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EXPERIMENTAL USE OF KENAF FIBER IN HOT MIXED PAVEMENT

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Abstract: In India, most of the pavement is made with hot mix asphalt (HMA) as this is one of the most economical materials available and it is also very suitable for the climate here. However, the HMA pavement normally required frequent maintenance and rehabilitation due to damages caused by excessive traffic loadings. Therefore, one of the alternatives to minimize the damages of pavement and to prolong the service life is to use modified asphalt pavement. HMA can be modified with filler, extender, rubber, plastic, rubber-plastic combinations, fibre, antioxidants, hydrocarbon, anti-stripping agents, waste materials and etc. This study demonstrates the properties of HMA added with kenaf fibre. The concept of using natural fibers and waste materials to replace these energy intensive synthetic fibres or polymer additives is a recent development in this field. India, being an agricultural economy produces fairly huge quantity of natural fibres such as coconut, sisal, kenaf, jute etc. Now- a -days the disposal of waste plastics is a major concern for an eco- friendly sustainable environment. In line with these thoughts, this research focuses on the utilization of natural fibres and waste plastics as additives to improve the performance of pavement. Marshall test is conducted for optimizing the pavement mixtures (Control mixture-without additives and Stabilized mixtures with additives). Indirect tensile strength tests are conducted to study the engineering properties of stabilized mixtures. The comparison of the performance of all stabilized mixtures with the control mixture and among them are carried out.

Keywords: Natural fiber, Kenaf fiber, Marshall Stability,

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INTRODUCTION

Kenaf (Hibiscus Cannabinus) is a valuable fibre from an East Indian hibiscus plant which is now widespread in cultivation, and used especially for its cordage, canvas and sacking. Primarily grown in India and Pakistan but also grows in Africa, South East Asia, Indonesia, Russia, Mexico, the Philippines, Cuba and the United States. Kenaf usually grows up to 5 m in height, and is cylindrical and either branched or un-branched. The stem is composed of two fibres, bast and core. The bast fibres, located in the bark, are long compared to the core fibres, produced in the stem interior. The leaves either are entirely heart shaped or display radiating lobes. Flowers are typically yellow with deep red centres.

Kenaf are strong fibres but exhibiting brittle fracture and have only a small extension at break. They have a high initial modulus, but show very little recoverable elasticity. The elongation at which a fibre breaks is a more fundamental property than the load at which it breaks. It is not affected significantly by changes in linear density, or by changes in the method of loading.

REVIEW OF LITREATURE

P.Gopal , C.S Mehereen Begum (January 2017)

This paper presents A Review on Comparative Study on Bitumen Modification Using Natural Fiber. Flexible pavements are often plagued with problems of cracking and rutting due to repeated traffic loads. It has been shown that the addition of Coir fibers results in the improved Marshall Stabilities, tensile strength.
Further they added different fibers at different scales and compared the result with the bituminous mix with fiber and without fiber.

- The effect of Coir fiber reinforcement on the mechanical behavior of bitumen is studied by performing the mix design, Marshall Stability and ITS tests. The presence of Coir fiber showed improved performance when compared with reference mix.

The following conclusions are made from the results.

- Addition of Coir fiber showed a slight increase in the OBC compared with reference mix. OBC increases with increase in fiber length/aspect ratio.
- The marshal stability increases i.e. 25% and 30% for Coir fibers of 6mm and 12mm with respect to reference mix.
- The ITS results indicate an increase in tensile strength by 15% and 20% for Coir fibers of 6mm and 12mm respectively
- No cracks are observed in Coir fiber reinforced mix
- The addition of Coir fiber lead to increase in capacity of creep recovery of bitumen binder, leading to increased rutting resistance of the binder. The addition of Coir fibers to bitumen binder significantly increased the stiffness of bitumen at low temperatures.

Saswat Biswapriya Dash, Mahabir Panda 2016

In the present study is to use waste materials such as bottom ash and fly ash along with some locally available natural or vegetative fibers in bituminous paving mixes. To achieve this objective, the optimum mix design conditions such as optimum fiber content, optimum fiber length and optimum bitumen content in addition to the appropriate replacement of bottom ash and fly ash are decided as per Marshall Method of mix design. Further, the bituminous mixes thus developed have been evaluated in terms of the engineering properties.
Conclusion of their results were:

- The compressive strength of Natural fiber mixed bituminous mix is increased.
- It is also observed that with increase in fiber content and fiber length up to a given level, air-void and flow value decreases whereas Marshall Quotient increases. The latter is a good indication of rutting resistance of bituminous paving mixes in case of the recommended mix composition.
- The coal ash dumping which is a serious concern to everyone associated in respect of its disposal and environmental pollution, can find a possible approach for its reuse in a partial manner in an economical way by substituting natural resources of sand and stone dust which are depleting fast.

Mohsen Zahedi, Ramin Bayat , Mehdi Nazemi Jalal (2014)

In this article usage of this fiber in civil engineering and especially in asphalt mixtures is investigated; Mixing methods of fiber with aggregates and bitumen are dry, wet and complex are investigated and the most appropriate method because of homogenous mixing and better result is introduced.

Dry method- In this method, first, aggregates and bitumen were heated. Then Fibers added to aggregates and were mixed. After that, bitumen added gradually to mixture of aggregates and PP. In this method observed that fibers were shirked and there was no mixing between fibers and other materials; so it wasn't a suitable method for mixing of nylon in asphalt mixture.

Wet method-In this method, first, aggregates and bitumen were heated. Then fibers added to bitumen and were mixed. After that, aggregates added to mixture of bitumen and nylon. In this method observed that because of absorbing bitumen by fibers, balling happened that resulted in unsuitable mixing of fibers with aggregates; so this method wasn't suitable for mixing, either.
Since there were no homogenous mixtures in two first methods, so another method was evaluated that had better results. In this method as before methods, aggregates and bitumen were prepared according to ASTM-D1559 standard; then both were mixed for 5 to 10 seconds by mixer. After that, segregated fibers gradually were added to mixture. It was observed that fibers were completely mixed with the mixture homogenously and this would be the best method that in this research was used for constructing and performing experiments.

The result excluded as- nylon fiber has a function of reinforcing and by mixing it with aggregates and bitumen homogenously; increasing of mixture stability would be the result. Mixing this polymer in asphalt mixture is through dry, wet and complex methods that the one can provide homogenous mixture, is complex method. In complex method, first, bitumen and aggregates should be mixed together and then add nylon fiber in primary mixture.

Hasan Taherkhani, Hossein Amini (January 2016)

In this research, the effects of the nylon fiber length and content on some engineering properties of a typical binder course asphalt concrete have been investigated. The fibers at different contents of 0.3, 0.4 and 0.5% (by the weight of total mixture), each at three different lengths of 10, 25 and 40 mm have been used, and the properties of the mixtures, such as, volumetric properties, Marshall stability, flow, Marshall quotient, indirect tensile strength and moisture damage have been studied. It is found that the highest Marshall quotient is obtained by using 0.4% of 25mm long nylon fibers. The results also show that the indirect tensile strength and tensile strength ratio, which is an indication of moisture damage of asphalt concrete, decreases with increasing the length of fibers and fiber content.

The following conclusions are made from the results.

- The air voids content of asphalt concrete increases with increasing fiber length and content.
- The Marshal stability of the mixtures increases with increasing the fiber content and length up to a certain amount after which decreases with increasing the fiber length or content.
- The flow of the mixtures decreases with increasing the fiber length and content, up to a certain amount, after which increases with increasing the fiber length or content.
- The highest Marshall quotient is achieved at 0.4% fiber content of 25mm fibers.
- Tensile strength of asphalt concrete decreases with increasing the fibers content and length. However, the mixtures containing fibers have more toughness and are energy absorbent.
- The moisture damage of the mixtures increases with increasing fiber content and length, with some mixtures not satisfying the specification requirement. However, the mixture with the optimum fiber length of 25mm and content of 0.4% satisfy the minimum TSR of 80%.

Kavalakuntla Kiran Kumar, Ch Praveen Babu (2017)

A comparative study has been made in this investigation between Bituminous Concrete (BC) and Stone Matrix Asphalt (SMA) mixes with varying binder contents (4% - 7%) and Fibre contents (0.3% - 0.5%). In the present study 60/70 penetration grade bitumen is used as binder and Sisal fibre is used as stabilizing additive.

The whole work is carried out in four different stages which is explained below.

1. Study of Marshall Properties of BC mixes using three different types of fillers without fibre (fly-ash, cement, stone dust)
2. Study of BC mixes with fly ash as filler and sisal fibre as stabilizer
3. Study of SMA mixes with fly ash as filler and sisal fibre as stabilizer

4. Evaluation of SMA and BC mixes using different test like Drain down test, Static conclusion from the study

Here two type of mix i.e. SMA and BC is prepared where 60/70 penetration grade bitumen is used as binder. Also a naturally available fibre called sisal fibre is used with varying concentration (0 to 0.5%). OBC and OFC is found out by Marshall Method of mix design. Generally by adding 0.3% of fibre properties of Mix is improved. From different test like Drain down test, Indirect Tensile Strength and static creep test it is concluded that SMA with using sisal fibre gives very good result and can be used in flexible pavement.

Anuj Narwal (June 2016)

In the present study, an effort has been created to review the consequences of use of a naturally and locally obtainable fiber known as SISAL fiber is employed as stabilizer in SMA and as an additive in BC. For preparation of the mixes aggregate gradation has been taken as per MORTH specification, binder content has been varied often from 4% to 7% and fiber content varied from 0.33 to maximum 0.5% of total mix. As a section of preliminary study, fly ash has been found to result satisfactory Marshall Properties and thus has been used for mixes in resultant works. Using Marshall Procedure Optimum Fiber Content (OFC) for each BC and SMA mixes was found to be 0.3%. Similarly Optimum Binder Content (OBC) for BC and SMA were found to be 5-hitter and 5.2% severally.

It can be conclude that from the drain down study of the SMA mixtures, it can be concluded that all the five additives used in the stone matrix asphalt for the present investigation act as effective stabilizing agents. The role of additive is to stiffen the mastic and thereby reducing the drainage of the mixture at high temperatures during storage, transportation, placement and compaction of SMA mixtures. Due to the gap graded gradation and rich binder content in SMA, the control mixture is subjected to heavy drain down. This strongly supports the need of the additive in SMA mixtures.

The coir fiber which has a higher stabilizing capacity as compared to other additives is found to be more effective than the others. From the studies it can be concluded that the natural fibers and the waste plastics can replace the imported synthetic fibers and the expensive polymers in Stone Matrix Asphalt.

R.R Singh, Er. Shelly Mittal (2017)

In this study, the stabilizing effect of Natural fiber (coconut coir) on soil properties has been studied. Over the last decade the use of waste material and fiber has recorded a tremendous increase. Soil samples for unconfined compression strength (UCS) and California bearing ratio (CBR) tests are prepared at its maximum dry density corresponding to its optimum moisture content in the CBR mould without and with coir fiber. The percentage of coir fiber by dry weight of soil is taken as 0.25%, 0.50%, 0.75% and 1% and corresponding to each coir fiber

content unsoaked and soaked CBR and UCS tests are conducted in the laboratory. Tests result indicates that both unsoaked and soaked CBR value of soil increases with the increase in fiber content. Soaked CBR value increases from 4.75% to 9.22% and unsoaked CBR value increases from 8.72% to 13.55% of soil mixed with 1% coir fiber. Adding of coconut coir fiber results in less thickness of pavement due to increase in CBR of mix and reduce the cost of construction and hence economy of the construction of highway will be achieved. This is because of composite effect of natural fiber changes the brittle behavior of the soil to ductile behavior.

The present study has shown quite encouraging results and following important conclusions can be drawn from the study:

- Coir fiber is a waste material which could be utilized in a sub base for flexible and rigid pavements.
- The OMC of soil-coir mix increases with increasing the percentage of coir fiber.
- CBR and UCS values of soil-coir fiber mix increases with increasing percentage of fiber.
- Maximum improvement in U.C.S. and C.B.R. values are observed when 1% of coir is mixed with the soil.
- It is concluded that proportion of 1% coir fiber in a soil is optimum percentage of material having maximum soaked CBR value. Hence, this proportion may be economically used in road pavement and embankments.

Summary of the Literature

A Review of the literature show that it is possible to improve the performance of bituminous mixture used in surface course with the help of various natural additives. India produces fairly large amount of naturally occurring agro fibers such as kenaf, sisal, coir, banana, coconut etc. which need to be explored for their application in bituminous road construction. This will improve the characteristic and service life of bituminous surface and also the utilization of the natural fibers.

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