

Effects of Waste Glass Powder on Compressive Strength of Concrete

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ABSTRACT

In this research an attempt is made to study the effect of waste glass powder in Concrete using waste glass, which is non biodegradable and not suitable to landfill. This study is carried out to use such waste materials into construction industries so that our environment is free to one of the major pollutant produced by the manufacturing industries.

The main aim of this study is to utilization of waste glass powder as a partial replacement of fine aggregate. In this study the aim is to determine the percentage of glass replacement, resulting in optimal compressive strength.

Concrete nominal mix of M20 with different percentages of Glass powder has been evaluated as per IS 2386(part IV) and IS 383. Waste glass powder was replace with fine aggregate in various percentages such as 5%,10%,15%,20%,25%,30%,35%,40%,45%, and 50%. Reference concrete mix is also made for comparative reasons.

KEYWORDS: Nominal Mix, Waste Glass powder, Compressive Strength, construction industries

1. INTRODUCTION

Waste management has become a significant issue in today's growing society. As in India there is no such procedure to manage the waste properly it is caused a significant damage to the environment as well as the human health. Now we need some new and innovative technologies to reduce this waste so that it is used by other industries to fulfill their requirements.

Glass is an amorphous solid that has been found in various forms for thousands of years and has been manufactured for human use since 12,000 BC. Glass is one the most versatile substances on Earth, used in many applications and in a wide variety of forms, from plain clear glass to tempered and tinted

varieties, and so forth. The interest of the construction community in using waste or recycled materials in concrete is increasing because of the emphasis placed on sustainable construction. Glass is an inert material which could be recycled and used many times without changing its chemical property (Aimin Xu and Ahmad shayam, 2004). In this present research some efforts have been made for the concrete industries so that this harmful waste can be used as useful.

Various research are carried out to use waste glass powder as partial replacement of cement but there are almost no detailed investigation made so far on the performance of concrete replacing fine aggregate.

Concrete is the second largest material in the world and placed after water, the most useful for human as well as animals.

Fine aggregate is mainly finding from river and now a day's become highly expensive and scare hence there are large demand of alternative material from waste industries.

In this experimental study waste glass are collected from the local market and waste dumped areas. This waste is crushed in Los angles machine and finally convert to sand size.

2. Purpose and methodology

The main purpose of the study is to utilize the glass waste as a partial replacement of fine aggregate and also check the performance of glass concrete with respect to the control mix in strength consideration. The methodology is clearly understand with the help of flow diagram showing in figure no 1

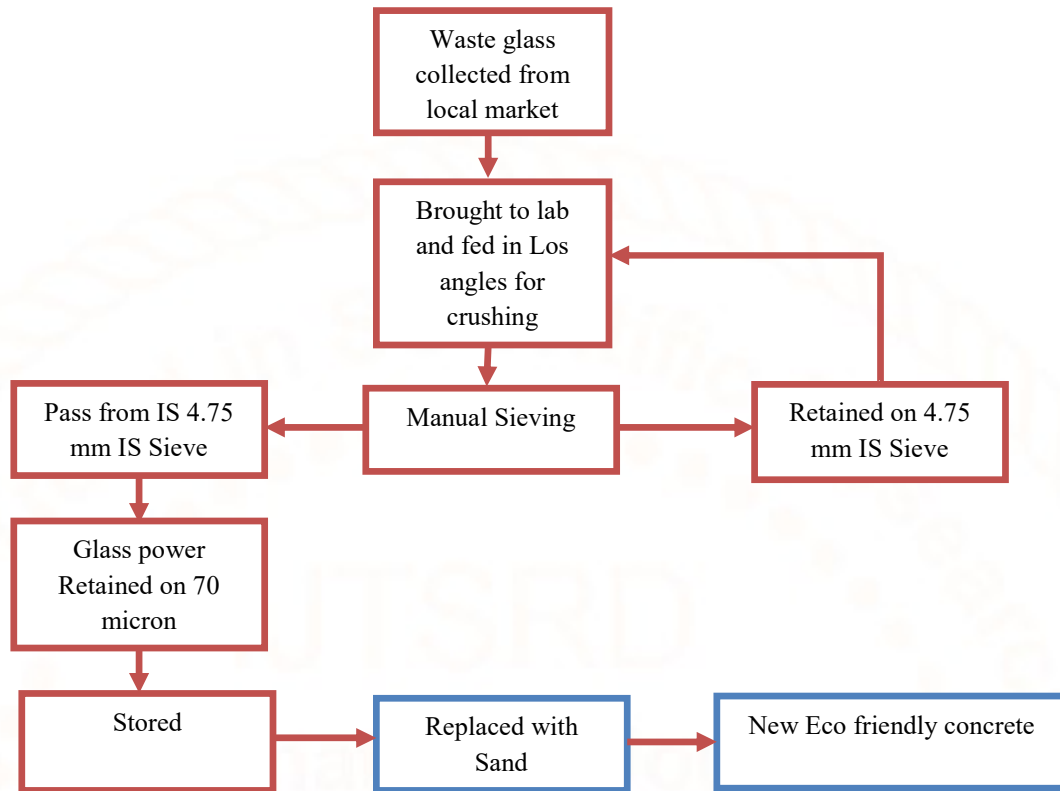


Figure 1: flow chart of methodology

3. Experimental investigation

Various basic tests are carried out for different materials. The most common test on concrete is the compressive strength test. This test is done to check the ability of concrete to resist the compression force. Testing of concrete cube is taken as per the guidelines given in IS 516-1959 And cube mould are taken as per the guidelines given in IS 10086-1982.

3.1 Particle size analysis of waste glass powder and fine aggregate

Particle size analysis of glass powder 1000 gm total weight						
S. NO	SET OF SIEVE	SIEVE SIZE mm	WEIGHT RETAINED	% RETAINED gm	CUMULATIVE % RETAINED	CUMULATIVE WEIGHT PASSING(% FINER)
1	4.75mm	4.75	16.5	1.65	1.65	98.35
2	2.36 mm	2.36	35	3.5	5.15	94.85
3	1.00 mm	1	60.5	6.05	11.2	88.8
4	600micron	0.6	215.5	21.55	32.75	67.25
5	425micron	0.425	215.5	21.55	54.3	45.7
6	300micron	0.3	165.5	16.55	70.85	29.15
7	250micron	0.25	86	8.6	79.45	20.55
8	150micron	0.15	140.5	14.05	93.5	6.5
9	75micron	0.075	56.5	5.65	99.15	0.85
10	Pan	8.5	0.85	100	0
	Total		1000			

Table 1: sieve analysis of glass powder

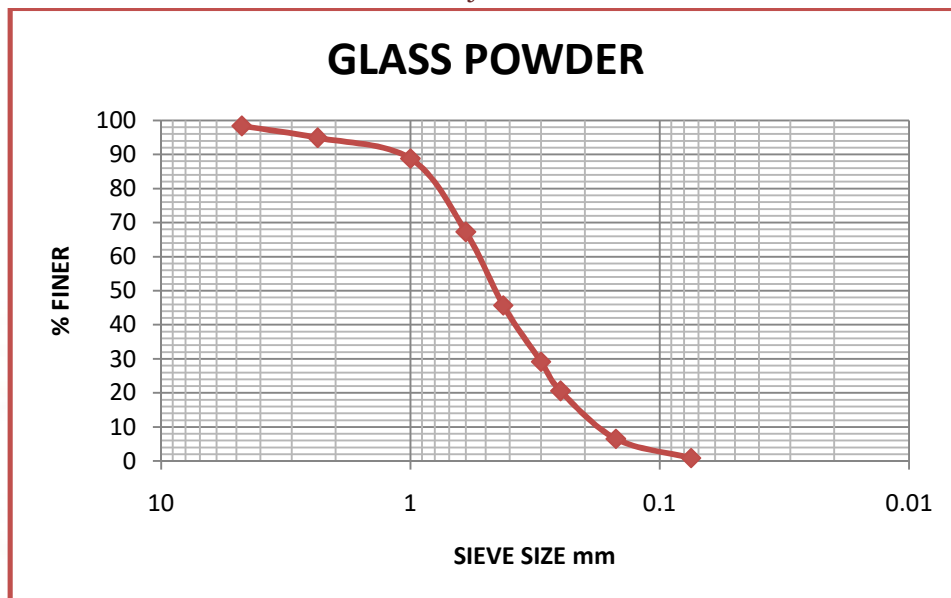


Figure 2: particle size curve of glass powder

Particle size analysis of sand 1000 gm total weight						
S No	Set of sieve	Sieve size mm	Weight retained	% retained gm	Cumulative % retained	Cumulative weight passing (% finer)
1	4.75mm	4.75	32	3.2	3.2	96.8
2	2.36mm	2.36	30	3	6.2	93.8
3	1.00mm	1	131.5	13.15	19.35	80.65
4	600micron	0.6	136.5	13.65	33	67
5	425micron	0.425	222	22.2	55.2	44.8
6	300micron	0.3	216	21.6	76.8	23.2
7	250micron	0.25	81.5	8.15	84.95	15.05
8	150micron	0.15	105.5	10.55	95.5	4.5
9	75micron	0.075	40.5	4.05	99.55	0.45
10	Pan		4.5	0.45	100	0
	Total		1000			

Table 2: sieve analysis of sand

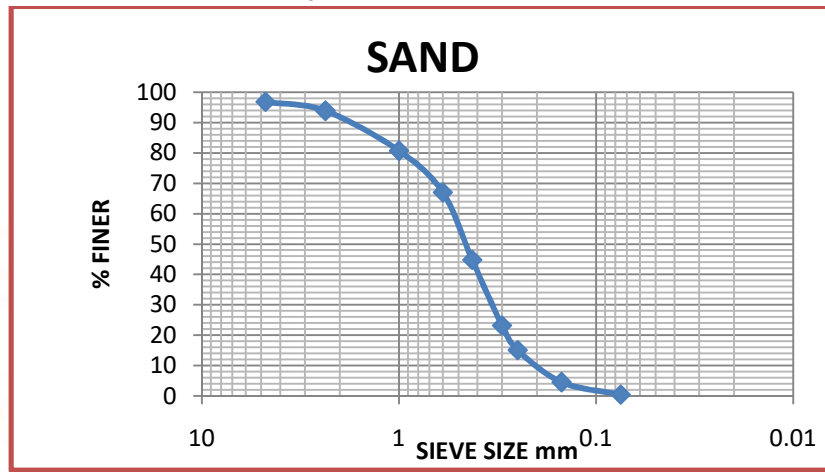


Figure 3: particle size curve of sand

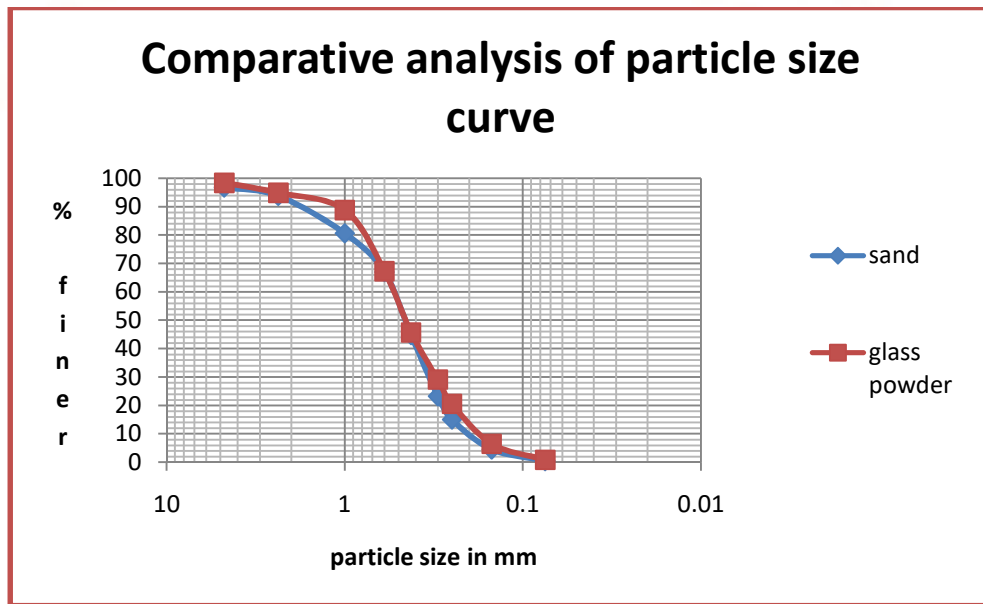


Figure 4: Comparative analysis of particle size curve

From the above curve shown in figure2, 3, and 4 it is clearly shown that both the materials are fall under the Grading Zone of II (IS: 383-1970)

3.2 SPECIFIC GRAVITY OF WASTE GLASS POWER AND NATURAL SAND

This test is done with reference to SP 206-7.1 and IS 2386 part IV-1963 with the help of standard pycnometer

Specific gravity of Sand		
s no	weight	value (gm)
1	M1	621.5
2	M2	821.5
3	M3	1639
4	M4	1514

Table 3: Specific gravity of sand

Specific gravity of Glass powder		
s no	weight	value (gm)
1	M1	620
2	M2	820
3	M3	1638
4	M4	1514

Table 4: Specific gravity of glass

From the above data the specific gravity of sand is found 2.66 and for waste glass power it is 2.63

3.3 Physical properties of glass powder and fine aggregate

Compositions	Name	Sand (%)	Glass powder (%)
SiO_2	Silica	81.98	78.13
Na_2O	Sodium Oxide	1.5	14.5
CaO	Lime	2.8	11.1
Al_2O_3	Alumina	9.88	2.6
MgO	Magnesia	5.2	1.9
K_2O	Potassium oxide	1.32	0.26
Fe_2O_3	Ferrous oxide	1.18	0.36
SO_3	Sulphur trioxide	Nil	0.11
Cr_2O_3	Chromium oxide	Nil	0.02
All other oxides		Nil	Nil

Table 5: Physical properties of glass powder and fine aggregate

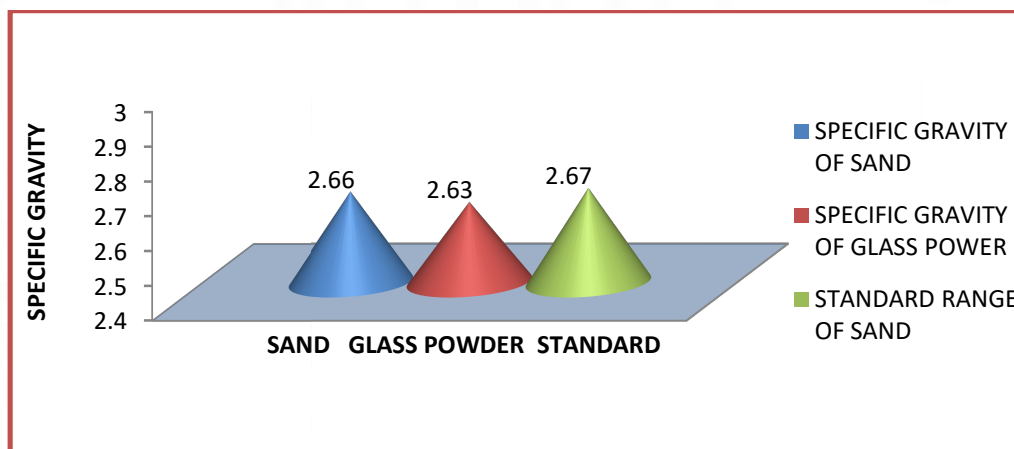


Figure 5: Comparative analysis of specific gravity

4. Experimental Procedure

4.1 For this study, 43 grade ordinary Portland cement were used. Graded angular aggregates of nominal size 20 mm and 10 mm; and river sand confirming to zone II were used. The coarse aggregates was of angular in nature and with nominal maximum size of 20mm. the fine aggregate used here is in the form of river sand, and it is originate from the Banas river, Tonk district. The physical properties of both coarse and fine aggregates are conformed to requirements specified in IS 383-1970(reaffirmed 2002).

Mix proportion was calculated on saturated surface dry (SSD) condition of aggregates. Workability of fresh concrete was selected as 125- 130 mm slump value for high workable concrete. Based on codal

provisions of IS 456: 2000 and IS 10262: 2009, design mix proportions for M20 grade concrete for different ingredient compositions were calculated.

In nominal mix(Control Mix) M20 grade concrete, graded angular aggregate of nominal size 20 mm, zone II river sand, 43 grade OPC were used in conventional ratio 1.00 (cement) : 1.5 (sand) : 3.0 (CA). For required workability, w/c was maintained as 0.45. Density and cement content of the fresh concrete were found 23.45 kN/m³ and 390.83 kg/m³ respectively.

4.2 Cement

The cement used in this experimental study for production of concrete was ordinary Portland cement

43 grade manufactured in INDIA and conformed to requirements specified in IS 8112-2013.

4.3 In a nominal mix concrete 43 grade OPC were used in conventional ratio 1.00 (cement): 1.5 (sand): 3.0 (CA) and super plasticizer admixture 2% of weight of cement. The ratio of water to cement is fixed to 0.45 and slump is taking constant between 120-130 mm.

Fresh concrete properties	G0	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
Slump in mm	130	130	130	130	130	130	130	125	125	125	120
Temperature °C	24	24	24	24	24	24	24	24	24	24	24
W/C Ratio	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Curing method	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water

Table 6 :Fresh concrete properties

S No	Symbol	Notification
1	G0	Control Mix M 20
2	G1	Control Mix M 20+ 5% waste glass powder replaced with FA
3	G2	Control Mix M 20+ 10% waste glass powder replaced with FA
4	G3	Control Mix M 20+ 15% waste glass powder replaced with FA
5	G4	Control Mix M 20+ 20% waste glass powder replaced with FA
6	G5	Control Mix M 20+ 25% waste glass powder replaced with FA
7	G6	Control Mix M 20+ 30% waste glass powder replaced with FA
8	G7	Control Mix M 20+ 35% waste glass powder replaced with FA
9	G8	Control Mix M 20+ 40% waste glass powder replaced with FA
10	G9	Control Mix M 20+ 45% waste glass powder replaced with FA
11	G10	Control Mix M 20+ 50% waste glass powder replaced with FA

Table 7 : notification of symbol



Figure 6: slump value test



Figure 7 : compaction of concrete cube



Figure 8: curing and testing of cube

5. Results and discussion

5.1 Compressive Strength of concrete cube

Concretes containing glass powder as fine aggregates, with a mixing ratio of 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45% and 50%. In this experimental study it was seen that there is a increasing trend of compressive strength than that of plain concrete with the addition of waste glass powder up to a optimum percentage of 25% of 28 days.

Mix name	Symbol	3 days strength (MPa)	7 days strength (MPa)	28 days strength (MPa)
Control Mix M 20	G0	18.67	22	26.89
Control Mix M 20+ 5% waste glass powder replaced with FA	G1	18.7	22.44	27.33
Control Mix M 20+ 10% waste glass powder replaced with FA	G2	18.74	22.78	28
Control Mix M 20+ 15% waste glass powder replaced with FA	G3	18.79	23.98	28.44
Control Mix M 20+ 20% waste glass powder replaced with FA	G4	18.81	24	28.89
Control Mix M 20+ 25% waste glass powder replaced with FA	G5	19	24.96	30
Control Mix M 20+ 30% waste glass powder replaced with FA	G6	18.11	24	28.89
Control Mix M 20+ 35% waste glass powder replaced with FA	G7	16.23	23.6	27.11
Control Mix M 20+ 40% waste glass powder replaced with FA	G8	16.45	22	26.67
Control Mix M 20+ 45% waste glass powder replaced with FA	G9	14.67	21.09	26.22
Control Mix M 20+ 50% waste glass powder replaced with FA	G10	14	20	24.22

Table 8: Characteristic strength of concrete in MPa

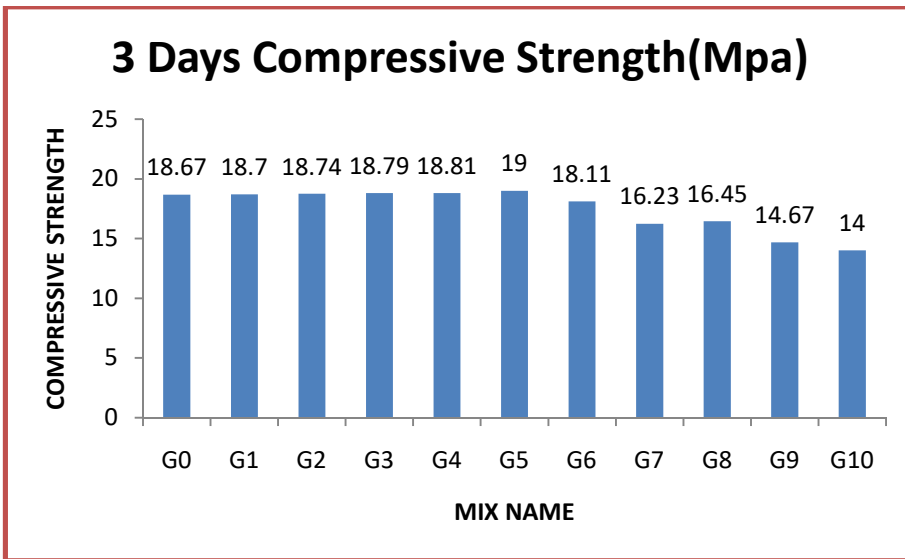


Figure 9: 3 Days compressive strength

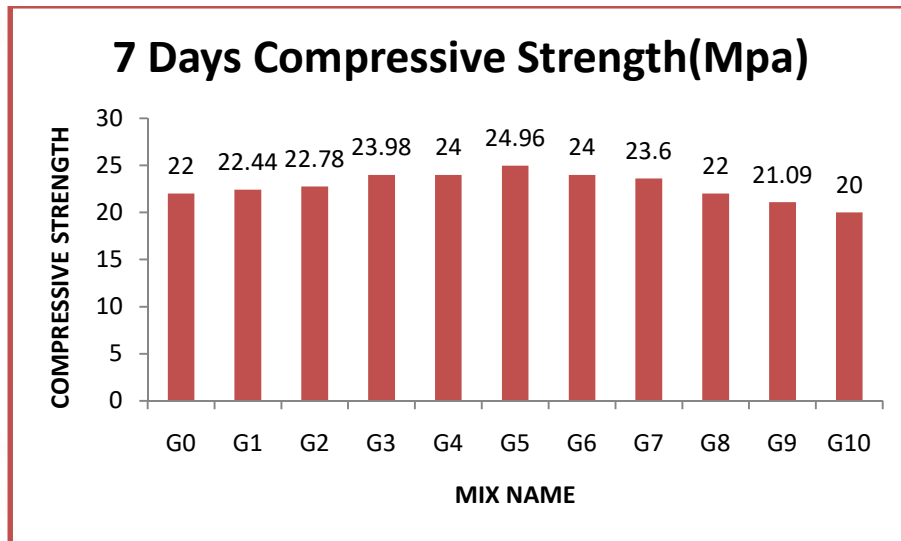


Figure 10: 7 Days compressive strength

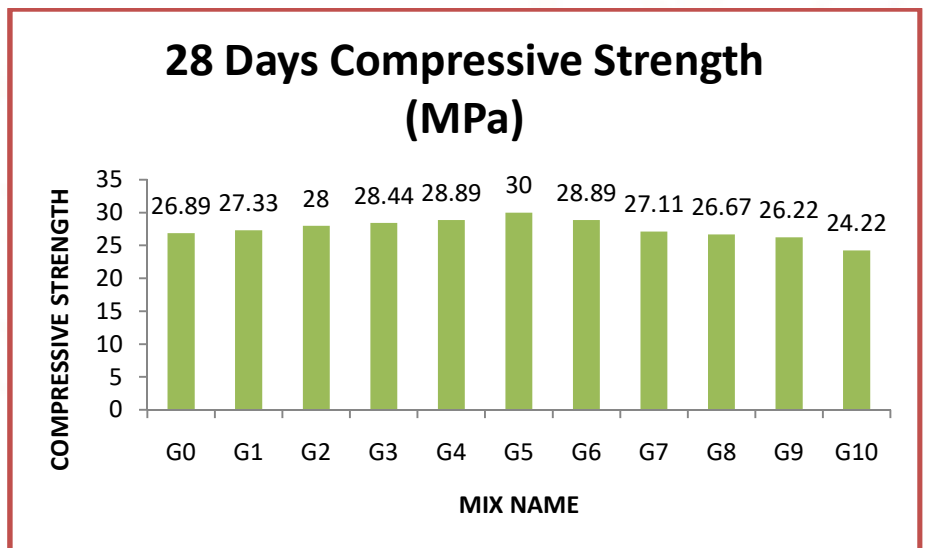


Figure 11: 28 Days compressive strength

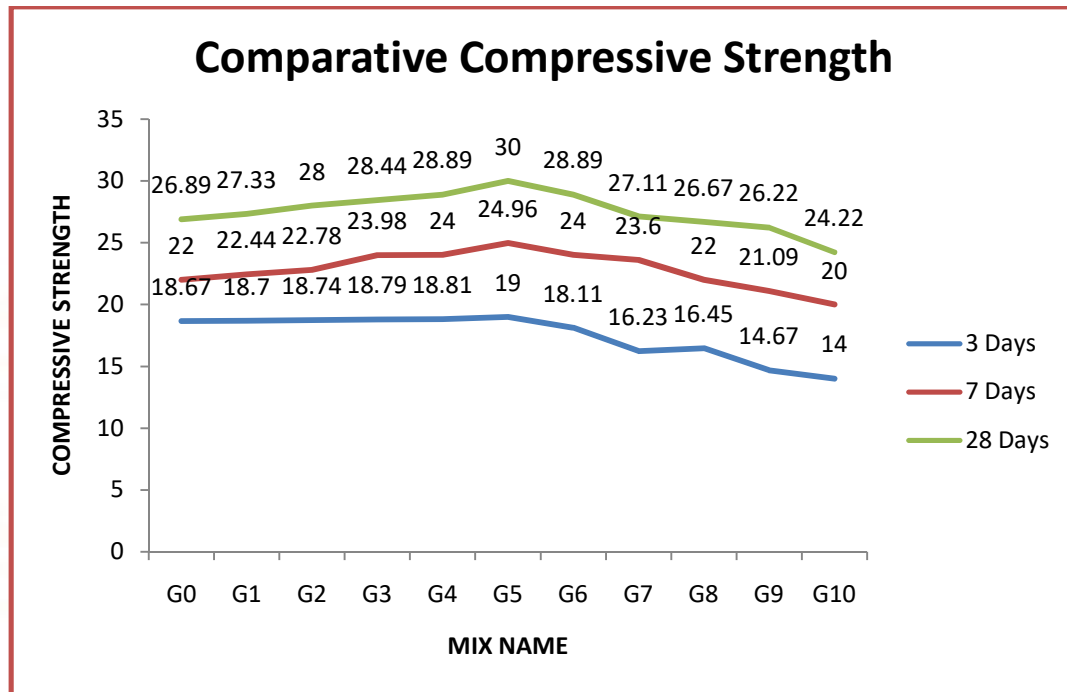


Figure 12: Comparative Compressive Strength

This experimental study was found optimum percentage of glass waste power was found to be 25% by weight of fine aggregate at which addition of glass waste power increase the cube compressive strength of concrete in 28 day to an extent of 11.56% which is approximately equal to M 30 grade of concrete. Results proved that adding of glass waste power with 25% of weight of fine aggregate leads to improvements in compressive strength. Hence, glass waste power may be used as a way for safe disposal of waste glass.

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