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Flexural Behaviour of Steel Fibre Reinforced Geopolymer Concrete

G. Jegatheeswaran[1], K. Soundhirarajan[2]

[1]PG Student, [2]Head of Department in Civil Engineering,
[1,2]Gnanamani College of Engineering, Namakkal, Tamil Nadu, India

ABSTRACT

Concrete is the most used construction material from ancient days. It was expected that the production of cement would be increased from about from 1.5 billion tons in 1995 to 2.2 billion tons in 2020. But 2018 china using 2.37 billion tons individually. India is the second largest producer of cement in the world. Cement industry is expected to reach 550 – 600 million tons per annum at 2025. The cement production contributes nearly 8% of worlds global warming due to emission of greenhouse gases, such as CO2, to the atmosphere. Hence, it is essential to find a substitute material for cement. The technology geopolymer concrete found as alternative for this problem. In this present research, cement is replaced with Fly Ash and GGBS in different percentages with steel fibers. The studies show that the load carrying capacity of most of the gpc mix was in the most cases more than that of conventional ordinary Portland cement concrete mix. The fresh and hardened properties of geopolymer concrete were found with and without steel fiber. The mechanical characteristics of all the examined mixes are to be enhanced by the GGBS content, in both plain and steel fibre reinforced geopolymer concrete. A comparative analysis has been carried out for normal conventional concrete to that of the steel fibre reinforced geopolymer concrete under ambient curing in relation to compressive, split tensile, flexural strengths. As the fibre content generally increases compressive, split tensile and flexural strengths are proportionally increased.

KEYWORDS: *Fly Ash, GGBS, steel fibre reinforced geopolymer concrete, CO2, ordinary Portland cement concrete*

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1. INTRODUCTION

Ordinary Portland cement is one of the most important binding materials in terms of quantity produced. Since it is manufactured at a very high temperature, it consumes lot of energy. Besides huge amount of energy consumption, it emits harmful gases, which pollute the atmosphere. The production of every ton of Portland cement contributes about one ton of CO_2 in the atmosphere. Small amounts of NO_2 and CH_4 gases are also emitted. Apart from energy consumption and emission of harmful gases, calcium hydroxide, one of the hydration products, obtained during the hydration of cement, is a nuisance for construction industry. This affects the durability properties of cement based materials. The optimum workability of fresh concrete varies from situation to situation. E.g. the concrete that can be termed as workable for pouring into large sections with minimum reinforcement may not be equally workable for pouring into heavy reinforced thin sections.

- Study of the effect of using Ground Granulated Blast Furnace Slag and Fly Ash in concrete and its benefits.
- For checking the effect of replacement of cement by using Ground Granulated Blast Furnace Slag and Fly Ash and strong alkali solutions such as potassium hydroxide (KOH), sodium hydroxide (NaOH).
- To study the behavior of steel fiber in geopolymer concrete.
- An approach towards the use of alternative materials as concrete admixture.
- To reduce the CO2 emission and the environmental pollution from the manufacture of cement.

2. MATERIALS STUDIES

2.1. Materials Used

- Cement
- Fly ash (f)
- GGBS (Ground-granulated blast-furnace slag)
- STEEL FIBRE
- Fine Aggregate
- Coarse Aggregate
- Water

3. PRELIMINARY STUDIES

3.1. Cement Properties

S. NO	DESCRIPTION	VALUES
1	Specific gravity	3.15
2	Fineness (%)	0.2
3	Initial setting time (minutes)	30
4	Final setting time (hours)	5

Table 3.1 Cement Properties

3.2. Fine and Coarse Aggregate Properties

S. No	Description	Fine Aggregate Values	Coarse Aggregate Values
1	Specific gravity	2.7	2.85
2	Fineness (%)	5.5	6.12
3	Water absorption (%)	1.72	0.51

Table 3.2 Fine and Coarse Aggregate

3.3. Fly Ash Properties

S. NO	DESCRIPTION	VALUES
1	Specific gravity	2.24
2	Fineness (%)	0.2
3	Silicon dioxide	59
4	Aluminium oxide	21
5	Iron oxide	3.7
6	Calcium oxide	6.9
7	Magnesium oxide	1.4
8	Sulphur trioxide	1
9	Potassium oxide	0.9
10	Ignescent material	4.62

Table 3.3 Fly Ash Properties

3.4. Ground Granulated Blast furnace Slag (GGBS) Properties

S. NO	DESCRIPTION	VALUES
1	Specific gravity	2.9
2	Fineness (m^2/kg)	350
3	Bulk density(kg/m3)	1200
4	Calcium oxide	40
5	Silica	35
6	Alumina	13
7	magnesia	8

Table 3.4 Ground Granulated Blast furnace Slag (GGBS) Properties

3.5. Steel Fiber Properties

S. NO	DESCRIPTION	VALUES
1	Specific gravity	7.85
2	Elastic modulus(GPa)	300
3	Length(mm)	30
4	Diameter(mm)	0.5

Table 3.5 Steel Fiber Properties

4. EXPERIMENTAL INVESTIGATION

4.1. Mixing, Placing and Compaction

For casting, all the mould were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Careful procedure was adopted in the batching, mixing and casting operations. The concrete mixture was prepared by machine mixing. For Cube (150mm x 150mm x 150mm), cylinder (150mm x 300mm) and Prism (100mm x 100mm x 500mm) the mixture was cast in three layers. Each layer received 25 manual strokes. Fly Ash was added to the mixture in dry condition during the mixture of cement and fine aggregate after mixing the mixture with water.

5. RESULTS

5.1. Compressive Strength Test Result

S. No.	Specimen	Compressive Strength (N/mm^2)
1	Conventional Concrete	26
2	Fly Ash (90%) + GGBS (10%)	33.3
3	Fly Ash (90%)+GGBS (10%)+Steel Fibre (0.25%)	35.85
4	Fly Ash (90%)+GGBS (10%)+Steel Fibre (0.5%)	37.80

Figure.5.1 Testing of Cube

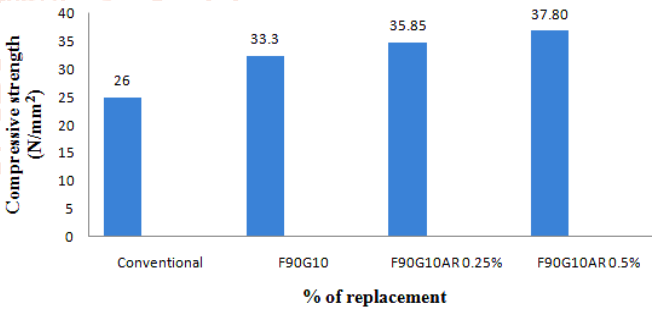

Figure.5.2 Graphical representation of compressive strength test results

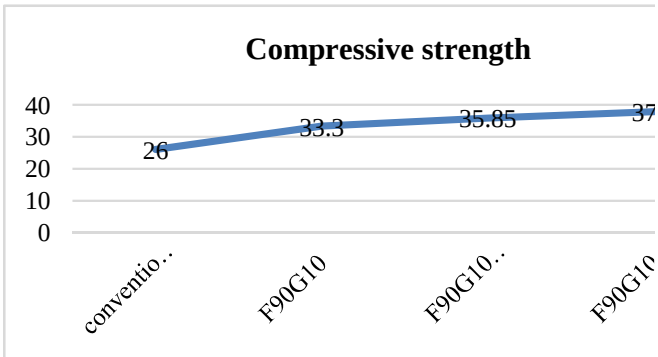

Figure 5.3Graphical representation of compressive strength test results

5.2. Split Tensile Strength Test Results

S. No.	Specimen	Split Tensile Strength (N/mm²)
1	Conventional Concrete	2.39
2	Fly Ash (90%) +GGBS (10%)	2.58
3	Fly Ash (90%) +GGBS (10%) +Steel Fibre (0.25%)	2.76
4	Fly Ash (90%) +GGBS (10%) +Steel Fibre (0.5%)	2.97

Table 5.2 Split Tensile Strength test results on concrete cylinders

5.3. Flexural Strength Test Results

S. No.	Specimen	Flexural Strength (N/mm²)
1	Conventional Concrete	3.4
2	Fly Ash (90%)+GGBS (10%)	3.8
3	Fly Ash (90%)+GGBS (10%)+Steel Fibre (0.25%)	4.64
4	Fly Ash (90%)+GGBS (10%)+Steel Fibre (0.5%)	4.9

Table 5.3 Flexural Strength test results on concrete prisms

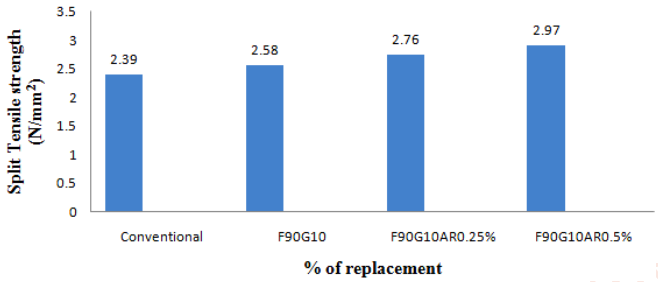

Figure 5.4 Graphical representation of split tensile strength test results

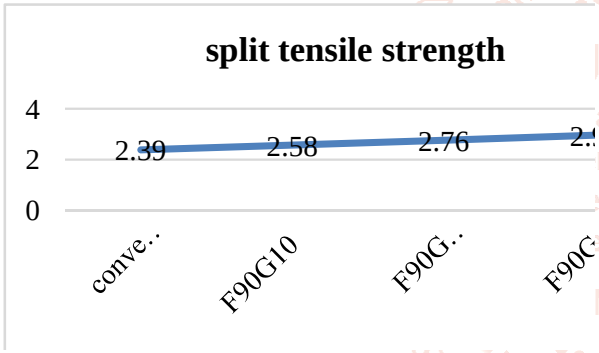

Figure 5.5Graphical representation of split tensile strength test results

Figure 5.6 Testing of Cylinder

Figure 5.7 Testing of Prism

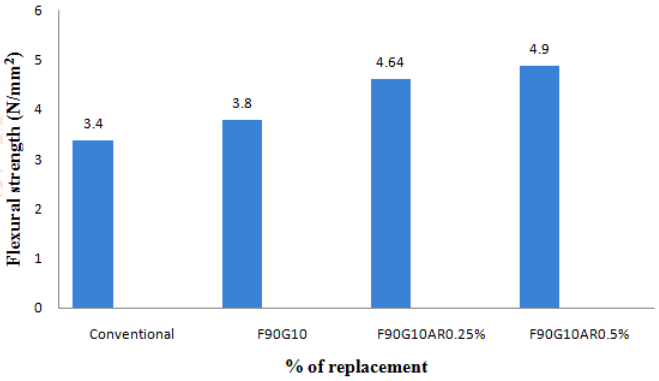

Figure 5.8 Graphical representation of flexural strength test results

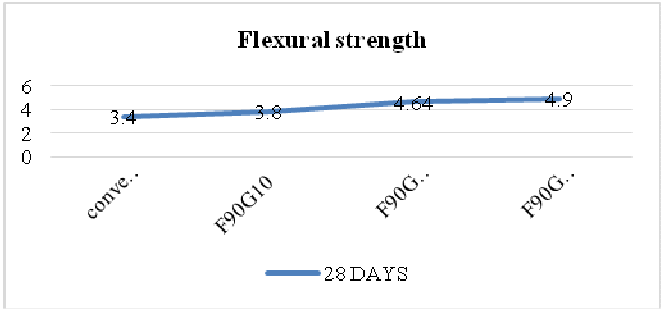

Figure 5.9 Graphical representation of flexural strength test results

6. CONCLUSION

- The use of steel fibre on geopolymer concrete has produced the optimum compressive strength value and geopolymer, will enhance the reduction of cement usage in concretes, thereby reducing the environmental pollution caused by the cement manufacture.
- It was observed from the test results that the compressive strength of fibre reinforced geopolymer possess better results than gopolymer concrete.
- The flexural behavior and split tensile strength of fibre reinforced geopolymer concrete possess good ductile in nature than geopolymer concrete
- It arrests the intial crack and makes the concrete to attain more loads.
- Compared to geopolymer concrete fibre reinforced geopolymer concrete yields better mechanical properties.
- The addition of steel fiber gives better results of compressive, tensile, flexural values.

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