"EXPERIMENTAL INVESTIGATION ON WASTE PLASTIC ADDED ASPHALT MIX INCLUSION OF BAMBOO FIBER TO RISE PROPERTY AND RUTTING FREE SURFACE"

Rahul Kumar

(R18ET2SE0023)

Under Supervision of

Prof. Kapil Soni

DEPARTMENT OF CIVIL ENGINEERING

UNIVERSITY INSTITUTE OF TECHNOLOGY

RABINDRANATH TAGORE UNIVERSITY

ABSTRACT

Pavements play an influential role in economic development of any country it provides effective assistance in transportation, Majority of transportation system is possible due to Pavements. These Pavements are basically two types **Rigid** and **Flexible**, Rigid Pavements includes the batching of Cement Concrete and Flexible Pavement consists of Bituminous with different sizes of aggregate. In addition of **Waste Plastic** with different **Natural** and **Synthetic fibers** to enhances Marshall Properties of pavements.

In present analysis experimental analysis was performed on flexible pavements to determine temperature distribution with respect to time, in our study an experimental investigation was performed on flexible pavements with different percentage of Waste Plastic with Admixtures like **Coir fiber**, **Bamboo Fiber** & **Nylon Fiber**. Waste plastic and each Fiber are combined in ratio of 10:0, 9:1, 8:2, 7:3 & 6:4 respectively and adding 8% of Optimum Binder Content in flexible pavement mix. This Modified flexible pavement improvement in marshal Properties to resist ambient conditions in each climatic zones, Rutting Free Surfaces and No appearance of Wheel path also bonding Properties better than Conventional flexible pavement mix. In my experimental investigation found that waste plastic & Bamboo fibers adding in ratio of **7:3** respectively then obtain much better results to others Combination of mix.

Keywords – Flexible Pavement Construction, Bitumen, Coir Fiber, Bamboo Fiber, Nylon Fiber and Waste Plastic.

CHAPTER – I

INTRODUCTION

1.1 GENERAL

Bituminous binders are broadly utilized by paving industry. A pavement has one-of-a-kind layers. The primary parts of Bituminous concrete (BC) is mixing of bitumen. Typically, all the difficult surfaced pavement types are categorized into two agencies, i.e. Flexible and Inflexible (Rigid).

i. **Flexible Pavement:-** If the floor course of a pavement is bitumen then its miles known as "Bituminous" seeing that the full pavement shape can bend or deflect because of site visitors loads. This Pavement having quality that Load Transfer to top layer to bottom layer.

ii. **Rigid Pavement:-** If the floor course of a pavement is Cementitious then its miles referred to as "Rigid" seeing that the whole pavement structure can't bend or deflect due to site visitors loads. Such pavements are much stiffer than the bendy pavements due to the excessive modulus of elasticity of the plain Cement Concrete cloth. Importantly, we will use reinforcing metallic in the inflexible pavements, to lower or do away with the joints. This Pavement having quality that Load carrying on top layer not transferring to other layers.

1.2 TYPE OF MIX

- **Hot Mix asphalt concrete**
- **Warm Mix asphalt concrete**
- **Cold Mix asphalt concrete**
- **Cut-back asphalt concrete**
- **Mastic asphalt concrete or sheet asphalt**

Waste plastic is a situation Plastics are long lasting & non-biodegradable, the chemical bonds make plastic very durable & proof against ordinary herbal approaches of deterioration. When you consider that 1950s, around a thousand million tons of plastic had been discarded, and they will persist for masses or even, heaps of years. The plastic receives combined with water, doesn't fall apart, and takes the shape of small pallets which causes the dying of fishes and lots of other aquatic animals who mistake them as meals substances. Nowadays the provision of the plastic wastes is massive, because the plastic substances have emerge as the element and parcel, of our daily lifestyles has results increase of quantum of plastic waste in India, this is the Serious problem for our Environment. We have one solution to use this Plastic by recycle

Process or others way. One way to use this some Bitumen replaced by Waste plastic in bituminous layer and got one more advantages that saving of natural Bitumen which is distilled by Petroleum sources.

1.3 ROLE OF PLASTIC OR POLYMER IN PAVEMENT

Amendment of BC, with the synthetic polymer binder may be considered as a solution to overcome the troubles, bobbing up due to the speedy boom in wheel masses and alternate in climatic conditions. Polymer change can be taken into consideration as one in every of the solution to improvise the fatigue life; lessen the rutting & thermal cracking inside the pavement. Asphalt mix when blended or blended with the polymer, forms a multiphase system, containing plentiful asphaltness which are not absorbed through the polymer. This will increase the viscosity of the mix by way of the formation of an extra internal complicated structure.





Fig.1(a)-Example of Bituminous Pavements **Fig.1(b)-Paving of Bituminous Pavement**

1.4 IMPORTANT ISSUES

A visitor continues on growing, even as the prices of substances and techniques preserve on mountain climbing, as budgets dwindle anywhere. The only way to preserve up and still have precise roads is through studying and the usage of accurate standards, enforcing proven new thoughts and era, and continually reading for better materials and techniques.

Consequently, this could be summarized as follows:

Drainage is wanted to drain water far away from the pavement.

- The substances must be evaluated and decided on well so we will resist the effects of the site visitors and the surroundings.
- The combo wants to be designed nicely such that it can face up to net website visitors and environmental elements.

- The form ought to be designed nicely such that it has suitable enough thickness to face as a lot as excessive deformation below traffic and under incredible environmental situations.
- The pavement ought to be constructed properly such that it has proper tendencies.
- The pavement need to be maintained/controlled well through periodic artwork, normal attempting out, and well timed rehabilitation.

Generation of expertise through studies is crucial for ensuring awesome pavements in the destiny. A pavement's primary cause is to provide a realistic surface for a particular transportation need. The easy function is to stand as much as load underneath first rate seasonal environmental situations, without deforming or cracking, at the same time as you remember that both of these misery situations would lessen the capability of the pavement. The feature of the specific layers inside the pavement is to spread out the weight on the ground and decrease its depth with depth, such that the pressure at the sub-grade is a whole lot lots a great deal much less than the pressure at the floor and can be tolerated by using the sub-grade without gift system immoderate deformation.

1.5 FUNCTIONAL REQUIREMENTS

A pavement which encompasses asphalt with Granular and soil layers most effective is known as a bendy pavement, for the purpose that pavement layers deflect below a website visitors load. The everyday implemented concept of a flexible (asphalt) pavement is that a layered form with higher materials close to the pinnacle may also distribute the weight in this kind of way that the ensuing stress inside the bottom maximum layer can be small sufficient that allows you to cause no huge deformation of the layer. The bottom most layer is the existing layer or the winning layer changed with a few substances. The materials and the thicknesses of the precise layers can be together with that permits you to stand as much as the specific consequences of temperature and moisture due to changes in season mainly region. The Sub-base, in addition to presenting structural help, can also characteristic a platform for constructing the lowest and save you the nice substances from the sub-grade from contaminating the bottom layer. If the sub-grade is of frost-susceptible fabric, then the sub-base can be product of non-frost inclined materials to prevent frost-associated harm.

Inflexible (or concrete) pavements, which deflect very little underneath visitors masses, behave in every other manner than flexible pavements below hundreds. The carrying layer, it virtually is in contact with the website visitors, is a cement concrete slab that ranges in thickness among 5 and 12 inch.

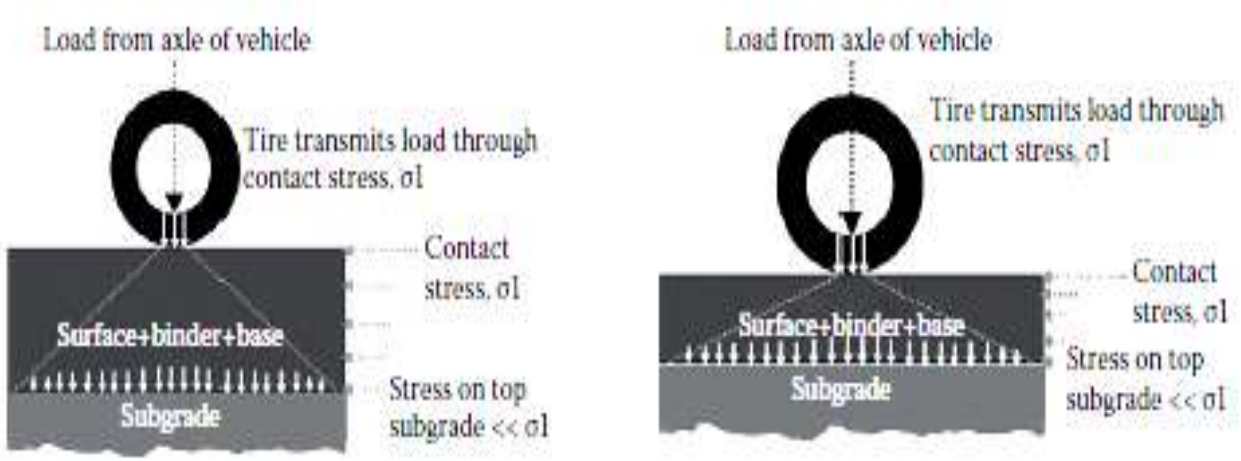


Fig.2 - Function of the pavement is to decrease the tire contact stress on the sub-grade

CHAPTER 2

LITERATURE REVIEW

2.1 SURVEY OF PREVIOUS RESEARCH WORK

DoniaSavio et al. [1] 2016 - In this paper, using a comprehensive net web site visitors and axle load facts and the use of sturdy cloth homes, the distresses of an real-existence pavement have been quantified. A place along NH-13 which had the maximum overloading changed into determined on for the analysis. The stress-strain evaluation modified into finished for an ordeal section using the general overall performance conditions specified in IRC: 37-2012. The actual time traffic information and climatic conditions touching on this vicinity have been used for the format..

Peng Bo et al. [2] 2017 - This paper determines the strength conservation and emission reduction combining scheme, carbon emissions can be reduced via greater than 30% with the beneficial resource of enforcing the plan to trade the combination and bituminous heating power. The research outcomes will provide a reference route and a theoretical foundation for the research of strength-saving and emission cut price technology for bituminous pavement advent.

Angela Farina et al. [3] 2016 - Focuses on existence Cycle evaluation (LCA) of diverse sorts of avenue paving era based on the use of bituminous combinations containing recycled substances which includes crumb rubber from cease-of-existence tires and reclaimed asphalt pavement. Analyses had been achieved thru thinking about great scenarios which stem from the combination of producing, manufacturing and protection operations, and by using manner of way of comparing them with a reference case related to use of desired paving materials.

Adrian Nosetti et al. [4] 2018 - Investigated in increasing the amount of recycled fabric utilized in asphalt mixes due to the beneficial impact on the surroundings. This is primary to the development of various recycling techniques, from cold in-situ to warm in-plant recycling. The cause of the have a look at supplied on this paper is to evaluate cracking resistance of recycled mixes artificial through 3 types of strategies, i.e., cold with emulsion, warm with excessive penetration bitumen's and warmth with emulsion (half of-heat aggregate), the use of one hundred % of reclaimed asphalt pavement (RAP) at specific temperatures. Differences of their workability and ease of use are also analyzed via gyratory compaction.

Dario Topini et al. [5] 2018 - This paper offers the usage of recycled fillers in bituminous mixtures for avenue pavements. The fillers had been acquired by the use of crushing and sieving (0.00–0.063 mm) Stabilized bottom Ashes from municipal waste incinerators and electric Arc Furnace steel Slogs. Moreover, currently used calcareous filler changed into blanketed inside the research for comparative features. Filler dosages had been taken into consideration in the experiments. Laboratory assessments geared closer to investigating compaction houses, volumetric traits, and civil traditional normal overall performance of the bituminous mixtures. The consequences endorse that each types of recycled filler are suitable to be used in bituminous combinations, moreover demonstrating that in tremendous situations the investigated fillers increase the overall performance of the corresponding combos in evaluation to conventional (calcareous) filler.

T. Anil Pradyumna et al. [6] 2013 - This paper gives the effects of all such universal overall performance checks finished on asphalt mixes with RAP and virgin mixes. The laboratory results imply that the asphalt mixes with RAP and rejuvenating agent offer higher overall performance in evaluation to virgin mixes. The paper additionally recommends that the increased Pavement trying out Facility (APTF) should be placed to apply to evaluate the actual area performance of recycled pavements in a faster and effective way.

Etienne Jeoffroy et al. [7] 2018 - Bituminous avenue pavements can also be bothered by using cracking over time because of repeated stresses. Evaluate the impact of various sizes and chemical compositions of magnetically-responsive iron-primarily based completely particles used as additives to warmness up street pavements and as a result to shut cracks. With the aid of making use of alternating magnetic vicinity (AMF), we determined that there's a maximum fine length counting on the particle electric conductivity at which the temperature on the ground of asphalt samples is the very satisfactory. Even as particles are properly-disbursed after blending, we positioned that asphalt samples containing huge debris show inhomogeneous heating during the exposure to the AMF.

M. Barral et al. [8] 2012 -The examiner is targeted on the effectiveness of various sepiolite clays and their combos, mixed with the fire retardant motion of aluminums tri-hydrate (ATH). Our effects advocate that the overall performance in competition to fireplace is favored through the high porosity and density of the

sepiolite, and via its loss of affinity with bitumen. Mixing varieties of sepiolites we collect mastic which offers a synergism among the exact harmony/adhesiveness of one of the formulations and the superior fire overall performance of different one.

A.C. Raposeiras et al. [9] 2013 - In severe laboratory checks, effectiveness of a newly designed tool to govern the tack coat dosage applied on internet page is studied, wherein the most influential variables are ground macro-texture and amount of tack coat carried out, with a negligible effect of the emulsion type. In step with the effects acquired, the geo-textile absorbs higher opportunities of emulsion for samples of bituminous combos with lower ground macro-texture values, e.g. AC16D, at the same time as the lowest possibilities of absorbed emulsion are acquired for samples with higher ground macro-texture values, e.g. BBTM11A. The emulsion percentage absorbed via using the geo-textile is immediately related to the amount of emulsion in fee of the bond among layers.

Mallick, Chen et al [10] 2018 - Within the experimental research, one form of carbon nano-tubes and types of nano clays were mixed with 3 base bitumen at numerous dosages through following a protocol primarily based totally on the use of shear blending and sanitation. All rheological measurements were achieved with the aid of a Bending Beam Remoter at temperatures comprised among 6 and 24 C. Effects, which have been interpreted via combining outstanding assessment fashions, showed that the effectiveness of nano-change is exactly brought about via the combination of base binder, additive type and dosage.

A.C. Raposeiras et al. [11] 2013 -The durability and d safety of pavements rely upon severe factors. One of the maximum in fluently is the bond the geo-textile absorbs better possibilities of emulsion for samples of bituminous combinations with decrease ground macro-texture values, e.g. AC16D, even as the bottom possibilities of absorbed emulsion are acquired for samples with better floor macro-texture values, e.g. BBTM11A. The emulsion percent absorbed via manner of the geo-textile is right now related with the amount of emulsion in fee of the bond amongst layers.

Cristina Bonica et al. [12] 2016 -The experimental studies herein described is aimed toward understanding the effects of cellulose-based totally fibers at the Civil homes of bituminous mastics for paving applications. 3 bitumen (two of which modified with SBS polymers), calcareous filler and 4 incredible forms of fiber with severe content material had been used to put together the investigated mastics. The filler to bitumen ratio changed into maintained constant. The laboratory investigations had been targeted on empirical tests (Needle Penetration and Ring and Ball - R&B - Temperature) and dynamic-Civil checks, the latter finished in a extensive sort of temperatures. Effects recommend that fibers beautify the conduct of mastics for respectable blend asphalts, mainly with recognize to the prevention of rutting phenomena at high service temperatures.

Aitor C. Raposeiras [13] 2012 -The effectiveness of an emulsion applied as a tack coat amongst bituminous pavement layers is normally analyzed consistent with the dosage and breakage of the emulsion used on web net site. In this paper specific dosages amongst one in every of a kind bituminous mixtures were analyzed using shear tests, most important to the belief that the maximum useful software variety varies from 250 to 500 g/m^2. At the identical time, the impact of the ground macro-texture of numerous forms of asphalt mixtures at the bond among layers comes to be studied. It has grown to be decided that the maximum values of shear electricity are obtained for a tough texture of 0.17 mm and a dosage of 250 g/m^2.

Marco Pasetto [14] 2012 - The experimental studies have become finished with the 4-problem bending test. The fatigue lifestyles has been evaluated through 3 one-of-a-kind strategies, primarily based on the 50% bargain of the initial stiffness modulus, the dissipated electricity and the harm accumulation. With apprehend to the reference mixture, composed thru a natural combination skeleton, the bituminous combinations with RAP combination and metallic slag have supplied stepped forward fatigue houses and overall performance.

F.Moreno-Navarro et al. [15] 2017 - This paper tested the structural behavior of bituminous combinations used in avenue ground layers (thinking about charges and typical standard performance), and analyzed the viability of the usage of these substances for the rehabilitation of mild-medium site visitors volume roads. The consequences showcase that polymer-changed substances can be extra structurally and economically green than unmodified materials, imparting a option to designers for the rehabilitating of mild-medium traffic amount roads.

2.2 IDENTIFIED GAPS IN LITERATURE

- In above literature addition of waste plastic in flexible pavement work is performed less, because of having less durability, flexibility, workability and temperature resistibility is less to conventional mix.
- Marshall Stability and flow test including waste plastic with fiber in different combination of percentage is not yet performed in literature.
- Marshall Test analysis with inverted tensile strength has not been yet performed including waste plastic and fibers.
- Inclusion of waste plastic with combination of synthetic and natural fiber has not been yet performed experimentally in literature.

2.3 PROBLEM IDENTIFICATION

As per literature survey the previous investigations on flexible pavement addition of waste plastic, a studied the durability, flexibility, workability, Marshall Properties and temperature resistance is less to the conventional mix. Flow stability and strength of pavement during high temperature and loads, hence required to be improvement in stability, strength, maintain durability and temperature resistibility of pavement due to different traffic conditions including environmental effects.

2.4 PROBLEM FORMULATION

To resolve the above described identified problem the 12 sets of sample of bituminous pavement was prepared including different percentage of natural and synthetic fibers in bituminous mix with Waste plastic, the several tests is to be performed on each sample for following outcome results i.e. temperature resistibility, Marshall properties, durability, flexibility of flexible pavement in different conditions.

2.5 OBJECTIVES

- To create samples of bituminous pavement (Bearing Course Bituminous Concrete Grade-II) including combination of waste plastic in different percentage with natural and synthetic fibers.
- To perform tests for determination of different effects which will be obtained after optimizing the flexible pavement?
- To compare the results and to determine optimum strength and properties of flexible pavement.
- Particular test would be performed in flexible pavement sample whose optimum results are improved than other samples.

CHAPTER - 3

METHODOLOGY

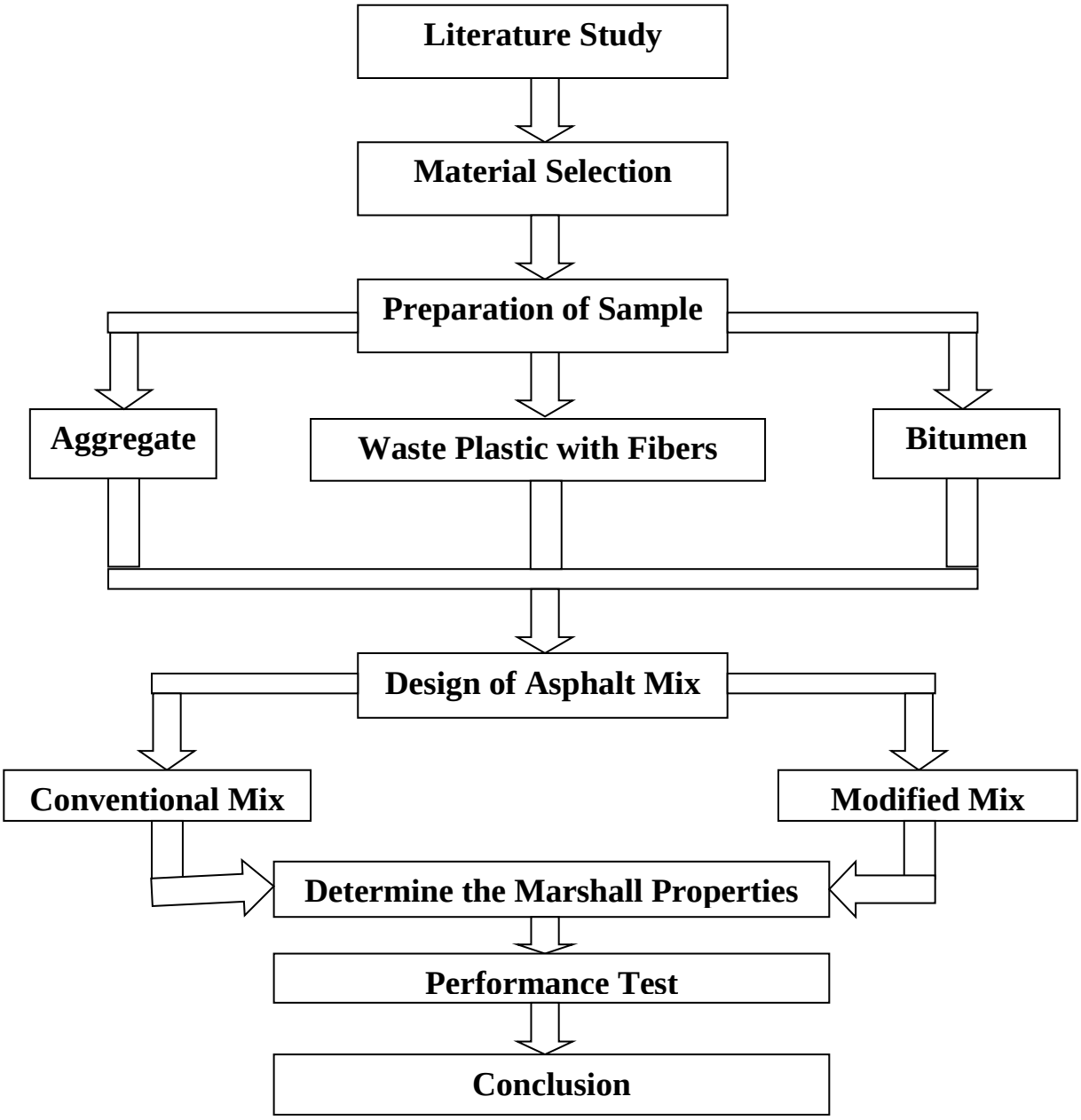


Fig. 3 - Follow the Chart Sequence For Investigation

3.1 PROPERTIES OF AGGREGATE

Aggregate taken from nearest Quarry Kannad, Maharashtra. Properties of Aggregate Shown in **Table 1** and required test Results For Bituminous Concrete (G-II).

Specific Gravity of Aggregate						
Hot Bin Sieve Size	**Bulk Sp. Gravity**		**Apparent Sp. Gravity**		**Water Absorption**	**Reference Code**
< 19 mm	**G_1 =**	**2.654**	**Ga_1 =**	**2.705**	**0.71**	IS-2386, P-3
10 mm	**G_2 =**	**2.634**	**Ga_2 =**	**2.702**	**0.96**	
Dust	**G_3 =**	**2.578**	**Ga_3 =**	**2.666**	**1.28**	

Test	Results	Required Results	Reference Code
Aggregate Impact Value	13.53	Max 24 %	IS-2386, P-4
Los Angeles Abrasion Value	16.77	Max 30%	IS-2386, P-4
Flakiness & Elongation Index	18.04	Max 35 %	IS-2386, P-1
Sand Equivalent Value	63.92	Min. 50%	IS-2720, P-37
Atterberg limit	NP	Not More Than 4 %	IS-2720, P-5
Polished Stone Value	57.45	Min. 55 %	BS-812,P-112

Cleanliness:-

< 19 mm	0.507	Max. 5%	IS: 2386 , P-1
10 mm	0.657		
Dust	0.910		

Soundness Test :-

	Coarse Agg.	Fine Agg.	Limit	
Loss with sodium Sulphate	1.47%	3.94%	Max 12% For Coarse & 10% For Fine Agg.	IS-2386, P-5

Table. 1 - Properties of Aggregate



Fig. 4 -Sample of Aggregate

3.2 PROPERTIES OF BITUMEN

Bitumen (VG-40) Collected From NH-52 Construction Site Laboratory, Source of HPCL, Mumbai. Properties of Bitumen Shown in **Table 2** .

Sl. No.	Test Description	Result	Specified Limits (As per IS-73-2013)	Reference Code
1	Specific Gravity at 27 ° C **(G_b)**	1.043	Min 0.99 g/cc	IS :1202
2	Penetration at 25 ° C, 0.1mm, 100g, 5 Sec	42 mm	Min-35 mm	IS :1203
3	Softening Point	53.6 °C	Min-50 °C	IS :1205
4	Absolute Viscosity	3685 Poise	3200-4800 Poise	IS :1206 (II)
5	Kinematic Viscosity	502 Cst	Min. 400 Cst	IS :1206 (III)
6	Ductility	43 cm	Min-25 cm	IS :1208

Table. 2 – Properties of Bitumen



Fig. 5 – Sample of Bitumen (VG-40)

3.3 PROPERTIES OF FIBERS (SENTHETIC & NATURAL)

Nylon fiber one of the Synthetic fiber Coir and Bamboo fiber example of Natural fiber. Properties of Nylon, Coir and Bamboo fibers Shown in **Table 3 .**

Properties	Nylon fiber	Coir fiber	Bamboo Fiber
Bulk Density (gm/cc)	1.140	1.220	0.7
Elongation at break (%)	62.2	30.02	14.24
Max Size (mm)	5.0	5.0	5.0
Moisture (%)	0.32	10.28	6.92
Tensile Strength (Mpa)	92.5	178	262
Young Modulus (Gpa)	2.70	5.2	9.8

Table. 3 -Properties of Fibers



Fig. 6 - Sample of Nylon Fiber



Fig. 7 - Sample of Coir Fiber



Fig. 8 - Sample of Bamboo Fiber

3.4 PROPERTIES OF WASTE PLASTIC

Waste Plastic Purchase from **Bhogilal Gordhandas Trade Infra, Indore**, **M.P**. We are using Waste Plastic (LDPE) in asphalt mix which is passing from 2.36 mm sieve. Properties of Waste plastic shown in **Table 4**.

Properties	Results
Bulk Density (gm/cc)	0.52
Fineness Modulus (%)	2.8
Melting Point (^{0}C)	130
Tensile Strength (Mpa)	45
Young Modulus (Gpa)	1.9

Table. 4 – Properties of Waste Plastic



Fig. 9 - Sample of Waste Plastic

3.5 SIEVE ANALYSIS OF AGGREGATE (HOT BIN)

We are taken 5 individual Samples of Course & Fine Aggregate, Total 15 Samples. Grading each samples in Bituminous Concrete (G-II) Specified Sieve Size and Finding Average Percentage of Passing value of Different Size of Aggregate.

Sieve Analysis of Individual Aggregates as Per MoRT&H Table: 500-17

Sieve Size (mm)	Average % Passing of 5 Individual Gradation		
	(19 - 12.5) mm	(12.5-4.75) mm	(4.75-Down) mm
19.0	100.00	100.0	100.0
13.2	76.64	100.0	100.0
9.5	24.84	83.24	100.0
4.75	4.88	43.85	98.30
2.36		12.96	91.86
1.18		4.35	75.40
0.600			60.84
0.300			45.69
0.150			31.69
0.075			13.07

Table. 5 - Sieve Analysis of Individual Aggregate

3.6 BLENDING OF AGGREGATE

Blending Report, BC (Grade-II)										
IS Sieve (mm)	Individual % of Passing (Avrg. Of 5 Gradation)			Blended % of Passing			Combined % of Passing	Specified Mid Value	Specified Limits	
	Hot Bin-1	Hot Bin-2	Hot Bin-3	Hot Bin-1	Hot Bin-2	Hot Bin-3				
	< 19 mm	10 MM	Dust	<19mm	10mm	Dust			Lower	Upper
				24%	**24%**	**52%**	**100 %**			
19.0	100	100	100	24.00	24.00	52.00	**100**	100	100	100
13.2	76.64	100	100	18.39	24.00	52.00	**94.39**	95	90	100
9.5	24.84	83.24	100	5.96	19.98	52.00	**77.94**	79	70	88
4.75	4.88	42.85	98.30	1.17	10.52	51.12	**62.81**	62	53	71
2.36		12.96	91.86		3.11	47.77	**50.88**	50	42	58
1.18		4.35	75.40		1.04	39.21	**40.25**	41	34	48
0.600			60.84			31.64	**31.64**	32	26	38
0.300			45.69			23.76	**23.76**	23	18	28
0.150			31.69			16.48	**16.48**	16	12	20
0.075			13.07			6.80	**6.80**	7	4	10

Table. 6 - Blending of Aggregate

3.7 JOB MIX FORMULA

The JMF shall be established to produce a uniform mix conforming to the approved job mix formula subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used within the limits as specified in the Table 500-17 of MoRT&H.

Sieve size (mm)	**% of Passing**	**Permissible variations**	**JMF limits**	**Specified limits** (As per MoRT&H Table 500-17)
19.00	100.00	+/-7%	**100**	100
13.20	94.39	+/-6%	**90-100**	90-100
9.50	77.94	+/-6%	**72-84**	70-88
4.75	62.81	+/-5%	**58-68**	53-71
2.36	50.88	+/-4%	**47-55**	42-58
1.18	40.25	+/-4%	**36-44**	34-48
0.600	31.64	+/-4%	**28-36**	26-38
0.300	23.76	+/-3%	**21-27**	18-28
0.150	16.48	+/-3%	**13-19**	12-20
0.075	6.80	+/-1.5%	**6-9**	4-10

Table. 7 - Job Mix Formula of Dry Mix

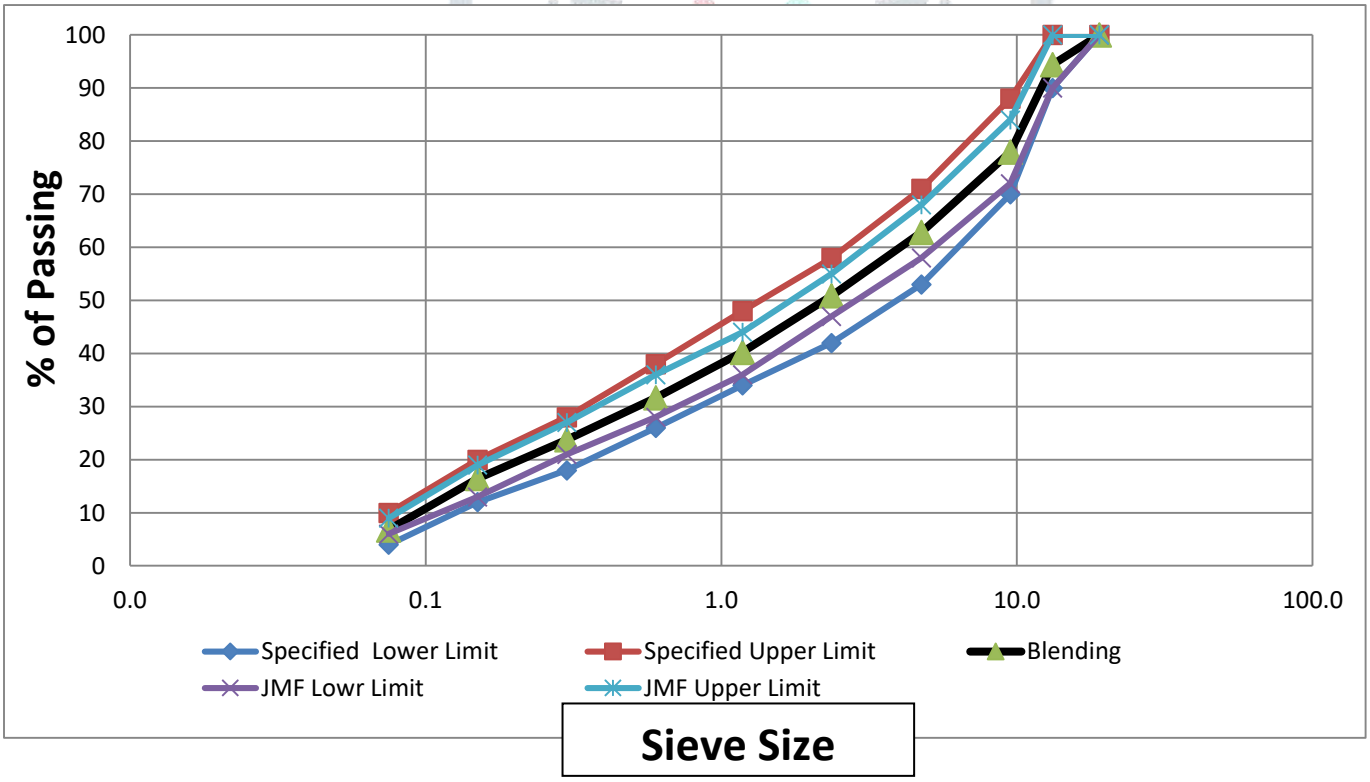


Fig. 10 –Blending Graph

3.8 PREPARATION OF SPECIMENS

Taken Samples of individual Aggregate According to Blending proportion, approximately 1250 gms of material is required for casting each specimen. Different trials have been made with varying bitumen contents from 4.5% to 6.5% as Per ASTM D 6926-04.

Retained Wt. On each Sieve Size (grams)	USED % OF BINDER CONTENT				
	4.5%	5.0%	5.5%	6.0%	6.5%
19.00	0.00	0.00	**0.00**	0.00	0.00
13.20	64.10	63.77	**63.43**	63.10	62.76
9.50	196.25	195.23	**194.20**	193.17	192.14
4.75	204.37	203.30	**202.23**	201.16	200.09
2.36	132.27	131.58	**130.88**	130.19	129.50
1.18	104.33	103.79	**103.24**	102.70	102.15
0.600	117.70	117.09	**116.47**	115.86	115.24
0.300	101.95	101.41	**100.88**	100.35	99.81
0.150	83.56	83.13	**82.69**	82.25	81.81
0.075	111.14	110.56	**109.97**	109.39	108.81
Pan	78.07	77.66	**77.25**	76.85	76.44
Binder Weight	56.25	62.50	**68.75**	75.00	81.25
Total weight	1250.00	1250.00	1250.00	1250.00	1250.00

Table. 8 - Material Weight for Sample Preparation

Each set of trial consists of three specimens and each specimen mixing and compacting temperature exercised during the design mix as described given below table:-

During Marshall Mould Casting (°C)			
Binder Temperature	Aggregate Temperature	Mixed Material Temperature	Compacting Temperature
166-167	165-172	165-170	152-158

In my investigation Optimum Binder Content (OBC) of Conventional Mix is **5.5%**. Herewith **1181.25 gms** aggregate & **68.75 gms** Bitumen taken for the **1250 gms** Sample preparation. Now **8% (5.5 gms)** Bitumen replaced by Different Combination of Waste plastic and Admixture. Where Nylon, Coir and Bamboo Fibers used as Admixture.

Ratio of Waste Plastic & Fibers	10:0	9:1	8:2	7:3	6:4
Waste Plastic weight (gms)	5.50	4.95	4.40	3.85	3.30
Admixture Weight (gms)	0.0	0.55	1.10	1.65	2.20

Table. 9 - Different Combination of Waste Plastic & Fibers

Casting of 15 Set (45 sample) of Marshall Mould in different combination of waste plastic with different admixture.



Fig. 11 - Preparation of Sample



Fig. 12 - Sample of Bituminous Concrete (G-II)



Fig. 13 - Marshall Mould Casting by Automatic Compactor

Mould Diameter 100 mm, Compacter Rammer weight of 4.54 kg. Rammer tumbling from 45.7cm with 75 stokes on each side of specimen. Compacted thickness of specimen is near to 63.5 mm.



Fig. 14 - Marshall Mould

3.9 DENSITY TEST OF SPECIMENS (G_{mb})

Casted Specimen are removed from the mould after 24 hours at room temperature. Follow the standard ASTM D2726.

- Weight of Specimen in Air
- Weight of Specimen in water
- Weight of Specimen in SSD Condition
- Volume of Specimen =SSD Weight-Weight in water
- Density of Specimen **(G_{mb})** =Air weight ÷ Volume of Specimen



Fig. 15 - Checking of Density of Marshall Mould

3.10 THEORETICAL MAXIMUM SPECIFIC GRAVITY (G_{mm})

A weighed sample of oven dry paving mixture in loose condition is placed in a tarred vacuum vessel. Sufficient water at a temperature of 25 ^{0}C is added to completely submerge the sample. Vacuum is applied for 15 ±2 minutes to gradually reduce the residual pressure in the vacuum vessel to 4.0 kpa. At the end of the vacuum period, the vacuum is gradually released. The volume of the sample of paving mixture is obtained by filling the vacuum container level full of water and weighing in air. At the time of weighing the temperature is measured as well as the mass. From the mass and volume measurements, the specific

gravity as 25 ^{0}C is calculated. This test performed on the basis of ASTM D 2041. G_{mm} which mean 0% Air Voids.

$$G_{mm} = \frac{A}{A+B-C}$$

Where, A =Weight of oven dry loose sample in gms

B=Weight of Container Filled with water in gms

C=Weight of Container filled with water & Sample in gms



Fig. 16 - Determine the Theoretical Maximum Specific gravity of paving Mix

3.11 TYPICAL CALCULATION OF MIX

A. Bulk Specific Gravity of Combined Aggregate (G_{sb}) :-

$$G_{sb} = \{P_1+P_2+P_3+.....+Pn\} / \{ \frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_3}{G_3} + --- + \frac{P_n}{G_n} \}$$

B. Apparent Specific Gravity of Combined Aggregate (G_{sa}) :-

$$G_{sa} = \{P_1+P_2+P_3+.....+Pn\} / \{ \frac{P_1}{Ga_1} + \frac{P_2}{Ga_2} + \frac{P_3}{Ga_3} + --- + \frac{P_n}{Ga_n} \}$$

C. Calculation of Effective Specific Gravity at Different Binder Content (G_{se}) :-

$$G_{se} = \frac{(P_{mm} - P_b)}{\left(\frac{P_{mm}}{G_{mm}}\right) - \left(\frac{P_b}{G_b}\right)}$$

Where, P_{mm} = 100

P_b= Binder %

G_b= Specific Gravity of Binder

P_1, P_2, P_3 …Pn is Percentage of blended individual aggregate.

3.12 DETERMINE AIR VOIDS, VMA & VFB

Air Voids (Va) - The total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as percent of the total volume of the sample.

$$\text{Air Void (Va)} = 100 \times \left(\frac{G_{mm} - G_{mb}}{G_{mm}}\right)$$

Voids in Mineral Aggregate (VMA)- It is the volume of inter granular void space between the aggregate particles of a compacted paving mixture. It includes the air voids and the volume of the bitumen not absorbed into the aggregate.

Its expressed as a Percentage of the total volume of the mix.

$$\text{Voids in Mineral Aggregate (VMA)} = 100 - \left(\frac{P_s \times G_{mb})}{G_{sb}}\right)$$

Where, **Ps** is the % of Aggregate in total Mix.

Voids Filled By Bitumen (VFB)- The portion of the volume of intergranular void space between the aggregate particles (VMA) that is occupied by the effective asphalt.

In VMA air voids and bitumen are there, if we remove air voids from them VFB can be obtained,

$$\text{Voids filled by Bitumen (VFB)} = 100\times \left(\frac{\text{VMA - Va}}{\text{VMA}} \right)$$

3.13 MARSHALL TEST

Specimens are heated in a thermostatically controlled water bath at a temperature of $60^0C\pm 0.5^0C$ for a period of 60 minutes the specimens should be completely immerged in the water.

The inside faces of the testing heads should be thoroughly cleaned and the guide rods lightly oiled, so that the upper head slides freely. The heads should then be immerged in the water bath at $60^0C\pm 0.5^0C$ so they are heated to the correct test temperature.

Essential that the test machine, gauges etc. , are all prepared ready for use before removing the specimens from the water bath.

On completion of the heating period, the specimen and breaking heads are removed from water bath; specimen placed on its side centrally in the lower test head, the upper head is then located on the slides and brought into contact with the specimen. The whole assembly is then placed on the test machine directly below the plunger.

The deformation dial gauge should be placed into position and either zeroed or the initial reading taken. The load ring dial gauge should previously have been zeroed.

The load is applied to the specimen by the machine at the rate of 50.8 mm/minutes ±5 %.The reading on the load ring gauge should be observed and the instant the load stops increasing, machine should be switch off. The maximum load gauge reading should be taken. The corresponding reading on the deformation (flow) gauge may then be taken.

Description	Requirements for Viscosity Grade Bitumen	Requirements for Modified Bitumen (Hot Climate)	Specification
Marshall Stability	9.00 KN Min.	12 KN Min.	MoRT&H Table No. 500-11
Marshall flow (mm)	2-4	2.5-4	MoRT&H Table No. 500-11
% Air voids (Va)	3-5	3-5	MoRT&H Table No. 500-11
% Voids filled with Bitumen (VFB)	65 – 75%	65 – 75%	MoRT&H Table No. 500-11

Table. 10 - Required data as per Specification



Fig. 17 - Marshall Stability & Flow Determination

3.14 INDIRECT TENSILE TEST

The tensile Properties of bituminous mixtures are defining the tensile properties of the bituminous mixture which is further be related to the cracking properties of pavement. At low temperature cracking, fatigue and rutting are the three major distress mechanism.

The tensile characteristics of bituminous mixture are evaluated by loading the Marshall specimen along a diametric plane with a compressive load at a constant ate acting parallel to and along the vertical diametrical plane of the specimen through two opposite loading strips. This loading configuration develops a relatively uniform tensile stress perpendicular to the direction of the applied load and along the vertical diametrical plane. Ultimately causing the specimen tested to fail by splitting along the vertical diameter. A 13 mm wide strip loading is used fo 101 mm diameter specimen to provide a uniform loading with which produces a nearly uniform stress distribution. The Static Indirect tensile strength of a specimen is determined using the procedure outline in ASTM D 6931. Loading rate is 51 mm/minute is adopted. Peak load is recorded and it is divided by appropriate geometrical factors to obtain the split tensile strength using the following equation:



Fig. 18 - Indirect Tensile strength Test

$$S_t = \frac{2000P}{\pi t D}$$

Where, S_t =IDT Strength , kPa

P =Maximum load, N

t =Specimen height immediately before test, mm

D =Specimen diameter, mm

3.14 PERFORMANCE TEST FOR RUTTING

For asphalt pavements, rutting is one of the most serious forms of pavement distress, and several rutting is a significant cause of pavement failure. To prevent rutting, the pavement structure needs to provide sufficient support for the road surface. Rutting is the permanent deformation of flexible pavement that accrued by wheel paths. Rutting may be accrued by fatigue cracking and other distresses. Marshall Stability of mix is the important factors to resist rutting. Rutting is the not only concern for driving safety, it's also reduce the pavement strength and life, increasing the difficulties of pavement maintenance as well as its cost.

We are observing rutting performance of Asphalt mix by "HUMBURG WHEEL TRACKING DEVICE" (HWTD) ,Which is developed in Germany for finding the Rutting life of Asphalt mix. Maximum Permissible rutting depth is 4mm for 20000 cycles. Procedure of this test taken by **AASHTO TP 63**,

- We are casted 3 beam (75 mm Thickness) of Asphalt mix by slab compactor at 5% air voids and this beams hold inside the Oven for 6 hours.
- Set the Humburg wheel Tracking Device Like, Hose Pressure at 120 psi (827 kPa) and Load 120 lbs (534 N).
- Stabilize the test Chamber at the desired temperature and insert the heated Casted Asphalt beam again place the rutting depth measurement template over the Sample.
- Push the Sample holding tray in, close the doors, and allow 10 minutes for the test temperature stabilized and set apparatus for 4000 cycles in 1st attempt again repeat 4000 cycles up to 20000 cycles.

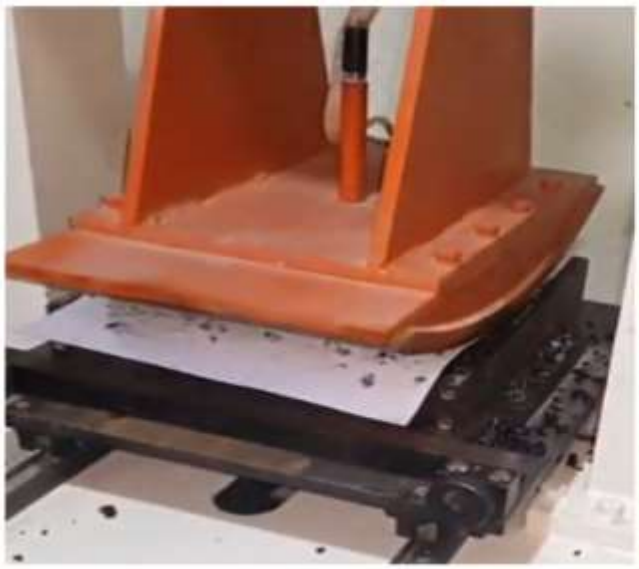


Fig. 19-(a) During Slab Compaction



Fig. 19-(b) Compacted Slab



Fig. 20-(a) Sample inside HWTD



Fig. 20 -(b) Wheel Tracking on Slab

CHAPTER - 4

RESULT AND DISCUSSION

Comparison of Modified Asphalt Mix & Conventional Mix:

Here in this situation best grade asphalt concrete is used to manufacture of pavement block. The material homes of pavement block are mention within the above section.

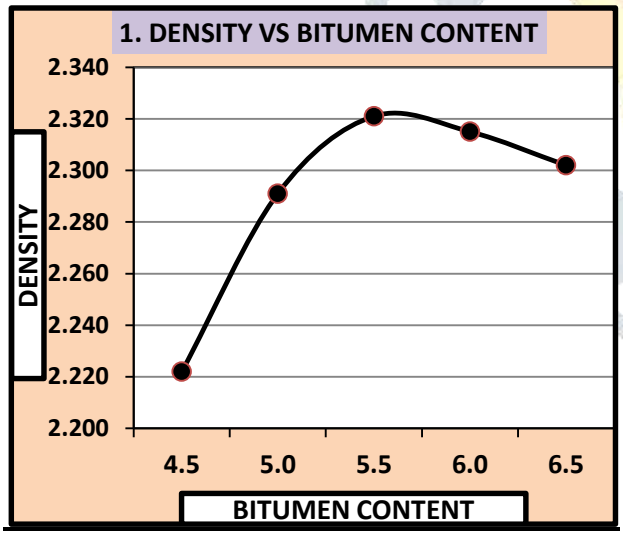
During the evaluation of bituminous pavement four types of fiber are mixed i.e. coir fiber, bamboo fiber, nylon fiber with melted plastic waste of different percentage by analyzing their strength and temperature stability the several tests that were done and obtained are demonstrated below -

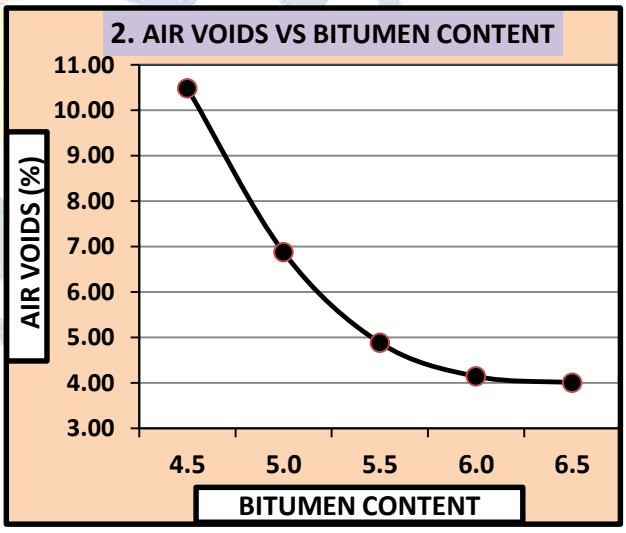
4.1 Marshall Properties of the Conventional mix:

Bitumen Content (%)	Density (g/cc)	Air Voids (%)	VMA (%)	VFB (%)	Stability (Kg)	Flow (mm)
4.5	2.222	10.48	18.70	43.96	615.0	2.9
5.0	2.291	6.87	16.61	58.64	830.3	3.4
5.5	**2.321**	**4.88**	**15.96**	**69.42**	**984.0**	**3.9**
6.0	2.315	4.14	16.62	75.09	953.3	4.8
6.5	2.302	4.00	16.65	75.98	830.3	5.6

Table. 11 – Marshall test results of Conventional mix

According to Design Parameters & Marshall Test Results of Conventional Mix, Optimum Binder Content (OBC) is **5.5 %.**





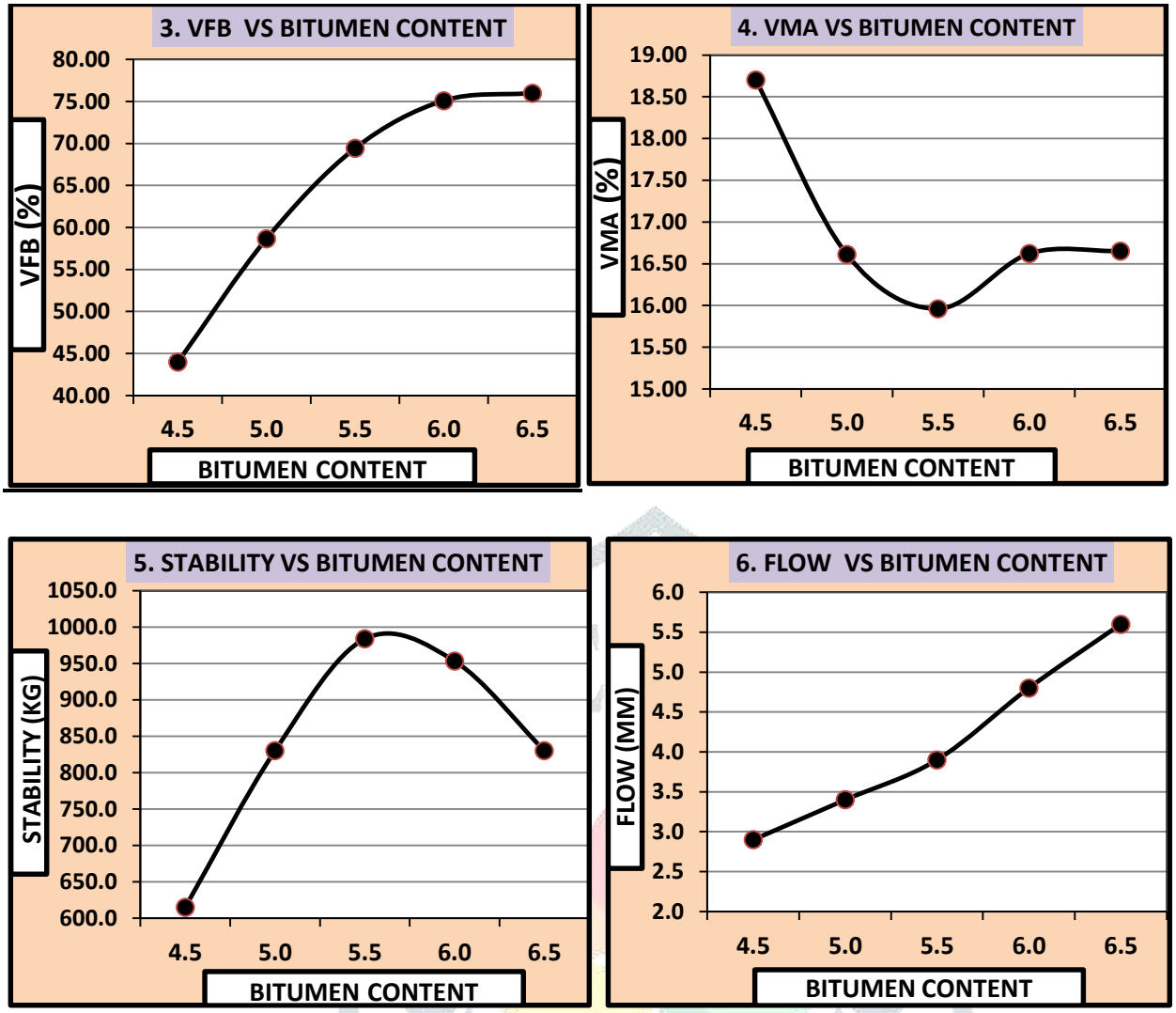


Fig. 21 - Graphs of Marshall Test of Conventional Mix

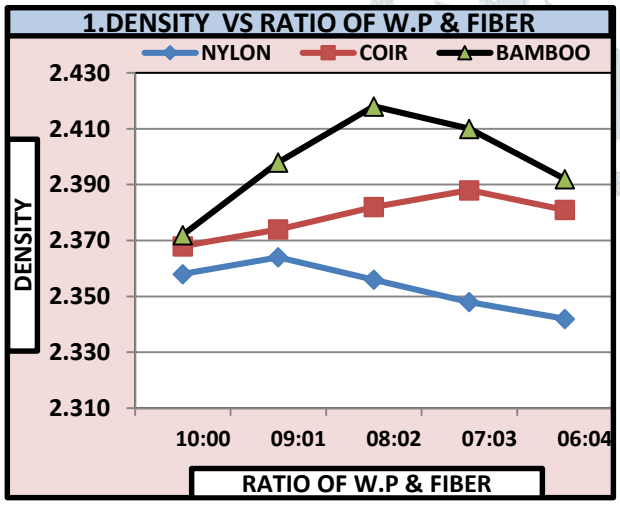
4.2 Marshall Properties of the Modified mix:

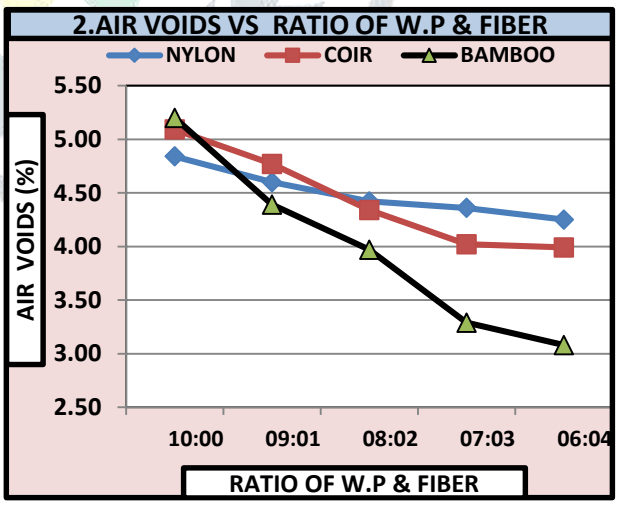
Modified Mix with Waste Plastic & Nylon Fibers						
Ratio of waste plastic & fiber	**Density (g/cc)**	**Air Voids (%)**	**VMA (%)**	**VFB (%)**	**Stability (Kg)**	**Flow (mm)**
10:00	2.358	4.84	15.98	69.71	1353.0	3.9
09:01	2.364	4.60	15.76	70.81	1383.8	4.1
08:02	2.356	4.42	16.05	72.46	1291.5	4.4
07:03	2.348	4.36	16.30	73.30	1230.0	4.5
06:04	2.342	4.25	16.55	74.32	1199.3	5.0

Modified Mix with Waste Plastic & Coir Fiber						
Ratio of waste plastic & fiber	Density (g/cc)	Air Voids (%)	VMA (%)	VFB (%)	Stability (Kg)	Flow (mm)
10:00	2.368	5.09	15.62	67.41	1377.6	3.8
09:01	2.374	4.77	15.41	69.05	1414.5	3.7
08:02	2.382	4.34	15.12	71.30	1445.3	3.5
07:03	2.388	4.02	14.91	73.04	1476.0	3.9
06:04	2.381	3.99	15.16	73.68	1402.2	4.3

Modified Mix with Waste Plastic & Bamboo Fibers						
Ratio of waste plastic & fiber	Density (g/cc)	Air Voids (%)	VMA (%)	VFB (%)	Stability (Kg)	Flow (mm)
10:00	2.372	5.20	16.67	68.81	1414.5	3.7
09:01	2.398	4.39	15.76	72.14	1654.0	3.3
08:02	**2.418**	**3.97**	**15.06**	**73.64**	**1782.0**	**3.0**
07:03	2.410	3.29	15.34	78.55	1660.5	2.6
06:04	2.392	3.08	15.97	80.71	1599.0	2.3

Table. 12 – Marshall test results of Modified mix





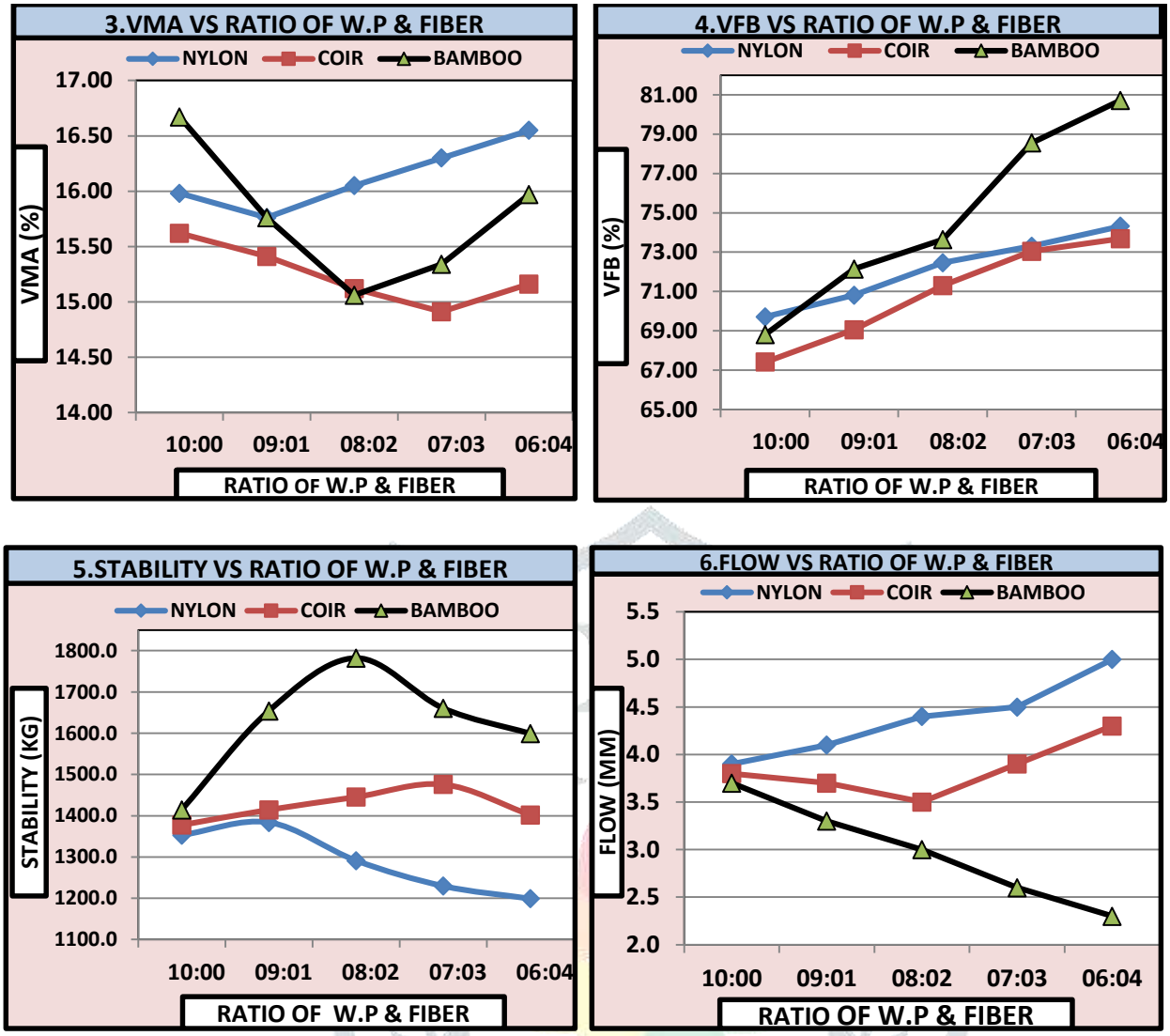


Fig. 22 - Graphs of Marshall Test of Modified Mix

4.3 Rutting Depth by Humberg Wheel Tracker Device:

No. Of Passes	0	4000	8000	12000	16000	20000
Rutting Depth of Conventional mix (mm)	0	3.14	5.86	7.84	9.85	10.98
Rutting Depth of Modified mix (mm)	0	0.48	1.04	1.86	2.88	3.8

Table. 13 – Data of Rutting depth

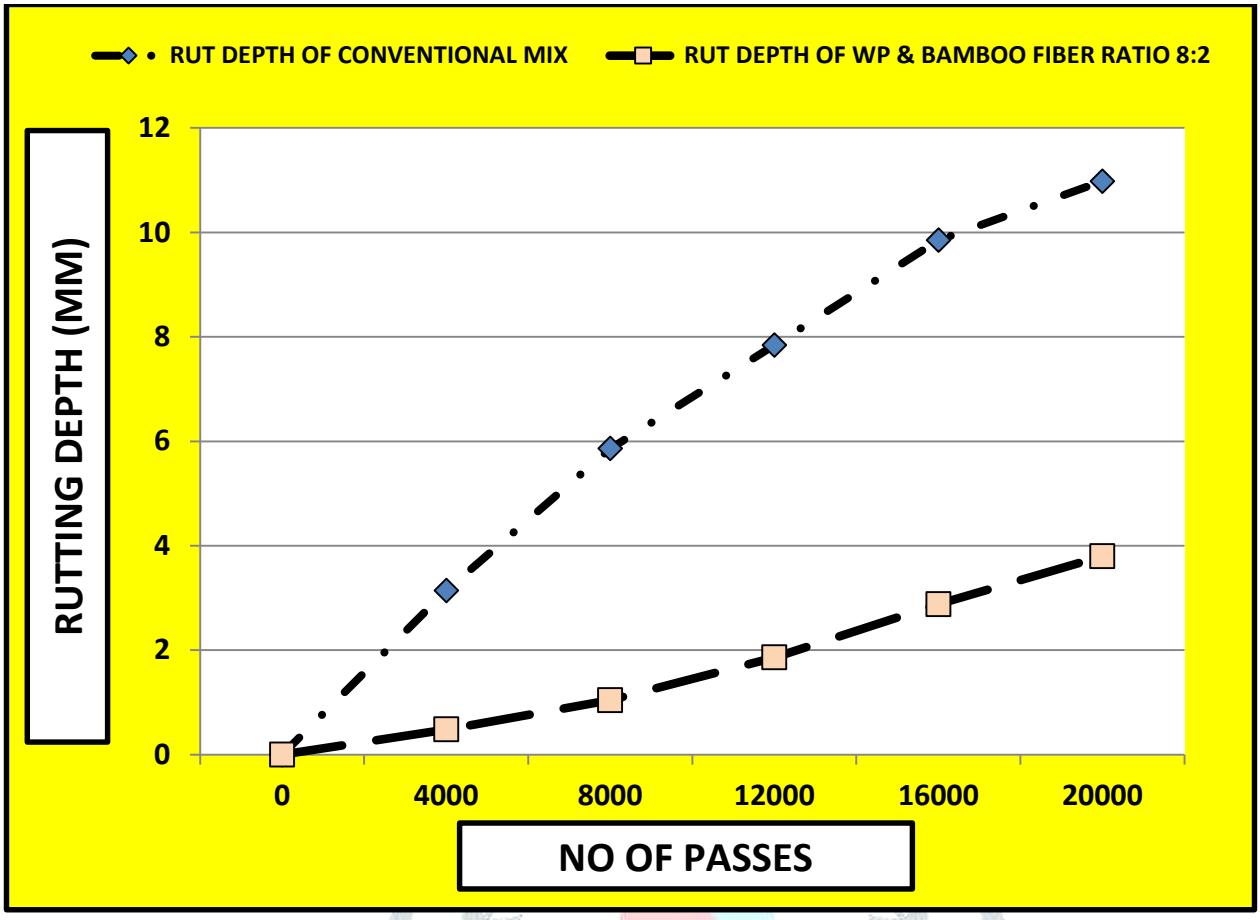


Fig. 23 - Graphs of Rutting Depth

Rutting depth of Conventional Mix = 11 mm

Rutting depth of Modified Mix of WP & BAMBOO FIBER(08:02) =3.8 mm

CHAPTER-5

CONCLUSION

According to above results and experimental Observation of asphalt mix, Obtained Binder Content is 5.5 % of conventional mix. In this Investigation 8 % Binder is replaced by many combination of Waste plastic and fibers (Nylon, Coir & Bamboo) when we are using waste plastic and Bamboo fiber in ratio of 8:2, then obtained results is much better than other combination, Like Stability of Conventional mix is 984 kgs but 1782 kgs Stability found when 8 % Binder is replaced by many combination of Waste plastic and Bamboo fibers in ratio of 8:2, this is the final combination of this investigation. Above both obtained stability is acceptable due to required stability is min 9KN (917.74 kg as Per MoRT&H. Density of Finalized mix is increased to the conventional mix and also all Marshall Properties is better than the conventional mix. Specially Rutting depth of the finalized mix is 3.8 mm which is much better than conventional mix so finalized mix having more capability to resists more rutting compare to Conventional

mix. Addition of Combination of Waste plastic and Bamboo fibers in ratio of 8:2 in Conventional mix then its life is increased and better of Road life.

5.1 Recommendations –

- The following experiment could be performed with other synthetic materials
- Thickness and weight reduction is to be focused in further experiment
- Orientation of fibers could be changed to predict effect on pavement
- Aggregate size could be used to predict the effect on bituminous pavement.

5.2 Future Scope –

- Plastic is a harmful and non-biodegradable waste responsible mainly for land pollution. Utilizing it for road construction will results in its efficient management.
- It is a Simple and easy technique which does not involve any complex or new machinery.
- The addition of plastic to bitumen will help in improving the strength and durability of the pavement.

REFERENCES

[1] Donia Savio, M.R. Nivitha, B.K Bindhu, J.M. Krishnan "Overloading analysis of bituminous pavements in India using M-EPDG." Transportation Research Procardia 17 (2016) 607 – 616.

[2] Peng Bo, Fan Xueyong, Wang Xunjie, Li Wenying"Key steps of carbon emission and low-carbon measuresin the construction of bituminous pavement." International Journal of Pavement Research and Technology 10 (2017) 476–487.

[3] Angela Farina, Maria Chiara Zanetti, Ezio Santagata, and Gian Andrea Blending"article Life cycle assessment applied to bituminous mixtures containing recycled materials: Crumb rubber and reclaimed asphalt pavement." Resources, Conservation and recycling xxx (2016) xxx–xxx

[4] Adrián Nosetti, Domingo Pérez-Madrigal, Félix Pérez-Jiménez, Adriana H. Martínez. "Effect of the recycling process and binder type on bituminous mixtureswith 100% reclaimed asphalt pavement."Construction and Building Materials 167 (2018) 440–448.

[5] Dario Topini, Emanuele Toraldo, Luca Andena, Edoardo Mariani"Use of recycled fillers in bituminous mixtures for road pavements." Construction and Building Materials 159 (2018) 189–197.

[6] T.Anil Pradyumna, Abhishek Mittal, Dr.P.K.Jain"Characterization of Reclaimed Asphalt Pavement (RAP) for Usein Bituminous Road Construction." Procedia - Social and Behavioural Sciences 104 (2013) 1149 – 1157.

[7] Etienne Jeoffroy, Florian Bouville, Moisés Bueno, André R. Studart, Manfred N. Partl.Iron-based particles forthe magnetically-triggered crack healingof bituminous materials. Construction and Building Materials 164 (2018) 775–782

[8] M. Barral, P. Garmendia, M.E. Muñoz, Z. Palmillas, R. Romera, A. Santa Maria, S. Villanueva"Novel bituminous mastics for pavements with improved fire performance." Construction and Building Materials 30 (2012) 650–656.

[9] A.C. Raposeiras, A. Vega-Zamanillo, M.A. Calzada-Pérez, D. Castro-Fresno. New procedure to control the tack coat applied between bituminouspavement layers.Construction and Building Materials 44 (2013) 228–235.

[10] Lucia Tsantilis, Orazio Baglieri, Ezio Santagata. "Low-temperature properties of bituminous nano composites for road applications. "Construction and Building Materials 171 (2018) 397–403.

[11] A.C. Raposeiras, D. Castro-Fresno, A. Vega-Zamanillo, J. Rodriguez-Hernandez. "Test methods and influential factors for analysis of bonding between bituminous pavement layers." Construction and Building Materials 43 (2013)372–381.

[12] Cristina Bonica, Emanuele Toraldo, Luca Andena, Claudia Marano, Edoardo Mariani. "The effects of fibers on the performance of bituminous mastics for road pavements" 10.1016/j.compositesb.2016.03.069

[13] Aitor C. Raposeiras, Ángel Vega-Zamanillo, Miguel Ángel Calzada-Pérez, Daniel Castro-Fresno. "Influence of surface macro-texture and binder dosage on the adhesion between bituminous pavement layers." Construction and Building Materials 28 (2012) 187–192.

[14] Marco Pasettoa, Nicola Baldo. Fatigue Behavior Characterization of Bituminous Mixtures made with Reclaimed Asphalt Pavement and Steel Slag. Procedia - Social and Behavioural Sciences 53 (2012) 297 – 306.

[15] F. Moreno-Navarro, M. Sol-Sánchez, M.C. Rubio-Gámez. "Structural analysis of polymer modified bituminous materials in the rehabilitation of light-medium traffic volume roads" Construction and Building Materials 156 (2017) 621–631.

[16] Salvatore Mangiafico, Hervé Di Benedetto, Cédric Sauzéat, François Olard, Simon Pouget and Luc Planque, Relations between Linear ViscoElastic Behaviour of Bituminous Mixtures Containing Reclaimed

Asphalt Pavement and Colloidal Structure of Corresponding Binder Blends. Procedia Engineering Volume 143, 2016, Pages 138–145.

[17] Salvatore Mangiafico, Hervey Di Benedetto, Cleric Sauz´eat, François Olard, Simon Pouget, Luc Planque, Effect of colloidal structure of bituminous binder blends on linear viscoelastic behaviour of mixtures containing Reclaimed Asphalt Pavement, doi: 10.1016/j.matdes.2016.07.124.

[18] S. Kültür, N. Türkeri, Assessment of long term solar reflectance performance of roof coverings measured in laboratory and in field, Build. Environ. 48 (2012) 164–172, http://dx.doi.org/10.1016/j.buildenv.2011.09.004.

[19] D. Kolokotsa, P. Maravelaki-Kalaitzaki, S. Papantoniou, E. Vangeloglou, M. Saliari, T. Karlessi, et al., Development and analysis of mineral based coatings for buildings and urban structures, Sol. Energy 86 (2012) 1648–1659, http:// dx.doi.org/10.1016/j.solener.2012.02.032.

[20] L. Huang, J. Li, D. Zhao, J. Zhu, A fieldwork study on the diurnal changes of urban microclimate in four types of ground cover and urban heat island of Nanjing, China, Build. Environ. 43 (2008) 7–17. buildenv.2006.11.025.

[21] H. Takebayashi, M. Moriyama, Study on the urban heat island mitigation effect achieved by converting to grass-covered parking, Sol. Energy 83 (2009) 1211– 1223,

[22] X. Yang, L. Zhao, M. Bruse, Q. Meng, Evaluation of a microclimate model for predicting the thermal behaviour of different ground surfaces, Build. Environ. 60 (2013) 93–104, http://dx.doi.org/10.1016/j.buildenv.2012.11.008.

[23] A. Synnefa, M. Santamouris, I. Livada, A comparative study of the thermal performance of reflective coatings for the urban environment, in: International Conference ‘‘Passive and Low Energy Cooling for the Built Environment”, May 2005, Santorini, Greece.

[24] A. Synnefa, M. Santamouris, I. Livada, A study of the thermal performance of reflective coatings for the urban environment, Sol. Energy 80 (2006) 968–981,.2005.08.005.

[25] H. Li, J. Harvey, A. Kendall, Field measurement of albedo for different land cover materials and effects on thermal performance, Build. Environ. 59 (2013) 536–546,.2012.10.014.

[26] V. Di Maria, M. Rahman, C. Sangiorgi, P. Collins, G. Dondi, The thermo physical properties of asphalt and concrete paved surfaces, Int. J. Pavement Res. Technol. 6 (2013) 414–422, (4).414.

[27] H. Akbari, H.D. Matthews, Global cooling updates: reflective roofs and pavements, Energy Build. 55 (2012) 2–6. enbuild.2012.02.055.

[28] M. Noro, R. Lazzarin, Urban heat island in Padua, Italy: simulation analysis and mitigation strategies, Urban Climate (2015

[29] K. Wayne Lee, S. Kohm, Cool pavements, Green Energy Technol. 204 (2014)439–453, -662-44719-2_16.

[30] A.L. Pisello, G. Pignatta, V.L. Castaldo, F. Cotana, Experimental analysis of natural gravel covering as cool roofing and cool pavement, Sustainability 6–8 (2014) 4706–4722.

