ISSN No: - 2456 - 2165

Use of Steel Slag as a Sub-Grade Material in Road Pavement

Umair Shaikh[1], Asif Patel[2], Ghanasham Sarode [3]
Civil Department, Dr. D. Y. Patil Institue of Technology, Savitribai Phule Pune University, Pune, India
Civil Department, Dr. D. Y. Patil Institue of Technology, Savitribai Phule Pune University, Pune, India
Civil Department, Dr. D. Y. Patil Institue of Technology, Savitribai Phule Pune University, Pune, India

***ABSTRACT*: In India there are many steel rolling mills, producing billets/ingots everyday, these billets/ingots contain 20% of steel slag by weight. This slag is crushed and steel is again extracted from the slag about 1% of both finer slag and steel is obtained and 18% is wasted again. After conducting various tests, the properties obtained are similar to that of natural aggregates. Properties like gradation, impact value, crushing value, abrasion value of aggregate are within limits of Ministry of Road Transport and Highways (MORTH). Also the California bearing ratio (CBR) value is more than the natural aggregates. By utilizing this slag in roads, the waste material will be used and slag will not cause any harmful impact on the environment and also natural aggregates can be conserved. The basic aim is to make different mix proportion of natural soil and slag and check its consistency.**

***Keywords*: Steel rolling mills, billets/ingots, steel slag, mix proportion, conservation of natural aggregates.**

I. INTRODUCTION

About 18% of slag by weight is wasted while manufacturing of steel by the industries. Steel slag is having the basic properties of aggregates. When the properties of steel slag and the rock aggregates are compared, the generation of igneous rock is in the form of lava and the generation of steel sage in furnace, there will be slight temperature difference in the manufacturing of steel and that of rock. There is huge problem to dispose the steel slag. Basically steel slag is the by-product obtained when the molten form is separated from impurities in steel manufacturing process. The slag occurs in molten form and is made up of silicates and oxides which solidify on cooling.

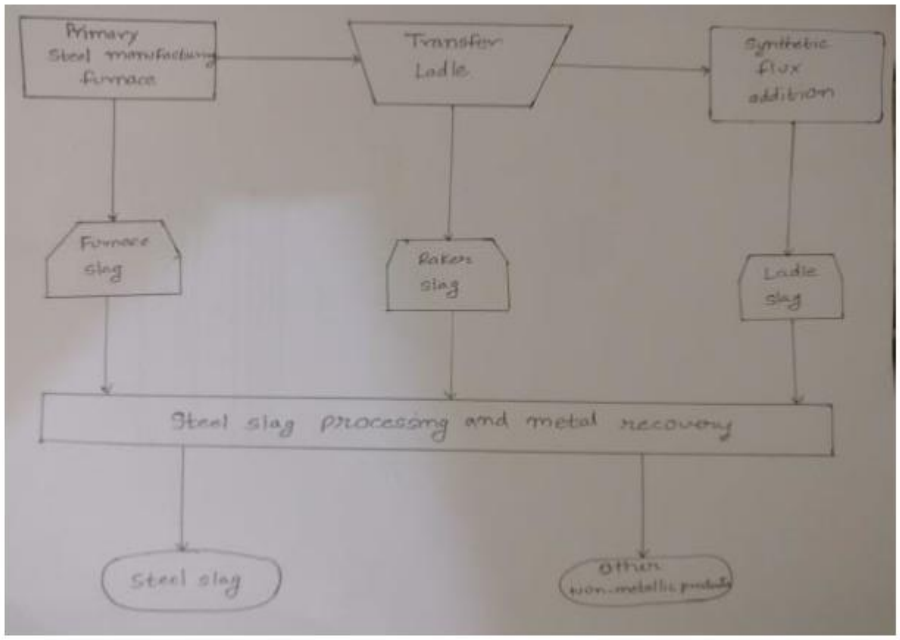

Fig 1 Flowchart of steel slag production

ISSN No: - 2456 - 2165

Fig. 2 Production of steel

II. CHEMICAL COMPOSITION OF STEEL SLAG

Steel slag has the same properties as steel; the chemical composition is also same. The primary components of iron and steel are limestone (CaO) and silica (SiO2). A small amount of Sulphur (S) is also present. In the case of steel slag, the slag contains metal elements (such as iron) in oxide form, however because the refining time is short and the amount of limestone contained is large, a portion of the limestone remains undissolved as free CaO. These components exist in the natural world in places such as the Earth's crust, natural rock, and minerals, and the chemical composition is similar to that of cement. The shape and physical characteristics of iron and steel slag are similar to ordinary crushed stone and sand, however due to differences such as the chemical components and cooling processes. Many applications utilizing the physical and chemical characteristics of slag has been developed and are put to use all over the world.

Table:-1 Chemical composition of steel slag

Constituent	Percentage(%) approx.
Calcium oxide(CaO)	46.32
Silicon dioxide(SiO2)	15.3
Aluminum oxide (Al2O3)	2.4
Magnesium oxide (MgO2)	11.24

ISSN No: - 2456 - 2165

III. ENGINEERING PROPERTIES OF SLAG

A. Grain size analysis

To prepare a material which satisfies the gradation requirements of sub-base specification, grain sise analysis is an important analysis which is to be done to check the consistency of steel slag. The steel slag should be screened and crushed as a pre-requisite.

B. Compacted Density

The value of compacted density varies in accordance to size and grading of the slag. The compacted density of Slag aggregates ranges from 1120 kg/m3 to 1940 kg/m3, which is less than that of conventional granular materials. In the case of Mix proportion of sand (70%) and steel slag (30%) the compacted density is 2134 kg/m3 which is more than the conventional granular materials, hence mixing steel slag and sand turns out to be an advantage.

C. Stability

Slag aggregate has high angularity friction angle (40° to 50°) which contributes to high bearing capacity (California Bearing Ratio (CBR).

D. Hardness and Impact Resistance:

The hardness of slag is measured by Mohr's scale. Slag aggregate is a brittle material and prone to breaking when subjected to impact loading.

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

E. Abrasion

According to ASTM International there is no relation between steel slag aggregates and abrasion test, hence ASTM and other organization has skipped this test. In other words there no value that is obtainable for abrasion test like plasticity of steel slag.

Table 3. Engineering Properties of slag

Maximum Dry Density (Standard)	12.30-16.9 kN/m3
Optimum Moisture	9-11%
Fractured Faces	100%
Dry Strength	200-220 KN/m2
Wet Strength	180-200 KN/m2
Liquid Limit	Not obtainable
Plastic Limit	Not obtainable
Plasticity Index	Non- plastic
Linear Shrinkage	0%

ISSN No: - 2456 - 2165

F. Comparison Between Natural Aggregates, steel slag aggregates and mix proportion of natural aggregates and steel slag.

Table 3:- Comparison Between Natural Aggregates, steel slag aggregates, and mix proportion of natural aggregates and steel slag

NO.	Name of test	Steel Slag	Natural Aggregate	Mix proportion(70% sand and 30% steel slag)
1	Water content	7.62	14.28	8.668
2	Bulk Density	18.74	1.87	20
3	Specific Gravity	2.71	2.60	2.42
4	MDD	1.58 g/cc	1.95 g/cc	2.134 g/cc
5	OMC	9.67%	14%	8.66%
6	CBR	15.57	7.6	6.50

IV. Conclusion

As the development of nation depends on the connectivity between metro cities-cities-towns-villages we need roads, for constructing the roads natural aggregates are quarried. For the conservation of the natural resources we should always think about the waste products that can be used in the construction of the roads.

1. Abrasion value of slag aggregates is 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. Crushing value of the steel slag aggregates is 5.20 %.

3. CBR value of the Mix proportion (70% sand and 30% steel slag) is 6.50.

4. Environmental wastage has been minimized by utilizing steel industrial waste in road sector, natural aggregates are replaced very well and conserved.

5. The industrial steel slag can be used well in order to prohibit Soil pollution.

6. Slag can be used anywhere in road sector, we can replace the top layered metal by material enhancing the resistance against skidding due to this property of slag it can be used for sloping gradients of roads.

7. The Expansion of steel slag is less hence it can be used in different mix proportions:-

a) 70% sand and 30% steel slag
b) 50% sand and 50% steel slag
c) 30% sand and 70% steel slag

A. Utilization of slag for other purposes:

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

2. Basalt, granite, these are all natural stones that has useful characteristics. But to use of them, they have to be quarried. In many fields, application of natural stone can be replaced with slag products.

3. Slag is mostly used for the manufacturing of blast furnace slag cement.

4. Slag can be used for manufacturing of bricks that can be replaced by natural resources which are scarce.

5. Slag can be used in low-lying area as filler material.

V. REFERENCES

[1]. A. Asokan Pappu, Mohini Saxena, Shyam R. Asolekar, “Solid wastes generation in India and their recycling potential in building materials”. Journal on Building and Environment volume 42 (2007) pp -211-232

[2]. B. J.K. Mohapatra and B.P. Chandrasekhar, RURAL ROADS" Indian Infrastructure Report pp 120 JOHN EMERY, "STEEL SLAG UTILIZATION IN ASPHALT MIXES" Canadian Technical Asphalt Association Proceedings,(1984) MF 186-1.
[3]. C. Report of National Slag Association, Blast Slag Used as Sub Base Aggregate to Minimize Load Stresses on Soft Soils." MF 185-7,(2003) .
[4]. D. Rodica Istrate, Adrian Calimente, "Slag Road Construction- Experience and Solutions", Journal of Engineering Annals of Faculty of Engineering Hunedoara, (2009) Tome VII Fascicule 3, (ISSN 1584) .
[5]. E. Marko Makikyro , "Industrial slag use in engineering: slag in the geotechnical project." Proceeding of International conference on practical applications in environmental geo-technology,(2000), and also international journal Geological Survey of Finland, special paper 32, 2001, PP 31-37.
[6]. F. S. Diener, L. Andreas, I. Herrmann And A. Lagerkvist (2007), "Mineral transformations in steel Slag used as landfill cover liner Material" Proceedings Sardinia 2007, Eleventh International Waste Management and Landfill Symposium, S. Margherita di Pula, Cagliari, Italy, October,2007