



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Special Issue 3, May 2024

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 8.423**

9940 572 462

6381 907 438

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# Experimental Investigation of Polypropylene Fiber Wrapped with Plastic Modified Bitumen

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**ABSTRACT:** An extensive experimental investigation aimed at improving the strength and durability of bitumen by integrating polypropylene fibers wrapped with plastic modifiers. The study encompasses a comprehensive series of tests to evaluate the efficacy of this novel approach, including Marshal stability tests conducted on bitumen samples. Additionally, the project conducted flakiness index tests, elongation tests, impact tests, and Los Angeles abrasion tests to assess various performance parameters comprehensively. The results of the study exhibit a notable enhancement in the strength of bitumen samples following the addition of 1% polypropylene fiber. Specifically, a remarkable 66% increase in strength was observed, indicating the optimal composition for maximizing bitumen performance. This enhancement underscores the potential of polypropylene fiber wrapped with plastic-modified bitumen to address the challenges of durability encountered by traditional bitumen materials.

**KEYWORDS:** Bitumen, Polypropylene, fibre, Plastic, Marshal stability.

## I.INTRODUCTION

Intra country transport communication is so vital that it has become one of the integral functions of both economic stability and progress. However, pure, and unmodified asphalts used in Pakistan are prone to temperature cracking due to weather extremities. A resultant penetration of water is caused by these distresses leading to partial or complete pavement-failure, making it necessary to improve the properties of pavement. Being a viscoelastic material, pavement performance such as rut resistance owes itself greatly to bitumen. In hot weather extremes problem is aggravated due to bitumen's lower stiffness. These limitations call for research and innovation in materials and techniques and innovations in pavement engineering to advance the pavements in terms of durability and resistance to distresses and thereby requiring lesser maintenance. The research to achieve these goals has culminated into development of the techniques that are collectively known as 'modification of asphalt'. They employ various types of fibers and polymers that are applied to the asphalt. Fiber application is very advantageous for increased durability as it improves fatigue and rutting resistance, increases service life, and reduces thermal cracking. In conventional mixes, Fiber-reinforced asphalt concrete materials (FRAC) materials are used for overlays or maintenance of pavements and bridge-deck membranes. They are also used in composite pavements and multi-course flexible pavements. Test like Indirect Tensile Test (IDT), Marshall Stability, susceptibility to moisture damage, susceptibility to freeze/thaw, modulus of resilience, and deformation under repeated load performed by Simpson and Kamyar after modifying the mix by adding polypropylene fibers, showed an increased tensile strength and cracking resistance for polypropylene-modified mixtures of polymers. Under repeated load deformation test, rutting potential was observed to reduce only in polypropylene- modified specimens. Scientists and engineers are constantly improving the performance of the flexible pavements. The cost of rehabilitation and maintenance of asphalt concrete pavement is one of the major problems because of improper mix design and/or using improper asphalt either in amount or quality. In order to ensure pavement long-term durability, thus minimizing maintenance cost and conserving resources, proper selection of paving materials together with optimal mix and pavement design are of great importance.

Polypropylene addition into the asphalt concrete in a dry basis increases Marshall stability values, decreases flow values and increases the fatigue life in a marked way. Stiffness of bitumen also increases with the addition of polypropylene fibers resulting in more stiff mixtures with reduced drain-down and increased fatigue life. Another research shows that addition of polypropylene into asphalt has shown the decrease in the Marshal Flow (38%), increase in stability values (26.3%) and increase in air voids (67.5%) . As far as the bonding and strengthening of bitumen is concerned, polypropylene fibers depict excellent results. Also, for consistent fiber lengths at lower temperature, higher

fiber contents have shown higher strengths and fracture toughness. Earlier, limitations have been showed in the mixing process of polypropylene fibers using dry method. This study use different percentages of polypropylene fiber incorporating small size (i.e. 6mm) to explore the impact of smaller fiber size on dry mixing process. Marshal Stability test was performed for flow and stability values to investigate polypropylene fiber's impact on Optimum Binder Content (OBC) and to find resistances against distresses in asphalt concrete. Polypropylene Fiber Polypropylene is a 100 percent synthetic fiber formed of 85 percent of monomer 'propylene (C<sub>3</sub>H<sub>6</sub>)' which is a hydrocarbon. Having high molecular weight and mode, the propylene polymerizes to produce polypropylene fibers with very useful properties like lowest density, less moisture absorption, excellent resistant to chemicals, acids and alkalis, and lower conductivity in comparison to other synthetic fibers. Polypropylene fibers are widely used as a reinforcing agent in concrete. The polypropylene fibers provide three-dimensional reinforcement of the concrete. By this way, concrete becomes more tough and durable.

## II. LITERATURE SURVEY

The problems related with the bituminous pavements are their premature distress in the form of cracks, raveling, surface undulations and segregation. This results in huge maintenance cost. To minimize the maintenance cost, the proper quality of work and material is important. Improving the qualities of bitumen and improving the stability of bituminous mixes may be one of the solutions. We, in this project deal with use of polypropylene fiber as an admixture to bitumen. Various tests on bitumen and polypropylene added bitumen are conducted to compare the properties. Initially, aggregate to be used for the project was selected and brought from Margalla stone quarry. Then the bitumen grade of 60/70 was selected. Based on material properties, a fine gradation of NHA class B was preferred over the NHA class A gradation. After having performed the requisite testing on the materials, the challenge to prepare mix and to select percentage of fibers for Marshal Mix Design was overcome by reviewing the literature. The dosages of 0.5% and 1.0% were selected by weight to determine Optimum Binder Content through Marshal. After OBC determination, sample of slab was prepared for indirect tensile test separately for control mix and reinforced fiber mix for performance analysis. Dry method was used to mix the fibers with aggregate and bitumen. In the end, a comparison was drawn for different results obtained from unmodified, 0.5% polypropylene modified and 1% polypropylene modified asphalt concrete. A conclusion was drawn through experimental results.

## III. PROPOSED METHODOLOGY

From this literature review fiber reinforced specimen that the marshal stability value increased and flow value decreases in a noticeable manner. Fatigue life of the specimen was also increased significantly. The improvement of the properties of bituminous concrete shows positive effect of polypropylene fiber. Addition of polypropylene fiber significantly improved the deformation resistance of asphalt mixture. Polypropylene fiber are projected to improved the properties of bituminous mixture significantly. because polypropylene fiber melt at temperature above 250 °C, they were not evenly distributed in the binder.

## IV. DISCUSSION

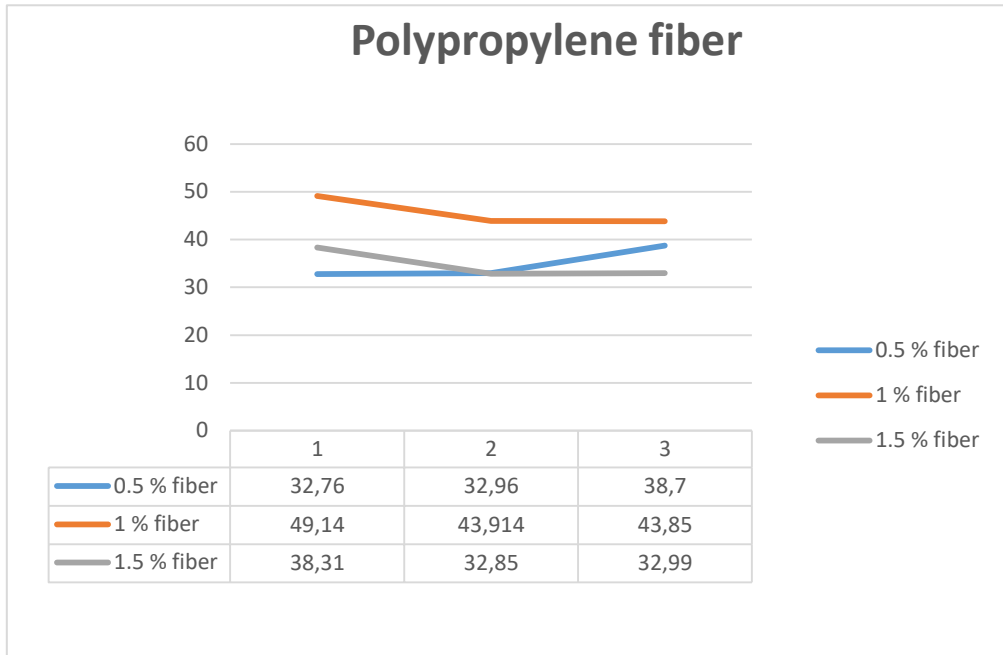
Polypropylene fibers are new generation chemical fibers. They are manufactured in large scale and have fourth largest volume in production after polyesters, polyamides and acrylics. About 4 million tons of polypropylene fibers are produced in the world in a year. Polypropylene fibers were first suggested for use in 1965 as an admixture in concrete for construction of blast resistant buildings meant for the US Corps of Engineers. Melting process of polypropylene can be achieved via extrusion and molding. Asphalt modification with addition of polypropylene fiber shows higher performance grade for rutting resistance at increased temperature. Also, this modification reduces the susceptibility of asphalt to changes in temperature. Additionally, benefits like drain down prevention and improved fatigue performance by enhancing crack resistance of asphalt material are also achieved.

Bruce Marshall, a former Bituminous Engineer with the Mississippi State Highway Department. Formulated the concepts of the Marshall method of designing paving mixtures. The U.S. Army Corps of Engineers, through extensive research and correlation Studies, improved and added certain features to Marshall's test procedure and ultimately Developed mix design criteria. The original Marshall method is applicable only to hot-mix asphalt paving mixtures containing aggregates with maximum sizes of 25mm or less. This method covers the measurement of the resistance to plastic flow of cylindrical specimens of bituminous paving mixture loaded on the lateral surface by means of the Marshall apparatus.



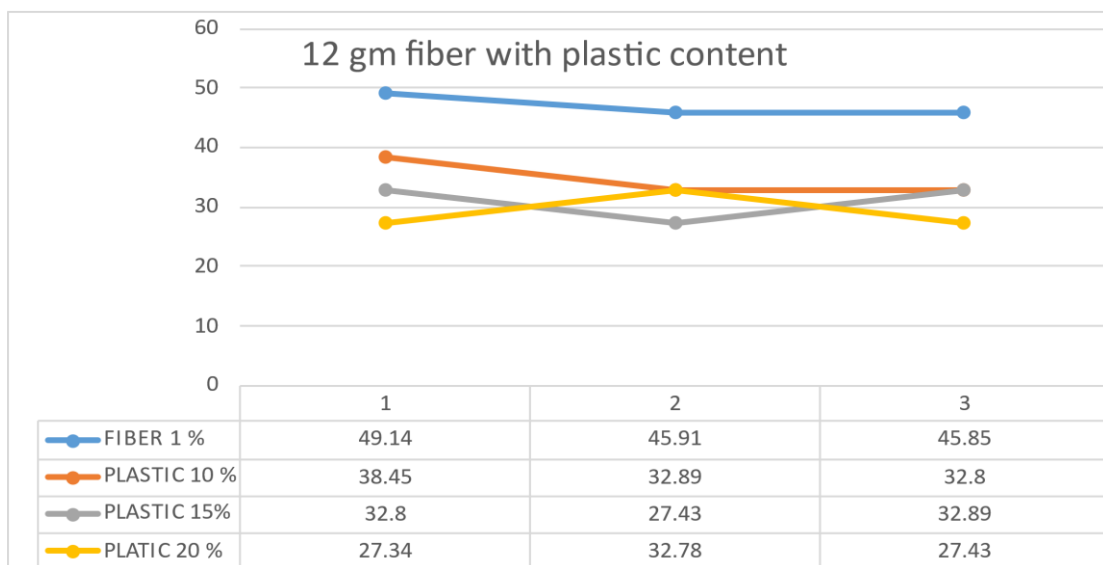
**V. RESULT**

In the Graph 1, Graph depicts the comparison of bitumen to percentage of fibre added to the sample of bitumen



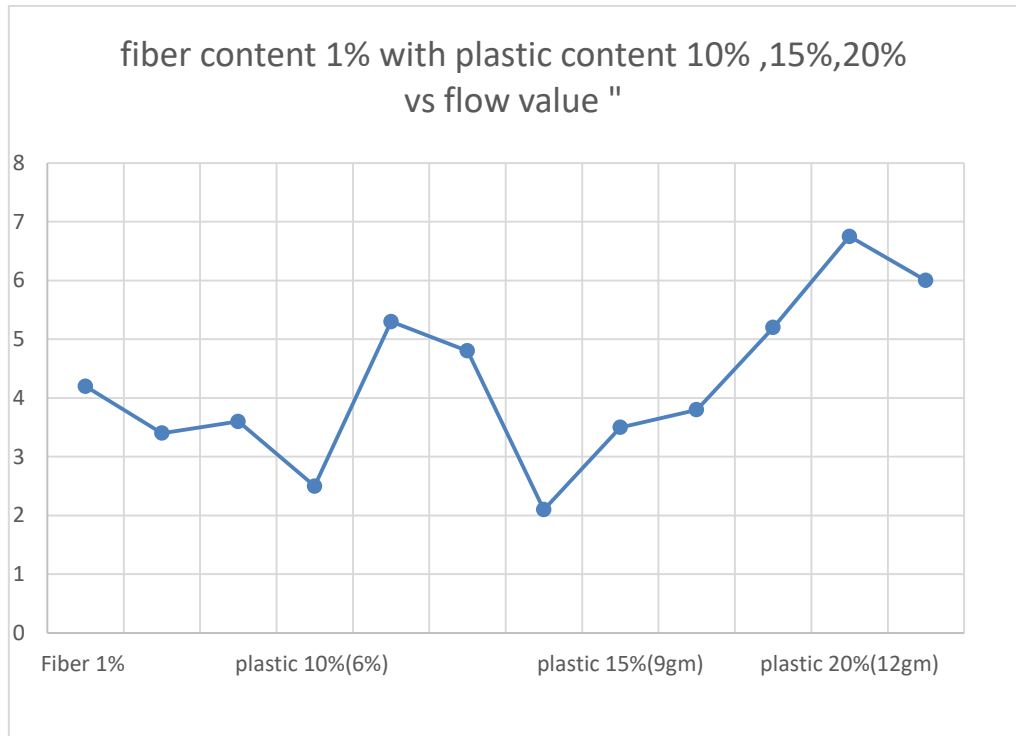
Graph1.Bitumen sample to percentage of fibre added

In the graph 2, graph shows the relation between fibre and plastic content used in fibre to make modified bitumen



Graph-2 Relation between fibre and plastic

In graph 3, graph interprets the relation between plastic content used in fibre with flow value of same



Graph-3 Graph showing relation between fiber with plastic content and flow value.

Table-1 observation table shows that, 1% of fibre and 10% of plastic added in bitumen sample gives maximum strength.

Sr. no.	Sample	Stability (KN)	Flow value (MM)
1.	Fiber(polypropylene 12gm)	49.14	4.20
		45.91	3.40
		45.85	3.60
2.	With plastic 10%(6gm)	38.45	2.50
		32.89	5.30
		32.80	4.80
3.	With plastic 15%(9gm)	32.80	2.10
		27.43	3.50
		32.89	3.80
4.	With plastic 20%(12gm)	27.34	5.20
		32.78	6.75
		27.43	6.0

Table-1

## VI.CONCLUSION

The results of the study exhibit a notable enhancement in the strength of bitumen samples following the addition of 1% polypropylene fiber. Specifically, a remarkable 66% increase in strength was observed, indicating the optimal composition for maximizing bitumen performance. This enhancement underscores the potential of polypropylene fiber wrapped with plastic-modified bitumen to address the challenges of durability encountered by traditional bitumen materials. Furthermore, the project findings highlight the positive impact of polypropylene fiber reinforcement on key mechanical properties such as resistance to deformation, fatigue, and crack propagation. Such improvements are crucial for ensuring the longevity and structural integrity of asphalt pavements under various loading and environmental conditions. The comprehensive testing regime employed in this study provides valuable insights into the performance characteristics of polypropylene fiber-wrapped bitumen, offering a scientific basis for its application in road construction and maintenance projects. The project's outcomes contribute to advancing the state-of-the-art in pavement materials and lay the groundwork for further research and implementation of innovative solutions in infrastructure development.

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