Comparative Evaluation of Steel Mesh Reinforced Concrete Along With Steel Slag As Value Added Material in Concrete

Naveen Kumar S., T.M. Prakash, Kajal R., Lakshmi P.S.

Abstract: ***This experimental study deals with assessing the potential of the steel slag as a partial replacement of fine aggregate along with wire mesh reinforcement in concrete mixes. The concrete mix is designed as per IS 10262: 2009 for target strength of 31.6MPa. With the partial replacement of fine aggregate with 10%, 20% and 30% of the steel slag and this replacement along with the one and two layers of wire mesh reinforcement.. The hardened properties like compressive, split tensile and flexural strength of concrete mixes increased with increase in percentage of replacement of steel slag up to 30% with wire mesh reinforcement. The test results show that the use of wire mesh with closely spacing decreases the crack width among those concrete specimens. Based on test results, it can be inferred that up to 30% replacement of the fine aggregate with steel slag along with the addition of layers of wire mesh reinforcement enhances the strength in concrete.***

Key words: Steel slag; Wire mesh; Fresh properties; Hardened properties;

INTRODUCTION

Water, aggregate, and cement composes main composite material in concrete. By replacing the construction materials from the industrial waste materials. In the concrete mix the percentage of aggregate is 60 – 70%. When comparison is done to the conventional concrete and the concrete prepared by replacing by product shows improved workability and durability and can be used in the construction works. Artificially manufactured aggregate and waste products from the industries can be used, in order to reduce the exhaustion of natural aggregates. 1 ton of steel slag is generated from 3 tons stainless steel production. By replacing the conventional one by alternative cheap materials which are locally available ones reduce the environmental stresses, rising cost of construction, preserves the natural rock.

1.2 Steel Slag

In the manufacturing of iron and steel, steel slag is obtained as a byproduct from the blast furnace. The use of steel slag effects in concrete production, numerous investigations are carried out. By cooling steel liquid slag in the air, slag is produced. In this study the main component is steel slag which can be available locally.

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About 95% of steel slag is made by constituents like silica, alumina, calcium, and magnesia. Manganese, iron, sulfur compounds and traces of several other elements constitutes minor elements.

1.3 Wire mesh

From dispersed and arranged manner of reinforcing elements wire mesh reinforcement differs from conventional reinforcement. The steel plate behavior of wire mesh is due to distributed and aligned reinforcement in wire mesh. Reinforcing steel can supplement concrete in bearing compressive forces in column, as reinforced concrete is a composite material which is stronger in compression. Increased number of wire mesh sustain greater loading when compared to plain concrete specimens because of greater strain carrying capacity. The specimen bonded with wire mesh performed better and delayed the first crack and this associated with increase in number of layer.

MATERIALS

Concrete mix is composed of cement, coarse aggregate, fine aggregate and steel slag. Crushed granite stone are used as coarse aggregate and river sand particle size < 4.75mm as fine aggregate. The properties of materials used, procedures adopted and the experimental program in this experiment is explained in this section.

A. Physical Properties of Cement

The physical properties of the cement are determined as per IS: 1727-1967. The test is done as specified in IS: 4031-1968. The results are listed in Table 1

Particulars	Test Results	References
Normal consistency %	29	IS:12269-2008
Relative density	3.15	IS: 12269-2008
Setting time(minutes) Initial setting time Final setting time	 90 210	IS: 12269-2008 Should not be less than 30 min Should not be less than 600 min

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Compressive strength of mortar cubes for 3 days 7 days 28 days	 32.3Mpa 43.5 Mpa 58.2 Mpa	 Should not be less than 27 Mpa Should not be less than 37 Mpa Should not be less than 53 Mpa

B.Chemical Composition of Steel Slag

Constituent	CaO	SiO_2	FeO	MnO	MgO	Al_2O_3	P_2O_5	S	Metallic Fe
Composition (%)	40 - 52	10 - 19	10 – 40	5 - 8	5 – 10	1 - 3	0.5 - 1	< 0.1	0.5 - 10

II. PHYSICAL PROPERTIES OF AGGREGATES

Based on procedures specified in the codes IS 2386 Part (1to4)-1963, the physical properties are determined. Table 3 shows the test results.

Table 3 Physical Properties of Fine Aggregates

Tests	M-sand	Coarse Aggregate
Relative density	2.165	2.983
Water Absorption	1%	0.5%

III. MIX CONSTITUENTS

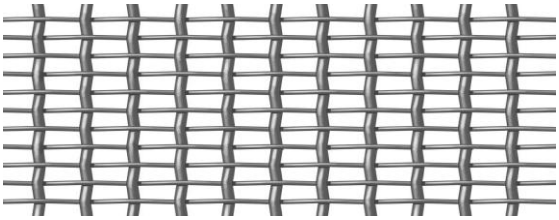
The M25 grade mix is designed as per IS: 10262-2009 by considering the properties of aggregates. Fine aggregate is partially replaced by steel slag. The mix proportion corresponds to 1:1.55:3.15, with water cement ratio as 0.5 with no chemical admixtures.Coarse aggregates passing 20mm and retained on 4.75mm are used. The mix proportions are listed in the Table 4.

Table.4.Mix proportion for M25concrete

Proportion of steel slag	Cement (kg/m^3)	M-sand (kg/m^3)	Steel slag (kg/m^3)	Coarse Aggregate (kg/m^3)	W/C ratio
0%	383	594.07	0	1209.02	0.5
10%	383	534.66	59.4	1209.02	0.5
20%	383	475.26	118.8	1209.02	0.5
30%	383	415.84	178.2	1209.02	0.5

SPECIFICATION OF STEEL MESH USED

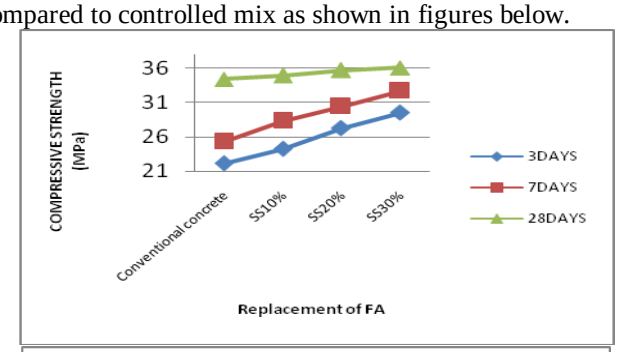
Wire diameter = 0.5mm
Clear opening = 3mm
Centre to centre = 3.5mm

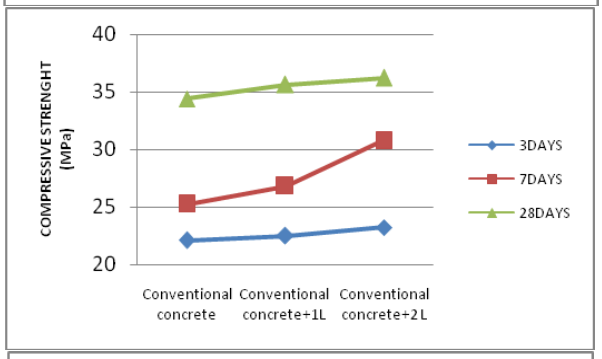


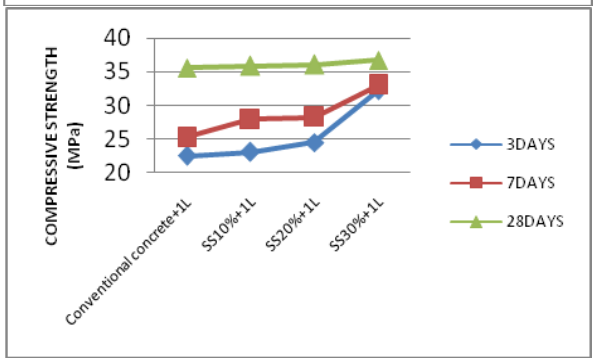
IV. RESULTS AND DISCUSSIONS

1. Compressive Strength of Concrete

The cubes are tested as per IS: 516-1959 .Three cubes are tested at 3, 7, and 28 days, for each mix variants in addition to the mesh reinforcement. This early strength development in concrete is due to the steel slag replaced by fine aggregate. At 7 and 28 days also there will be increase in compressive strength value of replaced concrete at 30% replacement of Steel slag by 29.39% for 7 days and 4.76% for 28 days. The concrete at 30% replacement of Steel slag along with wire mesh 1 and 2 layer was 23.05% for 7 days, 3.08% for 28days and 13.17% for 7days ,7.42% for 28 days respectively as compared to controlled mix as shown in figures below.







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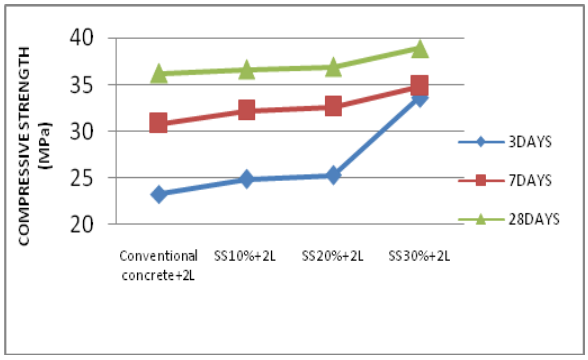


Figure 1. Compressive Strength of 3,7 & 28 days.

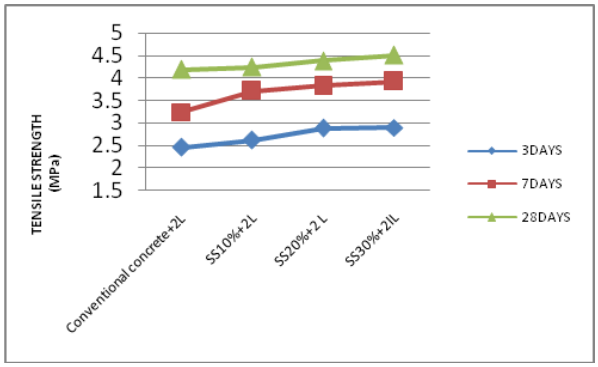
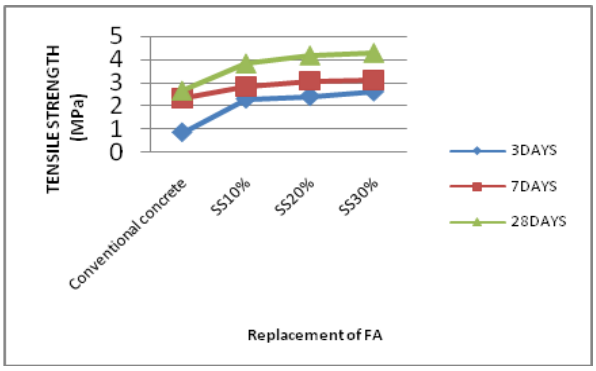
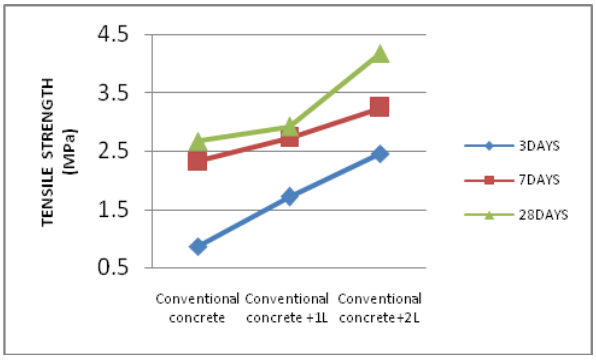


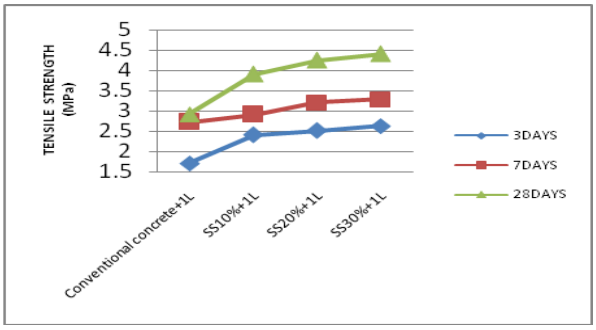
Figure 2 .Split tensile strength at 3, 7 & 28 Days

2. Split tensile Strength of concrete

From Figures below, it was observed that increase in steel slag content up to 30% replacement there is a higher tensile strength value of steel slag replaced concrete by 34.76% at 7 days and 60.2% at 28 days. And tensile strength value of steel slag replaced concrete along with the wire mesh reinforcement in 1 and 2 layers are 20.95% for 7 days, 50.66% for 28 days and 20.98% for 7 days,7.65% for 28 days respectively compared to controlled mix.

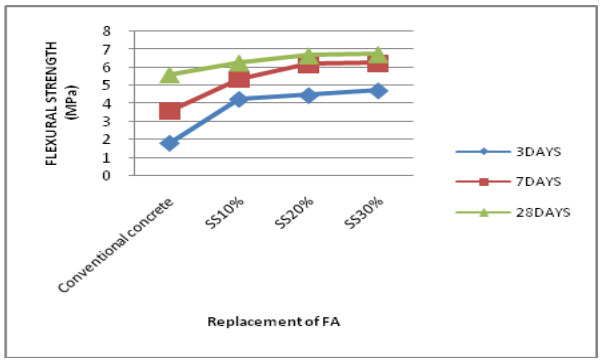


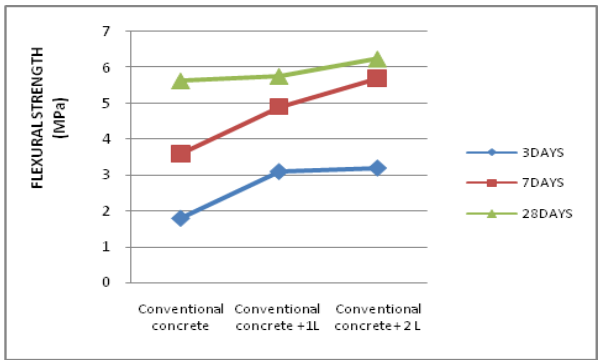


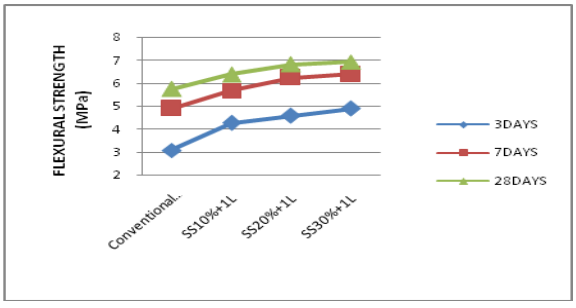


3. Flexural Strength of concrete

From Figures below, it is observed that increase in % of the steel slag content up to 30% replacement there was a higher flexural value of steel slag replaced concrete by 74.58% at 7 days and 20.10% at 28 days. And tensile value of steel slag replaced concrete along with wire mesh reinforcement in 1 and 2 layers are 30.6% for 7 days, 20.86% for 28 days and 15.96% for 7 days,11.85% for 28 days respectively compared to controlled mix.







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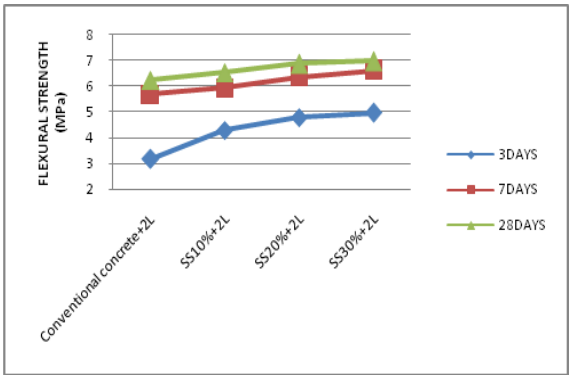

Figure 3 Flexural Strength of 3, 7, 28days

CONCLUSIONS

From this investigation work, the following conclusions were noted.

- Steel slag concrete cubes, cylinders and beams retain its strength up to a fine aggregate replacement upto 30%. Hence steel slag is a viable alternative with fine aggregate replacement up to 30% without any loss in strength.
- From the compressive, split tensile and flexural strength, it was found that upto 30% of steel slag replacement with fine aggregate will yield better compressive strength when compared to controlled concrete.
- The increase in percentage of steel slag replaced with fine aggregate resulted in higher normal consistency.
- The steel slag concrete cubes, cylinders and beams strength increases up to a fine aggregate replacement up to 30% with wire mesh reinforcement. Hence steel slag as alternative with fine aggregate replacement up to 30% with wire mesh reinforcement increases strength compared to that of conventional concrete.
- Thus, we can conclude that addition of up to 30% of steel slag as alternate material for fine aggregate with the wire mesh reinforcement to produce concrete can be used for practical structural applications.
- Using steel slag replaced concrete reduces the problem of disposal of waste products and clean environment.

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