

AN EXPERIMENTAL STUDY ON STRENGTH AND DURABILITY PROPERTIES OF CONCRETE BY PARTIAL REPLACEMENT OF STEEL SLAG WITH FINE AGGREGATE AND GLASS POWDER WITH CEMENT

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ABSTRACT:- Non-degradable wastes has been a major issue now in the forth 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 the most widely used man-made material in existence. It is second only to water as the most-consumed resource on the planet. But, while cement - the key ingredient in concrete - has shaped much of our built environment, it also has a massive carbon footprint. Cement is the source of emissions. If the cement industry were a country, it would be the third largest emitter in the world. It contributes more CO₂ than aviation fuel (2.5%) and is not far behind the global agriculture business (12%).

As 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 CO₂.

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 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 CO₂, to the atmosphere. Among the greenhouse gases, CO₂ 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 on-going 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.

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 cement by Glass powder in various percentages namely 70% - 30%, 80% - 20% and 90% - 10%.

EXPERIMENTAL INVESTIGATION OF MATERIALS

Cement: Ordinary Portland cement of 53 Grade 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 mm and 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 ₂ O ₃	1-3
P ₂ O 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 60 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 ₂ O ₃	2.620
3	Fe ₂ O ₃	1.420
4	TiO ₂	0.157
5	CaO	12.450
6	MgO	2.738
7	Na ₂ O	12.050
8	K ₂ O	0.638
9	ZrO ₂	0.019
10	ZnO	0.008
11	SrO	0.016
12	P ₂ O ₅	0.051
13	NiO	0.014
14	CuO	0.009
15	Cr ₂ O 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 1m³ 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

FUTURE WORK

- By the testing of materials achieved glass powder & steel slag has similar properties like cement and fine aggregate.
- In future, plan to do strength and durability properties of concrete and compare the results with conventional concrete.

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