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An experimental investigation of replacement of cement by steel slag and glass powder

Vijayalakshmi.P[1], Ranjith.V[2],Sudhakar.K[3],Ashok.A.K[4],Tharanya.S[5]

[1]UG Student, B.E Civil Engineering, Nandha Engineering college, Erode, Tamilnadu, India

[2]UG Student, B.E Civil Engineering, Nandha Engineering college, Erode, Tamilnadu, India

[3]UG Student, B.E Civil Engineering, Nandha Engineering college, Erode, Tamilnadu, India

[4]UG Student, B.E Civil Engineering, Nandha Engineering college, Erode, Tamilnadu, India

[5]Assitant professor, Department of Civil Engineering, Nandha Engineering college, Erode, Tamilnadu, India.

E – Mail: sstharanya@gmail.com

Abstract— **Steel slag and Glass powder is actually created from waste steel dust which is normally 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 building material that could be made from over 95% recycled material. Steel slag and Glass powder is the viable alternative to cement, which can be mixed and poured to make concrete with strength of concrete. In reality, Steel slag and Glass powder is actually quite a bit stronger than Portland cement, by far 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 CO_2. Thus we are casting a Steel slag and Glass powder concrete cube and compare the compressive strength with the normal Concrete cube.**

1.INTRODUCTION

Cement is almost unbelievably polluting. Researching this article fully 5% of worldwide, man-made emissions come from the production of cement. Though they're often referred to interchangeably, cement is the material that binds concrete. Between the chemical processes and the fuel burned powering them, they emit an incredible 900 kg of CO_2 for every 1 ton of cement produced and worldwide we produce about 4 billion tons of cement. A viable replacement for cement that cut these emissions could certainly have an impact.

Steel slag and Glass powder is a viable alternative to cement, that could be mixed to make concrete. In reality, Steel slag and Glass powder is actually quite a bit stronger than Portland cement. It can be resistant to the shocks of small Earthquakes or industrial processes. Steel slag and Glass powder's hardness comes when it dries, the material absorbs atmospheric CO_2.

Steel slag and Glass powder is made with waste steel dust left over from steel manufacturing processes, which is usually a residue. The iron content reacts with $CO_2$and rusts, forming iron carbonate that is fused into the matrix of the Steel slag and Glass powder; like concrete, when Steel slag and Glass powder dries you can't just melt it back to the liquid phase.

II. LITERATURE REVIEW

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 by the waste materials which is obtained by means of various industries. Slag is a by-product of metal smelting and hundreds of tons of it are produced every year all over the world in the process of refining metals and making alloys. This substance is produced during the smelting process in several ways. Firstly, slag represents undesired impurities in the metals, which float to the top during the smelting process. Secondly, metals start to oxidize as they are smelted, and slag forms a protective crust of oxides on the top of the metal being smelted, protecting the liquid metal underneath. When the metal is smelted to satisfaction, the slag is skimmed from the top and disposed of in 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

Physical properties of cement

investigation an attempt is made to study the effect of partial replacement of fine aggregate by steel slag in the mechanical properties of M20 grade concrete.

Dr.G.Vijayakumar, Ms H.Vishaliny, Dr.D. Govindarajulu - Cement manufacturing industry is one of the carbon dioxide

emitting sources besides deforestation and burning of fossil fuels. The global warming is caused by the emission of greenhouse gases, such as CO_2, to the atmosphere. Among the greenhouse gases, CO_2 contributes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with cement manufacturing, there is a need to develop alternative binders to make concrete. Consequently, extensive research is ongoing into the use of cement replacements, using many waste materials and industrial by products. Efforts have been made in the concrete industry to use waste glass as partial replacement of coarse or fine aggregates and cement. In this study, finely powdered waste glasses are used as a partial replacement of cement in concrete and compared it with conventional concrete. This work examines the possibility of using Glass powder as a partial replacement of cement for new concrete. Glass powder was partially replaced as 10%, 20%, 30% and 40% and tested for its compressive, Tensile and flexural strength up to 60 days of age and were compared with those of conventional concrete; from the results obtained, it is found that glass powder can be used as cement replacement material up to particle size less than 75µm to prevent alkali silica reaction.

III.MATERIALS

The basic tests are conducted on various materials like fine aggregate, coarse aggregate, glass powder and steel slag to check their suitability for making concrete. The experimental investigation has been carried out on the test 3 specimens of Cubes, Cylinders, and Prisms each to study the strength properties as a result of replacing fine aggregate by Steel slag and Glass powder in various percentages namely 70% - 30%, 80% - 20% and 90% - 10%.

IV.EXPERIMENTALINVESTIGATION OFMATERIALS

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

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 mmand 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 obtained from Agni Steels Private Limited, Ingur, TamilNadu, India and its specific gravity in fine form was found to be 2.95.The predominant compounds are dicalcium silicate, tricalcium silicate, dicalcium ferrite, merwinite, calcium aluminate, calcium-magnesium iron oxide, and some 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: Waste glass available locally is been collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete it has to be powdered to desired size. In this studies glass powder ground in ball/ pulveriser for a period of 30 to 6o minutes resulted in particle sizes less than size 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

V. CONCRETE MIX PROPORTIONS

The mixes were designed in accordance with IS 10262-2009 mix design method. Based on the result, the mix proportions M25 was designed. Concrete mix with the W/C ratio of 0.45 was prepared. The details of mix proportion and materials required for 1m³ of concrete.

TABLE V - Mix proportion

Grade	Cement (kg)	FA (kg)	CA (kg)	Water
M25	430	600	1030	197
Mix ratio	1	1.3	2.3	0.45

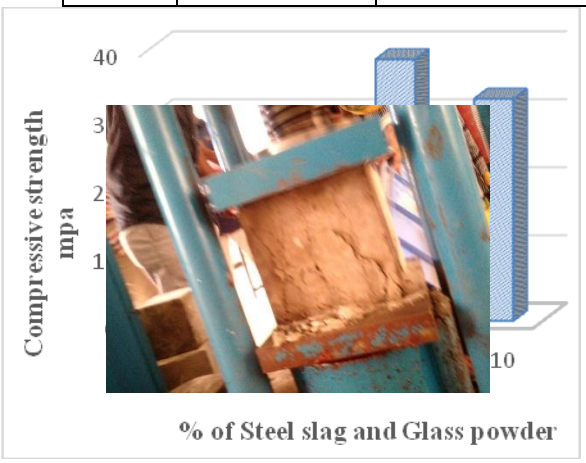
Compressive Strength

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 testresults 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

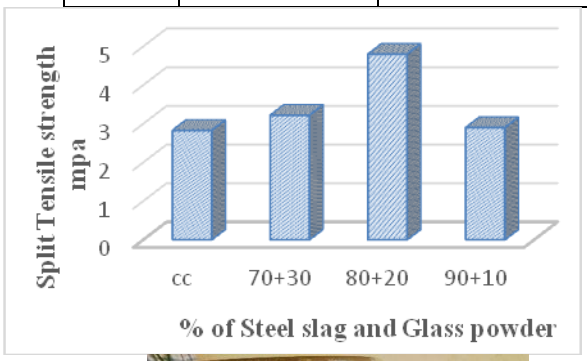


Split tensile strength

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

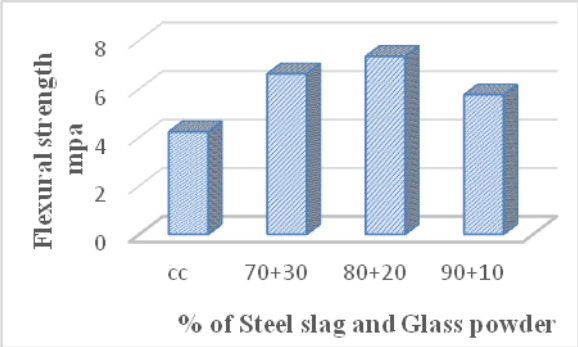


Flexural strength

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



- Strength enhancement in splitting tensile strength due to replacement of cement by Steel slag and Glass powder is up to 30%.
- The compressive strength, split tensile strength increase with the replacement of Steel slag and Glass powder as compared with conventional concrete.
- Compressive strength of material increases with increasing Steel slag added.
- Up to 80% - 20% of Steel slag and Glass powder there is optimum percentage in increase of all mechanical properties.
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VI. CONCLUSION

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