Analysis of Strength and Durability Of Road Pavement with Stell Slag and Natural Aggregate

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Abstract - Steel slag is a by product from steelmaking industry and has been recycled in many countries around the world for decade. One of the main application of the recycled steel slag is aggregate for asphalt pavement. This particle aims to present an overview of the application of steel slag in the pavement industry covering the regulation in different parts of the world that govern the reuse of steel slag ,how the properties of steel slag influence the strength and durability of the pavement mixtures, and the environmential impact as a result of the reuse of steel slag. This article elaborates on supply chain management issues in steel slag recycling industry, as the quality of steel slag relies not only on the treatment and processing technique but also the way the material are handled throughout their lifetime. This study is evaluates the used of steel slag aggregate in the proportion(SSA) as a substitute for natural aggregate in the production of hot mix plant(HMA) for road construction. Based on intensive laboratory testing program the the characteristic properties of SSA were assessed to determine its suitability to be used HMA. (Four different percentages (0, 50, 75, and 100%) of SSA were used, and the proposed mix designs for HMA were conducted in accordance with Marshall mix design. The experiment results revealed that the addition of SSA has a significant improvement on the properties natural aggregate. An increase in density and stability and a reduction in flow and air voids values were clearly observed in specimens prepared with 100% SSA. It is concluded that the steel slag can be considered reasonable alternative source of aggregate for road construction

Keywords - Steel slag 1, Pavement 2,SSA steel slag aggregate3, Hot mix plant 4

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INTRODUCTION

The use of steel slag as a replacement for natural aggregate in road pavement has gained attention in recent years due to its potential benefits. Steel slag is a byproduct of the steel manufacturing process and can be obtained from steel mills. Its utilization as a construction material helps in reducing waste and conserving natural resources. Steel slag comes from the the steelmaking process. The major fluxing agent, quicklime combine with the impurities in the iron or steel scrap, mainly silica, to from a mineral complex which separate from the purified steel. After being discharged and cooled ,steel slag solidifies to from a rock-like material, which can be processed to replaced natural rock in the construction industry. The slag properties are similar. This research deals with the sustainable replacement of natural aggregate, in which coarse aggregate were partially replaced with steel slag aggregate in the construction of roads and also review the engineering properties of steel slag.

Properties of steel slag

- **Physical properties**

Steel slag aggregates (SSA) possess a high degree of angularity and exhibit either roughly cubical shapes or elongated forms. They have a vesicular nature with numerous non- interconnected cells, resulting in a significantly larger surface area compared to natural aggregates of the same volume. This characteristic enables them to establish a strong bond with bitumen. The rough texture of SSA surfaces promotes particle interlock, and when adequately compacted, they can achieve the high stability necessary for durable pavements. Furthermore, SSA particles have increased porosity, enhanced adhesion to binders due to their surface structure and chemical composition, and favorable shapes.

Chemical Properties

The chemical composition of steel slag is a complex matrix structure that can be determined through elemental analysis using x-ray fluorescence. It primarily consists of simple oxides, with the four major ones being lime, magnesia, silica, and alumina. In addition to these, steel slag contains minor elements such as sulfur, iron, manganese, alkalis, and traces of several others. Steel grades are classified as high, medium, or low based on their carbon content. High-grade steels have a higher carbon content, while the steel-making process requires increased levels of oxygen to reduce the amount of carbon in the steel.

METHODOLOGY

The objective of this coursework was to investigate the feasibility of utilizing slag aggregates in Dense Bituminous Macadam grade-I mix. The suitability of various materials, including coarse aggregate, fine aggregate, bitumen, and slag, was assessed through basic tests. A comparative study was conducted to evaluate the strength of hot bituminous mixes containing slag aggregates compared to conventional aggregates. sThe properties of the bituminous mix were analyzed using the Marshall Stability test in a laboratory setting.

Components of the Hot Bituminous Mix:

1. Coarse aggregate: The material that remains on the 2.36mm IS sieve is considered the coarser fraction. In this study, LD slag and blast furnace slag were used as replacements for conventional coarse aggregate.

2. Fine aggregate: The fraction that passes through the 2.36mm IS sieve and is retained on the 0.075mm IS sieve is considered the fine fraction. Blast furnace slag was used as a partial replacement for conventional fine aggregates

3. Filler: Stone dust and cement were used as fillers in this study.

4. Binder: Viscosity Grade-30 (VG-30) was utilized as the binder in this study.

Necessity of the Use of Steel Slag

With the increase in steel production, there has been a corresponding rise in the production of steel slag. For several decades, steel slag has been utilized as a construction material forpavements. Initially, it was discovered that the remaining material from steel production could be crushed and processed to resemble crushed rock. Subsequent studies and tests were conducted to explore the potential applications of this "by-product," leading to the realization that its rough-textured, vesicular, highly angular, and pitted surfaces provide excellent particle interlock. When appropriately compacted, it can achieve the necessary stability for well-functioning pavements. Some developed countries have successfully implemented technologies to fully utilize the generated waste. While waste utilization has also commenced in India, there is a need for the emergence of technologies and research efforts to maximize the utilization of the generated waste.

Resource conservation: The use of steel slag as a replacement for natural aggregate helps to conserve natural resources. Traditional aggregate extraction from quarries can lead to environmental degradation, habitat destruction, and depletion of finite resources. By utilizing steel slag, the demand for natural aggregates can be reduced, minimizing the need for quarrying and preserving natural resources for future generations.

Price: Steel slag might be a more affordable option than natural aggregates. Steel slag is a byproduct that is frequently accessible and less expensive to purchase than natural aggregates. For infrastructure projects with limited funding, using steel slag in the creation of road pavement can assist cut material costs.

MATERIAL USED

The materials used in testing include bitumen , natural aggregate, and steel slag aggregate. The bitumen used in preparing all specimen of grade VG-30. The natural aggregate used in the study is crushed stone of different size . Steel slag delivered from the byproduct off steel slag manufacturing from steel industry. After the steel slag has been crushed and grade to the desired sizes, it was stockpiled for delivered .The surface texture of the steel slag observed to be quit variable. Steel slag aggregate samples were selected from three different from coarse aggregate, fine aggregate, and mineral filler.

RESULT

Table No-1 Aggregate Test Result

Parameter	Steel Slag Aggregate	Natural Aggregate	Requirement as per MoRT &H specification
Impact Value test	26.87 %	18.81 %	Maximum 27
Crushing Value test	21.74 %	30%	Maximum 30
Flakiness Index Test	25.88 %	25.68 %	Maximum 30
Elongation Index Test	27.23 %	24 %	Maximum 30
Water absorption Test	1.86 %	1.97 %	Maximum 2
Specific gravity test	2.7	2.6	2.5-3.0

Table No-2 Mix Design result of Steel Slag and aggregate

Property	Percentage of steel slag aggregate				Requirements as per MoRT&H V revision
	0	50	75	100	
Optimum Bitumen content %	5.1	5.5	6.1	5.3	4.00-7.00
Air Voids	4.6	4	4.2	3.1	3.0-6.0
Stability (Kg)	960	1025	1134	1240	900kg
Flow	2.3	2.7	3.1	3.5	Minimum 2.0

CONCLUSIONS

Strength Improvement: Incorporating steel slag as a partial or complete replacement for natural aggregate in road pavement construction can enhance the strength characteristics of the pavement. Steel slag aggregates exhibit good load-bearing capacity, which contributes to improved structural integrity and resistance against deformation under heavy traffic loads.

Cost-effectiveness: Implementing steel slag in road pavement can offer cost advantages. Steel slag aggregates are often more economical compared to natural aggregates, providing cost savings in road construction projects. Furthermore, the enhanced durability of steel slag-based pavements reduces the need for frequent repairs or resurfacing, resulting in long-term cost-effectiveness

Environmental Benefits: The utilization of steel slag in road pavement aligns with sustainable practices and environmental considerations. By utilizing steel slag as a substitute for natural aggregate, the demand for virgin materials is reduced, conserving natural resources and minimizing the environmental impact associated with quarrying activities. Additionally, recycling steel slag reduces waste and landfill usage.

Skid Resistance and Safety: Steel slag aggregates typically possess a rough texture and angular shape, which improves skid resistance and enhances road safety, especially during wet or slippery conditions. The increased frictional properties of steel slag-based pavements contribute to better vehicle control and reduced accident risks

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