**Investigation of the potential of incorporating nanomaterials to enhance self-healing capabilities in concrete structures**

SURAJ ANAND1, Prof. P. K. ROY 2

1 M. Tech Scholar, Department of Civil Engineering, NIRT Bhopal, India

2 Prof. Department of Civil Engineering, NIRT Bhopal, India

**Abstract.** This project is mainly undertaken to study the behavior and performance of concrete using materials such as silica fume. This type of use of a waste material can solve problems in various construction sites and reduce environmental problems. The use of SILICA FUME can also reduce the cost of the concrete production and increase the workability.

KEYWORDS: Concrete mix, Silica Fume, Strength parameter, sustainable construction, workability

**Introduction**

* Durability of concrete is partly and sometime significantly affected by the occurrence of cracks in the surface layer; therefore, it is necessary to develop new methods to eliminate cracks in concrete structures. Different measures have been attempted to address the environmental impact related to frequent repairs of concrete structures. Bio-mineralisation of calcium carbonate by using certain bacterial species is one of these measures toward solving this issue. Alkali-resistant spore-forming bacteria with self-healing attribute will heal the cracks by utilising its microbial activity and inorganic precursors embedded in concrete to precipitate calcium carbonate. It will be an alternative for the other self-healing materials to improve concrete durability by decreasing the potential for the ingress of detrimental substances and enhancing strength properties.

Unavailability of test data for self-healing cementitious composites subjected to accelerated and weathering exposure observed in the existing literatures necessitates the investigation of bacteria based self-healing cementitious composites behaviour under accelerated and weathering exposure. Considering the identified gabs in the previous studies on long term performance of SHCC, the research study presented in this thesis has mainly focused on the experimental investigation of the long-term performance of SHCC under three separate environmental conditions, namely, freeze-thaw cycles, wet-dry cycles and outdoor environment up to 18 months. The outcomes of this study will help generate comprehensive data bases for long term performance of bacteria based self-healing concrete and develop an expert system to disseminate knowledge on bacterial concrete for constructing infrastructures in real life..

Material Used

The following materials are used during the research work-

 Cement

 Fine aggregates (Sand)

 Coarse Aggregates(10-20 mm)

 Bacillus Bacteria

 Silica Fume

 Super Plasticizer

 Water

Methodology

Results

**Table 5.1:** *slump value on varying Silica Fume Dose*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| %SF used | 0 | 5 | 10 | 15 | 20 |
| Slump value mm | 75 | 73 | 72 | 69 | 68 |

**Table 5.1:** *Graphical Representation of variation of slump value on varying Silica Fume*

* 1. **COMPRESSIVE STRENGTH**

**Table 5.2:** C*ompressive strength of sample containing Silica Fume*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Compressive strength (N/mm2) on Cement replacement** | | | | | |
| **Silica Fume %** | **0** | **5** | **10** | **15** | **20** |
| **Compressive strength MPa after 7 days** | 32.59 | 35.35 | 36.30 | 31.10 | 29.23 |
| **Compressive strength MPa after 28 days** | 43.59 | 45.23 | 45.66 | 46.00 | 48.05 |

**Figure 5.2:** *Compressive Strength Contain of Silica Fume*

## SPLIT TENSILE STRENGTH

**Table 5.3:** split tensile strength *of sample containing Silica Fume*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **split tensile strength (N/mm2) on Cement replacement** | | | | | |
| **Silica Fume %** | **0** | **5** | **10** | **15** | **20** |
| **split tensile strength MPa after 28 days** | 3.87951 | 4.02547 | 4.06374 | 4.094 | 4.27645 |

**Figure 5.3:** *split tensile strength Contain of Silica Fume*

## FLEXURAL STRENGTH TEST

**Table 5.4:** *Flexural Strength of M35 having SF*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Silica Fume* %** | **0** | **5** | **10** | **15** | **20** |
| **Flexural strength MPa after 28 days** | 4.07 | 4.10 | 4.20 | 4.25 | 4.55 |

**Figure 5.4:** *Flexural Strength of M35 having SF*

Conclusion

* Addition of bacteria into a concrete makes it beneficial. Self healing concrete can be a great concrete sealant. It improves durability of concrete, life of the structure. It reduces need of regular maintenance and inspection.
* Specimens incorporated with bacteria without Nanoparticles resulted in lower compressive strength at early age and later stage when compared with Mixes prepared with nanomaterials.
* If Single-doped silica fume replaces part of the cement, then for the same curing time, and the compressive strength increases in the early stage and later stage. When the content of silica fume reaches 20%, the performance of concrete reaches the best.
* It is observed that the flexural strength for concrete with replacements was increased when the silica fume was added up to level of 20% replacement.
* It is observed that the split tensile strength for concrete with replacements was increased when the silica fume was added up to level of 20% replacement.

References

1. *John Hanna. Self-Healing Concrete Techniques and Technologies and Applications. Recent Progress in Materials. 2024, volume 6, doi:10.21926/rpm.2401006.*
2. *Wenhui Duan, Lihai Zhang and Surendra P. Shah.**Nanotechnology in Construction for Circular Economy Lecture Notes in Civil Engineering Volume 356 Proceedings of NICOM7, 31 October–02 November, 2022, Melbourne, Australia.*
3. *R. M. Ashwini , M. Potharaju and V. Srinivas. Compressive and Flexural Strength of Concrete with Different Nanomaterials: A Critical Review. Hindawi Journal of Nanomaterials Volume 2023, Article ID 1004597, 15 pages https://doi.org/10.1155/2023/1004597*
4. *Daniel Lahmann, Carola Edvardsen and Sylvia Kessler. Autogenous self-healing of concrete: Experimental design and test methods—A review. Engineering Reports. 2023;5:e12565.*
5. *: Huseien, G.F. A Review on Concrete Composites Modified with Nanoparticles. J. Compos. Sci. 2023, 7, 67. Https://doi.org/10.3390/ jcs7020067 Academic.*
6. *Esaker, M., Hamza, O., Souid, A. And Elliott, D., 2021. Self-healing of biocementitious mortar incubated within neutral and acidic soil. Materials and Structures, 54(2), pp.1-1*
7. *Nikhil Sanjay Gaikwad and Sakshi Chetan Bhalerao. REVIEW PAPER ON SELF HEALING CONCRETE. International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 08 Issue: 11 | Nov 2021.*
8. *Hamza, O., Esaker, M., Elliott, D. And Souid, A., 2020. The effect of soil incubation on bio self-healing of cementitious mortar. Materials Today Communications, 24, p.100988*
9. *Maria Stefanidou , Eirini-Chrysanthi Tsardaka and Aspasia Karozou. The Influence of Curing Regimes in Self-Healing of Nano-Modified Cement Pastes. Materials 2020, 13, 5301; doi:10.3390/ma13225301.*
10. *Changjiang Liu and Xin He. Application of nanomaterials in ultra-high performance concrete: A review. Nanotechnology Reviews 2020; 9: 1427–1444.*
11. *Suleiman, Ahmed Ramadan, "Self-healing of Concrete Under Diverse Environmental Exposure" (2019). Electronic Thesis and Dissertation Repository. 6755.*
12. *Ishraq Mohammad Ali Khattab, Hazhar Shekha and Mohammed Abukar Abdi. Study on Self-healing Concrete types. Sustainable Structure and Materials, Vol. 2, No .1, (2019) 76-87 DOI: https://doi.org/10.26392/SSM.2019.02.01.076.*
13. *Wei Wang et Research Status of Self-healing Concrete. 2019 IOP Conf. Ser.: Earth Environ. Sci. 218 012037*
    1. *.*