International Journal of Innovative Research in Science and Engineering
Vol. No.2, Issue 10, October 2016
www.ijirse.com
ISSN (O) 2454-9665
ISSN (P) 2454-0663

EFFECTIVE USE OF BLAST-FURNACE SLAG IN ROAD CONSTRUCTION PROJECTS IN INDIA

[1]Mr. KundanPawar, [2]Mr. Shivam Singh, [3]Mr. Sanjay Gupta, [4]Prof. Siddesh K. Pai

[1, 2, 3]Student of Post Graduate Program in Advance Construction Management
National Institute of Construction Management and Research (NICMAR), Goa.
[4] Assistant professor, National Institute of Construction Management and Research (NICMAR), Goa & Research scholar, University of Petroleum and Energy Studies (UPES), Dehradun.

ABSTRACT

India's economic growth plan of over 6 % per annum for the next 20 years will, to a great extent depend on an efficient road infrastructure not only national highways but other roads to, including link roads for rural connectivity, which can provide fast movement of goods and people with safety and economical cost to the user. Government of India has drawn up Pradhan Mantri Gram SadakYojna (PMGSY) for implementation of rural connectivity. It is estimated that in next 7 years roadwork, under PMGSY worth Rs.1,20,000Crore are to be constructed/ upgraded.

Since Road Pavement are an important parts of these projects costing about 50% of the investment, a careful evaluation of the alternatives is necessary to make the right choice on a rational basis, which may be comparatively more beneficial to the nation. India has a wide network of roads comprising of National Highways and expressways. But, the quality of these roads is significantly not up to the standard as compared to the developed countries and India is still using conventional materials for construction of roads. Blast Furnace slag has been used for development of pavement in the form of slag aggregate and GGBS in Cement by many developed countries for rigid pavement construction.

Keywords: Blast Furnace Slag, Bituminous Roads, Concrete Roads, Industrial Waste

I. OBJECTIVES

To study the feasibility of Blast furnace slag produced from steel plant by:

1. Effect of replacing conventional materials by alternate raw materials like blast furnace slag.
2. Performingcomparison of properties & cost between conventional aggregates and blast furnace slag aggregate.
3. Performing Cost comparison between cement used in concrete roads and Ground Granulated Blast Furnace Slag Cement.
4. Reuse of Industrial waste from steel plants and constructing environment friendly roads.

II. INTRODUCTION

2.1 Current Scenario of Road And Problems Faced

Current Progress of Roads and Planned expansion of Roads as per 12th fifth year plan (2012-2017):

Fig.1 [1]

Phase	Total Length(Km)	Length Completed(Km)	Length Under Imp.(Km)	To be Awarded (Km)
GQ,EW-NS Corridor,Port Connectivity & Other	7522	7442	80	-
4/6-Lanning North South, East West Corridor, Others	6647	5302	901	444
Upgradation,4/6-Lannning Phase III(Phase IIIA+IIB)	12109	2555	6173	3390
IV 2-lanning with paved shoulders	20000	-	846	19154
V 6-laning of GQ and High Density Corridor	6500	653	1984	3863
VI Expressways	1000	-	NIL	1000
VII Ring Roads, Bypasses and flyovers and other structure	700 Km of ring roads/bypass + flyovers	-	41	659

Most of the Indian roads are unsurfaced (42.65%) and are not suitable for use of vehicular traffic & other problems associated with Indian roads are as follows:

2.1.1 India has Poor Quality Roads and Highways

Although India is home to over fifty national highways the sad state of affairs is that most national highways are just two lanes or even lesser. The design of the highways is a matter of great importance since only properly designed highways can withstand the pressure created by heavy vehicles. Apart from being narrow they are also highly congested since quite a large part of India's freight is carried on these highways.[2]

2.1.2 Rural Areas have Bad Roads

India is home to quite a large rural population. Most of the rural areas in India do not have access to all weather roads and hence have a tough time during the monsoons. This problem is more significant in the northern and northeastern part of the country. The government in its 11th five year plan has allotted Rs 100,000 Crore for the construction and maintenance of roads in villages. [2]

2.1.3 Urban Areas are Severely Congested

Traffic is one common problem in most of the metropolitans today. Cities like Mumbai, Delhi, and Kolkata are extremely congested during office hours. This is mainly because of industrialization and the sudden rise in vehicle ownership over the last few years. If India wants to be in tandem with the growing traffic, the government will need to construct around 15,000 km expressways in the next ten years. Currently India's annual expenditure on the road sector is around Rs 20,000-30,000 Crore. One of the major reasons behind this huge expenditure on maintaining roads is due to the problems of overloading and poor maintenance.[2]

One of the major reasons for the damage of roads in India is overloading. It is said that about 70 percent of funds meant to be spent for the maintenance of roads actually goes behind paying laborers. The magnanimity of the expenditure incurred in order to repair roads is alarming and hence the government is stressing on building large scale concrete roads instead of the common bituminous roads. Although building concrete roads is a little expensive but it is beneficial for the country in the long run& cost can be reduced by using steel & iron slag for construction. India's road network is extensive and accounts to almost 3.3 million km which is only to the United States of America which has a total road network of 6.3 million km.[2]

Transportation in developing countries is of great significance because of its contribution to national and regional economic, industrial, social, and cultural development. However, most developing countries are facing problems related to traffic and transportation. Inadequate transportation facilities retard the process of socioeconomic development in a country. Especially in a heavily populated country such as India, managing different aspects of transportation is a difficult task. The most important problem concerning highway/transportation professionals in India is that of highway safety. Ministry of Transport figures show that approximately 60,000 people died in road accidents in 1992. The fatality rates are high in many cities in the subcontinent. India has the dubious distinction of accounting for 6 percent of the world's road deaths while having just 1 percent of the world's vehicles.[2]

2.2 Various Problems Faced For Rigid Pavement Construction

2.2.1 Cement Problem

Cement industry, which has a direct co-relation of 1.1 to 1.2 with GDP, plays a pivotal role in the infrastructure development of the country. Buoyed with various infrastructure policies and schemes of the government, particularly after 1982 (partial decontrol) of cement, this industry had added substantial cement capacities year-after-year, much ahead of the actual cement demand taking place.

- **Disparity in pricing of cement across the country.**

- Different states have different rates for cement because of cartelization by cement manufacturers across the country. This causes unavailability of cement at nominal prices.[3]

2.2.2 Health and Environmental Effects of Cement Plant

- Cement plants are a significant source of sulfur dioxide, nitrogen oxide and carbon monoxide, which are associated with the following health and environmental impacts:
- Nitrogen oxide (NO2) can cause or contribute to a variety of health problems and adverse environmental impacts, such as ground-level ozone, acid rain, global warming, water quality deterioration, and visual impairment. Affected populations include children, people with lung diseases such as asthma, and exposure to these conditions can cause damage to lung tissue for people who work or exercise outside.
- Sulfur dioxide (SO2) in high concentrations can affect breathing and may aggravate existing respiratory and cardiovascular disease. Sensitive populations include asthmatics, individuals with bronchitis or emphysema, children, and the elderly. SO2 is also a primary contributor to acid deposition, or acid rain.
- Carbon monoxide (CO) can cause harmful health effects by reducing oxygen delivery to the body's organs and tissues, as well as adverse effects on the cardiovascular and central nervous systems. CO also contributes to the formation of smog (ground-level ozone), which can cause respiratory problems.[4]

2.2.3 Environmental Effect of Excavation for Aggregate & Cement:

- Creating the pits or quarries requires the removal of virtually all natural vegetation, top soil and subsoil to reach the aggregate underneath. Not only does this lead to a loss of existing animal wildlife, it also leads to a huge loss of biodiversity as plants and aquatic habitats are destroyed. Moreover, adjacent eco-systems are affected by noise, dust, pollution and contaminated water.[5]
- Pits and quarries disrupt the existing movement of surface water and groundwater; they interrupt natural water recharge and can lead to reduced quantity and quality of drinking water for residents and wildlife near or downstream from a quarry site.
- Most old pits and quarries are not being properly rehabilitated.
- Potential impairment of water quality on the site, including harm to the aquifer
- The water quality of residential wells close by could be harmed
- The water level of on-site lakes could be reduced, detrimentally affecting provincially specific wetlands
- Heightened summer water temperature in an on-site lake could have a detrimental impact
- Potential harm to on-site and off-site wetlands.
- Loss of natural habitat.
- Potential loss and fragmentation of continuous natural environment [5]

2.3 Blast Furnace Slag as a Problem Solver

Effect of Replacing Conventional Materials by alternate raw materials like blast furnace slag

2.3.1 Change in Ultimate Strength and Setting Time of concrete

Fig 2 [6]

Concrete Type	Curing Temp(Degree Celsius)	Setting Time		Ultimate Strength(MPa)
		Initial	Final	
100% OPC	6	0.413	0.667	63.79
	20	0.208	0.292	79.82
	35	0.163	0.208	63.28
	60	0.100	0.117	87.34
	80	0.075	0.092	68.78
30%Slag,&70%OPC	6	0.463	0.675	62.26
	20	0.258	0.354	77.34
	35	0.138	0.179	60.94
	60	0.083	0.100	58.09
	80	0.075	0.083	67.66
50%Slag,50%OPC	6	0.525	0.783	80.39
	20	0.254	0.383	78.86
	35	0.133	0.179	54.49
	60	0.092	0.117	59.63
	80	0.071	0.083	74.52

2.3.2 Change In Specific Gravity

Steel slag contains sufficient amount of iron oxide, therefore it has greater value of specific gravity as compare to the natural aggregates. Number of researchers has evaluated the specific gravity of other construction materials and that of steel slag fall within the range of 3 to 4. Steel slag is about 20 % heavier than the lime stone and granite. This may be an economic disadvantage, but is not considered, as it provides more advantages like high strength and durability.[7]

2.3.3 Change in Grain-Size Distribution:

Grain size distribution, an important factor which is highly influenced the mechanical properties of the material. It is difficult to break it in to particles of different sizes during its generation in the steel mill. During the cooling process, it breaks down into different particle size containing larger size as boulders up to the sizes of silt. Further it is processed to obtain proper grade of steel slag by crushing plants as discussed earlier. The coarse gradation particles found in the range of about 64mm to 200mm, similarly the medium size particles are up to 64mm. The fine gradation is like well graded sand consisting of varying sizes of gravel up to the silt size particles, retained at No. 4 sieve; 36Mohd. Rosli Hainin et al / Jurnal Teknologi (Sciences & Engineering) 73:4 (2015) 33–38 4.75mm and passing through No 200 sieve; 0.075mm. The silt size particle %age remains within the range of 10% to 15% [7].

2.3.4 Change in Compaction Characteristics

Limited studies have been carried out on the compaction of general steel slag. The results of previous researches show higher values of maximum dry unit weight of steel slag then natural aggregate. Rohde et al., (2003) have studied the compaction characteristics of EAF steel slag of different grades by standard proctor compaction test method [32]. The optimum moisture content and maximum dry weight of EAF steel slag were in the range of 3%-6% and 23-26kN/m3.[7]

2.3.5 Change in Shear Resistance

Steel slags are rough in surface texture, cubical and angular as compare to the natural material. It provides better interlocking and friction which results stability, resistance to rutting and higher skid resistance. The friction angle of steel slag is reported 40^0 to 50. Because of its better shear resistance, can be use all the layers of pavements.[7]

2.3.6 Change in Thermal Properties

It has been noticed that steel slag, has a potential to retain the heat as longer than natural aggregate. The heat retention property of steel slag aggregate is an advantage. It helps to prepare hot mix asphalt concrete to coat the aggregates properly specially repairing of pavements surface in cold weather [7].

III. PERFORMING COMPARISON OF PROPERTIES & COST BETWEEN CONVENTIONAL AGGREGATES AND BLAST FURNACE SLAG AGGREGATE

3.1 Property Comparison of Aggregates

Fig 3 [8]

No.	Name of Test	Steel Slag Aggregate	Results Of natural Aggregate
1	Water Content	7.62%	14.28%
2	Bulk Density	18.74	1.87
3	Specific Gravity	2.71	2.6
4	Liquid Limit	10.78%	48%
5	Shrinkage Limit	12.90%	25%
6	MDD	1.58g/cc	1.9g/cc
7	OMC	9.67%	14%
8	California Bearing Ratio	15.57	7.6
9	Impact Value	13.90%	12.03%
10	Flakiness Index	4.80%	22.75%
11	Water Absorption	1%	1.01%
12	Aggregate Crushing Value	5.20%	10.21%

3.2 Cost Comparison of Aggregate

Fig 4 [9]

Cost Of Steel Slag Aggregate(per Ton)	Cost Of natural Aggregate(Per Ton)
Rs.800 (Table – 4 ,Page 6,Indian MineralsYearbook 2013(Part- II : Metals & Alloys)52nd Edition)	Rs. 1200(Construction Aggregate Metal)(http://www.indiamart.com/uttamenterprisemumbai/construction)aggregates.html#aggregate-metals

3.3 Cost comparison between cement used in concrete roads and Ground Granulated Blast Furnace Slag Cement

Fig 5[10][11]

OPC Cement Rate(Per 50Kg Bag)	GGBS Cement Rate(per 50Kg Bag)
Rs 360(For 43Grade JP cement)(http://www.materialtree.com/building-materials/cement/43-grade-cement)	Rs. 300(For Poona GGBS Cement) (http://www.indiamart.com/sonatadesignertiles/poona-ggbs-cement.html#poona-ggbs-cement)

IV. CASE STUDY

4.1 Utilization of Steel Slag in Roads of Marathwada Region

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 tons Billets/ Ingots every day, wasting 20% i.e.12000 tons 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.[8]

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 differencein 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. [8]

4.2 Construction Procedure Adopted At Marathwada

4.1.1 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.

4.2.2 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.

4.2.3 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.[8]

V. CONCLUSION

There is tremendous need for raw materials needed for pavement construction like aggregates and cement. But we have tremendous shortage of aggregates in India. Also cement, primarily used in concrete road construction has serious implications on environment and natural resources. In this paper we try to study the use of processed slag as a green construction material which is capable to satisfy industry demands in the foreseeable future in an economical way. Steel slag is an unavoidable by product in Iron and Steel making. Using slag instead of natural materials is a sustainable alternative with high durability in several applications. Slag is exceptionally well suited for road construction, both as asphalt and other construction materials, possesses a number of positive characteristics such as durability and high skid resistance. Using slag is a solution that addresses the economic, technical as well as environmental impact of road construction. The usage of slag results in far more cost savings than using natural materials. Running a basic cost analysis, quarrying and producing natural materials and manufactured aggregates is eliminated to a large degree by using steel slag available at very competitive prices. Using industrial co products in place of traditional material conserves reserves of naturally occurring material. There are potential environmental impacts associated with aggregate extraction including the conversion of land use, changes to the landscape, loss of habitat, noise, dust, blasting effects, erosion, and sedimentation. In addition, extracting aggregate from some areas may alter the dynamic equilibrium of the area, resulting in cascading environmental impact. In addition to that there is also a question of the quality of natural aggregates. With these factors considered, slag is an economically, technically and environmentally sound choice to replace natural materials

This paper reviewed the engineering properties of steel slag. Steel slag has a number of advantages with high engineering properties. It has been declared a useful construction material not an industrial waste. Literature showed that steel slag has enough potential and can be utilized in subgrade or embankments, but very rare research have been done in this area. Economically the steel slag may be cheaper if utilized in urban roads but it would be expensive for rural roads due to the transportation charges.

A. Cost of steel slag aggregate & GGBS cement is less in comparison to conventional aggregate & cement. Therefore it can be used for replacing conventional material for road construction.
B. 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.
C. The expansion of slag is very less so we can replace the expansive soil by utilizing this industrial slag rather than utilizing murum.
D. The industrial slag which is wasted anywhere that can be utilized, very well, so soil pollution that can be prohibited.
E. This slag can be used in anywhere in road sector, we can replace the top layered metal by replacing the slag with bituminous cementing material enhancing the resisting against skidding due to this property this special slag can be utilized on the sloping gradients of roads.

REFERENCES

[1] Ministry Of Road Transport and Highways,. 12Th Five Year Plan (2012-17) Report Of The Working Group On Central Roads Sector. Planning Commission, 2011. Print.
[2] Bad Roads In India". Badroadsinindia.com. N.p., 2016. Web. 7 Oct. 2016.
[3] Indian Cement Review Magazine | Emerging Trends & Challenges In Indian Cement Industry". Indiancementreview.com. N.p., 2012. Web. 8 Oct. 2016.
[4] Cement Manufacturing Enforcement Initiative | Enforcement | US EPA". Epa.gov. N.p., 2016. Web. 7 Oct. 2016.
[5] The Environmental Impacts of Aggregate Extraction | Toronto Environmental Alliance". Torontoenvironment.org. N.p., 2008. Web. 7 Oct. 2016.
[6] USE OF BLAST-FURNACE SLAG IN ROAD CONSTRUCTION. Raichur: NIT Raichur, 2016. Print.
[7] Hainin, Mohd. Rosli et al. "Steel Slag As A Road Construction Material". Jurnal Teknologi73.4 (2015): n. pag. Web.
[8] Koranne, Shubhada S. and S. S. Valunjkar. "UTILISATION OF STEEL SLAG IN ROADS OF MARATHWADA REGION". INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT] 2.7 (2016): 5. Web. 7 Oct. 2016.
[9] http://www.materialtree.com/building-materials/cement/43-grade-cement
[10] Poona GGBS Cement Manufacturer From Pune". Indiamart.com. N.p., 2016. Web. 8 Oct. 2016.
[11] Poona GGBS Cement Manufacturer From Pune". Indiamart.com. N.p., 2016. Web. 8 Oct. 2016.

[12] Indian Minerals Yearbook 2013 (Part- II : Metals & Alloys) 52nd Edition SLAG-GOVERNMENT OF INDIA MINISTRY OF MINES INDIAN BUREAU OF MINES Indira Bhavan, Civil Lines,NAGPUR – 440 001

[13] JOINT TRANSPORTATION RESEARCH PROGRAM FHWA/IN/JTRP-2009/32 Final Report USE OF STEEL SLAG IN SUBGRADE APPLICATIONS IremZeynepYildirim Monica Prezzi