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An Experimental Study on the Use of Fibers (Coir and Polypropylene) in Geopolymer Concrete in Pavement Applications

C. S. Sahana[1], R. Suhas[2]
[1]*Student, Department of Construction Technology & Management, Dayananda Sagar College of Engineering, Bengaluru, India*
[2]*Assistant Professor, Department of Construction Technology & Management, Dayananda Sagar College of Engineering, Bengaluru, India*

***Abstract*: In the construction industry the most vital parameter considered in the current scenario is the sustainable development of the structures especially pavement. The most used material in construction is concrete, which is primarily made up of Portland cement. The manufacturing of Portland cement is almost about 2.6 billion tons per year and is increasing at the rate of 5% annually. The concrete industry contributes about 5-8% of all human generated carbon dioxide worldwide. In this paper, the effects of coir and polypropylene fibers on the strength of geopolymer concrete are studied under the tests, namely compressive test, flexural test and fatigue testing.**

The geopolymer concrete used for testing is produced with 100% substitute of cement with geopolymer material as binder. The mixes will be considered for molarity of 12M. The combination utilized in the current study is the blend of sodium silicate and sodium hydroxide solutions in the proportion of 1:2.5. Coir fiber and polypropylene fibers with the varying percentages of 0.5, 1.0, 1.5, 2.0 2.5 and 3.0 are used. Cubes and beams will be cast and cured encompassing temperature conditions. Also, fatigue behavior of this type of concrete will be studied subjecting the beams under flexural fatigue loading taking 85%, 90% and 95% stress ratio. Cost of the material is calculated and rate analysis will be carried out taking into consideration an existing on-going project work as an example.

***Keywords*: Polypropylene + Coir, fiber reinforced geopolymer concrete (FRGPC), Flexural, Compressive and Fatigue strengths, sodium sulphate, sodium hydroxide, GGBS.**

1. Introduction

In developing and developed countries, concrete is used entirely in the world as construction material. The ingredients of concrete are important for its performance in the mix. We knew that concrete is brittle in nature. Addition of fibers controls cracks in concrete. The fibers were cheap and waste material, which can be used in concrete to develop strength. The organic and in organic fibers are added in concrete and its different strengths are determined by many researchers in the world. The present investigation, an attempt has been put in this paper is to control the cracks due to addition of Artificial and natural fibers in geo polymer concrete.

2. Scope and objective of work

1. To introduce polypropylene + Coir fiber in geopolymer concrete.
2. To vary the percentage of polypropylene + Coir fiber in geopolymer concrete
3. To compare conventional geo polymer concrete with polypropylene + Coir fiber geo polymer reinforced concrete in terms of different strengths of concrete.
4. To find out optimum % of fiber content.
5. To determine pavement thickness for different temperatures using IIT RIGID software.

Table 1
Description of concrete specimen

Description of concrete	Designations	% of fibres	No. of specimens	
			Cubes	Beams
conventional GPC	CGPC	0	3	3
GPC +0.5 % of fibres	FRGPC	0.5	3	3
GPC+1.0% of fibres	FRGPC	1	3	3
GPC+1.5% of fibre	FRGPC	1.5	3	3
GPC+2.0% of fibre	FRGPC	2	3	3
GPC+2.5% of fibre	FRGPC	2.5	3	3
GPC+ 3.0% of fibre	FRGPC	3	3	3

3. Experimental investigation

A. *Materials*

1) *GGBS*

Ground Granulated Blast Furnace Slag is an off-white cementitious material. Here GGBS is a binding material and mostly used in ready mix concrete with the ratio of 30-70%. It is used to produce an ecofriendly concrete.

2) *Fine aggregate*

The character of concrete depends on the quality and quantity of M-sand. In this paper, locally available M-sand was used for the present research. Tests are conducted.

M-sand properties are presented in Table 2.

3) Coarse aggregate

The character of concrete depends on the quality and quantity of coarse aggregate. In this paper, coarse aggregate was used and tests are conducted according to IS – 2386 1963.

Table 2
Fine Aggregate Properties

S. No.	Physical properties	Results
1	Specific Gravity	2.25
2	Fineness Modulus	3.73
3	Bulk density (kg/m^3)	1445

Table 3
Fibers properties

properties	Polypropylene fibers	Coir fibers
Length (mm)	25	25
Diameter (mm)	0.234	0.240
Tensile strength (N/mm^2)	226	189

Fig. 1. Polypropylene fiber

Fig. 2. Coir fiber

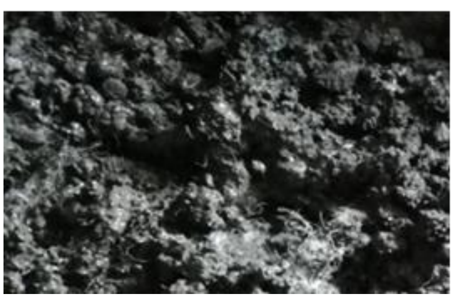

Fig. 3. Geo polymer Concrete with fibers

Design Mix

M-40 was designed according to IS-10262-2009.

Experimental programme

M-40 mix design is prepared by addition of fibers. The cube size 100*100*100mm, cylindrical size length- 300 and dia-150 mm and prism size 100*100*500mm specimens were casted with fibers of 0.5%, 1.0%, 1.5%,2%,2.5% and 3.0%.

Concrete specimens were tested for different fibers and various strengths like compression, fatigue and flexural strengths respectively according to IS specification after curing 28 days

Compressive strength

Compressive test is conducted according to IS – 516:1959.

Flexural strength

Flexure test conducted according to IS – 516:1959.

Fatigue strength

Fatigue test conducted according to IRC- 58-2015.

4. Results and discussions

A. *Strength of cubes*

The mean compressive strength of different GPC with and without the addition of natural and artificial fibers at 3, 7 and 28 days are provided in the bar chart is shown. The mix GP 5 i.e., the addition of 2.5% of fibers produces a maximum compressive strength which are attained 37.5, 40.3 and 41.2 Mpa for 3, 7 and 28 days respectively. The results have verified that there is a positive increment in the quality because of its toughness properties.

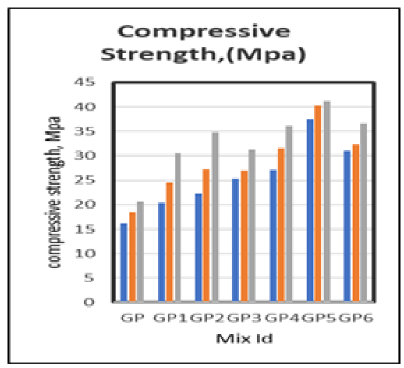

Fig. 4. Comparison of cube strength of concrete for various % of fiber. (compressive strength)

B. *Strength of prisms*

Flexural strength of various geopolymer concrete suggests substantial improvement with the addition of fibers using 2-point loading arrangements, the very best execution used to be stated for the geopolymer mixture consisting of 2.5% incorporation of fibers and proven in chart.

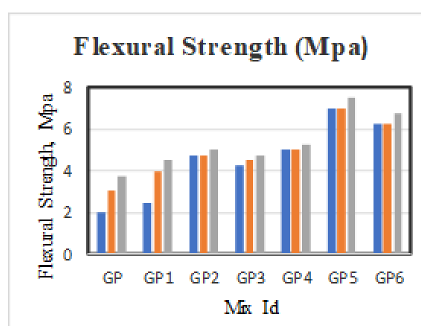

Fig. 5. Comparison of prism strength of concrete for various % of fiber, (flexural strength)

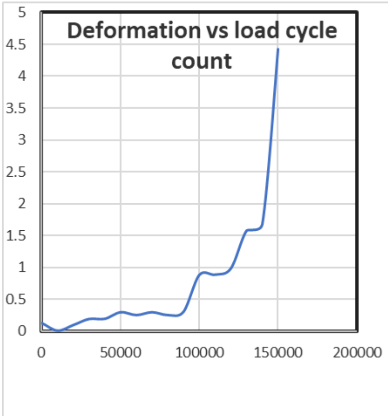

Fig. 6. Comparison of prism strength, (fatigue strength) for 30% loading

C. Comparison of strength of concrete for various % of Fiber

The addition of Polypropylene+ Coir fiber (FRGPC) in concrete has more influence on prism strength and rather than the Cube strength.

For an optimum Percentage of 2.5% of fiber the Cube strength and prism strength compare to normal Geopolymer concrete increased by 23.5%, 35% and 30.7% respectively.

D. Pavement thickness for different temperatures (using IIT rigid software)

1. The pavement thickness of geopolymer concrete treated with 2.5% polypropylene fibres and coir fibres gets reduced up to 20% of concrete slab thickness compared to normal GPC.
2. Different temperature of slab is affected on thickness of pavement slab. Due to increases in differential temperature of slab, thickness also increases respectively.

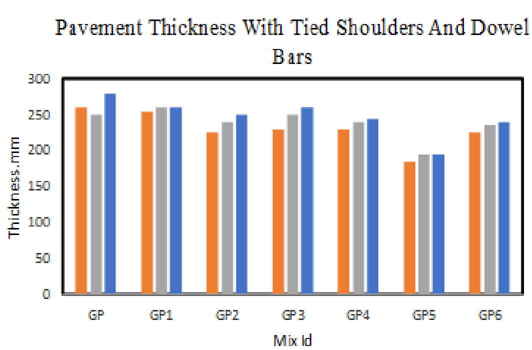

Fig. 7. Pavement thickness with tied shoulders and dowel bars

5. Conclusions

- With the addition of Polypropylene + Coir fiber in the concrete (FRGPC) compare to conventional Geopolymer concrete (CC) the cube and prisms strengths increase.
- The strength of FRGPC increases up to 2% of fiber which is optimum further increase in percentage of fiber (up to 3%) decreases the strength. however, the strength is higher than CC up to 2.5% of fiber content.
- The presence of fiber increases the strength of concrete than the normal GPC.
- The pavement thickness of GGBS treated with 2.5% fibres is maximum reduces up to 28% of concrete slab thickness compared to plain GPC.
- Wastes can be effectively utilized in increasing the strength of concrete efficiently, instead of destroying its useful inherent properties. Also, in turn reducing the problem of disposal.

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