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USE OF RECYCLED GLASS IN CONCRETE MIX

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Abstract **:**

Now-a-days glass is mostly used in daily life in various forms. As it is a delicate material, it is prone to breakages. Also scraps from various other utilities are also available in abundance. Either it is disposed off or dumped. It is a non-biodegradable material. Use of recycled glass in making concrete mix provides a good environmental friendly solution against its free disposal. Though glass is very prone to alkali-silica reaction (ASR), it's effect can be prevented by using low alkali content cement. A small amount of metakaolin, chromium oxide, zirconia or lithium also suppresses the (ASR). In the current research work, use of waste glass, in various forms, in concrete mix is done. Glass powder, polishing dust is used for replacement of cement. Fine aggregates and coarse aggregates are also replaced by glass aggregates. Thus, the research aims at environmental friendly utilization of waste glass in concrete making.

Key words **:** ***non-biodegradable, recycle, alkali-silica reaction ASR***

1. INTRDUCTION

Glass and Concrete both are versatile materials which are largely used across the globe. Due care for waste reduction and it's recycle should be taken to conserve the natural resources, checks the demand for raw materials for new products, reduces energy and pollution and reduces demand of landfill space. It also creates new jobs. The use of waste glass in manufacturing of new glass items reduces raw materials to be used and energy consumption. But, not all waste glass can be used for recycling because of mixed colours, chemicals, impurities and cost.

A large amount of waste glass is available which can be utilized in making concrete. But, prior use, we have to understand the chemical and physical properties of various types of glasses. The alkali-silica reaction produces a very highly expansive silicate gel in concrete which have expansive force more than the tensile strength of concrete, which tends to crack it in days, months or years too. Addition of metakaolin, chromium oxide, zirconia or lithium can act as a pozzolans which remediates the problem of ASR. The main aim of pozzolans is to chemically tie up/sequester alkalies.

Table 1. Chemical Composition of Recycled Glass Types

Constituents	Bottle Glass	Float Glass	Fibre Glass	Borosilicate Glass	TV Panel Glass
SiO_2	74	73	50 - 55	65 - 85	62 - 85
Al_2O_3	1.3	0.15	15 - 20	1 - 5	0.5 - 2.5
CaO	10.5	9	20 - 25	0 - 2.5	0 - 4.5
MgO	0.2	5	< 1	-	0 - 2.7
Na_2O	13	14	< 1	3 - 9	6 - 11
K_2O	0.3	0.03	< 0.2	0 - 2	4 - 7

B_2O_3	-	-	0 - 6	8 - 15	-
Others	0 - 2	0 - 2	0 - 2	0 - 1	~ 20

The recycled glass aggregates from bottle glass shows delayed reaction. Pyrex and Borosilicate glass in any form should never be used in concrete. Vitrified calcium alumino-silicate VCAS white pozzolan, commonly known as fibre glass has a very optimum contents of Ca, Si and Al ions which reacts with lime to form CSH gel densifies within the pores, increasing the strength. It reacts quickly and can cement can be replaced upto 20% without concern of ASR failure and lime efflorescence.

The study focuses the use of glass cutting and polishing sludge, powder, F.A and C.A in concrete seperately.

2. LITERATURE REVIEW

Dr. G. Vijayakumar, at.el. [1] conducted experiments on concrete prepared by partial replacement of cement by waste glass powder of particle size less than 75µm. The mix design for M20 grade was prepared by I.S. Code method and cement was replaced by the waste glass powder by 10%, 20%, 30% and 40%. The normal mix design was done for the cement content of 330 kg/m^3 and water /cement ratio of 0.53. After 28 days the glass powder showed a compressive strength of 41.96N/mm^2 at 30% cement replacement. The pH value observed from the alkalinity test showed that the specimen tested found to be more alkaline and hence more resistant towards corrosion.

Jihwan Kim, at. el. [2] conducted a study to evaluate the possibility to use the waste glass sludge (WGS) from the cutting and polishing process of glass plates to partially replace the cement. They got a lower early strength but improved strength at later age. The ASR expansion can be reduced by the use of FA. They concluded that, the WGS has a higher reactivity than FA, and therefore, the WGS can be used as a pozzolanic admixture.

Aseel B. Al-Zubaid at.el. [3] used different waste glasses as a partial replacement to cement at 11%, 13% and 15% for each type and studied its effect on mechanical properties of concrete. The compressive and flexural strength showed highest results at 13% neon glass, as it has high concentration of around 68% of silicon oxide (Si_2O)which reacts with high content of calcium oxide, about 66%, in OPC which leads to formation of high amount of calcium carbonate ($CaCO_3$) during hydration process whereas splitting tensile strength was highest at 13 % for green glass.

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Kaveh Afshinnia, at.el. [4] studied the properties of fresh concrete and hardened concrete by using waste glass as both cement and aggregate replacement. When glass powder was used as a cement replacement, they got an improved workability of concrete but a reduced compressive strength due to higher air content. But, when it was used as fine aggregate replacement, the compressive strength was on higher side.

Gerry Lee, at.el. [5] studied the influence of various sizes of glass cullets while completely replacing fine aggregate in concrete. Glass cullets passing through 5.0 mm, 2.36 mm, 1.18 mm and 0.60 mm sieves were used. Pozzolanic fly ash and Metakaolin were used to study the ASR expansion. They found that ASR expansion reduced with reducing partical sizes of glass. At lower replacement level, PFA was more effective in controlling ASR. However, at higher replacement level, both PFA and MK showed simililar results in mitigating ASR expansion.

Andrea Saccani, at.el. [6] studied the ASR behavior of different types of glass cullets with different chemical composition. They studied the glass reactivity in different alkaline viz., sodium and calcium hydroxide solutions. The expansion of mortars containing different amounts of the glasses as fine aggregate in different alkaline exposure conditions soda-lime glass showed negligible expansion, lead-silicate glass showed expanding trends while boro-silicate glass showed different behaviours depending on its colour.

Gayal Kuruppu, at.el. [7] studied the applicability and adaptability of use of glass coarse aggregate. They found that concrete made with glass coarse aggregate has 16% less strength in compression, flexure than conventional concrete. They recommended that, the recycled glass can be used as an alternate coarse aggregate in concrete and will have wider applications in aesthetic workings.

3. EXPERIMENTAL PROGRAM

3.1 Introduction

The research program was divided in three parts. The first part was study of using glass powder as partial replacement to cement. in second part study of glass cullets were used as partial replacement to fine aggregate. And in third part, study of partial replacement of coarse aggregate with glass aggregates is studied.

3.2 Materials

3.2.1 PPC 53 grade cement was used.

3.2.2 Fine Aggregate as natural wardha river sand with specific gravity 2.62 was used.

3.2.3 Coarse Aggregate as 20 mm and 12 mm from natural black stone ballast with specific gravity 2.65 were used.

3.2.4 Super-plasticizer as 0.45% as cement weight.

3.3 Test Combinations

Following tables shows the proportions of the various constituents used during the study for the concrete mixes. Firstly, Glass powder/sludge **GP** was used to replace cement by 10% 12.5% and15%. Secondly, Glass fines **GFA** were used to replace fine aggregate by 15%, 20% and 25% and lastly Glass Pellets **GCA** were used to replace coarse aggregate by 15%, 20% and 25% by weight.

Table 1. Mix proportions for various mixes

S. N.	Replacement to	Notation	Cement	G P	F A	G F A	C A	G C A
1	Cement	NC	320	-	720	-	1090	-
		GP10	288	32	720	-	1090	-
		GP12.5	280	40	720	-	1090	-
		GP15	272	48	720	-	1090	-
2	Fine Agg.	NC	320	-	785	-	1100	-
		GFA15	320	-	667.25	117.75	1100	-
		GFA20	320	-	628	157	1100	-
		GFA25	320	-	588.75	196.25	1100	-
3	Coarse Agg.	NC	385	-	660	-	1154	-
		GCA10	385	-	660	-	1038.60	115.40
		GCA20	385	-	660	-	923.20	230.80
		GCA30	385	-	660	-	807.80	346.20

3.4 Mix Procedures

Pan mixer was used to mix the concrete. Dry mix was first prepared for 2 minutes and then water was added and thoroughly mixed until a uniform homogeneous mix was prepared for around 6 – 8 minutes.

3.5 Specimens

The standard cubes of size 150 mm x 150 mm x 150 mm were used. 3cubes each for 7 days, 21 days and 28 days for each notation were casted. After drying for about 24 hours, those were demoulded and kept submerged for curing.

4. RESULTS AND DISCUSSION

The comparison of compressive strength of nominal mix done for each replacement of cement, fine aggregate and coarse aggregate is tabulated as below. Glass powder, glass fine aggregate and glass coarse aggregates can be used in concrete mixes.

Table 3. Comparison of compressive strength

S. N.	Notation	7 Day		21 Days		28 Days	
1	NC	29.40	29.47	38.66	38.31	46.08	46.26
		29.87		37.87		46.32	
		29.14		38.40		46.37	
	GP10	29.12	29.21	38.02	38.19	46.48	46.36
		29.96		38.42		45.67	
		28.56		38.14		46.92	
	GP12.5	29.43	29.42	39.10	38.88	48.24	48.52
		29.16		38.86		48.96	
		29.66		38.67		48.36	
	GP15	20.16	20.92	26.84	27.58	38.87	37.55
		21.54		27.66		37.46	
		21.05		28.25		36.33	
2	NC	28.56	29.05	36.76	36.71	48.72	48.21
		29.33		36.14		47.73	
		29.27		37.22		48.18	
	GFA15	28.12	27.55	35.16	34.83	42.66	43.22
		27.44		34.28		43.74	
		27.08		35.06		43.26	
	GFA20	29.24	28.17	36.92	36.21	45.56	45.70
		28.76		35.54		46.22	
		26.50		36.18		45.33	
	GFA25	25.54	25.48	30.66	30.59	34.87	35.92
		25.18		32.86		34.66	
		25.72		28.25		38.24	
3	NC	28.86	29.21	36.28	35.80	48.84	48.42
		29.45		35.78		47.96	
		29.33		35.33		48.47	
	GCA10	28.78	29.39	36.88	35.79	48.82	48.37
		29.54		34.66		48.24	
		29.86		35.83		48.06	
	GCA20	28.40	28.03	33.24	33.26	45.62	45.70
		28.54		33.48		46.33	
		27.16		33.07		45.16	
	GCA30	24.72	24.37	29.54	29.19	40.38	40.07
		24.28		29.15		39.62	
		24.12		28.88		40.22	

5. CONCLUSION

1. Glass powder when used as replacement to cement @ 12.5%, it gives higher compressive strength. The rise in compressive strength found was 4.88%

2. When glass fines were used to replace natural fine aggregates, the compressive strength reduced than normal concrete. But for 20% replacement a rise in compressive strength was noted. So, if mix design is revised, it can be effectively used as a partial replacement to fine aggregates.

3. When glass coarse aggregates were replaced @ 10 % with natural coarse aggregates, there was nominal increase in 7 days compressive strength but nominal fall in 28 days compressive strength. So, it can be recommended for replacement.

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