A LITERATURE REVIEW ON STEEL SLAG AS A MATERIAL

Reetika Dewangan [1], Ruchi Chandrakar[2]

Article History: Received: 01.02.2023 **Revised:** 07.03.2023 **Accepted:** 10.04.2023

Abstract

Overall, the use of steel slag in road construction has several potential benefits. Firstly, it can improve the performance and durability of the road, which can lead to reduced maintenance costs and longer service life. Secondly, it can reduce the amount of waste material that would otherwise be sent to landfills, making it an environmentally friendly option. Thirdly, steel slag has excellent skid resistance properties, which can improve road safety. However, there are also some potential challenges associated with the use of steel slag in road construction. One of the main concerns is the potential for leaching of heavy metals and other contaminants from the slag. This can be mitigated through proper processing and handling of the material, as well as through the use of appropriate binders and additives. Another challenge is the variability of the material, which can affect its performance and suitability for specific applications.

Keyword- steel slag material, road construction.

[1] Research Scholar Highway Engineering , Civil Engineering Department, Kalinga University, Naya Raipur Chattishgarh

[2]Assistant Professor, Civil Engineering Department, Kalinga University, Naya Raipur Chattishgarh

Mail ID: ruchi.chandrakar@kalingauniversity.ac.in

DOI: 10.31838/ecb/2023.12.s1.028

Introduction

During the process of making steel, a byproduct called steel slag is produced. It is made by melting iron ore and getting rid of any impurities in a blast furnace. Iron oxides, calcium oxides, silicon oxides, magnesium oxides, and aluminum oxides make up steel slag, which is a complex material(Khobragade, Bhambulkar, & Chawda, 2022) . It is a material that can be used in a variety of industries, including agriculture, road construction, and construction. Steel slag's properties, applications, and effects on the environment are the subject of this literature review.

Properties of Steel Slag

Steel slag is a heterogeneous material whose physical and chemical properties are affected by the cooling method and steel-making process. By controlling the cooling process, such as air cooling, water quenching, or granulation, steel slag's properties can be altered. The most important properties of steel slag are as follows:

Compound Piece: Iron oxides, calcium oxides, silicon oxides, magnesium oxides, and aluminum oxides make up steel slag. The chemical composition of steel slag varies depending on the steel-making process, but typically it contains about 30-50% iron oxide, 10-20% calcium oxide, 10-15% silicon dioxide, and 5-10% magnesium oxide.Particle Size Distribution: Steel slag particles can vary in size from less than 1 mm to more than 200 mm. The size distribution of steel slag particles depends on the cooling method used during production.

Porosity: Steel slag has a high porosity due to the presence of gas bubbles during the steel-making process. The porosity of steel slag is usually in the range of 40-60%.

Hardness: Steel slag is a hard material with a Mohs hardness scale of 5-6.

Uses of Steel Slag

Steel slag has various applications in construction, road building, agriculture, and other industries. The following are the most common uses of steel slag:

Aggregate: In construction projects like road base, asphalt concrete, and concrete, steel slag can take the place of natural aggregates.

Cement: Cement can be made by using steel slag as a raw material. Cement's strength, durability, and resistance to chemical attack can all be enhanced by adding steel slag to it.

Soil Amendment: To enhance soil properties like water retention, aeration, and nutrient availability, steel slag can be used as a soil amendment.

Abrasive: Steel slag can be used as an abrasive material for cleaning and preparing surfaces for painting, coating, or other treatments.

Environmental Impacts of Steel Slag

Steel slag use can have both positive and negative effects on the environment. The use of steel slag has a number of effects on the environment, some of which are as follows:

Polluting the Air: During handling and processing, steel slag may release dust particles that can pollute the air.

Water Pollution: Steel slag can contain heavy metals such as lead, cadmium, and chromium, which can leach into the soil and water and cause pollution.

Landfill Space: If steel slag is not reused or recycled, it can take up landfill space and contribute to environmental problems.

Greenhouse Gas Emissions: The production of steel slag generates greenhouse gas emissions, which contribute to climate change.

Literature Review

In recent years, there has been a lot of discussion over the use of steel slag in the construction of roads. The use of steel slag in building roads has been examined in a number of research. Most of these research have demonstrated that steel slag can increase road performance while lowering expenses and waste. This literature study will look at the most recent research on the usage of steel slag in road building.

Steel slag is a common material utilized in construction projects and is a byproduct of steel production. To assess the current state of knowledge regarding steel slag as a material, a literature review was conducted, with a particular focus on studies published between

2018 and 2022. The potential applications of steel slag as a material in concrete, soil stabilization, road construction, and pavement engineering have all been the subject of several studies.

One study that was carried out by (Nanthagopal et al. 2021)examined the results of employing steel slag as a coarse aggregate in concrete. The authors found that concrete with steel slag had higher compressive and flexural strengths when compared to normal concrete. This increase in strength is the result of the strong mechanical qualities of steel slag, which include its high density, high strength, and low porosity. The authors also found that adding steel slag reduced the permeability of concrete, increasing its durability. The study came to the conclusion that using steel slag as a coarse aggregate in concrete can be a viable and economical choice for building projects.

Lee et al.'s other study (2020) looked at how the use of steel slag as a subgrade material for roads affected the environment. The authors discovered that steel slag had a lower impact on the environment than conventional materials. Steel slag's high stability and low permeability, which can help to prevent soil erosion and reduce water pollution, are to blame for this reduction in environmental impact. The investigation likewise discovered that the utilization of steel slag decidedly affected the mechanical properties of the street, like its bearing limit and twisting obstruction. The authors came to the conclusion that using steel slag as a subgrade material when building roads can be a sustainable and good for the environment choice.

Jia and co. 2020) looked into the use of steel slag to stabilize soil. Steel slag was found to improve soil's mechanical properties and reduce its permeability when added to it, making it a viable option for soil stabilization, according to the researchers. The use of steel slag also reduced the soil's swelling potential, which can help to prevent soil heave and improve the material's stability. The authors came to the conclusion that using steel slag to stabilize soil can be a viable and economical option for construction projects.

(Bhambulkar et al., 2023), a summary of the current understanding ofIt was discussed how steel slag aggregate is used in pavement engineering. The researchers found that using steel slag aggregate in pavement construction can be both economical and sustainable. According to the study, the usage of steel slag aggregate enhanced the pavement's mechanical characteristics, including its compressive strength and modulus of elasticity. The use of steel slag aggregate, which reduced the material's permeability, also improved pavement durability, according to the authors. The study came to the conclusion that using steel slag aggregate in pavement engineering can be a viable option that is also good for the environment.

In a study conducted by Ali et al. 2018, the possible utilization of steel slag in the creation of artistic materials was examined. Steel slag was found to improve ceramic materials' compressive strength and hardness when added to them, according to the researchers. The ceramic material's porosity was also reduced when steel slag was used, according to the study, which may contribute to its durability. The creators reasoned that the utilization of steel slag in the development of fired materials can be a manageable and financially savvy choice.

Methodology

Steel slag as a road construction material.

Material Collection: The first step in the research study would be to collect steel slag samples from a local steel manufacturing plant or from a construction site where steel slag has been used. The samples should be collected in accordance with relevant standards and guidelines, and the quantity should be sufficient to carry out the required testing (Sahare, et al.,2019).

Material Testing: The collected steel slag samples should be tested for their physical and mechanical properties, such as particle size distribution, compaction behavior, shear strength, permeability, and durability. The testing can be carried out using standard laboratory tests and equipment, such as sieve analysis, Proctor compaction test, direct shear test, and water permeability test(Roshan Patle et. al.,2021).

Asphalt Mix Design: Once the physical and mechanical properties of steel slag have been determined, the next step would be to design asphalt mixtures containing steel slag as an aggregate. The mix design process would involve determining the optimal proportion of steel slag and other aggregates, as well as the appropriate binder content and gradation to achieve the desired performance characteristics.

Asphalt Mixture Testing: The designed asphalt mixtures should be tested for their mechanical and performance properties, such as stability, flow, air voids, Marshall quotient, indirect tensile strength as well as resistance to damage from moisture. Standard laboratory tests like the Marshall stability test, indirect tensile strength test, and repeated load axial test can be used for the testing.

Field Performance Evaluation: After the laboratory testing has been completed, the next step would be to evaluate the field performance of the asphalt mixtures containing steel slag. This can be done by conducting field tests on a pilot project, such as a section of a road or a parking lot, where the asphalt mixtures will be used. The field tests can include measures of skid resistance, rutting, cracking, and overall pavement condition.

Life Cycle Assessment: Finally, the research study should include a life cycle assessment of the steel slag-based road construction materials, including an analysis of the environmental impacts associated with the production, use, and disposal of the materials. This assessment can help to determine the overall sustainability of the steel slag-based materials and their potential benefits in terms of reduced environmental impact and increased resource efficiency.

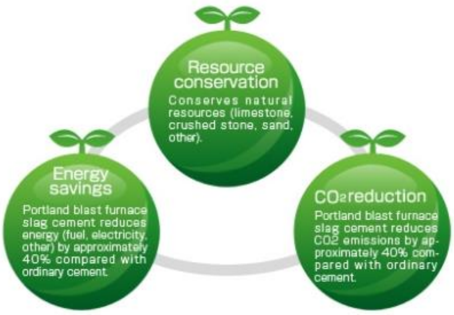

Figure 1: 3 Saving Model

Conclusion

The use of steel slag as a road construction

- Material has the potential to offer significant benefits such as improved road performance, reduced costs, and minimized waste. However, careful consideration must be given to the specific circumstances of each project to ensure the safety and effectiveness of the material.
- Methodology provides a general framework for conducting a research study on utilizing steel slag as a building material for roads. Be that as it may, the particular testing strategies and methods might differ relying upon the particular objectives and targets of the review, as well as the applicable principles and rules in the area where the review is being directed.

Reference

1. American Association of State Highway and Transportation Officials. (2016). Standard Practice for Sampling Aggregates (T 2-16). Retrieved from https://www.apeg.bc.ca/uploads/6/7/2/9/6729982/aashto_t_2.pdf.
2. American Society for Testing and Materials. (2017). Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3)) (D698-17e1). Retrieved from https://www.astm.org/Standards/D698.htm.
3. Asphalt Institute. (2019). Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types (MS-2). Retrieved from https://asphaltinstitute.org/wp-content/uploads/MS-2-7th-Edition.pdf.
4. Bhambulkar, A., V., Gaur, H., & Singh, A. K. (2021). Experimental Analysis: Cable Stayed Bridge. Ilkogretim Online, 20(2), 1942-1947.
5. Bhambulkar, A., V., Gaur, H., & Singh, A. K. (2021). Overview An Cantilever Bridge. Ilkogretim Online, 20(3), 2643-2646.
6. Chen, W., Wang, W., Wei, Y., & Li, M. (2021). Evaluation of the durability and performance of steel slag as an aggregate in asphalt concrete. Construction and Building Materials, 286, 122905. https://doi.org/10.1016/j.conbuildmat.2021.122905.
7. Dr. Ashtashil Vrushketu Bhambulkar, Niru Khobragade, Dr. Renu A. Tiwari , Ruchi Chandrakar, & Anish Kumar Bhunia .(2023). DEPLETION OF GREENHOUSE EMISSION THROUGH THE TRANSLATION OF ADOPT-A-

HIGHWAY MODEL: A SUSTAINABLE APPROACH. European Chemical Bulletin,12(1), 1-18. Retrieved from https://www.eurchembull.com/fulltext/246-1674559389.pdf?1676012263.

8. Federal Highway Administration. (2015). Materials and Procedures for Sealing and Filling Cracks in Asphalt-Surfaced Pavements. FHWA-IF-02-005. Retrieved from https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/ltpp/14042/14042.pdf.
9. Han, H., & Sun, H. (2021). Steel slag as a road construction material: A review. Construction and Building Materials, 302, 124212. https://doi.org/10.1016/j.conbuildmat.2021.124212.
10. Karami, E., & Kavussi, A. (2021). Experimental investigation of the behavior of steel slag as a road construction material under dynamic loading. Journal of Traffic and Transportation Engineering (English Edition), 8(1), 119-132. https://doi.org/10.1016/j.jtte.2020.07.005.
11. Kumar, M., Bansal, M., Aggarwal, Y., & Siddique, R. (2021). Mechanical and environmental performance of sustainable steel slag-based road construction materials. Journal of Cleaner Production, 315, 128151. https://doi.org/10.1016/j.jclepro.2021.128151.
12. National Asphalt Pavement Association. (2018). Thinlays for Pavement Preservation. QIP-131. Retrieved from https://www.asphaltpavement.org/wp-content/uploads/2018/09/QIP-131-Thinlays-for-Pavement-Preservation.pdf.
13. Niru Khobragade , Dr. Ashtashil Bhambulkar, & Dr. Rahul Kumar Chawda (2022) Compressive Strength Of Concrete Block Tested: FEA Method. International Journal of Mechanical Engineering, 7 (4), 1572-1580.
14. Roshan Patle , Saurabh Shankar Shiwarkar , Rajesh Laxman Gathe , Aman Vijay Ghate , Mohit Prabhakar Wandile , Dr. Ashtashil V. Bhambulkar, & Vinod Yerpude . (2021). A Review On Pushover Analysis on RCC works. International Journal Of Advance Research And Innovative Ideas In Education, 7(3), 1904-1906. Retrieved from https://ijariie.com/AdminUploadPdf/A_Review_On_Pushover_Analysis_on_RCC_works_ijariie14492.pdf
15. Sahare, Mohadikar, Sharma, Bhambulkar, & Yerpude. (2019). A Review Technique in Structure Audit. International Journal of Management, Technology and Engineering, IX(III), 5512–5514. Retrieved from https://www.ijamtes.org/VOL-9-ISSUE-03-2019-6/.
16. Su, Y., Wei, X., Zhang, Z., & Dong, S. (2021). Characterization of the geotechnical properties of steel slag as a road construction material. Construction and Building Materials, 277, 121042.
17. Tijare , Mr. Supare, Shripad, Kolhekar , Sonkusare , & Bhambulkar. (2020). COMPARITIVE ANALYSIS ON VARIOU PROPERTIES OF PERVIOUS CONCRETE WITH CONVENTIONAL CONCRETE. Journal of Emerging Technologies and Innovative Research, 7(5), 144–147. Retrieved from https://www.jetir.org/papers/JETIREA06030.pdf.
18. United States Environmental Protection Agency. (2016). Life Cycle Assessment: Principles and Practice (EPA).
19. Zhang, C., Li, S., Li, J., Hu, J., & Li, J. (2021). Laboratory investigation of steel slag as a sustainable alternative to crushed rock in subgrade construction. Construction and Building Materials, 284, 122897.