. S. Annamalai, S. Thirugnanasambandam and K. Muthumani [Asian Journal of Civil Engineering (2017)]

The flexural behavior of GPC beams cured under ambient temperature was compared to control beams, showing reduced deflection and increased flexural strength in GPC beams. Portland cement production is energy-intensive and emits significant CO2, driving the need for alternative materials like GPC to reduce environmental impact

iv. R. Rajkumar, N. Umamaheswari, Abhishek Kumar, Mrinal Kumar, L.R. Vineeth Gupta, Raoshan Pandey [Science Direct (2019)]

Concrete mixes with metakaolin and marble powder exhibited higher compressive and split tensile strength than conventional concrete across various curing ages. Substitution levels of cement with metakaolin and fine aggregate with marble powder were assessed, demonstrating enhanced mechanical properties in beams. Admixtures improved concrete's microstructural properties and decreased calcium hydroxide concentration.

v. S.P.Sangeetha, P.S Joanna[American Journal of Engineering Research(2014)]

Ultimate moment capacity of GGBS beams increased by 21% at 56 days compared to 28 days. Deflections of GGBS beams were less than controlled beams at 56 days, showing improved performance over time. Crack widths in GGBS concrete beams were within allowable limits, indicating structural integrity. GGBS concrete beams exhibited behavior similar to traditional cement concrete beams, suggesting the potential use of GGBS in reinforced concrete beams.

vi. Ahmed M. Maglad, etc., [International Journal of Concrete Structures and Materials (2023)]

Sawdust concrete (SDC) had 15% sawdust substitution for sand, reducing compressive strength by 4% compared to normal concrete. Strengthening with a wooden plate and steel angles increased load capacity by 20% compared to control beams. SDC-2A beam showed the highest load-carrying capacity and post-peak performance among tested beams.

4. PRELIMINARY TESTS AND MIX DESIGN

The basic characteristics of the materials used for the preceding study are examined first. To determine the necessary mix design, tests for cement, m-sand, foundry sand, coarse aggregate, specific gravity, water absorption, sieve analysis, bulk density, impact, and crushing are conducted. Test results are utilized.

Table 1: Mix Proportion of M30 Grade of Concrete

CEMENT	FA	CA	WATER
1	1.62	3.07	0.4

5. FRESH AND HARDENED CONCRETE TEST

In accordance with the requirements of the IS code, the slump cone is used to determine the concrete's workability when it is still fresh. Tests of compressive strength are performed on 150 mm x 150 mm x 150 mm cubes. The outcomes are compared with the results from a control mix of specimens.

Table 2: Slump Cone Value

Mix ID	Slump Value in (mm)	Workability
Conventional	96	MEDIUM

Geocement	98	

Table 3: Compression Strength Test After 28th Day

Mix ID	Compression Strength (N/mm^2)
Conventional	33.9
Geocement	36.25

6. DESIGN OF BEAM

The beam was manually designed using the provision from IS 456:2000 for M30 grade of concrete and Fe500 grade of steel as follows Fig 1 represents the reinforcement details of the beam.

Figure 1: Longitudinal Section of Beam

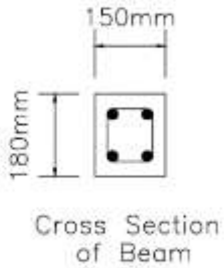

Figure 2: Cross Section of Beam

7. FLEXURAL BEHAVIOUR OF BEAM

The beams were tested for their flexural behaviour. The beam was placed on the setup that was simply supported. The support distance was marked as 100mm on both the sides of the beam. A steel I section was placed on the beam and the load cell was adjusted and set up. A three-point loading setup was made in order to distribute the load equally on the beam. An LVDT (Linear Variable differential transformer) was used to measure the deflection at L/2 distance (center of the beam) from the supports. A dial gauge was used to record the deflection values at a distance of L/3 from one of the supports. The experimental setup is given in figure 3.

Figure 3: Experimental Setup of Beam in the Loading Frame

8. EXPERIMENTAL RESULTS ON CONVENTIONAL REINFORCED CONCRETE BEAM

The beam started to develop cracks at a load of 4 tons at which it had a deflection of 1.51 mm in L/2 and 1.25 mm in L/3. Further, minor cracks started to develop from the tension zone towards the compression zone which indicates that the mode of failure is flexural in this case. The major parameters that were recorded during the conduct of this test is given below in table 3.

Table 4: Final Observation for Conventional Beam

Parameters	**Results**	
1st Crack Load	39.2266 kN (4 T)	
Deflection at 1st Crack Load	L/2 = 1.51 mm	L/3 = 1.25 mm
Ultimate Load	142.1964 kN (14.5 T)	
Ultimate Deflection	L/2 = 9.1 mm	L/3 = 8 mm

9. EXPERIMENTAL RESULTS ON GEOCEMENT REINFORCED CONCRETE BEAM

The beam started to develop cracks at a load of 4.5 tons at which it had a deflection of 2.57 mm in L/2 and 2.15 mm in L/3. Further, minor cracks started to develop from the tension zone towards the compression zone which indicates that the mode of failure is flexural in this case. The major parameters that were recorded during the conduct of this test is given below in table 5.

Table 5: Final Observation for Geocement Beam

Parameters	**Results**	
1st Crack Load	44.129925 kN (4.5 T)	
Deflection at 1st Crack Load	L/2 = 2.57 mm	L/3 = 2.15 mm
Ultimate Load	163.771 kN (16.7 T)	
Ultimate Deflection	L/2 = 8.5 mm	L/3 = 7.5 mm

10. LOAD DEFLECTION CURVES

The loads (P) and their corresponding deflections (δ) were recorded. Load was recorded in tons and then converted to kN. The deflection was measured using dial gauge which has a least count of 0.01mm. So, the deflection values in the form of divisions are then converted to mm with the help of least count. The load deflection curves were drawn as shown in figures 4 and 5.

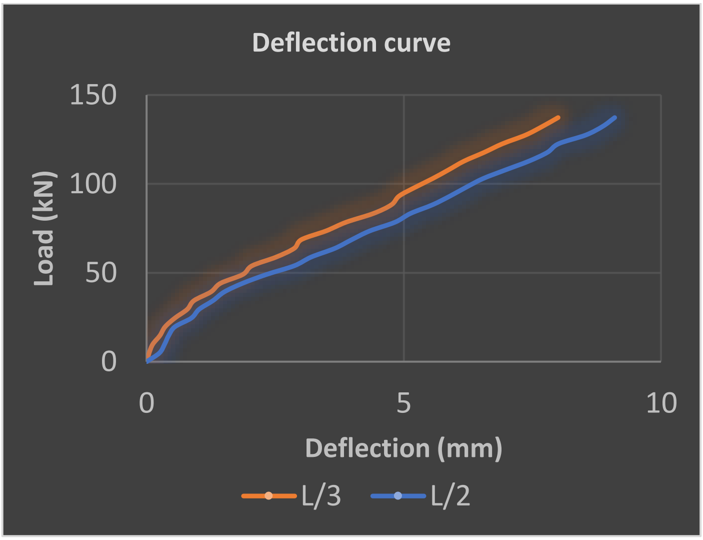

Figure 4: Load Deflection Curve (Conventional Beam)

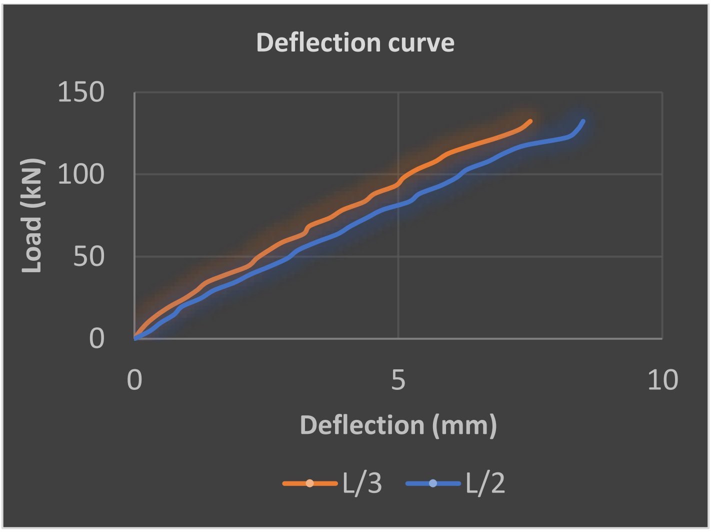

Figure 5: Load Deflection Curve (Geocement Beam)

11. ANALYTICAL OF RC BEAM

ANSYS stands as a pivotal software solution within structural engineering, emphasizing the paramount importance of reliability and precision. This tool empowers engineers to conceptualize, simulate, and scrutinize structures with unparalleled efficiency and accuracy. Renowned for its versatility across various engineering domains such as electromagnetics, fluid dynamics, and structural analysis, the extensive simulation software package ANSYS offers engineers a dependable platform to meticulously model and simulate complex structures under diverse loading conditions. ANSYS, Inc. is the entity behind its development.

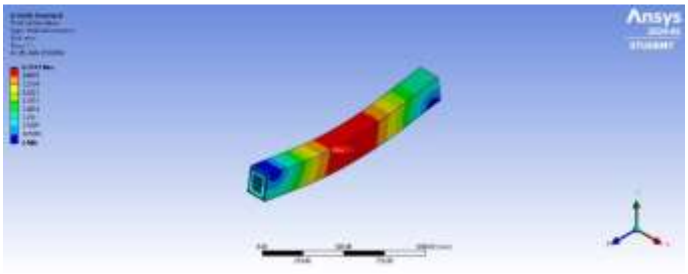

Figure 6: Total Deformation of Conventional Beam

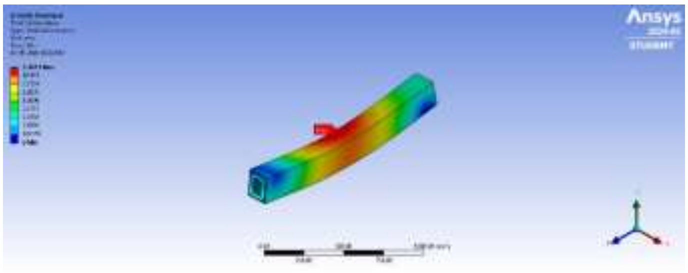

Figure 7: Total Deformation of Geocement Beam

Table 6: Comparison Result of Flexural Behaviour ANSYS

Specimen	**Maximum Deflection (mm)**	
	Experimental Result	**ANSYS Result**
Conventional Reinforced concrete Beam	9.1	6.75
Geocement Reinforced concrete Beam	8.5	7.36

The flexural behavior of conventional and geocement beams is shown in this table based on experimental and ANSYS results. The geocement beam has shown more deflection in both experimental and ANSYS calculations as compared to the conventional beam.

12. CONCLUSION

After making a detail study on this work the following result and discussion were done,

- Concrete's fresh, hardened, and durable qualities were discovered when geocement was substituted. Every batch of specimens has achieved the proper slump value, which improves the concrete's workability.
- Concrete increases stronger as geocement is replaced due to its GGBS is activated by special chemicals.
- In comparison to the nominal concrete mix, the GC2 mix, which consists of 75% geocement and 25% OPC, exhibits an increase in compressive, split tensile, and flexural strength.
- The beam had a deflection of 1.25 mm in L/3 and 1.51 mm in L/2 when it began to fracture under a 4-ton strain. Additionally, little cracks began to appear from the tension zone toward the compression zone, indicating that flexural failure is the mode of failure in this instance.
- A load of 4.5 tons caused the beam to begin split up, deflecting 2.57 mm in L/2 and 2.15 mm in L/3. Additionally, little cracks began to appear from the tension zone toward the compression zone, indicating that in this instance the mode of failure is flexural.
- The conventional reinforced concrete beam appears to have had an experimental maximum deflection of 9.1 mm, whereas the ANSYS simulation produced a lower value of 6.75 mm. This is based on a comparison of the experimental and ANSYS results for the two types of reinforced concrete beams. However, the ANSYS simulation showed a slightly higher value of 7.36 mm for the geocement reinforced concrete beam, although the experimental configuration showed a maximum deflection of 8.5 mm.

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