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INVESTIGATION OF MODIFIED BITUMEN USING ASBESTOS FIBER IN DENSE BITUMINOUS MACADAM

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ABSTRACT

Research has been devoted to modify the properties of bitumen and improve the performance of the flexible pavements. Use of different fibers in mixtures is known as beneficial HMA (hot mix asphalt) modifier. Although applying these modifiers increases the initial cost, they may increase pavement resistance for rutting therefore, postpone the rehabilitations and decrease maintenance cost.

Due to Increasing in traffic condition , Overloading of commercial vehicle and significant variations in daily and seasonal temperatures have shown some disadvantages of conventional bitumen performance. With the help of additives is one of the factor to improve performance of Flexible Pavements. ASBESTOS Fibers have been use to improve the performance of asphalt mixtures against permanent deformation and fatigue cracking because of their inherent compatibility with asphalt cement and excellent mechanical properties.

Bitumen is available in different types and grades. For classifying bitumen and studying the performance Dense Bituminous Macadam (DBM) ,Penetration and ductility tests are essential. The other tests like softening point, flash and fire point test are more important to guide the paving technologists during field investigations.

In the present investigation ,an attempt has been made to study the effects of use of mineral fiber called Asbestos fiber as an additive in Dense Bituminous Macadam (DBM) mix. An experimental study should carry out on conventional bitumen and fibers modified binder using Marshall procedure , Optimum Fiber Content(OFC) and Optimum Binder Content (OBC) for DBM are to be found respectively.

The modified bitumen at different percentages i.e 0.5% to 2.5% are subjected to different performance.

Keyword: Dense Bituminous Macadam (DBM), Asbestos Fiber, ,Marshall Properties, Optimum Fiber Content (0PC), Optimum Binder Content(0BC).

I.INTRODUCTION

Aggregates bound with bitumen are conventionally used all over the world in construction and maintenance of flexible pavements. The close, well, uniform, or dense graded aggregates bound with normal bitumen normally perform well in heavily trafficked roads if designed and executed properly . However, it is not always possible to arrange dense graded aggregates available at the site. In such situations , Bituminous mix with different fiber can be attempted. Due to High number of vehicles imposing repetitive axle loads on roads can occur undesirable effects to environment condition and construction methods. These usually cause permanent deformation (rutting), fatigue and low temperature cracking, service life of the road pavement is going to be decreased. Fatigue and Rutting are the most common distresses in road pavement which result in the shortening of pavement life and increase maintenance cost as well as road user cost. So, it is necessary to find out ways to decreasing the asphalt pavement deterioration and increasing longevity of pavement . Various research have been conducted to improve road pavement characteristics which can provide convenient ride , ensure greater durability and longer service life against climate changes and traffic loading.

A proper execution and design of bituminous mix makes the results in a mix which is adequately strong,durable, improves skid resistance, resistive to fatigue and permanent deformation ,reduce permeability, environment friendly and economical etc.

Based on the structural behaviour, Pavements are generally classified into two categories of Flexible pavements and Rigid pavements. Flexible pavements are so named because the total pavement structure deflects, or flexes, under loading. A flexible pavement structure gets undulated due to undulation of lower layer of pavement. Each layers transmit the loads to the lower layer by grain to grain transfer through the point of contact in the granular structure. The lower layers have lesser magnitudes of stress due to

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traffic loads.The well compacted granular structure forms a good flexible pavement.

1.1 TYPES OF FLEXIBLE PAVEMENT

The following types of construction have been used in flexible pavement:
• Conventional layered flexible pavement,
• Full - depth asphalt pavement, and
• Contained rock asphalt mat (CRAM).

Conventional flexible pavements are layered systems with high quality expensive materials are placed in the top where stresses are high, and low quality cheap materials are placed in lower layers.

Full - depth asphalt pavements are constructed by placing bituminous layers directly on the soil subgrade. This is more suitable when there is high traffic and local materials are not available.

Contained rock asphalt mats are constructed by placing dense/open graded aggregate layers in between two asphalt layers. Modified dense graded asphalt concrete is placed above the sub-grade will significantly reduce the vertical compressive strain on soil sub-grade and protect from surface water.

TYPICAL LAYER OF FLEXIBLE PAVEMENT

A flexiblePavement structure consisting of four components :

- **Soil Sub-grade** . The layer provides the adequate support to the pavement from bebeath under adverse climate and loading conditions.It is the lowest layers of the prepared surface consisting of the local soil itself.It should be atleast 50cm layers under controlled conditions of optimum moisture content and maximum dry density. It is essential that at no time soil sub-grade is overstressed. It should be compacted to the desirable density, near the optimum moisture content.
- **Sub-base course**. This is the layer of stabilized soil or selected granular soil under the base layer. Smaller size of boulder stones or bricks are also used as a sub-base in some places. A sub-base course is not always needed or used when a pavement constructed over a high quality, stiff sub-grade may not need the additional features offered by a sub-base course. In such situations, sub-base course may not be provided.
- **Base course**. This is the layer directly below the surface layer and generally consists of aggregate (either stabilized or unstabilized) to prevent intrusion of sub-grade soils into the surface. it provides additional load distribution and contributes to the sub-surface drainage.
- **Surface course**: This is the top layer and to resist the abrasive traffic load. It may be composed of one or several different HMA sub layers. HMA is a Mixture of course and fine aggregates and asphalt binder. It provides smooth riding surface. It provides characteristics such as friction, smoothness, drainage, etc. it will prevent the entrance of excessive quantities of surface water into the underlying base, sub-base and sub-grade, It should be tough to resist the distortion under traffic and provide a smooth and skid- resistant riding surface, and also must be water proof to protect the entire base and sub-grade from the weakening effect of water.

1.2 SELECTION OF BINDER

Many researchers have used different types of binders such as conventional 60/70 penetration grade bitumen and many modified binders such as Polymer Modified Binder (PMB), Crumb Rubber Modified Binder (CRMB), Natural Rubber Modified Binder (NRMB) etc. in HMA mixes. Superpave performance grade binder such as PG 76 -22 has also been used by some investigators. Reddy et al. (2006) have reported that use of CRMB in the bituminous mixes significantly improves fatigue life, temperature susceptibility and resistance to moisture damage characteristics compared to other unmodified mixes. Considering this fact, an attempt has been made in this investigation to study the HMA mixes made with locally available coarse aggregates, commonly used binders such as 60/70 penetration grade bitumen and CRMB 60. An attempt has been made in this investigation to use a commonly used binder, i.e. 60/70 bitumen in HMA mixes, mainly with the objective of exploring the scope of using the same in presence of fibers.

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Fig:1 Represent Selecting Binder

1.3 SELECTION OF STABILIZING ADDITIVE

Different stabilizing additive like fibre such as mineral fibres, natural fibres and synthetic fibres etc., many polymer, plastic, waste material such as carpet fibre, tires, polyester fibre are added to bituminous mix mainly with Hot Mix Asphalt to prevent excessive draindown of binder and to provide resistance to deformation and longevity of the pavement condition. Mineral fibre like Carbon fibre and Basalt fibre are also used by many researchers. Here an attempt has been made in this research work to utilise a mineral available fibre called ASBESTOS FIBRE in bituminous mixture both in Dense Bituminous Macadam (DBM) as well as Hot Mix Asphalt(HMA).

1.4 BITUMINOUS MIX DESIGN

The purpose of this study is improving workability and performance of the hot mix asphalt (HMA). Bituminous concrete consists of a mixture of aggregates which graded from maximum size, typically less than 25mm, through the fine filler that is smaller than 0.075mm. Sufficient bitumen is added to the mix so that the compacted mix is effectively impervious and will have acceptable dissipative and elastic properties. The bituminous mix design involves to determine the properties of bitumen, filler, fine aggregates and course aggregates to produce a proper proportion mix which is workable, strong, durable and economical. The objective of the mix design is to produce cost effective blend and gradation of a bituminous mix by proportioning various materials so as to have:

1. Sufficient bitumen to ensure a durable flexible pavement
2. Sufficient mix stability to satisfy the traffic demand without deformation
3. Sufficient air voids in the compacted bitumen to allow for additional compaction under traffic loads.
4. Sufficient workability while placing and compacting the mix without segregation
5. Sufficient resistance to avoid premature cracking due to repeated bending by traffic
6. Sufficient skid resistance to prevent shrinkage cracks under unfavourable condition.

1.5 OBJECTIVES OF THE PRESENT STUDY

In this research, we are concentrating about the quantity of Asbestos fiber that is added to the bituminous mix and which will give the optimum fiber content and as an outcome expecting an increase in strength. Dense bituminous concrete mix is used in our investigation. Fiber content varies between (0.5% - 2.5%). VG 30 bitumen is used as binder in the present study.

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

Study on Marshall Properties of DBM mixes using hydrated lime as filler with different percentages of Bitumen content to determine optimum Bitumen content.

Study on Marshall properties of DBM mixes with different percentages of Asbestos fiber to determine Optimum Fiber Content

II. REVIEW OF LITERATURE

A detailed literature review made on works related to HMA mixes is described in the following paragraphs. Majority of the roads all over the world are made up of flexible pavements. Flexible pavements consist of a bituminous layer on the surface course and sometimes in base course followed by granular layers in base and sub base courses over the subgrade. Asphalt concrete is a composite material commonly used in construction projects such as road surfaces, airports and parking lots. It consists of asphalt (used as a binder) and mineral aggregate mixed together, then are laid down in layers and compacted. Asphalt Concrete Pavement or Hot Mix Asphalt pavement are the bound layers of a flexible pavement structure at the surface course. The most common type of flexible pavement surfacing used in India is a premix bituminous material, commonly called outside as Hot Mix Asphalt (HMA). HMA is a mixture of coarse and fine aggregates and asphalt binder. HMA, as the name suggests, is mixed, placed and compacted at higher temperature. HMA is typically applied in layers, with the lower layers supporting the top layer, which is known as surface course or friction course. The aggregates used in the lower layer are to prevent rutting and the aggregates which are used in the top layer are generally selected on the basis of their friction properties and durability. There are several types of HMA mixes. These include conventional Dense Graded Mixes (DGM) , Gap graded and various Open graded HMA. The HMA mixes differ from each other mainly in maximum aggregate size, aggregate gradation and binder content or type of binder used.

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Figures 2.1 and Fig 2.2 show pictures of typical dense graded HMA and Dense Graded Core Sample.

Fig. 2 Dense graded HMA surface

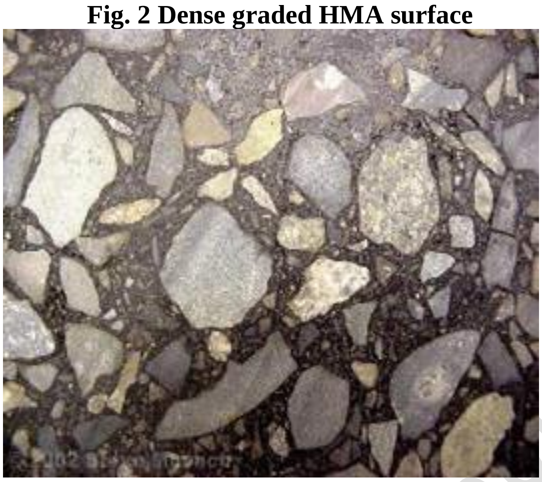

Fig. 3 Dense graded core

The surface course in flexible pavements consists of aggregates in large volume with a suitable grading bound by a small quantity of bitumen. A dense graded HMA mix is a well – graded one which is normally used for heavily trafficked roads in the surface course.

III. EXPERIMENTAL INVESTIGATION

3.1 TESTS ON MATERIALS USED

Tests on Aggregates

For preparation of Bituminous mixes (DBM,BC, SMA) aggregates as per MORTH grading as given in Table 3.1 and Table 3.2 respectively, a particular type of binder and fibre in required quantities were mixes as per Marshall Procedure.

Fig4:Represent collected the required materials

Sieve size,mm	% passing
26.5	100
19.5	95
9.5	70
4.75	50
2.36	35
0.30	12
0.075	5

Table 1 : Adopted aggregate gradation for DBM(MORTH)

3.2 Coarse Aggregates

Coarse aggregates consisted of stone chips collected from a local source, up to 4.75 mm IS sieve size. Its specific gravity was found as 2.75. Standard tests were conducted to determine their physical properties as summarized in Table 3.2

Property	TestResult
Aggregate Impact Value (%)	14.3
Aggregate Crushing Value (%)	13.02
Los Angels Abrasion Value (%)	18
Flakiness Index (%)	18.83
Elongation Index (%)	21.5
Water Absorption (%)	0.1

Table 2 Physical Properties of Coarse aggregate

3.2.1. Fine Aggregates

Fine aggregates, consisting of stone crusher dusts were collected from a local crusher with fractions passing 4.75 mm and retained on 0.075 mm IS sieve. Its specific gravity was found as 2.6.

3.2.2 Filler

Aggregate passing through 0.075 mm IS sieve is called as filler. Here hydrated lime filler used as filler whose specific gravity are 3.0.

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. **3.2.3 Binder**

Here 60/70 penetration grade bitumen is used as binder for preparation of Mix, whose specific gravity was 1.01. It's important property is given in table 3.3 .For testing the binder quality ,we have checked by the following two test:

Penetration Test:

Penetration value is a measure of hardness or consistency of bituminous material. It is the vertical distance traversed or penetrated by the point of a standard needle in to the bituminous material under specific conditions of load, time and temperature. This distance is measured in one tenths of a millimetre. This test is used for evaluating consistency of bitumen. It is not regarded as suitable for use in connection with the testing of road tar because of the high surface tension exhibited by these materials.

Softening Point Test:

The Softening Point of bitumen or tar is the temperature at which the substance attains particular degree of softening. As per IS: 334-1982, it is the temperature in ºC at which a standard ball passes through a sample of bitumen in a mould and falls through a height of 2.5 cm, when heated under water or glycerin at specified conditions of test. The binder should have sufficient fluidity before its applications in road uses. The determination of softening point helps to know the temperature up to which a bituminous binder should be heated for various road use applications. Softening point is determined by ring and ball apparatus.

Property	**Value**
Pentration at 25ºC (mm)	67.7
Softening point(ºC)	48.5
Specific gravity	1.03

Table 3 Properties of Binder

3.2.4 Fibre

Here Asbestos fibre is used as additive whose length is about several millimetre,10 cm or above. and diameter variedfrom 0.3 to 0.6 mm. The sisal fibres were cleaned and cut in to small pieces of 10-12 mm in length to ensure proper mixing with the aggregates and binder during the process of mixing

3.2.5 SPECIFIC GRAVITY AND WATER ABSORPTION TESTS

These two tests are conducted

i. To measure the strength or quality of the material
ii. To determine the water absorption of aggregates

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material, Stones having low specific gravity are generally weaker than those with higher specific gravity values.

The size of the aggregate and whether it has been artificially heated should be indicated. ISI specifies three methods of testing for the determination of the specific gravity of aggregates, according to the size of the aggregates. The three size ranges used are aggregates larger than 10 mm, 40 mm and smaller than 10 mm.

The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0 with an average of about 2.68. Though high specific gravity is considered as an indication of high strength, It is not possible to judge the suitability of a sample road aggregate without finding the mechanical properties such as aggregate crushing, impact and abrasion values. Water absorption shall not be more than 0.6 per unit by weight

3.3 PREPARATION OF MIXES

There are three principal bituminous mix design methods in general use. They are Marshall Method , Hveem Method and Super pave Method. Marshall mix design is the widely used method throughout India. In this method load is applied to a cylindrical specimen of bituminous mix and the sample is monitored till its failure as specified in the ASTM standard (ASTM D1559). For the present work, the bituminous mix is designed using the Marshall method and arrived at the volumetric properties.

The mixes were prepared according to the Marshall procedure specified in ASTM D1559. The coarse aggregates,fine aggregates were mixed according to the adopted gradations as explain in blinding. The binder as already stated were used in different proportions in the mixes starting from 3% to 5% with an increment of 0.5% of the total mix to obtain the optimum binder requirement and different fiber contents 0.5% to 2.5% with interval of 0.5% to obtain the optimum fiber content. The mineral aggregates and modified binders were heated separately to the prescribed mixing temperature. The temperature of the mineral aggregates was maintained at a temperature 10°C higher than the temperature of the binder. Required quantity of binder was added to the pre heated aggregate-fiber mixture and thorough mixing was

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done manually till the color and consistency of the mixture appeared to be uniform. The mixing time was maintained within 2-5 minutes. The mixture was then poured in to pre-heat Marshall moulds and the samples were prepared using a compactive effort of 75 blows on each side. The specimens were kept overnight for cooling to room temperature. Then the samples were extracted and tested at 60 C according to the standard testing procedure.

Fig 5 Represents preparation of Marshall Mix

3.3.1 Aggregate Blending

Aggregate gradation is the distribution of particle size as percent of the total weigh. Aggregate gradation is one of the most important properties of an aggregate. It affects almost all the important properties of bituminous mix including, stability, durability, stiffness, permeability, workability, fatigue resistance, skid resistance and resistance to moisture damage. Therefore, gradation is a primary consideration in bituminous mix design. Specifications used by most agencies place limits on aggregate gradations that can be used in bituminous mix . Theoretically, it seems reasonable that the best gradation for bituminous mix is the one that gives the densest particle packing. The gradation having maximum density provides increased stability through inters particle contacts and reduced voids in the mineral aggregates. However, there must be sufficient air void space to permit enough bitumen to be penetrated to ensure durability, while still leaving some air space in the mixture to allow secondary compaction and to avoid bleeding, rutting etc.

3.3.2 Job Mix Formula (JMF)

The steps of the evaluation of an appropriate job mix formula (JMF) are as follows:

1) In accordance with the IRC (requirements for pavement) and with respect to its experiences with former JMFs, mixing, paving and selects the aggregates and the filler, with the selected material (aggregates, filler, additives) and on the basis of the feedback from other sites and JMFs, a tentative gradation is chosen.

2) Mixes with the required minimum asphalt content and with three adjacent asphalt contents are prepared.

3) Marshall specimen are prepared at 135/145 of 5°C and by 50 blows on each side the Marshall tests are running for the evaluation of the air void content which must be 4% by volume. If the required air void content is not achieved, the following alterations of the tentative mix within the enforceable limits of the specifications are recommended:
   - Change content of single sizes of aggregates
   - Change filler content

It has to be emphasized that the marshall stability and flow are not an adequate basis for the right choice and evaluation of HMA Job Mix Formula. On the basis of the mix design results, the JMF will take.

Aggregate Blending for Dense Bituminous Macadam [Hot Bin] (Spec. Limits As per MORT & H, Table-500-10, Grading-2)									
Aggregate Size(mm)	Description	% Passing I.S Sieve							
	I.S Sieve Size(mm)	37.5	26.5	19	13.2	4.75	2.36	0.3	0.075
Bin-4(40-20mm)	Individual Gradation	100	46.00	0.31	0.12	0	0	0	0
Bin-3(20-10)		100	100	78	29.03	0.83	0.61	0.47	0.35
Bin-2(10-4.75mm)		100	100	100	100	5.18	1.08	0.67	1
Bin-1(4.75-0mm)		100	100	100	100	95	72.35	20.10	6.00
Filler(Lime)		100	100	100	100	100	100	100	90
	% Feed								
Bin-4(40-20mm)	8	8	3.68	0.02	0	0	0	0	0
Bin-3(20-10mm)	21	21	21	16.34	6.10	0.17	0	0	0
Bin-2(10-4.75mm)	28	28	28	28	28	1.45	0	0	0
Bin-1(4.75-0mm)	42	42	42	42	42	39.90	30.39	8.44	2.52
Filler(Lime)	1	1	1	1	1	1	1	1	0.90
Combined Grading(JMF)		100	95.68	87.36	77.11	42.52	31.82	9.73	3.63
Spec.Upper Limits		100	100	95	80	54	42	21	8
Spec.Lower Limits		100	90	71	56	38	28	7	2
Mid Limits		100	95	83	68	46	35	14	5
Permissible variation by Et.of total mix in %age		±8	±8	±8	±7	±6	±5	±4	±2
JMF Upper Limit		100	100	95	84	49	37	14	6
JMF Lower Limit		100	90	79	70	38	28	7	2

Table 4 Adopted aggregate Gradation of DBM

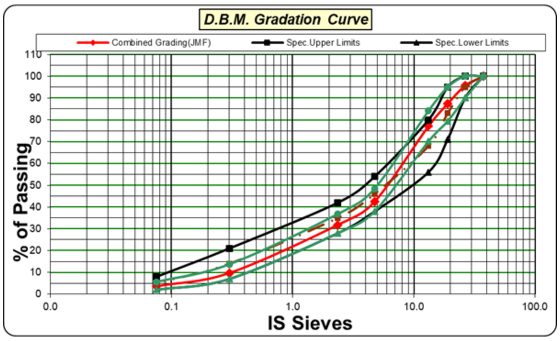

Fig 6 DBM Gradation Curve

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Fig7 Represent some Marshall Moulds Using Asbestos Fiber content

3.4 TESTS ON MIXES

Presented below are the different tests conducted on the bituminous mixes with variations of fiber concentration in the mix.

3.4.1 Marshall Test

Marshall Mix design is a standard laboratory method, which is adopted worldwide for determining and reporting the strength and flow characteristics of bituminous paving mixes. In India, it is a very popular method of characterization of bituminous mixes. This test has also been used by many researchers to test bituminous mixes. This test method is widely accepted because of its simplicity and low of cost. Considering various advantages of the Marshall method it was decided to use this method to determine the Optimum BinderContent (OBC) of the mixes and also study various Marshall Characteristics such as Marshall Stability, flow value, unit weight, air voids etc. The Marshall properties such as stability, flow value, unit weight and air voids were studied to obtain the optimum binder contents (OBC) and optimum fiber contents (OFC).

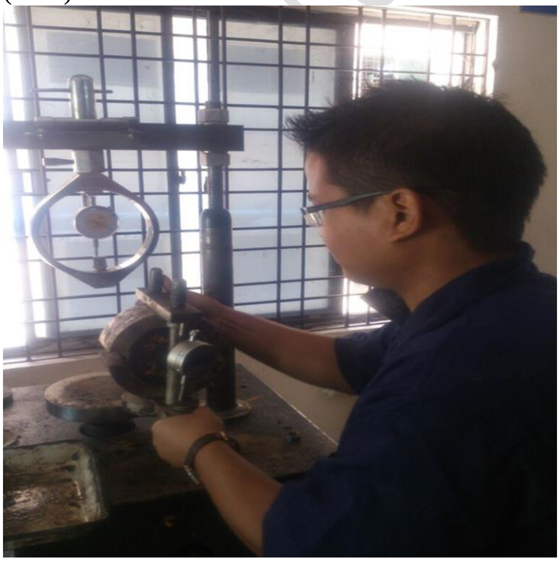

Fig 8 :Represent testing the stability test

In the Marshall Test method of mix design three compacted samples are prepared for each binder content. All the compacted specimens are subject to the following tests:

- Bulk Density Determination
- Stability and Flow Test

3.4.2 Density and Voids Analysis

The aggregates are heated to a temperature of 165°C to 175°C the compaction mould assembly and rammer are cleaned and kept pre-heated to a temperature of 90°C to 145°C . The bitumen is heated to a temperature of 121°C to 138°C and the required amount of first trial of bitumen is added to the heated aggregate and thoroughly mixed. The mix is placed in a mould and compacted with 75 blows. The sample is taken out of the mould after 24 hours using sample extractor. The bulk density of the sample is usually determined by weighting the sample in air and in water. It may be necessary to coat samples with paraffin before determining density. In conducting the stability test, the specimen is immersed in a bath of water at a temperature of 60°C for a period of 30 minutes. It is then placed in the Marshall Stability testing machine and loaded at a constant rate of deformation of 5 mm per minute until failure. The total maximum in kg (that cause failure of the specimen) is taken as marshall stability. The stability value so obtained is corrected for volume. The total amount of deformation is units of 0.25 mm that occurs at maximum load is recorded as flow value. The total time between removing the specimen from the bath and completion of the test should not exceed 30 seconds.After the completion of the stability and flow test,a density and voids analysis is made for each series of test specimens.

a) Average the bulk specific gravity values for all test specimens of a given asphalt content; values obviously in error shall not be included in the average. These values of bulk specific gravity shall be used in further computations of voids data.

b) Determine the average unit weight for each asphalt content by multiplying the average bulk specific gravity value by density of water (1,000 kg/m3 or 62.4 pcf)

c) Determine the theoretical maximum specific gravity (ASTM D2041) for at least two asphalt contents, preferably on mixes at or near the design asphalt content. An average value for the effective specific gravity of the total aggregate is then calculated from these values. This value may then be used for calculation of miximum specific gravity of mixtures with different asphalt contents, as discusses.

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d) Using the effective and bulk specific gravity of the total aggregate, the average bulk specific gravities of the compacted mix, the specified gravity of theasphalt and the maximum specific gravity of the mix determined above in (c), calculate the percent absorbed asphalt by weight pf dry aggregate, percentage air voids (Va), percent voids filled with asphalt (VFA) and percent voids in mineral aggregate (VMA). These values and calculations are more fully described in MS2

This study compared the difference in air voids, voids in mineral aggregate (VMA), and Voids in coarse aggregate. The critical air voids level at which stone matrix asphalt mixtures are considered to become permeable was also determined for the gradations used in this study. Before mix properties are discussed in detail, the Technician is required to understand that paving mix properties are more effected by volume and not weight; however, production and testing of asphalt mixture is by weight. Much of what determines long term pavement performance of the asphalt mixture, such as Air Voids, VMA and VCA are based on volume not weight.

Specific Gravity

The density of the compacted mix is the unit weight of the mixture (the weight of a specific volume of asphalt mixture). Density is important because proper density in the finished product is essential for lasting pavement performance. Mix properties are required to be measured in volumetric terms as well as weight. Density allows us to convert from units of weight to volume. There were two types of specific gravity:

1. Bulk Specific Gravity of Compacted Mixture (Gmb)
2. Theoretical Maximum Specific Gravity (Gmm)

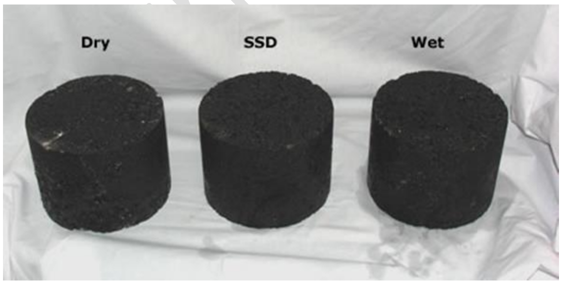

Fig 9 Represents samples for specific gravity of mix

Fig 10 Represents Rice Apparatus for testing maximum specific gravity

IV. ANALYSIS RESULTS AND DISCUSSION

4.1 Introduction

In this chapter Result and Observation of test carried out in previous chapter is presented, analysed and discuss. This chapter is divided into five sections, first section deals with analysis of aggregate properties. Second section deal with rheological properties. . Third section deals with parameters used for analysis. Fourth section deals with calculation of Optimum Binder Content (OBC) and Optimum Fiber Content (OFC).

4.2 Aggregate Properties

.Particle shape, strength tests, specific gravity and water absorption tests have been conducted and data is as follows:

Si. No	Property	Name of the test	Test results	Specification limit (MORTH &H)	Test method
1	Particle shape	Combined flakiness & elongation indices of aggregate	21.75 %	Max. 35%	Is:2386 part -1
2	Strength	Aggregate impact value	21.4 %	Max.27%	Is:2386 part -4

Table 5 Physical Properties of Coarse aggregate

Specific Gravity of Aggregates

SIZE	BULK SP.Gravity (G sb)	Apparent Specific gravity (G sa)	Water Absorption(%)
40MM	2.656	2.664	0.1
20MM	2.654	2.661	0.1
10MM	2.656	2.663	0.1

Table 6 Specific Gravity of Aggregates

4.3 Rheological Properties

4.3.1 Common laboratory tests like penetration test and softening point test are performed on plain bitumen VG30 and the results are tabulated as below:

Test	Reading
Penetration	49mm
Softening	53ºC

Table 7 Properties of Binder

4.4 Volumetric Properties

Fundamentally, mix design is meant to determine the volume of bitumen binder and aggregates necessary to produce a mixture with the desired properties. Since weight measurements are typically much easier, weights are taken and then converted to volume by using specific gravities. The following is a discussion of the important volumetric properties of bituminous mixtures. The properties that are to be considered, include the theoretical maximum specific gravity Gmm, the bulk specific gravity of the mix Gmb, percentage air voids VA, percentage volume of bitumen Vb, percentage void in mineral aggregate VMA and percentage voids filled with bitumen VFB.

V. CONCLUSION

The following conclusions were drawn from the above results obtained from tests conducted on Dense Bituminous Macadam Mix. This study looked at the effect of bitumen content and amount of fiber to it.

Marshall Properties

Marshall Stability

It is observed that with increase in binder content the Marshall Stability value increase upto certain binder content value and the decrease, like conventional bituminous mixes. Highest stability value achieved at 1% of fiber modified bituminous mix.

1) Flow Value

The value of flow increase with increasing in fiber content, to bitumen content of 4.5%. The maximum flow value obtained ate 2.5% of fiber content.

2) Unit Weight

The unit weight increase with the increase in binder content upto a certain binder content and their after decrease. The maximum unit weight is for 2% of fiber modified bituminous mix.

3) Air Voids

The amount of air voids decrease with increase in binder content in the mix. It also increase or decrease depending on the fiber content in the mix. The mix is observed to have the lowest air voids content in the higher fiber mix. Highest air voids have obtained at 2.5% of fiber modified mix.

4) OPTIMUM BITUMEN CONTENT

The optimum bitumen content (OBC) of DBM mix based on the Marshall Test results since, all Marshall Parameters are satisfy the requirement of MORTH specification, and the optimum binder content is fixed as 4.5%.

5) OPTIMUM FIBER CONTENT

The optimum fiber content is based on the Marshall stability test itself which gives the 1% of Kevlar modified bituminous mix gives the highest stability strength.

OPTIMUM BITUMEN CONTENT

The Optimum Bitumen Content (OBC) of DBM mix based on the marshal Test results since, all Marshall Parameters are satisfying the requirement of MORTH specifications, the Optimum Binder Content is fixed as 4.5%

OPTIMUM FIBER CONTENT

From Marshall Properties it is seen that, 4% of Air voids is obtained at 1.5% Asbestos fiber content and the stability is also maximum at this percentage

From the above conclusion on i.e DSR and Marshall Properties it was observed that 1.5%

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Asbestos fiber is the optimum fiber content which gives better results.

5.1 Future Scope

Many properties of DBM mix such as Marshall Properties, have been studied in this investigation.

1. Only VG 30 Viscosity grade bitumen is used, some other grades of bitumen like VG 20 VG 40 can be further investigated
2. Further research can be done on Dense Bituminous Macadam (DBM) and other wearing courses with other grades.
3. Asbestos fiber as modifier can be done for Stone Matrix Asphalt etc
4. Some of the properties such as fatigue properties, moisture susceptibility characteristics, resistance to rutting can be further investigated.
5. Some other synthetic and natural fibers can be investigated and compared.
6. Fillers like cement, Fly ash and other industrial wastes also can be investigated
7. Asbestos fibers used in this study is a low cost material; therefore a cost-benefit analysis can be made to know its effect on cost of construction.
8. Other properties of DBM mix such as Dynamic Shear Rheometer characteristics, Creep characteristics can be investigated.

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