Studies on Jute–Asphalt Composites

Prabir K. Banerjee, Mahuya Ghosh

Department of Textile Technology, Indian Institute of Technology, New Delhi 110016, India

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ABSTRACT: The tensile properties of jute make it a suitable raw material for asphalt overlay (A/O) fabric. In this study, the thermal stability of jute under conditions of asphalt overlaying process was investigated and the compatibility of jute with asphalt was assessed through experimentation on jute–asphalt composites under mechanical and hygral loads. Fourier transform infra red (FTIR) spectroscopic study revealed probable chemical bonding between jute and asphalt. The test for ascertaining the capability of asphalt encasement for protecting jute against biodegradation under enzymatic attack was found positive. A 6-month hygral treatment, of the jute–asphalt composite, showed significant increase in modulus of the material. The results indicate that although the strength of jute deteriorates by about 10% under asphalt overlaying condition, the overall tensile behavior of jute fabric–asphalt composite material is considerably superior to that of the pure jute fabric, even under biological and extended hygral loading conditions. © 2008 Wiley Periodicals, Inc. J Appl Polym Sci 109: 3165–3172, 2008

Key words: natural fiber asphalt overlay fabric; thermal stability; mechanical properties; FTIR; biodegradable

INTRODUCTION

Asphalts or bituminous binders of various grades are widely used in flexible pavements because of their good adhesion to mineral aggregates and viscoelastic properties. Propagation of reflective crack in such pavements is one of the major distresses during vehicular traffic. Hence, during rehabilitation of old cracked roads, asphalt overlay (A/O) fabrics are placed between new overlay and cracked pavement for preventing upward flow of crack from the old pavement to the new one.

The construction of A/O fabrics was initially based on a nonwoven structure (spun-bonded or needle punched) having low breaking load with high elongation at break made out of PP or polyester.[1–3] This kind of structure after bituminous tack coat application could only serve as moisture-proof layer to prevent damage of pavement structure owing to water infiltration. This gave way subsequently to a polymeric grid structure having high breaking load with low elongation at break and ultimately to a composite of grid structure and a nonwoven.[4–8] Fiber glass (FG) A/O grids exhibit strength in the range 50–100 kN/m, having extension at break of only 3% in both fabric directions.[9] Raw materials used for grid part are FG, Kevlar, and high-modulus polyester in knitted or woven form and the nonwoven part is made either from PP or polyester.

Correspondence to: P. K. Banerjee (pkbt60@yahoo.com).

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From the discussion so far, a transition can be observed in selection of raw materials for A/O material from common synthetic fibers like PP, polyester, to high-modulus fibers like kevlar, FG. But, no standard A/O material made up of natural fibers has been produced though some of the natural fibers like jute, sisal, hemp, flax, ramie, etc., have mechanical properties better in many respects than PP or polyester. Natural fiber like jute is also known to have good adhesion with bitumen as evident from the widespread application of bituminized jute fabric. Hence, it appears reasonable to propose that A/O fabrics can also be manufactured from jute which is relatively inexpensive and available abundantly in India, Bangladesh, and some neighboring countries.

A jute-based product may not last long enough due to its biodegradability when subjected to elements of nature. However, past trials carried out with jute in road application[10,11] tend to suggest that the *in situ* behavior of jute may be quite different from that in isolation. Hence, investigations have been planned to ascertain the mechanical behavior of jute in asphaltic medium and the biodegradability of jute in asphaltic medium before actually developing a jute-based A/O fabric and identifying its domain of applicability.

EXPERIMENTAL

Plan

During overlaying of existing cracked pavement with A/O fabric, the fabric is laid over hot asphalt coated pavement surface and subsequently the hot

mix of asphalt concrete mixture (≈160°C) is spread over. The sudden jump in heat followed by the confinement in very hot but slowly cooling environment may, depending upon the thermal stability of constituent fiber, deteriorate the fabric mechanical property. Das[12] reported a 10% strength-loss of jute fiber when subjected to thermal loading profile experienced by an A/O fabric. Gassan and Bledzki[13] reported a maximum of 15% loss in tenacity of jute after an exposure of 120 min at 170°C. This loss in strength was attributed to depolymerization. The thermal loading profile to which jute was subjected by Das[12] is however different from that of Gassan and Bledzki.[13] Hence, it was decided to investigate the cause behind the strength loss experienced by jute at the thermal loading profile caused by hot asphalt, by subjecting raw jute fibers to thermogravimetric analysis (TGA) and both the raw and thermally treated jute fibers to X-ray diffraction tests for determining structural changes.

Pavements undergo hygral and mechanical loads. Consequently, a set of experiments was designed to study the mechanical behavior of jute in asphaltic environment as also its deterioration under hygral loading. In this experimental program, specimens of asphalt, asphalt–jute fiber composite, and asphalt–jute fabric composite were prepared and subsequently subjected to hygral treatments of four different durations, followed by testing of typical mechanical properties.

To ascertain the nature of jute–asphalt bonding, Fourier transform infrared (FTIR) spectra analyses were carried out on the jute, asphalt, petrol-washed asphalt-treated jute, and benzene-soxhlated asphalt-treated jute samples.

As the deterioration of A/O fabric made of jute would also be aided by microbial agents, another set of experiments was framed to investigate the deterioration of jute in asphaltic environment under biologically accelerated mode. In this study, raw and asphalt-coated jute fibers were treated with cellulase, followed by determination of strength-loss.

Materials

Asphalts

Asphalt grade is specified in terms of softening point and penetration value. Penetration value is the consistency of a bituminous material expressed as the distance in tenths of a millimeter that a standard needle vertically penetrates a sample of the material under known conditions of loading, time, and temperature (ASTM D 5-97, D 5-06). Asphalt 85/25 and asphalt 80/100 were used in the sample preparation for the tests pertaining to the behavioral study of jute in asphalt medium. Asphalt 80/100 indicates a softening point (ASTM D 36-95(2000)$^{\varepsilon 1}$) of about 80°C and penetration value (ASTM D 5-97 and D 5-06) of 100 (i.e. $100 \times 1/10 = 10$ mm).

Jute fibers and fabric

Jute fiber of grade TD5 in sliver form was used to conduct the tests associated with determination of strength-loss of jute with concerned reasons under asphalt overlaying condition and for preparation of jute fiber–asphalt composite samples. TD5 indicates tossa jute (derived from the plant *Corchorus olitorius*) of grade 5; grading is done on a scale from 1 (indicating superior) to 8 (inferior).[14]

Jute reed of bundle strength 45.88 g/tex was used for carrying out the tests for assessing the capability of asphalt encasement in preventing biodegradation of jute.

A 2/1 double warp twill jute fabric with 96 ends/dm and 37 picks/dm, 289.1 tex warp, 988.7 tex weft, and an area/density of 656.57 g/m^2 was used for preparing jute fabric–asphalt composite samples and conducting FTIR scan of jute.

Methods

Characterization of asphalt

Asphalt 85/25 and asphalt 80/100 were subjected to penetration test (ASTM D 5-97), ductility test (ASTM D 113-99), and TGA test. Additionally some characterizing tests, like differential scanning calorimetry (DSC) and melt flow index (MFI) tests were conducted only on asphalt 85/25 to acquire an idea about thermal behavior and change in rheological behavior of asphalt with temperature.

The TGA runs were conducted in the temperature range of 50 –189°C at an incremental rate of 10°C/min.

The DSC run was carried out within a temperature sweep of 0–195°C at an incremental rate of 10°C/min.

MFI in g/10 min was measured as per ASTM D 1238-01$^{\varepsilon 1}$ by modifying the same suitably.[15] Accordingly, the temperature of the MFI tester was set at the experimental value first. Approximately 10 g of molten asphalt was then gradually poured into the barrel of the instrument and the piston was put in place. The asphalt was then allowed to equilibrate with the set temperature. After reaching steady state, the flow rate was measured after placing the predecided weight on piston. The experiments were carried out at four different temperatures, viz. 90, 100, 110, and 120°C, respectively, with the piston load of 2.16 kg and die diameter of 2.095 mm. Beyond 120°C the flow rate jumped up abruptly creating difficulty of measurement.

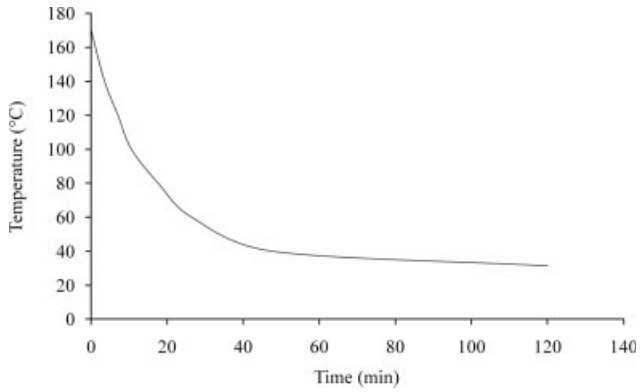

Figure 1 Temperature profile applied for jute thermal treatment.

Determination of thermal stability of jute under asphalt overlaying condition

Raw and thermally treated jute fibers in sliver form were tested for their bundle strength using ''beam balance'' type bundle strength tester at zero gauge length in standard atmospheric condition. Thermal treatment of jute fiber was carried out by subjecting the same to temperature of 170°C in an oven and then reduced in a manner, similar to that experienced by hot asphalt in an ambient temperature of 28°C (Fig. 1).

TGA test was conducted on the raw jute in the temperature range of 30–169°C at the rate of 1.5°C/min.

The percent crystallinity of raw and treated jute fiber were determined adopting wide-angle X-ray diffraction method.[16] The diffraction patterns were recorded by varying the diffraction angle (2θ) over the range of 10–35°. To determine the index of orientation[17] by X-ray diffraction method, intensity scanning against azimuthal position (ψ) for raw and thermally treated jute were recorded for the diffraction arc, 2θ = 22.4°. Percent crystallinity and index of orientation of raw and treated jute were calculated from these plots as described in concerned literature.[16,17]

Determination of mechanical properties of jute in asphalt medium with/without hygral treatment

For this study, specimens of asphalt, asphalt–jute fiber composite, and asphalt–jute fabric composite of dimension 200 mm × 100 mm × 6 mm were prepared in compression molding machine using a fabricated wooden mold of suitable inner dimension to produce samples of uniform dimension. The adopted sample dimension was suitable for conducting Grab test (ASTM D 4632-91). For preparation of all categories of samples, homogeneous blend of asphalt of grades 85/25 and 80/100 in the ratio of 60 : 40 was used because this blend was found to have the required rigidity for handling and proper flow at the processing temperature for penetrating well inside the jute substrate. Asphalt samples were prepared using the asphalt blend only. For preparation of asphalt–fiber composites, 2% by weight of jute fibers of 1 cm length was mixed properly with the asphalt blend. Asphalt–fabric samples of jute content 10% by weight were produced by sandwiching the twill jute fabric of dimension 200 mm × 100 mm in the asphalt blend. Subsequently all types of sample were subjected to hygral treatments of four different durations, namely 0.5, 1.0, 2.0, and 6.0 months. Subsequently, Grab testing of untreated and hygrally treated samples were carried out. Experimental results of this experimental set are depicted in Figures 2–4.

FTIR spectroscopy of jute fiber

FTIR scan was conducted on jute fiber in KBr pellet form in an IR spectrometer. To prepare the pellets, jute yarns from the twill fabric used for composite preparation were finely cut and mixed properly with KBr by grinding for 10 min in a mortar such that the weight ratio of jute and KBr was 1 : 99. The jute-KBr mixture in a very small quantity was taken in a die and pressed for 5 min under a pressure of 7.64 tonnes/cm^2 to transform into a very thin pellet.

FTIR spectroscopy of asphalt

FTIR scan was carried out on a film of blended asphalt that was used in composite preparation. To prepare asphalt films, the blended asphalt was thinned in petrol (lightest fraction of the same origin as that of asphalt) and one drop of this mixture was poured on water in a beaker by means of a glass rod. Because of the interfacial nature (surface forces) of water and the petrol–asphalt mixture, the drop quickly spread over the entire water surface forming a very thin film. This arrangement was kept undisturbed overnight to allow the petrol to evaporate from the film completely. Subsequently the film was very cautiously taken out of the water surface with the help of a thin metallic wire attached with a small aluminum foil frame having an aperture at the center. This film held within the aluminum foil aperture was dried for 2 h at room temperature as over-drying would cause bursting. Films prepared in this manner were then subjected to FTIR scanning.

FTIR spectroscopy of petrol washed and benzene soxhlated asphalt treated jute

Asphalt treated jute samples were taken from the fabric–asphalt composites. Initially the samples were washed few times with petrol manually until jute

yarn became visible to naked eye. Final washing was carried out in two different methods. Approximately 20 mg of cleaned sample was kept dipped overnight in petrol within a container followed by drying in an oven at 50°C for 0.5 h. Additionally 1 g of clean sample was also subjected to benzene (solvent of asphalt) soxhlation for 4 h with a siphon cycle duration of 15 min, followed by drying in an oven at 50°C for 0.5 h. Both these samples were scanned for obtaining FTIR spectra in KBr pellet form as mentioned in the case of jute samples.

Tests for ascertaining the capability of asphalt encasement for protecting biodegradable jute from microbes

In this experimental program, fiber strands were cut from the jute reed such that 20 cm of each of these strands weighed between 300 mg and 600 mg so that the bundle strength test [IS 7032 (Part 7): 1986] could be carried out afterwards. These strands were strapped on a Teflon sheet covered metallic plate and dipped in hot asphalt. After the samples had cooled down, the jute strands were taken off the metallic plate, turned over, and strapped again to the metallic plate for coating the other side. In this way, amount of asphalt coating applied on jute fiber bundle was ~ 5.92 L/m^2. Subsequently, noncoated and coated jute fiber strands were treated with cellulase in a bath of optimum cellulase activity of 0.86 IU/mL (i.e., international unit of enzyme activity/mL) kept inside an incubation chamber at a temperature of 44°C for 24 h. After conditioning in standard atmospheric condition for 48 h, all four combinations of jute samples, namely, control (i.e. noncoated and nontreated), noncoated and cellulase-treated, coated and nontreated, coated and cellulase-treated, were tested for their bundle strength.

RESULTS AND DISCUSSION

Characterization of asphalts

The measured penetration values (in 1/10th of mm) of the asphalts of grade 80/100 and 85/25 are 82 and 25.4, respectively. The measured ductility values of the asphalts of grade 80/100 and 85/25 are above 100 cm and 2.88 cm, respectively. These tests reveal that the 80/100 is more ductile and offers less resistance to penetration than the grade 85/25. Hence, 80/100 grade has higher plasticity and is therefore more suitable as a binder of aggregate in asphalt-concrete application.

The TGA tests for grades of asphalt 85/25 and 80/100 reveal mass loss of 0.50 and 0.56%, respectively, in the temperature range of 50–189°C. It signifies that there would be very marginal degradation of these categories of asphalt during the mixing process of asphalt and aggregates.

The DSC test of grade 85/25 gives no specific melting point which implies that asphalt is totally amorphous. Glass transition temperature of this asphalt is also not present in this temperature range because glass transition of asphalts takes place at subzero temperature as reported in literature.[18–20] Apparently, no phase change of asphalt 85/25 takes place in this temperature domain. Hence, asphalt 80/100, a softer variety, would also not show any phase change in this temperature domain.

MFI test of asphalt 85/25 reveals that its flow rate becomes abruptly high in the temperature range of 110–120°C. A very similar behavior can also be expected from the grade 80/100 (softer variety) in a slightly lower temperature domain. The rapid rise in flow rate of asphalt 85/25 beyond 120°C implies that at the asphalt concrete mixing temperature of 160°C both the varieties of asphalt would be flowing easily—a prerequisite for making good composite with fiber and fabric.

Thermal stability of jute fiber

A 10.34% strength-loss of jute fiber bundle, significant at both 95% and 99% level of significance, was observed due to thermal shock treatment of jute fiber (Fig. 1) simulating asphalt overlaying condition.

The TGA test of raw jute gives a mass loss of 7.48% in the adopted temperature range. The weight loss could be only due to moisture and natural wax removal from fiber as no volatilization of degraded product from cellulose-based fiber has been suggested in this temperature domain in concerned literature.[21] It is apparent that the removal of moisture present in the fiber is only partial as the moisture content of jute in the ambient relative humidity is much higher. This could be also supported from the fact that the fiber was kept above 100°C and up to 169°C for only 47 min which is not sufficient to make it 100% moisture free (ASTM D 629-99). The initial part of faster weight loss up to 100°C is probably due to the removal of loosely attached water molecules from the fiber and subsequently the rate dropped drastically because directly attached water molecules by the fiber are firmly fixed to hydrophilic groups of the fiber–polymer.[22]

Crystallinity percent measurement result exhibits increment in percent crystallinity by 4.66 (8.65%) owing to thermal treatment. This observation is supported by that reported by Gassan and Bledzki.[13] They also reported that thermal exposure at 170°C for maximum of 120 min led to chain scission, i.e., depolymerization of the fiber–polymer, which was followed by realignment of chain molecules and consequently a marginal increase in crystallinity. This

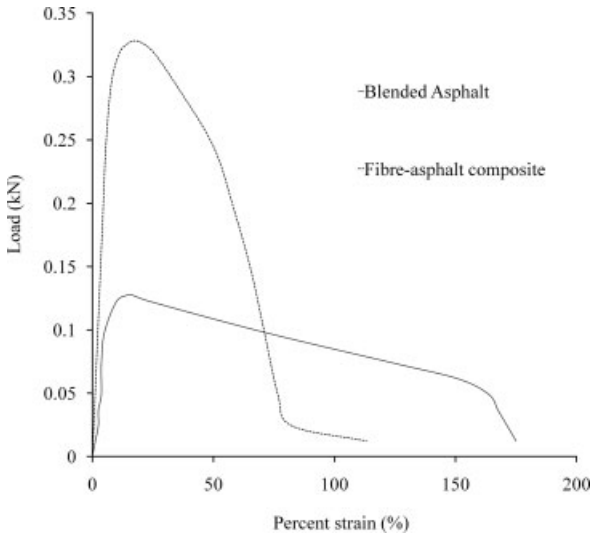

Figure 2 Typical load–percent strain profile of blended asphalt and fiber–asphalt composite.

change in percent crystallinity might not be significant by itself to affect mechanical properties of the fiber but depolymerization of jute adversely affected the tenacity of jute. Based on this report, and also from the result of this study, the strength loss of jute fiber on thermal shock can be attributed to depolymerization of the fiber–polymer.

Index of orientation value also increases by 1.5° due to thermal treatment, signifying some disorder created in molecular chain orientation with respect to fiber axis.

From the observations described in the foregoing, it is reasonable to conclude that the thermal loading of asphalt overlaying causes some deterioration in the fine structure of jute fiber. These nonreversible changes in fiber fine structure may lead to a drop in bundle strength in the region of 10% of its original value.

Mechanical behavior of jute in asphalt medium

A typical trace of load–percent strain of 60 : 40 blended asphalt samples is shown in Figure 2. It shows a sharp initial rise up to peak load, followed by continuous ductile deformation with a moderate slope up to ~ 160% of strain. Beyond this point the curve becomes distinctly much steeper and deformation is almost completes at about strain of 180%. This sharp drop is due to excessive narrowing of width and thinning down of the specimen. Complete failure of the specimens occurs in the strain range of 180–224%. The results of test on five samples indicate an average peak load of 0.13 kN and average percent strain at peak load of 17.15%.

The load–percent strain profile of randomly oriented fiber reinforced composites exhibit steeper initial rise up to peak load, followed by a fall up to the complete failure at the strain of about 80–146% which is more rapid in comparison to that of asphalt specimens. A typical load–percent strain plot is shown in Figure 2. The average peak load and percent strain at peak load of fiber–asphalt composites are 0.36 kN and 16.92%, respectively. Because of fiber reinforcement, the peak load and the initial modulus increase by 2.87 and 2.55 times, respectively, in comparison to asphalt specimen, while percent strain at peak load is almost similar as the latter. The ratio of the experimental fiber–asphalt composite modulus to the theoretically obtained value of the same, considering 100% interfacial bonding and perfectly randomized fiber orientation in three-dimension, is slightly higher than unity, which also proves the existence of very strong interfacial bonding between jute fiber and asphalt.

The load–percent strain plots of fabric–asphalt composites are completely different in nature than those of asphalt and fiber–asphalt composite specimens and resemble closely to that of the jute fabric in isolation. The trend is shown by a typical plot in Figure 3. There is a steep rise up to the peak load, followed by a much steeper fall up to the strain of 18.48%, and then the curve becomes almost flat and continues in this manner until the strain becomes 29.34% while the trace becomes again steep up to the complete failure at the strain of about 35%. Jute fabric reinforcement increases the specimen tensile strength and initial modulus by 11.41 and 5.23 times over asphalt sheet. The average peak load and percent strain values from five samples are 1.44 kN and 14.49%, respectively. The fabric composite peak load is higher than that of the fabric by 1.63 times. The value of peak load which is higher than the total contribution of asphalt and fabric indicates existence of strong interfacial bond in between jute fabric and

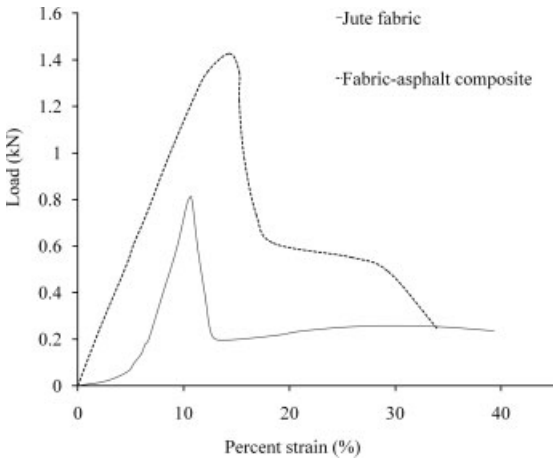

Figure 3 Typical load–percent strain profile of jute fabric and fabric–asphalt composite.

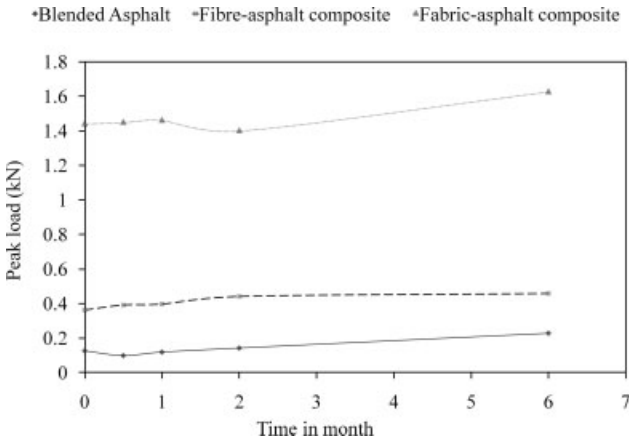

Figure 4 Effect of hygral treatment on peak load of blended asphalt, fiber–asphalt composite, and fabric–asphalt composite.

asphalt. The extension at peak load values of the fabric–asphalt composite and jute fabric are close, which implies that the applied tensile load is carried together by the asphalt and fabric up to the peak load of the composites. But beyond the peak load position, fabric starts rupturing, showing rapid fall in strength of composite. After a short interval the load–percent strain curve becomes flat, implying that load is supported by the system again. This is because of the Grab method of testing where the extra threads on both sides beyond the jaws start to contribute after failure of the threads clamped by the jaws. This continues up to the start of rupture of the side threads, which results in the sharp fall in strength again. The behavior of the composites suggests that the rise in peak load is caused by reduced fiber slippage in the yarn while the moderately high strain at failure would point at some crimp interchange in the fabric embedded in the ductile asphalt matrix.

Mechanical behavior of jute in asphalt medium with hygral treatment

The peak load (Fig. 4) values of hygrally treated samples were plotted as a function of duration of hygral treatment. Peak load plots exhibit marginal rise with duration of exposure to hygral strain. Asphalt specimens exhibit significant rise in peak load over the 6-month period of hygral treatment although the samples subjected to 15-day hygral treatment exhibit a significant fall in strength. For fiber–asphalt composites, peak load increment becomes significant at longer durations (beyond 2 months) of hygral treatment. No significant change in peak load occurs in lower levels of hygral strain for fabric–asphalt composites, but at the highest level, peak load increment becomes significant at the 95% level of significance only.

Extension values at peak load exhibit remarkable decrease at 6-month hygral treatment level, but no particular trend can be observed at the shorter levels of hygral treatment up to 2-month exposure level.

A gradual increase in initial modulus of asphalt samples takes place with duration of hygral treatment (Fig. 5). In the case of fiber–asphalt composites, increase in initial modulus value is significant at 95% level only up to 2-month hygral treatment, but hygral treatment of 6-month duration makes this incremental difference significant at both 95% and 99% level of significance. Hygral treatment of fabric–asphalt composite causes no significant change in initial modulus at the shorter exposure levels up to 2-month duration while hygral exposure of 6-month increases the same to such an extent that it becomes significant at both 95% and 99% level of significance.

It has been reported in the concerned literature[23,24] that moisture diffuses into the asphalt and thereby reduces its strength (cohesion) and stiffness. Moisture conditioning periods adopted, however,[23,24] were very short, viz. 8 h and 1 h, respectively, in comparison to the present case. On the contrary, it has been reported in literature[20,25] that asphalt undergoes hardening due to oxidation, volatilization of lighter components, exudation, and molecular restructuring (steric hardening) with time. Said[25] has reported that hardening of asphalt pavement occurs very fast up to 1 year after construction, but subsequently the process gradually becomes very slow with time. Based on these reports, it can be inferred that the loss of strength (cohesion) of asphalt caused by moisture diffusion and hardening of asphalt due to oxidation by dissolved air in water and steric hardening (very slow process) are the two determining factors that ultimately define the strength of the asphalt samples. In short-term hygral treatment (15-

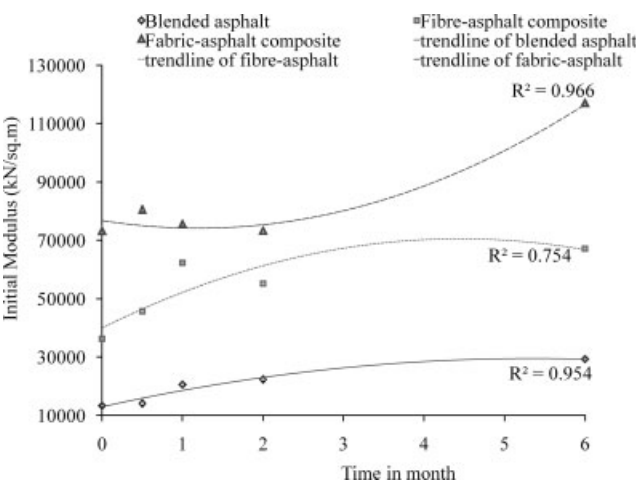

Figure 5 Effect of hygral treatment on initial modulus of blended asphalt, fiber–asphalt composite, and fabric–asphalt composite.

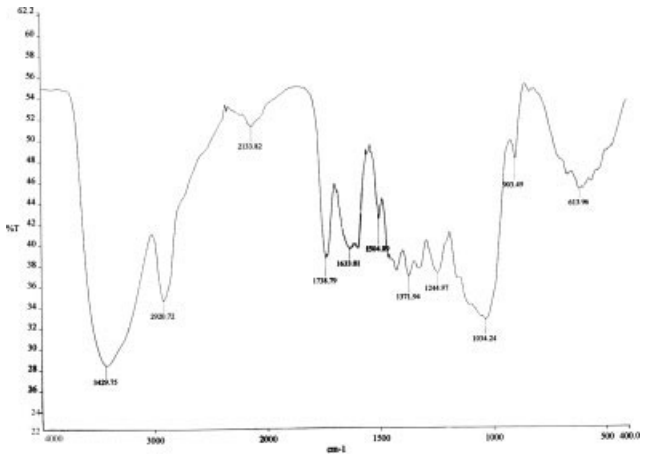

Figure 6 FTIR spectrum of jute.

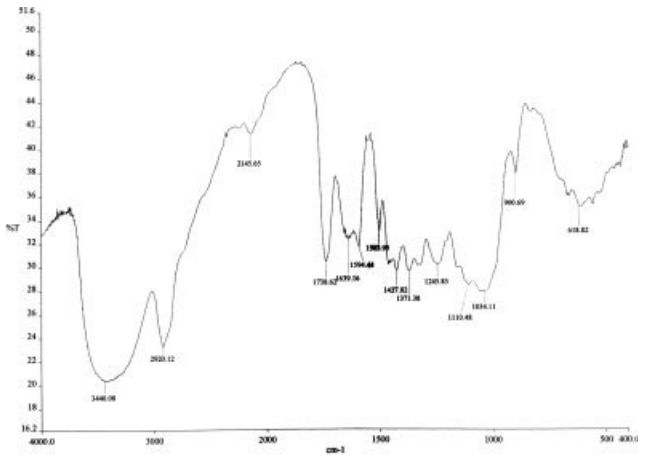

Figure 8 FTIR spectrum of petrol-washed asphalt-treated jute.

day) of asphalt, effect of moisture damage is more than stiffening of asphalt as also observed by the researchers.[23,24] But in long-term hygral treatment (6-month), effect of asphalt stiffening overcompensates the effect of moisture damage gradually. Moisture not only reduces strength of asphalt but also deteriorates its adhesion with aggregate. Cheng et al.[23] have observed that aggregates with higher specific surface area per unit mass are more resistant to moisture adhesion failure. In this study, jute is the substrate in place of aggregate with much higher specific surface area per unit mass than that of any aggregate. Consequently, chance of moisture adhesion failure is also very low in the case of jute fiber/fabric embedded asphalt composites. Hence, moisture damage of asphalt (matrix) and jute–asphalt interface up to the period of 6 months is not effective to deteriorate the mechanical property of jute encased within asphalt.

FTIR spectra analysis

FTIR spectra of jute, asphalt, and asphalt-treated jute washed with petrol/benzene are shown in Figures 6–9, respectively. Comparative spectra analysis reveals a remarkable increase in absorbency at 2920–2924 cm^{-1} region (C—H stretching) for treated jute samples. This is indicated by the prominent reduction in difference between the two peak heights at 3369–3429 cm^{-1} (the broad peak due to the presence of —OH groups) and at 2920–2924 cm^{-1}. In the FTIR spectra of jute, the difference in absorbency between the two concerned peaks is 6.25%, which becomes 2.89% and 1.5% in the cases of petrol-washed treated jute and benzene-soxhlated treated jute, respectively. These observations indicate a fair probability of the existence of chemical interaction between jute and asphalt in addition to physical bonding owing to rough surface texture of jute fiber.

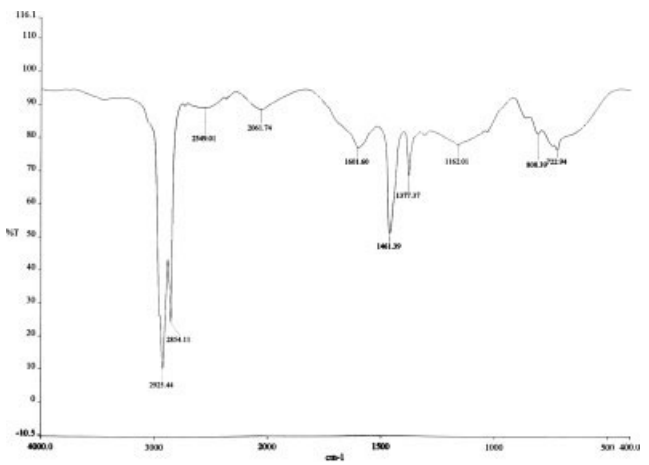

Figure 7 FTIR spectrum of blended asphalt.

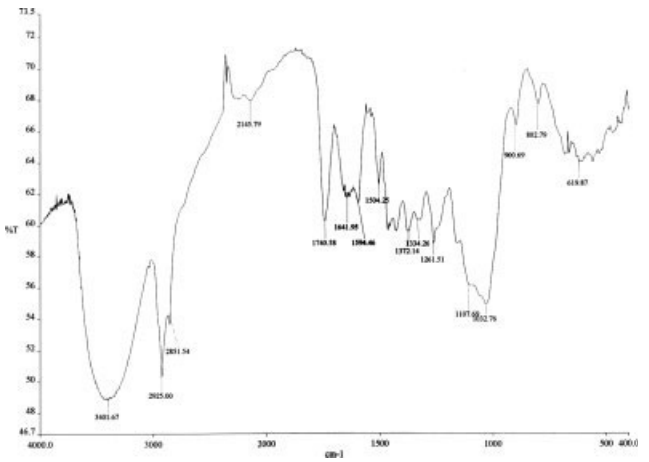

Figure 9 FTIR spectrum of benzene-soxhlated asphalt-treated jute.

The capability of asphalt encasement for protecting jute against microorganisms

Cellulase treatment under the experimental condition adopted has resulted in about 30.5% drop in jute fiber bundle strength. Asphalt coating increases the bundle strength of jute fiber strand by 29.21% through creating strong interfacial bond. This fact again proves that the adhesion in between jute and asphalt is very good. Under the similar experimental condition, the drop in bundle strength value of asphalt-coated jute is only 11.51%, which implies that asphalt coating provides a degree of protection to jute fibers against degradation by cellulase.

CONCLUSIONS

From the forgoing discussion, it is very clear that the thermal condition of asphalt overlaying deteriorates the strength of jute by about 10%. Mechanical property study of blended asphalt samples, fiber–asphalt composite, and fabric–asphalt composite reveals that jute is very much compatible with asphalt and reinforces the system to a considerable extent either in the form of fiber or fabric. Fabric reinforcement is however more effective than fiber reinforcement. Hygral treatment for even a 6-month period is ineffective in damaging the jute–asphalt interface and the encased jute element too. This strong interface is created due to the coexistence of chemical and physical bonding between jute and asphalt. Another important outcome of this study is that asphalt itself acts as a protector for jute which is prone to biodegradation. Consequently, it can be concluded that jute can be effectively used as asphalt overlay material.

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