International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Evaluation Mechanical Properties of Concrete Replaced with Copper Slag and Silica Fume.

Niket Singh[1], Ravindra Kumar Raj [2]

[1, 2,] Department of Civil Engineering, Sagar College of Technology, Sagar (M.P.)

ABSTRACT—

Workability of cement with partial replacement of copper slag and silica fume at different stages. Normal consistency of cement with copper slag and silica fume substitutes. Flexural strength in M30 grade concrete with varying levels of copper slag and silica fume replacements. Compressive strength in M30 grade concrete with different levels of copper slag and silica fume substitutes. Results show that flexural and compressive strengths exhibit variations based on the levels of copper slag and silica fume replacement. The study demonstrates that optimizing mix design variables can lead to concrete with improved properties, highlighting the potential for more durable and sustainable construction practices.

Key word: - mix design, optimizing mix, construction, compressive strength, workability, consistency.

I. Introduction

The roots of concrete date back to ancient times when Greek and Roman builders mixed limestone, lime, water, sand, and crushed stone to create a cementing mixture. Over the years, engineers have experimented with materials that can be molded in a plastic state and then solidified into a strong product. The performance of concrete depends on the properties of its components.

Concrete technology has evolved over time and with changing needs. In the late 19th century, concrete was often placed in a relatively dry state and compacted manually. Reinforcement wasn't commonly used during that era. The advent of reinforced concrete in the early 20th century led to the popularity of wetter concrete mixes, and reinforcement became an integral part of the concrete structure.

When considering concrete characteristics, it's important to evaluate them based on the specific construction requirements. The quality of concrete needs to meet the standards necessary for the intended purpose. Concrete's adaptability and properties should be assessed on an individual basis, taking into account the construction goals and environmental considerations.

Concrete is a robust and generally aesthetically pleasing material when used in conditions that offer protection against various external factors. However, it might be ill-suited for areas with significant exposure to deteriorating influences.

Silica fume is another Constituent material that has gained considerable attention in recent times. Various organizations have been increasingly focused on research aimed at conserving energy in the cement and concrete industry. This has led to the promotion of Constituent materials like fly ash, slag, and Constituent. Silica fume has also gained attention as a potential partial replacement for Portland cement. This interest arises from the material's availability in different regions and the stringent enforcement of pollution control measures to prevent its dispersion into the environment. Additionally, the availability of high-range water- reducing admixtures (super plasticizers) has opened new possibilities for utilizing silica fume in concrete and mortars to create high-strength products.

The use of silica fume as a partial cement replacement is known to significantly enhance concrete strength. However, there is a debate regarding the mechanisms behind this strength increase. Some researchers believe that the strength increase is primarily due to a stronger cement paste system, while others are confident that the enhanced bond between the cement paste and aggregate contributes to the higher strength.

Research has shown that silica fume enhances homogeneity and reduces the number of large pores in the concrete paste, both of which contribute to higher strength (Mehta and Gjorv 1982, Feldman and Huang 1985). The work of Darwin, Shen, and Harsh (1988) with cement paste and mortar supports the notion that the quality of the paste plays a vital role in controlling concrete strength.

In summary, silica fume's impact on concrete quality is multi-faceted, involving improvements in the cement paste-aggregate bond, pore structure, and overall homogeneity. Its utilization holds promise for creating high-strength and durable concrete, especially when combined with modern admixtures and quality control measures.

II. Literature review

Shirdam et al. (2019) emphasized the importance of considering workability, strength, durability, economics, and sustainability when designing concrete mixes. The utilization of copper slag as a partial replacement for cement is an effective way to reduce pollution and conserve resources due to its reduced cement content. The study aimed to enhance concrete durability by optimizing key mix design variables such as cement factor, water-to-binder ratio, copper slag, and silica fume. Experimental research based on standards was conducted to optimize these variables. Durability assessment involved tests for electrical resistance, bulk electrical conductivity, and chloride migration coefficient. Microstructural analysis using X-ray and scanning electron microscopy was also performed. The study concluded that combining copper slag and silica fume with appropriate cement factor and water-to-binder ratio led to a mix design that is stronger, more durable, and more workable. An optimized mix was proposed, replacing 7% of cement with silica fume and 20% with copper slag, resulting in a practical, cost- effective, and durable concrete mix.

Thesarajan et al. (2020) investigated the effects of partially replacing cement and fine aggregate with silica fume and copper slag in concrete. The study focused on assessing compressive strength, split tensile strength, and flexural strength for various combinations of silica fume and copper slag content. The study found that replacing 10% of cement with silica fume and 40% of fine aggregate with copper slag produced the best strength results compared to other combinations and normal concrete. The utilization of industrial waste materials as byproducts helped reduce material costs without compromising concrete strength.

Pradeepa and Umamaheswari (2020) explored the behavior of concrete with partially replaced cement and fine aggregate by silica fume and copper slag. M60 grade concrete was evaluated for various properties such as workability, compressive strength, split tensile strength, flexural strength, and water absorption. The study concluded that utilizing silica fume and copper slag as partial replacements for cement and fine aggregate improved concrete properties.

Chandramouli and Chaitanya (2021) investigated the use of silica fume as a partial replacement for cement and steel slag as a partial replacement for coarse aggregates in concrete. The study aimed to provide eco- friendly concrete with enhanced strength and a lower CO2 footprint. Different replacement percentages were considered for both materials. The study concluded that optimal compressive strength was achieved with 7.5% replacement of cement with silica fume and 40% replacement of coarse aggregate with steel slag.

Santhosh et al. (2021) focused on utilizing waste materials for partial replacements in concrete. Copper slag and nano silica were used to replace traditional components. The study found that adding copper slag increased workability, while the addition of nano silica and silica fume improved compressive and tensile strengths. Higher strength gains were observed with silica fume-replaced concrete.

Nirmala et al. (2022) investigated the performance of reinforced beams with substituted aggregates, including copper slag, silica fume, and fly ash. Various replacement levels were tested, and the study aimed to determine the effectiveness of these replacements on beam performance.

Nagarajan et al. (2022) examined the feasibility of using high-volume copper slag as a replacement for river sand in high-strength geopolymer concrete. The study aimed to determine optimal mix proportions to enhance concrete strength and durability. The addition of micro silica further improved the properties of the concrete mix. The study also explored curing techniques and evaluated the created concrete's performance through mechanical tests and microstructural analysis.

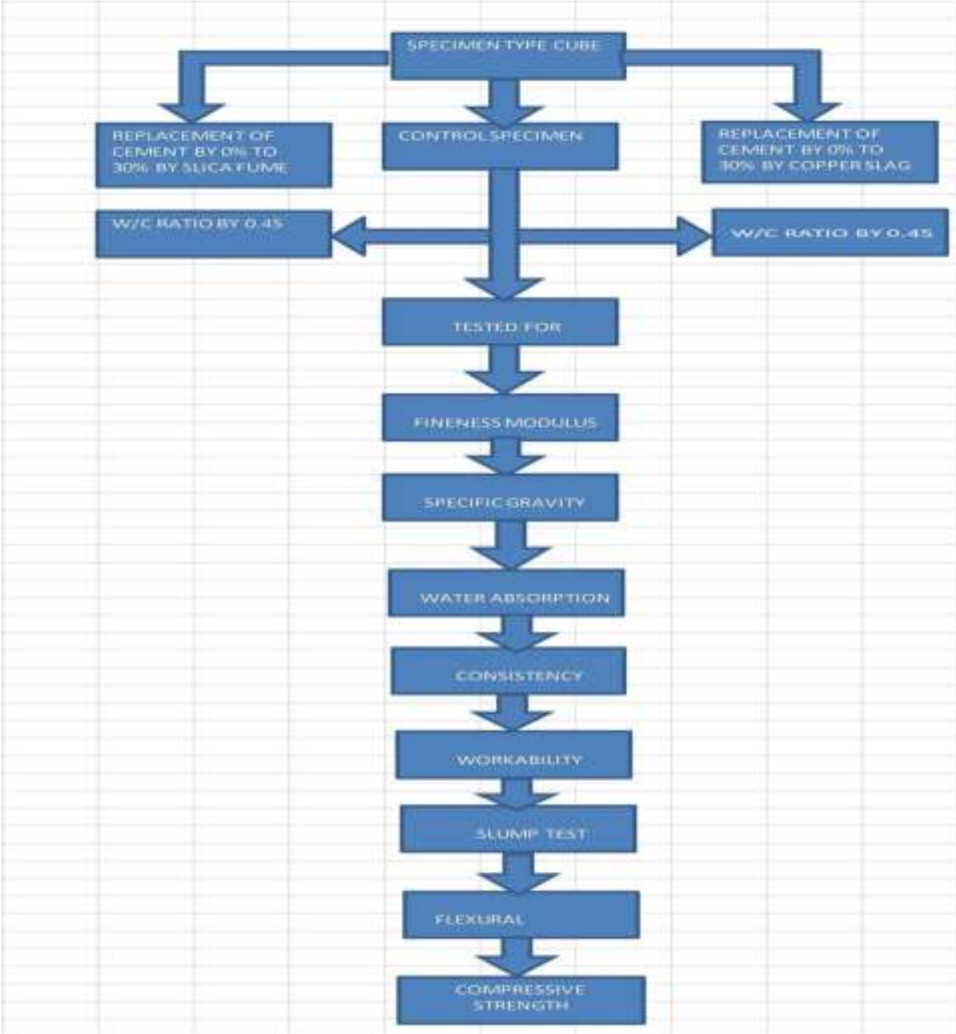
Revathi et al. (2023) conducted a study to investigate the effects of replacing sand with copper slag and adding coconut fiber as reinforcement in concrete. The study found that copper slag can effectively replace sand in concrete while maintaining or even enhancing compressive strength, split tensile strength, and toughness. The addition of coconut fiber further improved concrete properties. An optimized mix was proposed, demonstrating improved strength and durability compared to standard concrete.

Revathi et al. (2023) focused on enhancing recycling by utilizing PET plastic bottle fibers and silica fume as replacements in concrete. The study found that incorporating PET fibers and silica fume in concrete improved its mechanical and durability properties. The optimal mix included 10% cement replacement with silica fume and 0.3% inclusion of PET fibers, resulting in increased compressive strength, split tensile strength, and flexural strength.

Biao Li et al. (2023) studied geopolymeric recycled aggregate concrete (GRAC) containing recycled concrete aggregate (RA) and industrial wastes, along with the addition of silica fume (SF). The study found that GRAC's mechanical properties are influenced by the content of SF, with an optimal SF content of 10%. This enhanced the mechanical strengths of GRAC with RA components.

Wu et al. (2023) investigated the effects of silica fume (SF) and ground granulated blast furnace slag (GGBS) binders in ultra-high-strength and high-ductility cementitious composites (UHS-HDCC). The study revealed that the combination of GGBS and SF affected the flowability, mechanical properties, and microstructure of the UHS-HDCC. GGBS improved flowability, and varying the content of GGBS and SF impacted the composites' mechanical strengths and behavior.

III. METHODOLOGY



Fine aggregate (sand) particle size passing through 4.75mm BIS sieve BIS:383-1970. In the nature (ATM) sand is

Figure 1. Methodology for Cube

IV. Workability of concrete

An examination of several test findings on concrete is given in this section. These tests include determining if concrete with blended mortar that has copper slag and silica fume in it is workable. The evaluation is predicated on the M30 grade concrete's compressive strength, as shown in Table 1.

Table 1 Workability of Cement with Different Properties of Different Material

S. No.	**Material**	**Partial Replacement**			
		0%	**10%**	**20%**	**30%**
1	**Silica fume**	65	94	184	254
2	**Copper Slag**	65	134	194	284

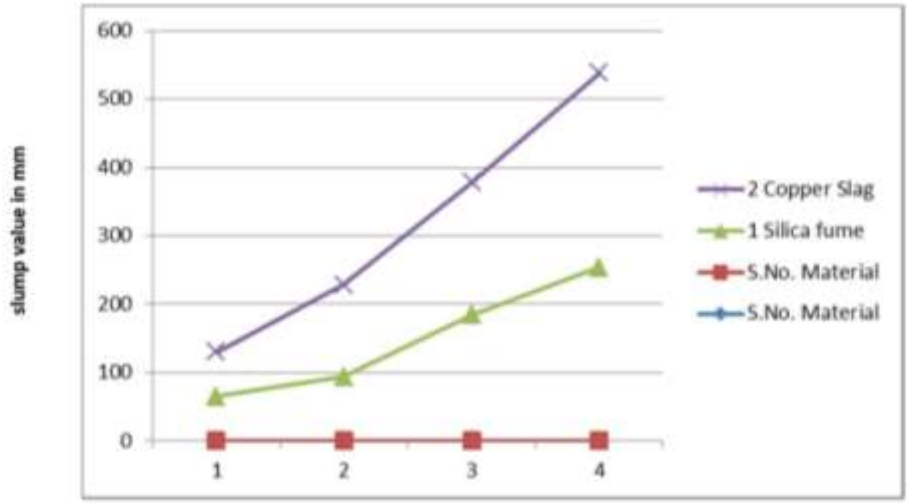


Figure 1: Slump Values of Different Waste Material

Based on the figure and table presented above, it is evident that the slump test results indicate an increase in workability when incorporating silica fume and copper slag into the concrete mix.

Table 2: Flexural Strength with 10% silica fume

S. No.	M30,Normal concrete beam with 10% Replacement of cement by silica fume	Flexural Strength after 28 days curing
1	Beam 1	5.8
2	Beam 2	5.5
3	Beam 3	5.3
4	Average	5.5

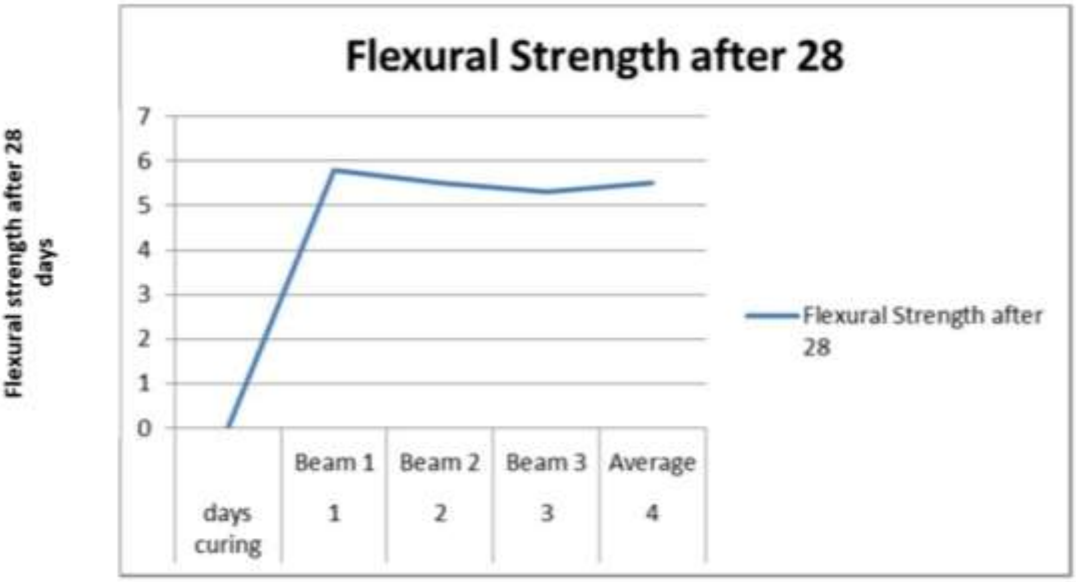


Figure 3: Flexural Strength with 10% silica fume

Three beams measuring 700 by 100 by 100 inches are cast in M30 grade concrete for this test, with additional replacements up to 20%, using cement and silica fume.

V. Conclusion

Based on the above study following conclusions can be made:

- The workability values for cement that contains partial replacement of copper slag at 0%, 10%, 20%, and 30% are 64.5mm, 134.5mm, 194.5mm, and 284.5mm, in that order. Likewise, the workability values for cement that has silica fume partially replaced at 0%, 10%, 20%, and 30% are 64.5mm, 94.5mm, 182.5mm, and 254.5mm, respectively.
- The data suggests that using 10% copper slag replacement in cement yields the highest flexural and compressive strength for the M30 grade concrete mix.

References

1. Nirmala, R., Praveen kumar, S., Akash Nithish, K.M. (2022). Experimental Investigation on the Copper Slag, Silica Fume and Fly Ash in High-Performance Concrete. In: Naganathan, S., Mustapha, K.N., Palanisamy, T. (eds) Sustainable Practices and Innovations in Civil Engineering. Lecture Notes in Civil Engineering, vol 179. Springer, Singapore. https://doi.org/10.1007/978-981-16-5041-3_24.
2. P. Thej Kumar, R. Harshini Reddy and DVS Bhagavanulu "A Study On The Replacement Of Cement In Conrete By Using Cow Dung Ash" International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-9, December 2015 ISSN: 2395-3470.
3. Patnaik Binaya, Seshadri Sekhar.T, Srinivasa Rao strength and durability properties of copper slag admixed concrete IJRET: International Journal of Research in Engineering and Technology Eissn:
4. 2319-1163 | Pissn: 2321-7308.
5. Prabagar subramaniam, kalya subasinghe, w. R. Keerthi fonseka (2015) "wood ash as an effective raw material for concrete blocks" ijret: international journal of research in engineeringand technology eissn: 2319-1163 | pissn: 2321-7308.
6. Pradeepa P., Umamaheswari R., (2020). Study the Behaviour of Copper Slag and Silica Fumein M60 Grade Concrete. World Academics Journal of Engineering Sciences, 7(2), 51-55.
7. Pranshu Saxena, Ashish Simalti (2015) "Scope Of Replacing Fine Aggregate With Copper Slag In Concrete" International Journal of Technical Research and Applications e-ISSN: 2320-8163.
8. Ravanbakhsh Shirdam, Mahdiye , Nematollah Bakhshi (2019) "Investigating the Effects of Copper Slag and Silica Fume on Durability,Strength, and Workability of Concrete" International Journal of Environmental Research (2019) 13:909–924.
9. Roy, D. K. (2012). Effect of Partial Replacement of Cement by Silica Fume on Hardened Concrete. International Journal of Emerging Technology and Advanced Engineering, 2(8), 472-475.
10. S. Revathi, M. Dinesh, S.G. Suba Sri Varsan,Mechanical properties of concrete incorporating coconut fibers and copper slag,Materials Today: Proceedings,2023,, ISSN 2214-
11. 25. 7853,https://doi.org/10.1016/j.matpr.2023.02.276.
12. S. Revathi, P. Sathis kumar, D. Suresh, S. Thowfick Anwar,Behaviour of concrete with PET bottles as fibers & silica fume as partial replacement of cement, Materials Today: Proceedings,2023,,ISSN 2214- 7853,https://doi.org/10.1016/j.matpr.2023.03.580.
13. Santhosh G., Sanju Sreedharan, Muhammad Fayiz, Vishnu E. S. (2021) "Sustainable Use of Nano Silica, Silica Fume and Copper Slag in Concrete" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056..
14. Shirdam, R., Amini, M. & Bakhshi, N. Investigating the Effects of Copper Slag and Silica Fume on Durability, Strength, and Workability of Concrete. Int J Environ Res 13, 909–924 (2019). https://doi.org/10.1007/s41742-019-00215-7.
15. Sumit L. Chauhan, Raju A.Bondre(2015) "Partial Replacement of Sand by Copper slag in Concrete" International Journal of Scientific and Research Publications, ISSN 2250-3153.
16. Xiaofeng cong ,shanglong gong, david ,darwin steven l. Mccabe "role of silica fume in compressive strength of cement paste, mortar, and concrete" university of kansas lawrence, kansas april 1990.