



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 4, April 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

 9940 572 462

 6381 907 438

 ijirset@gmail.com

 www.ijirset.com

Exploring Copper Slag as an Eco-friendly Substitute for Fine Aggregates in Concrete Manufacturing: A Review of Literature

Arya Babu¹, Muhammed Abid T. K.¹, Ajith C. S.¹, Sam Varghese¹, Soorya M. Nair *²(0000-0001-9193-0892),
Suhas Nair S.², Dr. Alwyn Varghese³ (0000-0002-4916-6293)

UG Students, Department of Civil Engineering, Jyothi Engineering College, Cheruthuruthy, Thrissur, Kerala, India¹

Assistant Professor, Department of Civil Engineering, Jyothi Engineering College, Cheruthuruthy, Thrissur,
Kerala, India²

Associate Professor, Department of Civil Engineering, Jyothi Engineering College, Cheruthuruthy, Thrissur,
Kerala, India³

ABSTRACT: The escalating consumption of concrete, a fundamental material in the construction sector, has amplified environmental issues linked to the extraction and processing of natural aggregates. This review investigates the potential of copper slag, a residual product of copper smelting, as a viable eco-friendly substitute for fine aggregates in the manufacturing of concrete. It delves into the benefits concerning copper slag, investigating its impact on exploring concrete characteristics, its environmental advantages, and its cost-efficiency. The study of literature indicates that the partial replacement of fine aggregate by copper slag, up to a certain limit (40-60%), improves mechanical characteristics like compressive strength, workability, and mass. Furthermore, incorporating copper slag tackles waste management obstacles and reduces the environmental footprint of concrete manufacturing. This review highlights the promise of copper slag as an eco-friendly substitute in concrete manufacturing, fostering the adoption of environmentally mindful construction methods..

KEYWORDS: Concrete, Natural Aggregates, Copper Slag, Sustainable Construction, Environmental Impact, Compressive Strength, Cost- Effectiveness.

I. INTRODUCTION

Concrete, a fundamental material in the construction industry, is primarily composed of cement, water, and aggregates. These aggregates, which make up approximately 70% of the concrete's volume, are traditionally derived from natural resources such as river sand and crushed stone. However, the extraction and processing of these natural aggregates have led to significant environmental concerns, including deforestation, water and air pollution, and resource depletion. In light of these environmental challenges, there is an urgent need to explore sustainable alternatives to natural aggregates in concrete production. One such promising alternative is copper slag, a byproduct of the copper smelting process. Copper slag, comprised predominantly of silicates, oxides, and metals, it offers potential as either a partial or complete replacement for natural aggregates in concrete.

Incorporating copper slag into concrete not only aids in preserving natural resources but also offers notable environmental and economic advantages. By incorporating copper slag in concrete, we can reduce the dependence on landfills for copper slag disposal, thereby mitigating environmental pollution. Furthermore, utilizing copper slag in concrete production aligns with the overarching objectives of sustainable construction practices, advancing environmental responsibility and economic efficiency.

II. LITERATURE REVIEW

Considerable research has been undertaken to assess the viability and efficiency of substituting copper slag for fine aggregates in concrete production. Here, we explore key findings from various studies:

Al-Jabri *et al.* (2011) investigated the utilization of copper slag in cement mortars and concrete. Their findings suggest that substituting up to 40-50% of fine aggregates with copper slag enhances strength and durability of concrete. However, exceeding this limit can result in decreased strength due to increased free water content.

Velumani *et al.* (2013) researched on M30 grade concrete revealed that the inclusion of up to 50% copper slag enhances workability, density, and mechanical properties, including compressive and tensile strength. The concrete also demonstrated superior resistance to chemical attacks.

Soni *et al.* (2018) explored the impacts of copper slag on the workability, density, and strength of concrete. Their findings demonstrated that incorporating copper slag substantially improves these properties up to a 50% replacement level, after which a decrease in strength was noted. Tests on leaching confirmed the environmental safety of copper slag when used in concrete.

Babu & Ravitheja (2019) explored the practicality of employing high-volume copper slag (up to 100%) as a substitute for fine aggregate in the production of High Strength Concrete (HSC). Their findings suggest that complete replacement with copper slag is technically achievable, highlighting the potential for extensive copper slag utilization in concrete.

Gursel & Ostertag (2019) investigated the utilization of copper slag as an alternative to natural sand in high-strength concrete, with a particular focus on environmental factors. A life cycle assessment unveiled that substituting 40-50% of fine aggregates with copper slag produced similar environmental effects while preserving desired strength characteristics.

Ameri *et al.* (2020) examined the utilization of copper slag as a partial substitute for natural sand in concrete blends. Their findings showed that incorporating a higher percentage of copper slag (up to 60%) led to enhanced mechanical properties, including increased compressive strength and improved impact resistance.

Zhang *et al.* (2022) offered a thorough examination of the mechanical attributes and long-term endurance of concrete containing copper slag. Their study employed statistical methods to establish a mix design theory, revealing a 40% replacement rate as optimal for maximizing compressive strength. Furthermore, they utilized electrochemical impedance spectroscopy to demonstrate enhanced corrosion protection for embedded steel bars in concrete containing copper slag. Additionally, SEM analysis indicated that incorporating copper slag minimizes initial damage within the concrete structure.

Jagan *et al.* (2023) studied the influence of copper slag content on the efficacy of high-strength concrete. Their study found that a 50% replacement with copper slag resulted in improved strength at 28 and 90 days, however surpassing this threshold resulted in diminished performance, attributed to the elevated angularity and reduced water absorption of copper slag.

Pal *et al.* (2023) conducted research to evaluate the feasibility of replacing river sand with copper slag in Pavement Quality Concrete (PQC). The investigation unveiled that substituting river sand entirely with copper slag resulted in enhanced strength properties compared to the control mix. An optimal blend was identified at 20% fly ash and 60% copper slag replacement.

Rohini & Padmapriya (2023) undertook a study centered on the influence of microorganisms on the mechanical characteristics of concrete containing copper slag. The findings from the research suggest that replacing 50% to 75% of natural sand with copper slag results in improved mechanical properties, especially flexural strength. The study also emphasizes the role of microbiologically induced calcium carbonate in further improving the properties of copper slag concrete.

Sankaralingam *et al.* (2023) conducted research to evaluate the impact of copper slag on greenhouse gas emissions and concrete properties. Their study used varying replacement percentages (20%, 30%, and 60%) and conducted tests such as compressive and tensile strength to evaluate the hardened concrete. The findings affirmed that integrating copper slag into concrete aids in mitigating greenhouse gas emissions.

Sahu *et al.* (2024) studied the mechanical and durability performance of recycled aggregate concrete (RAC) incorporating copper slag as a fine aggregate. Their discoveries unveiled a notable correlation between the presence of copper slag and the concrete's strength. The most notable enhancement in strength corresponded with a 40% copper slag content, consistent with the observed increase in silicon oxide and quartz concentration at this level. The study underscores that the impact of copper slag on the composition, crystalline structure, and, ultimately, the strength of RAC is contingent on the specific replacement ratio. Collectively, these investigations indicate that integrating up to 40% copper slag as a substitute for fine aggregate can improve the strength, durability, and microstructural attributes of RAC.

III. CONCLUSION

This review extensively analyzed the potential of copper slag as a sustainable alternative to natural fine aggregates in concrete production. The integration of copper slag presents several advantages:

- **Improved Concrete Properties:** Studies suggest that replacing up to an optimal level (usually between 40% and 60%) of natural sand with copper slag can improve the mechanical properties of concrete, such as compressive strength, flexural strength, and workability. However, surpassing the suggested replacement limit may lead to a reduction in strength due to an increase in free water content. Additionally, concrete with copper slag has shown superior resistance to chemical attacks.
- **Environmental Sustainability:** Utilizing copper slag helps divert waste from landfills and diminishes the environmental impact linked with the extraction of natural aggregates, and decreases greenhouse gas emissions during concrete production.
- **Durability and Resistance:** Concrete that incorporates copper slag exhibits increased resistance to harsh conditions, including improved water penetration resistance and potentially superior performance at elevated temperatures.
- **Cost-Effectiveness:** Depending on local availability and transportation costs, copper slag can be a cost-effective alternative to natural aggregates.

The encouraging results from various studies, which incorporate copper slag at different replacement percentages and investigate its performance under diverse conditions (such as elevated temperatures and with recycled concrete aggregate), underscore the potential for its widespread adoption in the construction industry. Future research efforts should concentrate on optimizing the content of copper slag and the mix design for different concrete applications. Additionally, long-term durability studies and investigations into the potential leaching of heavy metals from copper slag are essential for ensuring the sustainability and safety of this innovative approach to concrete production. By adopting copper slag as a viable alternative, the construction industry can progress towards a more sustainable future, minimizing environmental impact and promoting responsible resource management.

REFERENCES

1. Al-Jabri, K. S., Al-Saidy, A. H., & Taha, R. (2011). Effect of copper slag as a fine aggregate on the properties of cement mortars and concrete. *Construction and Building Materials*, 25(2), 933-938.
2. Velumani, M., Nirmalkumar, K., & Yuvaraj, K. (2023). Copper slag and high-strength concrete. *Materials Today: Proceedings*.
3. Soni, M. M., Mangroliya, J. R., & Kim-Surat, K. S. (2018). Performance of copper slag on strength as partial replacement of fine aggregate in concrete. *International Journal of Engineering Research and V7*, 347-349.
4. Babu, K. M., & Ravitheja, A. (2019). Effect of copper slag as fine aggregate replacement in high strength concrete. *Materials Today: Proceedings*, 19, 409-414..
5. Gursel, A. P., & Ostertag, C. (2019). Life-cycle assessment of high-strength concrete mixtures with copper slag as sand replacement. *Advances in civil engineering*, 2019.
6. Ameri, F., Shoaee, P., Musaei, H. R., Zareei, S. A., & Cheah, C. B. (2020). Partial replacement of copper slag with treated crumb rubber aggregates in alkali-activated slag mortar. *Construction and Building Materials*, 256, 119468.
7. Zhang, L., Gong, H., Liu, J., & Li, H. (2022). Mechanical properties and chloride penetration resistance of copper slag aggregate concrete. *Fractal and Fractional*, 6(8), 427.
8. Jagan, S., Karupasamy, N., Dharmaraj, R., Thiyaneswaran, P., Karthikeyan, S., & Navaneethan, K. S. (2023). Properties of Sustainable High Strength Concrete with Waste Copper Slag. *Journal of Wuhan University of Technology-Mater. Sci. Ed.*, 38(4), 815-822.
9. Pal, A. C., Panda, M., & Bhuyan, P. K. (2023). Mechanical and microstructural properties of pavement quality concrete using both Class-F fly-ash and copper slag. *Road Materials and Pavement Design*, 1-28.
10. Rohini, I., & Padmapriya, R. (2023). Properties of bacterial copper slag concrete. *Buildings*, 13(2), 290.
11. Sankaralingam, S., Nagarajan, S. V., & Veerachamy, V. P. N. (2023, June). Impact on greenhouse gas mitigation using traditional concrete and partial replacement by copper slag of fine aggregate. In *AIP Conference Proceedings* (Vol. 2766, No. 1). AIP Publishing.
12. Sahu, A., Kumar, S., Srivastava, A. K. L., & Pratap, B. (2024). Performance of recycled aggregate concrete using copper slag as fine aggregate. *Journal of Building Engineering*, 82, 108364.



13. Thejasree VB., Seethal Anna Korulla., Sinto Simon O., Soorya M Nair., Dr. Alwyn Varghese., (2024) Shear failure response of concrete specimens to positive cyclic loading with cementitious material alternatives: A review. *International Research Journal of Modernization in Engineering Technology and Science*, 06-04, 3361-3365
14. Solomon, A. Arun, et al. "Impact of heating cooling regime on flexural behaviour of self-compacting concrete beams exposed to elevated temperatures." *Materials Today: Proceedings* 60 (2022): 466-474.
15. Patel, Vikas, et al. "Effect on mechanical properties and stress strain characteristics of normal and high strength concrete at elevated temperature." *Journal of Building Materials and Structures* 7.2 (2020): 199-209.
16. Varghese, Alwyn, et al. "Influence of fibers on bond strength of concrete exposed to elevated temperature." *Journal of Adhesion Science and Technology* 33.14 (2019): 1521-1543.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details