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REPLACEMENT OF CEMENT BY GLASS POWDER IN FRC COSIDERING STRENGTH AND DURABILITY ASPECT

Prashant M. Shiyani[1], Prof. Dhruti J. Dhyani[2]

[1]*Department of Civil Engineering, S.V.I.T. Vasad,*
[2]*Department of Civil Engineering, S.V.I.T. Vasad,*

Abstract - *As we knownow days, most of developing countries are facing shortage of post consumers waste disposal sites and this has raised very serious problems. For this reason, regenerating and using waste product as resources and prevent environmental pollutions is very essential. Here efforts are made for usage of waste glass in concrete. The objective of this work is to identify the usage of finely powdered glass as a partial replacement of cement to determine the pozzolanic reactivity of finely powdered glass in concrete. Different tests will be performed to examine the effect of 10%, 20% and 30% replacement of cement by powdered glass on mechanical and durability properties.Also Technology in Concrete has been developing in many ways to enhance the quality and properties of concrete. Here study will also be conducted to evaluate the possibility of incorporating the natural banana fibers, which are abundantly available in India, as an additional admixture for concrete mix design. The mechanical and durability aspect of the concrete, containing natural banana fibers 0.5%, 1% and 1.5% of cementitious content, will be evaluated in the course of this study.*

Keywords *– Glass powder**(GP)**; Banana fibers**(BF)**; Workability; Compressive strength; Flexural strength; Split tensile strength; Acid attack*

I. INTRODUCTION

The increasing scenario towards the environment, rising inadequacy of landfills, reducing sources of standard aggregate in many districts, rising transportation charges and rising landfill costs are the factors which enforces the use of recycled waste of concrete in new concrete. Recycling the waste of constructions, involving concrete, and the landfill binding ingredients of the solid waste stream of municipality, involving glass which is available mostly as mixed colour waste glass having lower market value, may be considered significant step leading to sustainable construction.
Concrete is weaker in tension and contains a character like brittle. The idea of usage of fibers to raise the characteristics of building material is so earlier. Usage of continual reinforcement in reinforced concrete improves ductility and strength, but it require good placement and skilled labour. Introduction of fibers with discrete form with reinforced and plain concrete may give a good solution. Since use of synthetic fibers is somewhere costly and are non-biodegradable. In this study focus is given on the use of wastage in concrete to improve concrete properties. Therefore, here natural banana fibers are used in concrete which are extracted from wasted trunk of banana trees and also it is biodegradable hence environment friendly.

EXPERIMENTAL WORK

Experimental investigation was carried out on concrete made with partial replacement of cement by waste glass powder with particle size less than 100 µm. The cement was partially replaced by 10%, 20% and 30% by glass powder and the mix design was prepared. After deriving the optimum dosage of glass powder, banana fibers in 0.5%, 1.0% and 1.5% by weight of cement were added to the optimal concrete mix.The different materials used in concrete are cement, fine aggregate, coarse aggregate, glasspowder as a mineral admixture, banana fibers, superplasticizer and water. The mix design of M30 grade concrete was prepared as per Bureau of Indian Standards, IS: 10262-2009. The proportion mix of concrete used was 1.00: 2.05: 2.83 and w/c ratio was 0.41 with superplasticizer at 1.3% by the weight of binder. The compressive,flexural, split tensile and durability tests were conducted on the concrete specimens at 7 days and 28 days. The chemical and physical properties of glass powder was obtained by XRF are presented below.

A. Materials used

I. Cement, aggregate and water: Concrete is made from various mixing materials like cement, aggregate, water etc. which are available naturally. OPC 53 grade cement conforming to IS 8112 was used in this work. Cleanriver sand was used as fine aggregate in this experimental program, with sizes not exceeding 4.75 mm, conforming to zoneI. Coarse aggregate used was asbestos stone,machine crushedand angular shaped. Coarse aggregate used was in two different sizes, one passing from 12.5

mm and retained on 10 mm sieve and second 25 mm passing and retained on 20 mm sieve.To improve workability polycarboxylate base super plasticizer brand name REDWOP is used.

II. Glass powder: The glass powder used in present study is brought from wastage of glass factory at Vitthalnagar GIDC, Anand. This material replaces the cement in mix proportion. The glass powder was less than 100 micron and sieved through 90 micron IS sieve. The chemical and physical properties of glass powder used are presented below in table 1 and 2.

Sr. No.	Physical properties of glass powder	
1	Fineness passing through 90 µm	98.1
2	Specific gravity	2.4

Table 1: Physical properties of glass powder

Sr. No.	Compound	Concentration(%)
1	Na_2O	14.003
2	MgO	2.539
3	Al_2O_3	0.694
4	SiO_2	64.029
5	P_2O_5	0.008
6	SO_3	0.372
7	K_2O	0.06
8	CaO	12.14
9	TiO_2	0.026
10	Cr_2O_3	0.016
11	MnO	4.309
12	Fe_2O_3	0.709
13	ZnO	0.507
14	SrO	0.008
15	ZrO_2	0.006
16	MoO3	0.008
17	WO_3	0.517
18	Cl	0.048

Table 2: Chemical properties of glass powder

B. Mix proportion and testing of specimens

*I. Mix Design:*The concrete mix proportion was obtained by using Indian Standard code IS:10262-2009. The concrete was designed for M30 grade.

Sr. No.	Mix	Cement	Glass Powder	Banana fibers	F.A.	C.A.		Water	W/C ratio	SP (% of binder)
						10 mm	20 mm			
1	M (Normal)	395	-	-	810	447	671	162	0.41	1.3
2	M1 (10GP)	355.5	39.5	-	810	447	671	162	0.41	1.3
3	M2 (20GP)	316	79	-	810	447	671	162	0.41	1.3
4	M3 (30GP)	276.5	118.5	-	810	447	671	162	0.41	1.3
5	M4 (10GP+0.5BF)	355.5	39.5	0.5	810	447	671	162	0.41	1.3
6	M5	355.5	39.5	1	810	447	671	162	0.41	1.3

	(10GP+1.0BF)									
7	M6 (10GP+1.5BF)	355.5	39.5	1.5	810	447	671	162	0.41	1.3

Table 3: Mix Design

Workability test (Cement + GP):

Workability is the property of freshly mixed concrete that determines the ease with which it can be properly mixed, placed, consolidated and finished without segregation. The slump test was carried out to determine workability as per IS: 1199-1989. Using slump cone, slump value was measured before placing the concrete in the moulds. Here, in this experimental investigation, the variation in the slump value of different concrete mix is determined.

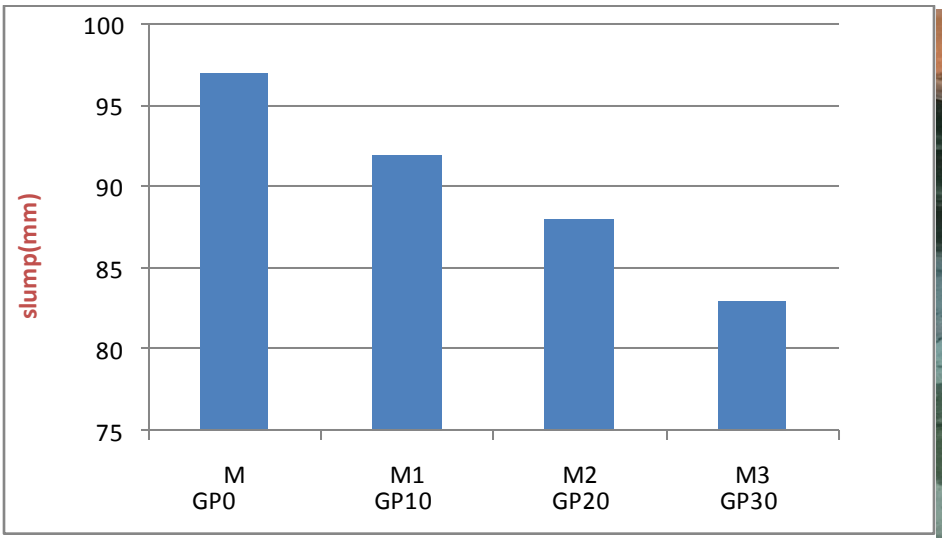


Figure 1:Slump (cement + GP)

Figure 2: Slump cone

Compressive strength (Cement + GP):

Results of compressive strength showed that glass powder can be replaced up to 10% with cement without harmful effect. After 10% replacement compressive strength decreases than 28 days characteristic compressive strength.With more percentage increases in glass powder compressive strength decreases.

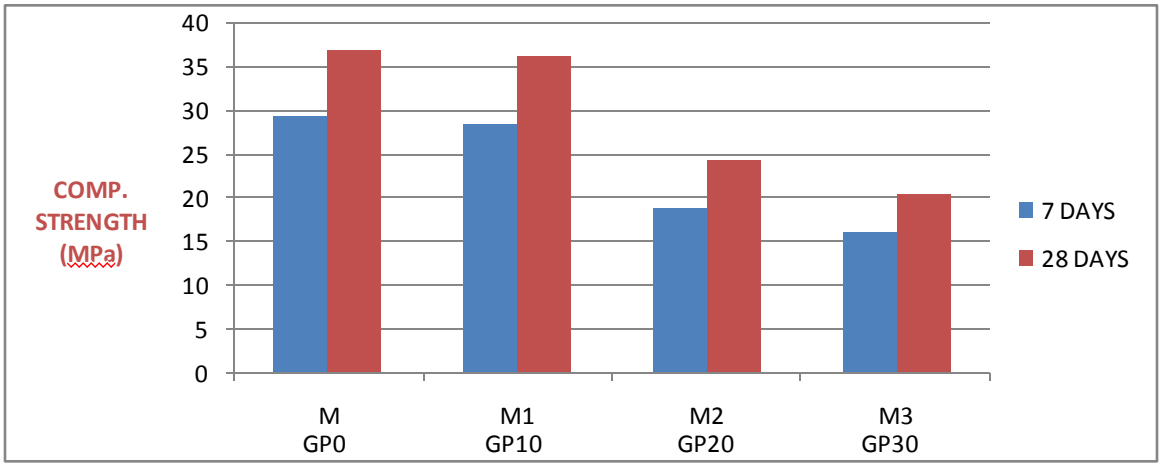


Figure 3: Compressive strength (Cement + Glass powder)

Flexural strength (Cement + GP):

From results it can be seen that at 10% replacement of cement with glass powder, flexural strength increases than normal concrete. With more percentage increases in glass powder flexural strength decreases.

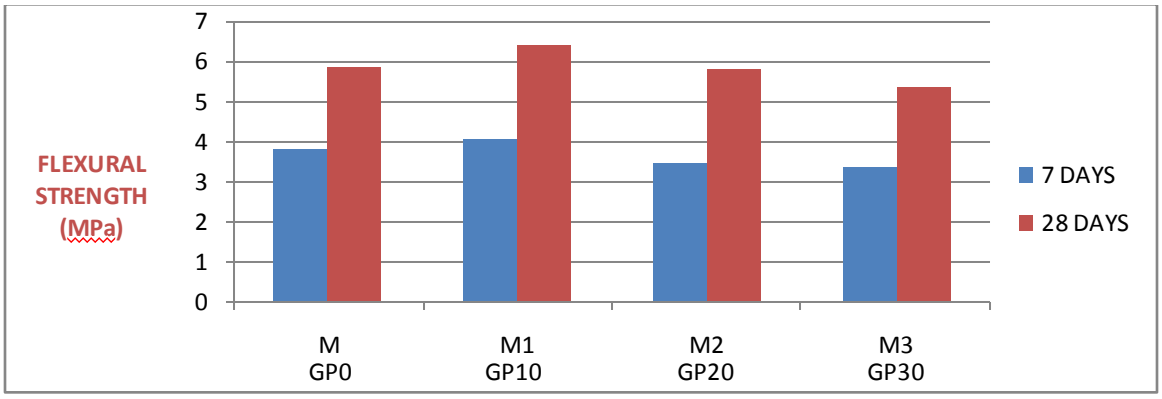


Figure 4: Flexural strength(Cement + Glass powder)

Split tensile strength (Cement + GP)

From results it can be seen that at 10% replacement of cement with glass powder, split tensile strength increases than normal concrete. With more percentage increases in glass powder it decreases.

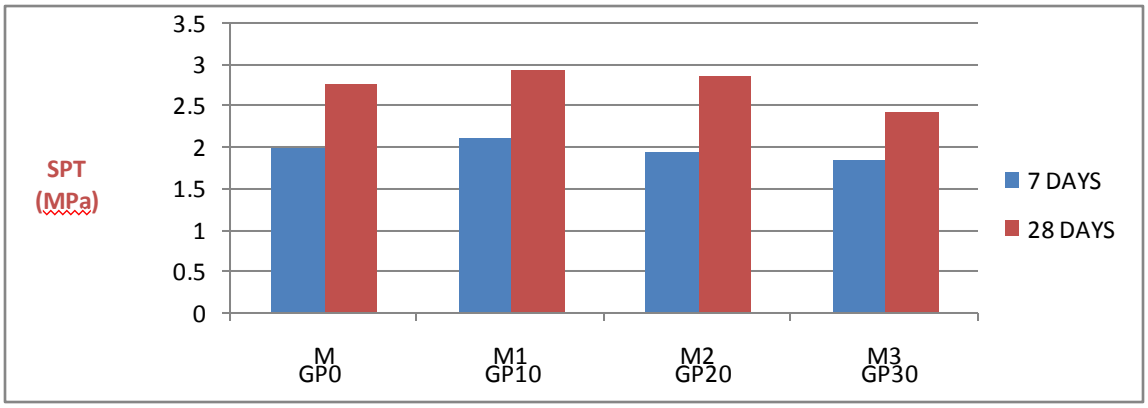


Figure 5: Split tensile strength (Cement + Glass powder)

Workability test (GP10 + BF)

The values of slump are decreasing as percentage of glass powder and/or banana fibers areincreases. Hence workability decreases with increasing percentage of glass powder and/or banana fibers.

Figure 6: Slump test (GP10 + BF)

Compressive strength (GP10 + BF)

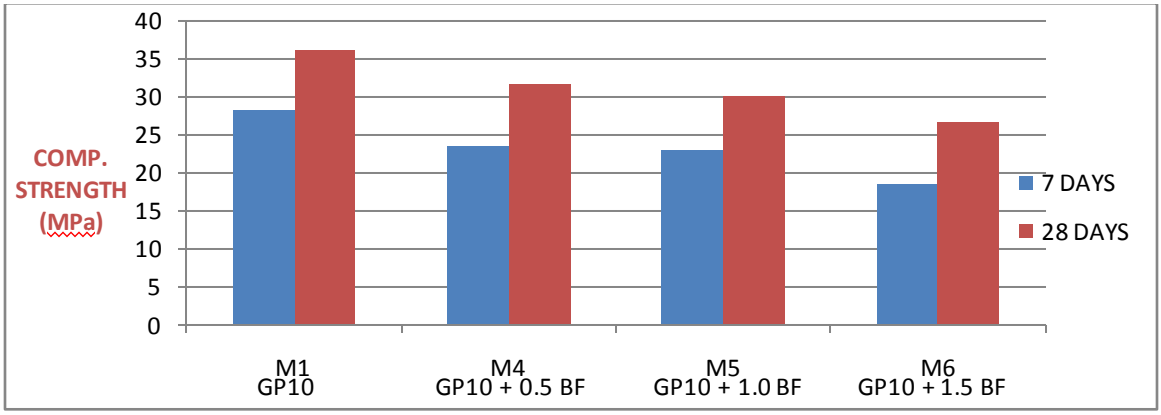


Figure 7: Compressive strength (GP10 + BF)

Flexural strength (GP10 + BF)

From results it can be seen that with addition of 1% banana fibers in to concrete the flexural strength of concrete increases . With addition of 1% BF, flexural strength of concrete increases by 1%.

Figure 8: Flexural strength (Initial crack) (GP10+BF)

Figure 9: Flexural strength (GP10+BF)

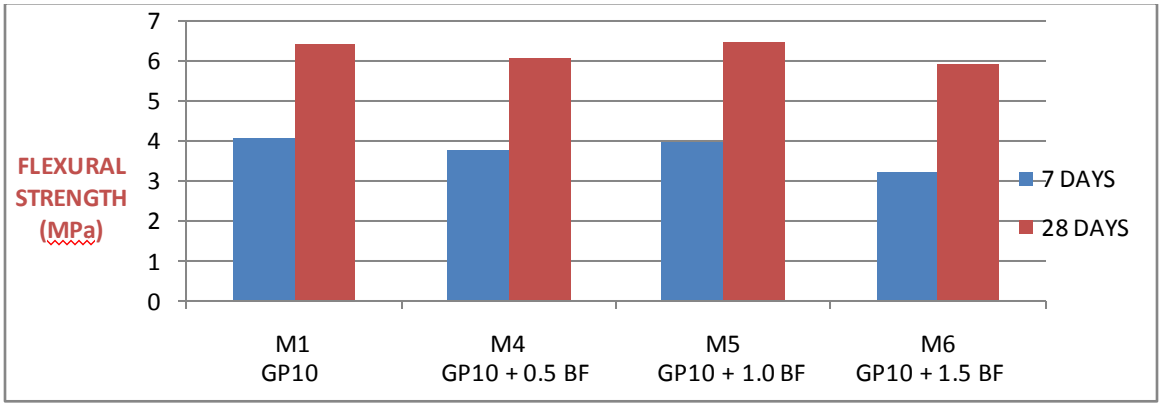


Figure 10: Flexural strength (GP10+BF)

Split tensile strength (GP10 + BF)

From results it can be seen that with addition of 1% banana fibers in to concrete the split tensile strength of concrete increases.With addition of 1% BF, split tensile strength of concrete increases.

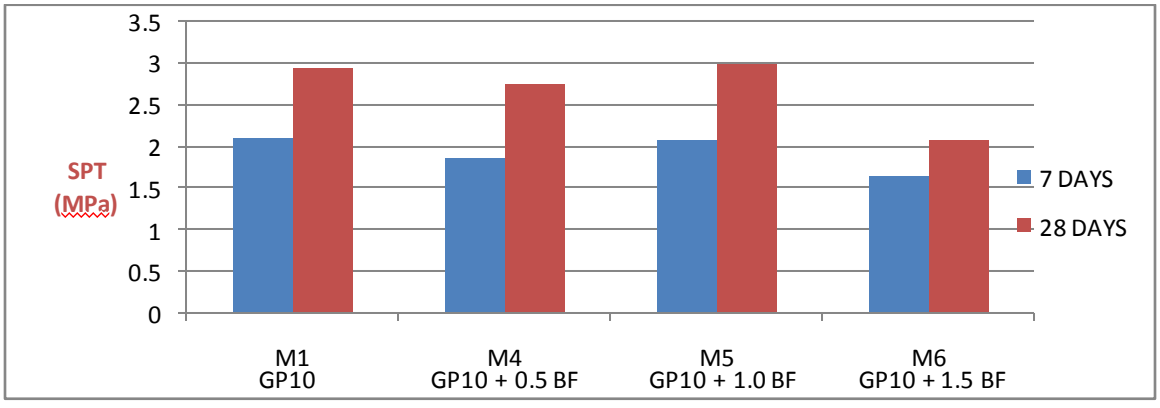
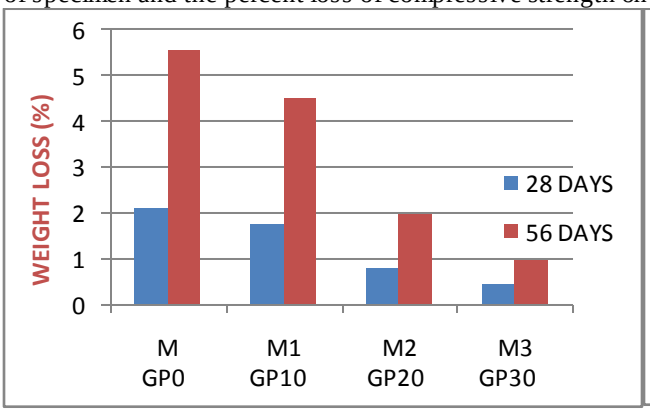


Figure 11: Split tensile strength (GP10+BF)

Durability test:

The acid attack test on concrete cube is conducted by immersing the cubes in the sulfuric acid water for 28 days and 56 days after 28 days of curing. Sulfuric acid (H_2SO_4) with pH of about 2 at 1% weight of water was added to water in which the concrete cubes were stored. The pH was maintained throughout the period of testing. After targeted days of immersion, the concrete cubes were taken out of acid water. The resistance of concrete to acid attack was found by the percent loss of weight of specimen and the percent loss of compressive strength on immersing concrete cubes in acid water.



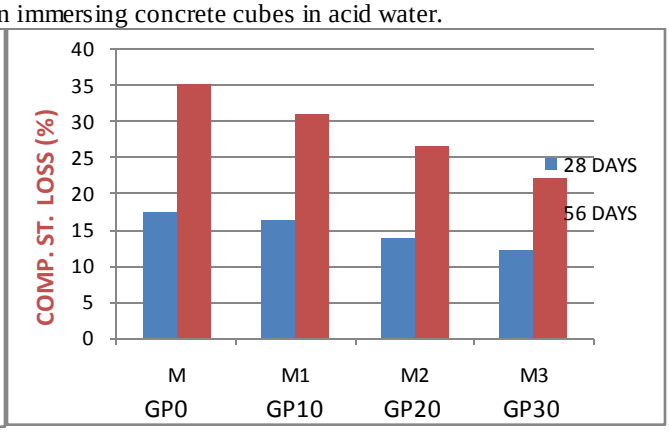
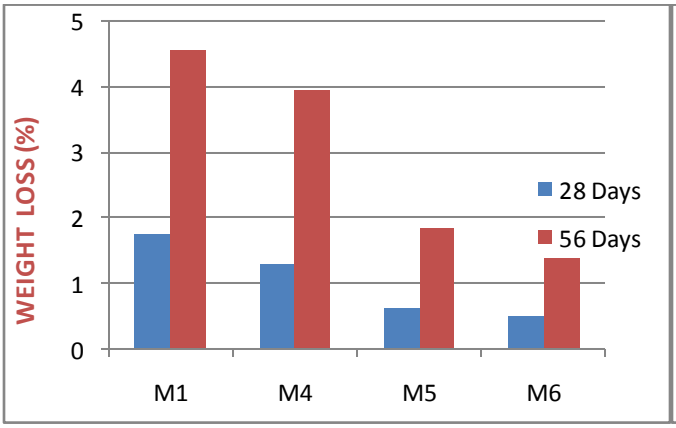


Figure 12: Percentage weight loss (Cement + GP)Figure 13: Percentage Comp. st. loss (Cement + GP)



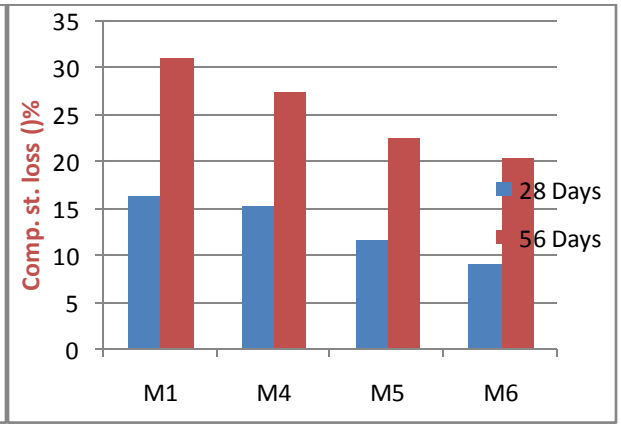


Figure 14: Percentage weight loss (GP10 + BF)Figure 15: Percentage comp. st. loss (GP10 + BF)

Conclusions:

- Glass powder can be replaced with cement up to 10% without harmful effect to concrete.
- 10% replacement of cement with glass powder increases flexural & split tensile strength by 8.13% & 5.48% respectively than control mix.
- In sulfuric acid attack, as % of glass powder increases, % loss in weight & % loss in compressive strength decreases. Hence concrete with glass powder is more durable than normal concrete.
- As the percentage of fibers is increased, the sudden and brittle failure of sample was resisted.
- With addition of 1% BF, flexural and tensile strength of concrete increases by 1% & 2% respectively. However, compressive strength slightly decreases.
- With addition of banana fibers , % loss in weight & % loss in compressive strength decreases in concrete made with cement partialy replaced by glass powder.

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