The effect of flax of bamboo on the estimation of stone matrix asphalt (SMA) using SLAG as aggregate replacement

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***Abstract*: Bituminous surface pavement accounts for most of the roadway's features. When the surface layer makes contact with the stone, the asphalt becomes stronger. It is a type of concrete/stone matrix asphalt known as SMA. This information is collected in order to produce the most stable product feasible while also obtaining the highest possible flow value, with the least quantity of binder material. SMA's major components are crushed aggregate (SMA), which accounts for 40%, binder (which accounts for 40-70%), filler (which accounts for 20-40%), and fibre (which acts as a stabiliser and accounts for 0.3-0.5%). Because of this, the coarser aggregate of the combination helps to fill up any gaps between the aggregates, which minimises tearing and wear. Additionally, the supplied fibres assist in reducing drainage during the project manufacturing, installation, and shipping stages.**

***Keywords*: Bituminous Surface, Rugged Crushed Aggregate, Stone Matrix Asphalt (SMA), Flax of Bamboo**

I. INTRODUCTION

The primary distinguishing peaks. feature that share are members of huge, the biggest monocotyledone in the world and has the greatest number of species. The blades, which are made up of a sheath and a ligule, are another distinguishing feature. Among the many varieties of bamboo rhizomes, there are two that stand out: monopodial (runners) and sympodial (clumpers). seen may in, as they are in temperate zone bamboo's ability to grow—for example is a grass for regeneration, among other things. Bamboos are able to grow at a rapid pace due to their intercalary growth. Bamboo increases in the of plant. The juvenile peak is still very soft, but as the stem height increases, the peak becomes more difficult to break. The process of lignification and cellulose deposition in the fibre cell walls is what brings the process to a close and makes it more durable. It takes a long time for the diameter of the stem to grow, and the thickness of the stem only minimally rises throughout the course of the development. Bamboos, in contrast to plants, use photosynthesis, which is highly efficient at fixing CO2 in the atmosphere. discovered that bamboo, may accumulate silica in its tissues, with concentrations reaching up to 100 mg 1 SiO2 in certain cases. The presence of between 5 and 10 mg g1 SiO2 in the stems may have consequences for the conditions that exist throughout the pulping process. Tabashir, a rich white silica deposition found, is used in traditional to treat a variety of ailments.

Bamboo Composition

The features of bamboo's hollow wooden stems, which are steep and light, are responsible for the majority of the plant's practical uses. an network of fibres as well as parenchymal age trunk has an effect on the structure of the bamboo (Wang et al., 2012a,b). It is well acknowledged that elder stems are stronger and more rigid. Because of the elongation of the internodes, the development of bamboo peaks has been seen to proceed very rapidly. Cell wall old in the amounts of cellulose, hemicellulose, and lignin found in the cell walls of young and senior bamboos. The composition of cell walls varies from node to node and between typically normal percent to 45 percent cellulose, 25 percent lignin, and 25 percent to 30 percent hemicellulose or pentosan, with cellulose accounting for 40 percent to 45 percent of the total (Fengel and Shao, 1984). It is when the internode has been lengthened that the fibre takes place. lowest part have a higher percentage of hemicellulose than the rest of the plant, which is a typical trend.

Application of bamboo fibre

Flax of bamboo is a bamboo-regenerated cellulosic fiber. Starchy pulp is generated from bamboo stems and leaves by alkaline and multi-phase bleaching processes. Additional chemical procedures create flax of bamboo. It is softer than cotton, having a texture akin to a combination of cash and silk (8). Since the cross-section of the fiber is packed with different micro-gaps and micro-holes, it absorbs and ventilates moisture considerably better. Moisture absorption is double that of exceptional soil release cotton. A feature of flax of bamboo is that it absorbs moisture because of micro-lapses and it is hard to produce static electricity. Flax of bamboo does not contain electron free and it is thus anti-static and so fits extremely well with, but does not stick to, the human skin. It fluctuates gently throughout the body. Flax of bamboo towel offers outstanding natural functions. It is antibacterial in nature as well as deodorizing. Without usage of pesticides, bamboos may flourish naturally since they are seldom eaten by pests or afflicted by pathogens. Scientists have discovered that bamboo has a unique bio-agent called 'bamboo kun' for anti-bacteria and bacteriostatic diseases. The final bamboo fabric maintains this material because it is firmly linked to the bamboo cellulose molecule. Bacteria will quickly spread to cotton and other fibers from wood pulp, creating a foul odour and in some instances even causing early fiber deterioration. But nearly 75 percent are destroyed in flax of bamboo after 24 hours. Flax of bamboo products are eco-friendly and organic (9). Because of its anti-bacterial characteristic, the flax of bamboo offers a broad range of hygienic potential textiles for household textiles including mattresses, sanitary towels and table napkins. Fiber is also the favorite for decoration goods like as curtain, TV cover, couch slipcovers, bathroom items such as towels and bathrobes used in wellness centres, hotels and home consumers.

SMA

Stone-matrix asphalt (SMA) is a gap graded asphalt floor that improves rut resistance and longevity via the use of a stable skeleton, held together with a rich blend of asphalt cement and stabilizing additives such as fibers and/or modifiers of asphalt. SMA is mostly utilized for paving U.S. interstates and roads with a large volume, attaining high levels of routing strength and longevity. SMAs offer extremely excellent friction properties as well as better durability and routing resistance. They have been proven to reduce road spray and motor noise effectively. SMAs have also effectively been deployed on heavy bus and truck traffic high-volume metropolitan roads.

Over the years, India has witnessed a significant increase in both the amount of traffic and heavy loads. Vehicles with large loads have specially constructed pipes inflating at high pressure that cause considerable paving stress. Under such circumstances, mixtures of traditional thick grades classified mix, SMA is ductile, robust, stable, to squids, high in coarse compounds, stone-based on the contact with stone, strong and binding rich created at end of the and in Europe the 1970's, and in the USA since the 1990's. for training training

SMA - Concept

The SMA-CONCEPT may be summarized simply as:

- Strong stability and high resistance to wear via a superior particle interlocking and high concentration of crushed high-quality aggregates.
- Longevity & length to early cracking and cracking with a very high bitumen content and a void with a less mastic mortar fills the vacuum of the stone skeleton and connects it: High binder quantity and quality are prerequisites for a lengthy service life.
- The stabilization of [cellulose fibre] additives ensure uniformity throughout production, transport, laying and compaction.
- High quality and high bitumen (thick binder films) and coarse aggregates are key to SMA's extended service life.

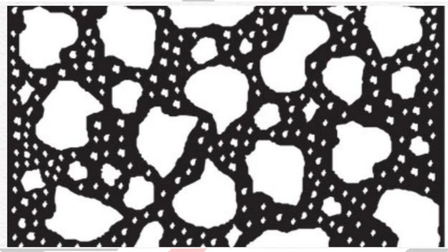

Fig. 1: Construction of a distinctive dense graded asphalt mix (BC)

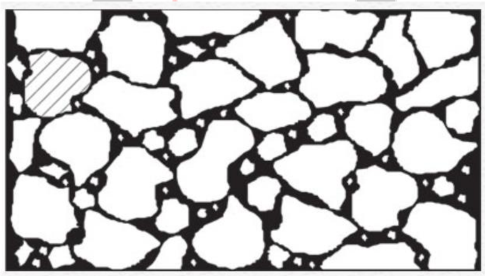

Fig. 2: Presented gap graded asphalt mix (SMA)

The coarse aggregates are a thick, have no contact and bear the weight. that has no fixed sizes of aggregates, and contains an abundance of gross aggregate particles. SMA has a high filling content, typically between 8 and 12 percent [passing 0,075 mm], as compared to BC with filling content lower than 5 percent. The SMA has a greater concentration of bitumen > 6%, therefore the use of pellets of cellulose fiber inhibits the drainage of large amounts of bitumen.

Stone mastic asphalt was created in Germany in the 1960s with the first SMA pavements installed in Kiel in 1968, also known as SMA. It offers a deformation-resistant, durable surface material suited for highways. SMA has been used as a long-term asphalt surface solution for residential roads and roads in Europe, Australia, the United States and Canada. SMA has a high rough aggregate content, which is interlocking into a stone skeleton resistant to permanent deformation. The skeleton of stone is filled with a mastic of bitumen and a filler to which fibers are added to provide sufficient stability of the bitumen and prevent binder drainage during shipping and installation. The typical SMA composition is made up of 70-80% coough, 8-12% filler, 6-7% filler and 0.3% fiber.

SMA is deformed resistant to a coarse stone skeleton that provides greater contact between the stone and stem than standard dense graded asphalt (DGA) mixtures (see above picture). The increased bitumen content, a thicker bitumen layer and reduced air gaps are the consequence of enhanced binder durability. This high amount of bitumen also increases flexibility. A little amount of cellulose or mineral fiber inhibits bitumen drainage during shipping and placing. There are no exact SMA mix design rules in Europe. The key characteristics that are the ground aggregates of the skeleton and mastic composition and the resulting surface texture and mixture stability are mainly influenced by the choice of aggregate grading and the filler and binder type and proportion. Detailed mix design recommendations for SMA have been established in the US and published in their Quality Measurement Publication QIP 122, according to the references, by the US National Asphalt Pavement Association.

Manufacture

SMA is mixed and put in the same plant as the normal hot mixture. In batch plants, the fiber addition is supplied to the pugmill directly via individually wrapped press packs or mass distribution devices. Mixing periods may be prolonged to achieve a homogenous distribution of the fiber across the mix and regulated temperatures to prevent overheat and fiber breakage. In drum plants, special attention should be paid to ensuring that both the increased filler content and fiber additive are included in the mix without excessive loss via the dust extraction system. Filling systems that add filler directly to the drum are preferable over aggregate feed. Pelletized fibers may be supplied via systems intended for the addition of recycled materials, but a specific supply line that is linked with the supply of bitumen, allows the fiber to be collected by bitumen at a point at which the mixture is added.

II. Material and Method

Materials used

Materials a main component, fine aggregate, filler, and stabiliser that are utilised in the SMA mix for the purpose of producing and testing samples in order to collect and compare project work There are two types of rough materials used in this application. Over the course of the whole case, fine aggregates are referred to as stone dust. Stabilizers include bamboo fibre and Topcel cellulose, which are both renewable resources. The bitumen grade 60-70 is used as a binder since it is the grade that is most helpful in the Indian environment.

Table 1: The characteristics of the materials utilized are as follows:

1.Physical properties of the Stone Aggregates Test description	Coarse aggregates	Fine aggregates	Standard values
Combined flakiness & elongation index (%)	28	-	< 30
Specific gravity	2.76	2.64	2.6-2.9
Los Angeles abrasion value (%)	27	-	< 30
Impact value (%)	21.4	-	< 18
Aggregate Crushing value (%)	27	-	<30
Angularity number	10	-	0-11

Table 2:

Properties of Slag Aggregates			
Properties		Value	
Limestone	Iron slag		Steel slag
Coarse aggregate			
Bulk sp. gr. (gr/ cm3)	2.65	3.44	3.51
Apparent sp. gr. (gr/ cm3)	2.69	3.63	3.74
Water absorption (%)	0.7	1.7	1.6
L.A. abrasion (%)	25.4	20.7	19.5
Soundness<comma> Na2SO4 (%)	4.5	3.2	2.4
Fine Aggregates			
Bulk sp. gr. (gr/ cm3)	2.43	2.91	2.98
Apparent sp. gr. (gr/ cm3)	2.77	3.68	3.86
Plasticity index	Non-plastic	Non-plastic	Non-plastic

3. Physical properties of Bitumen

Test description	Results	Standard values
Penetration at 25oC (1/10 mm)	65	50 to 89
Softening point oC	65.2	>48 oC
Ductility, cm	> 90	>50
Specific gravity	1.025	-

Apparatus Requirement

Material gradation is required in accordance with the IRC:SP-79 standard. As a result, the IS Sieve size is the same for all gradations achieved via sieving. The sample is impassioned to 153°C to 163°C once the screening process is complete, which necessitates the use of an oven. After that, the sample is mixed in the sample mixing equipment, which incorporates. Molds are required for the casting process, which is carried out using a hammer of certain weight and specified fall. A water bath is used to prepare the sample for testing.

1. IRC: SP-79 progression chart for 13 mm Mix

IS Sieve	**Cumulative %**	**Mean**	**% retained**
26.5	-	-	-
19	100	100	0
13.2	90-100	95	5
9.5	50-75	67.5	32.5
4.75	20-28	24	38.5
2.36	16-24	70	4
1.18	13-21	17	3
0.6	12-18	15	2
0.3	10-20	15	3
0.75	8-12	10	2

Fig 3: Moulds

Fig 4: Sledgehammer

Fig 5: Water Tub

Fig 6: MT machine

III. ANALYSIS AND EXPERIMENTATION RESULT

MARSHALL EXAMINATION ON SAMPLE

The test has been maintained at 60 degrees Celsius in a water bath for 30 minutes, it is placed in the marshall test equipment for analysis. The dial gauge with a stability reading of 25 kN is utilised for this purpose. The loaded Marshall stability testing equipment is then allowed to continue to load until it fails at continuous deformation rates of 5 mm per minute until the failure is reached. Stability values were recorded for each total load produced in the dial gauge. These values were computed again. Which are computed using the differential weight of the sample taken in water against the sample collected outside water.

Fig 7: MAT Loaded with Sample

Fig 8: Example after M TEST

Result aggregate with Bamboo fibre

Sample No.	Bitumen content	Temp oC.	Wt. before paraff. Coating (gm)	Wt. aftr paraff coating (gm)	Wt in water (gm)	Heigh (mm)t	Radius (mm)	Wt. of aggr. Mix. (gm)	Flow (mm)	Load take (kN)
B -4-1	4%	160	1176	1185	730	60	50	1162	3	380
B -4-2	4%	160	1182	1191	742	58	50	1162	2.9	350
B -4-3	4%	160	1181	1189	739	59	50	1162	2.5	400
B -5-1	5%	160	1175	1186	746	57	50	1140	4.6	490
B -5-2	5%	160	1178	1188	745	57	50	1140	2.4	475
B -5-3	5%	160	1193	1201	751	57.5	50	1140	3.6	420
B-5.5-1	5.5%	160	1183	1192	750	57	50	1140	3.9	485
B-5.5-2	5.5%	160	1179	1186	755	56	50	1140	4.2	425
B-5.5-3	5.5%	160	1181	1189	754	60	50	1140	4.8	500
B-6-1	6%	160	1194	1204	758	57	50	1128	3.9	415

Result as stabilizer

Sample No.	Bitumen content	Temp oC.	Wt. before paraff. Coating (gm)	Wt. aftr paraff coating (gm)	Wt in water (gm)	Heigh (mm)t	Radius (mm)	Wt. of aggr. Mix. (gm)	Flow (mm)	Load take (kN)
C-4-1	4%	160	1194	1204	758	57	50	1162	2.8	350
C-4-2	4%	160	1204	1215	742	60	50	1162	2.8	340
C-4-3	4%	160	1201	1211	749	61	50	1162	2.7	380
C-5-1	5%	160	1185	1197	709	59	50	1140	3.6	420
C-5-2	5%	160	1182	1196	701	58	50	1140	4.2	470

C-5-3	5%	160	1198	1209	719	57.5	50	1140	4	480
C-5.5-1	5.5%	160	1194	1204	758	56	50	1128	4	470
C-5.5-2	5.5%	160	1204	1215	742	60	50	1128	4.6	425
C-5.5-3	5.5%	160	1201	1211	749	61	50	1128	3.7	495
C-6-1	6%	160	1194	1204	758	58	50	1128	4.3	380
C-6-2	6%	160	1204	1215	742	61	50	1128	5.6	400
C-6-3	6%	160	1201	1211	749	60	50	1128	4.5	375
C-7-1	7%	160	1186	1191	752	58	50	1116	5.7	355
C-7-2	7%	160	1179	1186	750	58	50	1116	4.8	375
C-7-3	7%	160	1203	1211	767	59	50	1116	6.2	350

IV. Conclusion and Future Scope

When it comes to constructing road flooring, flexible floor designs are always favoured over rigid floor options because of their versatility. This results in greater resilience to severe circumstances, as well as increased estimate strength under these settings. The bulk of the road's features are attributed to the bituminous surface pavement that covers the road's surface. SMA is a kind of stone matrix asphalt in which the surface layer gives strength via contact with the stone and, therefore, with the stone matrix. As part of the SMA assessment process, this information is collected in order to offer the most stable product feasible, as well as the highest possible flow value and the lowest possible quantity of binder material. In general, SMA is made up of rough aggregate, which accounts for % of total aggregates, binder, which accounts for 4-7 percent of total aggregates, filler, which accounts for 8-12 percent, and fibre, which acts as a stabiliser and accounts for 0.3 to 0.5 percent of total aggregates. The fact that the coarser aggregate of the mixture includes interactions is essential because it serves to fill in any gaps between the aggregates, which helps to minimise ripping and wearing of the mixture. The supplied fibres serve as stabilisers, increasing the stability of the mixture at high temperatures while also reducing drainage throughout the manufacturing, installation, and shipping operations.

Materials including a primary component, fine aggregate, filler, and stabiliser that are used in the SMA mix for the purpose of generating and testing samples in order to gather and compare project work are known as SMA mix materials. There are two kinds of rough materials that are utilised in this application: natural and synthetic. Fine aggregates, often known as stone dust, are used throughout the case to describe the fine particles. Stabilizers such as bamboo fibre and Topcel cellulose, both of which are derived from renewable resources, are used. In India, bitumen grades 60-70 are often utilised as a binder since they are the grades that are most beneficial in the country's climate.

After 30 minutes of maintaining the temperature at 60 degrees Celsius in a water bath, the test is put in the marshall test equipment for analysis. Specifically, a dial gauge with a stability reading of 25 kN is used for this application. Afterwards, the loaded Marshall stability testing equipment is permitted to continue to load until it fails at constant deformation rates of 5 millimetres per minute until the failure is achieved. The dial gauge was used to generate a total load, and the stability values were recorded for each one. These values were recalculated a second time. That are calculated by comparing the differential weight of a sample obtained in water to a sample collected outside of water, respectively.

References

[1] Hamedi, G. H., Sakanlou, F., Omari, B., & Azarhoosh, A. (2021). Laboratory Investigation of the Effect of Ceramic Fiber on SMA Rutting Estimation. *Journal of Materials in Civil Engineering*, *33*(1), 04020431.

[2] Liu, K., Li, T., Wu, C., Jiang, K., & Shi, X. (2021). Flax of bamboo has engineering properties and estimation suitable as reinforcement for asphalt mixture. *Construction and Building Materials*, *290*, 123240.

[3] Xia, C., Wu, C., Liu, K., & Jiang, K. (2021). Study on the Durability of Flax of bamboo Asphalt Mixture. *Materials*, *14*(7), 1667.

[4] Yu, Demei, Anming Jia, Chao Feng, Wendi Liu, Tengfei Fu, and Renhui Qiu. "Preparation and mechanical properties of asphalt mixtures reinforced by modified flax of bamboos." *Construction and Building Materials* 286 (2021): 122984.

[5] Masri, K. A., Fatin, N. N., Chin, S. C., Syafiqah, S. N., & Shaffie, E. (2021, February). Utilization of Flax of bamboo towards sustainable asphalt mixture. In *IOP Conference Series: Earth and Environmental Science* (Vol. 641, No. 1, p. 012002). IOP Publishing.

[6] Adeboje, A. O., Modupe, A. E., Fadugba, O. G., & Busari, A. A. (2021, April). Engineering Properties of Paving stones made with Bamboo ash as a Partial Replacement for Cement. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1107, No. 1, p. 012163). IOP Publishing.

[7] Li, N., Zhan, H., Yu, X., Tang, W., & Xue, Q. (2021). Investigation of the aging behavior of cellulose fiber in reclaimed asphalt pavement. *Construction and Building Materials*, *271*, 121559.

[8] Kurrey, V. K., & Singh, A. K. (2020). Comparative Study on Stone Mastic Asphalt Mix for Coir Fiber and Flax of bamboo. *International Journal of Research in Engineering, Science and Management*, *3*(8), 305-310.

[9] Mahmood, O. T., & Ahmed, S. A. (2020). Influence of Natural Fibers on the Estimation of Hot Mix Asphalt for the Wearing Course of Pavement. *ARO-THE SCIENTIFIC JOURNAL OF KOYA UNIVERSITY*, *8*(2), 57-63.

[10] Sheng, Y., Zhang, B., Yan, Y., Li, H., Chen, Z., & Chen, H. (2019). Laboratory investigation on the use of flax of bamboo in asphalt mixtures for enhanced estimation . *Arabian Journal for Science and Engineering*, *44*(5), 4629-4638.
[11] Dubey, S., Gond, S., Singh, P., Varma, S., & Munenakoppa, M. (2019). Effect Of Flax of bamboo And Slag Aggregate On The Estimation Of SMA .
[12] Marathe, S. P., & Huddar, S. S. (2019). SMA Based Flexible Pavement.
[13] Liu, Y., Huang, Y., Sun, W., Nair, H., Lane, D. S., & Wang, L. (2017). Effect of coarse aggregate morphology on the mechanical properties of SMA . *Construction and Building Materials*, *152*, 48-56.
[14] Sheng, Y., Li, H., Guo, P., Zhao, G., Chen, H., & Xiong, R. (2017). Effect of fibers on mixture design of SMA . *Applied Sciences*, *7*(3), 297.
[15] Liu, H., Hao, P., & Xu, J. (2017). Effects of nominal maximum aggregate size on the estimation of SMA . *Applied Sciences*, *7*(2), 126.
[16] Kamaraj, C., Lakshmi, S., Rose, C., & Muralidharan, C. (2017). Wet Blue Fiber and Lime from Leather Industry Solid Waste as Stabilizing Additive and Filler in Design of SMA . *Asian Journal of Research in Social Sciences and Humanities*, *7*(11), 240-257.
[17] Suaryana, N. (2016). Estimation evaluation of SMA using Indonesian natural rock asphalt as stabilizer. *International Journal of Pavement Research and Technology*, *9*(5), 387-392.
[18] Xie, Z., & Shen, J. (2016). Estimation properties of rubberized SMA mixtures produced through different processes. *Construction and Building Materials*, *104*, 230-234.
[19] Riccardi, C., Falchetto, A. C., Losa, M., & Wistuba, M. (2016). Back-calculation method for determining the maximum RAP content in SMA mixtures with good fatigue estimation based on asphalt mortar tests. *Construction and Building Materials*, *118*, 364-372.
[20] Sarang, G., Lekha, B. M., Krishna, G., & Ravi Shankar, A. U. (2016). Comparison of SMA mixtures with polymer-modified bitumen and shredded waste plastics. *Road Materials and Pavement Design*, *17*(4), 933-945.
[21] Satyavathi, M., Someswara Rao, B., & Venkata Rao, G. (2016). Experimental study of SMA with coir fiber and pineapple fiber. *International Journal of Engineering Sciences & Research Technology*, *5*, 378-377.
[22] Babagoli, R., Hasaninia, M., & Mohammad Namazi, N. (2015). Laboratory evaluation of the effect of Gilsonite on the estimation of SMA mixtures. *Road Materials and Pavement Design*, *16*(4), 889-906.
[23] Lavasani, M., Namin, M. L., & Fartash, H. (2015). Experimental investigation on mineral and organic fibers effect on resilient modulus and dynamic creep of SMA and continuous graded mixtures in three temperature levels. *Construction and Building Materials*, *95*, 232-242.
[24] Putman, B. J., & Amirkhanian, S. N. (2004). Utilization of waste fibers in SMA mixtures. *Resources, conservation and recycling*, *42*(3), 265-274.
[25] Brown, E. R., & Haddock, J. E. (1997). Method to ensure stone-on-stone contact in SMA paving mixtures. *Transportation research record*, *1583*(1), 11-18.
[26] Pouranian, M. R., Imaninasab, R., & Shishehbor, M. (2020). The effect of temperature and stress level on the rutting estimation of modified SMA. *Road Materials and Pavement Design*, *21*(5), 1386-1398.
[27] Al-Hadidy, A. I., & Yi-qiu, T. (2011). Effect of styrene-butadiene-styrene on the properties of asphalt and stone-matrix-asphalt mixture. *Journal of Materials in Civil Engineering*, *23*(4), 504-510.
[28] Prowell, B. D., Watson, D. E., Hurley, G. C., & Brown, E. (2010). Evaluation of SMA (SMA) for airfield pavements. In *2010 FAA Worldwide Airport Technology Transfer ConferenceFederal Aviation AdministrationAmerican Association of Airport Executives*.