Utilization of waste glass in concrete for sustainable construction

Gauri R. Kamble[1], S. Raji[2]

[1]*Student of construction engineering and management*
[2]*Professor of civil engineering Department of Civil Engineering, S. S. Jondhle college of engineering and technology, Asangaon, Maharashtra,India.*

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Abstract - *Concrete is generally composed of aggregates, cement and water. Use of waste material in concrete achieves a new height in the present construction world. In concrete all their ingredients are partially or fully replaced by many waste materials like Cement is replaced by Fly Ash, Rice Husk Ash, Wheat Straw Ash, etc., Fine aggregate is replaced by Saw Dust Ash, Quarry Fines, Glass Powder and crushed sand etc. And coarse aggregate is replaced by coconut shell, tire rubber, recycle aggregate etc. In this paper study of Compressive strength, Split Tensile Strength, Workability and flexural strength of concrete is done when its fine aggregate is replaced by Toughened Glass Powder and crushed sand. 150 * 150 * 150 mm cube and 150*300 mm cylinders and 150*150*600 mm beams are cased of M 30 grade of concrete.*

Key Words: concrete, Toughened glass, crushed sand , fine aggregate, replacement .

1. INTRODUCTION

In the today's construction world, the use of waste material achieves a new height. Concrete is a versatile material and it contain a mixture of Cement, Coarse aggregate, Fine Aggregate and Water. Many engineers, scientist and researchers introduced many of the waste material which can replace concrete ingredients. Aggregate is the natural material which we obtained naturally on earth, generally we use natural stone as coarse aggregate and river sand as fine aggregate, but in some region of the world availability of these natural is quite low and some region, it is not available, due to this waste material is introduced as a partial or full replacement of the natural aggregate. In this paper, toughened glass powder and crushed sand is introduced as a partial replacement of fine aggregate.

The use of wastes or by-products in concrete manufacturing has beneficial for enhancing some or all of the concrete properties. The interest of the construction community in using waste or recycled materials in concrete is increasing because of the emphasis placed on sustainable construction. The economic incentives and environmental profits in terms decreasing carbon footprint are also the reason for using wastes in concrete. This material can widely use to lower the cost of construction as well as improved the strength of construction.

Glass constitutes about 5% of the municipal solid waste stream, but only a small percentage of it is recycled. It has been estimated that several million tons of waste glass is generated annually worldwide due to the rapid growth of the population, enhance in the standard of living, industrialization and urbanization. It is also seeking attention to keep pace with the development in construction and sand is one of the necessary construction materials. One of the attractive alternatives to Sand is Manufactured Sand. It possesses properties similar to that of river sand and is a more sustainable construction material.

2. MATERIAL USED FOR CONCRETE

2.1 Cement concrete

Cement: Ordinary Portland cement of Grade 43 conforming IS 8112 [1] was used in the work

Aggregates: Fine aggregates used throughout the study comprised of white river sand and strictly pass from 4.75mm IS sieve, conforming to zone II as per IS383-1970 [2] with specific gravity of 2.61. Coarse aggregates used consisted of machine crushed stone angular in shape passing through 20mm IS sieve and retained on 4.75mm IS sieve with specific gravity of 2.72.

Toughened Glass Powder: Waste toughened glass was collected from GSC glass industry navi mumbai . Consisting of waste window glass (Toughened glass). It was pulverized in Los Angeles abrasion apparatus and then sieved through 2.36 mm IS sieve. The specific gravity of waste glass was found to be 2.4.

Fig. 1. Crushed toughened glass

Crushed Sand: Crushed Sand was used as fine aggregate. It is manufactured in a central plant by crushing stone making use of the Vertical Shaft Impact (VSI) crusher. Due to the use of this technology the sand particles can be shaped very similar to that of the naturally available fine aggregate

3. MIX DESIGN

Mix design of the concrete is done strictly as per the specification of the IS 10262: 2009. According to IS code specification mix of M30 grade is designed, 5 different types of mix are prepared with different percentage of Glass powder and crushed sand as Partial Replacement of Fine Aggregate. CC mix is prepared with 0% of Glass Powder, and crushed sand or we can also pronounce it is controlled concrete; GP20 mix contains 20% of the Glass Powder. While GP30, GP40 and GP50 contains 30, 40, 50 and of Glass Powder respectively, similarly CS20 (crushed sand) mix contains 20% of crushed sand, and CS30, CS40 and CS50 of crushed sand respectively, another combination is glass powder and crushed sand mix with natural sand, 5 different types of mix are prepared including CC mix and combination of glass and crushed sand as NCG20, NCG30, NCG40, NCG50 respectively.

4. TEST PERFORMED

4.1 Test on Fresh Concrete: Slump Test The workability of all concrete mixtures was intent through slump test using a metallic slump mould. The difference in grade between the height of mud and that of the highest level of the subsided concrete was measured and described as a depression. The slump tests were performed as per IS 1199- 1959 .

4.2 Tests on hardened concrete: From each concrete mixture, cubes of size 150mm x 150mm x 150mm, 150mm x 300mm cylinders and 150mm x 150mm x 600mm beams have been shed for the determination of compressive strength, splitting tensile strength and flexural strength respectively.

The concrete specimens were cured under normal conditions as per IS 516-1959 and were tested at 3 days ,7 days and 28days for determining strength as per IS 516-1959.

5. RESULT AND DISCUSSION

5.1 Fresh Concrete: Table 1 represents the slump value of the all concrete mix. In first combination with glass powder the slump increased with the growth in waste glass content. Waste glass particles absorbed less water as compared to sand and hence improving the workability of concrete admixture. The depression was the maximum for the concrete mixture containing 40% waste glass in place of fine aggregates. In the second combination of crushed sand maximum value of slump was on 50% replacement of natural sand with crushed sand .in the last combination of glass, crushed sand and natural sand maximum value of slump was on 50 % replacement. The variance of a slump with waste glass content is described in chart 1.

Table -1 workability test result on fresh concrete

REPLACEMENT	CM	20	30	40	50
W/C RATIO	0.43	0.43	0.43	0.43	0.43
	SLUMP IN MM				
NFA	120	130	145	165	155
CFA	105	115	125	140	150
NCGA	110	120	130	140	135

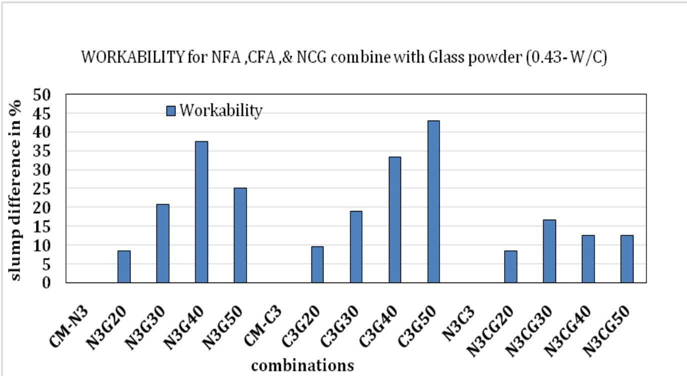

Chart -1: slump difference in percentage

5.1 Hardened Concrete: The compressive strength tests, flexural strength test and splitting tensile strength tests are shown in. table 2 Compressive strength test carried out at 3, 7 and 28 days. An increase in compressive strength was observed up to 40% replacement of fine aggregates with toughened glass, and crushed sand and thereafter lowering. The more compressive strength measured was 25% more than that of a mentioned mix at 28 days corresponding to concrete mixture containing 20% waste glass in lieu of fine aggregates. Compressive strength for concrete mix with 40% waste glass content was found to be more than that of reference mix. Splitting tensile strength and flexural strength decreased with increasing waste glass and crushed sand content above 40%. Chart. 2, 3 and 4 present compressive strength of all mixtures at 3, 7 and 28 days respectively. Chart. 5, 6 and 7 present splitting tensile strength of all mixtures at 28 days. Chart. 8, 9 and 10 present flexural strength of all mixtures at 28 days

Table -2: compressive strength test at 3,7,28 days

combinations	(%)	3days(kN/m2)	7 days(kN/m2)	28days(kN/m2)
NA	CM	25.02	35.12	46.45
	20	26.33	36.7	47.6
	30	27.9	38.46	49.2
	40	29.65	39.16	50.34

	50	28.47	37.99	49.16
CS	CM	22.79	33.56	43.71
	20	24.01	34.62	44.89
	30	24.61	35.24	45.47
	40	25.45	35.94	46.24
	50	25.02	35.7	45.45
NCG	CM	25.77	34.56	45.65
	20	26.69	35.52	46.62
	30	27.1	36.75	47.6
	40	28.81	37.98	48.67
	50	27.87	37.02	48.14

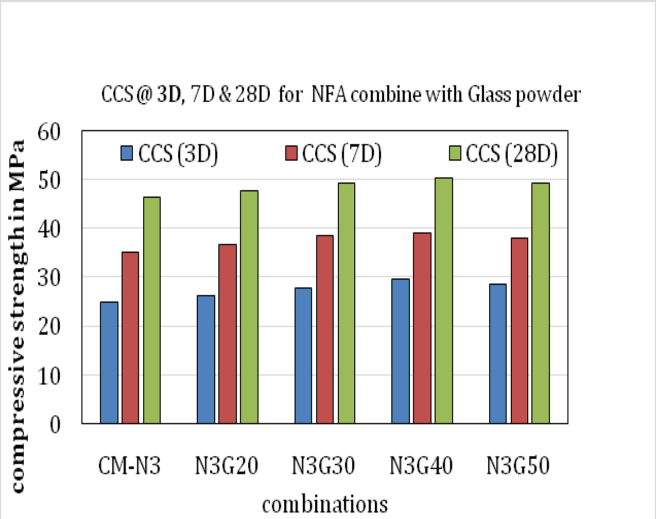

Chart -2: compressive strength for glass and natural sand

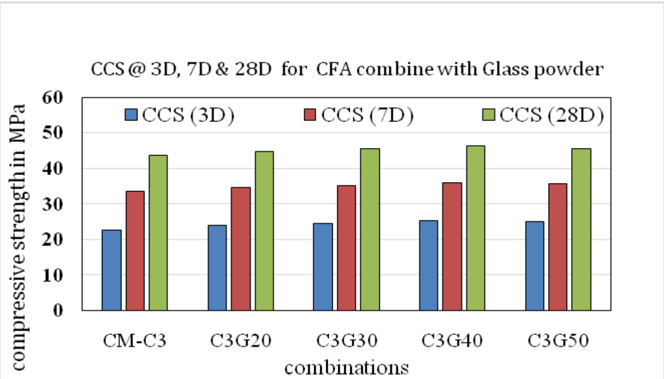

Chart -3: compressive strength for glass and crushed sand

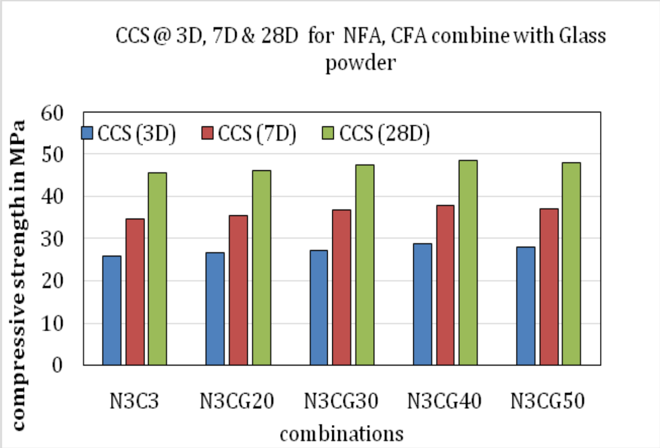

Chart -4: compressive strength for glass and natural sand and crushed sand

Table 3-: split tensile strength strength test at 28 days

COMBINATION	%	28 DAYS (kN/m2)
NA	CM	0.7
	20	0.71
	30	0.74
	40	0.76
	50	0.75
CS	CM	0.72
	20	0.69
	30	0.7
	40	0.71
	50	0.7
NCG	CM	0.74
	20	0.74
	30	0.74
	40	0.75
	50	0.75

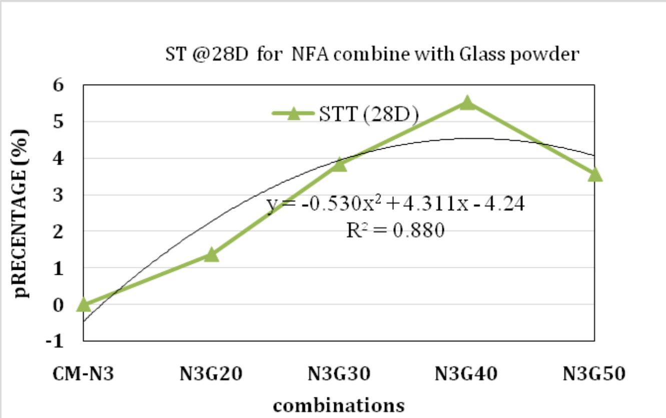

Chart -5: % difference in split tensile strength for glass and natural sand

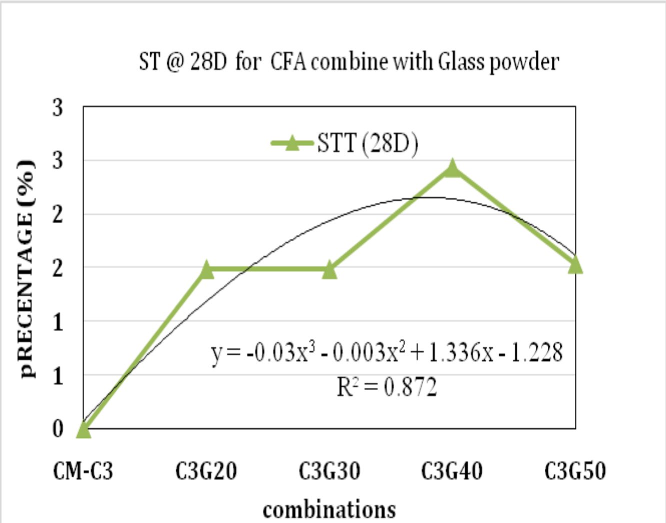

Chart -6: % difference in split tensile strength for glass and crushed sand

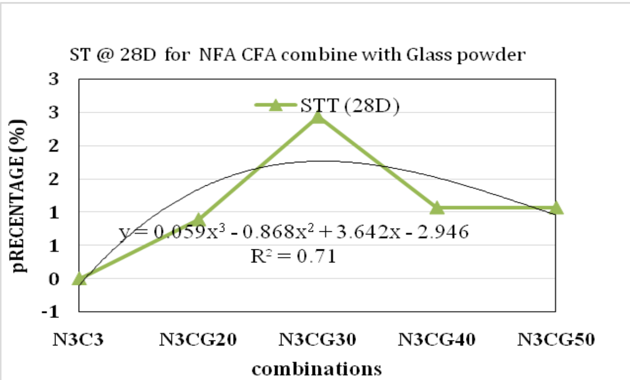

Chart -7: % difference in split tensile strength for glass, crushed sand and natural sand

Table 4-: flexural strength test at 28 days

COMBINATION	%	28 DAYS(kN/m2)
NA	CM	4.44
	20	4.63
	30	4.68
	40	5.05
	50	4.63
CS	CM	4.25
	20	4.39
	30	4.31
	40	4.43
	50	4.41
NCG	CM	4.41
	20	4.43
	30	4.65
	40	4.58
	50	4.58

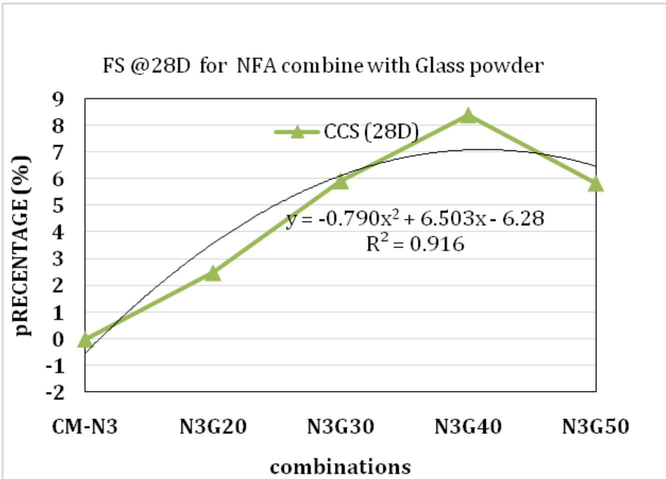

Chart -8: % difference in flexural strength for glass, and natural sand

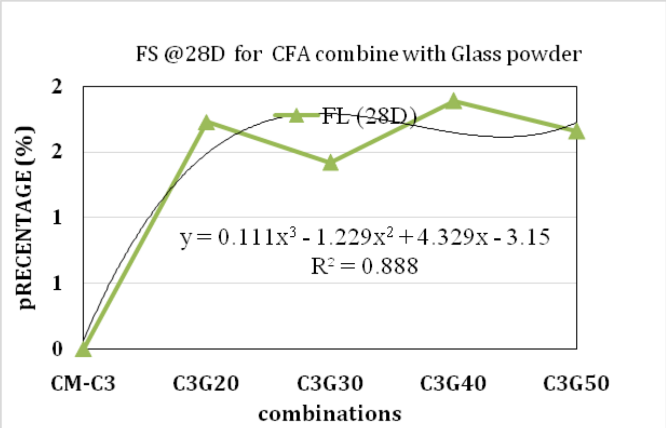

Chart -9: % difference in flexural strength for glass, and crushed sand

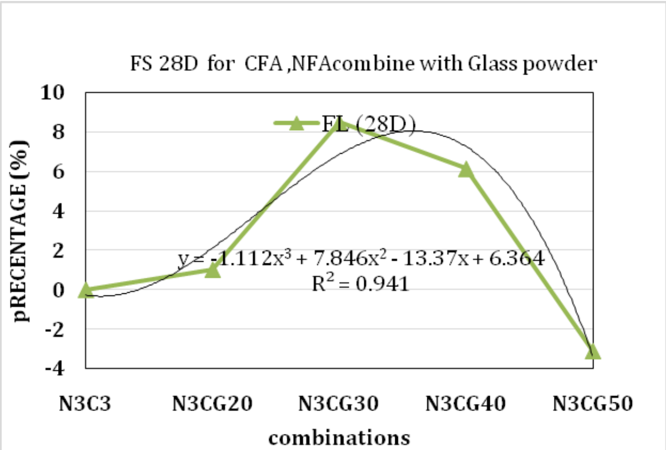

Chart -10: % difference in flexural strength for glass, crushed sand and natural sand

6. CONCLUSIONS

On the base of outcomes received, the following conclusions can be made:

(1) 40% replacement of fine aggregates by waste glass showed enhancement in compressive strength at 7 days and 28 days.

(2) Fine aggregates can be replaced by waste glass up to 30% by weight showing a 9.8 % increase in compressive strength at 28 days.

(3) With an increase in waste glass content, percentage water absorption decreases.

(4) Workability of concrete mix increases with an increase in waste glass and crushed sand content.

(5) Splitting tensile strength decreases with an increase in waste glass content.

(6) Utilization of waste glass and crushed sand in concrete can turn out to be economical as it is no useful waste and spare of cost.

(7) Utilization of waste glass in concrete will eradicate the disposal problem of waste glass and essay to be environment friendly, thus paving way for greener concrete.

(8) 40% replacement of fine aggregates by waste glass showed an increase in flexural strength at 28 days.

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