

Utilisation of Steel Slag in Roads of Marathwada Region

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Abstract—MIDC Jalna is declared as steel zone in Marathwada region of Maharashtra. There are about 38 steel rolling mills and 10 Billet/Ingot mills, producing 60,000 tonnes Billets/ Ingots every day, wasting 20 percent (i.e.12000 tones) of steel slag. This slag is crushed; steel is again extracted from the slag, which is held in pores in the slag. About 18Percent steel slag of it has been wasted (1percent finer slag and 1percent steel). After studying the properties of steel slag by geotechnical engineering point of view, the engineering properties of slag are too similar as compared to the natural aggregates. Properties like gradation, impact value, crushing value, abrasion value of aggregate are within limits of the MoRTH. Also the CBR value is found more than that of the natural aggregate. By utilizing this slag in roads, the waste material will be used and slag won't cause any harmful impact on the environment.

Keywords— Steel slag, CBR Value, Marathwada region

I. Introduction

For manufacturing of rolled steel, billet/ingots are generated, from these billets/ ingots, the steel slag is the waste generated from ingot/ billets, about percent steel is wasted from ingot/billets, from these 20 percent actually 1percent will be the finer slag and 1 percent lumps of steel that will be considered none of use. The steel lumps again mixed as a scrap material in the process of manufacturing of steel. About 18percent slag i.e.by the weight manufactured of the steel that will be wasted by the industries. Steel slag is having the basic properties of aggregates. Generally the aggregates are nothing but the hard rock which is in disintegrated in form. The disintegrated parts of the aggregates are having the same properties as their origin. If compared the properties of steel slag and the rock aggregates, the generation of igneous rock is in the form of lava, the generation of steel slag is furnace, but there will be slight temperature difference in the manufacturing of steel and rock. At MIDC Jalna, declared as steel zone in Marathwada region of Maharashtra state. There are about 38 steel rolling mills and 10 Billet/Ingot mills, producing 60,000 tonnes Billets/ Ingots every day. Total wastage of steel slag is about 1080 tones. This is a huge problem to dispose the steel slag. Steel furnace slag is the non-metallic product consisting essentially of calcium silicates with fused oxides of iron and, aluminium that is developed in a molten condition simultaneously with steel in a basic oxygen furnace. The material is produced in a molten condition simultaneously with steel in a basic oxygen furnace and is a predominantly crystalline, solid rock-like material. Slag is a broad term covering all non metallic co-products resulting from the separation of a metal from its ore. Its chemistry and morphology depends on the metal being produced and the

solidification process used. Slag can be broadly categorized as ferrous (iron/steel) and non-ferrous (copper, lead/zinc) depending on the industry from which they come. Non ferrous slag makes up only 12 percent of the total annual production. (i).



Figure 1: Production of Steel Slag

II. Material and Methodology

II.1 Chemical composition of steel slag

Soil is mainly made up of oxygen (46.7percent), silicon (27percent), aluminum (8.1 percent) and iron (5.0percent). Plant nutrients like Ca, Mg, K, Na, P and S are present in the minerals and in the soil solution. O₂, Si, and Al occur as constituents of minerals and as oxides. Fe occurs mainly in the form of oxides and ferromagnesium minerals. Ca occurs mainly in calcite, gypsum, apatite and dolomite. Mg is present mainly in dolomite and hornblend. K occurs mainly in microcline and mica. P occurs as aluminum phosphate and calcium phosphate and in the organic form as phospholipids, inositol, choline, etc. N occurs mainly in the organic form as proteins, amino acids, etc. All micronutrients like Mo, Fe, Mn, Zn, Cu, B occur in the inorganic form.

II.2 Engineering properties of slag

a) Gradation: Steel slag should be crushed and screened to produce a material that satisfies the grading requirements of granular base and sub base specifications, such as AASHTO M147.

b) Compacted Density: The compacted density varies with size and grading of the slag, method of measuring, and specific gravity of the slag. The compacted density of Slag aggregates ranges from 12.30 kN/m³ to 16.90 kN/m³, which is somewhat lower than that of conventional granular materials. Allowance for this differential should be considered during design and in specifications in order to ensure equal volume irrespective of the type of aggregate used.

c) Stability: Slag aggregate angularity and high friction angle (40° to 45°) contribute to high bearing capacity and higher California Bearing Ratio (CBR)

d) Freeze-Thaw Resistance: Slag aggregates display good durability with resistance to freeze-thaw weathering and erosion.

e) Hardness and Impact Resistance: The hardness of slag as measured by Moh's scale is between 5 and 6, corresponding to durable igneous rock. However, Slag aggregate is quite brittle and prone to breakdown when subjected to impact loading.

f) Abrasion: AASHTO M147 requirements for Los Angeles Abrasion loss for granular base aggregates are typically waived for Slag aggregate since no correlation between the Los Angeles Abrasion test loss for slag in laboratory tests and degradation in field applications has been observed. For this reason ASTM has deleted this test for slag in its specifications (e.g., ASTM D692, D1139), and major slag-using states, such as Michigan, Ohio and Indiana, do not use this test.

g) Drainage Characteristics: Granular base is free draining and is not frost susceptible (ii), (iii) and (iv)

Table 1 Chemical composition of steel slag.

Constituent	Percentage	
	Mean	Range
Calcium Oxide (CaO)	39	34-43
Silicon Dioxide (SiO ₂)	36	27-38
Aluminum Oxide (Al ₂ O ₃)	10	7-12
Magnesium Oxide (MgO)	12	7-15
Sulfur (S)	1.4	1.0-1.9
pH	11	10 – 12
Manganese Oxide (MnO)	0.44	0.15-0.76
Iron (FeO or Fe ₂ O ₃)	0.5	0.2-1.6

III. Results and discussion

a) *Material Handling and Storage:* The same equipment and procedures used for conventional aggregate may be used to stockpile and handle conventional aggregates as appropriate for slag aggregates. However, greater care is required when handling and stockpiling blast furnace slag aggregates to avoid brittle fracture that can result in excessive fines generation.

b) *Placing and Compacting:* Procedures should be employed to ensure uniform gradation and layer thickness. Good uniformity is obtained by combining the coarse and fine aggregates with optimum water for compaction at the blending plant just prior

to placing. The material should be graded and placed in a manner that allows free drainage.

c) *Quality Control:* The same test procedures used for conventional aggregate are appropriate for Slag aggregates Standard field tests and laboratory tests for compacted density and field measurement of compaction as per AASHTO

As the development of nation depend on the connectivity between metros cities-cities-towns-villages we need the roads, for constructing the roads natural aggregates are quarried. For the protection of the nature we should think always about the wastages that should be used in the construction of the roads.

Table 2: Comparison: Steel slag aggregates and Natural Aggregates:

No.	Name of test	Steel Slag Aggregate	Natural Aggregates
1	Bulk Density	18.84	17.65
2	Specific Gravity	2.71	2.60
3	Liquid Limit	Not	Not
4	Plastic Limit	Not	Not
5	Plasticity Index	Non-	Non-plastic
6	Maximum Dry	16.84	15.25
7	Optimum Moisture	10%	13%
8	California Bearing Ratio	15.57%	13.54%
9	Unsoaked California Bearing Ratio	12.27%	10.62%
10	Abrasion value	28%	22%
11	Impact Value	13.90 %	12.27%
12	Flakiness Index	4.80%	6.75%
13	Water Absorption	1.0 %	1.20%
14	Aggregate	5.20%	8%

Abrasion value of slag aggregates found to be 28percent which is within the specified limits as per MoRTH, and IS: 2386 (part 4), it should be less than 30percent i. e. maximum limit. So steel slag is suitable for the replacement of the natural aggregates.

Impact value of the steel slag aggregates is found to be 13.90 percent of the total weight. Crushing value of aggregates of the steel slag aggregate is 5.20 percent. CBR value of the steel slag aggregates is found to be 15.57percent (unsoaked) and 12.27 percent (soaked) (v) and (vi) .

Impact value of steel slag aggregates is found to be 13.90 percent The aggregate impact value should not exceed 45percent by weight of aggregate for concrete other than wearing surface. The aggregate impact value should not

exceed 30 percent by weight for concrete wearing surface such as runways, roads, pavements, floors etc. IS:383-1970, IS:2386 (Part-4).

Environmental wastage has been minimized by utilisation of the steel industrial waste in road sector and natural resources will be protected (vii).

IV. Conclusion

The expansion of slag is very less so we can replace the expansive soil by utilizing this industrial slag rather than utilising natural aggregates.

The industrial slag which is wasted anywhere that can be utilised, very well, so soil pollution can be prohibited.

We can replace the top layered metal by replacing the slag with bituminous cementing material enhancing the resistance against skidding due to this property slag can also be utilized on the sloping gradients of roads.

Utilization of slag for other purposes:

Slag products are also used in hydraulic engineering to stabilize natural course of river bed.

Natural stone sounds very ecological and very natural. Basalt, granite, these are all natural varieties of stone that have useful characteristics. But to use them, they have to be quarried and blasting, bulldozers are required and again waste is generated. In many fields application of natural stone can be replaced with slag products.

- a) Slag mostly used for the manufacturing of blast furnace slag cement.
- b) Slag also can be used for land filling and as a replacement of other filling material like, natural aggregates.
- c) Slag can be used for making the bricks saving natural clay.

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