# UTILIZATION OF COIR FIBRES IN STONE MATRIX ASPHALT FOR NATIONAL HIGHWAYS

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**Abstract:** The equitable research study aims at designing the optimum fiber content of waste fibers in the mix design for the Stone Matrix Asphalt (SMA). While enhancing the binder drain down characteristics of the SMA but also providing a Marshall stability, flow characteristics, minimum rut resistant flexible pavement which can be subjected under heavy traffic axle loads. The study aims at material procurement and it's testing as per the Indian Road Congress SP 79-2008 manual for the SMA. Also encouraging the use of this gap graded hot mix asphalt in the use of national highways which are the arterial roads of our country leading to economic triumphant. As the national highway's accounts for the 2 % percent road network in India but is subjected to 40 % of the total traffic conditions. Thereby, affecting the economic life span and increasing the maintenance cost. In such scenarios the use of SMA has been proved to be a boon to the conditioned roads subjected to heavy traffic.

***Keywords— Stone Matrix Asphalt, Marshall Stability, Moisture susceptibility, Rut depth, Binder drain down, Cost Benefit Analysis.***

## I. INTRODUCTION

Assuming the economy as the nervous system, roads are considered to be the arteries which leads to financial development of a country. In India, the network consists of the National highways (NH), State highways (SH), urban roads, District roads, rural roads and project roads with percentage share of different types of highways. The development and maintenance of roads in India are undertaken by various agencies of both Central and state government. The Ministry of Road Transport and Highway is responsible for the development and maintenance of National Highways and executes the same through National Highway Authority of India (NHAI). These routes run through the length and breadth of the country connecting the capitals of different states, union territories, roads connecting neighboring countries, industrial ports, railway stations & marine ports.

Stone Matrix Asphalt (SMA) is a gap-graded mix that relies on stone-to-stone contact to provide potency and an affluent mortar binder to provide durability. In order to encounter the overloading and maintenance strain there's a need to determine alternatives, Stone matrix asphalt has been proven to be one such remedial measure. The SMA has its initial use rooted to 1960 in the road pavement construction under Kiel in Germany. From then the use of SMA as primary flexible pavements has contaminated through the European countries and in the developing countries.

The composition of the SMA comprises of the gap graded coarse aggregates which contains a stone-to-stone contact. While the voids are filled with the mixture binder, filler and fibres. The following composition accounts for the formation of a film around the aggregates which leads to the retarding effect of the moisture penetration causing distress and fatigue.

Nowadays, there has been an increasing demand for the utilization of different types of fibres in SMA which leads to the accumulation in the landfills, so as to reduce the cost and maintain the environmental balance. As, the use of Carbon, steel, boron fibres have decreased due to higher cost. While the organic fibres such as polyester, polypropylene intertwine with each other in the design mix. Therefore, the use of waste nylon, coir fibres, jute fibres, has increased drastically.

## II. OVERVIEW

### *A. Need of Study*

Connectivity of distant locations by the means of the roadway transportation is an essential criterion for a country's economic development and prosperity. In India, national highways are considered to be the arterial roads responsible for the transportation system of our country. But due to substantial increase in vehicular traffic, the increasing axle loads due to overloaded vehicles & the poor maintenance of the roads have led to the deterioration of the structural characteristics of pavements thereby endangering the lives of people,

increasing the travel time and economy thereby affecting the development. Annually, the road accidents in India are increasing at a cumulative rate of 0.46 % due to potholes and distress in pavements led by moisture and binder drain down. In order to encounter the overloading and maintenance strain there's a need to determine alternatives, Stone matrix asphalt has been proven to be one such remedial measure.

### *B. Scope of Study*

The scope of the project is based on the concept to develop an SMA pavement layer i.e., a coarse aggregate skeleton so that stone on stone contact is obtained which provides rut resistant pavement suitable for heavy traffic. The material selection for the SMA Mix design would be based on characteristic specifications stated in Indian Road Congress manual SP 79-2008. The fatigue & distress component of the pavement under the continuous subject of heavy axle load vehicles would be determined on the specimen with the help of Wheel Rut Tester.

### *C. Objectives*

1. To develop a suitable mix design for the Stone Matrix Asphalt (SMA) as per IRC SP 79-2008 specifications.
2. To conduct different tests such as Marshall Stability, Moisture susceptibility, Rut depth for the designed specimen and result procurement.
3. To determine a suitable fibre material preventing the drain down of the binder from the SMA.
4. To develop a rut resistant, distress & fatigue countering pavement economically to reduce the construction cost.

## III. MATERIALS

STONE MATRIX ASPHALT (SMA) is based on the notion of designing a crude aggregate skeleton so that stone-on-stone interaction is obtained, which delivers an extremely rut-resistant bituminous path for hefty road traffic infrastructures. The Flexible Pavement Committee (FPC) of the Indian Roads Congress (IRC) industrialized a draft integrating the materials, stipulations, joints and method of edifice for the Stone Matrix Asphalt.

The rudimentary principle of Stone Matrix Asphalt lies on the crude aggregate skeleton, and it is very significant to attain proper stone to-stone interaction with good quality aggregates for any SMA blend. The coarse aggregate shall entail of crushed stalwart retained on 2.36 mm sieve. It shall be unsoiled, hard, hard-wearing of cubical shape and free from dirt and soft organic and other deleterious materials. The aggregate shall content the following corporeal necessities given in IRC SP 79-2008.

**Table no 1: Drain Down Test Result**

| PROPERTY | TEST | METHOD | SPECIFICATION |
|---|---|---|---|
| Cleanliness | Grain Size Analysis | IS:2386(P-1) | < 2% passing 0.075 mm sieve |
| Particle Shape | Combined Flakiness and Elongation Index | IS:2386 (P-1) | < 30% |
| Strength | Los Angeles Abrasion Value | IS:2386 (P-4) | < 25% |
| Strength | Aggregate Impact Value | IS:2386 (P-4) | < 18% |
| Durability | Sodium Sulphate | IS:2386(P-5) | < 12% |
| Water Absorption | Water Absorption | IS:2386 (P-3) | <2% |

Bitumen is an imperative agent obtained from fossil. Bitumen is known for being sturdily adhesive and impervious to damage from marine and oil spills. n. Coconut flax (coir) is also used as a construction substantial because the natural fibres are ecological. Furthermore, Coconut flax (CF) is resistant to thermal conduction, very tough, supple, durable, renewable and budget friendly. It was pragmatic in experimental analysis that with fractional replacement of 2% Coir Flax with cement, the compressive forte is augmented

## IV. SAMPLE PREPARATION

The weighed exhibits were heated in a preheated oven at a temperature of about 170 C for 2 hrs. so as to remove any humid content from it as well as to bring the exhibit to the temperature supporting its easy adulteration. Overheating of sample was obviated. The specimen was then taken out of the blight by a suitable instrument after 24 hrs. Name stickers representing the asphalt content and sample numeration were glued to the specimen which will be useful while operating the tests.

## V. EXPERIMENTAL ANALYSIS

### A. *Marshall Stability test*

The Marshall Stability and flow analysis provides the investigative prediction measure for the Marshall mix blueprint. The stability portion of the assessment measures the elevated load supported by the analytical specimen at a lading rate of 50.8 mm/minute. Load is applied to the exhibit till breakdown, and the peak load is designated as stability. During the lading, an attached dial barometer measures the specimen's plastic flow (deformation) due to

the loading. The flow appraisal is documented in 0.25 mm (0.01 inch) increments at the same time when the maximum load is documented.

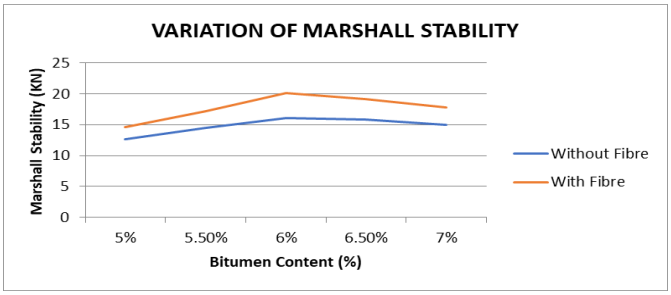


**Fig 1: Variation of Marshall Stability Graph**

### B. *Drain Down Test*

The analysis investigates the extent of drain down in an uncompacted bitumen mixture sample when the specimen is held at lofted temperatures, which are encountered during the manufacturing, commuting, and placement of the mixture. The quantity of the drained material is determined to quantify the extent of drain down as a percentage of the mass of the overall bitumen specimen.

**Table no 2: Drain Down Test Result**

| SR NO | DRAIN DOWN PERCENTAGE (%) |
|---|---|
| 1 | Without Coir Fiber- 1.42 % |
| 2 | With Coir Fiber – 0 % |

### C. *Indirect Tensile Strength test*

The analysis is used to evaluate the tensile potential parameter of compacted bituminous mixtures. The IDT vigor of asphalt mixtures is conducted by burdening a cylindrical exhibit across its vertical diametric degree at a definite rate of deformation and investigative temperature. The peak load at failure is documented and used to estimate the IDT strength of the exhibit. Deformation rate used for the analysis was 51 mm/min. mm in depth & 75 mm long, composed of stainless steel were used to transfer the applied lade to the exhibit. Marshall samples were procured with OBC using flex. The Perspex water bath maintained at the same test temperature was placed on the bottom plate of the Marshall appliance and the sample was put inside it. Care was taken such that lade is applied along the vertical diametrical degree. The load was applied till failure and the decline lade was noted using the dial gauges. The IDT was estimated using the formula:

$$St = \frac{2P}{\pi * t * D} \text{ Kpa}$$

| STONE MATRIX ASPHALT | | |
|---|---|---|
| LENGTH OF HIGHWAY - 1KM, WIDTH -8M, THICKNESS- 50 MM | | |
| SERVICE LIFE - 27 YRS | | |
| MAINTENANCE AFTER EVERY 9 YRS | | |
| | | |
| 1 | AMOUNT A- MATERIAL CONSUMPTION ANALYSIS | 3918907.25 |
| 2 | AMOUNT B - TRANSPORTATION COST | 361186.521 |
| 3 | AMOUNT C- MACHINERY COST | 657404 |
| 4 | AMOUNT D - MAINTENANCE COST | 6365700 |
| 5 | TOTAL AMOUNT | 11303197.77 |
| 6 | CONTRACTOR PROFIT @12% | 1356383.733 |
| 7 | ELECTRICITY AND WATER SUPPLY COST @2% | 226063.9554 |
| 8 | OVERHEAD CHARGES @1.5 % | 169547.9666 |
| 9 | OVERHEAD CHARGES @5% | 565159.8886 |
| | **FINAL AMOUNT PER KM** | **13620353.31** |
| | **PER SQM** | **1702.544164** |

**Table no 3: Cost Analysis for SMA**

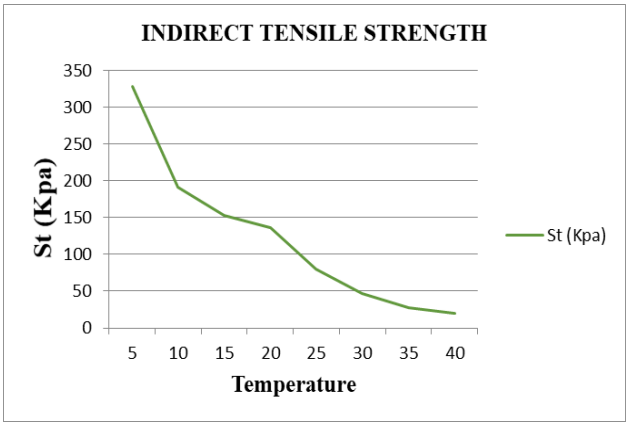


**Fig 2: Indirect Tensile Strength**

### D. *Interpretation of Results*

i. The flow value surges with the intensification in the bitumen content for both the mixtures thru and deprived of fibres.

ii. The Air Voids (VA) declines with rise in the bitumen content because with rise in bitumen content it goes on satisfying the air voids gradually. The VA of mixture with fibre is not as much than deprived of fibre. This is since the fibre already occupied up some portion of air voids (VA)

iii. The drain down investigations were evaluated out to compare the drain down characteristic of trials thru and deprived of fibres at Optimum Bitumen.

## VI. COST BENEFIT ANALYSIS

The methodical approximate involves the edifice and maintenance cost for the Stone Matrix Asphalt mix design acquired in comparison to the Bituminous Concrete pavement for a 1 KM road stretch. The material cost evaluated differs as per the proposed quantity acquired per cum for the individual mix design while the maintenance cost depends on wearing course. While the machinery and transportation cost for materials is considered to be the same for the Stone Matrix Asphalt and Bituminous Concrete pavement. The cost benefit analysis includes the construction as well as the continuation cost for the SMA & BC mix designs as per their respective service life span with individual annual interval at a finite interval. The composition of the SMA comprises of the gap graded coarse aggregates which contains a stone-to-stone contact. While the voids are filled with the mixture binder, filler and fibres. The following composition accounts for the formation of a film around the aggregates which leads to the retarding effect of the moisture penetration causing distress and fatigue.

## VII. CONCLUSIONS

The maintenance cost for bituminous concrete and stone matrix asphalt pavements differs as per their specifications and compositions as prescribed in Indian Road Congress manual. The construction and continuation i.e., maintenance cost for the Stone Matrix Asphalt for the respective service life was estimated as **1702.544 per sqm** while for the Bituminous Concrete Road it was approximated as **2104.56 per sq.** Indicating the productive efficiency and elongated lead time for the proposed design adopted for the Stone Matrix Asphalt as per Indian Road Congress specifications.

The construction cost for the 1 KM road stretch of Bituminous Concrete was acquired at an inferior rate of **3918907.25 INR** in comparison to Stone Matrix Asphalt having a higher edifice value of **3226024.57 INR**.While the improved rut resistance and heavy traffic load bearing capacity of Stone Matrix Asphalt indicated elongated life span and lower maintenance cost i.e., **6365700 INR** for SMA in comparison to BC pavement which accounted as **10020150 INR**.Thus, stipulation acquired for SMA mix design was found out to be methodical.

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