EXPERIMENTAL INVESTIGATION ON ADDITION OF GLASS FIBER WITH REPLACEMENT OF FINE AGGREGATE BY STEEL SLAG

S.K.GOWTHAM[1], S.ARUN[2]

[1]*Assistant Professor, Department of Civil Engineering, Nandha Engineering College, Tamilnadu, India*
[2]*PG Student, Department of Civil Engineering, Nandha Engineering College, Tamilnadu, India*

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Abstract - *Concrete is the third biggest material devoured by individuals after sustenance and water according to WHO. Concrete assumes a fundamental part in the outline and development of the country's foundation. These are acquired from common rocks furthermore river beds, accordingly debasing them gradually. Hence the idea of substitution of fine aggregate with steel slag appears to be encouraging. In this study the experimental investigation is done on the study of the Glass fibre reinforced concrete using steel slag as the replacement for fine aggregate. M40 grade of concrete was used. Possible optimum replacement of slag material was found to be 10%,20%,30%.To this optimum replacement of slag material glass fibres are dispersed at different volume fractions.*

The dimensions of the glass fibres are of 14micron dia and 12mm length , 0.33 to 1% Asspect ratio of size. The results showed that the steel slag can be partially replaced as the fine aggregate by 10%, 20%, 30%.Tests of compressive strength, flexural resistance ,split tensile strength tests are carried out on the specimens in which the glass fibres are dispersed in volume fractions of 1%. Key words: Steel slag, fine aggregate, Glass fibres, etc,. Over a period of time, waste management has become one of the most unavoidable complex and difficult problem in the world which is affecting the environment. Steel slag is byproduct material which is gathered from cast iron manufacturing unit. It is produced when molten steel is separated from impurity in Steel. Fine aggregate is partially replaced by Steel slag at optimum percentage of replacement. The utilization of Steel slag for concrete making also reduces its disposal problems to a great extent.

***Key Words*: AR Glass fiber, Steel slag, High Strength, Increased Durability.**

1 INTRODUCTION

1.1 General

Concrete is the most commonly used constructional material in the world, which can be attributed largely to the fact that its characteristics can be altered to meet the needs of a wide variety of applications. However concrete has some deficiencies such as low tensile strength, low post cracking capacity, brittleness and low ductility, limited fatigue life, not capable of accommodating large deformations, low impact strength. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementitious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suited for a wide range of applications.

1.2 OBJECTIVES

The main objective of this study is to determine the high strength and increased durability by partial replacement of fine aggregate by Steel Slag and addition of AR Glass fiber to the mixes and also to compare the results of mixes.

1.3 SCOPE

To determine the properties of the materials. To examine the mechanical properties of hardened concrete. To determine the permeability range.

2 LITERATURE REVIEW

2.1 A. Aderibigbe and A. E. Ojobo (1982) Investigations conducted on the pozzolanic properties of a Steel slag revealed that on the basis of chemical constituents alone, the steel slag could be considered a pozzolana. Physical tests, however, showed that the steel slag exhibited little pozzolanic activity. An improvement in physical properties was obtained by calcining the slag at 700°C for 5 hr. Without sacrificing appreciable strength (e.g. a 13.5% reduction in strength), up to 20% replacement of Portland cement by steel slag is possible in the preparation of cement mortar. This results in appreciable cost savings in areas where cement is expensive and steel slag is considered a waste product.

2.2 Balaraman and Dr. N.S. Elangovan (2018) Investigations conducted on Steel slag as partial replacement with fine aggregates. Fine aggregate requirements in construction is more and there availability is less so there is a need to search a replacing material like steel waste slag which is byproduct of cast iron manufacturing. The disposal of steel slag in open area causes environment pollution, it can be recycled for use in construction industry without producing any harm to human and environment. In this study a replacement of fine aggregates were replaced. The design mix for M40 grade concrete were arrived and the target strength was found to be 20.960N/mm2 at 7 days. Steel slag was used in concrete as partial replacements for fine aggregates (20%, 30%, 40%) to ascertain applicability in concrete. Since the maximum compressive strength attained was 5.33 N/mm2 for 40%(20%F.A and 20%C.A) at 7 days..The concrete with Steel slag as partial combined replacement gives less strength.

2.3 **Girish Sharma(2015)** studied in his work "Beneficial effects of steel slag on concrete" with the aim of replacing steel slag of M40 grade with fine aggregates, the percentage from 0% to 55% and tested on its 7th and 28th day after curing. Their deep analysis concludes that there is constant increment when replaced with that of steel slag and can be used practically. Decrement is mentioned after 55% in case of fine aggregate.

2.4 **Dr. P. Srinivasa Rao**, et al conducted durability studies on glass fiber reinforced concrete. The alkali resistant glass fibers were used to find out workability, resistance of concrete due to acids, sulphate and rapid chloride permeability test of M30, M40 and M50 grade of glass fiber reinforced concrete and ordinary concrete. The durability of concrete was increased by adding alkali resistant glass fibers in the concrete. The experimental study showed that addition of glass fibers in concrete gives a reduction in bleeding. The addition of glass fibers had shown improvement in the resistance of concrete to the attack of acids.

2.5 **Yogesh Murthy**, et al studied the performance of Glass Fiber Reinforced Concrete. The study revealed that the use of glass fiber in concrete not only improves the properties of concrete and a small cost cutting but also provide easy outlet to dispose the glass as environmental waste from the industry. From the study it could be revealed that the flexural strength of the beam with 1% glass fiber shows almost 30% increase in the strength. The reduction in slump observed with the increase in glass fiber content

3 METHODOLOGY

The constituent materials used were obtained locally and were Ordinary Portland Cement (O.P.C), M-sand as fine aggregate and crushed granite as coarse aggregate. Potable water was used for mixing and curing. The tests were carried out as per IS Standards.

4 MATERIALS TO BE USED

4.1 CEMENT

Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is only behind water as the planet's most-consumed resource.

4.2 M-SAND

Manufactured is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of river sand in most part of the world. Due to depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M Sand is its availability and transportation cost.

4.3 COARSE AGGREGATE

Coarse aggregate is mined from rock quarries or dredged from river beds, therefore the size, shape, hardness, texture and many other properties can vary greatly based on location. Even materials coming from the same quarry or pit and type of stone can vary greatly. Most generally, coarse aggregate can be characterized as either smooth or rounded (such as river gravel) or angular (such as crushed stone).

TABLE 4.1 PHYSICAL PROPERTIES OF FINE AGGREGATE AND COARSE AGGREGATE

Physical properties	Fine Aggregate	Coarse Aggregate
Bulk Density (kg/m^3)	1860	1300
Fineness modulus	5.24	7.53
Specific gravity	2.65	2.78

4.4 AR GLASS FIBER

AR Glass fiber is a material consisting of numerous extremely fine fibers of glass. Glassmakers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer machine tooling. Glass fibers can also occur naturally, as Pele's hairs. Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fibers. Although not as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively, lightweight fiber-reinforced polymer (FRP) composite material, also popularly known as "fiberglass". Unlike glass wool, it contains little or no air or gas, is more dense, and thus is a poor thermal insulator compared to glass wool; it is instead used structurally due to its strength and relatively low weight.

4.5 STEEL SLAG

There are many grades of steel that can be produced, and the properties of the steel slag can change significantly with each grade. Grades of steel can be classified as high, medium, and low, depending on the carbon content of the steel. High-grade steels have high carbon content. To reduce the amount of carbon in the steel, greater oxygen levels are required in the steel-making process. This also requires the addition of increased levels of lime and dolime (flux) for the removal of impurities from the steel and increased slag formation. There are several different types of steel slag produced during the steel-making process. These different types are referred to as furnace or tap slag, raker slag, synthetic or ladle slags, and pit or cleanout slag. Figure 18-1 presents a diagram of the general flow and production of different slags in a modern steel plant. The steel slag produced during the primary stage of steel production is referred to as furnace slag or tap slag. This is the major source of steel slag aggregate. After being tapped from the furnace, the molten steel is transferred in a ladle for further refining to remove additional impurities still contained within the steel. This operation is called ladle refining because it is completed within the transfer ladle. During ladle refining, additional steel slags are generated by again adding fluxes to the ladle to melt. These slags are combined with any carryover of furnace slag and assist in absorbing deoxidation products (inclusions), heat insulation, and protection of ladle refractories. The steel slags produced at this stage of steel making are generally referred to as raker and ladle slags.

TABLE 4.2.PHYSICAL PROPERTIES OF CONTENT

Properties	OPC 53 GRADE	AR Glass fiber	Steel slag
Specific gravity	3.15	2.68	3.3
Specific Surface Area (m^2/g)	3290	963	3210

5. CONCRETE MIX DESIGN AND MIX PROPORTION MIX PROPORTIONS:

M40 grade concrete was designed as per IS 10262- 2009. Quantity of materials per cubic meter of concrete and dosages of AR Glass fibers used are listed in Table. A constant water cement ratio of 0.36 was used.

TABLE 5.1 DESIGNATION OF SPECIMENS

MIX DESIGNATIONS	PROPORTION OF CEMENT AND SILICA FUME
0.5%GF + SS 0%	100% Fine aggregate
0.5%GF + SS 10%	90% FA + 10% Steel slag
0.5%GF + SS 20%	80% FA + 20% Steel slag
0.5%GF + SS 30%	70% FA + 30% Steel slag

GF- Glass Fiber

SS- Steel Slag

FA- Fine Aggregate

TABLE 5.2 : QUANTITY OF MATERIALS USED PER CUBIC METER OF CONCRETE

Contents	Values (kg/m^3)
Cement	439
Fine Aggregate	662
Coarse Aggregate	1256
Steel Slag	397.2
Water Cement Ratio	0.40
Carbon Fiber	0.5%, (by volume of concrete)

6. TESTS AND RESULT ON CONCRETE

6.1 COMPRESSIVE STRENGTH TEST

Compressive strength test is a mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. The strength of concrete is found and determined by the crushing strength of 150mm x 150mm x 150mm, at an age of 7 and 28 days. The moulds and its base rigidly clamped together so as to reduce leakages during casting. The sides of the moulds and base plates were oiled before casting to prevent bonding between the moulds and concrete. The cube was then stored for 24 hours undisturbed.

$$f_c = (P/A)\ N/mm^2$$

where,
P = Load at which the specimen fails in Newton (N)
A = Area over which the load is applied in mm
F_c = Compressive stress in N/mm^2

TABLE 6.1 COMPRESSIVE STRENGTH OBTAINED BY STEEL SLAG REPLACEMENT

STEEL SLAG	7 DAYS (N/mm^2)	28 DAYS (N/mm^2)
0.5%GF + 0% SS	28.22	42.53
0.5%GF +10% SS	26.77	40.13
0.5%GF + 20% SS	27.63	41.55
0.5%GF + 30% SS	28.78	44.52

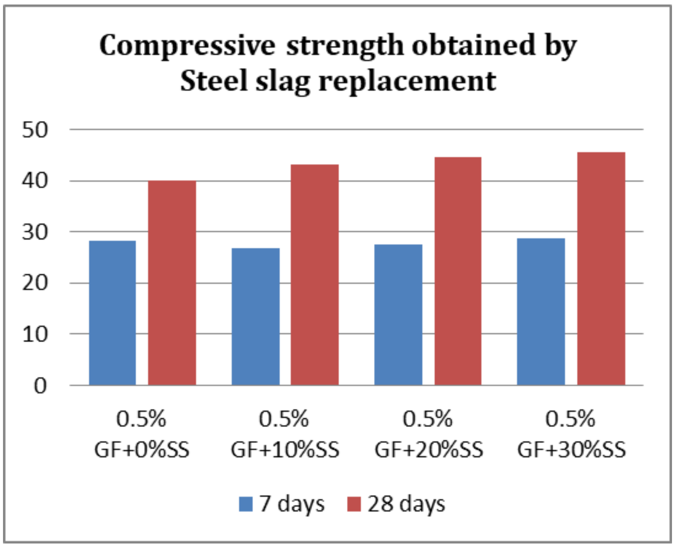

Fig 6.1 Compressive strength obtained by replacement by Steel slag

6.2 SPLIT TENSILE STRENGTH TEST

The determination of tensile strength of concrete is necessary to determine the load at which the concrete member cracks. In this test, cylindrical specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens are tested after 7 days and 28 days. The split tension test was conducted by using digital compression machine having 2000 kN capacity.

$$f_t = 2P / \pi DL\ (N/mm^2)$$

where, P = Maximum Load (kN)
D = Diameter of Specimen (150 mm)
L = Length of Specimen (300 mm)
f_t = Tensile strength N/mm^2

TABLE 6.2 SPLIT TENSILE STRENGTH OBTAINED BY STEEL SLAG REPLACEMENT

STEEL SLAG	7 DAYS (N/mm^2)	28 DAYS (N/mm^2)
0.5%GF + 0% SS	2.75	4.32
0.5%GF + 10% SS	2.89	4.41
0.5%GF + 20% SS	2.93	4.83
0.5%GF + 30% SS	3.83	5.34

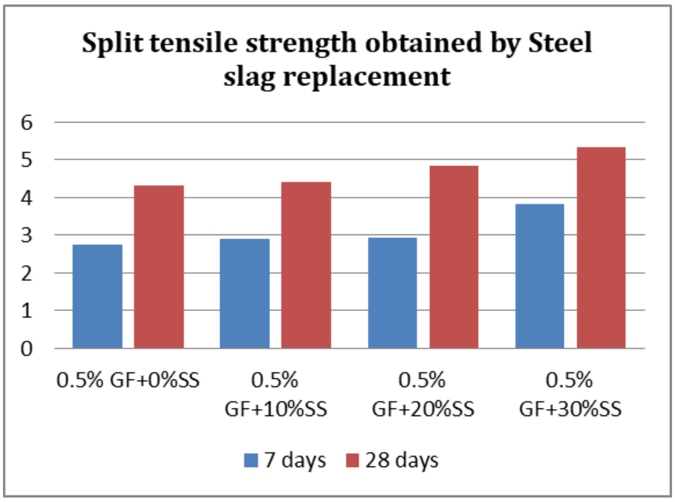

Fig 6.2 Split tensile strength obtained by replacement by Steel slag

7 CONCLUSIONS:

The following important conclusions were drawn based on the results obtained from the experimental studies:

On the basis of the results obtained in this study, the following conclusions have been drawn:

(i) It is possible to manufacture glass fiber concrete replacement of fine aggregate by steel slag with acceptable fresh and hardened properties.

(ii) The mix with 30% Steel slag gives the maximum strength.

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