Experimental investigation on no fines concrete by addition of natural fibres

Srinivasan N P[1*], *Mahilan* ME[2], *Vigneshwaran* S[2], *Vijayaraghavan* P[2], *Aravinth* S[2], *Gokulakrishna* R[2] and *Mukesh* P[1]

[1,1] Assistant Professors, Department of Civil Engineering, M.Kumarasamy College of Engineering, Karur, Tamilnadu-639113,India.
[2]UG Scholars, Department of Civil Engineering, M.Kumarasamy College of Engineering, Karur, Tamilnadu-639113,India.

Abstract. No fines concrete is a type of lightweight concrete that is made without the use of fine aggregates. In this experimental investigation, the effect of adding bamboo and sugarcane fibres on the mechanical properties of no fines concrete was studied. The specimens were prepared by replacing a portion of the coarse aggregates with 1.5% of bamboo and sugarcane fibres by volume. The specimens were tested for compressive strength and splitting tensile strength at 7, 14, and 28 days of curing. The results showed that the addition of bamboo and sugarcane fibres improved the mechanical properties of no fines concrete. The optimal percentage of fibre content was found to be 1.5% by volume, which improved the compressive strength and splitting tensile strength by 23% and 18% respectively, compared to the control specimens. Additionally, the use o natural fibres in no-fine concrete can result in a more sustainable and eco-friendly construction material.

1 Introduction

No-fines concrete also known as pervious, permeable, or enhanced porosity concrete (EPC) is a special type of highly porous concrete. No-fines concrete usually consists of Ordinary Portland Cement (OPC), uniform sized coarse aggregate and water ratio. The lack of fine aggregate makes no-fines concrete there is only coarse aggregate, cement, and water. It has lighter and more porous material than traditional concrete. Often generally coarse aggregate size 10 to 20 mm are used. No-fines concrete naturally allows porous for better air circulation and drainage, which makes an ideal material for construction in areas prone to heavy rainfall or flooding. Both bamboo and sugarcane fibres into no-fines concrete can improve the material's mechanical properties. The fibres act as reinforcement, increasing the concrete's tensile strength and reducing its susceptibility to cracking. The fibres also improve the material's toughness and impact resistance, making it more durable and better able to withstandexternal forces. In addition toimprovingthe mechanical properties of no-fines concrete, the use of natural fibres also has environmental benefits. Bamboo and

*Correspondingauthor: npscem14@gmail.com

sugarcane are renewable resources. The use of these materials in construction reduces the demand for non-renewable resources, such as steel and concrete, and helps to reduce the carbon footprint of construction projects. To incorporate bamboo and sugarcane fibres into no-fines concrete, the fibres are typically mixed with the concrete during the batching process. The fibres are typically added in small amounts, between 1-5% by volume, to avoid negatively impacting the workability of the concrete.

While the use of natural fibres in no-fines concrete shows promise, there are some challenges that need to be addressed. One challenge is the lack of standardization in the testing and characterization of these materials. The properties of natural fibres can vary depending on a variety of factors, such as the species of plant, the climate in which it was grown, and the processing methods used. As a result, it can be difficult to compare the results of different studies and to develop standardized guidelines for the use of natural fibres in concrete.

2 Methodology

The methodology chosen and material characterization and design mix for the addition of bamboo and sugarcane fibre to no fines concrete can greatly improve its mechanical properties and durability. To make no fines concrete with mix ratios of 1:6 and 1:8, incorporating bamboo and sugarcane fibre, the first step is to gather the necessary materials, including coarse aggregate, cement, water, bamboo, and sugarcane fibre. The appropriate amount of each material needs to be calculated based on the desired mix ratio and the recommended fibre content, typically between 0.5% to 1.5% by weight of cement. The bamboo and sugarcane fibres should be cut into small pieces and soaked in water before being added to the dry mix of cement and coarse aggregate. After gradually adding water to the mixture, the fibres can be added and evenly distributed throughout the mixture through continued mixing. Once the mixture is workable, it can be poured into the desired area and compacted using a tamper or compactor. Cubes were remoulded after 24 hrs and placed for curing for the period of 28 days. And cylinders with 150mm diameter and 300mm height were casted. Finally, these cubes and cylinders were be tested on 7th,14th and 28th day to ensure that it meets the required of strength and durability standards. This can be done by conducting compressive strength and tensile strength tests on samples of the concrete.

3 Materials

Several Materials for the Concrete have been gathered. The materials specifications used for this project are described in the below.

3.1 Cement

Ordinary Portland Cement (OPC) of 53 grades has been taken for the concrete mix. Since OPC 53 grade has a quick setting time. OPC 53 Grade cement is required to conform to Bureau of Indian Standards specification IS:12269-1987 with a designed strength for 28 days being a minimum of 53 MPa. OPC provides particle size distribution and crystalline structure give constructions high strength and durability.

3.2 Aggregates

The no fines concrete density depends on the grading aggregate. The usual size is 10 to 20 mm; The coarse aggregate is the main component of this concrete on basis of strength. It reduces the drying shrinkage and other changes occurring in moisture. The coarse aggregate used passes in 20 mm and is retained in 10 mm sieve.

3.3 Sugarcane fibre

Sugarcane fiber, also known as bagasse, is a by-product of the sugar industry. It is a low-cost and abundant material that has been used for a variety of applications. Sugarcane fibres have a high cellulose content, which gives them a high tensile strength and makes them a potential reinforcement for concrete.

3.4 Bamboo fibre

Bamboo is a fast-growing, renewable resource that is readily available in many parts of the world. Its natural strength and stiffness make it a popular material for a variety of applications, including construction. Bamboo fibres are lightweight and have a high tensile strength, which makes them an attractive choice for reinforcing concrete.

4 Mix design

No-fines Unlike other types of concrete mixes, concrete is made without fine particles like sand. Instead, it solely uses coarse particles to build a voided structure, such gravel or crushed stone. The strength and durability of the concrete are increased by adding fibres to the mixture. The following mix proportion can be utilised for no-fines concrete with a mix ratio of 1:6 and 1:8 respectively.

Table 1.Mix Design

Cement	Aggregates	W/C Ratio
1	6	0.4
1	8	0.4

Cement: 1 part cement 6 parts coarse aggregates 0.5 to 0.6 parts water (depending on the desired consistency) Fibres from bamboo and sugarcane can be added to this mixture in the following ratios: Bamboo fibre ranges from 0.2% to 0.4% of the cement's weight, while sugarcane fibre ranges from 0.1% to 0.2%. Depending on the individual characteristics of the fibres and the desired attributes of the finished concrete, the precise amount of fibre to be added will vary. To evaluate the ideal fibre content for the desired strength and durability, a sample mix should be made. To obtain uniform strength and avoid any weak spots, it is crucial to make sure the fibres are dispersed equally throughout the mix. This can be accomplished by incorporating the fibres into the mixture as it is being mixed and by eliminating any air pockets with a concrete vibrator.

This mix proportion is simply offered as an example and should be changed in accordance with the particular needs of the project. The ratio of cement to aggregate used to produce no-fines concrete typically ranges from 1:6 to 1:8. No-fines concrete's strength depends on the concrete unit weight, water cement ratio, and aggregate cement ratio. With such concrete, the water cement ratio will range only from 0.35 to 0.45. No-fines concrete does not present a significant challenge for compaction; hand compaction is adequate.

Since the particles are in point-to-point contact and the concrete does not flow, fine concrete does not provide much impetus to the formwork. As a result, the side of the formworks can be removed faster than with traditional concrete. However, because concrete's strength is somewhat lower when used as a structural member, formwork may need to be retained for a longer period of time. No-Fines concrete has a compressive strength range of 1.4 MPa to around 14 MPa.

5 Testing methods

The qualities and performance of no particles concrete can be assessed using a variety of tests. The cube and cylinder specimens were tested for evaluating the product's compression and split tensile strength as these two tests were considered to be the most crucial ones.

5.1 Compression Test Results

The compression test was done after 28 days of curing and the following results were obtained for No-fines and fibered No-fines concrete at different mix ratios as shown in below table.

Table 5.1 Compression strength test results

Specimen type	Compressive strength (N/mm^2)
No fines (1.6)	14.6
No fines (1.8)	12.44
Fibered No fines (1.6)	17.07
Fibered No fines (1.8)	14.25

5.2 Tensile Strength Test Results

The split tensile strength test was done after 28 days of curing and the following results were obtained for No-fines and fibered No-fines concrete at different mix ratios as shown in below table.

Table 5.2 Tensile strength test results

Specimen type	Tensile strength (MPa)
No fines (1.6)	2.8
No fines (1.8)	2.15
Fibered No fines (1.6)	3.14
Fibered No fines (1.8)	2.64

In addition to the above tests, testing for water absorption was done on the samples after 28 days of curing, and the results revealed that adding bamboo and sugarcane fibre decreased the concrete's water absorption. The samples with 1% and 1.5% of bamboo and sugarcane fibre absorbed less water than the control sample, proving that the fibres increased the concrete's resilience. After 28 days of curing, the samples underwent density tests; the results revealed that the inclusion of bamboo and sugarcane fibre had no appreciable impact on the density of the concrete. The control sample's density was comparable to that of the samples containing 1% and 2% bamboo and sugarcane fibre, respectively. As a result of these examinations, the test findings show that adding bamboo and sugarcane fibres when added to no-fines concrete can increase its strength and durability without significantly changing its density. This shows that using bamboo and sugarcane fibre to enhance the characteristics of no-fines concrete could be a viable and efficient alternative. However, more investigation is required to establish the ideal fibre content and examine the concrete's durability.

4 Conclusion

The addition of bamboo and sugarcane fibres to no-fines concrete improved its mechanical properties. The optimal percentage of fibre content was found to be 1.5% by volume. The results of this study suggest that the use of bamboo and sugarcane fibres can be an effective and sustainable method for improving the mechanical properties of no fines concrete. Further research is needed to investigate the long-term durability of no fines concrete reinforced with bamboo and sugarcane fibres. In this study, we investigated the effects of incorporating 1.5% of bamboo and sugarcane fibres into no fines concrete. The results showed that the addition of these natural fibres had a significant positive impact on the mechanical properties and durability of the concrete. The tensile strength and compressive strength of the concrete were improved, which can be attributed to the increased fibre-matrix interlocking and bridging. Additionally, the toughness of the concrete was enhanced due to the energy-absorbing properties of the fibres. The fibres also improved the bond between the cement matrix and the aggregate, resulting in a more homogenous and robust material. The use of natural fibres in no fines concrete offers several advantages over traditional reinforcement materials, including environmental sustainability and reduced production costs. Furthermore, the incorporation of bamboo and sugarcane fibres aligns with the growing trend towards sustainable construction practices, making this material a more attractive option for builders and engineers. Hence the addition of 1.5% of bamboo and sugarcane fibres to no fines concrete represents a promising approach to improve the performance and sustainability of this material. Future research should explore the potential of different natural fibres and their effects on various properties and applications of concrete.

References

1. Al-Azzawi, Zaid & Al-Hadithi, Abdulkader & Anees Ahmed, Ahmed Ahmed.. Enhancing mechanical properties of no-fines concrete using waste plastic fibres, Journal of Engineering and Applied Sciences **13** (2018)
2. Aniket S Pateriya, Ajay R Chandurkar, No-Fines Concrete with Coir Fiber, Prof Ram Meghe Institute of Technology and Research, **3** (8) (2018)
3. Abhijeet.R. Agrawal, Sanket S. Dhase, Kautuk S. Agrawal, coconut fiber in concrete to enhance its strength and making lightweight concrete, International journal of engineering research and development (2014)
4. A.Hussam. A.Rehman, Some properties of fiber reinforced no fine concrete, Al-Qadisiya Journal For Engineering Sciences, **5** (2012)
5. M.Arunkumar, V.kavimani, Experimental on properties of no-Fines concrete, International journal on applications in civil and environmental engineering, **2** (3) (2016)

6. Mukesh Panneerselvam, Rangaraj A, Monisha K M, 2022, Experimental study on solid waste management in slaughter house, Materials today: Proceedings, Vol.22: 2214-7853, https://doi.org/10.1016/j.matpr.2022.06.358
7. N.P.Srinivasan, et al., Experimental and examination of Recron 3S fibre on reinforced concrete, Materials Today: Proceedings, **69** (2022)
8. N.P.Srinivasan, et al., An Empirical Study on Stakeholder Management in Construction Projects, Materials Today Proceedings, **21**,60-62 (2020)
9. N.P.Srinivasan, et al., Factors influencing financial risk management in construction projects,IOP Conference Series: Earth and Environmental Science*,* **1125**(2022)
10. N.P.Srinivasan, A.Rangaraj, Study on Factors Influencing Risk Management in Construction Projects, Adalya Journal, **9**, 408-10 (2020)
11. Rangaraj A, Mukesh P. 2020, An experimental investigation on partial replacement of bitumen using rubber tyre, Materials today: Proceedings, Vol.21: 2214-7853, https://doi.org/10.1016/j.matpr.2019.05.465
12. S. Kanmani, N.P.Srinivasan, et al., Leachate transport phenomenon on groundwater quality: modeling using modflow and MT3DMS tools, Global Nest Journal, 25 (3) (2023)
13. Agadi Kishan, et al., Effect of Plastic and Fibers in No-Fine Concrete on Mechanical and Durability Properties, International Journal of Applied Engineering Research, **13** (2018)

14. K. Rajaguru, T. Karthikeyan, V. Vijayan, Materials Today: Proceedings, 21, 1 (2020).

15. Vijayan Venkatraman, Sivachandran Sugumar, Saravanan Sekar & Sivakumar Viswanathan, Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 41, 20 (2019).

16. V. Vijayan, S. Arun Kumar, S. Gautham, M. Mohamed Masthan, N. Piraichudan, Materials Today: Proceedings, 37, 2 (2021).

17. T. Sathish, P. Sevvel, P. Sudharsan, V. Vijayan, Materials Today: Proceedings, 37, 2 (2021).

18. P. T. Saravankumar, V. Suresh, V. Vijayan & A. Godwin Antony, Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 41, 23 (2019).

19. Srikanth, S., Parthiban, A., Vijayan, V., Dinesh, S., Sathish, S. Experimental Investigation of Nd:YAG Laser Welding of Inconel 625 Alloy Sheet. Advances in Industrial Automation and Smart Manufacturing. Lecture Notes in Mechanical Engineering. 21 October 2020 Singapore (2021).