

# EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF SISAL FIBRE REINFORCED CONCRETE WITH ALCCOFINE AS ADMIXTURE

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## Abstract:

This study examines the mechanical and flexural behaviour of M25 grade reinforced concrete incorporating Alccofine 1203 and Sisal Fibre. Experimental and numerical investigations were carried out to evaluate the influence of these materials on the performance of concrete and RCC beams. The results indicated that the combined use of Alccofine and Sisal Fibre enhanced the overall strength, crack resistance, and flexural behaviour of concrete compared to the conventional mix. Numerical modelling using ABAQUS showed good agreement with the experimental observations, confirming the reliability of the developed finite element model. The study demonstrates the potential of Alccofine and Sisal Fibre for producing sustainable and high-performance concrete for structural applications.

*Keywords* — M25 grade, Alccofine 1203, Sisal Fibre, ABAQUS

## I. INTRODUCTION

Concrete is one of the most widely used construction materials due to its strength, durability, and versatility. The replacement of a portion of cement with supplementary cementitious materials has become an effective approach for enhancing the performance and sustainability of concrete. Within this context the present study investigates the partial replacement of cement with alccofine, an ultrafine mineral admixture and the incorporation of sisal fibre as an additive.

### ALCCOFINE

Alccofine is an ultra-fine supplementary cementitious material produced from slag-based industrial by-products. Due to its high fineness and reactivity, it improves the strength, workability, and durability of concrete by producing a denser cement matrix. Alccofine is widely used as a partial replacement for cement in high-performance and sustainable concrete applications.

### SISAL FIBRE

Sisal Fibre is a natural fibre obtained from the leaves of the sisal plant (*Agave sisalana*). It is biodegradable, renewable, and environmentally friendly. In concrete, sisal fibre helps control crack propagation, improves tensile and flexural properties, and enhances the ductility and toughness of the material.

## LITERATURE REVIEW

1. Joshi et al. (2016) investigated the combined use of waste foundry slag and alccofine as partial cement replacements to improve concrete performance and promote sustainability. Concrete mixes incorporating varying slag contents with a fixed alccofine dosage were tested for strength properties. The study reported significant improvement in compressive, split-tensile, and flexural strength due to alccofine's ultrafine pozzolanic action, micro-filling ability, and enhanced hydration. Foundry slag contributed to long-term strength through better packing and latent hydraulic activity. However, excessive slag

replacement reduced performance. Overall, the study demonstrated that the optimal combination of Alccofine and slag enhances strength while reducing environmental impact and cement consumption.

2. Prakash et al. (2018) explored the use of sisal fibres as natural reinforcement in concrete to enhance strength and crack resistance. Concrete mixes with varying fibre contents were tested for compressive, split-tensile, and flexural strength. The study found that sisal fibres improved ductility, toughness, and post-cracking behaviour due to fibre-bridging action, which helped control crack width and delay crack propagation. Tensile and flexural strength increased at optimum fibre dosage, indicating better energy absorption capacity. However, excessive fibre content reduced workability and slightly affected compressive strength due to fibre clumping and water absorption. Overall, sisal fibres were proven effective for sustainable crack-resistant concrete.

3. Jagadeesan et al. (2023) analyzed the effect of Alccofine as a supplementary cementitious material on concrete strength and durability. The study used different replacement levels and found that Alccofine significantly improved workability due to its ultrafine particles that enhanced packing and reduced voids. Compressive and split-tensile strength increased at optimum dosage because of improved hydration and higher C-S-H formation, leading to early strength gain. Durability also improved, with better resistance to chloride attack, sulphate exposure, and water penetration due to a denser matrix. However, excessive Alccofine reduced strength slightly. Overall, the study confirmed Alccofine as an effective mineral admixture for durable high-performance concrete.

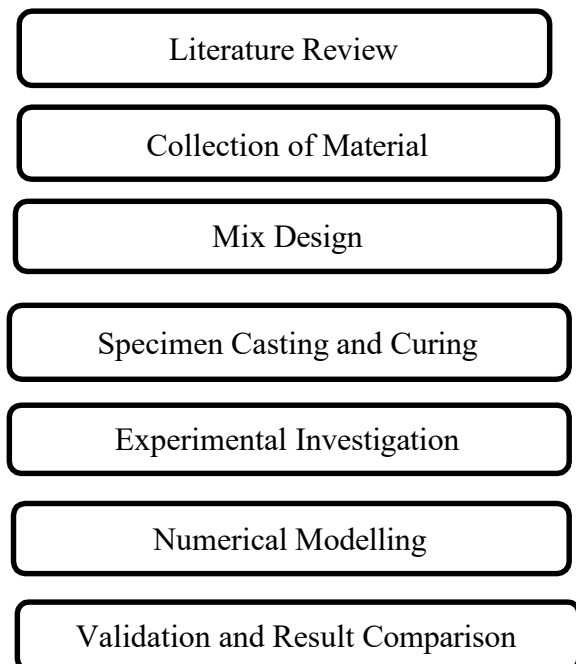
4. Harish (2022) examined high-strength concrete incorporating Alccofine as a partial cement replacement. The study showed significant improvement in compressive, split-tensile, and flexural strength due to the ultra-fine particles of Alccofine, which filled micro-voids and enhanced packing density. Its high pozzolanic reaction produced additional C-S-H gel, leading to a dense

and strong matrix. The optimum replacement level was found to be around 8–12%, improving early-age and later-age strength as well as workability. Beyond this range, strength slightly reduced due to excess fineness affecting water demand. Overall, Alccofine proved beneficial for high-performance structural concrete.

## OBJECTIVE

- To evaluate the mechanical properties of concrete to determine the optimum mix based on the strength results.
- To study the flexural behaviour of RCC beams under loading conditions.
- To analyse the load deflection response of beams.
- To develop a numerical model for the RCC beam and simulate its flexural performance.
- To check the experimental results with numerical analysis results to validate the performance of modified concrete.

## METHODOLOGY



## II. EXPERIMENTAL INVESTIGATION

### A. COMPRESSIVE STRENGTH TEST

The compressive strength test is performed on concrete specimens, typically prepared in the form of cubes or cylinders. In this study, cube specimens of size 150 mm × 150 mm × 150 mm were used. The cubes were casted immediately after mixing, ensuring proper compaction to eliminate segregation and prevent excessive laitance, thereby achieving dense and uniform specimens.

### B. SPLIT TENSILE STRENGTH TEST

The splitting tensile strength test on concrete cylinders is conducted to determine the tensile resistance of concrete. As concrete is inherently weak in tension due to its brittle nature, it is unable to withstand direct tensile forces and develops cracks under such stresses. Hence, the determination of tensile strength is essential to establish the load at which cracking may initiate in concrete members. In this test, the cylindrical specimen was positioned horizontally between loading of a universal testing machine, and the load was applied gradually until failure occurred. The maximum load at failure was recorded, and the tensile strength was subsequently calculated.

### C. FLEXURAL STRENGTH TEST

The flexural strength test is performed on reinforced concrete beam specimens of size 150 mm × 200 mm × 1000 mm. The beam specimens are reinforced with four 12 mm diameter main bars and 8 mm diameter stirrups provided at 150 mm centre to centre spacing. The concrete is placed in the beam moulds with proper compaction to ensure uniformity and to avoid segregation. After casting and curing, the specimens are tested under a two-point loading system using a loading frame. The load is applied gradually until failure occurs, and the load-deflection behaviour, ultimate load-carrying capacity, and failure characteristics of the beam.

## D. NUMERICAL MODELLING OF RCC BEAM

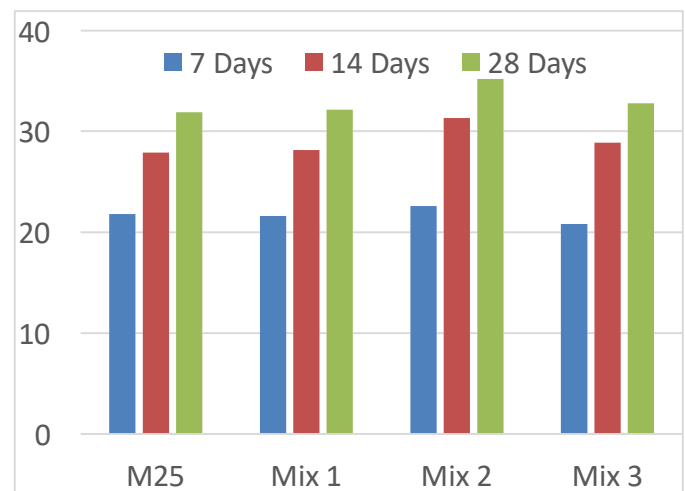
The RCC beam was numerically modelled using ABAQUS software to study its behaviour under loading. The finite element model was developed to predict the load deflection response, stress distribution, and structural performance of the beam. The numerical results were validated using the corresponding experimental results.

## III. RESULTS

### A. COMPRESSIVE STRENGTH TEST RESULTS

Mix	Compressive Strength in N/mm <sup>2</sup>		
	7 days	14 days	28 days
Control Mix	21.8	27.9	31.9
1%SF and 8% AF	21.6	28.13	32.13
1.5% SF and 10% AF	22.6	31.33	35.2
2% SF and 10% AF	20.8	28.87	32.77

*Table for compressive strength test results*

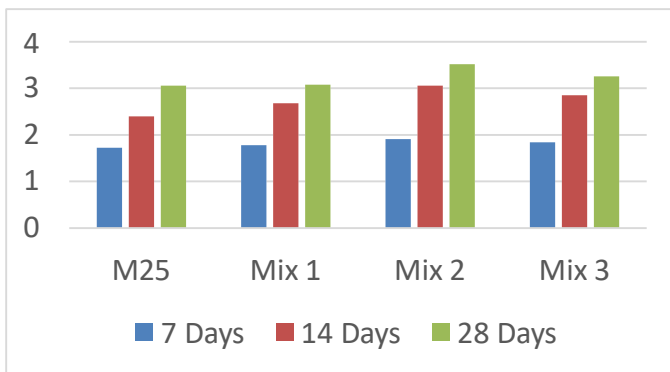


*Graph for compressive strength test results*

**B.SPLIT TENSILE STRENGTH TEST RESULTS**

Mix	Split Tensile Strength in N/mm <sup>2</sup>		
	7 days	14 days	28 days
Control Mix	1.72	2.58	3.06
1%SF and 8% AF	1.78	2.68	3.08
1.5% SF and 10% AF	1.91	3.06	3.52
2% SF and 10% AF	1.84	2.85	3.26

Table for split tensile strength test results

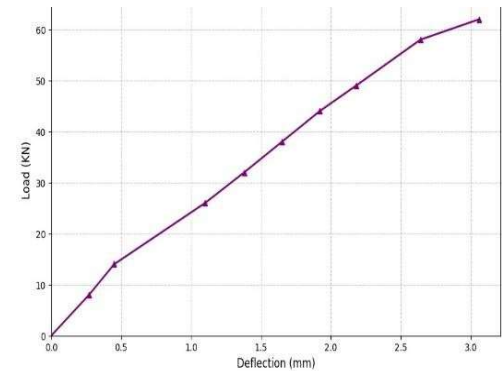
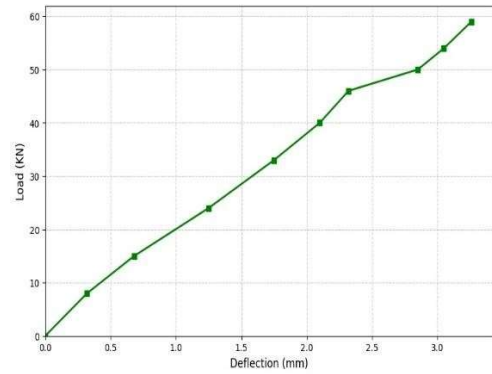


Graph for split tensile strength test results

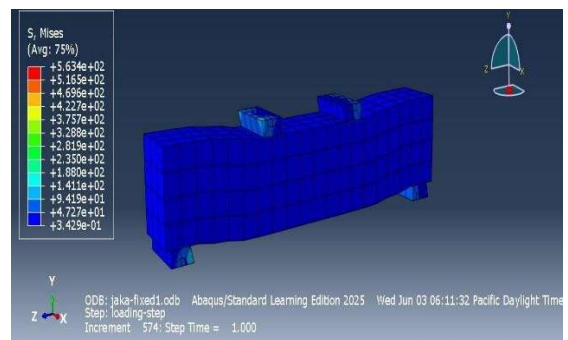
**C.FLEXURAL STRENGTH TEST RESULTS**

Control Mix Load (kN)	Deflection for Control Mix (mm)	1.5% SF & 10% AF Mix Load (kN)	Deflection for 1.5% SF & 10% AF Mix (mm)
0	0	0	0
8	0.32	8	0.27
15	0.68	14	0.45
24	1.25	26	1.10
33	1.75	32	1.38
40	2.10	38	1.65
46	2.32	44	1.92
50	2.85	48	2.18
54	3.05	59	2.64

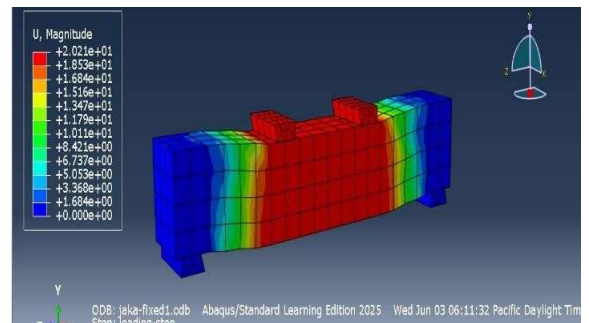
Table for Load-Deflection test results



**D.NUMERICAL MODELLING RESULTS OF RCC BEAM**



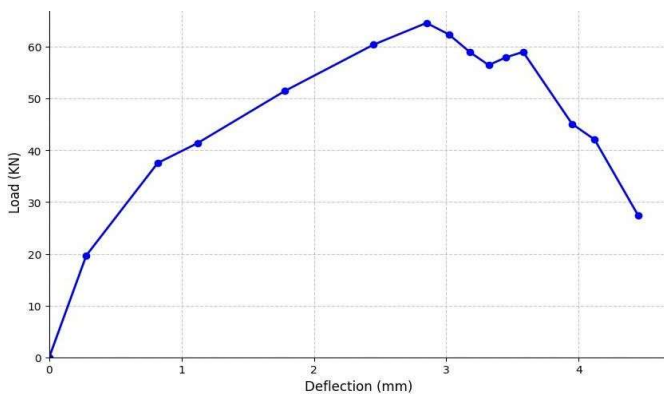
Shear representation of beam



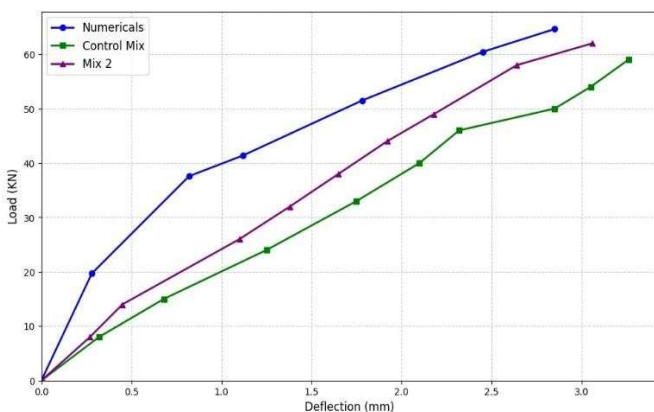
Deflection representation of beam

Load (kN)	Deflection (mm)
0	0
19.68	0.28
37.57	0.82
41.39	1.12
51.48	1.78
60.43	2.45
64.63	2.85
62.40	3.02
58.95	3.18
56.48	3.32
57.98	3.45
59.03	3.58
45.11	3.95
42.09	4.12
27.39	4.45

Table for numerical Load-Deflection test results



Graph for Load-deflection from numerical analysis



Graph for comparison of Load-deflection from numerical analysis for control mix and 1.5% SF& 10%AF mix

#### IV. CONCLUSION

The present study investigated the effect of Alccofine and Sisal Fibre on the mechanical and flexural behaviour of M25 grade concrete through both experimental and numerical approaches. Based on the experimental results, the incorporation of Alccofine and Sisal Fibre enhanced the overall performance of concrete compared to the conventional mix. The workability of concrete showed a slight reduction with the addition of Alccofine and fibres; however, it remained within acceptable limits for practical applications. Among the various combinations considered, the concrete containing 10% Alccofine and 1.5% Sisal Fibre exhibited superior performance in terms of compressive strength and split tensile strength. The improvement in strength can be attributed to the pozzolanic activity and micro-filling effect of Alccofine, along with the crack-bridging capability of Sisal Fibre, which improved the bond characteristics and delayed crack propagation within the concrete matrix.

The flexural behaviour of RCC beams prepared with the optimum mix was also found to be significantly better than that of the conventional beam. The modified beam exhibited higher first crack load, improved ultimate load carrying capacity, enhanced stiffness and better crack resistance. The presence of Sisal Fibre contributed to controlling crack growth and improving post-cracking behaviour, while Alccofine helped in producing a denser and stronger concrete matrix. The load-deflection response demonstrated that the optimum mix beam possessed improved structural performance and serviceability characteristics under flexural loading conditions.

Numerical modelling of the RCC beam was successfully carried out using ABAQUS software, and the obtained numerical results showed good agreement with the experimental observations. The developed finite element model was capable of accurately predicting the load-deflection behaviour and overall response of the beam. The close

correlation between experimental and numerical results validates the reliability of the modelling approach adopted in this study. Therefore, it can be concluded that the combined use of 10% Alccofine and 1.5% Sisal Fibre is an effective solution for producing sustainable and high-performance concrete with enhanced mechanical and structural properties, making it suitable for future reinforced concrete applications.

## V. REFERENCES

- [1] Ahmad, M., Khan, R., & Farooq, S. (2022). *Mechanical performance and sustainability of sisal fibre-reinforced concrete: A review*. Journal of Sustainable Construction Materials and Technologies, 6(3), 45–56.
- [2] Amsalu, F., Fode, D., & Abebe, S. (2024). *Durability enhancement of sisal fibre cement composites through fibre treatment and pozzolanic modification*. Construction and Building Materials, 391, 131482.
- [3] Benaoum, F., Bouchouicha, M., Bouiadjra, B.B., et al. (2020). *Finite element analysis of reinforced concrete beams strengthened with fiber reinforced polymer composites under bending load*. Frattura ed Integrità Strutturale, 54, 282–296.
- [4] Boobalan, K., Kumar, P., & Rajesh, S. (2021). *Strength behaviour of high-performance concrete incorporating Alccofine as a supplementary cementitious material: A review*. Materials Today: Proceedings, 47(5), 6523–6531.
- [5] Boudpalli, S., Kumar, A., & Thomas, M. (2023). *High-performance concrete incorporating Alccofine: A comprehensive review on strength and durability*. International Journal of Concrete Structures and Materials, 17(2), 218–229.
- [6] Gu, X., Li, Y., & Zhang, W. (2025). *Mechanical and high-temperature behaviour of ultra-high-performance concrete reinforced with treated sisal fibres*. Cement and Concrete Composites, 164, 106014.
- [7] Harish, R. (2022). *Performance of high-strength concrete using Alccofine as partial cement replacement*. International Journal of Engineering Research & Technology (IJERT), 11(8), 285–290.
- [8] Jagadeesan, P., Kumar, R., & Natarajan, R. (2023). *Effect of Alccofine on strength and durability properties of concrete*. Materials Today: Proceedings, 80(4), 1871–1878.
- [9] Joshi, D., Patel, A., & Desai, D. (2016). *Performance of concrete containing Alccofine and waste foundry sand as partial replacement of cement and fine aggregate*. International Journal of Engineering Research & Technology (IJERT), 5(6), 640–646.
- [10] Marcalikova, Z., Bujdos, D., & Cajka, R. (2020). *Approach to numerical modelling of fiber reinforced concrete*. Procedia Structural Integrity, 25, 27–32.
- [11] Prakash, S., Reddy, V., & Rao, A. (2018). *Experimental investigation on sisal fibre-reinforced concrete for enhanced crack resistance and ductility*. International Journal of Innovative Research in Science, Engineering and Technology, 7(9), 9218–9225.
- [12] Qu, Y., Chen, Z., & Liu, L. (2024). *Sisal fibre-reinforced geopolymer composites: A comprehensive review on preparation, properties, and durability*. Journal of Building Engineering, 85, 108527.
- [13] Rahman, A.F., Goh, W.I., Mohamad, N., Kamarudin, M.S., & Jhatial, A.A. (2019). *Numerical analysis and experimental validation of reinforced foamed concrete beam containing partial cement replacement*. Case Studies in Construction Materials, 11, e00297.
- [14] Ren, J., Wang, L., & Zhou, P. (2024). *Durability of sisal fibre-reinforced high-performance concrete under cyclic drying–wetting exposure*. Case Studies in Construction Materials, 22, e02493.
- [15] Sagar, K., & Sivakumar, V. (2021). *Study on the influence of Alccofine-1203 on mechanical and durability characteristics of concrete*. Materials Today: Proceedings, 43(7), 12135–12143.
- [16] Shcherban', E., Ivanov, D., & Petrov, A. (2024). *Development of sisal fibre-reinforced geopolymer concrete with GGBS and surface modification*. Journal of Cleaner Production, 452, 139911.
- [17] Vivek, R., Sharma, M., & Kannan, D. (2023). *Impact and durability performance of self-compacting concrete incorporating Alccofine and hybrid fibres*. International Journal of Civil Engineering and Technology (IJCIET), 14(1), 34–47.