Journal of Civil and Mechanical Engineering
Volume 01, Issue 01, July 2025
www.ijcme.com

Mechanical Characteristics of Bituminous Mixtures Reinforced with Coir Fiber

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To Cite this Article
Rohit Kumar, "Mechanical Characteristics of Bituminous Mixtures Reinforced with Coir Fiber", Journal of Civil and Mechanical Engineering, Vol. 01, Issue 01, July 2025, pp:05-08.

Abstract*: This work analyses the mechanical characteristics of coir fiber reinforced bituminous mixes, which is a bionatural product. Various quantities of coir fiber were applied to determine its effect in stability, flow, Marshall properties and moisture susceptibility. Based on research, the coir fiber enhances the tensile strength, durability and resistance to deformation of the bituminous mix. Workability is not compromised as performance is maximized by the ideal composition of fibers. This paper will illustrate how coir fiber can become an ecologically safe additive to enhance the mechanical characteristics of the bituminous pavements and aid in creating a sustainably constructed road.*

Keywords*: Bituminous blend, Waste fiber, Regular filaments*

I. Introduction

Natural fiber exists in pavement engineering and its application is increasingly becoming worldly because of the increased popularity of using sustainable and environmentally friendly building materials. Bituminous mixtures which are commonly applied to flexible pavements can be improved mechanically and have a longer life with the aid of reinforcement materials. Unlike other natural fibers, coir fibre, extracted out of coconut husk, stands out due to its excellent tensile strength, biodegradability and availability in large quantities in the tropical world. Coir fiber that has been considered a waste in past as agricultural material offers an eco-friendly alternative of improving the qualities of the asphalt mixes. This study is primarily based on the mechanical characteristics of bituminous blends with the addition of coir fiber. Coir fiber is added to improve desirable properties such as fatigue life, tensile strength, Marshall stability and immunity of moisture damage and rutting. Standard bituminous mixes were combined in different ratios with coir fiber in order to determine the optimum quantity by which maximum performances can be achieved without impairing homogeneity or workability. The research proposal examines how the bitumen interaction, distribution and fiber length affect the overall behavior of the mix. The study contributes to the efforts all over the world to make infrastructure greener, utilizing coir fiber as a reinforcement agent in manufacturing road construction material that will be long lasting and more sustainable.

II. Experimental Investigations

The experimental study aimed at evaluating the mechanical characteristics of coir fiber reinforced bituminous mixture. Bitumen of VG-30 grade and well-graded aggregates which were of MoRTH requirement were used. The bituminous mixes were loaded with coir fibers in varying proportions namely 0, 0.25, 0.5, 0.75 and 1.0 percent of the mix by weight. Coconut husk was processed into fibers which were cut to a length of 25 to 50 mm on average. The fibers were dispersed equally in order to distribute reinforcement uniformly in the mixture. In order to determine the optimum bitumen content (OBC) of each fiber-reinforced mix, Marshall mix design was employed. The parameters of strength and deformation were assessed by normal Marshall Stability and flow tests. Moisture susceptibility and indirect tensile strength tests (ITS) were also carried out to determine resilience to water damages and durability. Fatigue life of the mixes was also performed using repeated load tests. In the results it was found that the coir fiber addition gave a significant improvement in the stability, tensile strength, and rutting and moisture damage by about 125 to 140 strong after reaching an optimal percentage of coir fiber which is commonly under 0.75% or 0.5 percent coir fiber. The increased fiber content led to the increased number of voids and poor workability. Based on our

findings, coir fiber can be used as a viable and eco-friendly reinforcement substance enhancement of bituminous pavement performance.

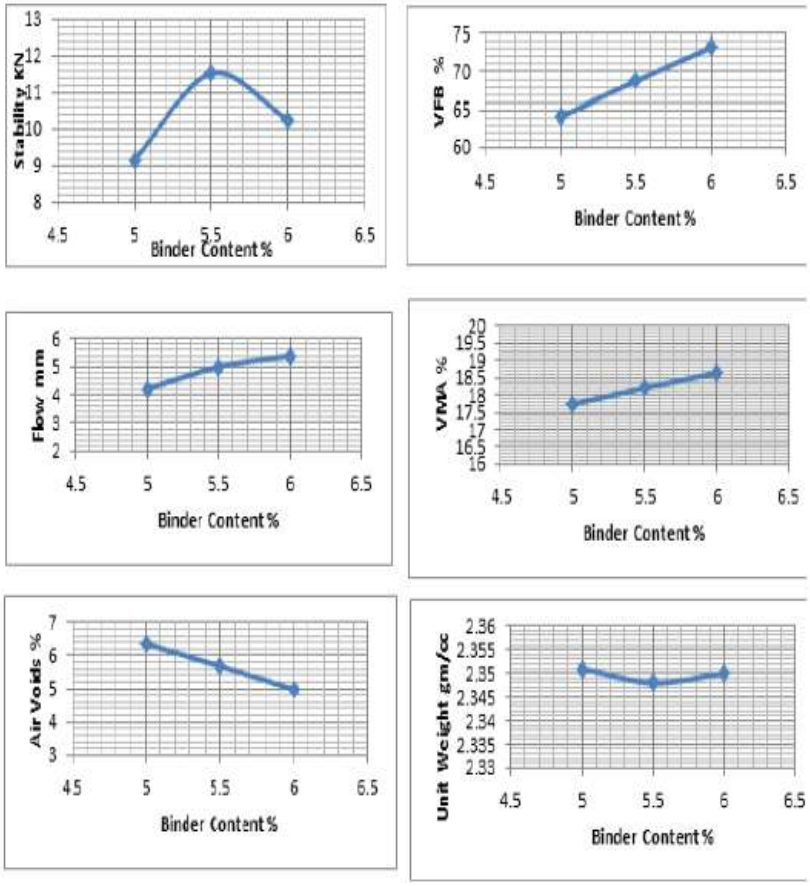

Fig 1: Bituminous Cement properties

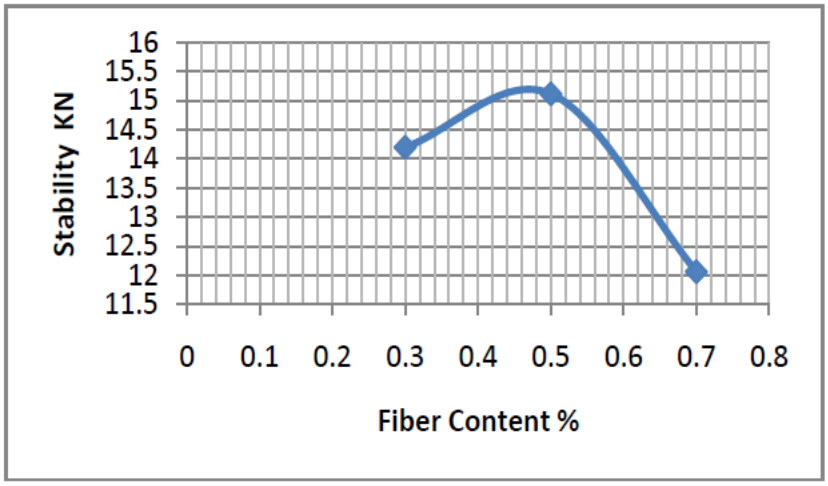

Fig 2: CFRBC stability criteria

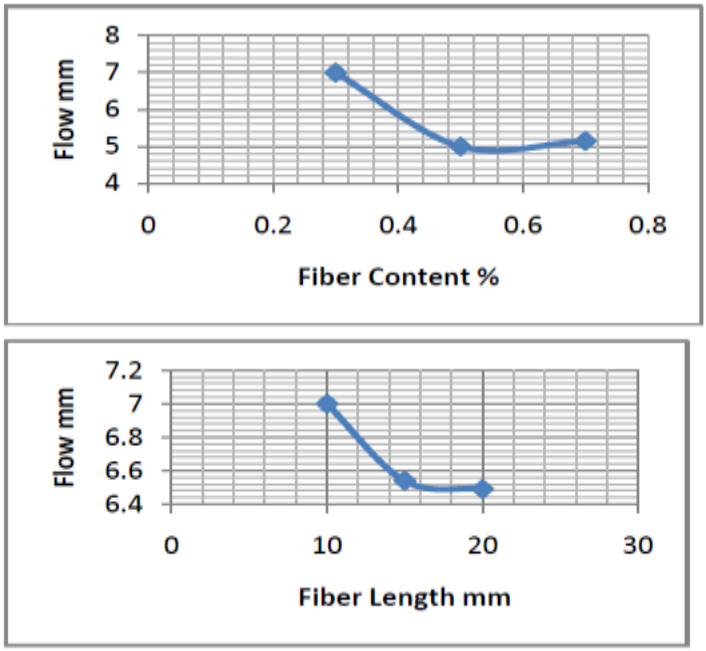

Fig 3: Flow property of CFRBC

III. Results and Discussions

The laboratory results indicated that during coir fiber addition to bituminous mixes, mechanical performance of the mixes improved greatly. Fiber concentrations of up to 0.5 % enhance Marshall Stability which connotes an increased scope of bearing. This led to decrease due to fiber agglomeration and more air gap between the fibers having an adverse impact on compaction and cohesiveness. Though, when fiber contents are raised, a small increment in the same meant that mix stiffness becomes lower, flow values however remained reasonable. Linking to the Indirect Tensile Strength (ITS), there was significant enhancement in the stiffness value where, tensile behavior was enhanced and better resistance to cracking was noted at 0.5 per cent coir fiber. The fatigue life also significantly improved at the optimal fiber fraction of the combinations and shows the ability of the fiber to absorb and distribute repetitive traffic load. Nevertheless, lack of proper fiber dispersion and loss in bitumen coating made too much fiber lead to a reduction so far as fatigue resistance is concerned. On the whole, it can be noted that coir fiber improved the strength, the durability and the sustainability of bituminous mixes at an optimum level of 0.5-0.75 percent, as a possible reinforcement agent in flexible pavements.

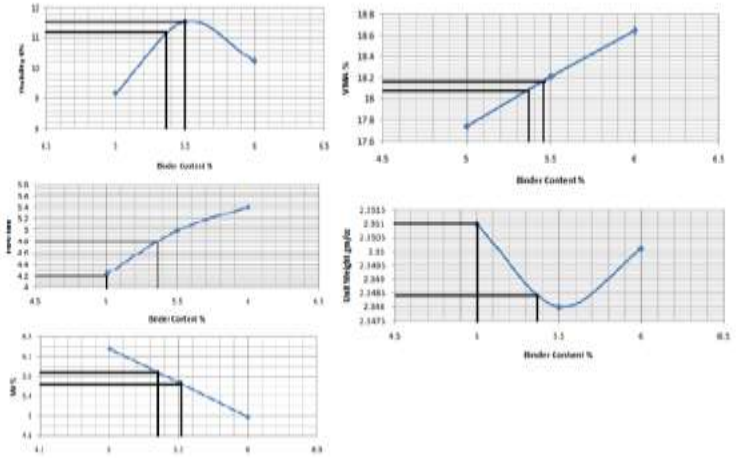

Fig 4: Optimum binder content for CFRBC

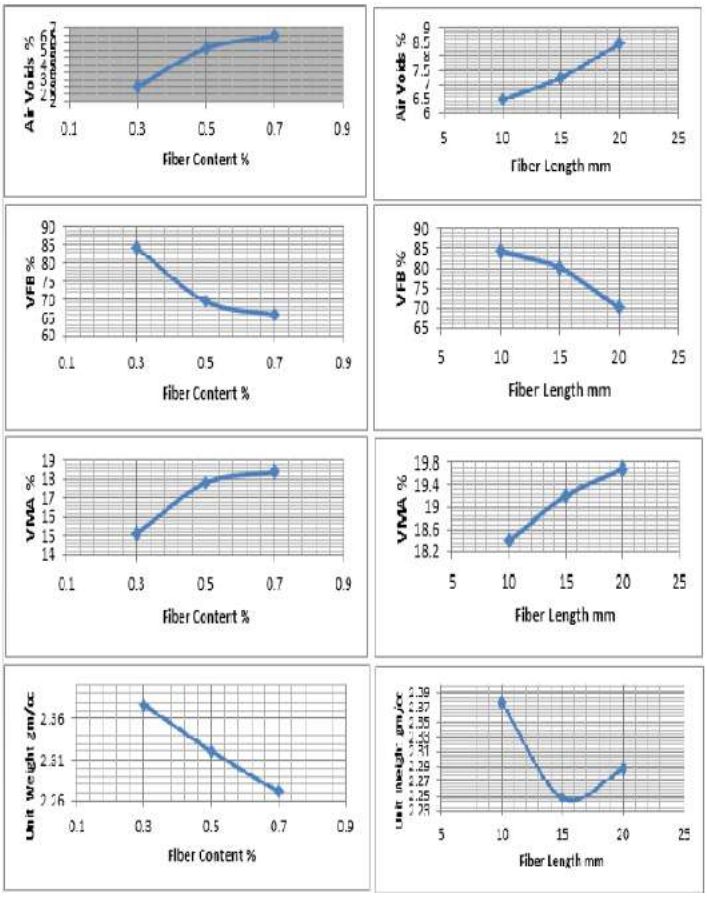

Fig 5: CFRBC volumetric property

IV. Conclusion

The mechanical performance of bituminous mixes according to the findings of the study is significantly enhanced by the use of coir fiber. 0.5 percent 0.75 percent by weight, Marshall Stability, Indirect Tensile Strength and fatigue life, and resistance to moisture damage are boosted with such ideal content in fibers. All these improvements are attributed to the ability of the fiber to enhance bonding in the mix, crack bridging as well as the more effective stress distribution. However, due to lack of dispersion and more voids, high fiber unfavorably affects the compaction and the workability. After all, through the employment of biodegradable, natural waste products, coir fiber is an effective, sustainable-friendly component that does not only enhance the performance of bituminous pavements, but stimulates sustainable construction methodologies. Long-term performance in the field and compatibility with other grades of bitumen can be looked into in more detail.

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