# A Review on Concrete Using Blast Furnace Slag as a Replacement of Coarse Aggregate

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***Abstract –****Natural resources are depleting day by day due to large utilization for infrastructural development. Blast furnace slag has a great potential as it can be used as an artificial aggregates. Keeping this in view, the present study encourages the utilization of waste material such as air cooled blast furnace slag (ACBFS) and fly ash in concrete. The combined effect of ACBFS as replacement for coarse aggregates and fly ash as a partial replacement of cement on the workability test, split tensile strength test, compressive and flexural strength of concrete has to be investigated.*

***Keywords****-Infrastructural development, fly ash, ACBFS,workability test, split tensile strength test, compressive and flexural strength.*

## I-INTRODUCTION

Concrete is a composite manmade construction material, most widely used for the reasonthat of its strength and longevity and it has emerged as the dominant construction material for the infrastructure needs of the present situation. By different constituents of concrete, depending upon the utility and application, the characteristics of concrete may also be varied. The strength of the concrete composite is based on the strength of different Constituents used in the preparation of concrete.

The Indian integrated iron and steel industry poses serious challenges to environment through its inherent complexity (Pandey et al., 1996) and may hazardous to environment (Khan and Shinde, 2013). Every tonne of steel production produces 20 percent of slag waste. Presently, India is the fourth-largest manufacturer of steel (Firoz, 2014; Kumar and Naidu, 2013) following China, Japan and the US. Due to high strength and durability of steel slag its suitability as construction material in many cases is superior to rock material, and use slag in construction also assist to decrease the quantity of land filled (Tossavainen, 2005).

Traditionally unutilized slag is stock piled in the steel plants, and eventually land filled at slag disposal sites. Since the current methods of stockpiling and land filling are not sustainable, disposal of slag has become a significant concern both to slag processor companies and to environmental agencies in the last decades. A number of slag sites around the world have been associated with groundwater and soil contamination from heavy metals and other toxic compounds concentrated in the slag. Therefore, improving the utilization rate of steel slag is an imperative way for the steel enterprise to realize sustainable development. It has been reported that, iron and steel slag have high pozzolanic potential and can be utilized as raw material or blending constituent in cement manufacturing and constructional activities (Khajuria and Siddique, 2014; Huang et al., 2012; Malhotra and Tehri, 1994; Kumar and Bhargavi, 2015).

## II-LITERATURE REVIEW

Slag is the result of a high blast furnace residue, produced by steel smelting industries that physically resemble rough aggregates. Iron and steel industry slag, either granulated or crystalline, is considered as a prominent and a useful raw material for developing of modern construction materials. Blast furnace slag is a by-product and using it as aggregates in concrete will might prove an economical and environmentally friendly solution in local region. Available literatures in India indicate that there is a lot of opportunity for utilization of integrated iron and steel slag.

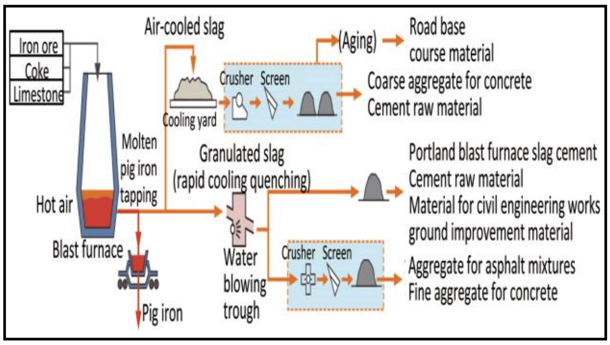


**Figure 1: Production flow of the blast furnace slag**

The main components of blast furnace slag are CaO, $SiO_2$, $Al_2O_3$, and MgO (Chandra, 1997). In last 5 years, an enhancement of over 18% for blast furnace slag and basic oxygen furnace slag has been achieved (GOI, 2013-2014). By continuing thrust on solid waste consumption at the integrated iron and steel plants, total solid waste utilization has increased from 77% in the 2007-08 to 86%; an increase of 9% over the last 5 years (GOI, 2013-2014). The major uses of steel slag in India are shown in figure 2.

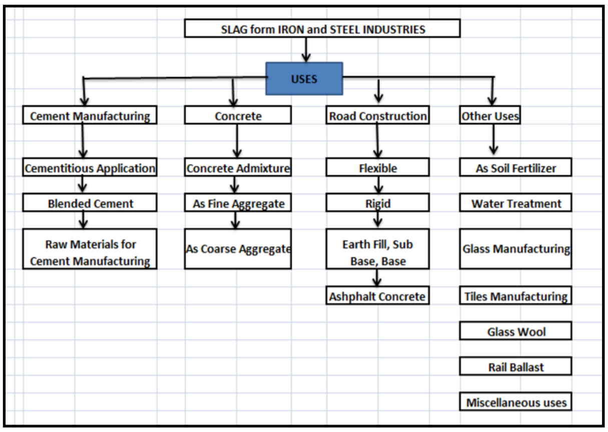


**Figure 2: Different uses of slag in India (Tiwari et al., 2016)**

Replacing all or some portion of natural aggregates with slag would lead to considerable environmental benefits. Most of the researchers have explored and focused slag potential as natural aggregate replacements for concrete and road construction along with cement manufacturing.

It is concluded that the strength of M20 and M25 concrete increases with the increase in the quantity of slag as replacement to natural aggregates. It is economical to use the blast furnace slag, as its costs of just about 50% of that of conventional aggregates (Pajgade and Thakur, 2013).

The ground granulated blast furnace slag (GGBFS) is a by-product of iron manufacturing (Suresh and Nagaraju, 2015) which when added to concrete improves its properties such as workability, strength and durability (Arasan et al., 2017).

Concretes containing slag as a partial replacement of cement (up to 40%) had higher compressive and flexural strengths casting and curing at +42°C than those of concretes made with Portland cement alone (Siddique and Kaur, 2012).

The compressive strength of Blast Furnace Slag aggregate concrete is found to be higher than that of conventional concrete at the age of 90 days and it has also reduced water absorption and porosity beyond 28 days in comparison to that of conventional concrete with stone chips used as coarse aggregate (Hiraskar and Patil, 2013).

The physical properties of crusher dust and blast furnace slag are satisfying the requirements of fine aggregate and coarse aggregate. The cost of concrete made with blast furnace slag and crusher dust is less than conventional concrete because the crusher dust and blast furnace slag which were less cast. At 30% replacement of coarse aggregate with blast furnace slag and fine aggregate with crusher dust there is no reduction in compressive strength with respect to controlled concrete. At 30% replacement of coarse aggregate with blast furnace slag and fine aggregate with crusher dust that shown only marginal increase in split tensile strength and flexural strength was observed (Dhanasri and Kumar, 2013).

The Compressive strength of 100% blast furnace slag concrete has been increased up to 2.8% in comparison to conventional concrete (Singh, 2014).

The compressive strength of concrete increases as BF Slag replacement increases up to 40% at all curing ages. The flexural strength of concrete also increases up to 40%, similar to the trend shown by compressive strength. The maximum increase in flexural strength at 28 days curing is 8.33% (Sandhu et al., 2015).

For the replacement of both coarse and fine aggregates from 30 to 50%, the compressive strength of concrete increased by 4 to 6%. However, in case of coarse aggregate the compressive strength increased by 5 to 7% over control mixes in M20, M30 & M40 grade of concrete (Nadeem, 2018).

The coarse aggregate was replaced by blast furnace slag at 10% to 100% and various tests were conducted to determine the optimum level of replacement of blast furnace slag in self compacting concrete (Krishnasami and Malathy, 2013).

The results obtained encourage the use of blast furnace slag in concrete as a partial replacement to fine aggregate up to 25%. The maximum compressive strength of 40.69 N/mm2 was obtained by replacing 25% of fine aggregate with BFS. Workability was found to be a problem with the fresh concrete, and hence usage of superplasticiser was recommended. The usage of BFS will reduce the cost of concrete by 8 to 10% (Babu and Mahendran, 2014).

It was observed that the compressive strength increased up to 35% replacement of coarse & Fine aggregate with slag and is gradually decreased for starting from 40% replacements. Hence replacement of coarse aggregate with 35% replacement will be reasonable (Harikumar et al., 2017).

Normal compressive strength of high quality concrete at age 1, 3,7,14, and 28 days respectively are 33.651 Mpa. 47.871 Mpa. 57.321 Mpa. 53.170 Mpa and 67.567 Mpa. While compressive strength of concrete with slag substitution at age 1, 3,7,14 and 28 days respectively are 43.896 MPa. 71.541 MPa. 77.282 MPa. 70.658 Mpa and 75.958. Thus it shows that high quality concrete made of steel slag as the main constituent aggregate has a compressive strength greater than that of conventional high-quality concrete. 2. The average tensile strength of high quality slag concrete with 28 days of concrete is 5.053 MPa. While the average tensile strength of conventional high quality concrete with 28 days of concrete is 5,435 Mpa. It shows that the tensile strength of conventional high quality concrete is stronger than the tensile strength of high quality concrete with slag steel replacement (Karolina and Putra, 2018).

The advantages of using slag in concrete are as follows (Karolina and Putra, 2018):

- Enhancing the compressive strength of concrete due to the tendency of slow increase in compressive strength.
- Increasing the ratio between flexibility and compressive strength of concrete.
- Reducing the variation of compressive strength of concrete.
- Increasing the resistance to sulphate in seawater.
- Reducing alkali-silica attack; reducing the heat of hydration and lowering the temperature.
- Fixing the final solution and giving a bright colour to the concrete.
- Enhancing the durability due to changes in the volume.
- Reducing porosity and chloride attack.

## METHODOLOGY

For this experimentation the percentage of the volume of natural aggregates normally used in concrete was replaced by blast furnace slag. This replacement was done in 10% increments for the optimum replacement level of the blast furnace slag as coarse aggregates is determined. To that optimum mix the steel fibres are added at volume fractions of 0.50%, 1.00% and 1.50%. For this the following experiments have to be conducted in the laboratory:

1. Characterization of natural aggregates (Coarse and fine)
2. Characterization of blast furnace slag
3. Characterization of cement
4. Selection of mix proportion
5. Preparation of concrete cubes, cylinder, and beam for strength analysis

## III-CONCLUSION

The original scope of this research was to investigate the properties of concrete with BF slag aggregates. The mechanical properties of concrete were tested with steel slag as replacement of coarse aggregates, to the optimum replacement level and several tests were also to be carried out such as compressive strength, split tensile strength, Young s modulus, flexural strength and the ultimate load carrying capacity of slag aggregate concrete at different volume proportions. The flexural properties are also determined for the beams with reinforcement.

Thus replacing the natural aggregates in concrete applications with steel slag would lead to considerable environmental benefits and at the same time the strength properties of the concrete is increased and would be economical.

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