

# Experimental Study on the Mechanical Strength Properties of Steel Slag in Concrete and Weld Slag in Concrete

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**Abstract:-** In this study, the effect of the fibre content and the characteristic on the fresh and hardened properties of steel slag and weld slag have been evaluated by testing and the measuring properties have been identify the various strength performance. Steel slag and weld slag can be determining the recycled material. Steel slag which is produced as a waste material in the steel industry and has a negative impact on environmental when disposed. Weld slag, steel slag and fibers are used in concrete with various proportions as a partial replacement in concrete. Polypropylene fiber being used for the post cracking purpose in concrete is used here for the mechanical properties of the concrete along with the addition of steel slag and weld slag. The aim of the recent work is to investigate the strength and durability of the concrete. Mechanical properties such as compression, tensile, and flexural test of steel slag and weld slag in concrete were determined. In this study fine aggregate is reduced in the percentages of 10%, 20% and 30% and additional added the polypropylene fibre. M30 grade of concrete will be used in steel slag and weld slag in concrete. Initial optimization of steel slag and weld slag aggregate was finding with 7 and 28 days strength. Finally when compared to weld slag, 20% of steel slag will obtain strength.

**Keywords:** concrete, steel slag, weld slag, polypropylene fibre, ordinary Portland cement.

## 1. INTRODUCTION

Concrete is widely used in construction of buildings, bridges and other structures. It consumes natural resource like lime, aggregate, water, etc. The worldwide production of cement has greatly increased and its production results in a lot of environmental pollution as it involves the emission of CO<sub>2</sub> gas [2]. Steel slag is a by-product of the process converting iron in to steel in industry. The emission of steel slag represented thirteen to 20% of all steel production[1]. This paper determined the waste to use the concrete material. The advancement of concrete technology can reduce the consumption of natural resources and energy sources and less the burden of pollutants on environment [3]. The construction materials

which have been using till now may create a huge demand in the future due to lack of availability [4]. It is effective that the waste comes from weld industries can be used in concrete as a replacement for normal construction materials such as aggregate [5]. Steel slag mainly used for road bases and surface concrete, asphalt concrete and as in hydraulic cement concrete [6]. Submerged arc welding slags were characterized by applying a variety of methods, including X-ray fluorescence, X-ray diffraction, particle size, and scanning electron microscope [9].welding concrete is a well established process capable of producing quality welds in a welds in a wide range of thickness in ferrous, stainless steel and non-ferrous metals[9].The process consists of an arc that is formed when an electric current pass continuously between a welding wire and the work piece [7]. Polypropylene fibres are widely employed in the reinforcement of concrete as they present some advantages including, high durability of the fibre reinforced concrete, they have a greater effect on reducing the shrinkage of the concrete and they reduce of the spalling of concrete effect in high strength concrete subjected to elevated temperature [8]. The effect of polypropylene fibre is more pronounced in the elastic modulus due to shrinkage cracking reduction and on the fracture behaviour of the fibre reinforcement concrete due to bridge effect of the cracks [10].

## 2. MATERIAL AND METHODS

### 2.1. Cement

Ordinary Portland cement of 43 grade conforming to IS: 8112-1989 and similar to ASTM type III (C150-95) was used. Its specific gravity was 3.15.

### 2.2. Fine Aggregate

The M-sand has required gradation of fines, physical properties such as shape, smooth, surfaces and textures and consistency which make it is the best and suitable for construction. The physical properties of sand provide greater strength to the concrete by reducing segregation, bleeding, honeycombing, voids and capillary. Thus required grade of sand for the given purpose helps

the concrete to fill voids between fine aggregate and makes concrete more compact dense, thus increases the strength of concrete.

Table 2.1: Test result for fine aggregate

Specific gravity	2.56
Fineness	5.75%
Water absorption	2.26%

**2.3. Coarse aggregate**

Crushed granite coarse aggregate of 20mm size were used. The specific gravity was 2.75

**2.4. Steel slag**

Steel slag is obtained from Agni steels private Limited, Ingur, Tamil Nadu, India and its specific gravity in form was found to be 2.95. The chemical composition of slag is usually expressed in terms of simple oxides calculated from elemental analysis determined by X-ray fluorescence. List the range of compounds present in steel slag from a typical base oxygen furnace.

Table 2.2: chemical composition for steel slag

Constituent	composition
C	1.40
O <sub>2</sub>	54.05
Na	0.58
Al	4.49
Si	18.28
K	0.33
Ca	1.46
Ti	0.49
Cr	0.32

**2.5 Weld slag**

Weld slag can also replace with sand in concrete. So, the present focuses to replace sand by welding in the production of concrete. The chemical characteristic of the welding slag were determine in the laboratory as per standard methods.

Table 2.3: chemical composition for weld slag

constituent	Composition
Fe	26.03
Mg	6.16
Zn	0.62
Al	63.9
Cu	0.13
Ca	0.22
Pb	0.12
Cr	0.2
k	2

**2.6. Polypropylene fibre**

Polypropylene fiber has been receiving an increased attention towards worldwide due to their superior properties in strength, low permeability, reduced shrinkage cracking, high abrasion resistance, and high flexural and splitting tensile strength. The addition of fibers improves the mechanical properties, ductility and reduces the brittleness of concrete.

**2.7. Super plasticizer**

In this study conplast (430) is used. It is used to increase the workability of the concrete. The specific gravity of CONPLAST is 1.21

**3. CONCRETE MIX DETAILS**

For Steel slag and weld slag in concrete there was no standard proportion. So we decided to find the better ratio for aggregate and cement by testing various proportions. In 1:1.6:2.8 (REDUCING 10%, 20%, 30% OF FINE AGGREGATE) keeping water cement ratio as constant. The w/c ratio is kept as 0.4

Table 3.1: Mix Ratio

Grade	M30
Ratio	1:1.6:2.8
w/c ratio	0.4
Cement	394 kg/m <sup>3</sup>
Fine Aggregate	637kg/m <sup>3</sup>
Coarse Aggregate	1109 kg/m <sup>3</sup>
Chemical Admixture	7
Polypropylene fiber	0.6%

**4. EXPERIMENTAL RESULT FOR STEEL SLAG AND WELD SLAG**

**4.1. Comparison of compressive strength for steel slag and weld slag**

Concrete cubes of size 150×150×150mm were made using various percentage replacement of steel slag for fine aggregate. The concrete cubes were made M30 grade. The percentage of steel slag and weld slag replacement of fine aggregate were 10%, 20%, and 30% and adding polypropylene fiber respectively. The cubes were tested 7, 14 and 28 days compressive strength as per IS standard and the result are given below

Table 4.1: compressive strength test result

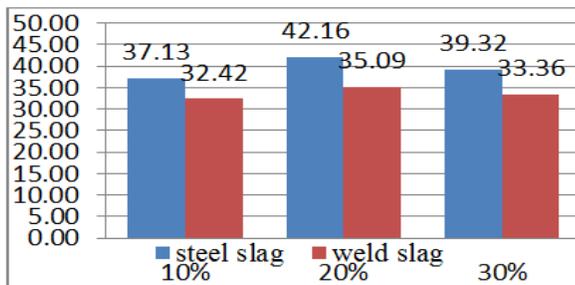
Sl.no	Specimen details	steel slag for (28 days) (N/mm <sup>2</sup> )
1	10% Replacement	37.13
2	20% Replacement	42.61
3	30% Replacement	33.36

Table 4.2: compressive strength for weld slag

Sl.no	Specimen details	Weld slag for (28 days) (N/mm <sup>2</sup> )
1	10% Replacement	32.42
2	20% Replacement	35.09
3	30% Replacement	33.36

Table 4.3: Split Tensile Test for steel slag

Sl.no	Specimen details	Weld slag for (28 days) (N/mm <sup>2</sup> )
1	10% Replacement	2.9
2	20% Replacement	3.4
3	30% Replacement	3.1



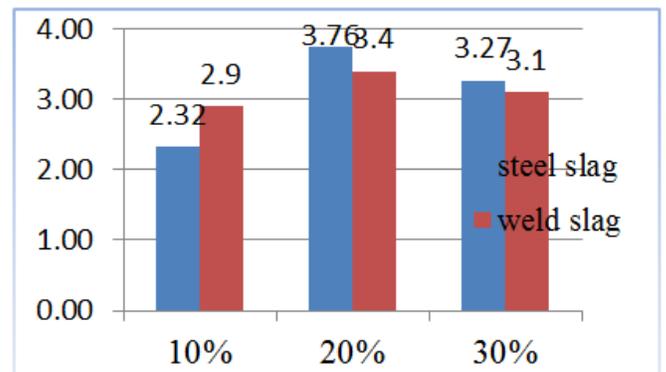
Graph 4.1: comparison of compressive strength for steel slag and weld slag

**4.2. COMPARISON OF SPLIT TENSILE TEST**

The test was conducted as per IS 5816:1999. For tensile strength test, cylindrical specimens of dimension 150mm diameter and 300mm length were casted. In each mix, three cylinders were casted and tested average value was taken and the results are tabulated and plotted below

Table 4.4: split tensile strength for weld slag

Sl.no	Specimen details	steel slag for (28 days) (N/mm <sup>2</sup> )
1	10% Replacement	2.32
2	20% Replacement	3.76
3	30% Replacement	3.27



Graph 4.2: comparison of Split Tensile Test

**5. RESULT AND DISCUSSION**

From graph 4.1 and 4.2, it was observed that the compressive strength increases as the comparative percentage of steel slags increased up to 20% replacement. Comparative result for steel slag and weld slag compressive strength increased when compared to the weld slag. Hence we concluded that the complete replacement of fine aggregate with polypropylene fibre has increase the strength.

From the split tensile strength test, weld slag concrete is better than the steel slag concrete.

**6. CONCLUSIONS**

- Finally it is concluded that the comparison of steel slag and weld slag in strength of concrete. The compressive strength is increased by 15% when compared with the steel slag concrete and the maximum strength is obtained in the concrete with 20% of sand reduction.

- The split tensile strength is increase by 16.88% when compared with the steel slag in concrete. The increase in the strength is due to the reduction of sand content in the concrete. Optimum level of replacement for steel and weld slag is found as 20% increase in strength initially is attributed to shape effect and decrease the strength beyond 20% is attributed to porosity of steel slag. This research confirms that the comparison of steel slag and weld slag in concrete in fact provided a lower compressive strength more than that of weld slag concrete.
9. Zainab & Enas A (2015), "Reuse of waste iron as a partial replacement of sand in concrete", *Journal of Waste Management*, Vol. 28, pp. 2048-2053.
  10. Zhihong pan & Juanlan Zhou(2019), "Investigating the effects of steel slag powder on the properties of self compacting concrete with recycled aggregate", *Journal of Construction and Building Materials*, Vol.20, pp. 570-577

## REFERENCES

1. Alnuaimi S (2012), "Effect of copper slag as a replacement for fine aggregate on the behavior and ultimate strength of reinforced concrete slender columns", *Journal of Engineering Research*, Vol. 9, pp. 90-102.
2. Bouharoun, Caro & Dubois (2013), "Effect of super plasticizer on the properties of the concrete/ oil/ formwork interface", *Journal of Construction and Building Material*, Vol. 47, pp.1137-1144.
3. Cabrera M & Agrela F (2017), "Effect of stainless steel slag waste as a replacement for cement in mortar", *Journal of Construction and Building Material*, Vol. 142, pp.444 - 458.
4. Carlos Thomas & Julia Rosales(2019), "steel slag", *Laboratory Of Material Science And Engineering*, Vol.7, pp. 170-190.
5. Jin liu & Dongmin wang(2017), "Influence of steel slag – silica fume composting mineral admixture on the properties of concrete", *Journal of Power Technology*, Vol.320, pp.230-238.
6. Liwu mo, Feng zhang & Min deng (2017), "Accelerated carbonation and performance of concrete made with steel slag as binding material and aggregates", *Journal of Cement and Concrete Composites*, Vol. 83, pp.138-145.
7. Nidheesh P (2013), "Use of furnace slag and welding slag as replacement for sand in concrete", *International Journal of Energy and Environmental Engineering*, Vol. 43, pp.86-93.
8. Sadiqul Islam & Sristi Das Gupta(2016), "Evaluating plastic shrinkage and permeability of polypropylene fiber reinforced concrete", *International Journal of Sustainable Built Environmental*, Vol.5, pp.345-354.