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DEVELOPMENT AND OPTIMIZATION OF GEOPOLYMER CONCRETE WITH DIFFERENT SUPPLEMENTARY CEMENTITIOUS MATERIALS.

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ABSTRACT

Sustainable construction materials are developed using alternative cementitious materials. Concrete durability is aligned with longevity of structures, especially when exposed to aggressive environments. This study explores the effects of partial replacement of cement with supplementary cementitious materials (SCMs) like silica fume (SF), metakaolin (MK), and fly ash (FA) on the durability and strength of concrete exposed to nitric acid solution. Concrete cubes were developed varying percentages of SF, MK, and FA, and were subjected to water curing. Developed samples were exposed to Nitric acid to assess the performance of material against harsh environment. The study includes performance analysis of mechanical properties through compressive strength tests, rebound hammer tests, as well as durability assessments using the volume of permeable voids (VPV) and mass loss measurements. The results indicate that the inclusion of SCMs significantly enhances the resistance of concrete to nitric acid attack, reducing both mass loss and strength degradation. Optimal performance was observed with 10% SF showing 52.22 MPa strength, which provided superior durability and maintained structural integrity under acidic conditions. This study has been conducted to developed concrete materials for Industrial plants, wastewater treatment plants and infrastructures exposed to chemically challenging environment like acidic rain and aggressive chemical exposure. This study is aligned with achievement of sustainable goals regarding innovation for industry and sustainable development of cities and communities.

INTRODUCTION

Concrete, the second-most consumed material on this globe, is crucial for infrastructure and vulnerable to chemical attacks that deteriorate its mechanical and structural properties. Acid attacks, especially those brought about by nitric acid, dissolve calcium hydroxide and weaken the cement matrix, which leads to loss of strength and durability. This paper aims to investigate the possibility of SCMs such as silica fume, metakaolin, and fly ash in improving concrete performance. These SCMs have positive contributions through pozzolanic reactions, content reduction in calcium hydroxide, improvement of the microstructure, and the decrease of permeability. The requirements for carrying out this research include studying the mechanical and durability properties of concrete that contain SCMs, its pore structure, and resistance to acid attack.

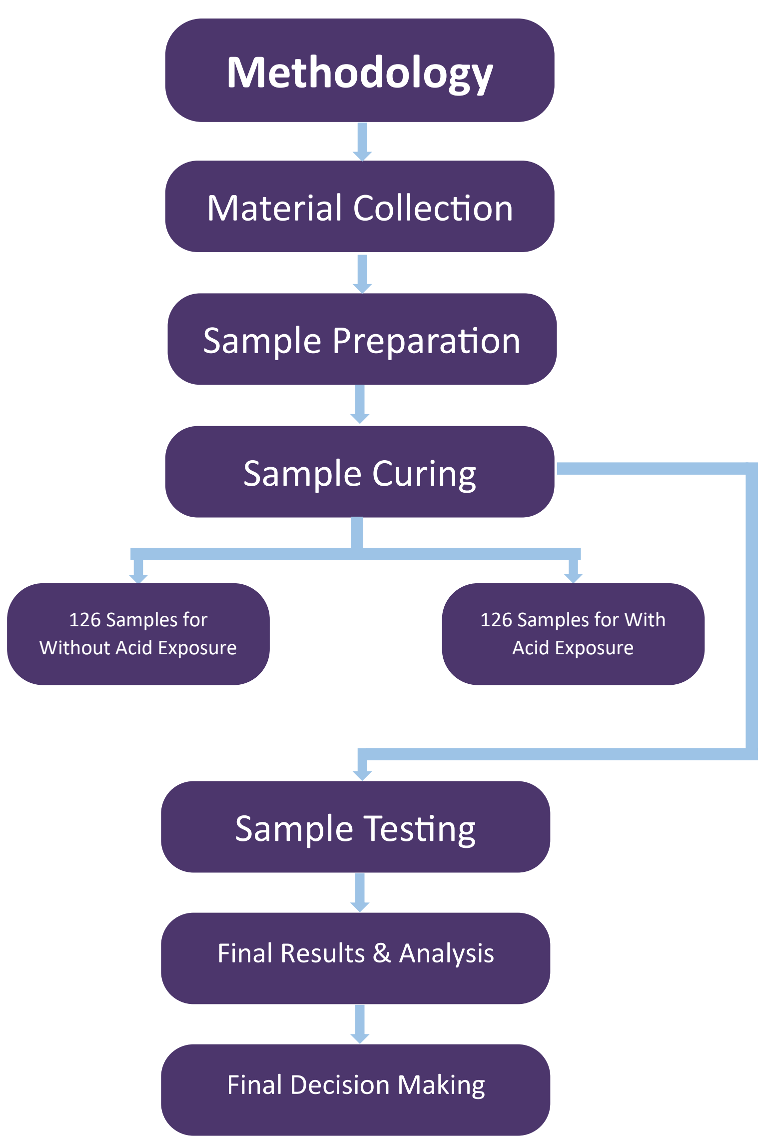
Utilizing industrial byproducts, it serves the cause of sustainability while enhancing the resilience of concrete, reduces maintenance needs, and minimizes carbon emissions. Main objective is set for an in-depth experimental analysis, focusing on the effectiveness of SCM in producing acid-resistant and durable concrete mixtures for long-term infrastructure development.

METHODOLOGY, RESULTS & ANALYSIS

THEME

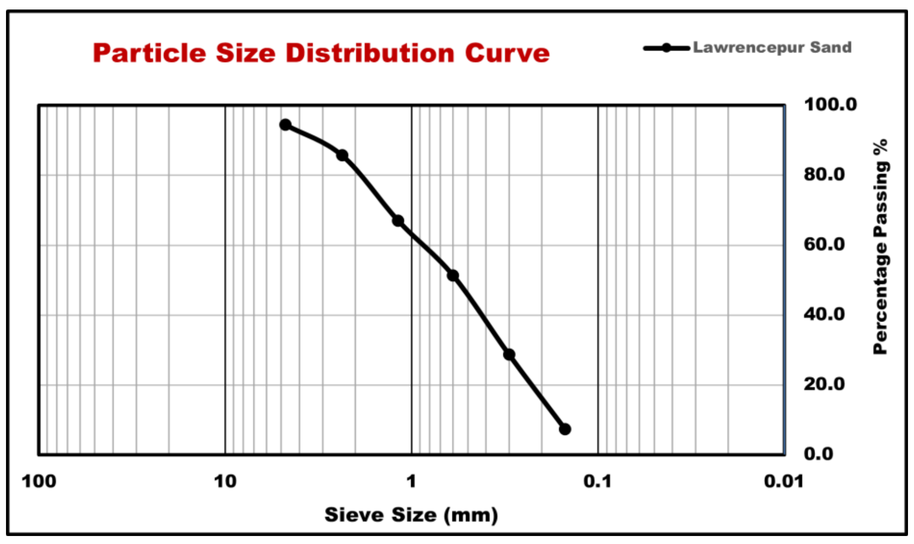
Concrete which contains SCMs is more durable in harsh environments, which supports SDGs 9 ,11, 12 & 13. SCMs provide lasting-longer resilient infrastructure (SDG9) and sustainable cities (SDG11). By lowering cement consumption and carbon emissions, they encourage responsible consumption (SDG12). Additionally, by enhancing concrete's environmental performance, SCMs support climate-resilient practices (SDG 13). When combined, they make long-lasting and sustainable building solutions possible. These targeted goals no. 9, 11, 12 & 13 are shown in Figure.

METHODOLOGY

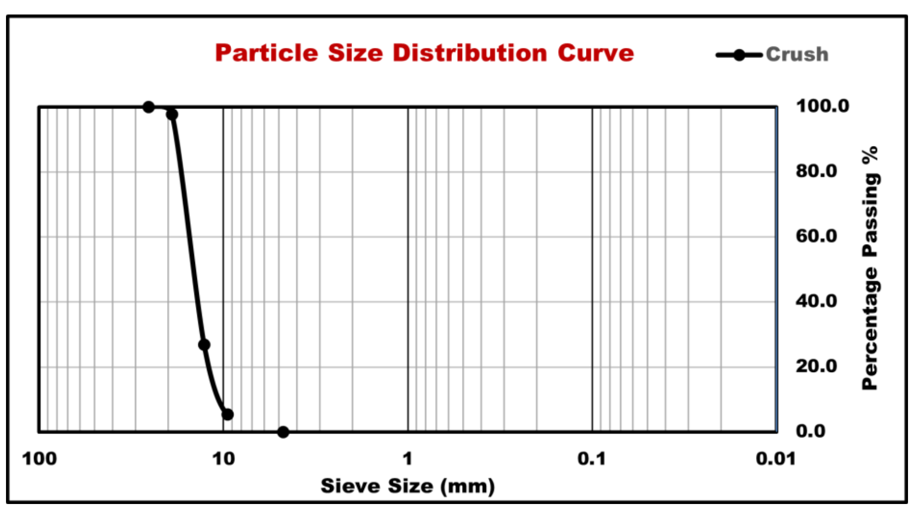


RESULTS & ANALYSIS

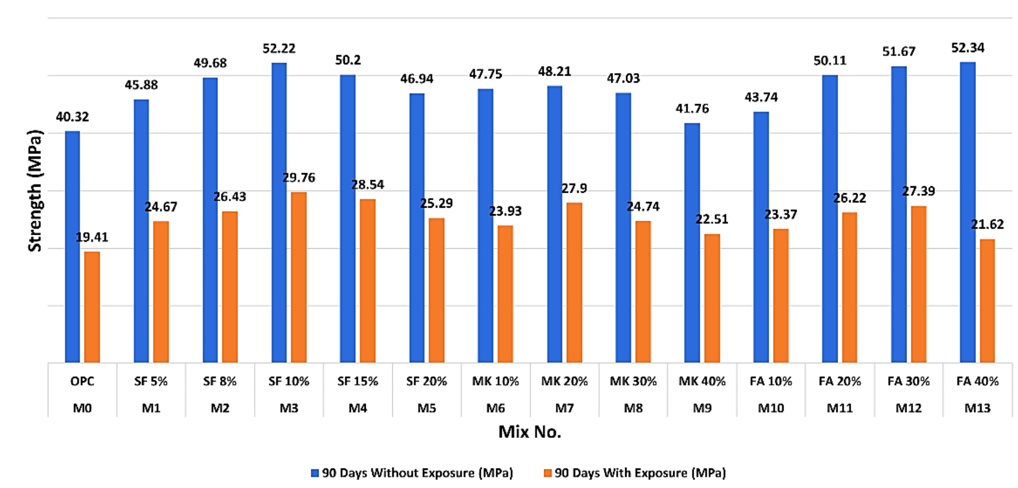
The study examines the impact of partially replacing cement with SCMs on concrete durability under nitric acid exposure. SCMs like fly ash and silica fume improved acid resistance by reducing porosity and enhancing the microstructure while maintaining sufficient strength. Optimal results were achieved with silica fume by 10% replacement, balancing durability and strength, showcasing SCMs' potential for sustainable concrete in harsh conditions.



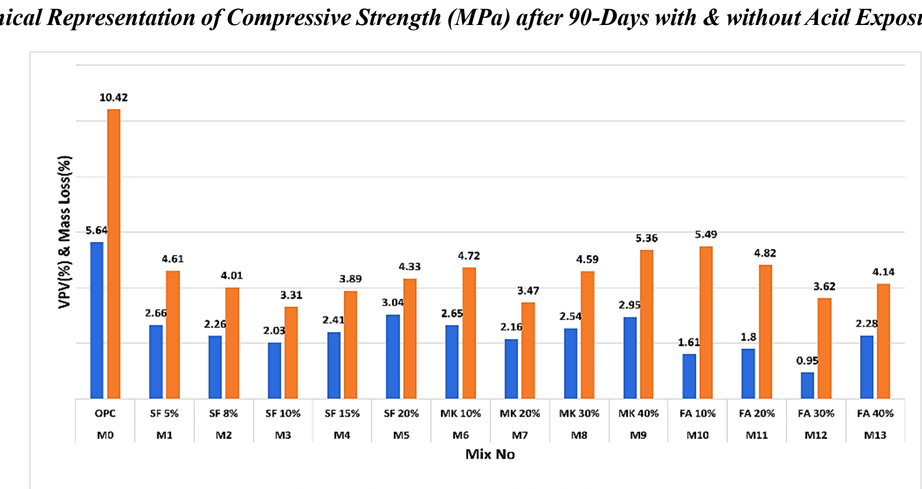
Graphical Representation of Gradation Curve of Sand



Graphical Representation of Gradation Curve of Aggregate



Graphical Representation of Compressive Strength (MPa) after 90-Days with & without Acid Exposure



Graphical Representation of Pore Structure (%) after 90-Days with & without Acid Exposure

CONCLUSION

Analyzing the test results presented in the study following can be concluded:

- Eco-friendly buildings can be developed by using SCMs with cement and applying them in building construction process.
- The results shows that after adding these SCMs with cement it can increase the strength of concrete and can reduce its porosity.
- We can reduce the cost of construction by adding these SCMs with cement.
- Finally, the current study shows that the optimum percentages of these are with 10% SF, 20% MK and 30% FA. Amoung these three SCMs 10% SF shows better results in maximum strength and minimun reduction of mass loss.

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