American Journal of Science and Learning for Development

ISSN 2835-2157
Volume 2 | No 9 | Sep -2023

A Review on Utilization of Industrial Wastes and Byproducts in Highway Construction

Md. Faiyaz Alam [1], Ajay Kumar [2], Ritesh Kumar [3]

[1, 2] Assistant Professor, Department of Civil Engineering, Sandip University, Madhubani, Bihar, India

[3] Research Scholar, Department of Civil Engineering, Sandip University, Madhubani, Bihar, India

Abstract: *Industrial waste and their disposal are currently a major issue in India while highway materials such as crushed stone, sand, and gravel are in high demand, yet economic resources are often scarce. The development of significant amounts of industrial waste necessitates not only its disposal, but also its treatment prior to disposal in order to reduce contamination of soil, water, and air. Given the sharp increase in the number of factories and industries, it is important to understand the advantages of waste materials that can be recycled and used in various ways. Adopting these waste materials from industry for highway construction is the best use for them. These aspects are also a factor influencing production costs. So, the current study is concerned with the utilization of waste materials in highway construction, including waste tires, waste glass, retrieved paving materials, slag and ashes, construction rubble, and sewage waste. Based on technical, environmental, and economic factors, reclaimed paving materials, coal fly ash blast furnace slag, boiler slag, steel slag, and rubber tire have significant potential to replace conventional materials in various applications in highway construction and should be projected for future construction. Increased use of wastes and byproducts will reduce demand for accessible materials while also assisting in the resolution of many disposal issues.*

Keywords: *Industrial wastes, Byproduct, Environment, Highway construction.*

1. Introduction

Building roads is a crucial component of infrastructure development since it helps to link and grow cities and regions. However, the traditional techniques for building roads frequently rely on finite natural resources, causing environmental damage and a rise in carbon emissions. Sustainable procedures and the use of industrial waste materials for road construction have gained popularity in recent years.

Industrial waste materials generated during diverse manufacturing processes provide substantial disposal and management issues. These waste materials, on the other hand, frequently have unique qualities that make them ideal alternatives to typical construction materials. We can gain several benefits by using industrial waste materials into road building, including reduced environmental impact, natural resource conservation, and increased road performance. One of the primary benefits of using industrial waste materials in road construction is the possibility of reducing landfill waste. By diverting these products from landfills, we can reduce the impact on already overburdened landfills while also supporting a circular economy approach. Incorporating industrial waste materials into road building not only helps to address the waste management crisis, but it also improves the construction industry's overall sustainability. Furthermore, the use of industrial waste materials can

All rights reserved. © 2023

result in large reductions in carbon emissions. Traditional road construction materials, such as asphalt and concrete, need a lot of energy to make and contribute significantly to greenhouse gas emissions. We may reduce the carbon footprint connected with road construction by substituting a portion of these materials with industrial waste products, contributing to worldwide efforts to mitigate climate change. Furthermore, industrial waste materials frequently have useful properties that might improve road performance. Certain waste materials, for example, have good binding characteristics making them appropriate for use as road stabilizers or fillers. These materials have the potential to improve the longevity, strength, and robustness of road surfaces, enabling more durable and economical infrastructure.

To summarize, using industrial waste materials in road building is a viable strategy to addressing environmental problems, reducing trash output, and improving road performance. We can establish a more efficient and eco-friendly road infrastructure that satisfies the needs of modern civilization while limiting our environmental effect by embracing sustainable techniques and incorporating these materials into construction techniques.

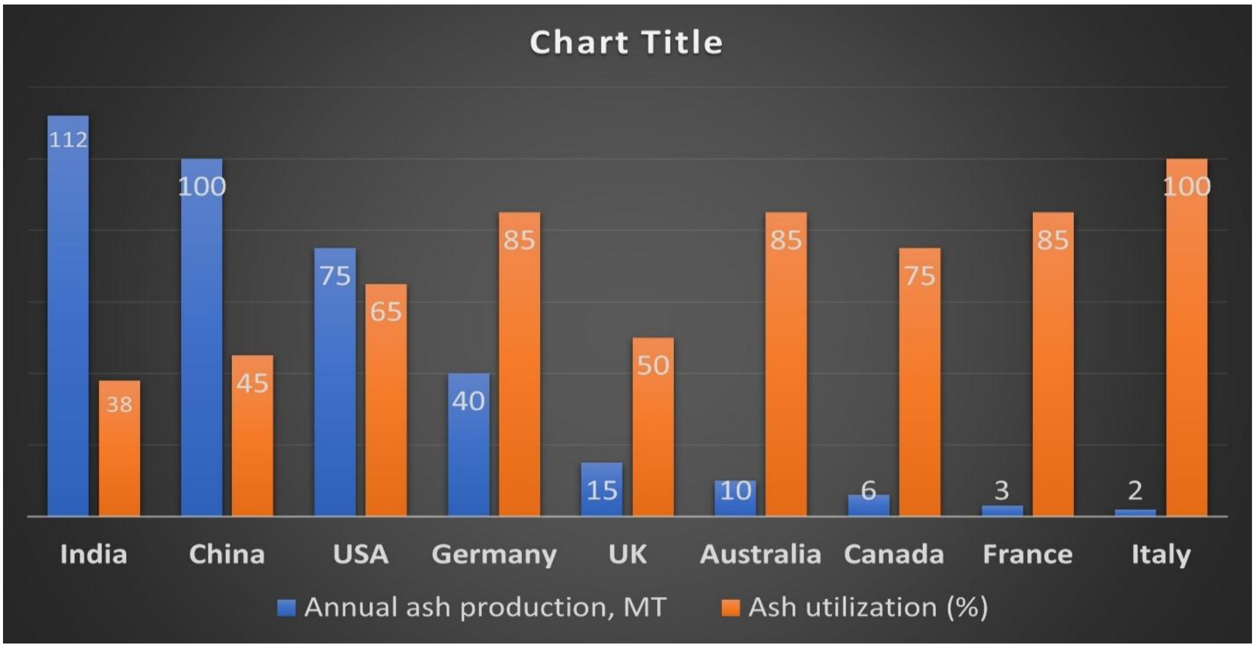
2. Literature Survey

Material characteristics of industrial waste byproducts:

Several industrial waste byproduct materials have been explored for their potential use in road construction. Because of its pozzolanic qualities and propensity to improve the strength and longevity of road pavements, fly ash, a byproduct of coal combustion, has been intensively researched. Fly ash is currently utilized annually in about 20 million metric tons (22 million tons) of technical applications. Portland cement concrete (PCC), soil and road foundation stabilization, flowable fills, grouts, structural fill, and asphalt filler are examples of common highway engineering applications.

S. Kumar and C.B.[1] Currently, more than 70 operational coal-based thermal power plants in India produce about 100 million tonnes of fly ash annually (mtpa). In the next two to three years, this number is anticipated to surpass 120 mtpa; with increased thermal power generation, it will rise even more and might double in the next ten to twelve years. In comparison to affluent nations, India now uses just about 19% of its fly ash resources. A strategy for reducing the amount of resources used in road construction was discussed by S. Kumar and C.B. Patil. Depending on embankment height and pavement type, soil savings by utilizing the fly ash are reported to range from 358 to 1492 kg/m^3 of road formation. It is found that GSB construction cost saved the most natural resources overall, with WBM construction cost and other layers coming in second and third. A road formation with flexible pavement can save around 400 kg of stone aggregate, 70 kg of stone chips, and 15 kilogram of moorum per m^3. Fly ash use in road development results in significant land area savings since it can replace topsoil and lower ash pond size for a given dyke height.

O. Simsek et.al.[2]Due to the increasing global environmental concerns, the recycling of concrete and industrial wastes in the creation of new concrete structures has seen an increase in popularity. In order to better understand how it impacts on the stability of dimension and longevity aspects of fly ash-blended Portland cement concrete, recycled concrete aggregate was investigated in this study at various replacement amounts (0-100%) as fine or coarse aggregate sources. The use of coarse recycled concrete aggregate resulted in better compressive strength values of concrete exposed to with and without wetting–drying and freezing-thawing cycles when compared to fine ones. The 90-day compressive strength of concrete was dramatically increased by the addition of fly ash.



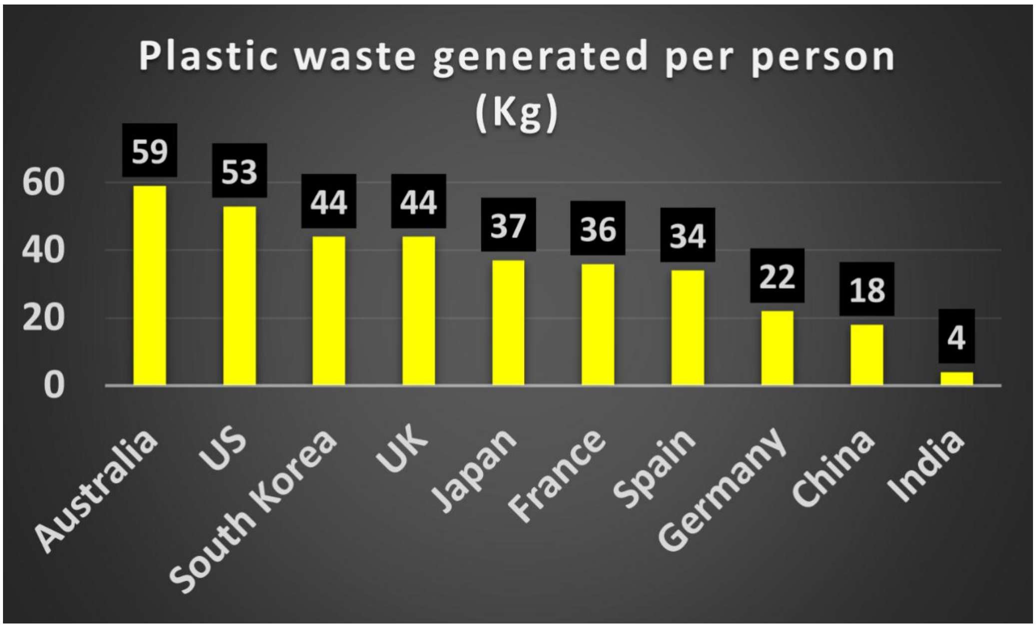
Annual ash production and its utilization by the different countries

G Dondi et.al.[3] The mechanical characteristics of steel slag in this study support its usage as aggregate in the creation of bituminous mixtures. In road construction, they are used to replace fine aggregate and filler in bituminous mixtures. The laboratory performance of the mixes was evaluated using mechanical characterizations, Marshall stability, and indirect tensile resilient modulus (ITSM) tests. The study authors used these materials in the characterization of cementitious layers as well as those with bituminous conglomerate in this investigation. The introduction of steel slag in both cases encouraged an increase in stiffness in the mixtures. The asphalt mixture with a higher percentage of slugs in weight of aggregate has more stability and stiffness. The best mixture contained 4.5% bitumen and 30% slag.

B.G. Buddhdev et. al. [4] The effect of blast furnace slag (BFS) as a fine aggregate, as a replacement of sand to build concrete mostly for pavement, is shown in this work using laboratory tests.The laboratory program comprised material characterization, such as BFS and workability, density, heat of hydration, compressive strength, and flexural strength of concrete using natural sand and BFS. The findings of laboratory studies on concrete with various grades M30, M40, and M50, which are commonly used in pavement construction, have been published.The trial results indicate a prospective use of BFS in concrete manufacturing by replacing natural sand, which surely saves natural resources, as artificial sand is now used for concrete production in metro centers. Finally, this research looks into a novel material called BFS for concrete in general and pavements in particular.

According to the test results given in Table 7, the compressive strength of all grades of concrete with BFS was found to be lower than that of conventional concrete after 7 days of maturation. The compressive strengths of all remaining maturity periods, such as 28, 91, and 365 days, for all classes of concrete with BFS were determined to be greater than the conventional concrete. The greater compressive strength value in concrete containing BFS after 28 days of aging is attributable to nucleation and pozzolanic components present in the BFS. When conventional and BFS specimens were evaluated for compressive strengths, the cracking pattern and failure mechanism of both concretes were discovered to be similar. Up to 7 days, the flexural strength of concrete with BFS is lower than that of regular concrete. However, after 28 days of maturation, the strength of concrete with BFS increases. The flexural strength of BFS concrete is equivalent to conventional concrete because the strength changes are only 1 to 4%.

S Shamim and A Vikram [5] The purpose of this research is to determine how much waste plastic will be produced when a suitable proportion of an admixture such as TiO_2 is blended into the standard plastic waste mix that will be used to make waste plastic pavements. There were two types of plastic trash samples cast, one with Tio2 and one without TiO_2. Both types of samples were created using the Marshall Mix design as required by MORTH (IV revision). Tests such as the Marshall stability test and the indirect tensile strength test were performed on both types of samples, and the results were compared. It was discovered that the Marshall stability and indirect tensile strength tests show a significant increase in their respective values of plastic samples blended with Tio2 when compared to normal plastic waste samples at 17% waste plastic. When compared to regular plastic waste samples, the Marshall stability value was found to be the greatest, while the indirect tensile strength at 17% plastic waste blended with 17% Tio2 showed the highest values. It was discovered that using TiO_2 as an admixture produced excellent results and displayed maximum values for engineering and rheological parameters such as Marshall Stability. This experimental study reveals that the utilization of plastic waste, blended with Tio2, for DBM (dense graded bitumen mix), increased the value of the strength parameter, i.e. Marshall Stability, and the maximum values increased by approximately 35% by the addition of TiO_2& PET.



Plastic waste generation per persion in different countries

A Baikerikar et. al. [6] The purpose of this research is to investigate the combined influence of waste glass powder and waste glass sand as a partial replacement for cement and sand, respectively, in the production of eco-friendly concrete. During the current investigation, cement concrete mixtures with waste glass powder contents ranging from 5% to 25% as cement replacement with 5% incremental steps and glass sand contents ranging from 10% to 50% as fine aggregate replacement with 10% incremental steps were tested. The combination of 5% glass powder and 10% glass sand was determined to be optimal in terms of both strength and durability. The usage of waste glass lowered water absorption as well as chloride ion penetration, showing to be quite beneficial. FESEM and EDX analyses were also performed on the modified samples to observe the morphological and elemental changes that occurred as a result of the concrete alteration. Using an optimized combination of waste glass powder and waste glass sand as cement and fine aggregate replacements, a unique and eco-friendly concrete with increased performance was proposed in this research work.

D Panda and A Satapathy[7] In this investigation, scrap tire crumb rubber (CR) was collected from a local source and employed as a modifier to bituminous mix. Other materials were collected and tested for suitable qualities, such as aggregates, filler, and bitumen. In the Marshall Mix design, CR size 300 with quantities of 5 and 10% was blended in with aggregate and then coated with bitumen. When the modified and conventional mixes were compared, it was discovered that the stability value of the 5% crumb rubber modified mix (CRMM) increased by 8.08-21% and the flow value decreased by 10-8% in comparison to the conventional mix with a high Marshall Quotient, and that the stability value of the 5% CRMM at optimum binder content increased by 21.2% and specific gravity decreased by 1.29%, but that the stability of the 10% CRMM decreased to 63.73%. As a result, it is determined that using 10% CR in bituminous roads eventually reduces the quality and strength, whereas using 5% CRMM can possibly increase the mix quality and improve the strength performance of the pavement.

Conclusion

To summarise, the use of industrial waste in highway construction provides several benefits and has enormous potential for long-term infrastructure development. It may solve environmental problems, reduce landfill consumption, and encourage resource conservation by repurposing waste materials from companies. Integrating industrial waste into highway buildings provides a cost-effective alternative to typical construction materials while also improving the infrastructure's longevity and performance. By diverting waste from landfills and lowering the demand for raw material extraction, the use of industrial waste in highway constructing helps to alleviate the environmental impact of industries. This method adds to waste management techniques, pollution reduction, and the promotion of a circular economy. In addition, using industrial waste in highway construction improves the infrastructure's overall performance and toughness. Many waste materials have desirable qualities that can enhance the strength and durability of roads and bridges, such as high strength, thermal stability, or increased binding capabilities. Additionally, recycling waste materials might aid in solving particular technical problems like lowering heat island effects or boosting erosion and crack resistance. The use of industrial waste in highway building does, however, necessitate appropriate testing, quality control, and adherence to pertinent laws and norms. To verify the acceptability and compatibility of waste materials with particular construction needs and conditions, in-depth research and evaluation are required.

REFERENCES

1. S. Kumar, C.B. Patil, Estimation of resource savings due to fly ash utilization in road construction, Resources, Conservation and Recycling 48(2) (2006) 125-140.
2. Kumar, A., 2023. WEB OF SYNERGY: International Interdisciplinary Research Journal
3. Ajay Kumar and Sujeet Kumar (2023) "Review Paper on Assessment of Deterioration in Concrete Filled with Steel Tubular Section via Guided Waves", World of Science: Journal on Modern Research Methodologies, 2(8), pp. 12–19. Available at: https://univerpubl.com/index.php/woscience/article/view/2444 (Accessed: 8 August 2023).
4. Ajay Kumar,Onkar Yadav,Sagar Kumar, "AN OVERVIEW ARTICLE ON INCORPORATING HUMAN HAIR AS FIBRE REINFORCEMENT IN CONCRETE", International Journal of Creative Research Thoughts (IJCRT), ISSN:2320-2882, Volume.11, Issue 6, pp.e967-e975, June 2023, Available at :http://www.ijcrt.org/papers/IJCRT2306566.pdf
5. O. Şimşek, H. Pourghadri Sefidehkhan, H.S. Gökçe, Performance of fly ash-blended Portland cement concrete developed by using fine or coarse recycled concrete aggregate, Construction and Building Materials 357 (2022) 129431.
6. Kumar, A. and Yadav, O., 2023. Concrete Durability Characteristics as a Result of Manufactured Sand. Central Asian Journal of Theoretical and Applied Science, 4(3), pp.120-127.
7. Kumar, A., Yadav, O. and Shukla, R., 2023. A COMPREHENSIVE REVIEW PAPER ON PARTIAL CEMENT SUBSTITUTION IN CEMENT MORTAR WITH WOOD ASH. Research in Multidisciplinary Subjects, 1, p.26.
8. G. Dondi, F. Mazzotta, C. Lantieri, F. Cuppi, V. Vignali, C. Sangiovanni, Use of Steel Slag as an Alternative to Aggregate and Filler in Road Pavements, Materials, 2021.
9. B. Buddhdev, H. Varia, Experimental Investigation on Utilization of Blast Furnace Slag as Fine Aggregate in Pavement Concrete, 2017.
10. Kumar, A., Yadav, O. and Kumar, A.N., A REVIEW PAPER ON PRODUCTION OF ENVIRONMENT FRIENDLY CONCRETE BY USING SEWAGE WATER. International Journal of Creative Research Thoughts (IJCRT), ISSN, pp.2320-2882.

Published by inter-publishing.com | All rights reserved. © 2023
Journal Homepage: http://inter-publishing.com/index.php/AJSLD
OPEN ACCESS

11. Kumar, A. and Bohara, J., A REVIEW REPORT ON INFLUENCE OF FIBER ADDITION ON THE MECHANICAL AND DURABILITY CHARACTERISTICS OF NO-FINES CONCRETE.
12. Kumar, A. and Nirala, B., 2023. Studies on Strength and Durability of Concrete Made with Manufactured Sand. Studies, 7(2).
13. Kumar, P. and Alam, M.F., Seismic Analysis of RC Building with Steel Bracing.
14. Madsen, J. 2005. "Concrete vs. Steel. Which is the better building material? You be the judge." Buildings; 99 (6): 62-64.
15. De Schepper, Mieke &Heede, Philip & Van Driessche, Isabel & De Belie, Nele. (2014). Life Cycle Assessment of Completely Recyclable Concrete. Open Access Materials Science Journal. 7. 6010-6027. 10.3390/ma7086010.
16. Ajayi, Saheed&Oyedele, Lukumon&Ceranic, Dr Boris &Gallanagh, Mike &Kadiri, Kabir. (2015). Life cycle environmental performance of material specification: a BIM-enhanced comparative assessment. International Journal of Sustainable Building Technology and Urban Development. 6. 10.1080/2093761X.2015.1006708.
17. Lu, Hangyong&Hanandeh, Ali & Gilbert, Benoit P &Baillères, Henri. (2017). A comparative life cycle assessment (LCA) of alternative material for Australian building construction. MATEC Web of Conferences. 120. 02013. 10.1051/matecconf/201712002013.
18. Biswas, Wahidul&Alhorr, Yousef &Lawania, Krishna & Sarker, Prabir &Elsarrag, Esam. (2017). Life cycle assessment for environmental product declaration of concrete in the Gulf States. Sustainable Cities and Society. 35. 10.1016/j.scs.2017.07.011.
19. Di Maria, Andrea & Salman, Muhammad & Dubois, Maarten & Van Acker, Karel. (2018). Life cycle assessment to evaluate the environmental performance of new construction material from stainless steel slag. The International Journal of Life Cycle Assessment. 23. 10.1007/s11367-018-1440-1.
20. Kumar, N., Kumar, P., Kumar, A. and Kumar, R., 2023. An Investigation of Asphalt Mixtures Using a Naturally Occurring Fibre. AMERICAN JOURNAL OF SCIENCE AND LEARNING FOR DEVELOPMENT, 2(6), pp.80-87.
21. Tighnavard Balasbaneh, Ali & Ramli, Mohd. (2020). A comparative life cycle assessment (LCA) of concrete and steel-prefabricated prefinished volumetric construction structures in Malaysia. Environmental Science and Pollution Research. 10.1007/s11356-020-10141-3.
22. Rakhmawati, Annisa&Devia, Yatnanta Padma &Wijatmiko, Indradi. (2020). Life Cycle Assessment (LCA) Analysis Of Concrete Slab Construction For Estimating The Environmental Impact. RekayasaSipil. 14. 232-237. 10.21776/ub.rekayasasipil.2020.014.03.10.
23. Martínez-Muñoz, David & Martí, Jose &Yepes, Victor. (2021). Comparative Life Cycle Analysis of Concrete and Composite Bridges' Varying Steel Recycling Ratio. Materials. 14. 4218. 10.3390/ma14154218.
24. Kumar, N. ., Kumar , P. ., Kumar, A. ., & Kumar, R. . (2023). An Investigation of Asphalt Mixtures Using a Naturally Occurring Fibre. AMERICAN JOURNAL OF SCIENCE AND LEARNING FOR DEVELOPMENT, 2(6), 80–87. Retrieved from http://inter-publishing.com/index.php/AJSLD/article/view/1977.
25. Kumar, A., & Yadav, O. (2023). Concrete Durability Characteristics as a Result of Manufactured Sand. Central Asian Journal of Theoretical and Applied Science, 4(3), 120-127. https://doi.org/10.17605/OSF.IO/8P5HE.
26. Islam, Md Azijul. (2022). Comparative Life Cycle Assessment of Anaerobic Bio-Digesters for Rural Areas in Developing Countries.