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STUDY OF BITUMINOUS MIXES USING A NATURAL FIBRE

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ABSTRACT

A bitumen mixture is made up of aggregate, fine and coarse aggregates, filler, and binder in general. A hot mix bitumen is a bituminous material that is mixed, poured, and compacted at a high temperature. HMA can indeed be Dense Graded Mixes (DGM), also known as Bitumen Concrete (BC), or Stone Matrix Asphalt, which is gap graded (SMA). To keep the mix from draining, SMA requires stabilising additives made of cellulose fibres, mineral fibres, or polymers.

The purpose of this study was to investigate the effects of using SISAL fibre, a naturally and locally sourced fibre, as a stabiliser in SMA and as an additive in BC. The mix proportion was taken according to MORTH specifications, the binder percentage was varied on a regular basis from 4% to 7%, and the fibre content was varied from 0% to 0.5 percent of the entire mix. Fly ash was discovered to have satisfactory Marshall Properties as part of a preliminary investigation and has so been employed for mixes in later works. The Optimum Fibre Content (OFC) for both BC and SMA mixtures was found to be 0.3 percent using the Marshall Procedure.

Key Words: Bituminous Concrete (BC), Stone Matrix Asphalt (SMA), Sisal Fibre, Marshall Properties, Static Indirect Tensile Strength, Static Creep

INTRODUCTION

Highway construction necessitates a significant financial expenditure. A exact engineering design can save a lot of money while also ensuring that the in-service highway performs well. Pavement design and mix design are two significant factors to consider in flexible pavement engineering. The current research is focused on mix design considerations. A properly designed bituminous mix should produce in a mix that is adequate.

(i) Robust (ii) long-lasting (iii) resistant to fatigue and deformations (iv) eco-friendly (v) cost-effective, and so on. A mix designer attempts a number of different proportions in the mix to meet these parameters before settling on the ideal one. The purpose of this study is to identify a few of the challenges that arise in the art of bitumen mix design, as well as the current research direction.

EVOLUATION OF MIX DESIGN

According to Das et al. (2004), bituminous pavement was originally employed on country roads in the early 1900s to handle the rapid removal of fine particles in the form of dust from Water Driven Macadam, which was caused by the rapid growth of automobiles. Heavy oils were utilized as a dust palliative at first. The required quantity of heavy oil in the combination was estimated using an eye estimation procedure known as the pat test. The mixture was flattened into a pancake shape and pushed against brown paper using this method. The suitability of the amount was determined based on the amount of stain it left on the paper. The Habbard fields method, which was initially conceived on a sand-asphalt combination, was the first systematic mix design method. Hubbard field approach could not manage mixes with big aggregates. It was one of the procedure's shortcomings. The Hveem stabilometer was created by Francis Hveem, a construction manager of the California Department of Highways. Hveem had no prior experience assessing the perfect mix based on its colour, so he chose to test several mix factors to determine the optimal bitumen quantity. To estimate the amount of bitumen necessary, Hveem employed

The surface morphology calculation approach (which was already in use at the time for cement mix design). In 1946 and 1954, the Hveem test was expanded to include moisture sensitivity and sand equivalent testing. Just before World War II, Bruce Marshall invented the Marshall testing machine. In the 1930s, it was accepted by the US Army Corps of Engineers and later modified.

BITUMINOUS MIX DESIGN

Objective of Bituminous mix design:-

Asphaltic/bituminous concrete is made up of aggregates that are continually graded from the largest size, typically less than 25 mm, to the smallest filler, typically less than 0.075 mm. Asphalt is added to the mix in sufficient quantities to make the compacted mixture impermeable and have adequate dissipative and elastic qualities. The goal of bituminous mix design is to identify the proportions of bituminous, fillers, aggregates, and aggregates in order to create a mix that is workable, robust, long-lasting, and cost-effective. The goal of the mixture design is to create a bituminous mix by adjusting the proportions of various components to achieve the following results:

1. Enough bitumen to create a lengthy pavement

2. Sufficient strength to withstand shear deformation in high-temperature traffic

3. Enough air holes in the compressed asphalt to allow for extra traffic compaction.

4. Workability sufficient to allow for convenient insertion without segregation

5. Adequate resistance to avoid early cracking as a result of traffic bending.

6. Sufficient resistance to shrinkage cracks at low temperatures

Requirements of Bituminous mixes:-

Stability

The resilience of the paving mix to deform under traffic pressure is known as stability. Shoving - a transverse stiff deformation that occurs at locations prone to extreme acceleration - and grooving - horizontal ridging due to traffic channelization - are two examples of failure. The inter-particle friction, predominantly of the aggregates, and the cohesion provided by the bitumen, determine stability. A substantial binder must be supplied to coat all of the particle at the same time, and the liquid friction must be sufficient. When the binder content is too high and the particles are maintained apart, however, the stability falls.

Durability

The resilience of the mix to weathering and abrasive effects is defined as its durability. Due to the loss of volatile matter in the bitumen, weathering induces hardness. Wheel loads generate tensile strains, which cause abrasion. Potholes, local pavement degeneration, and stripping, where the aggregates lose their binder and the aggregates are exposed, are two common forms of failure. High binder content reduces disintegration because it makes the mix air and waterproof, and the bitumen coating is more resilient to stiffening.

Flexibility

Flexibility refers to the amount of bending strength required to withstand traffic loads and prevent surface cracking. Fracture refers to surface cracks (hairline cracks, alligator cracks), which are caused by shrinkage and the brittleness of the binder. Cracks caused by shrinkage are known as shrinkage cracks.

Due to aging-related volume changes in the binder Brittleness is caused by the surface bending repeatedly as a result of traffic stresses. Exibility and fracture will be improved with a higher bitumen percentage.

REVIEW OF LITERATUR

Pavement is made up of multiple layers of different materials that are held together by a subgrade layer. In general, there are two types of pavement: ability to be able and rigid pavement. Flexible pavements get their name from the fact that the entire pavement structure deflects (or flexes) under weight. Typically, a pavement structures construction is made up of numerous layers of material. Each layer gets the pressures from the layer above, distributes them, and then sends them on to the layer below. The following is an example of a flexible pavement structure:

• The course of the surface. This really is the top layer, which is in direct touch with traffic. It could be made up of a single or many HMA sublayers. HMA is made up of a mix of fine aggregates as well as an asphalt binder.

• The fundamentals. This is the layer that sits right beneath the HMA layer and is made up mostly of aggregate (either stabilised or un-stabilized).

• This is a sub-base course. This layer (or layers) sits beneath the foundation layer. It is not always necessary to use a sub-base.

ASPHALT CONCRETE OR (BITUMINIOUS MIXTURE)

Bitumen concrete is a mixture that is extensively used in road building, airports, and parking lots. It is made up of a mixture of asphalt (as a binder) and rock aggregate, which is then placed down in layers & compacted. Asphalt and aggregate can be mixed in a variety of ways, including:

HMAC or HMA stands for hot mix asphalt concrete, which is made via heating the asphalt mixture to reduce its viscosity and drying the aggregates to remove moisture before mixing. The aggregate is usually mixed at around 300 degrees Fahrenheit (approximately 150 degrees Celsius) for virgin asphalt and 330 degrees Fahrenheit (166 degrees Celsius) for polymers modified asphalt, with the asphalt concrete at 200 degrees Fahrenheit (95 degrees Celsius). Laying and compaction must take place when the asphalt is still hot enough. Paving is restricte

to the summer months in many countries because the compacted base cools the asphalt too much in the winter before it has been packed to the ideal air content.

Warm mix asphalt Concrete : Asphalt with a warm mix Prior to mixing, zeolite waxes, bitumen emulsions, or even water are added to the asphalt binder to make concrete (often abbreviated as WMA). This allows for substantially lower mix and laying temperatures, as well as decreased fossil fuel usage, resulting in lower emissions of carbon dioxide, aerosols, and vapours. Not only are workplace standards better, but the lower laying temperature also means that the surface is available for use more quickly, which is vital on construction sites with tight deadlines. These additions in hot mix asphalt (hma asphalt (seen above) may make compaction easier and enable for cold weather laying or longer hauls.

Cold mix asphalt : The asphalt is emulsified in water using (basically) soap before being mixed with the aggregate to make concrete. The bitumen is less viscous in its emulsified state, making the mixture easier to work with and compact. After enough water has evaporated, the emulsion will split, and the cool mix will, in theory, take on the qualities of cold HMAC. Cold mix is widely used as a mending material and on service roads with low traffic.

Cut-back asphalt concrete: The binder is dissolved in kerosene or the other lighter proportion of petroleum before being mixed with the aggregate to make cut-back asphalt concrete. The bitumen is less viscous in its dissolved state, making the mix easier to work with and compact. The lighter fraction of the mix evaporates after it is placed down. Cut-back asphalt has been mostly supplanted by asphalt emulsion due to worries about pollution from the lighter fraction's volatile organic compounds.

Mastic asphalt concrete: Mastic asphalt concrete, also known as sheet asphalt, is made by oxidising hard grading blown bitumen in a green oven (mixer) until it becomes a viscous liquid, then adding the aggregate mix. The bitumen aggregate mixture is then cooked (matured) for approximately 6 to 8 hours, after which the mastic asphalt mixer is brought to the job site, whereupon experienced layer empty the mixer and then either machines or hand lay its mastic asphalt contents on the road. For sidewalk and road applications, mastic bitumen concrete is often poured to a thickness of 34–1 316 inches (20-30 mm), and for floor or roof applications, to a thickness of 38 of an inch (10 mm). Additives are used in addition to asphalt and aggregate

Stone Matrix Asphalt (SMA)

Stone mastic asphalt (SMA), sometimes known as stone matrix bitumen, is a gap-graded HMA that was developed in Europe to improve mating season strength and good in high-traffic areas. SMA contains a large amount of coarse aggregate, which interlocks to produce a stone skeleton that prevents permanent deformation. The stone framework is filled with a bitumen and filler mastic with fibres added to ensure bitumen stability and prevent binder drainage during transportation and placement. 70–80 percent coarse aggregate, 812 percent filler, 6.0–7.0 percent binder, and 0.3 percent fibre make up a typical SMA composition. SMA's deformation resistance comes from a rough stone skeleton that allows for greater stone-on-stone contact than traditional dense graded bitumen (DGA) mixes. Higher binder content, a thinner bitumen layer, and reduced air voids content all contribute to improved binder durability. Flexibility is further improved by the high bitumen concentration. The addition of a little amount of cellulose or mineral fibre to the bitumen stops it from draining during transportation and placement. For SMA mixes, there are no specific design guidelines. The fine aggregates skeletal and mastic composition, as well as the resulting surface texture and mix stability, are largely governed by aggregate grading as well as the kind and percentage of filler and binder. Rut tolerance and durability were increased because to SMA. It has a high tensile and fatigue strength. SMA is almost solely utilised for high-volume road surface courses. Gap-graded aggregate, asphalt mixture binder, and fibre filler are among the materials utilised in SMA. Wet weather friction (because to a rougher surface texture), lower tyre noise (because to a rougher surface texture), and less acute reflective cracking are all advantages of SMA. To reduce asphalt mixture drain-down during building, raise the quantity of asphalt binder utilised in the mix, and improve mix durability, mineral admixtures and additives are used

Fig.2.3 SMA Surface

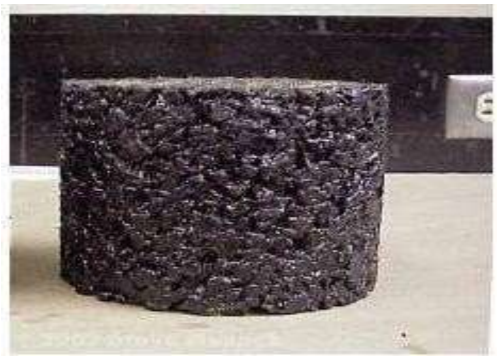


Fig.2.4 SMA Lab Sample

Open-Graded Mixes

An open-graded HMA mixture, unlike dense-graded mixtures and SMA, is meant to be water permeable. Only broken rock (or gravel) and a limited percentage of artificial sands are used in open-graded mixtures. The following are the two most common open-graded mixes:

• Friction course with open grades (OGFC). There are typically 15% air voids, with no maximumpressure voids specified.

• Permeable bases that have been treated with asphalt (ATPB). Because it is exclusively utilised for drainage beneath densely graded HMA, SMA, or Portland cement concrete, it has less severe criteria than OGFC.

OGFC - Only used on the surface of the course. In rainy weather, they reduce tyre splash/spray and produce smoother surfaces than dense-graded HMA. The high air gaps in their tyres reduce tire-road noise by up to 50%.

Aggregate (coarse aggregate or gravel, as well as artificial sands), and asphalt binder (with modifiers). OGFC is more costly per tonne than dense-graded HMA, however the unit weight of a mix in place is lower, therefore the higher per-ton cost is partially compensated. The open gradation in the mix provides pores, which are necessary for the mix's correct function. Anything that clogs these pores, including such low-speed traffic or too much dirt on the road, can reduce performance.

Fig.2.5 OGFC Surface

Fig 2.6 OGFC Lab Samples

PROPERTIES OF HOT MIX ASPHALT (HMA)

The qualities of the bituminous mix should be as follows:

- Permanent Deformation
- Resistance Fatigue
- Resistance and Reflective
- Cracking Resistance
- Low-temperature (thermal) cracking resistance
- Durability.
- Moisture Resistance is a term used to describe a material's ability to withstand moisture damage (Stripping)
- Workability.
- Resistance to slipping

Table 2.1 Main differences of SMA and bituminous mix (Bose et al., 2006)

Properties	SMA	BC
Definition	SMA is a gap graded mix which consists of high amount of coarse aggregate firmly bonded together by a strong asphalt matrix Consisting of fine aggregate, filler, Bitumen and stabilizing additives.	.BC consists of well graded coarse and fine aggregate, filler and bitumen.
Sample fig.		
Mass of Coarse Aggregate Content, (%)	75 – 80	50-60
Mass of Fine Aggregate (%)	20 – 25	40 - 50
Mass of Fine Aggregate (%)	20 – 25	40 - 50
Mass of Filler content,(%)	9 – 13	6 – 10
Binder Type	60/70, PMB- 40	60/70, 80/100 and modified binders
Minimum binder content by weight of mix, (%)	>6.5	5 - 6
Stabilizing Additives by weight of mix,(%)	0.3 – 0.5	--------
Air Voids (%)	3—4	3--6

Stabilizing Additives:-

- Polymer
- Materials that resemble powder and flour (Silicic acid, Special Filler)
- Plastics are a type of material that can be used to make (Polymer Powders or Pellets)

Fibre from nature: -Natural fibre is divided into three categories based on the part of the plant from which it is extracted:

- stem fibre, leaf fibre, and root fibre (jute, banana etc.)

- Fibre from leaves (sisal, pineapple)

- Fiber from fruits (cotton, coir, oil palm)

Sisal fibre (http://en.wikipedia.org/wiki/sisal) is made from the leaves of the Mexican agave Sisalana tree and is currently grown in Brazil, Africa, Haiti, India, and Indonesia. Sisal Fiber is extremely durable, requiring little maintenance and requiring little wear and tear. It is also recyclable. Sisal fibres are extracted from the protective outer skin after the interior pulp has been removed. Plaid, herringbone, and twill are examples of fine fibres. Sisal fibres are anti-static, don't attract or retain dust, and don't readily absorb moisture or water. The delicate texture readily accepts dyes and has the widest spectrum of coloured colours of any natural material. It has excellent sound and impact absorption qualities.

Fig-2.7 Sisal fiber

Fig-2.8 Sisal Tree

Table 2.2 Physical Properties of sisal fiber

PROPERTY	VALUE
Density (gm/cm^3)	1.5
Elongation (%)	2.0-2.5
Tensile Strength (MPa)	511-635
Young Modulus (MPa)	9.4-2.0

Table 2.3 Chemical Properties of sisal fiber

PROPERTY	VALUE
Cellulose (%)	66-78
Hemi-cellulose (%)	10-14
Lignin (%)	10-14
Pectin (%)	10
Moisture content (%)	10-22
p^H	5.7-6.2

Tests on Materials Used

Aggregates

A specific type of binders and fibre in required proportions were mixed according to Marshall Procedure to generate Bituminous mixtures (BC, SMA) aggregate as per MORTH grading as shown in Table 3.1 and Table 3.2, respectively.

Table 3.1 Adopted aggregate Gradation for BC (MORTH)

Sieve size (mm)	Percentage passing
26.5	100
19	95
9.5	70
4.75	50
2.36	35
0.30	12
0.075	5

Table 3.2 Adopted aggregate Gradation for SMA (MORTH)

Sieve size (mm)	Percentage passing
16	100
13.2	94
9.5	62
4.75	34
2.36	24
1.18	21
0.6	18
0.3	16
0.15	12
0.075	10

Table 3.3 Physical Properties of Coarse aggregate

Property	Test Method	Test Result
Aggregate Impact Value (%)	IS: 2386 (P IV)	14.3
Aggregate Crushing Value (%)	IS: 2386 (P IV)	13.02
Los Angels Abrasion Value (%)	IS: 2386 (P IV)	18
Flakiness Index (%)	IS: 2386 (P I)	18.83
Elongation Index (%)	IS: 2386 (P I)	21.5
Water Absorption (%)	IS: 2386 (P III)	0.1

Binder

For the manufacture of Mix, 60/70 dense - graded bitumen was used as a binder, with a specific gravity of 1.01. Table 3.4 lists its key characteristics.

Table 3.4 Properties of Binder

Property	Test Method	Value
Penetration at 25°C (mm)	IS : 1203-1978	67.7
Softening Point (°C)	IS : 1203-1978	48.5
Specific gravity	IS : 1203-1978	1.03

Marshall Test

Marshall Mix design is a standardized laboratory method for measuring and reporting the hardness and flow parameters of bituminous pavement mixes that is used all over the world. It is a widely used method of characterisation of bituminous mixtures in India. Many researchers have used this test to evaluate bituminous mixtures. Because of its simplicity and low, this test method is widely used. Because of the benefits of the Marshall method, it was decided to utilise it to establish the Optimal Binder Content (OBC) of the mixes as well as to investigate other Marshall Qualities such as Marshall Stability, flowability, unit weight, air voids, and so on.

The Marshall specimen and Marshall Equipment with a loaded Marshall specimen are shown in Figures 3.1 and 3.2. To determine optimal binder contents (OBC) and increasing fiber contents (OFC), the Marshall qualities of stability, flow value, unit weight, and air voids were investigated (OFC). The Marshall samples' mix volumetrics, such as unit weight and air voids, were estimated using the procedure described by Das and Chakroborty (2003). Due to time constraints, all tests on all sorts of mixes can indeed be done. As a result, it was agreed to conduct the following set of studies on the mixes produced at their OBC and OFC, including a drain down test, a static indirect tensile test, and moisture susceptibility tests.

Fig 3.1 Marshall Sample

Fig 3.2 Marshall Test in Progress

Drain down test

The drain-down properties of bituminous mixtures can be evaluated using a variety of approaches. In this investigation, the drain down approach proposed by MORTH (2001) was used. Figure 3.3 shows the drainage baskets that were made locally according to MORTH's (2001) specifications. The loose, uncompacted mixes were then placed to drainage baskets and baked for three hours at 150°C in a preheated oven. To collect the draining out binder drippings, pre-weighed plates were placed beneath the drainage baskets. The binder outflow has been determined from of the drain off test using the equation:-

Drain down equation is

$$d = \frac{W_2 - W_1}{1200 + X}$$

Where

W_1 = initial mass of the plate

W_2 = final mass of the plate and drained binder

X = initial mass of fibres in the mix

Three mixtures were made at the optimum binder content for each binder, and the drain down was calculated as the average of the three. The draining of 60/70 bitumen is depicted in Figure 3.3.

Fig 3.3 Drainage of 60/70 bitumen sample (SMA without fibre)

The Marshal test apparatus was used for this test, which had a displacement rate of 51 mm / min. A compression load was applied in the vertical diametrical plane, and the load was measured with a proving ring. To keep the testing temperature constant, a Perspex pot of water (270 mm x 250 mm x 195 mm) was created. Two stainless steel loading strips, 13 mm (1/2) wide, 13 mm

deep, and 75 mm long, were utilised to transmit the imposed load to the specimen. The strip manufactured has the same interior diameter as a Marshall sample (102 mm). The stationary indirect tensile test on a specimen is shown in Figure 3.5.

Before the test, the sample was held in a water bath at the necessary temperature for at least 1/2 hour. On the bottom plate of a Marshall apparatus, a Perspex water bath kept at the same specified temperature was installed. Within the two loading strips, the sample was placed inside the Perspex water bath. A 51 mm/minute loading rate was chosen.

The load was applied and the failure load was noted from the dial gauge of the proving ring. The tensile strength of the specimen was calculated by using the formula given in ASTM D 6931 (2007) and mentioned in Equation given below:-

$$S_T = \frac{2000 \times P}{\pi \times t \times d}$$

Where

S_T == Indirect Tensile Strength, KPa

P = Maximum Load, N

t = Specimen height before testing, mm

D = Specimen Diameter, mm

The test temperature ranging in 5°C increments from 5°C to 40°C. Three Marshall specimens were examined at a specific temperature in this test, and the tensile strength was calculated as that of the average of the three values.

Fig 3.4 Static Indirect Tensile Test in progress

Fig 3.5 Close View of loaded sample

Fig 3.6 Specimen tested at 5°C

Fig 3.7 Specimen tested at 10°C

Fig 3.8 Specimen tested at 40°C

Static Creep Test

Samples for the Static Creep test were made at their OBC and OFC. There are two stages to the test. A vertical load of 6 KN is allowed to stand for 30 minutes in the first stage. The deformation was measured with a dial gauge calibrated in 0.002 mm units and capable of registering a deflection of 5 mm throughout these 0, 10, 20, and 30 minutes. Second, the load was withdrawn, and its deformation was recorded for the next 10 minute intervals, i.e. 40, 50, and 60 minutes. The temperature is kept at 40°C during the test. A graph between time-deformation has been plotted, which will be illustrated in the future chapter.

Fig 3.9 Static Creep Test In Progress

RESULTS & DISCUSSION

The results and observations of the tests conducted in the previous chapter are given, examined, and discussed in this chapter. There are five sections in this chapter. The first section discusses the parameters that were used in the analysis. The second section covers the computation of BC's Optimum Binder Content (OBC), which includes fillers such as cement, fly ash, and stone dust. The third section discusses how to calculate the Optimal Binder Content (OBC) and Optimal Fibre Content (OFC), as well as the Marshall Properties of BC with and without fibre. The fourth section discusses how to calculate the Optimum Binder Content (OBC) and Optimal Fibre Content (OFC), as well as the Marshall Properties of SMA with and without fibre. The fifth section discusses the results of the Drain Down and Stationary Indirect Tensile Stress tests, as well as the static Creep test.

PARAMETERS USESD:-

Some definitions of dry density are proposed based on the volume considered while evaluating the relative density of an aggregate. According to Das A. and Chakroborty P. (2010), the following are the definitions and other equations utilised in the calculations:

Bulk Specific Gravity Of aggregate (G_{sb})

$$G_{sb} = \frac{M_{agg}}{volume\ of\ (agg.mass + air void\ in\ agg. + absorb\ bitumen)}$$

Where M_{agg} = Mass of aggregate

Effective specific gravity of aggregate(G_{se})

$$G_{se} = \frac{M_{agg}}{volume\ of\ (agg.mass + air\ void\ in\ aggregate)}$$

Where M_{agg} = mass of aggregate

$$G_{se} = (M_{mix} - M_b) / \left(\frac{M_{mix}}{G_{mm}} - \frac{M_b}{G_b} \right)$$

Where M_b = mass of bitumen used in mix

G_b = specific gravity of bitumen

Apparent Specific Gravity (G_a)

$$G_a = \frac{M_{agg}}{volume\ of\ aggregate\ mass}$$

Theoretical Maximum Specific Gravity of Mix (G_{mm})

$$G_{mm} = \frac{M_{mix}}{volume\ of\ (mix - air\ voids)}$$

Bulk Specific Gravity of Mix (G_{mb})

$$G_{mb} = \frac{M_{mix}}{bulk\ volume\ of\ mix}$$

Bulk Specific Gravity of Mix (G_{mb})

$$G_{mb} = \frac{M_{mix}}{bulk\ volume\ of\ mix}$$

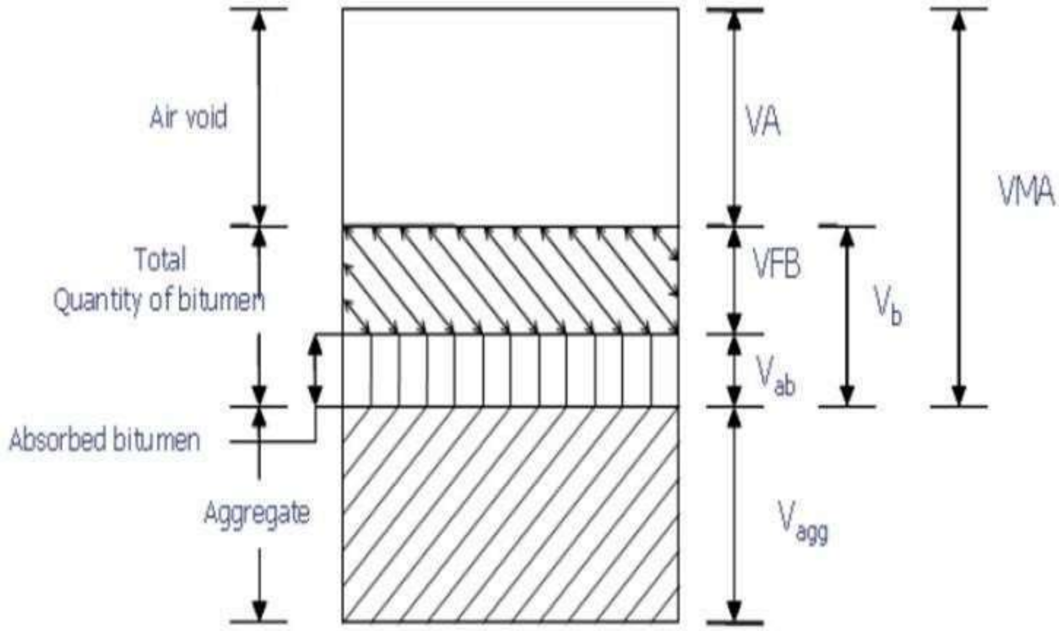
Air Voids (VA)

$$VA = [1 - \frac{Gmb}{Gmm}]*100$$

Voids In Mineral Aggregates (VMA)

$$VMA = [1 - \frac{Gmb}{Gmm} * P_s] *100$$

Where P_s = percentage of aggregate present by total mass of mix



Marshall's variation The properties of bitumen concrete (BC) with various fillers are described below. Marshall Stability is a term used to describe a state

It has been observed that when binder content grows, stability value increases until a specific binder content is reached, after which stability value declines. Figure 4.1 shows how the Marshall Stability value changes with varying binder content and filler.

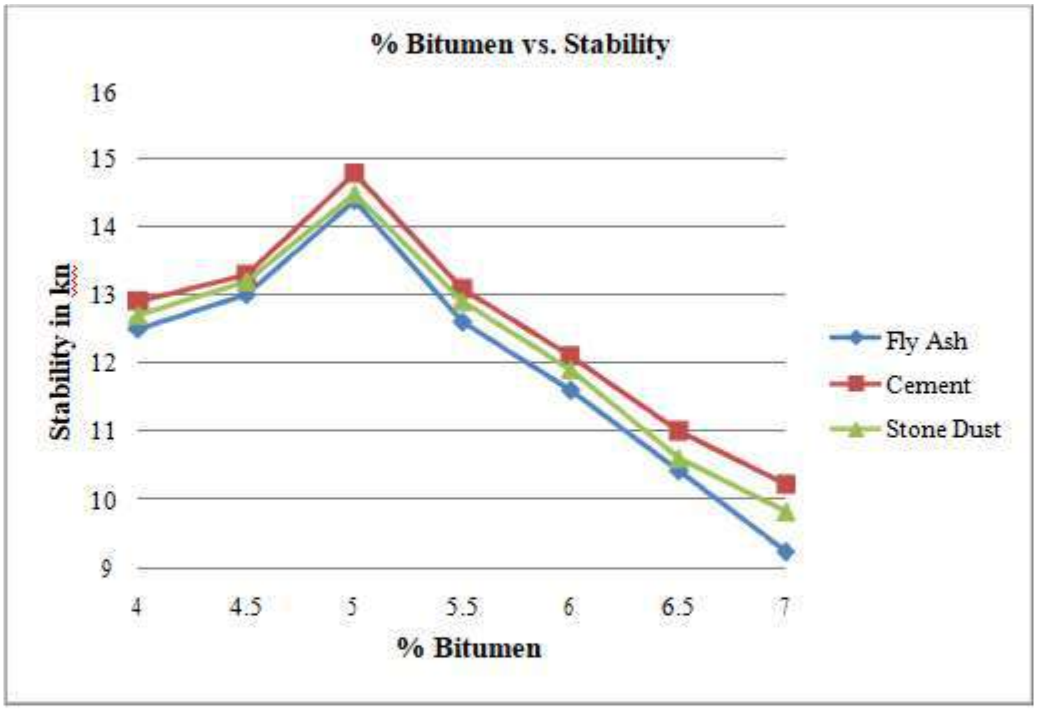


Fig 4.2 Variation of Marshall Stability of BC with different binder content

(With different type of filler)

Table 4.1 Maximum Marshall Stability values and their corresponding binder content

BC with filler type	Max. Stability (KN)	Corresponding Binder Content (%)
Cement	14.78	5
Stone dust	14.48	5
Fly ash	14.38	5

Flow Value

Variation by Marshall Below are the parameters of bituminous concrete (BC) with various fillers. The term "Marshall Stability" is used to describe the state.

When binder content increases, stability value rises until a certain binder content is achieved, at which point stability value decreases. Figure 4.1 illustrates how the Concrete Strength adjusted by adjusting when the binder and filler content changes.

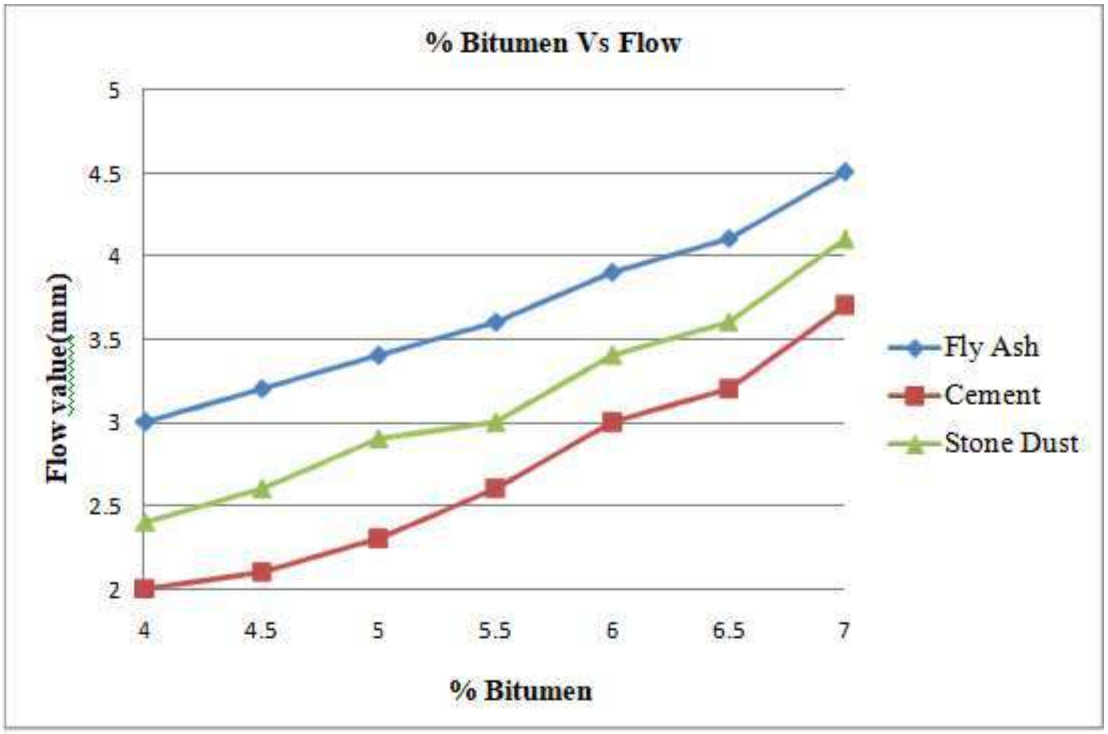


Fig 4.3 Variation of Flow Value of BC with different binder content

(With different type of filler)

Unit Weight

It has been found that as binder content increases, unit weight increases until a certain point, at which point it drops. Figure 4.3 shows the variation in unit weighting with various binder and filler contents.

FIBRE'S EFFECT ON BC

Binder content ranges from 4 to 7 percent, while fibre content ranges from 0.3 to 0.5 percent. The Marshall Method is used to calculate OBC, OFC, and other Marshall characteristics. Marshall Stability is a term used to describe a state

It has been observed that when binder content grows, stability value increases until a specific binder content is reached, after which stability value declines. Also, as the fibre content grows, the stability value increases, and as the fibre content increases, the stability value drops. Marshall's variation Figure 4.7 shows the stability value for various binder content and fibre types.

FIBRE'S EFFECT ON SMA

The following table shows the results of varying Marshall Properties with variable binder content, where fibre content is taken as 0 percent, 0.3 percent, and 0.5 percent.

Marshall Stability:

It can be seen that as the binder content grows, the stability value increases until a specific binder content is reached, after which it declines. Similarly, increasing the fibre stability value raises it up to a point, after which it starts to decrease. Perhaps this is due to an excess of fibre that is unable to properly mix with the asphalt matrix. Figure 4.13 depicts the outcome

Table 4.9 Maximum Marshall Stability values and their corresponding binder content

Fibre content (%) >	0		0.3		0.4	
SMA with binder	Max. Stability (KN)	Binder Content (%)	Max. Stability (KN)	Binder Content (%)	Max. Stability (KN)	Binder Content (%)
60/70	12.3	6	14.5	5.5	14	6

Characteristics that drain

The MORTH (2001) standards were used to verify the drain down characteristics of the SMA mixes created at their OBC and OFC. The findings of the drain down tests are described in this section .Mixes with no fibre should be drained.

Table 4.5 shows the results of drain down experiments on mixtures without fibre, which were calculated using Equation 3 in chapter 3. Because SMA Mixes contains a higher percentage of bitumen, the results show that it provides more drain down than BC.

Table 4.13 Drain down of mixes without fibre

MIX	Drain down value (%)
SMA	0.08
BC	0.02

Mixtures containing fibre should be drained.

The drain down features of mixtures are reduced when sisal fibre is added; the Drin down value of SMA is lowered to 0.02 percent, and there is no drain down of BC binder.

Indirect Tensile Static Test

The static indirect tensile of bituminous mixes determines the mix's indirect tensile strength (ITS), which aids in determining the mix's resistance to thermal cracking. Static indirect tensile tests on SMA and BC mixes at their OBC and OFC, as specified in Chapter 3. Temperature effects on the ITS of mixes with and without fibre are also investigated. The static indirect tensile test results are shown.

Temperature has an effect on static indirect tensile.

Figures 4.19 show how the ITS value changes with temperature for blends with and without fibre, as well as mixtures with varying binder content. It has been discovered that as the temperature rises, the ITS value of a certain binder drops. SMA blends provide the strongest indirect tensile strength than BC at lower temperatures.

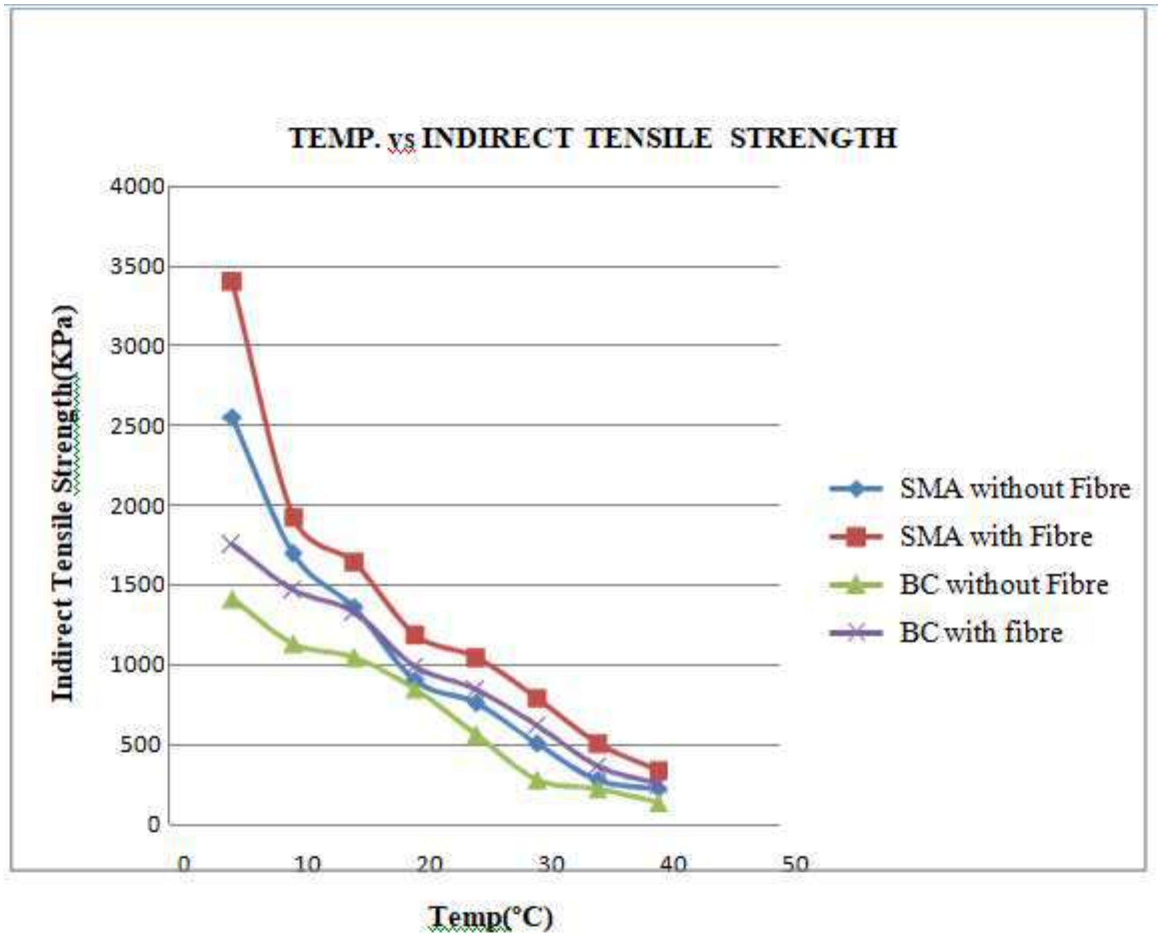


Fig 4.20 Variation of ITS Value of SMA and BC with different Temperatures

CONCLUSION

Based on the findings and discussion of a mix-related experimental inquiry,Following the conclusion, SMA and BC are drawn.

BC with various types of filler

Table 5.1 shows the MORTH Specification mix design requirements for bituminous mix.

Table 5.1 MORTH Specification mix design requirements of bituminous mix

Property	Value
Marshall stability (KN at 60°C)	>9KN
Flow Value (mm)	2-4
Air Void (%)	3-6
VFB (%)	65-75
OBC (%)	5-6

2) As BC made of from all the three type filler satisfy above requirements we can use them as filler.
3) Although BC with cement as filler gives maximum stability, as it is costly we can also use fly ash and stone dust as filler material.
4) Use of fly ash is helpful in minimize industrial waste.

BC with a variety of fibre content

1) In this case, OBC is 5% and OFC is 0.3 percent.

2) The Marshall Stability value increases with the addition of fibre up to 0.3 percent, but falls with the addition of more fibre. However, the addition of the fibre stability value did not result in a significant rise in SMA.

3) When fibre is added to a mix, the flow value lowers as well, but when 0.5 percent fibre is added, the flow value increases.

SMA Fibre content that varies

Table 5.2 IRCSP79-2008 Specification mix design requirements of SMA

Property	Value
Void (%)	4
Binder Requirement (%)	5.8 min
VMA (%)	17
OFC (%)	SHOULD NOT EXCEED 0.3%

BC with a variety of fibre content

1) In this case, OBC is 5% and OFC is 0.3 percent.

2) It was discovered that SMA without fibre had a binder need of 5.8%, which is reduced to 5.2 percent by adding 0.3 percent sisal fibre to SMA. With the addition of fibre, it rises to 6, resulting in maximum drainage.

3) Fiber is added to SMA at a rate of 0.3 percent. The value of stability increases dramatically, and as more is added, stability declines.

4) Adding 0.3 percent fibre to SMA reduces flow value, but adding more fibre raises flow value.

5) The main benefit of employing fibre is that the air void in the mix is reduced.

6) Binder drainage decreases.

At their OBC and OFC, MIX

Different tests are performed on MIX at their OBC and OFC, including drain down tests, indirect tensile strength (ITS), and static creep tests, with the results listed below.

1) SMA drains more quickly than BC without fibre. The amount of binder drains down at their OFC.

2) It can be deduced from Indirect Tensile Strength that SMA has a higher Tensile Strength than BC.

3) The addition of fibre to BC and SMA mixes reduced deformation, according to the

Static Creep Test. Permanent distortion should not exceed 0.5 mm, according to MORTH. The distortion of the SMA sample with fibre is 0.45mm, which is acceptable.

Remarks at the End:

Here, 60/70 dense - graded bitumen is employed as a binder in two types of mixes: SMA and BC. A naturally occurring fibre known as sisal fibre is also utilised in varied concentrations (0 to 0.5 percent). The Marshall Method of Mix Design is used to determine OBC and OFC. The characteristics of Mix are generally improved by adding
0.3 percent fibre. SMA with sisal fibre produces extremely good results and can be utilised in flexible pavement, according to several tests such as drain down test, indirect tensile strength, and static creep test.

Future Perspectives

This experiment looked at a variety of properties of SMA and BC mixes, including Marshall properties, drain down characteristics, and tensile strength characteristics. In this study, only 60/70 penetration grade bitumen and a modified natural fibre called sisal fibre were used. However, some of the qualities can be explored further, such as fatigue properties, moisture susceptibility characteristics, rutting resistance, and dynamic creep behaviour. Other synthetic and natural fibres, as well as other types of binder, can be compared in blends. Because the sisal fibre utilised in this study is a low-cost material, a

Cost-benefit analysis can be performed to determine its impact on construction costs.Experimental stretches may also be used to ensure the success of this new material.

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