Experimental Investigation of Waste Glass Powder As Partial Replacement of Fine Aggregate In Concrete

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Abstract- *Waste management is becoming a major issue for communities worldwide. Glass, being non- biodegradable, is not suitable for addition to landfill, and as such recycling opportunities need to be investigated. In this paper study of Compressive strength, Split Tensile Strength and Workability of concrete is done when its fine aggregate is replaced by crushed waste Glass Powder. 150 * 150 * 150 mm cube and 150*300 mm cylinders are cased of M 25and M30 & M35 grade of concrete. Four concrete samples were tested at 7 , 14 and28 days, for glass replacement proportions of 0, 10,20 and 30%.This demonstrates that concrete containing up to 20% fine glass aggregate exhibits higher compressive strength development than traditional concrete.*

Keywords- Concrete, Glass powder, Fine aggregate, Compressive strength

I. INTRODUCTION

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. Many researchers introduced many of the waste material which can replace concrete ingredients. Glass, being non-biodegradable, is one such material that is not suitable for addition to landfill. Fortunately, glass can be recycled indefinitely without any loss in quality, but first needs to be sorted by color. It can therefore be seen that incorporating recycled glass as an aggregate in structural concrete has the potential to not only produce environmental benefits but also reduce consumption of natural aggregate which ultimately reduce construction industry cost.

II. REVIEW OF LITERATURE

A study undertaken by Shayan and Xu (2006) demonstrated that concrete specimens containing glass as a fine aggregate achieved higher levels of compressive strength than those containing glass as a cement replacement. In order to minimize alkali-silica reaction (ASR), the partial replacement of fine aggregate and/or cement in concrete has been investigated. Research has concluded that the increasing proportions of crushed glass as a replacement for fine aggregate results in an increase in ASR expansion (Oliveira et al. 2013, Serpa et al. 2013).Early studies into the effects of incorporating waste glass into concrete focused on its suitability as a replacement for coarse aggregate. The results from these tests demonstrated that the presence of larger glass particles caused excessive expansion and cracking of the concrete specimens, resulting in compromised structural integrity.(M. Adaway & Y. Wang 2015)Fine aggregates were replaced by waste glass powder as 0%, 10%, 20%, and 30% and by weight for M-20 mix. The concrete specimens were tested for compressive strength, splitting tensile strength at the 7th and 28th days of age and the results obtained were compared with those of normal concrete. The results conclude the permissibility of using waste glass powder as partial replacement of fine aggregates up to 30% by weigh for particle size of range 0-1.18mm.(D.Elavarasan, Dr.G.Dhanalakshmi 2016).The compressive, flexural and split tensile strengths of concrete increase initially as the replacement percentage of cement by glass powder increases become maximum at about 20% and later decrease. The workability of concrete reduces monotonically as the replacement percentage of cement by glass powder increases. The replacement of cement up to about 20% by glass powder can be done without sacrificing the compressive strength.(Rakesh Sakale, Sourabh Jain, Seema Singh2016)Flow and compressive strength tests on mortar and concrete were carried out by adding 0–25% ground glass in which water to binder (cement + glass) ratio is kept the same for all replacement levels. With increase in glass addition mortar flow was slightly increased while a minor effect on concrete workability was noted. To evaluate the packing and pozzolanic effects, further tests were also conducted with same mix details and 1% super plasticizing admixture dose (by weight of cement) and generally found an increase in compressive strength of mortars with admixture**(**G.M.Sadiqul Islam , M.H.Rahman, NayemKazi 2017)Compressive strength were found to increase by 3% and 7% at 7 and 28 days respectively as waste glass content was increased up to 15%

replacement level, after which the compressive strength started to decrease. Flexural strength remained constant between the control value and 15% replacement level, after which it started to fluctuate, (decreasing by 25% and 47% at 25% replacement level at 7 and 28 days, and experienced an increase of 33% and 37.5% at 35% at replacement level. (A.W. Otunyo and B. N. Okechuku 2017).As for fine aggregates, in order to account for the numbers of variables and clearly establish a bench mark, the sand grading, color of glass, source of waste glass (bottles and non-bottles), and design mix strength were used as parameters. Fine aggregates from green, brown, and transparent bottles in addition to clear window waste glass were used. Concrete properties were tested in fresh and hardened states. The incorporation of glass sand regardless of the ratios of replacement showed no significant influence on fresh or mechanical properties of concrete except for the case of transparent bottles.(Najib N. Gerges, Camille A. Issa, Samer A. Fawaz 2018)Replacements higher than 30% can cause negative impacts as insufficient amounts of CaCO3 remain to react with the silica from the glass, known as thedilution effect. As the fine aggregate replacement for waste glass increases over 20%, the mechanical properties decrease proportionally; however, up to 20% has similar results to traditionally mix.(Edward Harrison, Aydin Berenjian, Mostafa Seifan 2020)

III. MATERIALS & METHOD

A. Material

In this investigation, the following materials were used:

- OrdinaryPortlandCementof53GradecementconformingtoIS:169-1989

Fig 1. Ordinary Port l and cement

- FineaggregateconformingtoIS:2386-1963. Fine aggregate used throughout the study comprised of white river sand and strictly pass from 4.75mm IS sieve, conforming to zone III as per IS383-1970.

Fig 2: Fine aggregate

- CoarseaggregateconformingtoIS:2386-1963. Coarse aggregates used consisted of machine crushed stone angular in shape passing through 20 mm IS sieve and retained on 4.75mm ISsieve.

Fig3:Coarse aggregate

- Water: Water is an important ingredient of concrete and mortarasitis actively participates in the chemical reaction with cement. Since it helps to form strength, giving cementgel, the quantity and quality of water is to be looked very carefully.
- Crushed glass powder as an artificial sand: Waste glass was collected from Shree Ashta vinayak Glass Pvt. Ltd. glass Industry, Pune. Consisting of waste window glass(SodaLime glass). It was pulverized in Los Angeles abrasion apparatus and thensieved through 1.18 mm ISsieve.

Fig 4. Crushed Glass Powder

B. Method(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 M25,M30,M35 grade is designed, 5 different types of mix are prepared with different percentage i.e. 0% ,10%,20% ,30% of Glass powder as Partial Replacement of Fine Aggregate. CC mix is prepared with 0% of Glass Powder or we can also pronounce it is controlled concrete (Normal concrete), GP10 mix contains 10%of the Glass Powder. While GP20, GP30 contains10, 20 and 30 percentage of Glass Powder respectively.

Table1 : Concrete Mix Design Summary (M25)

Concrete Mix ingredient	Glass Replacement Percentage			
	0%	10%	20%	30%
Water	191.6	191.6	191.6	191.6
Cement	383.2	383.2	383.2	383.2
Coarse Aggregate	1087.75	1087.75	1087.75	1087.75
Natural Fine Aggregate	800.94	720.846	640.752	560.658
Glass Fine Aggregate	0	80.094	160.188	240.282

Table2 : Concrete Mix Design Summary (M30)

Concrete Mix ingredient	Glass Replacement Percentage			
	0%	10%	20%	30%
Water	197	197	197	197
Cement	438	438	438	438
Coarse Aggregate	993	993	993	993
Natural Fine Aggregate	812	730.8	649.6	568.4
Glass Fine Aggregate	0	81.2	162.4	243.6

Table3 : Concrete Mix Design Summary (M35)

Concrete Mix ingredient	Glass Replacement Percentage			
	0%	10%	20%	30%
Water	197.16	197.16	197.16	197.16
Cement	438	438	438	438
Coarse Aggregate	1185.91	1185.91	1185.91	1185.91
Natural Fine Aggregate	545.01	490.51	436	381.51
Glass Fine Aggregate	0	54.50	109	163.50

IV. EXPERIMENTAL PROCEDURE

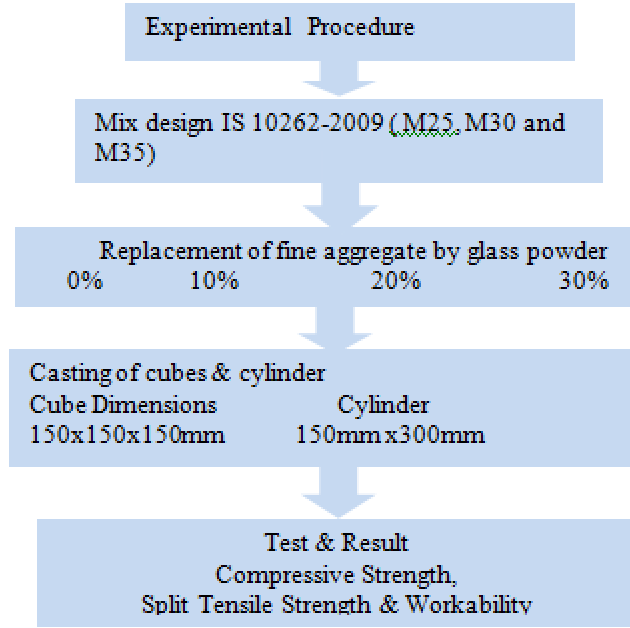

Fig 5. Experimental Procedure

A.Cube Casting

In order to study effect of replacement of cement in various ratio of industrial waste glass powder compression, flexure, splittension on 108 cubes and 12 cylinders were casted respectively. The experimental program was divided into fourgroups.

Eachgroupconsistsof3cubes,1cylinderof15x15x15cm,15(dia)x 30cmrespectively.

- Thefirstgroupisthecontrol(Plain)concretewith0% glasspowder(CC)
- Thesecondgroupconsisted of10%glasspowder, withaspectratiobyreplacementofcement.
- Thethirdgroupconsistedof20%glasspowder, withaspect ratiobyreplacementofcement.
- Thefourthgroupconsistedof30%glasspowder, withaspectratiobyreplacementofcement.

B.Test Performed

1.Test on Fresh Concrete:

a) Slump Test: The workability of all concrete mixtures wasdetermined through slump testutilizing ametallicslumpmould. The difference in grade between the height of mudand that of the highest level of the subsided concrete wasmeasured and described as a depression. The slump testswereexecutedaccordingtoIS 1199-1959[8].

b)Test on Hardened Concrete: From each concrete mixture, cubes of size 150mm x 150mm x 150mm and 150mm x 300mm cylinders have been shed for the determination of compressive strength and splitting tensile strength respectively.The concrete specimens were cured under normal conditions as per IS 516-1959 [8] and were tested at 7 days and 28days for determining compressive strength as per IS 516-1959

V. RESULT & DISCUSSION

A. Fresh Concrete

Table 1 represents the slump value of the all concrete mix. 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 30% waste glass in lieu of fine aggregates. The variance of a slumpwith waste glass content is described in following fig.

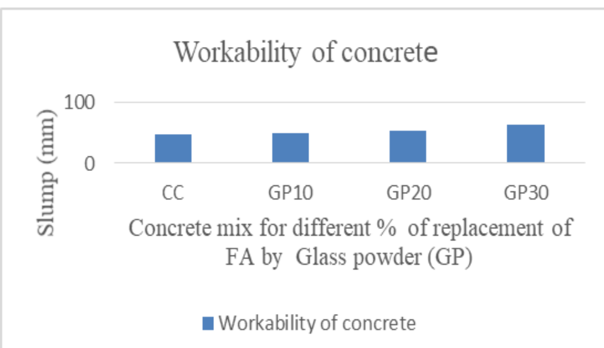

Table 4: WorkabilityofConcrete

Sr. No.	Mix	Slump(mm)
1	CC	47
2	GP10	49
3	GP20	54
4	GP30	63

B.Hardened concrete

Compressive strength tests and splitting tensile strength tests were carried out at 3,7 and 28 days. An increase in compressive strength was observed up to 20% replacement of fine aggregates of waste glass and thereafter decreasing. The maximum compressive strength measured was 25% more than that of a reference mix at 28 days corresponding to concrete mixture containing 20% waste glass in lieu of fine aggregate

Table5: Compressive StrengthofallConcreteMix for M25

Sr. No.	Mix	CompressiveStrength(N/mm2)		
		7 Day	14 Day	28 Day
1	Normal	21.65	25.66	29.32
2	GP10	23.54	23.73	34.15
3	GP20	24.72	30.51	36.77
4	GP30	22.11	25.98	32.20

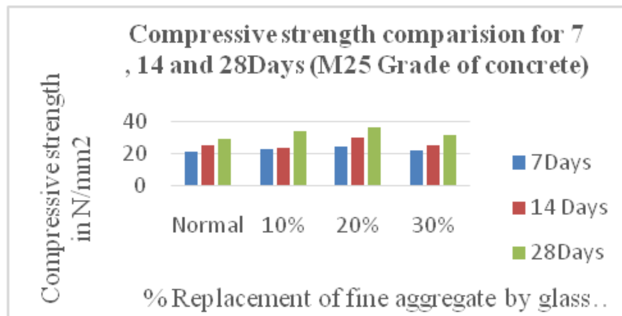

Table6: Compressive StrengthofallConcreteMix for M30

Sr. No.	Mix	CompressiveStrength(N/mm2)		
		7 Day	14 Day	28 Day
1	Normal	22.88	31.36	35.51
2	GP10	25.12	34.87	38.65
3	GP20	28.45	39.52	43.70
4	GP30	25.30	35.07	38.91

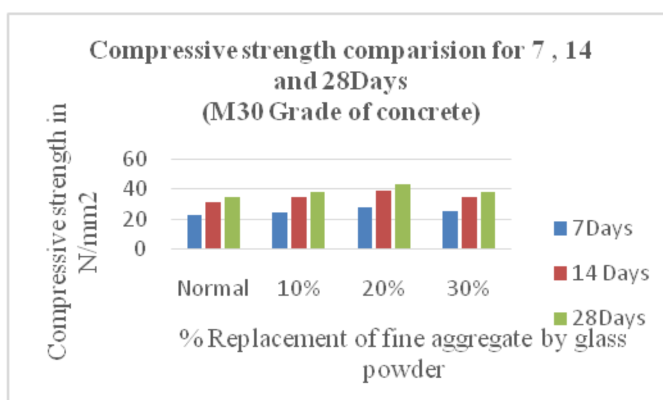

Table7: Compressive StrengthofallConcreteMix for M35

Sr. No.	Mix	CompressiveStrength(N/mm2)		
		7 Day	14 Day	28 Day
1	Normal	31.58	35.16	39.63
2	GP10	33.41	36.33	42.03
3	GP20	34.83	40.36	44.58
4	GP30	32.08	35.77	41.10

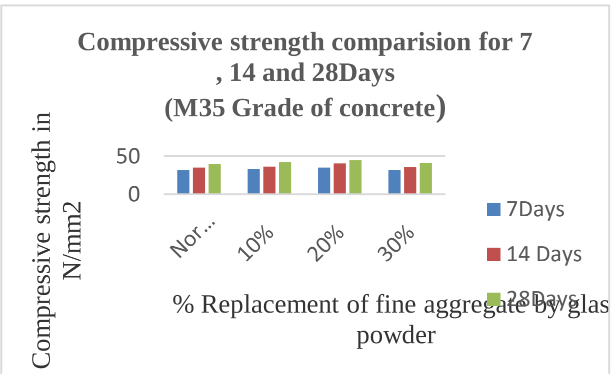

Table8: SplitTensileStrength ofConcreteMix

Sr.No.	Mix	SplitTensileStrength(N/mm2)		
		7 Day	14 Day	28 Day
1	Normal(CC)	2.16	2.39	2.75
2	GP10	2.07	2.215	2.53
3	GP20	2.01	2.125	2.32
4	GP30	1.86	1.935	2.15

VI. CONCLUSION

On the base of outcome received ,the following conclusion can
be made:

1) Utilization of waste glass in concrete will keep natural resources, particularly river sand and therefore constitute the concrete construction industry sustainable.
2) 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.
3) 20% replacement of fine aggregates by waste glass showed a 13 % increase in compressive strength at 7 days and 21% increase in compressive strength at 28 days.
4) Fine aggregates can be replaced by waste glass up to optimum level 20% by weight showing a increase incompressive strength maximum and later optimum level strength decrease.
5) With an increase in waste glass content, percentage water absorption decreases.
6) Work ability of concrete mix increases with an increase in waste glass content.
7) Splitting tensile strength decreases with an increase in waste glass content.

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