REPLACEMENT OF FINE AGGREGATE BY STEEL SLAG IN CONCRETE

Priyanka A Raikar[1], Renuka G Bhanuvalli[2], Seema G N[3], Pavitra P[4], Smt Sweta C Patil[5]

[1,2,3,4]*UG Student, Dept. of Civil Engineering, STJIT Ranebennur, Karnataka, India*
[5]*Assitant Proffesor, Dept. of Civil Engineering, STJIT Ranebennur, Karnataka, India*

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Abstract - *In construction materials, concrete is the largest production of all other materials. Aggregates are the important constituents in concrete. 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. Steel slag is a waste product generated during the production of steel. These wastes are disposed in the form of landfills causes an enormous amount of land pollution. So for the increasing demand to protect the normal environment, especially in build-up areas, the needs to use these wastes are very important. Therefore, replacing all or some portion of natural aggregates with steel slag would lead to considerable environmental benefits. The utilization of waste materials from the industries has been continuously emphasized in the research work. The present work is to use steel Slag as replacement for fine aggregate. The M30 concrete with high volume steel slag replacement for fine aggregate are examined in the present study. According to material properties compressive strength, flexural strength and split tensile strength were found experimentally. The results were compared with conventional concrete property. The results showed that replacing about 0%, 25 % and 50% of steel slag aggregates by volume for natural aggregates will not do any harm to concrete and also it will not have any adverse effects on the strength and durability.*

1. INTRODUCTION:

Concrete plays a critical role in the design and construction of the nation's infrastructure. Almost three quarters of the volume of concrete is composed of aggregates. To meet the global demand of concrete in the future, it is becoming a more challenging task to find suitable alternatives to natural aggregates for preparing concrete. The continues use of Natural Sand leads to the depletion of river beds results into the ecological imbalance. Availability of natural aggregates is getting depleted and also it becoming costly, therefore the replacement of natural sand by the waste industries by-products (Mineral admixtures) has been continuously emphasized during recent years. Natural sand is replaced by slag sand in various percentage.. In this study, therefore an attempt has been to study the effect of replacement of fine aggregate using steel slag on compressive strength, split tensile strength, flexural strength of concrete. . Great amount of wasted materials is generated by industries and has caused tremendous harm to both the environment and ecology. The waste removed from the furnace separately in a rate of about (10-15%) of the produced steel. Reuse of waste material has become very important during the past decade because of the reinforcement of environmental regulations that require minimizing waste disposal.

In the past 20thcentury, steel slag was found to be excellent aggregate for road paving. Chemical composition of typical steel slag consist mainly SiO_2, Al_2O_3, CaO, MnO, MgO, TiO_2, P_2O_5andFe_2O_3. The steel slag is considered as the waste material, which would have a promising future in the construction field.

1.1 Steel slag:

Steel Slag is the main component of this study, which is locally available material. Steel Slag used in is work is collected from Steel industry. Steel slag is a byproduct obtained either from conversion of iron to steel in a furnace. The molten liquid is a complex solution of silicates and oxides that solidifies on cooling and forms steel slag. Steel slag is defined by the American Society for Testing and Materials (ASTM) as a non-metallic product, consisting essentially of calcium silicates and ferrites combined with fused oxides of iron, aluminum, manganese, calcium and magnesium that are developed simultaneously with steel in basic oxygen, electric arc, or open hearth furnaces. The chemical composition and cooling of molten steel slag have a great effect on the physical and chemical properties of solidified steel slag. Steel furnace slag is produced in a Basic Oxygen Furnace (BOF) or Electric Arc Furnace (EAF) as a byproduct of the production of steel. In the Basic Oxygen Furnace (BOF), the hot liquid metal from the blast furnace, scrap and fluxes, which contain lime (CaO) and dolomitic lime, are charged to a furnace. A lance is lowered into the converter and then oxygen in injected with high pressure. The oxygen then combines with and removes the impurities. These impurities consist mainly of carbon in the form of gaseous carbon monoxide, silicon, manganese, phosphorous and some iron as liquid oxides, which combine with lime and dolomitic lime to form steel slag. At the end of the refining stage, the steel in the liquid form is poured into the ladle while the slag is retained at the top in the vessel and is then subsequently removed in separate slag pot. This slag is in molten state and is then processed to remove all free metallic impurities with help of magnetic separation and then sized into construction aggregates.

1.2 Properties of steel slag:

Physical properties:

Steel slag aggregates are highly angular in shape and have rough surface texture.

Table 1: physical properties of steel slag

property	Values
Specific gravity >	3.2 – 3.6
Unit weight kg/m³ lb/ft³	1600 – 1920 (100-120)
Absorption	Up to 3%

Chemical properties:

Table 2: chemical properties of steel slag

Constituent	Composition in %
CaO	40 – 52
SiO_2	10 – 19
FeO	10 – 40 (70 – 80% FeO, 20 – 30% Fe_2O_3)
MnO	5 – 8
MgO	5 – 10
Al_2O_3	1 – 3
P_2O_5	0.5 – 1
S	< 0.1
Metallic Fe	0.5 - 10

2. Objectives:

- To study the effect of varying percentage of replacement of fine aggregate by steel slag on concrete
- To investigate the appropriate replacement percentage for steel slag based on the strength and workability parameters
- To determine compressive strength, flexural strength and split tensile strength for various proportion
- To study the degree of workability of concrete all proposed replacement percentages

2. Methodology:

- The raw materials are firstly cleaned such that it should be free from impurities and then they are subjected to the basic tests.
- Based on the appropriate water cement ratio the mix designs are obtained for M30 grade concrete as per the codal provisions.
- For the obtained mix design the steel aggregates are replaced by 25% in place of fine aggregates with various percentages.
- The fresh concrete, slump test is carried for the proportion. For the blended proportioned percentage the cubes, beams and cylinders are casted in order to determine hardened properties of concrete.
- The above specimens are kept for curing for 28days and then the test results are determined. The above process is carried for the one grade of conventional concrete. After testing the light weight aggregate concrete the proportion at which optimum strength obtained is determined.
- Further the steel slag replaced concrete is compared with that of conventional grade concrete, so that the amount of strength gained with respect to normal conventional concrete is determined.

3.1 Results and discussions:

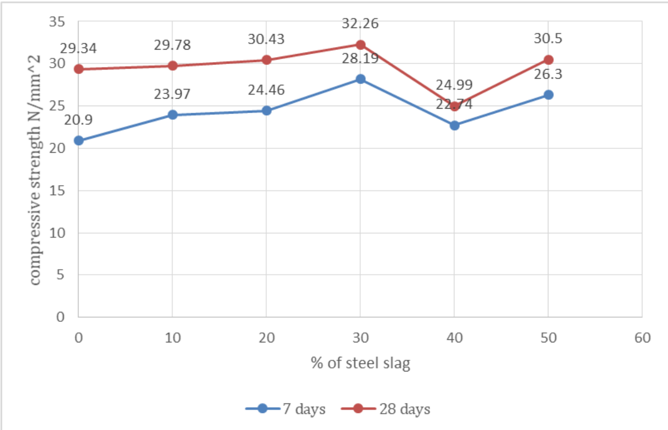
Compressive strength test:

Fig1 : compressive strength test

Table 3: compressive strength test results

% of steel slag	Average compressive strength @ 7 days	Average compressive strength @ 28 days
0	20.90	29.34
10	23.97	29.78

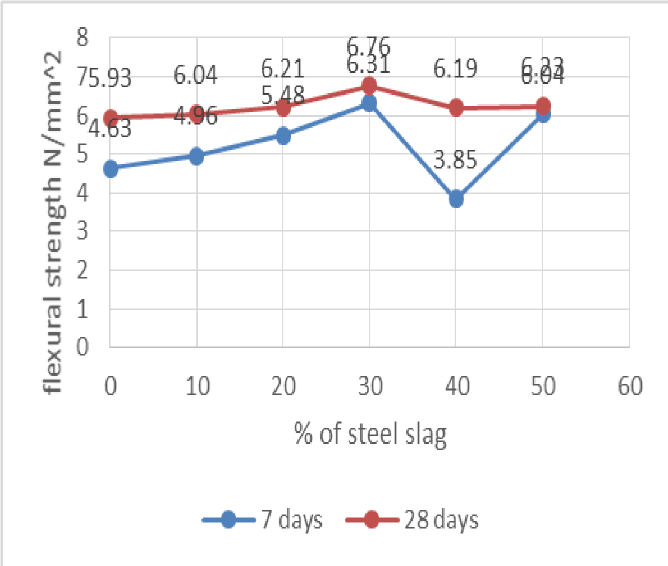
20	24.46	30.43
30	28.19	32.26
40	22.74	24.99
50	26.3	30.5



Flexural strength test:

%of steel slag	Flexural strength @ 7 days	Flexural strength @ 28 days
0	4.63	5.93
10	4.96	6.04
20	5.48	6.21
30	6.31	6.76
40	3.85	6.19
50	6.04	6.23

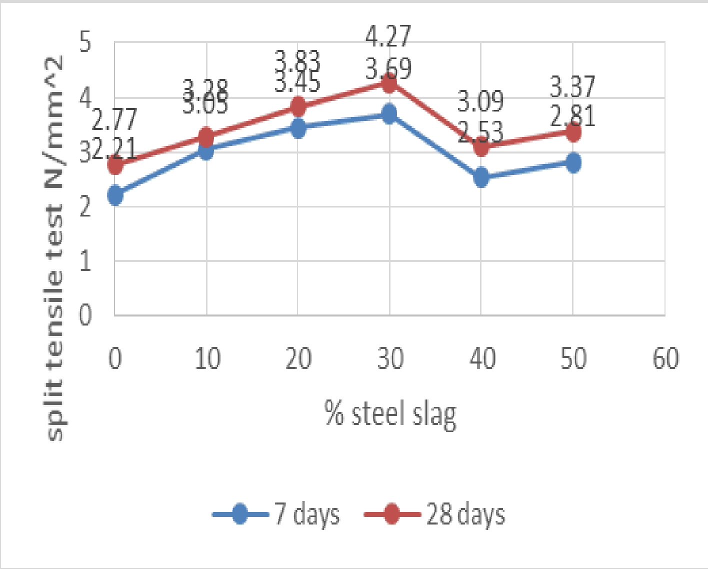
Fig 2: flexural strength test



Split tensile strength test:

Fig 3: split tensile strength test

Split tensile strength at 7 days	Split tensile strength at 28 days
2.21	2.77
3.05	3.28
3.45	3.83
3.69	4.27
2.53	3.09
2.81	3.37



4. Conclusion:

The Compressive strength, flexural strength and splitting tensile strength for steel slag aggregates concrete were similar to conventional concrete. The strength may be affected with time and so long term effects on hardened properties of concrete require further investigation. The slight improvement in strength may be due to shape, size and surface texture of steel slag aggregates, which provide better adhesion between the particles and cement matrix. No major difficulty in handling the concrete which incorporated steel slag aggregates was encountered – Proper care should be taken during the aging of steel slag and during the stockpiling of steel slag. This project initiative will give solution to solid waste disposal and also reduces the natural sand exploitation. Hence this attempt towards eco-friendly built environment is need of hour. This work relates the use of steel slag, a waste cheap material used as fine aggregates in M30 grade of concrete and recommends the approval of the material for use in concrete as a replacement material for fine aggregates.

REFERENCES

[1] S. T. Borole et. al (2016) "Replacement of fine aggregate by steel slag" International journal of innovative research in science and engineering. Vol.No.2, Issue 03

[2] Gozde Inan Sezer et. al (2015) "Use of Steel slag in Concrete as fine aggregate" "Indian journal of Engineering and materials Sciences. Vol. 22,June 2015.

[3] Prof. Subathra Devi" et al. (2014) "Properties of concrete manufactured using steel slag", research scholar, department of civil engineering.

[4] Gaurav Desai et al. "Partial replacement of fine aggregate using steel slag" International journal of engineering department and research (IJEDR) ISSN: 2321-9939 Volume 6, Issue 2

[5] Mahadev Shreemanth, K.P Shivananda and J.K Dattattreya et. al "Effect of replacement of fine aggregate by steel slag aggregates in concrete" Journal of civil engineering and environmental technology p ISSN; 2349-8404; e-ISSN: 2349-879X; Volume 2, Number 15.

[6] "Anurag Jain, Sandeep Gupta & Mayank Gupta" et al "Steel slag as a replacement of fine aggregate in terms of high strength concrete" International journal of engineering sciences and research Technology.ISSN;2277-9655.

[7] Radhu Chandini et.al "Use of steel slag in concrete as fine aggregate" International journal of Innovative technology (IJEIT) Vol 7, Issue 4.

BIOGRAPHIES

Priyanka Arun Raikar, Student of STJIT Ranebennur

Renuka G B, Student of STJIT Ranebennur

Seema G N, Student of STJIT Ranebennur

Pavitra P, Student of STJIT Ranebennur