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Laboratory Simulation Study of Bituminized Jute Paving Fabric for Its Commercialization and Potential Application in Road Constructions

Ghosh Swapan Kumar
Department of Jute and Fibre Technology, University of Calcutta, 35, Ballygunge Circular Road, Kolkata-700019, West Bengal, INDIA

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Abstract

Geotextiles have witnessed unparalleled growth worldwide in recent years in the field of different civil engineering constructions. With the growing environmental concern the global emphasis is towards the application of eco-concordant, bio-degradable, renewable green products and this has inclined towards the natural fibre-made fabrics and making them a natural choice for the mankind. Jute Geotextile (JGT) is increasingly gaining ground over its synthetic non-biodegradable and toxic counterpart leading significant innovation in the design of geotechnical and geoenvironmental systems. One of the prime applications of JGT in civil engineering gamut is in road construction where JGT has been restricted so far as underlay. Hence, there is an urgent need to design and develop an innovative fabric as overlay on existing pavements to stay technically and economically competitive in the global market. Such a fabric will not only prove techno-economically viable but will also reduce the carbon foot-print generation to a large extent. This paper focusses on the laboratory simulation study of Bituminized Jute Paving Fabric (BJPF) carried out by the Department of Jute and Fibre Technology, University of Calcutta in collaboration with Central Road Research Institute (CRRI), New Delhi to establish its efficacy in reducing the cost of maintenance of the road and serving as a partial substitute of bitumen mastic enhancing thereby the life expectancy of the road.

Keywords: Jute Geotextile (JGT), Bituminized Jute Paving Fabric (BJPF), overlay, techno-economic viability, polymer modified bitumen (PMB).

Introduction

From the very foundation of the Indian Jute Industry, jute fibre has proved its authority over other fibres particularly in the area of packaging for food grains, in terms of its performance and reusability due to its considerable tensile strength, low extensibility and good dimensional stability, which is evidently the natural choice for packaging[1-3]. One of the growing alternatives in today's context is the advent of technical textiles made out of natural fibres which includes geotextile products for geotechnical applications, agrotextile products as well as other such relevant areas[4-6]. Jute geotextile (JGT) can certainly be considered as a potential aspirant replacing majority of today's popular synthetic products which are posing severe threats to our environment thereby adversely affecting the eco-congruity[7-15]. Several exhaustive studies and research works related to the design and engineering of JGTs with end-use requirements have been carried out over the years by several research organizations of national and international status to establish the potentiality of JGTs in mitigating the geotechnical problems[4, 15]. Jute Geotextile (JGT) is increasingly gaining ground over its synthetic non-biodegradable and toxic counterpart leading significant innovation in the design of geotechnical and geoenvironmental systems. One of the prime applications of JGT in civil engineering gamut is in road construction where JGT has been restricted so far as underlay. Hence, there is an urgent need to design and develop an innovative fabric as overlay on existing pavements to stay technically and economically competitive in the global market. Such a fabric will not only prove techno-economically viable but will also reduce the carbon foot-print generation to a large extent. Very recently a laboratory simulation study of Bituminized Jute Paving Fabric (BJPF) has been carried out by the Department of Jute and Fibre Technology, University of Calcutta, India in collaboration with Central Road Research Institute (CRRI), New Delhiwith the purpose to achieve the efficacy of potentially important Jute Geotextile suitable for use in road construction in the context of condition prevalent in India. In execution of the above mentioned laboratory simulation study Department of Jute and Fibre Technologyhas designed and engineered BJPF and then tested and characterized the sample in the state-of-the art laboratory of flexible pavement division, CRRI, New Delhi.

Material and Methods

The materials used in the study for preparation of samples included aggregates, bitumen alongwith Grey Jute Paving Fabric (GJPF) of the specification as furnished in table-1. The GJPF has been designed and engineered as a multilayered fabric and is prepared in the needle punching machine by combining three layers of woven fabrics and two layers of nonwoven fabrics. The different property parameters that have been tested in the Geotextile Laboratory, Department of Jute and Fibre Technology, University of Calcutta have been shown in Table 2. It is necessary to conduct the physical testing of the materials used to check their suitability for use in the bituminous layers[16].

Table-1
Specifications of the Grey Jute Paving Fabric (GJPF)

Sl. No.	Parameters	Values
1.	Mass per unit area expressed in gsm	1035.00
2.	Thickness expressed in mm	6.80
3.	Wide-Width Tensile Strength expressed in kN/m (machine direction × cross-machine direction)	25.00 × 26.00
4.	Elongation at break expressed in percentage (machine direction × cross-machine direction)	6.0 × 15.0
5.	Bursting Strength expressed in kgf/cm^2	36.00

Table-2
Physical tests along with the standard test methods of GJPF carried out at Geotextile Laboratory, Department of Jute and Fibre Technology, India

Sl. No.	Test Parameters	ASTM No.
1.	Mass per unit area	D5261-92(2009)
2.	Fabric Thickness	D5199-01(2006)
3.	Tensile Properties of Geotextiles by Wide Width Strip Method	D4595-09
4.	CBR Puncture Resistance	D6241-04(2009)
5.	Bursting Strength – Ball	D3787-07
7.	Permittivity	D4491-99(2009)
8.	Apparent Opening Size (AOS)	D4751-04

Results and Discussion

Physical Tests on Aggregates: Aggregate forms the major part of the pavement structureas they have to primarily bear load stresses occurring on the pavement[17]. So, naturally they have to withstand the high magnitude of load stresses and wear and tear. The aggregates of different sizes (20mm, 10mm, 6mm, stone dust and lime) were obtained from a hot mix plant near Delhi, India and various physical tests were carried out on them to check their suitability for use.

Specific Gravity Test for Aggregates: The specific gravity test aids in understanding the nature of stone[18]. Porous stones have more water absorption capacity and are generally unsuitable. They can be only accepted based on their property parameters like strength, impact and hardness tests[19]. The test results are presented in table 3. The gradation of individual aggregates is presented in table 4.

Impact Test: Toughness of a material measures its resistance to impaction[20]. Repeated and frequent movement of traffic cause a tremendous impact on the road stones and there is possibility of stones breaking into smaller pieces. The impact test measures the resistance of the stones to fracture under iterated impactions. The test results are presented in Table 5.

Table-3
Test Results for Specific Gravity and Water Absorption

Type of aggregates	Specific Gravity	Water Absorption (%)	Permissible Limits as per MoRTandH, 2001
Coarse aggregates (20mm)	2.62	0.50	2 % max.
Fine aggregates (13.2mm)	2.61	0.67	
Fine aggregates (6mm)	2.63	0.71	
Stone dust	2.68	-	-
Lime	2.24	-	-

Table-4
Gradation of Individual Aggregates

Sieve Size, mm	Percent of Aggregates Passing through sieve size				
	20 mm	13.2 mm	6 mm	Stone Dust	Lime
26.5	100.0	100.0	100.0	100.0	100
19	65.8	100.0	100.0	100.0	100
13.2	4.7	84.1	100.0	100.0	100
9.5	0.3	24.5	96.1	98.9	100
4.75	0.0	0.5	14.5	96.2	100
2.36	0.0	0.2	0.4	81.7	100
1.18	0.0	0.1	0.3	58.8	100
0.6	0.0	0.1	0.3	48.2	100
0.3	0.0	0.1	0.3	30.9	99
0.15	0.0	0.1	0.2	18.9	89
0.075	0.0	0.1	0.1	9.7	62

Table-5
Test results for Aggregate Impact Test

Type of aggregates	Aggregate Impact Value (%)	Permissible Limits as per MoRTandH, 2001 (For BC)
Coarse aggregates (20mm)	19 %	24 % max.
Fine aggregates (10mm)	13.35 %	

Shape Test: The particle shape of aggregates is determined by the percentage of flaky and elongated particles contained in it [21] [IS: 2386 (Part 1), 2002]. The presence of flaky and elongated particles is considered undesirable as they may cause inherent weakness with possibilities of breaking down under heavy loads. Angular shape is preferred due to increased stability derived from the better interlocking. The flakiness index of the aggregates is the percentage by weight of particles whose least dimension (thickness) is less than three-fifth (0.6) of their mean dimension. This test is not applicable to sizes smaller than 6.3 mm. The elongation index of the aggregates is the percentage by weight of particles whose greatest dimension is (length) is greater than one and four fifth times (1.8 times) their mean dimension. The elongation test is not applicable to sizes smaller than 6.3 mm.

Stripping Test for Aggregates: The aggregates used in bituminous pavements should have less affinity with water when compared with bituminous materials, otherwise the bituminous coating on the aggregate will be stripped off in presence of water[22] (IS: 6241, 1971). To check the stripping properties of the aggregates IS: 6241-1971 describes the procedure for stripping test. The stripping test was done on the aggregates with 60/70 bitumen. The retained coating was found to be more than 95 %, which conforms to the requirements as per MoRTandH specifications, 2001 (Fourth Revision). So, the test for water sensitivity has not been carried out in the present study.

Physical Tests on Bitumen: Bitumen is a petroleum product[23] obtained by distillation of petroleum crude is used in the construction of road pavement especially in flexible pavement to withstand a relatively adverse condition of traffic and climate. Different physical tests like ductility test[24] (IS: 1208, 1978), softening point test[25] (IS: 1205, 1978), specific gravity test[26] (IS: 1202, 1978), penetration test[27] (IS: 1203, 1978) and viscosity test have been carried out. However, the impregnation of the jute samples has been done with three different binders viz., 60/70, PMB-40 and 80/100, so the asphalt retention test has been done with all the three binders.

Asphalt Retention Testing of bitumen treated jute paving fabric: Asphalt retention is defined as the weight of asphalt cement retained by paving fabrics per unit area of specimen after submersion in the asphalt cement. The test has been done as per ASTM D 6140, "Standard Method to Determine Asphalt Retention of Paving Fabrics used in Asphalt Paving for Full-width Applications". The test procedure for determining asphalt retention is to select a random four-machine direction and four cross machine direction specimens measuring 100 by 200 mm (4 by 8 in.) forming the individual test sample this is followed by conditioning of the individual sample and weighing it to nearest 01 g. To preheat asphalt cement to 135 ± 2^{0}C. Then to submerge the individual test specimen in the specified asphalt cement maintained at a temperature of 135 ±2^{0}C in a mechanical convection oven. The specimen will then be submerged for 30 min. Two clamps may be placed on the fabric, one on each end to facilitate handling of specimen. After the required submersion, the coated asphalt cement to be removed, saturated test specimen and hang to drain (long axis vertical) in the oven at 135 ± 2^{0}C. This is followed by hanging the specimen for 30 min from one end and then from the other for the same time. The asphalt cement coated, saturated test specimen is then allowed to cool for a minimum of 30 min and then trim off the excess asphalt cement. The Asphalt retention is calculated as the average of the asphalt retention observed for all the specimens is as follows. RA= (Wsat - Wg)/ Ag, Where, RA is the Asphalt Retention in g/m2, Wsat is the weight of saturated test specimen in g, Wg is the weight of geotextile test specimen before saturation in g, and Ag is the area of geotextile specimen before test in m^2. Three samples have been tested for asphalt retention for each type of bitumen and the average value has been reported. The test results for asphalt retention are given in Table 6.

Table-6
Test results for Asphalt Retention of jute paving fabric

Sl. No.	Type of Bitumen used for impregnation of jute paving fabric	Asphalt retention in kg/m^2
1.	60/70 Bitumen	3.4
2.	PMB-40 Bitumen	3.6
3.	80/100 Bitumen	3.7

The procedure for asphalt retention test is shown in figures 1 and 2.

Figure-1
Jute samples ready for impregnation with bitumen

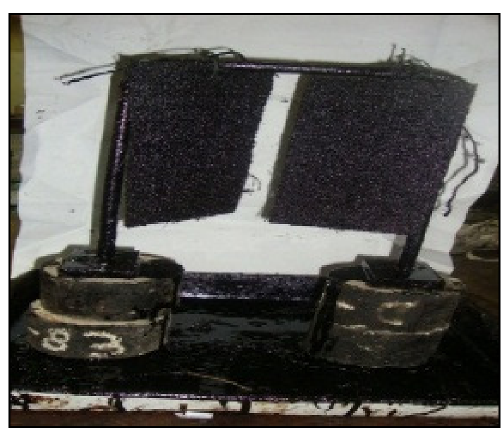

Figure-2
Jute samples after impregnation with bitumen

Marshall Mix Design Method: The test procedure has been standardized as perASTM D 1559 [28]. In this method, the resistance to plastic deformations of cylindrical specimen of bituminous mixture is measured when the same is loaded at the periphery at 5 cm per minute. The test procedure is used in designing and evaluating bituminous pavement mixes. The test procedure is extensively used in routine test programme for the paving jobs. There are two major features of the Marshall method of designing mixes namely density void analysis and stability – flow tests. The Marshall stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature at 60 °C. The flow value is the deformation the Marshall Test specimen undergoes during the loading up to the maximum load, in 0.01 mm units.

Design requirements of mix as per MoRTandH Specifications: As per the MoRTandH specifications for BC mix, when the specimens are compacted with 75 blows on either face, the designed BC mix should fulfil the following requirements:

Marshall stability value, kg (minimum)	900
Marshall flow value, mm	2 - 4
Voids in total mix, Vv %	3 - 6
Voids in mineral aggregates filled with bitumen, VFB, %	65 - 75
Loss of stability on immersion in water at 60°C	> 75 %

Marshall Mix design and determination of OBC for the present study Proportioning of aggregates: The objective of the mix design is to produce a bituminous concrete mix by proportionating various components so as to have sufficient bitumen to ensure a durable pavement and sufficient strength to resist shear deformation under traffic at higher temperature. This study was carried out using Bituminous Concrete mix design of 50 mm thick layer as per MoRTandH specification (Fourth Revision, 2001). The individual gradation of selected component aggregates and their proportion is given in table 7. Figure-3 shows proportioning of aggregates for BC Mix Design.

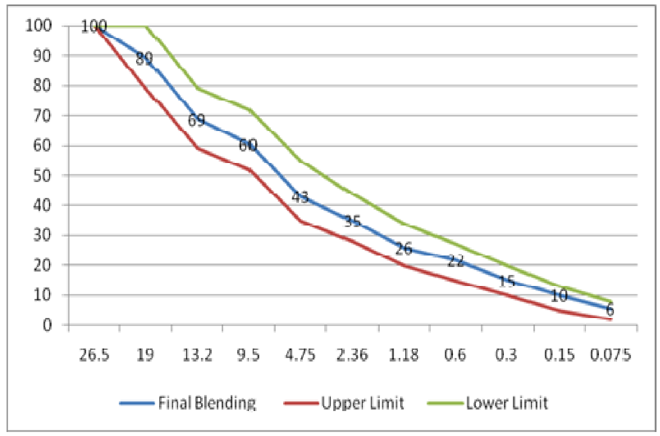

Figure-3
Proportioning of Aggregates for BC Mix Design

Table-7
Proportioning of Aggregates for BC Mix Design

Sieve Size	Percentage of aggregates passing through sieve size						
	Nominal size of aggregates					Blend Proportion by wt. of aggregate A : B : C : D : E 31 : 10 : 17 : 39 : 3	Specified Limits for 50 mm BC (MoRTandH, 2001)
	A 20 mm	B 13.2 mm	C 6 mm	D Stone Dust	E Lime		
26.5	100.0	100.0	100.0	100.0	100	100	100
19	65.8	100.0	100.0	100.0	100	89	79-100
13.2	4.7	84.1	100.0	100.0	100	69	59-79
9.5	0.3	24.5	96.1	98.9	100	60	52-72
4.75	0.0	0.5	14.5	96.2	100	43	35-55
2.36	0.0	0.2	0.4	81.7	100	35	28-44
1.18	0.0	0.1	0.3	58.8	100	26	20-34
0.6	0.0	0.1	0.3	48.2	100	22	15-27
0.3	0.0	0.1	0.3	30.9	99	15	10-20
0.15	0.0	0.1	0.2	18.9	89	10	5-13
0.075	0.0	0.1	0.1	9.7	62	6	2-8

Optimum Binder Content (OBC) had been determined following Marshall Method of the mix design as per ASTM D-1559. Volumetric and mechanical property parameters have been obtained for bituminous concrete mix and are given in Table 8 and the Marshall Parameters Obtained at Optimum Binder Content with 60/70 Bitumen are provided in table-9.

Beam Fatigue Testing: The flexure fatigue test[16] is conducted to evaluate the fatigue characteristics of an HMA mixture. Fatigue cracking of pavement is considered to be more a structural problem than simply a material problem. Several external factors influence the fatigue cracking in pavements, such as poor subgrade drainage, time of placement, and method of compaction and placement of the asphalt mix. The specimens for this test are 63.5 mm by 50 mm by 400 mm beams. The test is conducted in accordance to the procedures in AASHTO T 321-07. In this method, repeated haversine loads are applied at the third points of the specimen. The beam fatigue test can be conducted in controlled stress or controlled strain mode.

It can be seen from the above table that there is an improvement in the fatigue life of the beam where bitumen impregnated was used since they sustained more number of repetitions.

Table-8
Volumetric and Mechanical Parameters obtained for BC with 60/70 Bitumen

Binder Content, % by weight of Aggregate	Bulk Density, gm/cc	Stability, Kg	Flow, mm	Air Voids, %	Voids Filled with Bitumen, VFB, %	Voids in Mineral Aggregates, VMA
5.0	2.382	1047	2.8	5.37	67.67	5.0
5.5	2.391	1160	3.1	4.34	74.00	5.5
6.0	2.384	1093	3.3	3.95	77.17	6.0
6.5	2.371	984	4	3.82	78.94	6.5

Table-9
Marshall Parameters Obtained at Optimum Binder Content with 60/70 Bitumen

Parameters	Values obtained at OBC	Specified Values as per MORTandH, 2001
Stability, kg	1160	> 900
Flow, mm	3.1	2 - 4
Air Voids, %	4.4	3 - 6
Voids Filled with Bitumen, %	73.8	65 – 75
Density, gm/cc	2.390	-

Table-10
Beam Fatigue Testing Results

(A) BEAM SAMPLES (WITH NO JUTE)						
Strain Level (microstrain)	300		400		500	
Frequency (Hz)	5	10	5	10	5	10
Number of Repetitions to Failure (N_f)	159440	58110	112100	44120	28250	17670
(B) BEAM SAMPLES (WITH JUTE IMPREGNATED WITH 60/70 BINDER)						
Strain Level (microstrain)	300		400		500	
Frequency (Hz)	5	10	5	10	10	5
Number of Repetitions to Failure (N_f)	312320	153200	143640	131250	122590	55040
(C) BEAM SAMPLES (WITH JUTE IMPREGNATED WITH PMB-40 BINDER)						
Strain Level (microstrain)	300		400		500	
Frequency (Hz)	5	10	5	10	10	5
Number of Repetitions to Failure (N_f)	429510	159900	376900	186430	160120	112090
(D) BEAM SAMPLES (WITH JUTE IMPREGNATED WITH 80/100 BINDER)						
Strain Level (microstrain)	300		400		500	
Frequency (Hz)	5	10	5	10	10	5
Number of Repetitions to Failure (N_f)	198110	115390	184060	82000	125910	70900

Table-11
Effectiveness Factors for Beams for Different Test Conditions

(A) BEAM SAMPLES (WITH JUTE IMPREGNATED WITH 60/70 BINDER)						
Strain Level (microstrain)	300		400		500	
Frequency (Hz)	5	10	5	10	10	5
No. of Repetitions to Failure (N_f)	1.96	2.64	1.28	2.97	4.34	3.11
Average value of Effectiveness Factor (EF) = 2.72						
(B) BEAM SAMPLES (WITH JUTE IMPREGNATED WITH PMB-40 BINDER)						
Strain Level (microstrain)	300		400		500	
Frequency (Hz)	5	10	5	10	10	5
Number of Repetitions to Failure (N_f)	2.69	2.75	3.36	4.23	5.67	6.34
Average value of Effectiveness Factor (EF) = 4.17						
(C) BEAM SAMPLES (WITH JUTE IMPREGNATED WITH 80/100 BINDER)						
Strain Level (microstrain)	300		400		500	
Frequency (Hz)	5	10	5	10	10	5
Number of Repetitions to Failure (N_f)	1.24	1.99	1.64	1.86	4.46	4.01
Average value of Effectiveness Factor (EF) = 2.53						

Note: The reference beam for calculating the EF has been taken as plain beam without jute.

To evaluate the effect of bitumen impregnated jute in the fatigue life, a factor called "Effectiveness Factor" (EF) has been calculated as given below:

Effectiveness Factor (EF) =

$$\frac{\text{Number of repetitions to failure for reinforced beams}}{\text{Number of repetitions to failure for unreinforced beams}}$$

The effectiveness factors for the beams for different test conditions were calculated and are given in table 11.

It can be seen from the above table that average value of Effectiveness Factor (EF) was found to be highest for PMB-40 impregnated jute fabric. Also, PMB-40 gives higher values of EF for all the strain levels and frequency loadings. So, it can be concluded the PMB-40 is the most effective binder for increasing the fatigue life and will mitigate the propagation of reflective cracking. However, field performance evaluation is a must for evaluating the actual behavior under ambient climatic conditions.

Wheel Tracking Test: Wheel Tracking is used to assess the resistance to rutting of asphaltic materials under conditions which simulate the effect of traffic. A loaded wheel tracks a sample under specified conditions of load, speed and temperature while the development of the rut profile is monitored continuously during the test. A confined mould in which a 305×305×50mm specimen of asphalt mix is rigidly controlled on its four sides. The test specimen is mounted on a table which is reciprocated a distance of 230mm on linear bearings at the specified speed of 42 passes/minute along the length of the slab. A loaded rubber tyred wheel runs on top of the specimen and the resultant rut is monitored as the test proceeds using a calibrated displacement transducer. The temperature during the test is maintained by an insulated closed chamber maintained at a constant test temperature of 50 ± 1°C. The specimens are subjected to 20000 cycles. Two specimens were tested for each mix and average data on rut depth was found out. The rut depth was recorded at mid-point of the specimen length. The slabs for this test were prepared by filling the mould with the bituminous mix and applying static load through UTM till the depth of 50 mm is achieved. Two different types of slabs were prepared for this test one is the slab with control mix (in which no jute was used) and the other is the slab in which jute impregnated with PMB-40 was laid in the bottom one-third height of the sample. The results for the wheel tracking test are plotted in figure-2.

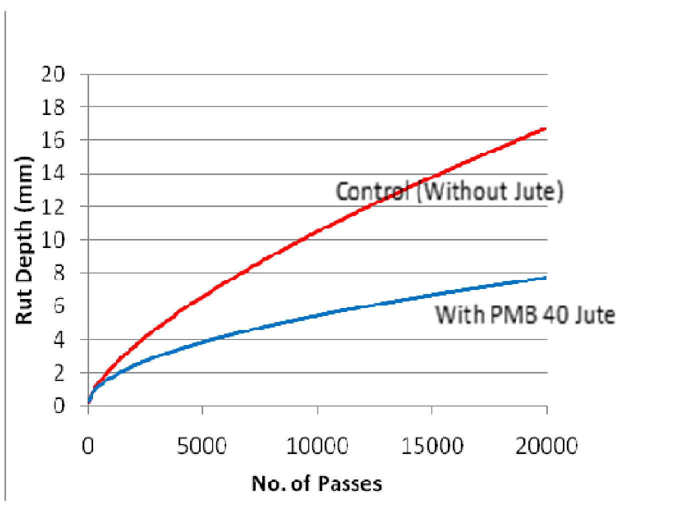

Figure-4
Number of Passes Vs Rut Depth (in Wheel Tracking Test)

Discussions: After thorough laboratory testing of the compatibility of different types and grades of Bitumen with grey jute fabric, the CRRI scientists observed and recommended that jute was found to be effective in increasing the fatigue life of bituminous mixes. Jute impregnated with 60/70 bitumen was found to have an average Effectiveness Factor (EF) of 2.72, i.e., it increases the fatigue life by 172 % compared to samples where no jute was used. Jute impregnated with PMB-40 bitumen was found to have an average Effectiveness Factor (EF) of 4.17, i.e., it increases the fatigue life by 317 % compared to samples where no jute was used. Finally, jute impregnated with 80/100 bitumen was found to have an average Effectiveness Factor (EF) of 2.53, i.e., it increases the fatigue life by 153 % compared to samples where no jute was used. A higher value of Effectiveness Factor (EF) indicates higher potential of the developed fabric to be used for field trial as per the objectives of the project.

Based on the laboratory testing and analysis of the results obtained, the CRRI scientists recommended that jute impregnated with PMB-40 bitumen was found to have the highest fatigue life and therefore, it is recommended to be used for the purpose of field trials. Proper impregnation of the jute fabric as per ASTM 6140 should be ensured. It must be ensured that the full thickness of the jute fabric is impregnated with the bitumen. However, any excess bitumen on the surface of jute fabric should be removed immediately. The laying of jute fabric should be done with mechanized equipment capable of providing a smooth installation with a minimum of wrinkling or folding. MORTandH specifications, 2001 must be adhered to during the construction operations and strict quality control must be ensured during the bituminous construction. The laying of the bitumen impregnated jute fabric should be done in accordance with the requirements of IRC: SP: 59-2002 (IRC:SP:59, 2002).

On the basis of the recommendations made by the CRRI scientists, applying PMB-40 bitumen on the GJPF, production of BJPF has been carried out in a Bitumen Treatment Plant, Kolkata. The specifications and process parameters of the developed BJPF have been furnished in table 12.

Commercialization (Field trials) of the developed BJPF: Field Trial of the developed Bituminized Jute Paving Fabric (BJPF) has been carried outat the premises of Department of Jute and Fibre Technology, University of Calcutta. The laying of the Bitumen impregnated Jute fabric has been done in accordance with the requirements of IRC: SP: 59-2002. Monitoring of the field trial as well as performance evaluation of the BJPF are going on which will be under a constant observation for at least two years. Close monitoring of the field trial is going on after every fifteen days and will continue for the next two years to assess the performance of the road under field trial. In the course of physical observation during monitoring of the road section under traffic simulated condition there were no signs of cracks and pot holes appearing on the surface of the road even after the completion of ten months of traffic simulation. Standardization and optimization of the product will be made and disseminated to the manufacturers and end users for commercial application after the completion of monitoring and performance evaluation of the product.

Table-12
Specifications of the Bituminized Jute Paving Fabric (BJPF)

Sl. No.	Parameters	Values
1.	Mass per unit area expressed in gsm	3500.00
2.	Thickness expressed in mm	8.00
3.	Wide-Width Tensile Strength expressed in kN/m (machine direction × cross-machine direction)	38.50×40.00
4.	Elongation at break expressed in percentage (machine direction × cross-machine direction)	11.0×09.0
5.	Bursting Strength expressed in kgf/cm^2	43.00
6.	Bitumen Add-on percentage	240.00

20 mm
TACK COAT
7-8 mm

Mastic Asphalt
BJPF
Existing Riding Surface

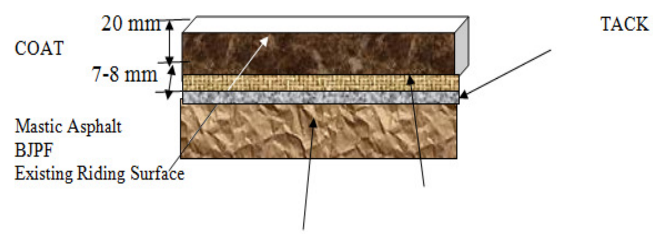

Figure-3
Schematic diagram of application of BJPF

Based on the pilot field trial performance, several full scale commercial field trials have been carried out at several traffic volume roads across West Bengal, namely over a stretch of lane of area -1000 sq. mts. approximately at Uday Shankar Sarani, Golfgreen, Kolkata, State Highway-5 (shown in figures 4 to 9), Contai-Beldah Carriageway, West Midnapore, and other places to evaluate both of the functional as well as structural contribution of the developed Bituminized Jute Paving Fabric (BJPF) reinforcement to the pavement system in a full volume traffic roadas shown in figure 5. The monitoring reports of these experimented roads taken at regular intervals show that even after two years of application of the geotextile and withstanding the traffic loads and severe climatic conditions including heavy monsoon the condition of the roads are fairly satisfactory without any major distress or disruption occurring in the roads.

Figure-6
Cleaning of road surface

Figure9
Laying of mastic on BJPF

Figure-7
Application of tack coat

Figure 10
Placing of antiskid stone chips

Figure-8
Laying of BJPF

Figure 11
Thermo sealing of the joints

Conclusion

An innovative bituminized jute paving fabric (BJPF) has been designed and engineered. The laboratory simulation analysis followed by the performances of the developed product in the several field trials till date are satisfactory. Conclusive remarks regarding the performance of the developed product may be ascertained after two years through extensive monitorings as per the guidelines of CRRI, New Delhi. No doubt, if the developed BJPF can prove its efficacy in engineering solution to the road constructions then this will not only open newer avenues to the class of Technical Textiles but also will give a huge impetus to the Jute Sector and the society as a whole. The developed product can be subjected to more number of field trials of different scales under different climatic and road conditions and can be evaluated for assessing the performance at regular intervals for having better understanding about the suitability of the developed product which will establish the acceptability of an innovative Jute Fabric-Mastic Asphalt road construction system.Such a fabric will not only prove techno-economically viable but will also reduce the carbon foot-print generation to a large extent.

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