An Experimental Study on M30 Grade Concrete by Partial Replacement of Coarse Aggregate as Steel Slag and Fine Aggregate as Crumb Rubber

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Abstract: **Steel slag and crumb rubber is an industrial by product, It possesses the problem of disposal as waste and is of environmental concern. The demand for aggregate in construction industry is increasing rapidly and so, is the demand for concrete. Thus, these two material becomes important to seek suitable alternatives for aggregates in future. In this study the natural coarse aggregate were partially replaced with steel slag aggregate at various proportions of 10%,20%,30%,40% to find the optimum usage value of steel slag in concrete and the natural fine aggregate is partially replaced with crumb rubber at various proportions of 5%,10%,15% in the obtained optimum value of steel slag used concrete. Experiment was conducted on M30 grade concrete to determine the compressive strength, split tensile strength and flexural strength. The results were compared with conventional concrete.**

Keywords: Steel slag, Crumb rubber, Natural coarse aggregate and fine aggregate.

I. INTRODUCTION

In many developed countries, concern over waste production, resource preservation and reduced material cost have focused attention on reusing solid waste materials. Waste materials when properly processed can meet various design specification in the construction industry. So recovering useful material from industrial waste not only offers environmental gains, but also helps to preserve natural resources.

Slag is a by-product of the iron and steel making process iron cannot be prepared in the blast furnace without the production of its by-product blast furnace slag. Similarly, steel cannot be prepared in the Basic Oxygen Furnace (BOF) or in an Electric Arc Furnace (EFA) without making its by product steel slag. The use of steel slag aggregate in concrete by replacing natural aggregate is a most promising concept.

Crumb rubber is recycled rubber produced from automotive and truck scrap tires. During the recycling process, steel and tire cord are removed, leaving tire rubber with a granular consistency. Continued processing with a granular or cracker mill, possibly with the aid of cryrogenics or by mechanical mean, reduces the size of the particles further. The particles are sized and classified based on various criteria including color (black and white). The granulate is sized by passing through a screen, the size based on a dimension (1/4 inch) or mesh. Crumb rubber is often used in construction industries so here partially replaced in concrete as fine aggregate.

II. LITERATURE REVIEW

V. Subathra Devi, B.K.Ganavel (1) examined the properties of concrete while using steel slag in it, which results optimum usage of steel slag in concrete as partial replacement of coarse aggregate is 30% and in fine aggregate is 40%. This gives high compressive strength and the salient feature is acid resistance.

Anil, Mukesh kumar, Pankaj (2) experimentally investigated the effect of steel slag as partial replacement of fine aggregate in M35 grade concrete, results that optimum value of compressive strength, split tensile strength, flexural strength can be achieved by 33% replacement of steel slag.

Praveen Mathew, Leni Stephen, Jaleen George (3) have analyzed steel slag in concrete pavement in various proportions of 20%, 40%, 60%, 80% and 100%. The results were increment in compressive, split tensile and flexural strength as certain percentage while partially replacing with coarse aggregate.

Prof.Pankaj Bhausaheb Autade (4) examined the effect of M40 Grade concrete while partially replacing it as fine aggregate, the result obtained as reduction of about 10%-20% in compressive strength was noticed in the proportion of 80% and 100% in concrete.

P.S.Kothai, Dr.R.Malathy (5) utilized steel slag in M20 grade concrete as fine aggregate, which was partially replaced in various proportions of 10%, 20%, 30%,40% and 50%. The result obtained is 30% of replacement is optimum in concrete.

M.A.Qurishee, I.T.Iqbal, M.S.Islam, M.M.Islam (6) analyzed the mechanical properties of concrete while using steel slag as coarse aggregate. The optimum value of replacement level is 40% which increases in compressive strength.

R.Padmapriya, V.K.Bupesh Raja, V.Ganesh Kumar (7) studied on replacement of coarse aggregate by steel slag and fine aggregate by manufactured sand in M40 grade concrete, which gives in result of increases in compressive strength while the optimum is 40%.

K.Thangaselvi (8) partially replaced coarse aggregate as steel slag in M40 grade concrete for different proportion of 0%, 20%, 40%, 60%, 80%. And the test result shows the optimum usage of steel slag is 60% which gives 10% increment of strength in concrete compare to conventional concrete.

S.Selvakumar, R.Venkatakrishnaiah (9) investigated the strength properties of concrete using crumb rubber with partial replacement of 5%, 10%, 15%, 20%, which results increase in compressive strength with 5% replacement.

L.Annie Mercy (10) reusing crumb rubber as fine aggregate in M20 grade concrete which results in reduction of compressive strength range about 4.34% were observed.

Nabeel Hamid Shah, Dr.B.K.Singh (11) were used Tyre Rubber crumb as replacement of fine aggregate in cement concrete grade of M40 with various percentage of 5%, 10% and 15% which results 10% of replacement for fine aggregate decreases in compressive strength.

III. RESEARCH SIGNIFICANCE

The objective of the work is to partially replace the coarse aggregate as steel slag and fine aggregate as crumb rubber in M30 grade concrete with an optimum manner and the results were compared with the conventional concrete.

IV. MATERIALS

A. Steel slag

In the present work steel slag were used for the investigation and their properties are tabulated as quoted in table 4.1 & 4.2.

Table 4.1 Chemical properties of Steel Slag

S.No	**Components**	**(%)**
1	Iron oxide (FeO)	10-35
2	Silicate Oxide (SiO_2)	8-20
3	Calcium oxide (CaO)	30-55
4	Aluminate oxide (Al_2O_3)	1-6
5	Sulfur (S)	1-1.5

Figure 4.1

Table 4.2 Physical Properties of Steel Slag

S.No	Type of test	Values
1	Specific gravity	2.83
2	Crushing strength in %	29.5
3	Impact value in %	29
4	Abrasion value in %	28

B. Crumb rubber

Crumb rubber is obtained as the waste product from the scrap tyres. The properties of material are shown in table 4.3.

Table 4.3 Properties of Crumb Rubber

S.No	Properties	Values
1	Color	Black
2	Specific Gravity	1.16
3	Water Absorption 24h (%)	0.01

Figure 4.2

C. Coarse aggregate

In this present investigation, locally available crushed granite aggregate was used, as per IS 383-1970, coarse aggregate in sieve size 20mm passing and 4.75mm retained were used. As shown in fig.4.3

Figure 4.3

D. Fine aggregate

The locally available river sand was used as fine aggregate in the present investigation. The sand was screened at site to remove deleterious material and tested as per procedure given in IS: 383-1970. As shown in fig.4.4

Figure 4.4

E. Cement

In this work Ordinary Portland Cement of 53-Grade cement were used which specific gravity of 3.12 as per IS: 8112-1989. As shown in fig.4.5

Figure 4.5

V. MIX PROPORTIONING

As per the recommended procedure of Bureau of Indian Standards IS 10262-2009, mix ratio is designed with the test result of workability, specific gravity, water absorption of materials.

Table 5.1 mix proportion for 1m^3 of concrete

Material	Cement (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)	Water (Kg/m^3)
Quantity	394	669.86	1001.2	197
Ratio	1	1.7	2.5	0.5

VI. TEST CONDUCTED

A strength test were conducted for concrete, such as

(i) Compressive strength test
(ii) Split tensile strength test
(iii) Flexural strength test

VII. TEST RESULTS

A. Test Result of Steel slag used concrete to find optimum

Compression Test :-

Days	Steel slag (0%) N/mm^2	Steel slag (10%) N/mm^2	Steel slag (20%) N/mm^2	Steel slag (30%) N/mm^2	Steel slag (40%) N/mm^2
7th day	13.95	13.98	14.86	15.19	14.87
14th day	22.10	22.1	23.1	23.23	21.97

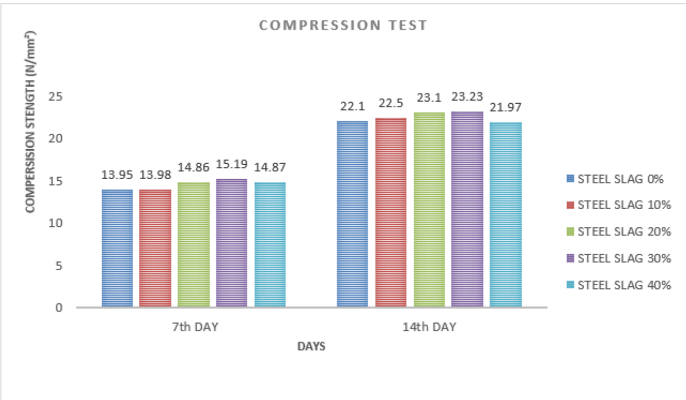

Figure 7.1 Average compressive strength of steel slag used concrete

It was found that the compressive strength for conventional concrete is 22.1 N/mm^2 at 14 days. The maximum compressive strength of 23.23 N/mm^2 was obtained from the 30% replacement of coarse aggregate to steel slag at 14 days.

Split Tensile Test :-

Days	Steel slag (0%) N/mm^2	Steel slag (10%) N/mm^2	Steel slag (20%) N/mm^2	Steel slag (30%) N/mm^2	Steel slag (40%) N/mm^2
7th day	1.80	1.82	1.85	1.89	1.63
14th day	2.59	2.63	2.68	2.80	2.74

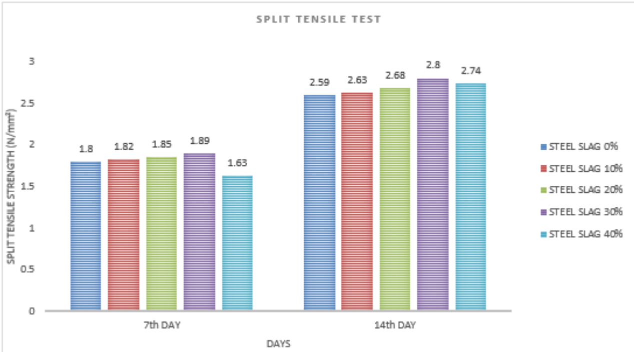

Figure 7.2 Average Split Tensile Strength of steel slag used concrete

It was found that the split tensile strength for conventional concrete is 2.59 N/mm^2 at 14 days. The maximum split tensile strength of 2.8 N/mm^2 was obtained from the 30% replacement of coarse aggregate to steel slag at 14 days.

Flexure Test :-

Days	Steel slag (0%) N/mm^2	Steel slag (10%) N/mm^2	Steel slag (20%) N/mm^2	Steel slag (30%) N/mm^2	Steel slag (40%) N/mm^2
7th day	2.83	2.89	2.92	3.11	3
14th day	2.91	2.92	2.98	3.22	3.10

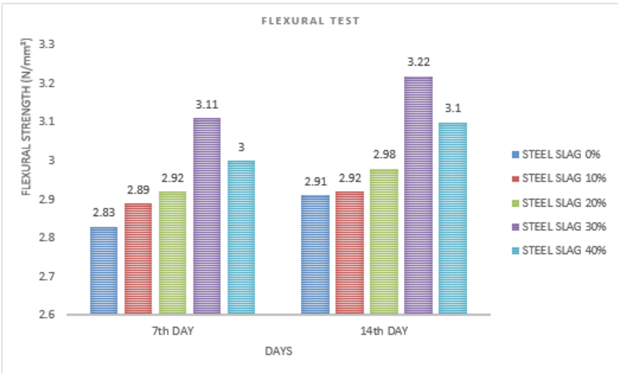

Figure 7.3 Average Flexural strength of steel slag used concrete

It was found that the flexural strength for conventional concrete is 2.91 N/mm^2 at 14 days. The maximum flexural strength of 3.22 N/mm^2 was obtained from the 30% replacement of coarse aggregate to steel slag at 14 day. So it can be concluded that 30% replacement of coarse aggregate to steel slag in concrete gives high strength, therefore 30% replacement if fixed to be optimum.

B. *Test Result of Steel Slag and Crumb Rubber Used Concrete*

Compression Test :-

Days	Steel slag (0%) and Crumb Rubber (0%) N/mm^2	Steel slag (30%) and Crumb Rubber (5%) N/mm^2	Steel slag (30%) and Crumb Rubber (10%) N/mm^2	Steel slag (30%) and Crumb Rubber (15%) N/mm^2
7th day	13.95	14.22	16.26	15.11
14th day	22.10	23.57	24.43	22.65
28th day	38.23	38.87	39.90	36.82

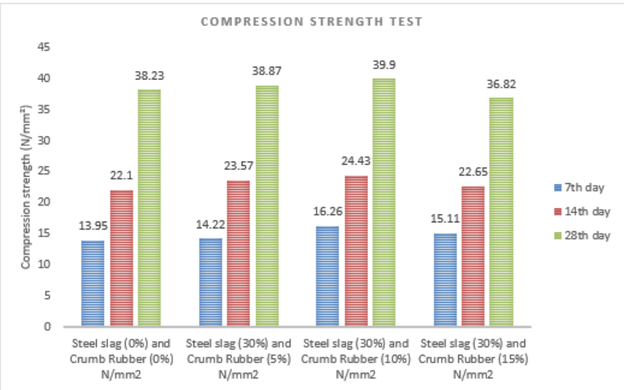

Figure 7.4 Average compression strength of steel slag and crumb rubber used concrete

It was found that the compressive strength for conventional concrete is 38.23 N/mm^2 at 28 days. The maximum compressive strength of 39.90 N/mm^2 was obtained from the 30% replacement of coarse aggregate to steel slag and 10% replacement of river sand to crumb rubber at 28 days.

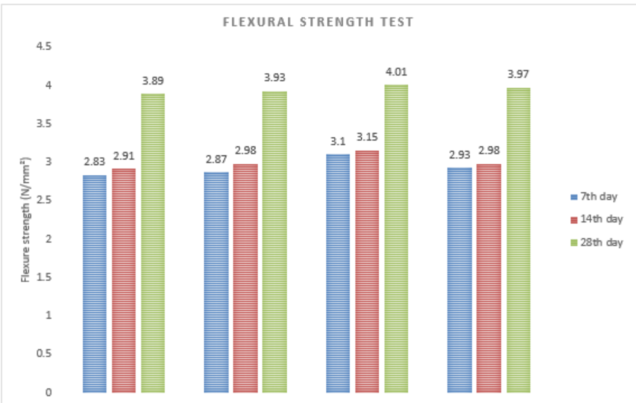

Figure 7.6 Average flexural strength of steel slag and crumb rubber used concrete

Split Tensile Test: -

Days	Steel slag (0%) and Crumb Rubber (0%) N/mm^2	Steel slag (30%) and Crumb Rubber (5%) N/mm^2	Steel slag (30%) and Crumb Rubber (10%) N/mm^2	Steel slag (30%) and Crumb Rubber (15%) N/mm^2
7th day	1.80	1.93	2.10	1.91
14th day	2.59	2.64	2.75	2.69
28th day	2.98	3.04	3.10	3.07

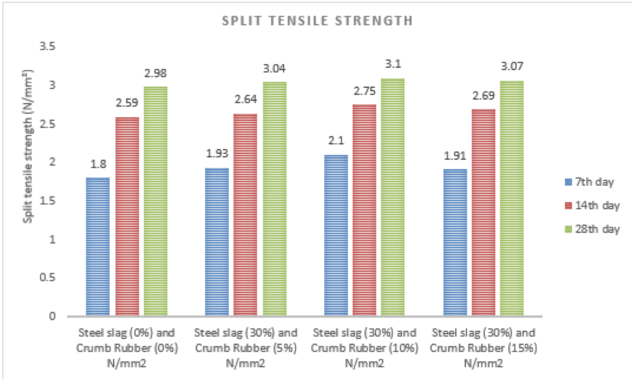

Figure 7.5 Average split tensile strength of steel slag and crumb rubber used concrete

It was found that the split tensile strength for conventional concrete is 2.98 N/mm^2 at 28 days. The maximum split tensile strength of 3.10 N/mm^2 was obtained from the 30% replacement of coarse aggregate to steel slag and 10% of river sand to crumb rubber at 28 days.

Flexure Test :-

Days	Steel slag (0%) and Crumb Rubber (0%) N/mm^2	Steel slag (30%) and Crumb Rubber (5%) N/mm^2	Steel slag (30%) and Crumb Rubber (10%) N/mm^2	Steel slag (30%) and Crumb Rubber (15%) N/mm^2
7th day	2.83	2.87	3.10	2.93
14th day	2.91	2.98	3.15	2.98
28th day	3.89	3.93	4.01	3.97

It was found that the flexural strength for conventional concrete is 3.89 N/mm^2 at 28 days. The maximum flexural strength of 4.01 N/mm^2 was obtained from the 30% replacement of coarse aggregate to steel slag and 10% replacement of river sand to crumb rubber at 28 days.

Figure 7.7 Test specimens

I. CONCLUSION

- The increases in strength for the replacement of coarse aggregate by steel slag upto 30% may be due to shape, size and surface texture of steel slag aggregates, which provide better adhesion between the particles & cement matrix.
- Optimum level of replacement for steel slag is found as 30% increases strength initially is attributed to shape effect and decreases in strength beyond 30% is to porosity of steel slag.
- The combination of 30% replacement of steel slag and 10% replacement of crumb rubber are of compressive strength of above 38.25 N/mm^2 and split tensile strength and flexural strength results showed maximum values for same percentage of replacement.
- From the test results obtained it may be concluded that replacement of river sand by 10% of crumb rubber and natural coarse aggregate by 30% of steel slag is the optimum and most suitable for areas not exposed to marine conditions.

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