IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

An Experimental Study Examining The Application Of Carbon Fiber & Coir In Bituminous Work

[1]Animesh Kumar, [2]Deepraj Kevat, [3]Lovepreet Kaur,[4]Kamalpreet Kaur,
[1]M. Tech Scholar, [2]Asst. Engineer, [3]Asst. Prof., [4]Asst. Prof.
[1]Civil Engineering (Highway)
[1]SRM Institute of Engineering & Technology, Ambala, India

Abstract: India's rapidly increasing urban population combined with its rapidly rising industrialization calls for automobile attractiveness. Street divides are important for the growth of an economy, professions, and nation. India has the second-longest street system on the planet, spanning about 55 lakh kilometers. The majority of streets—98%—are flexible, with the remaining 2% consisting of rigid asphalt. Of total street length, about 40% of streets are unpaved. During stormy seasons, regular bitumen exhibits dissatisfaction and serious problems. To maintain the asphalt surface's utility, bitumen needs to be treated and reinforced. Thus, fiber materials, a nanomaterial, are currently used as an additive to strengthen the asphalt surface and to enhance the asphalt's entry, pliability, and moisture damage the material used as a modifier is able to withstand variations in temperature. As a result, street projects are looking for a modifier that can be used to structure an appropriate Marshall blend for adaptable asphalt in accordance with MoRTH rule. In order to meet this need, VG40 bitumen is used for the development of bituminous solid asphalt with coir fiber and carbon fiber in accordance with the standard suggested in MoRTH, and the influence of coir fiber and carbon fiber over various properties is investigated.

Index Terms – Coir Fiber, Carbon Fiber, Bitumen Durablity, Marshal Stablity, Flow Value, Void Ratio.

I. INTRODUCTION

The requirement to monitor assets for parkway development is guided by the 21st-century criterion of supportability. The crucial limit of sufficient workability is toughness. While carbon fiber reinforcement in the field of geo-technology also produced the best soil quality, coir fiber has a successful history in the concrete technology industry, where it has been shown to have superior properties in resisting tensile loading and strengthening the member. The capacity to retain internal particles and the maximum resistivity towards tensile loads are the two characteristics that both carbon and coir fiber share. Initially, efforts have been made to identify the qualities of materials that are useful for design and investigate the impact of coir fiber and carbon fiber in both with and without it on VG 40 bituminous mixes, in accordance with the MoRTH requirements. The street segment is the driving force behind commercial, economic, and physical expansion.

The most important feature is that roadways are large, sturdy, and everywhere. Approximately 93% of all streets in India are bituminous, accounting for 5% of all folio material and 95% of the entire street area. To handle the increasing trend of heavily loaded cars, innovative new materials for highway construction are needed. People in India believe that a common issue is moisture-induced degradation to black-top asphalt. This moisture damage also severely degrades the quality of the black-top mix, resulting loss of grip. Additionally, it may result in premature asphalt failures like raveling and rutting on the asphalt surface. The typical bitumen becomes unsatisfactory and poses a significant problem for the growth of automobile traffic during windy seasons. The process known as stripping causes the black-top folio and total to separate from one another when there is a loss of grip at the interface between these materials when they are in contact with water. To mitigate the damaging effects of water, several analysts suggested using anti-strip additives to strengthen the link between bitumen and aggregates, resulting in enhanced wetting resistance. Innovative nano-innovation "Wetbond-S" is a silicon-based anti-stripping additive for asphalt. This product is a low portion, highly warm resistive additive for use in Hot Blend and Warm-Blend Street developments. It is especially suitable for totals with high and intense stripping profiles. "Wetbond-S" is an earthy, clear fluid at room temperature with a distinctive citrous scent. It functions as a water sealing specialist and bond advertiser. It is miscible with polar and hydrocarbon solvents and is non-miscible with water. Its warm security in Hot Bitumen (at 160°C) is greater than 15 days, and no additional portion expansion or alteration is needed on delayed capacity in Hot-Blend asphalt developments typically occur. The strength of the interlocking ability with the aggregate will be improved by the use of carbon and coir fiber in the asphalt-making process. This prevents problems with slipping on the road's surfaces as well.

Coir Fibre

The natural fiber known as coir, or coconut fiber, is taken from the outer husk of the coconut and is utilized in mattresses, doormats, floor mats, and brushes. The fibrous substance called coir is located between a coconut's hard inner shell and outer covering. Other use for brown coir, which is derived from ripe coconuts, include horticulture, sacking, and upholstery padding. To make finer brushes, thread, rope, and fishing nets, white coir is extracted from unripe coconuts. It may be used for extended periods of time in deep water without adding weight that would draw down boats and buoys since it has the virtue of not sinking. Coir pith, the powdery, spongy material that remains after the coir fiber is processed, should not be confused with coir. Confusion is increased in certain nations where coir fiber is referred to as "coprah" locally.

Carbon Fiber

Carbon fiber (CF) is a material reinforcement comprised of strong, thin carbon crystalline threads. When coiled like yarn, carbon fiber—which may be thinner than a human hair strand—gains strength. In addition to being strong, carbon fiber has a low weight to strength ratio, a high stiffness, a high tensile strength, and a tolerance to temperature susceptibility.

This study aims to envisage the use of Coir and Carbon Fiber reinforcement in bituminous concrete, which consists of various percentages of Coir and Carbon Fiber. Control mix, used as a reference while other samples contain different ratios of Coir and Carbon Fiber in Bituminous concrete. Decision analysis reveals that the characteristics of Coir and Carbon Fiber used are improve the Marshal Stability as well as the flow of the bituminous concert. Coir and Carbon fibers are those consisting of bituminous concrete mix and Coir and Carbon as fibers. This mix, have large number of volume fractions, geometries, orientations and material properties. Coir and Carbon fiber increases properties like ductility, shear resistance and stiffness.

II. RESEARCH METHODOLOGY

The plan and procedure used to perform the study are divided into four major segments viz.

1. Material and there testing
2. Design of the Bituminous Concrete Mix
3. Checking the properties of the bituminous Mix grade 2
4. Testing of the Marshal Moulds and Maximum Specific Gravity (Gmm) for their Stability and Flow Strength

III. EXPERIMENTAL RESULT AND DISCUSSION

Sieve Analysis 20 mm Aggregate

Sieve Size mm	**26.5**	**19.0**	**13.2**	**4.75**	**2.36**	**0.300**
% of Passing	100	69.68	33.74	3.01	0.71	0.71

Sieve Analysis 10 mm Aggregate

Sieve Size mm	**26.5**	**19.0**	**13.2**	**4.75**	**2.36**	**0.300**
% of Passing	100	100	99.34	26.18	9.25	3.93

Sieve Analysis 6 mm down Aggregate

Sieve Size mm	**26.5**	**19.0**	**13.2**	**4.75**	**2.36**	**0.300**	**0.075**
% of Passing	100	100	100	95.42	86.75	24.18	8.68

Other Parameter of the Course aggregate

S.no	**Property**	**Test**	**Result**	**Method of Test**
1.	Particle shape	Combined flakiness and Elongation index	26.77	IS:2386 Part I
2.	Aggregate Strength	Los Angeles Abrasion value or Aggregate Impact Value	25.40 % 18.31 %	IS:2386 Part IV
3.	Water Absorption	14 to 6 mm 6 mm down	0.95 % 1.21 %	IS:2386 Part III
4.	Specific Gravity	14 to 6 mm 6 mm down	2.687 2.690	IS:2386 Part III

Testing of the Bitumen VG-40 for following physical properties

S.No.	Physical Properties of Cement (OPC 43) Grade	Results	Requirement of as per IS 73:2006
1	Absolute Viscosity	4055.75	3200 to 4800 Poise.
2	Penetration	43	40-60 mm
3	Flash and Fire Point	320	Min 220 ºC.
4	Ductility	71.5	Min. 25 cm
5	Softening	51.90	Min. 50 ºC.
6	Specific Gravity	1.12	0.97 to 1.5

III. Design Mix of Bituminous Concrete Grade II

Proportioning of Aggregates (Trial and Error Method)

In this strategy, the extent of materials was differed until the necessary total degree was accomplished. The individual gradations of aggregates have been tested and recorded as tabulated below.

Aggregate gradation for 14-06mm

Sieve Size mm	26.5	19.0	13.2	4.75	2.36	1.18	0.600	0.300	0.150	0.075
% of Passing	100	90.66	68.17	30.40	16.43	6.67	1.63	0.00	0.00	0.00

Aggregate gradation for 06mm down

Sieve Size mm	26.5	19.0	13.2	4.75	2.36	1.18	0.600	0.300	0.150	0.075
% of Passing	100	100	100	95.01	82.16	71.57	59.42	43.19	27.13	5.68

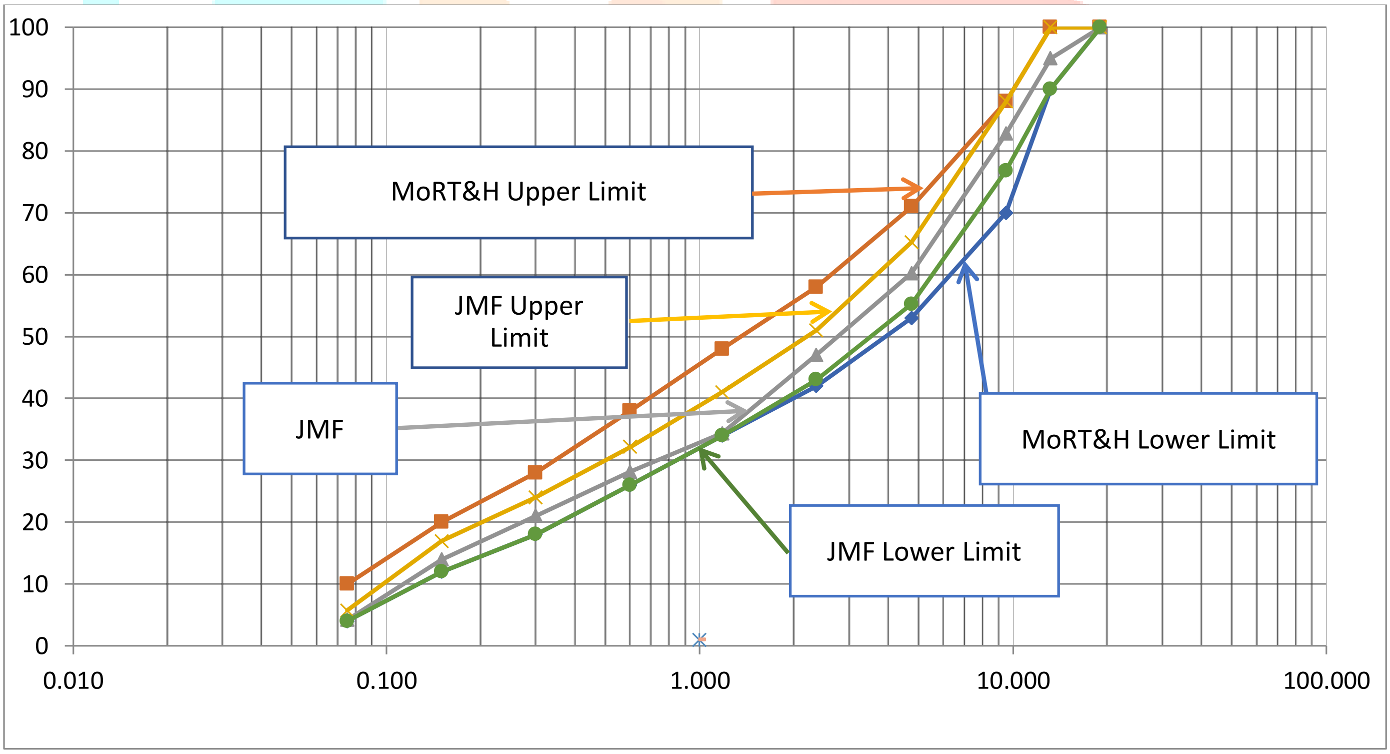
Gradation of Lime

Sieve Size mm	26.5	19.0	13.2	4.75	2.36	1.18	0.600	0.300	0.150	0.075
% of Passing	100	100	100	100	100	100	100	100	100	97.15

Combined gradation of aggregate as tabulated below

Sieve Size in mm	Size (14-06)	ize 06 Down	Filler	Combine Gradation % Passing	RT&H, Table 500- 17	JMF Limit As per MoRT&H(Table 500- 18)

Proportion of Mix	54%	44%	2%		Lower limit	Uper limit	Centre Line	Lower limit	Uper limit
19.0	100.00	100.00	100.00	100.00	**100**	**100**	100.0	**100**	**100**
13.2	90.66	100.00	100.00	94.96	**90**	**100**	95.0	**90**	**100**
9.5	68.17	100.00	100.00	82.81	**70**	**88**	79.0	**77**	**88**
4.75	30.44	95.02	100.00	60.25	**53**	**71**	62.0	**55**	**65**
2.36	16.43	82.19	100.00	47.04	**42**	**58**	50.0	**43**	**51**
1.180	1.63	71.60	100.00	34.38	**34**	**48**	41.0	**34**	**41**
0.600	0.00	59.47	100.00	28.17	**26**	**38**	32.0	**26**	**32**
0.300	0.00	43.23	100.00	21.02	**18**	**28**	23.0	**18**	**24**
0.150	0.00	27.16	100.00	13.95	**12**	**20**	16.0	**12**	**17**
0.075	0.00	5.17	97.15	4.22	**4**	**10**	7.0	**4**	**6**



MARSHALL METHOD OF MIX DESIGN

The Marshall strategy, which is detailed point by point in ASTM D 1559, is the most effective and widely used method for bituminous blend blend plans. Bruce Marshall, a former bituminous engineer with the Mississippi State Highway Department in the United States, originally developed the Marshall approach for bituminous blend blend plans in 1940. Following extensive investigation, the U.S. Corps of Engineers modified and improved the Marshall's test plan.

Proportion of Material (BC Grade - II)

Material	14-6 mm	6 mm	Filler	Bitumen	Totals
% Weight of Mix	50.92	41.49	1.89	5.70	100
Batch Weight (gms)	611.04	497.88	22.68	68.40	1200

Physical Test Results of BC Grade-II By Marshall Method at Optimum Binder content (5.70%)

SL NO	**Description**	**Test Result**	**Requirement as per MoRT**
1	Compacted Density of Mix (gm/cc)	2.334	
2	GMM Of Mix at 5.70% Bitumen Content	2.434	
3	Air vods in total Mix (%)	4.10	3 - 5
4	Voids In Mineral Agg. (VMA)	15.64	Min^{m} 12 %
5	Voids Filled with Bitumen (VFB)	73.77	65% - 75%
6	Marshal stability (kg)	1250.94	Min^{m} (900 kg)
7	Marshall Flow at 60 ^{o}C (mm)	3.6	(2-4 mm)
8	Optimum Bitumen Content (%)	5.70	Min^{m}. 5.4
9	Loss of Stability, %(Warer Sensitivity Test)	96.33	Min. 95 %
10	Striping value, (%)	Above 95%	Min^{m}. 95 %
11	Marshall Quotient (Stability / Flow) Kg/mm	347.48	250 - 500.
12	Dust to bitumen ratio (Fine / Bitumen)	0.84	0.6 - 1.2

Objective of Work

Different trails have been made with Optimum Bitumen content (OBC) with incorporating with coir Fiber and Carbon Fiber.

I. Blending the Different proportions of Coir Fiber as tabulated below.

Proportions

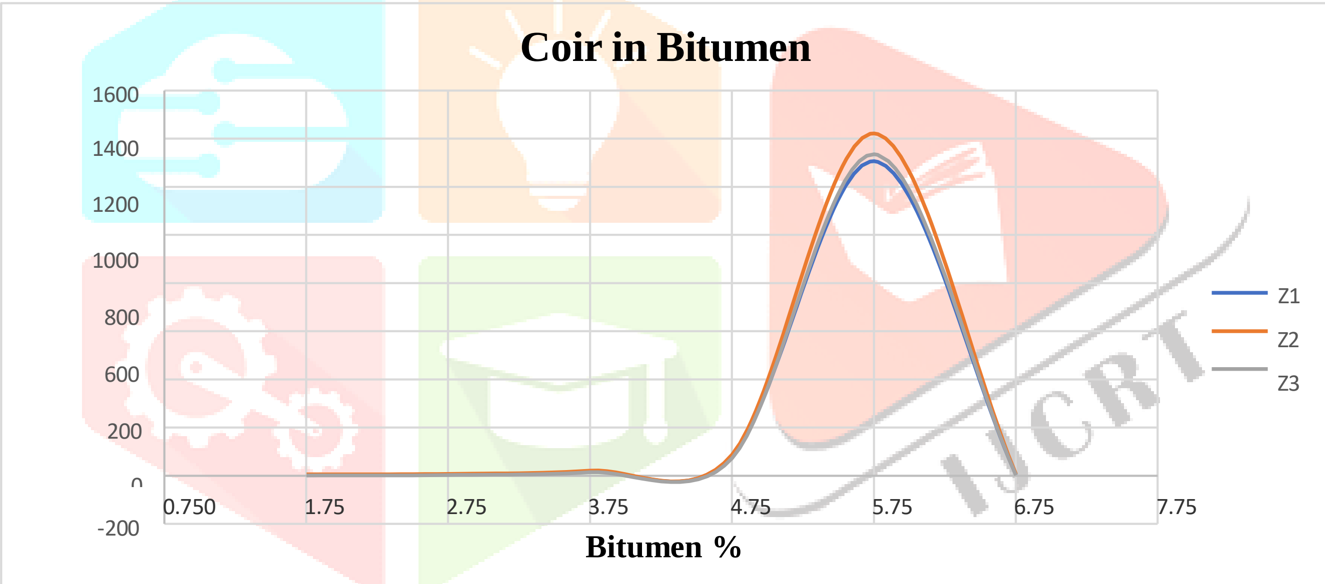
S.No.	**Mix ID**	**Material Proportion**
1	**Z1**	1% coir to Bitumen
2	**Z2**	2% coir to Bitumen
3	**Z3**	3% coir to Bitumen

Test Results addition of coir to bitumen

Mix ID	**Bitumen %**	**Coir %**	**Density**	**Air Voids**	**VMA**	**VFB**	**Stability**	**Flow mm**
Z1	5.7	1.0	2.328	4.32	15.86	72.76	1368	2.9
Z2	5.7	2.0	2.335	4.2	15.60	72.95	1410	3.1

Z3	5.7	3.0	2.333	4.15	15.68	73.53	1375	3.8

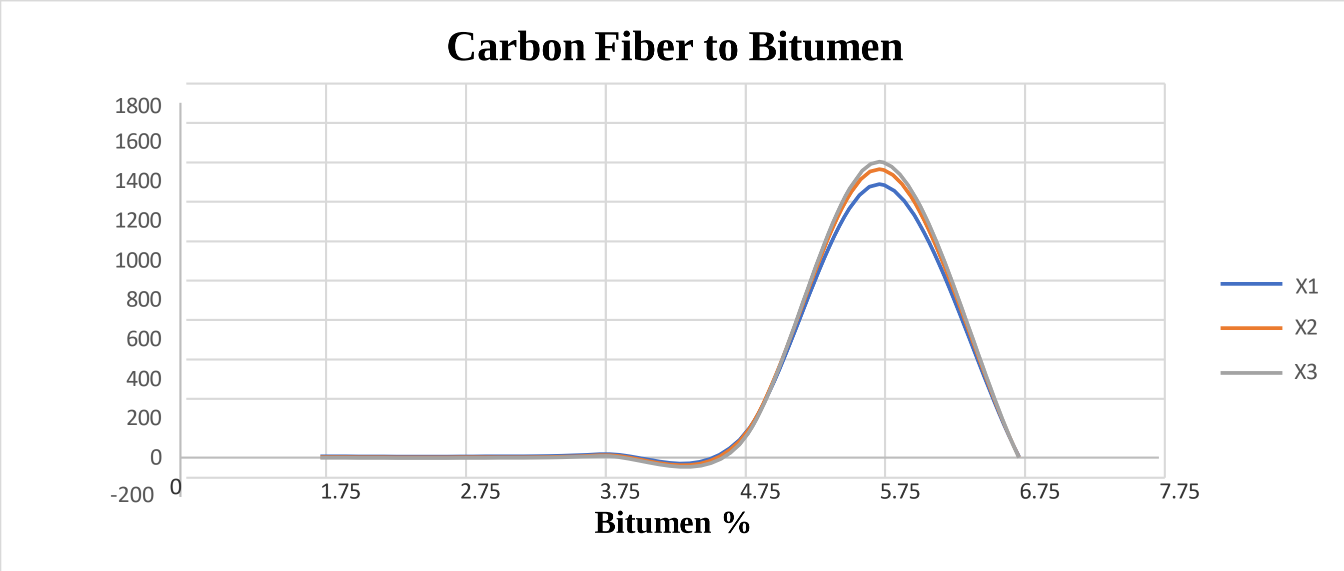
Mix ID	Bitumen %	Fiber %	Density	Air Voids	VMA	VFB	Stability	Flow mm
X1	5.7	0.2	2.387	4.25	13.72	69.02	1395	2.4
X2	5.7	0.4	2.395	4.20	13.43	68.73	1445	2.8
X3	5.7	0.6	2.406	4.11	13.04	68.48	1490	3.4



Blending the different proportions of Carbon Fiber as tabulated below

S.No.	Mix ID	Material Proportion
1	**X1**	0.2 % Fiber to Bitumen
2	**X2**	0.4% Fiber to Bitumen
3	**X3**	0.6% Fiber to Bitumen

Test Results addition of carbon fiber to bitumen



Comparative Study:

The above graphical represents that the use of coir and carbon fibers in bitumen has given better results in terms of density, void ratios and most importantly the stability of asphalt while auditioned with coir and carbon fibers has better results which could result further research to use in the road construction

Description	**Sample/Mix - ID**						
	OBC	**Z1 (1%Coir)**	**Z2 (2%Coir)**	**Z3 (3%Coir)**	**X1 (0.2% Carbon fiber)**	**X2 (0.4% Carbon fiber)**	**X3 (0.6% Carbon fiber)**
Density	2.334	2.328	2.335	2.333	2.387	2.395	2.406
Air voids	4.10	4.32	4.22	4.15	4.25	4.20	4.11
Voids in Mineral Aggregate (VMA)	15.64	15.86	15.60	15.68	13.72	13.43	13.04
Voids filled with Bitumen (VFB)	73.77	72.76	72.95	73.53	69.02	69.73	68.48
Marshal Stability (Kg)	1341.34	1368	1410	1375	1395	1445	1490
Flow at 60◦C (mm)	3.6	2.9	3.1	3.8	2.4	2.8	3.4

CONCLUSIONS

1. Using the specified ingredients and different bitumen percentages 4.5%, 5.0%, 5.5%, 6.0%, and 6.5% the bituminous concrete mix design was completed. The optimal bitumen content (OBC) was found to be 5.7% with density of 2.334 g/cc, marshal stability value of 1250 kg, and flow value of 3.6 mm.
2. When coir fiber is added to the optimal bituminous mix at different percentages, it was found that the Marshal stability rose by a maximum of 5% and the flow dropped by 14% at 2% (by the weight of bitumen) coir fiber; hence, 2% is the optimal proportion of coir fiber.
3. When carbon fiber is added to the optimal bituminous mix at different percentages, it was found that Marshal stability rose by a maximum of 7.17% and flow dropped by 22% at 0.4% (by the weight of bitumen) carbon fiber. This indicates that 0.4% is the optimal amount of carbon fiber.
4. The test findings show that a considerable increase in the amount of carbon and coir fiber in the mixture results in a large surface area being coated with bitumen. This leaves the aggregate and fiber particles insufficiently covered in bitumen, resulting in a loose mixture that subsequently exhibits high flow values and a drop-in stability.
5. The test results show that the other parameters, such as air voids (Va), voids in mineral aggregate (VMA), and voids filled with bitumen (VFB), are well within the extends indicated in the MoRTH-V guidelines. The addition of coir fiber at 2% and carbon fiber at 0.4% to the bituminous concrete enhances the stability of bitumen mix.
6. According to the study, adding Coir and Carbon fibers to Bituminous Concrete (BC) has an impact on the mix's qualities, such as increasing stability, tensile strength, and lowering flow value. The fibers may be able to prevent structural deterioration in the pavement, enhancing fatigue resistance and deformation resistance.

References:

1. Mahrez, A. Fatigue and Deformation Properties of Glass Fiber Reinforced Bituminous Mixes. J. East Asia Soc. Transp. Stud. 2005, 6, 997–1007.

2. Wu,S.; Chen, Z.; Ye, Q.; Liao, W. Effects of Fiber Additive on the High Temperature Property of Asphalt Binder. J. Wuhan Univ. Technol. Mater. Sci. Ed. 2006, 21, 28–31

3. Ratnasamy, M.; Bujang, B.K. Laboratory diameteral fatigue performance of SMA with cellulose oil palm fiber. Am. J. Appl. Sci. 2006, 3, 2005–2010.

4. Wu,Y.S.; Li, N. Investigation of the dynamic and fatigue properties of fiber-modified asphalt mixtures. Int. J. Fatigue 2009, 31, 1598–1602.

5. Ali, A. Influence of Crumb Rubber Modifier on Performance Characteristics of Stone Mastic Asphalt. MSc. Dissertation, University of Malaya, Kuala Lumpur, Malaysia, 2013.

6. M. Satyavathi, B. S. Rao and G. V. Rao “Experimental Study of Stone Matrix Asphalt with Coir Fiber and Pineapple Fiber” Int. J. Eng. Sci. Res. Technol., vol. 5, no. 11, pp. 378–385, 2016.

7. R. Thakur and J. Singh “Study of performance of bituminous concrete with addition of COIR/coconut fiber” Int. J. Mech. Eng. Technol., vol. 8, no. 7, pp. 1793–1799, 2017.

8. N. Mashaan, M. Karim, F. Khodary, N. Saboo and A. Milad “Bituminous Pavement Reinforcement with Fiber: A Review” CivilEng vol. 2, no. 3, pp. 599–611, 2021.

9. S. Dwivedi a d R. joshi “Effect of Natural Fiber o he Engineering properties of Dense Grade Bituminous Mixes with coal ash” vol. 5, no. 1, pp. 1–23, 2022.

10. Hamed,F.K.M. Evaluation of Fatigue Resistance for Modified Asphalt Concrete Mixture Based on Dissipate Energy Concept. Ph.D. Thesis, Technische University, Darmstadt, Germany, 2010.

11. Yildrim, Y. Polymer modified asphalt binder. J. Build. Constr. Mater. 2007, 21, 66–72.

12. O’Flaherty, C.A. Highway Engineering Textbook, 3rd ed.; Edward Arnold: London, UK, 1988.

13. ASTM D 1559 1989 “Test Method for Resistance of Plastic Flow of Bituminous Mixtures Using Marshall Apparatus”

14. ASTM D 6931 “Indirect Tensile (IDT) Strength for bituminous mixtures” American society for testing and materials, (2007).

15. ASTM D 792 “Standard test method for density and specific gravity y of plastic by displacement” American society for testing and materials, (2008).

16. MS-2, Manual for Hot Asphalt mix design