

Experimental Studies on High Performance Concrete Using Glass Powder

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ABSTRACT: Concrete is one of the most widely used construction materials in the world and cement is used as a binding material in the production of concrete. The production of portland cement leads to the release of significant amount of CO₂, a greenhouse gas. One ton of portland cement production produces approximately one ton of CO₂ and other greenhouse gases (GHGs). Environmental issues are playing an important role in the sustainable development of the cement and concrete industry. Hence, there is a need to replace a part of cement by some pozzolanic material to reduce the consumption of cement and also to control the environmental pollution to some extent. Some of the industrial wastes like fly ash, silica fume, blast furnace slag, etc. have already been used in concrete production. Recently, it has been identified that the waste glass can be effectively used in concrete either as glass aggregate or as a glass pozzolana. Waste glass when ground to a very fine powder shows some pozzolanic properties because of presence of silica content. Therefore, the glass powder to some extent can replace the cement and contributes to the strength development of concrete. In this paper, an attempt has been made to produce high performance concrete using waste glass powder as a substituting material for cement. The experimental work carried out and the results obtained are presented and discussed in this paper.

KEYWORDS: Cement, Glass powder, Greenhouse gases & Pollution control

I. INTRODUCTION

Concrete is a blend of cement, sand, coarse aggregate and water. The key factor that adds value to concrete is that it can be designed to withstand harshest environments significant role. Today global warming and environmental devastation have become manifest harms in recent years, concern about environmental issues, and a changeover from the mass-waste, mass-consumption, mass-production society of the past to a zero-emanation society is now viewed as significant. Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if not dealt carefully and it is less friendly to environment because it is non-biodegradable. Thus, the development of new technologies has been required. The term glass contains several chemical diversities including soda-lime silicate glass, alkali-silicate glass and boro-silicate glass. To date, these types of glasses glass powder have been widely used in cement and aggregate mixture as pozzolana for civil works. From the past literature studies, glass powder was partially replaced the cement in ordinary concrete. In this paper, the cement is replaced by glass powder in high performance concrete. The cement is replaced by glass powder as 10,20,30,and 40% in M50 grade concrete. The compression, split tensile and flexural tests are conducted and test results are compared to the conventional concrete.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 3, March 2017

II. MATERIALS

Glass powder

The introduction of waste glass in cement will increase the alkali content in the cement. It also help in bricks and ceramic manufacture and it preserves raw materials, decreases energy consumption and volume of waste sent to landfill. As useful recycled materials, glasses and glass powder are mainly used in fields related to civil engineering, for example, in cement, as pozzolana (supplementary cementitious materials), and coarse aggregate. Their recycling ratio is close to 100%, and it is also used in concrete without adverse effects in concrete durability. Therefore, it is considered ideal for recycling. Recently, Glasses and its powder has been used as a construction material to decrease environmental problems. The coarse and fine glass aggregates could cause ASR (alkali-silica reaction) in concrete, but the glass powder could suppress their ASR tendency, an effect similar to supplementary cementations materials (SCMs). Therefore, glass is used as a replacement of supplementary cementitious materials.

Glass is amorphous material with high silica content, thus making it potentially pozzolanic when particle size is less than 75 μ m. Finely ground glass does not contribute to alkali – silica reaction.

Cement

Ramco super grade conforming IS 8112 – 1989 was used. Generally, this cement is classified into 33, 43 and 53 grades as per IS 269:1989, IS 8112:1989 and IS 12269:1987. The main function of all the types of cement will be binding of aggregates. The cement used was dry, powdered and free from lumps.

Fine aggregate

Aggregates size is in between 150 microns to 4.75mm is used. The important function of fine aggregate in concrete are

- To produce workability and uniformity.
- To assist the cement paste to hold the particles of coarse aggregate in suspension and to prevent paste to hold the possibility of segregation.
- To fill up the voids in coarse aggregate.

Angular grained sand is preferable to round grained sand since it provides good interlocking properties.

Coarse aggregate

The strength of concrete depends on coarse aggregate. It should be hard, strong, dense, durable, rough and free from salt, alkali and organic matters. Blue organic, gneiss, crystalline lime stone or good sand stone are crushed in to small pieces of size varying from 5mm to 20mm are generally used as coarse aggregates. Coarse aggregates with a nominal maximum size of 20 mm is used in this study.

Water

Water used for mixing and curing of concrete shall be clean and free of oils, acids, alkalis, salts, sugar, organic material etc. Potable water is generally considered satisfactory for mixing concrete. PH value of 7 will be preferred.

Chemical Admixture

Super-plasticizer is an essential component for high strength concrete. CERAPLAST 300 is used. CERAPLAST 300 is the chloride free, super-plasticizer based on sulphonated naphthalene polymers super plasticizer is a unique workability retaining high performance super-plasticizer with high strength properties. Super-plasticizer admixture at 1.5% by weight of cement was used to obtain the desired workability.

III. RESULTS

Compression test

Testing of hardened concrete plays as important role in controlling and confirming the quality of cement concrete works. Compression test is the most common test conducted on hardened concrete. It is easy to perform the test. For

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Vol. 6, Issue 3, March 2017

this generally concrete cubes of size 15X15X15cm confirming to IS 10086:1992 – (specification for moulds for use in tests of cement and concrete) are preferred.

Compressive Test results

Compressive Test for 7 days (M50)

s.n o	Type of specimen % of glass powder	Compressive					
		Load in x 10 ³ N			Strength in N/mm ²		
		Trail1	Trail2	Mean	Trail1	Trail2	Mean
1	0	910	830	870	33.56	39.5	38.66
2	10	750	710	730	30.67	35.11	32.33
3	20	710	600	655	32.016	30.02	28.51
4	30	580	570	575	31.79	30.90	25.05
5	40	520	550	535	26.67	28.88	23.76

Compressive Test for 14 days (M50)

s.n o	Type of specimen % of glass powder	Compressive					
		Load in x 10 ³ N			Strength in N/mm ²		
		Trail1	Trail2	Mean	Trail1	Trail2	Mean
1	0	980	1010	995	43.27	44.59	43.93
2	10	880	990	935	38.60	44.00	41.3
3	20	730	735	732.5	32.23	32.24	32.24
4	30	620	700	660	27.37	30.90	29.14
5	40	570	610	590	25.34	27.11	26.23

Compressive Test for 28 days (M50)

s .no	Type of specimen % of glass powder	Compressive					
		Load in x 10 ³ N			Strength in N/mm ²		
		Trail1	Trail2	mean	Trail1	Trail2	Mean
1	0	1120	1050	1085	49.45	46.67	48.06
2	10	1090	985	1037.5	48.44	43.78	46.11
3	20	860	820	840	38.22	36.20	37.21
4	30	695	580	637.5	30.68	25.60	28.14
5	40	655	610	632.5	29.11	27.11	28.11

Tension Test

The split tensile is an indirect test used to determine the tensile strength at concrete. In this test, the compressive loads are applied along a vertical symmetrical plane setting up tensile stress normal to plane, which cause splitting of specimen.

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spilt tensile test for 7 days (M50)

S .no	Type of specimen % of glass powder	Spilt tensile					
		Load in x 10 ³ N			Strength in N/mm ²		
		Trail1	Trail2	mean	Trail1	Trail2	Mean
1	0	78.14	79.10	78.62	1.105	1.12	1.11
2	10	72.88	73.28	72.03	1.031	1.04	1.04
3	20	62.02	64.12	67.65	0.88	0.91	0.90
4	30	54.18	58.38	56.28	0.77	0.83	0.8
5	40	50.22	52.24	51.23	0.710	0.74	0.725

spilt tensile test for 14 days (M50)

s .no	Type of specimen % of glass powder	Spilt tensile					
		Load in x 10 ³ N			Strength in N/mm ²		
		Trail1	Trail2	mean	Trail1	Trail2	Mean
1	0	118	106.8	112.4	1.67	1.51	1.59
2	10	102.2	99.02	100.61	1.45	1.401	1.43
3	20	98.8	88.08	93.44	1.40	1.260	1.33
4	30	72.8	85.8	79.3	1.03	1.213	1.12
5	40	64.8	80.2	72.5	0.92	1.140	1.03

spilt tensile test for 28 days (M50)

s.n o	Type of specimen % of glass powder	Spilt tensile					
		Load in x 10 ³ N			Strength in N/mm ²		
		Trail1	Trail2	mean	Trail1	Trail2	mean
1	0	172.6	168.2	170.4	2.44	2.38	2.41
2	10	169.6	188.8	179.2	2.40	2.671	2.54
3	20	138.2	132.2	135.1	1.96	1.870	3.83
4	30	118.4	102.8	110.6	1.68	1.454	1.567
5	40	114.0	98.6	106.3	1.613	1.39	1.501

Flexural Strength Test

Flexural strength test is carried as per IS: 516-1979. In Compression testing machine beam specimen of size 150x150x700mm were cast for conducting flexural strength test for each mix. This test is conduct at the end of 28 days of curing and average of three sample taken as the representative flexural strength of the mix.

flexural test for 7 days

s.n o	Type of specimen % of glass powder	Flexural					
		Load in x 10 ³ N			Strength in N/mm ²		
		Trail1	Trail2	mean	Trail1	Trail2	Mean
1	0	7.68	6.82	7.25	3.84	3.41	3.63
2	10	6.52	6.34	6.43	3.26	3.17	3.215
3	20	6.24	5.68	5.96	3.12	2.84	2.98
4	30	5.78	5.42	5.6	2.89	2.71	2.80
5	40	4.20	3.78	3.99	2.10	1.89	2.84

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 3, March 2017

flexural test for 14 days

s.n o	Type of specimen % of glass powder	Flexural					
		Load in x 10 ³ N			Strength in N/mm ²		
		Trail1	Trail2	mean	Trail1	Trail2	mean
1	0	7.68	6.82	7.25	3.84	3.41	3.63
2	10	6.52	6.34	6.43	3.26	3.17	3.215
3	20	6.24	5.68	5.96	3.12	2.84	2.98
4	30	5.78	5.42	5.6	2.89	2.71	2.80
5	40	4.20	3.78	3.99	2.10	1.89	2.84

Flexural test for 28 days

s.n o	Type of specimen % of glass powder	Flexural					
		Load in x 10 ³ N			Strength in N/mm ²		
		Trail1	Trail2	mean	Trail1	Trail2	mean
1	0	14.92	13.2	14.06	7.46	6.6	7.03
2	10	14.88	8.08	11.48	7.44	4.04	5.74
3	20	12.4	8.16	10.28	6.21	4.03	5.12
4	30	11.4	7.98	9.68	5.7	3.99	4.85
5	40	10.68	7.02	8.85	5.34	3.51	4.43

IV. CONCLUSION

Generally, concrete is used for various construction purpose. High performance concrete is one of the type of the concrete. In high performance concrete, generally special materials like mineral admixtures such as flyash, blast furnace slag, silica fume, metakaolin, rice husk, etc., and chemical admixtures such as plasticizers and superplasticizers are added in concrete. However, waste glass powder has not been tried till now for the production of high performance concrete. Therefore, in this paper, an attempt has been made to produce high performance concrete using waste glass powder. In this paper mechanical properties such as compressive strength, flexural strength, and split tensile strength has been investigated for M50 grade high performance concrete by replacing cement with the help of waste glass powder of 10%, 20%, 30%, and 40% by weight of cement. The following results are observed in this experimental works. These results are

The Maximum compressive strength is achieved by 10% replacement of glass powder.

The Maximum split tensile strength is achieved by 20% replacement of glass powder.

Maximum flexural strength test is achieved by 10% replacement of glass powder.

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ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

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