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An experimental study on strength and durability properties of concrete by partial replacement of steel slag with fine aggregate and glass powder with cement

Vishnuprasad.K[1], Karthika .P[2]

[1]PG Student, [2]Assitant Professor

Department of Civil Engineering, Nandha Engineering College, Erode, Tamilnadu, India.

ABSTRACT

Non-degradable wastes has been a major issue now in the fourth coming century as more and more of these wastes are piling up in our world today and being disposed of in landfill areas without being recycled. These wastes take up a very long period of time to decompose. And due to the availability of raw material is very less due to higher use of concrete. Researchers have been done to partially utilize these wastes as the final products for construction materials such as concrete. To overcome this problem replaced the cement with glass powder and fine aggregate with steel slag. The primary objective of the project is to increase the strength of the concrete by replacing fine aggregate by steel slag and cement by glass powder. Mix design M30 was casted by replacement of cement with Glass powder by weight at 5%, 10%, 15% and fine aggregate with steel slag by weight at 5%, 10%, 15%.

Cubes, prisms, Cylinders were prepared for testing after seven, and twenty eight days natural process in water served as the control. Results are obtained by the tests like compressive strength, flexure strength and split tensile strength. Even it is compared with the conventional concrete for the difference between them.

INTRODUCTION

Concrete is that the most generally used man-made material alive. It is second only to water because the most-consumed resource on the earth. But, while cement - the key ingredient in concrete - has shaped much of our built environment, it also features a massive carbon foot print. Cement is that the source of about 8% of the world's CO2 (CO2) emissions. If the cement industry were a rustic, it might be the third largest emitter within the world. It contributes more CO2 than aviation fuel (2.5%) and isn't far behind the worldwide agriculture business (12%) As Steel slag and Glass powder is really created from waste steel dust which is generally discarded from industrial processes and silica from ground up glass. The potential for Steel slag and Glass powder is as a widely used green, alternative artifact that would be made up of over 95% recycled material. Steel slag and Glass powder is that the viable alternative to cement, which may be mixed and poured to form concrete with strength of concrete. In reality, Steel slag and Glass powder is really quite bit stronger than hydraulic cement, far and away the leading type in use today. Steel slag and Glass powder???s hardness comes from the fact that as it dries, the material absorbs and irreversibly binds large amounts of atmospheric CO2.

LITERATURERE VIEW

P.S.Kothai, Dr.R.Malathy - As a construction material, concrete is the largest production of all other materials. Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. The increase in demand for the ingredients of concrete is met by partial replacement of materials

Author for correspondence:

Department of Civil Engineering, Nandha Engineering College, Erode.

by the waste materials which is obtained by means of various industries. Slag may be a by-product of metal smelting and many plenty of it are produced per annum everywhere the planet within the process of refining metals and making alloys. This substance is produced during the smelting process in several ways. Firstly, slag represents undesired impurities within the metals, which float to the highest during the smelting process. Secondly, metals start to oxidize as they're smelted, and slag forms a protective crust of oxides on the very best of the metal being smelted, protecting the liquid metal underneath. When the metal is smelted to satisfaction, the slag is skimmed from the highest and disposed of during a slag heap to age. Aging material is an important part of the process, as it needs to be exposed to the weather and allowed to break down slightly before it can be used. In this experimental investigation an effort is formed to review the effect of partial replacement of fine aggregate by steel slag within the mechanical properties of M20 grade concrete [1, 2].

Dr.G.Vijayakumar, Ms H.Vishaliny, Dr.D. Govindarajulu - Cement fabricating industry is one of the carbon dioxide radiating sources other than deforestation and consuming of non-renewable energy sources. The worldwide temperature alteration is brought about by the emanation of ozone harming substances, for example, CO2, to the climate. Among the ozone harming substances, CO2 contributes about 65% of a dangerous atmospheric deviation. The worldwide concrete industry contributes about 7% of ozone harming substance emanation to the world's air. So as to address natural impacts related with concrete assembling, there is a need to create elective covers to make concrete. Subsequently, broad research is on going into the utilization of concrete substitutions, utilizing many waste materials and modern results. Endeavors have been made in the solid business to utilize squander glass as halfway substitution of coarse or fine totals and concrete. In this examination, finely powdered waste glasses are utilized as a halfway substitution of concrete in concrete and contrasted it and customary cement. This work looks at the plausibility of utilizing Glass powder as an incomplete swap of concrete for new concrete. Glass powder was incompletely supplanted as 10%, 20%, 30% and 40% and tried for its compressive, Tensile and flexural quality as long as 60 days of age and were contrasted and those of ordinary cement; from the outcomes acquired, it is discovered that glass powder can be utilized as concrete substitution material up to molecule size under 75µm to forestall soluble base silica response [3, 4].

MATERIALS

The essential tests are led on different materials like fine total, coarse total, glass powder and steel slag to check their appropriateness for making concrete. The exploratory examination has been done on the test 3 examples of Cubes, Cylinders, and Prisms each to think about the quality properties because of supplanting fine total by Steel slag and concrete by Glass powder in different rates to be specific 70% - 30%, 80% - 20% and 90% - 10%.

EXPERIMENTAL INVESTIGATION OF MATERIALS

Cement

Ordinary Portland cement of 53Grade conforming to IS 12269-1987, and the cement should be clean, dry and free from impurities.

Table I: Physical Properties of Cement

S.No	Properties	Obtained values
1	Consistency test	34%
2	Initial setting time	35 Minutes
3	Final setting time	370 Minutes
4	Fineness test	6%
5	Specific gravity	3.14

Fine Aggregate

Natural river sand with fraction passing through the 4.75 mm sieve and retained on 600 µm sieve was used and tested as per IS: 2386. The fineness modulus of sand used was 2.81 with a specific gravity of 2.65.

Coarse Aggregate

Crushed angular aggregate with maximum grain size of 20 m sand downgraded was used and having bulk density 1.38 kg/m3. The specific gravity is 2.82.

Water

According to IS 3025, Water to be used for mixing and curing should be free from injurious or deleterious materials. Potable water is generally considered satisfactory. In the present investigation, available water within the campus is used for mixing and curing purposes.

Steel Slag

Steel slag is acquired from Agni Steels Private Limited, Ingur, TamilNadu, India and its particular gravity in fine structure was seen as 2.95.The prevalent mixes are dicalcium silicate, tricalcium silicate, dicalcium ferrite, merwinite, calcium aluminate, calcium-magnesium iron oxide, and a few free lime and free magnesia (periclase).

Table II: Chemical Composition of Steel Slag

Constitution	Composition (%)
CaO	40-52
SiO_2	10-19
FeO	10-14
MnO	5-8
MgO	5-10
Al_2O_3	1-3
P_2O_3	0.5-1
S	<0.1
Metallic Fe	0.5-10

Glass Powder

Squander glass accessible locally is been gathered and made into glass powder. Glass squander is exceptionally hard material. Before including glass powder in the solid it must be powdered to wanted size. In this investigations glass powder ground in ball/pulveriser for a time of 30 to an hour brought about molecule estimates not exactly measure 150 µm and sieved in 75 µm.

Table III: Physical Properties of Glass Powder

S.No	Physical Properties of Glass Powder	
1	Specific gravity	2.6
2	Fineness Passing 150µm	99.5
3	Fineness Passing 90µm	98

Table IV: Chemical Composition of Glass Powder

S.No	Chemical properties of Glass powder	% by mass
1	SiO_2	67.330
2	Al_2O_3	2.620
3	Fe_2O_3	1.420

4	TiO_2	0.157
5	CaO	12.450
6	MgO	2.738
7	Na_2O	12.050
8	K2O	0.638
9	ZrO_2	0.019
10	ZnO	0.008
11	SrO	0.016
12	P_2O_5	0.051
13	NiO	0.014
14	CuO	0.009
15	Cr_2O_3	0.022

Concrete mix proportions

The mixes were designed in accordance with IS 10262-2009 mix design method. Based on the result, the mix proportions M30 was designed. Concrete mix with the W/C ratio of 0.50 was prepared. The details of mix proportion and materials required for $1m^3$ of concrete.

Table V: Mix Proportion

Grade	Cement(kg/m^3)	FA (kg/m^3)	CA (kg/m^3)	Water (kg/m^3)
M30	394	732	1139	197
Mix ratio	1	0.75	1.5	0.50

Compressive Strength

Compressive strength of concrete is tested on cube at different percentage of steel slag content in concrete. The strength of concrete has been tested on cube at 28 days. The strength of concrete is very much dependent up on the hydration reaction. In this experiment, in all cases, some percentage adding of sand by steel slag test results and show that twenty-eight days compressive. The reduction of the strength increased with increasing percentage of steel slag after some specific limit.

Table VI: Compressive Strength of Concrete

S.No	Steel slag and Glass powder (%)	Compressive Strength at 28 days(N/mm^2)
1	CC	24
2	70+30	28.03
3	80+20	38.5
4	90+10	32.66

Split tensile strength

Split Tensile strength of concrete is tested on cylinders at different percentage of polypropylene fiber Content in concrete. The strength of concrete has been tested on cylinder at 28 days. Compression testing machine is used for testing the Split Tensile strength test on concrete along with two wooden boards. At the time of testing the cylinder taken out of water and dried and then tested.

Table VII: Split Tensile Strength of Concrete

S.No	Steel slag and Glass powder (%)	Split tensile Strength at 28 days(N/mm^2)
1	CC	2.83
2	70+30	3.22
3	80+20	4.8
4	90+10	2.9

Flexural strength

Flexural strength of concrete is tested on prism at different percentage of Steel slag and glass powder content in concrete. The strength of concrete has been tested on prism at 28 days. Testing machine is used for testing the flexural strength test on concrete along the two point load.

Table VIII: Flexural Strength of Concrete

S.No	Steel slag and Glass powder (%)	Flexural Strength at 28 days(N/mm^2)
1	CC	4.23
2	70+30	6.62
3	80+20	7.34
4	90+10	5.76

Deflection of beam

The shafts were basically bolstered at the two finishes with concentrated point stacking framework and the bars exposed to static stacking. The beam of size 0.15 m x 0.18 m x 1.2 m were cast with the following reinforcement 5 quantities of 10mm width bars was utilized as principle support, 2 numbers at top and 3 numbers at base. 8 mm breadth stirrups divided 130 mm focuses were utilized as shear support.

Table 4.3 Deflection of beam with controlled mix

S.No	Load (kN)	Deflection at mid span (mm)		
		Beam 1	Beam 2	Beam 3
1	0	0	0	0
2	2	1.7	0.9	1.3
3	4	2.3	2.1	2.4
4	6	3.8	3.3	3.7
5	8	4.7	4.2	4.8
6	10	5.4	5.7	5.5
7	12	6.3	6.1	6.7
8	14	7.0	7.9	7.6
9	16	8.1	9.1	8.2
10	18	9.4	10.2	9.1
11	20	11.1	12.0	10.7
12	22	12.4	13.3	11.8

13	24	13.3	14.3	13.1
14	26	16.0	16.8	15.3
15	28	21.1	23.1	20.2
16	30	25.8	29.2	25.6
17	32	31.5	-	-

Table 4.4 Deflection of beam with design mix

S.No	Load (kN)	Deflection at mid span (mm)		
		Beam 1	Beam 2	Beam 3
1	0	0	0	0
2	2	1.8	1.3	1.6
3	4	3.1	2.8	3.1
4	6	4.2	4.4	4.2
5	8	5.1	5.2	5.3
6	10	6.3	6.0	6.5
7	12	7.5	7.1	7.3
8	14	8.7	8.3	8.6
9	16	9.5	9.1	9.4
10	18	10.7	10.6	10.7
11	20	11.9	12.2	11.5
12	22	13.2	13.4	12.9
13	24	15.8	15.0	15.0
14	26	17.9	17.5	17.1
15	28	23	23.1	19.9
16	30	32	29.2	25.0
17	32	32.3	33.2	34
18	34	-	36.1	36.5

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