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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% *i.e.*12000 tonnes of steel slag. This slag is crushed; steel is again extracted from the slag, which is held in pores in the slag. About 18% steel slag of it has been wasted (1% finer slag and 1% 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: *Billet and Ingot mills, slag*

1. 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 20% steel is wasted from ingot/billets, from these 20% actually 1% will be the finer slag and 1% 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 18% 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, aluminum 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.

Fig. 1 Production of steel slag

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% of the total annual Production.

2. CHEMICAL COMPOSITION OF STEEL SLAG:-

Soil is mainly made up of oxygen (46.7%), silicon (27%), aluminium (8.1 %) and iron (5.0%). Plant nutrients like Ca, Mg, K, Na, P and S are present in the minerals and in the soil solution. O_2, 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 aluminium 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.

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_2O_3)	10	7-12
Magnesium Oxide	12	7-15
Sulfur (S)	1.4	1.0-
pH	11	10
Manganese Oxide (MnO)	0.44	0.1
Iron (FeO or Fe2O3)	0.5	0.2-

Table 2:- Physical properties of slag

Physical Properties	Slag
Colour	Black
Specific gravity	2.71
Appearance	Crystalline
Compacted Unit	1120 – 1360
Absorption (%)	4.6 % of Total weight

3.ENGINEERING PROPERTIES OF SLAG:-

3.1 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.

3.2 Compacted Density:

The compacted density varies with size and grading of the slag, method of measuring, and bulk specific gravity of the slag. The compacted density of Slag aggregates ranges from 1120 kg/m3 to 1940 kg/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.

3.3 Stability:

Slag aggregate angularity and high friction angle (40° to 45°) contribute to high bearing capacity (California Bearing Ratio (CBR) greater than 100).

3.4 Freeze-Thaw Resistance:

Slag aggregates display good durability with resistance to freeze-thaw weathering and erosion.

3.5 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.

3.6 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 reportedly 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 procedure with ACBFS.

3.7 Drainage Characteristics:

Granular base is free draining and is not frost susceptible.

Table 3 Engineering Properties of slag

Maximum Dry Density (Standard)	12.30-16.9 kN/m^3
Optimum Moisture	9-11%
Fractured Faces	100%
Dry Strength	200 -220kN/m^2
Wet Strength	180 - 200kN/m^2
Liquid Limit	Not obtainable
Plastic Limit	Not obtainable
Plasticity Index	Non-plastic
Linear Shrinkage	0%

4. Construction Procedures:

4.1 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.

4.2 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 and prevents ponding within or adjacent to the material.

4.3 Quality Control

The same test procedures used for conventional aggregate are appropriate for Slag aggregates Standard field and laboratory tests for compacted density and field measurement of compaction are given by AASHTO T191(9), T205(10), T238(11), and T239(12) test methods.

5. Comparison in Between Natural Aggregates and steel slag aggregates:

Table 3:- Comparison in Between Natural Aggregates and steel slag aggregates:

No.	Name of test	Steel Slag Aggregate	Result of Natural aggregates
1	Water Content	7.62%	14.28%
2	Bulk Density	18.74 kN/cu.m	1.87 kN/cu.m
3	Specific	2.71	2.60
4	Liquid Limit	10.78%	48%
5	Shrinkage	12.90%	25%
6	MDD	1.58 g/cc	1.95 g/cc
7	OMC	9.67%	14%
8	California Bearing Ratio	(5mm) =15.57	7.6
		(5mm)=8.27	21.48
9	Impact Value	13.90 %	12.027%
10	Flakiness	4.80%	22.75%
11	Water	1.0 %	1.01%
12	Aggregate	5.20%	10.21%

6. Conclusion:-

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.

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

2. Impact value of the steel slag aggregates is found to be 13.90% of the total weight as per IS: 2386 (part-4) and as per MoRTH it should be less than 30 % i.e. maximum limit. So these steel slag aggregates can be utilized for the replacement of the natural aggregates.

3. Crushing value of aggregates of the steel slag aggregate is 5.20 %.

4. CBR value of the steel slag aggregates is found to be 8.27 and 15.57.

5. Impact value of steel slag aggregates is found= 13.90 % The aggregate impact value should not exceed 45% by weight of aggregate for concrete other than wearing surface. The aggregate impact value should not exceed 30% by weight for concrete wearing surface such as runways, roads, pavements, floors etc. IS:383-1970, IS: 2386 (Part-4)

6. Environmental wastage has been minimized by utilized the steel industrial waste in road sector, natural aggregates will be replaced very well. Natural resources will be protected.

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

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

9.This slag can be used in anywhere in road sector, we can replace the top layered metal by material enhancing the resisting against skidding due to this property this special slag can be utilized on the sloping gradients of roads.

6.1 Utilization of slag for other purposes:

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

b) Natural stone that sounds very ecological, very natural. Basalt, granite, these are all natural verities of stone that have useful characteristics. But to use of them, they have to be quarried. This means that quarries, blasting, bulldozers and degree of non-reusable waste. In many fields application of natural stone can be replaced with slag products.

c) Slag mostly used for the manufacturing of blast furnace slag cement.

d) Now a day's slag can be used for making the bricks that can be replaced by natural resource, clay.

e) This slag also can be used for land filling, replacement on other filling material like, murum.

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