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PARTIAL REPLACEMENT OF FINE AGGREGATE BY USE OF WASTE GLASS POWDER AS AN ARTIFICIAL SAND

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Abstract: This paper investigates the study of compressive strength and workability of concrete is done when its fine aggregate is replaced by waste glass powder as an artificial sand. 150 * 150 * 150 mm cube are casted of M25,M30 and M35 grade of concrete for compressive strength. This project aimed to determine the level of glass replacement resulting in optimal compressive, tensile and flexural strength. Three concrete samples were tested at 7, 14 days and 28 days, for glass replacement proportions of 0%, 10%, 20% and 30% for each concrete mix proportion. The optimum percentage replacement of sand with fine glass aggregate was determined to be 20%. By using low-cost and environmental friendly building materials from industrial waste, a sustainable concrete can be produced.

Keywords **– Artificial sand, waste glass powder, fine aggregate replacement, compressive strength, flexural 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. Population levels around the globe are increasing rapidly, resulting in unprecedented levels of waste material. New and innovative methods of recycling need to be established in order to ensure that we do not run out of room for storage. Glass, being non-biodegradable, is one such material that is not suitable for addition to landfill. Fortunately, glass can be recycled indefinitely with- out any loss in quality, but first needs to be sorted by color. 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. In order to minimize alkali-silica reactions the partial replacement of fine aggregate or cement in concrete has been investigated.

II. LITERATURE REVIEW

Adarsh Dubey ,Sanjay Saraswat, Devansh Jain (2014) expressed that 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, and Glass Powder etc. Andcoarse aggregate is replaced by cockle shell, tire rubber,recycle aggregate etc.

Jitendra B. Jangid, Prof.A.C.Saoji(2014) study showed that like PFA & GGBS a waste glass powder also act as a filler material in partial replacement of cement which takes some part of reaction at the time of hydration. Waste glass when ground to a very fine powder shows pozzolanic prosperities as it contains high SiO2 and therefore to some extent can replaced cement in concrete and contribute strength development.

D.Elavarasan, Dr.G.Dhanalakshmi (2016) expressed that concrete industry is one of the consumers of natural resources due to which sustainability of concrete industry is under threat. In this paper, the issues of economic concern are addressed by the use of waste glass as partial replacement of fine aggregates in concrete. 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.

Prajakta N. Haramkar, Sneha Maske, Rajesh M. Kushwaha, Rohit R. Sawalakhe (2018) expressed that Glass waste creates chronic environmental problems, mainly due to the inconsistency of waste glass streams. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing. Glass is an ideal material for recycling. The use of recycled glass helps in energy saving. The increasing awareness of glass recycling speeds up inspections on the use of waste

glass with different forms in various fields. One of its significant contributions is to the construction field where the waste glass was reused for concrete production. The properties of concretes glass dust waste as fine aggregate were investigated in this study.

Norfaniza Mokhtar and Nurul Atikah Jalani (2021) study expressed that Silica exists in waste glass components made it becomes a pozzolanic material and suitable to be used in a concrete mixture. The performance of the waste glass as fine aggregate was reviewed by considering the workability of fresh concrete, the strength, and the splitting tensile of hardened concrete. The range of the replacement waste are 0%, 10%, 20% and 30%. The influence of the waste glass on the microstructure of the concrete also have been evaluated. A total of seventeen previous research papers were collected and review based on the parameters selected.

III. MATERIALS AND METHODS

A.MATERIALS

In this investigation, the following materials were used:

(a)Cement: Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for chemical requirement in accordance IS: 4032-1988. The physical properties of the cement are listed in Table – 3.1

Table 3.1: Properties of cement

Sr.No	Properties	Test results	IS: 4013-1963
1.	Standard consistency	28.5%	24% - 34%
2.	Initial setting time	35min	Minimum of 30min
3.	Final setting time	480min	Maximum of 600min
4	Specific gravity	3.02	3 - 4
5	Fineness	5%	10%
6	Compressive strength		
	3days strength	29.2 Mpa	Minimum of 27Mpa
	7days strength	44.6 Mpa	Minimum of 40Mpa
	28days strength	56.6 Mpa	Minimum of 53Mpa

(b)Fine Aggregate: 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. M Sand is a industrial granular material which is mainly composed of fine divided rocky material and mineral particles.

Table 3.2: Properties of Fine Aggregate

Sr. No	Properties	Test Result	I.S Recommendation
1	M Sand zone	Zone- III	IS 383 Table- 3
2	Specific gravity	2.51	IS 2386 - 1963
3	Fineness modulus	4	IS 2386 - 1963
4	Moisture content	1%	----------
5	Water absorption	1.39%	IS 2386 - 1963

(c) Coarse Aggregate: Coarse aggregates used consisted of machine crushed stone angular in shape passing through20mm IS sieve and retained on 4.75mm IS sieve. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density, moisture content in accordance with IS: 2386-1963.

Table 3.3: Properties of Coarse Aggregate

Sr.No	Properties	Test Results	I.S Recommendation
1	Nominal size used	20mm and down	----------
2	Specific gravity	2.69	IS 2386 - 1963
3	Moisture content	0.1%	IS 2386 - 1963
4	Water absorption	0.15%	IS 2386 - 1963
5	Fineness Modulus	5.2	IS 2386 - 1963

(d) Glass Powder: Glass powder was pulverized in Los Angeles abrasion apparatus and then sieved through 1.18mm IS sieve. The glass was further subjected to a sieving process, with fractions in excess of 1.18 mm being discarded in order to avoid excessive ASR.

Table 3.4: Properties of crushed glass powder

Sr.No	Properties	Test Result	I.S Recommendation
1	Specific gravity	2.4	IS 2386 - 1963
2	Fineness modulus	3.32	IS 2386 - 1963

(e) Water: Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about $3/10^{th}$ of its weight of water. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.

B. METHOD

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 mixis 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 contains 10, 20 and 30 percentage of Glass Powder respectively.

Table 3.5: Concrete Mix proportion Summary

Concrete Grade	Mix Proportion	% Replacement of fine aggregate	Crushed glass Material (kg/m^3)	Fine Aggregates (kg/m^3)
M25	1:1.24:2.71	0%	-	545.01
		10%	54.50	490.51
		20%	109.00	436.01
		30%	163.50	381.51
M30	1:1.86:2.91	0%	-	702
		10%	70.2	631.8
		20%	140.4	561.6
		30%	210.6	491.4
M35	1:2.15:2.62	0%	-	812
		10%	81.2	730.8
		20%	162.4	649.6
		30%	243.6	568.4

In this study, the production of concrete for this test was conducted at the concrete laboratory. All preparation of concrete was undertaken in accordance with IS 10262: 2009. Nine specimens were created for each percentage replacement of glass, with three samples being used for the seven, fourteen and twenty eight days respectively. Mixing of the concrete was carried out by hand mixing. Concrete moulds used were cube of Size 150mmx150mmx150mm. To prevent adhesion, all moulds were coated with a thin layer grease, which consisted of 93% liquid hydrocarbons .In preparing the final samples, concrete was added to the concrete moulds incrementally. Each layer was subjected to vibration with a table vibrator for 5 - 10 seconds, and was ceased once visibly trapped air was eliminated. Concrete was al- lowed to air-cure for a period of 24 hours, before being removed from the moulds and transferred to a water bath set at 23 degrees for the remainder of the curing period.

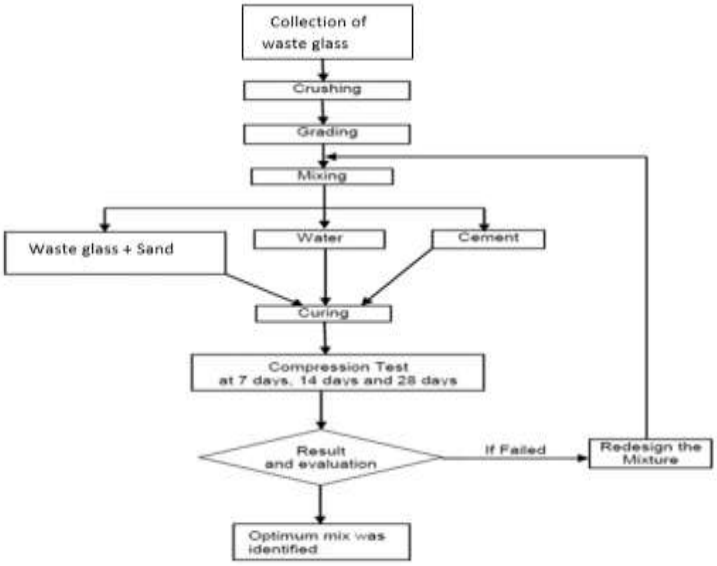

Fig.3.1 Flow chart showing experimental procedure for casting of cubes

IV. RESULT AND DISCUSSION

4.1 Test Performed Result For Fresh Concrete

4.1.1 Slump test of workability: Table 4.1 represents the slump value of the concrete mix M25,M30 and M35 . 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.

Table 4.1: Workability of Concrete

% Replacement of fine aggregate	Slump in mm		
	M25 Grade of Concrete	M30 Grade of Concrete	M35 Grade of Concrete
CC	62	59	52
GP10	68	63	61
GP20	71	76	66
GP30	81	84	78

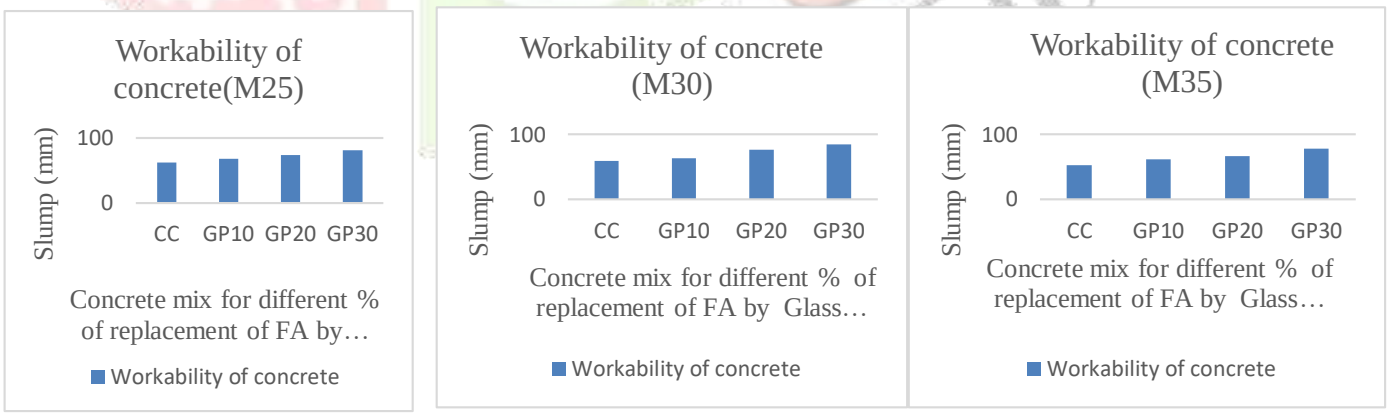

Fig.4.1 Variation in workability for different % replacement of glass powder

4.2. Test Performed Result For Hardened Concrete

4.2.1. Compressive Strength Results: The cubes of size 150 x 150 x 150mm were casted and tested for 7 days , 14 days and 28 days. The test results are tabulated below:

Table 4.2: Compressive test result for different grade of concrete

Grade of Concrete	Mix	Compressive Strength(N/mm2)		
		7 Day	14 Day	28 Day
M25	Normal CC(0%)	21.65	25.66	29.32
	GP10	23.54	23.73	34.15
	GP20	24.72	30.51	36.77
	GP30	22.11	25.98	32.20
M30	Normal CC(0%)	22.88	31.36	35.51
	GP10	25.12	34.87	38.65
	GP20	28.45	39.52	43.70
	GP30	25.30	35.07	38.91
M35	Normal CC(0%)	31.58	35.16	39.63
	GP10	33.41	36.33	42.03
	GP20	34.83	40.36	44.58
	GP30	32.08	35.77	41.10

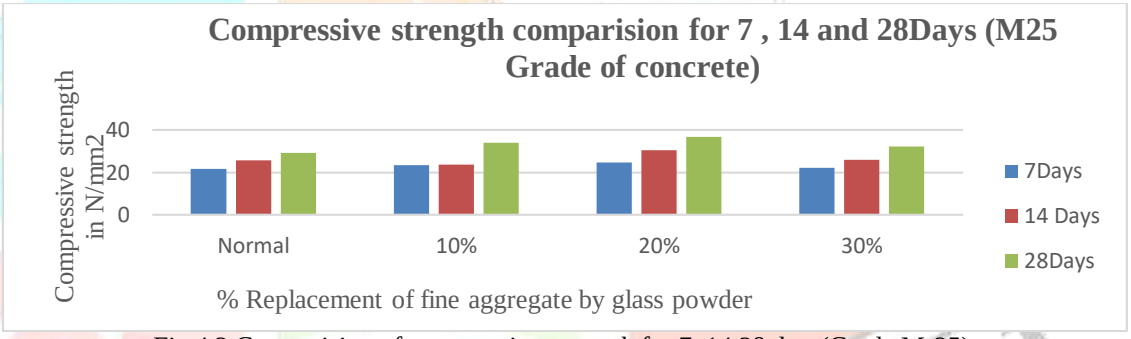

Fig 4.2.Comparision of compressive strength for 7 ,14,28 days(Grade M-25)

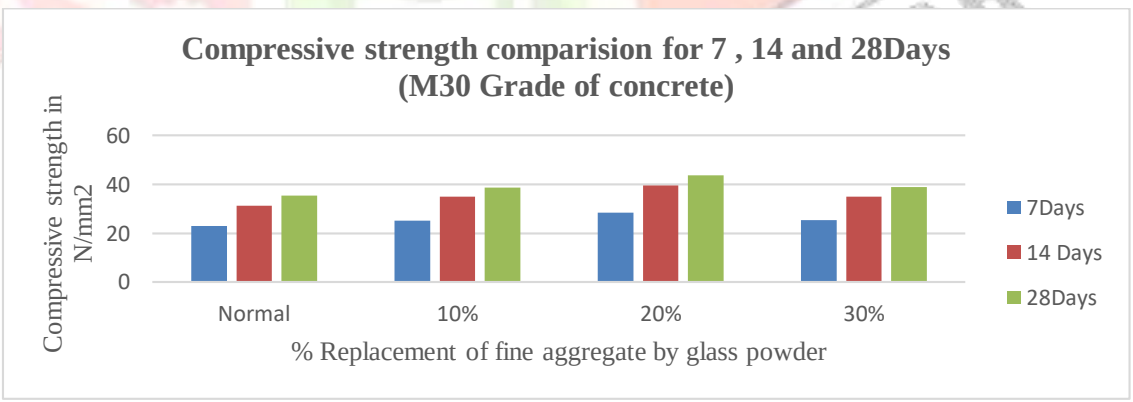

Fig 4.3.Comparision of compressive strength for 7 ,14,28 days(Grade M-30)

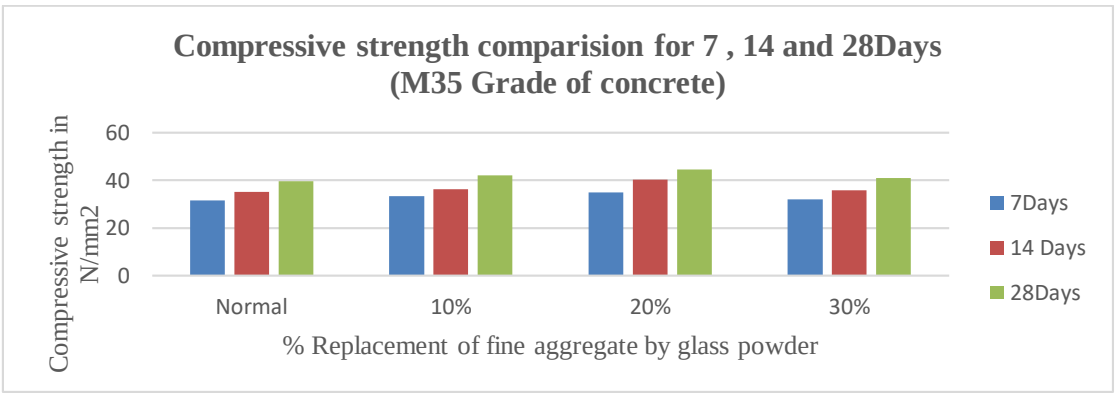

Fig 4.4.Comparision of compressive strength for 7 ,14,28 days(Grade M-35)

V. CONCLUSION

The test results for conventional and designed concrete werecompared in order to obtain the strength aspect of concrete. The variation of workability and compressive strength of concrete have studied considering the environmental aspects also and the following conclusions are obtained.

- The 7 days, 14 days and 28 days compressive strengths of concrete increase initially as the replacement percentage of fine aggregate with glass powder increases, and become maximum at about 20% and later decreases.
- Compressive strength was found to increase with the addition of waste glass to the mix up until the optimum level of replacement. This can be attributed to the angular nature of the glass particles facilitating increased bonding with the cement paste.
- Workability of concrete goes on increasing with increasing the replacement percentage of fine aggregate with glass powder content.
- The water absorption is found to be decreases with increases in percentage of glass powder content in concrete mix as fine aggregate have more water absorption in nature compare to glass powder.
- Utilization of waste glass in concrete can turn out to be economical as it is no useful waste and spare of cost.
- 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.
- Utilization of waste glass in concrete will keep natural resources, particularly river sand and therefore constitute the concrete construction industry sustainable.

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