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Waste Plastic's Effect on the Deterioration of Bituminous Mixes in Cold Climates

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ABSTRACT

The modifications in bitumen can be carried by addition of various types of additives. Polymers can be categorized as one of the types of additive. By the addition of Polymers to the bitumen, the temperature susceptibility and also the stiffness get increased. Due to this increase in stiffness, the resistance of the mix to rutting in hot climates is generally improved and thus we can use comparatively softer base bitumen, which results in improved performances at low temperatures. It was observed that after comparing the results of the mixes prepared by the addition of both Anti stripping material with Varying percentages and WPB, and the mixes containing only WPB, the latter provided better results in terms of Retained Marshall stability and Marshall Quotient. It was noticed that control mix after being subjected to repeated Freeze Thaw cycles can lose more than 50% of its original strength; hence modification to the mix should be done by addition of 6% WPB which highly enhances the strength of the mix. The mixes with 6% WPB even after 7 Freeze exhibit stability values similar to that of control mix under ideal conditions.

KEYWORDS: *Bituminous Mixes, Marshall Quotient, WPB*

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1. INTRODUCTION

Transportation is an essential component for the infrastructure of all the countries. The economy and economic status of any country is determined by its network of roads, railways, waterways, airways, pipes and ports. It is well known that road network is the largest and most important connecting way and so is its maintenance [1]. A good and long lasting road network requires proper designing, construction and maintenance approach. To enhance the economy and social status of a community roads are of great importance. The road network of India is the second biggest in the globe. It is responsible for carrying about more than half of the goods of country (60%) and the majority of passengers as well(85%).The total length of roadways is estimated as 5.4million Km. In the northern areas of the country, roads are the most important source of connectivity. Due to cold weather conditions which include factors like snow, rain, frost, and these roads suffer excessive damage and thus hamper the movement of people as well as goods across these parts of the country. [2]

2. BITUMINOUS MIXES

Bituminous mixes are broadly utilized in Pavement constructions. There are generally two groups of pavements, i) Flexible and ii) Rigid. Bituminous mixes are most generally utilized everywhere in flexible pavement Construction.

2.1. TYPES OF PAVEMENTS

2.1.1. Flexible Pavement

These can be defined as the pavements, which in general have low flexural strength and are somewhat flexible when acted upon by loads. In such pavements the disfigurement in the lower layers gets mirrored on the top layers as well. It ordinarily comprises of: sub grade made of naturally available soil, a sub base of 100-300 mm, a base course of granular material, a binder course (made of usually coarse graded aggregate) and a wearing course.[3] The transfer of load in a flexible pavement is due to distribution pattern which takes places laterally with increase in the depth. Because of the lower qualities of flexure of such pavements, they redirect quickly when acted upon by loads yet bounce back on the evacuation of such loads. . The design for thickness of the pavement is such that the stress on the soil sub grade is inside the bearing force and hence is kept from distortion of extravagant nature.[4] The pavement quality is decided mainly on the basis of such distortions endured by the sub-grade and also by its ability to resist such distortions.

2.1.2. Rigid Pavement

On the off chance that wearing course is made of cement concrete, it is then known as the rigid pavement because of the fact that the aggregate asphalt structure will not twist or redirect because of activity loads.[5] These kinds of pavements have higher stiffness as compared to others because of higher elasticity modulus of the material of which they are made of. Critically, for the joint diminishing and disposal strengthening bars can be utilized.

2.1.3. Layers of Flexible pavement

In General, customary black-top pavement comprises of Surface Course is normally built of bituminous concrete and largely comprises of material having high qualities. It forms the top layer and is sometimes, also known as wearing course. The vehicle load is directly taken by this layer. Capacities and necessities of the surface course are as Imparts riding qualities, for example, friction, smoothness, besides resisting the traffic load. It keeps the passageway of excess amounts of surface water away from the layers which are underneath. It should have the ability to oppose the deformations which may take place due to movement, thus give a slip safe surface for riding.[6] It should be resistant to water and thus ensure the protection of underlying layers from the detritus impact, if exposed to moisture. Binder Course the primary intention of this layer is the appropriate distribution of the load to the base course .This layer by and large comprises of aggregate with lower amount of bitumen than the surface layer. It gives the major portion of our structure. Base Course It comes quickly underneath the binder and wearing course. This layer helps to distribute load and also adds to the seepage. Its thickness is generally kept as 100-300 mm. Sub-base Course the main aim of this layer is to provide additional assistance to the structure, improvement of the drainage quality. The invasion of fines into the structure of the pavement is also prevented due to this layer. It is not always required[7]. Sub-grade or top soil is arranged to get the stress from the layers above. It is mostly a layer of natural soil. This layer should never be allowed get overstressed which is very fundamental. The compaction of this layer is done to the required thickness, close to the OMC are show in fig 1.

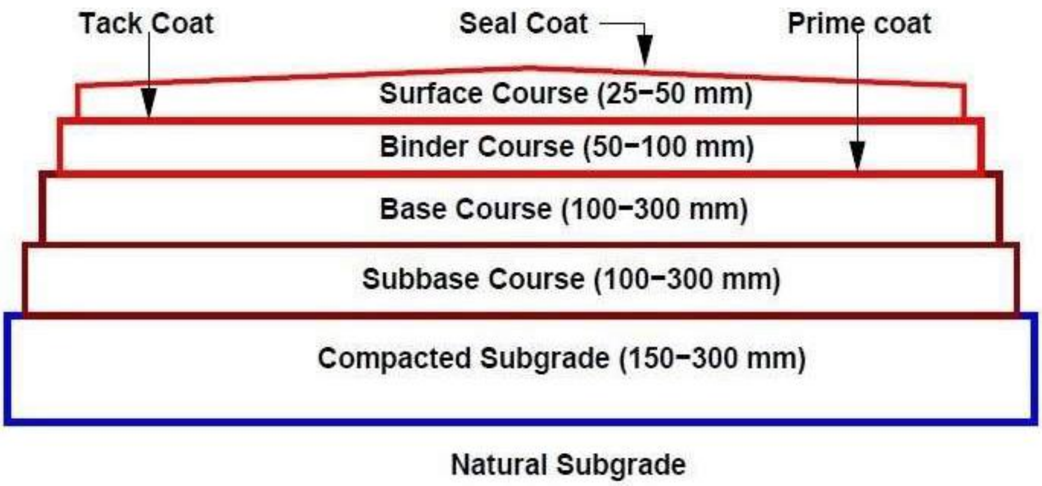

Fig 1 Typical cross section of a flexible pavement

3. BITUMEN

It may be defined as a black mixture which is made up of hydrocarbons and is viscous in nature. It can either be obtained in residual form at the process of distillation of petroleum or naturally. The reliance on responsive mechanical properties of such material at the time of loading is an imperative factor in the expressway designing [8]. These properties should be properly estimated at loads and temperatures which compare or resemble the conditions to which the pavement will be exposed. As such there are 4 levels of viscosity which have greater significance. These include Thickness amid compaction. Viscosity when the material is being mixed. Viscosity of bitumen when the pavement is exposed to the most elevated temperature. Viscosity of bitumen when the pavement is exposed to the lowest temperature.

3.1. Types of bituminous mixes

3.1.1. Dense Graded Mix

This type of bituminous mix consists of a great extent of all ingredients. Dense graded mix possesses great compressive quality and good amount of tensile strength.[9] For high load bearing pavement layers Dense Graded Mixes are suitable e.g. wearing course, binder and majority of other traffic conditions (Bituminous concrete, Semi dense bituminous concrete, dense bituminous macadam, Stone matrix asphalt).

3.1.2. Open-graded mix

In this type, finer aggregate is not present. Also filler may be missing. This type of mix is permeable. Open graded mixes exhibit great friction but lower quality strength. In Open-graded mixes only severely crushed stone is used. In order to make them resistant to moisture and durable, seal coat application is made.[10] Open graded blend is intended to be permeable with a high number of pores. Factors such as low velocity vehicles and high amount of dirt will reduce the performance of such mixes by blocking the pores.

3.1.3. Hot mix

This type of mix is created by warming the bituminous to high temperatures and thus diminishing the consistency of such mixes. Also the aggregates used are dried to expel the dampness.[11] Mixing of virgin bitumen and PMB with aggregate is done. The temperature of aggregates is kept as 150°C and 166°C respectively. Paving of the mix and compacting is done when the temperature of the binder is fairly high.

3.1.4. Warm mix

These types of mixes are obtained by including zeolites waxes, emulsions, and even water preceding the mixing process to binder. These additions fundamentally lower the temperature of mixing and lying, also results in bringing down the use of petroleum products, which further results in discharging lower amounts of Co2, vaporizers. The low temperatures of lying additionally prompt the surface to be available for utilization much more easily.[12] This is very vital in construction processes which have critical time plans. This use of added substances in hot mixes will make compaction easy and further allow paving in cold climatic conditions.

3.1.5. Cold mix
This type of mix is obtained by making an emulsion of bitumen with water before mixing. The viscosity of mix becomes lower and it becomes smaller in size and also easier for working.

When the appropriate amount of water vanishes, this emulsion breaks down and acts as cold HMAC.

3.1.6. Mix with Cut-back
This type of mix is low viscosity bitumen which is obtained by the desolation of bitumen binder in lamp oil or any fraction of oil which is lighter such as kerosene. This fraction which is lighter then vanishes due to evaporation. Due to the fear of getting contaminated by VOC's present, Asphalt emulsion has to a great extent replaced cut back asphalt.

3.1.7. Mastic asphalt
Mastic asphalt is prepared in a mastic cooker by initially adding filler and half quantity of binder. It is heated and mixed thoroughly. After this addition of half of fine aggregate and then bitumen is added.[13]The mix is cooked for an hour. Coarse aggregate is then added and the mix is cooked for 3 hours. It is constructed in a single layer of 25-50 mm laid over DBM in case of roads while that in case of bridge decks over a concrete base.

4. WASTE PLASTIC ROADS
The plastic waste is available in today's world in huge abundance. There has been a constant increase in the utilization of plastic in the form of plastic cups, bottles etc. It has been observed that the majority of plastic (around 60%) is utilized in the process of packaging. This Plastic is the main source of waste since it has high durability and is not biodegradable. This plastic waste is not properly disposed and may result in health problems such as cancer, genital problems in both humans and animals.[14] This plastic waste on coming in contact with water bodies breaks down. The aquatic animals mistake this for food resulting in deaths of a large number of fish and thus highly disturbing the aquatic life. Plastic waste in the form of municipal waste also contaminates the land and renders it useless for cultivation and other purposes. Many a times , this plastic waste is burned ,which results in harmful toxics getting discharged into the atmosphere thus causing harm to the environment.[15] Thus plastic is highly harmful to land, air as well as to the water bodies of earth. It is thus highly recommendable to find the alternatives of plastic and also a proper method for its disposal. One such method of disposal can be in the form of construction processes. For the last 20 years, trucks and other heavy vehicles have multiplied in percentage as well as volume. This has resulted in the increased demand for pavements with high service life and durability. In view of meeting this demand, investigations are being carried out with the help of new materials as additions to the already available construction processes. Also research works are being carried out to look for improvements in the properties of binder. The present study is based on a research for studying the "Effect of waste plastic on the deterioration of bituminous mixes in cold climates". The bitumen and plastic blend thus obtained will be used for construction of flexible pavements resulting in the improvement of their properties and also provide a safe means for disposal of highly harmful waste plastic. This use of Plastic for construction process is not new.[16] Polyvinyl chloride and High density polyethylene pipes already employ this idea of addition of plastic in the construction processes. The plastic roads help in prevention of Rutting by easing the tire pressures and also by distribution of activity loads throughout the surface.

5. Research Methodology
Evaluation of mixes shall be made using Marshall Method of Design. For this purpose various materials viz aggregates, binder, polythene, antistripping chemicals. Optimum binder content will be selected.Grading shall be done according to the specifications. The material to be used will be collected from the nearby area (Hot Mix Plant). The waste plastic material is then collected in the shredded form. Bitumen of grade VG-10 shall be used. Optimum binder content for normal mix shall be determined. Optimum plastic waste is kept as 7-8% for addition to the mix. Different samples having varying percentages of anti-stripping chemical as 0.5%, 0.75%, 1% are prepared. Optimum dosage of anti-stripping chemicals is determined. The effects on the mix by the addition of waste plastic and anti-stripping chemicals are examined by Marshall Stability Tests. Testing of Samples prepared with Waste Plastic will be done at 0°c. Samples shall be prepared by the addition of Waste plastic and anti-stripping chemicals. The samples are subjected to multiple cycles freeze thaw and then tested. The number of cycles can be 7, 14 or as suitable. The results obtained are then compared to examine the effects of addition of plastic and anti-stripping chemicals to the mix. From the above test information, the test outcomes might be investigated to make reasonable interpretation regarding our objective. The tests for the study will be completed at Civil Engineering Department, NITTTR Chandigarh.

6. RESULTS AND ANALYSIS
6.1. Required Value of Bituminous Mixes
Indian Road Congress has fixed certain guidelines for design of bituminous mixes which are given in "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS", MORTH (revision 5th) Show in table 1.1.

Table 1.1 Guidelines for Designing Bituminous Mixes

Properties	Required Values
Marshall Stability Value, KN	9
Flow	2-4
Air Voids	2-5
Marshall Quotient (Stability/Flow)	3-5
Minimum Voids in Mineral Aggregates(VMA) %	11-13
Voids Filled With Bitumen	65-75

6.2. Determination of Job mix formula for Bituminous Concrete control mix by Marshall Method.

The Grading of different aggregates was done for obtaining virgin mix. The results are as shown in table 1.2. After grading of aggregates, ratio of the blend is calculated. It was done by hit and trial method and the ratio used was 58:40:2

Table 1.2 Grading of Aggregates for Control Mix

IS Sieve Size	% passing (required)	% passing 19mm	% passing 13.2mm	% passing Stone dust	% passing Cement	Grading
19mm	90-100	89.75	100	100	100	97.54
13.2mm	59-79	13.05	99.5	100	100	78.979
9.5mm	52-72	1.85	78.7	100	100	69.2
4.75mm	35-55	0.05	5.05	96.8	100	45.665
2.36mm	28-44	0	0.05	75.05	100	32.037
1.18mm	20-34	0	0	62.35	100	26.94
600mm	15-27	0	0	47.95	100	21.18
300mm	10-20	0	0	34.1	99.2	15.62
150mm	5-13	0	0	20.05	98.5	9.99
75mm	2-8	0	0	34.6	99	7.8

6.2.1. Quantity of Aggregates used

After determining the ratio of aggregate blend, the quantity of aggregates required for the mix is calculated. This is given in table 1.3.

Table 1.3 Percentage and Quantity of Aggregates for Control Mix

Size of Aggregates	Percentage used	Weight of Aggregates(grams)
13.2	58%	696
Stone Dust	40%	480
Cement	2%	24

6.2.2. Quantity of Bitumen Used

Four different percentages of binder were chosen for making virgin mix and their quantities are as shown in table 1.4.

Table 1.4 Percentage and Quantity of Bitumen for Control Mix

Percentage of Bitumen	Weight of Bitumen (grams)
5.43%	69
5.66%	72
5.88%	75
6.1%	78

6.3. Marshall Stability Test results for Control Mix

Marshall Stability test result for control mix is show in table 1.5

Table 1.5 Marshall Stability Test results for Control Mix

Bitumen Content	5.43%	5.66%	5.88%	6.1%
Specific Gravity of Bitumen	1.0	1.0	1.0	1.0
Density (g/cc)	2.330	2.348	2.326	2.328
Specific Gravity of Aggregate Blend	2.68	2.68	2.68	2.68
Volume of Bitumen, V_b(%)	12.006	12.597	14.01	14.5
Volume of Aggregate, V_a(%)	82.21	82.65	81.68	81.56
Voids in Mineral Aggregate, VMA (%)	17.79	17.35	18.32	18.44
Voids Filled with Bitumen, VFB (%)	67.48	72.60	76.47	78.63
Air Voids, %	5.784	4.753	4.31	3.94
Stability, kg	1848	2038	1943	1914
Flow Value, mm	3.46	3.73	4.25	4.05

6.4. Determination of optimum binder content

After performing Marshall Stability Test, the optimum binder content was known to be 5.66%.The quantity of bitumen in accordance to its percentage was calculated as 72grams.

6.5. Determination of Job mix formula for Bituminous Concrete using Mix with Waste plastic bags 6%.

6.5.1. Quantity of aggregate used

The ratio which satisfies the grading requirements is selected. After deciding the ratio, the quantity of aggregates in accordance with the ratio is calculated. The quantity of aggregate used is shown in the table1.6.

Table 1.6 Percentage and Quantity of Aggregates for Mix with WPB 6%

Size of Aggregates	Percentage used	Weight of aggregate (grams)
13.2	54.52	654.24
Stone Dust	37.6	451.2
Cement	1.88	22.56
Waste Plastic Bags	6%	72

6.5.2. Quantity of Bitumen used

Two percentages of bitumen were selected for use in the mix. The quantities of the bitumen selected are shown in the table 1.7.

Table 1.7 Percentage and Quantity of Bitumen for Mix with WPB 6%

Percentage of Bitumen	Weight of Bitumen (grams)
5.43%	69
5.66%	72

6.6. Marshall Stability Test results for Mix with 6% WPB

Marshall Stability Test results for Mix with 6% WPB show in table 1.8.

Table 1.8 Marshall Stability Test results for Mix with 6% WPB

Bitumen Content	5.43%	5.66%	5.88%
Specific Gravity of Bitumen	1.0	1.0	1.0
Density (g/cc)	2.293	2.284	2.279
Specific Gravity of Aggregate Blend	2.557	2.557	2.557
Volume of Bitumen, V_b(%)	12.45	12.927	12.91
Volume of Aggregate, V_a(%)	84.80	84.26	84.15
Voids in Mineral Aggregate, VMA (%)	15.2	15.74	15.85
Voids Filled with Bitumen, VFB (%)	81.9	82.08	81.45
Air Voids, %	2.75	2.82	2.79
Stability, kg	2462.4	2885	2891
Flow Value, mm	3.812	3.98	4.412

6.7. Determination of Job mix formula for Bituminous Concrete using Mix with Waste plastic bags 7%.

6.7.1. Quantity of Aggregate used

The ratio which satisfies the grading requirements is selected. After deciding the ratio, the quantity of aggregates in accordance with the ratio is calculated. The quantity of aggregate used is shown in table 1.9.

Table 1.9 Percentage and Quantity of Aggregates for Mix with WPB 7%

Size of Aggregates	Percentage used	Weight of aggregate (grams)
13.2	53.94	647.28
Stone Dust	37.2	446.4
Cement	1.86	22.32
Waste Plastic Bags	7%	84

6.7.2. Quantity of Bitumen used

Three percentages of bitumen were selected for use in the mix. The quantities of the bitumen selected are shown in the table 1.10

Table 1.10 Percentage and Quantity of Bitumen for Mix with WPB 7%

Percentage of Bitumen	Weight of Bitumen (grams)
5.43%	69
5.66%	72
5.88%	75

6.7.3. Marshall Stability Test results for Mix with 7% WPB

Marshall Stability Test results for Mix with 7% WPB show in table 1.11.

Table 1.11 Marshall Stability Test results for Mix with 7% WPB

Bitumen Content	5.43%	5.66%	5.88%
Specific Gravity of Bitumen	1.0	1.0	1.0
Density (g/cc)	2.284	2.281	2.272
Specific Gravity of Aggregate Blend	2.557	2.557	2.557
Volume of Bitumen, V_b(%)	12.402	12.910	13.359
Volume of Aggregate, V_a(%)	84.473	84.15	83.62
Voids in Mineral Aggregate, VMA (%)	15.527	15.85	16.38
Voids Filled with Bitumen, VFB (%)	79.87	81.45	81.55
Air Voids, %	3.12	2.94	3.021
Stability, kg	2538	2991	3096
Flow Value, mm	4.61	4.8	4.85

6.8. Determination of Job mix formula for Bituminous Concrete using Mix with Anti stripping hemical.

6.8.1. Quantity of aggregate used

Table 1.12 Percentage and Quantity of aggregate for Mix with anti-stripping chemical

Size of Aggregates	Percentage used	Weight of aggregate (grams)
13.2	53.94%	647.28
Stone Dust	37.2%	446.4
Cement	1.86%	22.32
Anti-stripping chemical	0.5%	6
	0.75%	9
	1%	12
Waste Plastic Bags	6%	72

6.8.2. Quantity of Bitumen used

Only 1 percentage of bitumen was selected for use in the mix. The quantity of the bitumen selected is shown in the table1.13.

Table 1.13 Percentage and Quantity of Bitumen for Mix with anti-stripping chemical

Percentage of Bitumen	Weight of Bitumen (grams)
5.66%	72

6.8.3. Retained Marshall Stability Test results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB at 5.66% Bitumen content

Table 1.14 Retained Marshall Stability Test results for Control Mix, Mix with Anti- stripping chemical, mix with 6% WPB

Content	Anti-stripping chemical			Control mix	WPB (6%)
	0.5%	0.75%	1%		
Specific Gravity of Bitumen	1.0	1.0	1.0	1.0	1.0
Density (g/cc)	2.309	2.310	2.314	2.348	2.287
Specific Gravity of Aggregate Blend	2.557	2.557	2.557	2.68	2.557
Volume of Bitumen, V_b(%)	13.06	13.07	13.10	13.28	12.944
Volume of Aggregate, V_a(%)	85.19	85.22	85.39	85.65	84.37
Voids in Mineral Aggregate, VMA (%)	14.81	14.78	14.61	17.35	15.63
Voids Filled with Bitumen, VFB (%)	88.18	88.43	89.66	76.54	82.81
Air Voids, %	1.75	1.71	1.51	4.07	2.70
Retained Marshall Stability, kg	2493.5	2493.5	2512	1389	2506
Flow Value, mm	4.61	4.8	4.85	3.5	3.73

6.9. Observations from Retained Marshall Stability Test results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB at a bitumen content of 5.66%.

6.9.1. Air Voids

The maximum Air Voids are present in Control mix i.e. 4.07. The least amount of Air voids are present in mix having 1% of anti-stripping chemical i.e. 1.51. The mix with 6% WPB has an air void percentage of 2.7. Show in fig 2.

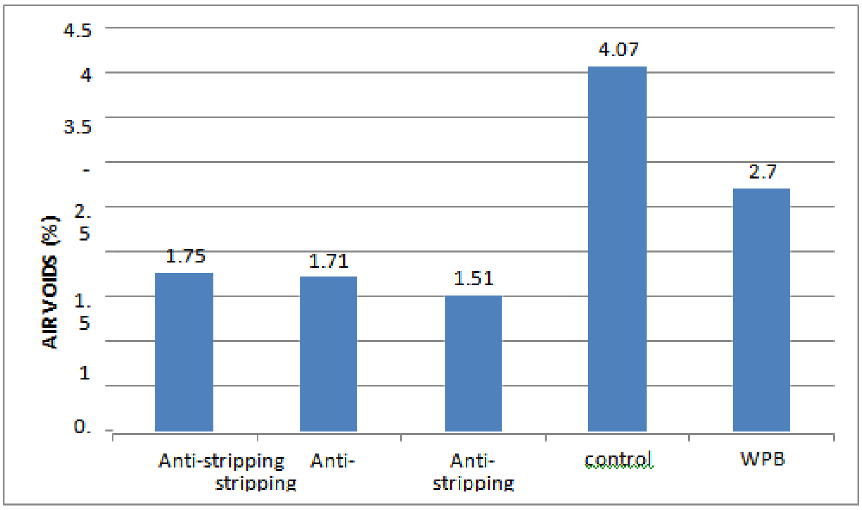

Figure 2 Comparison between Air Void results for Control Mix, Mix with various % of Anti-stripping chemical, mix with 6% WPB at bitumen content.

6.9.2. Density-

The maximum Density is exhibited by Control mix i.e. 2.348. The least amount of Density is present in mix with 6% WPB having a density of 2.287.The mixes with anti-stripping chemicals exhibit a density of 2.309, 2.31 & 2.314 for 0.5%, 0.75% and 1% respectively show in fig 3.

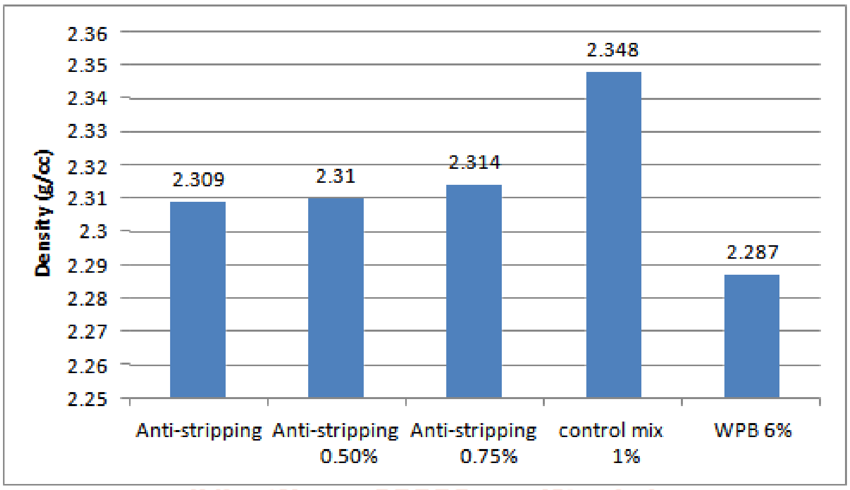

Figure 3 Comparison between Density results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB.

6.9.3. Retained Marshall Stability-

The maximum Retained Marshall Stability is exhibited by mix with waste plastic and anti- stripping chemical percentage 1% i.e. 2506 kg. The least amount of Retained Marshall Stability is shown by control mix having 1389 kg. The mix with 6% WPB has a Retained Marshall Stability value equal to 2506 kg show in fig 4.

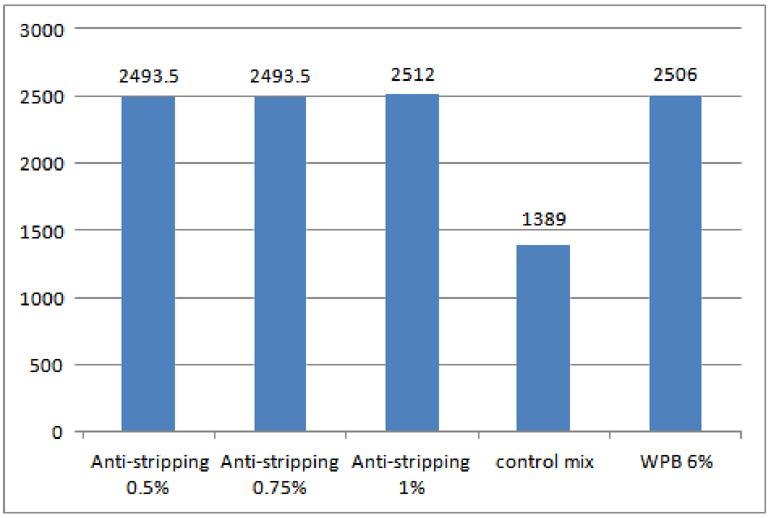

Figure 4 Comparison between Retained Marshall Stability results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB.

6.9.4. Flow Value-

The maximum Flow Value is exhibited by mix with waste plastic and anti-stripping chemical percentage 1% i.e. 4.85 mm. The least amount of Flow Value is shown by control mix having 3.5mm. The mix with 6% WPB has a Flow value equal to 3.73mm show in fig 5.

6.10. Tests results after Repetitive Freeze Thaw cycles (3,7 and 14 days)

Samples were made using job mix formula for control mix at bitumen content of 5.66%, mix with 6% WPB & mixes with two different percentages of anti-stripping chemicals viz 0.5% and 0.75%.Samples were subjected to repeated freeze thaw cycles for 3,7 and 14 days. The results of tests performed are as:

6.10.1. Marshall Stability Test results for Control Mix, Mix with various percentages of Anti- stripping chemical, mix with 6% WPB after 3 repeated Freeze thaw cycles.

Marshall Stability Test results for Control Mix, Mix with various percentages of Anti- stripping chemical, mix with 6% WPB after 3 repeated Freeze thaw cycles show in table 1.15.

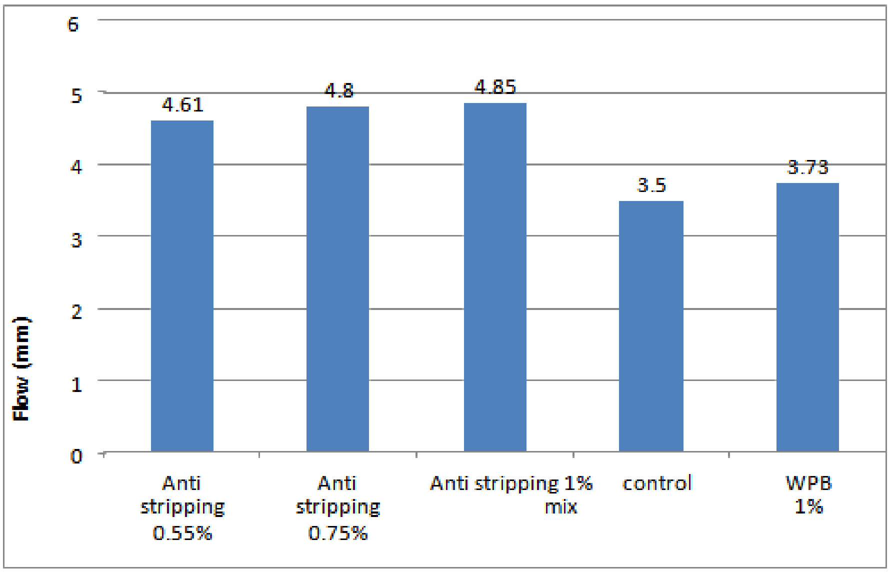

Figure 5 Comparison between Flow value results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB at bitumen content of 5.66%.

Table 1.15 Marshall Stability Test results for Control Mix, Mix with Anti-stripping chemical, mix with 6% WPB

Bitumen Content	Anti-stripping chemical		Control mix	WPB 6%
	0.5%	0.75%		
Specific Gravity of Bitumen	1.0	1.0	1.0	1.0
Density (g/cc)	2.303	2.327	2.34	2.285
Specific Gravity of Aggregate Blend	2.557	2.557	2.68	2.557
Volume of Bitumen, V_b(%)	13.03	13.187	13.170	12.933
Volume of Aggregate, V_a(%)	84.96	85.96	81.91	84.30
Voids in Mineral Aggregate, VMA (%)	15.04	14.04	18.09	15.7
Voids Filled with Bitumen, VFB (%)	86.63	93.92	72.80	82.37
Air Voids, %	2.01	1.853	4.92	2.76
Stability, kg	1482	1658	1368	2342
Flow Value, mm	2.92	2.78	2.65	3.4

6.10.2. Marshall Stability Test results for Control Mix, Mix with various percentages of Anti- stripping chemical, mix with 6% WPB after 7 repeated Freeze Thaw cycles.

Table 1.16 Marshall Stability Test results for Control Mix, Mix with Anti-stripping chemical, mix with 6% WPB

Bitumen Content	Anti-stripping chemical		Control mix	WPB 6%
	0.5%	0.75%		
Specific Gravity of Bitumen	1.0	1.0	1.0	1.0
Density (g/cc)	2.303	2.330	2.327	2.285
Specific Gravity of Aggregate Blend	2.557	2.557	2.68	2.557
Volume of Bitumen, V_b(%)	13.03	13.187	13.170	12.933
Volume of Aggregate, V_a(%)	84.96	85.96	81.91	84.30
Voids in Mineral Aggregate, VMA (%)	15.04	14.04	18.09	15.7
Voids Filled with Bitumen, VFB (%)	86.63	93.92	72.80	82.37
Air Voids, %	2.01	1.853	4.92	2.76
Stability, kg	1202.7	1368	1007	2003
Flow Value, mm	2.72	2.63	2.55	3.1

6.10.3. Marshall Stability Test results for Control Mix, Mix with various percentages of Anti- stripping chemical, mix with 6% WPB after 14 repeated Freeze Thaw cycles.

Table 1.17 Marshall Stability Test results for Control Mix, Mix with Anti-stripping chemical, mix with 6% WPB

Bitumen Content	Anti-stripping chemical		Control mix	WPB 6%
	0.5%	0.75%		
Stability, kg	792	854	613	1524
Flow Value, mm	2.61	2.58	2.47	2.96

6.11. Observations from Marshall Stability Test results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB after 3 Freeze Thaw cycles.

6.11.1. Air Voids-

The maximum Air Voids are present in Control mix i.e. 4.92. The least amount of Air voids are present in mix having 0.75% of anti-stripping chemical i.e. 1.853. The mix with 6% WPB has an air void percentage of 2.76 show in fig 6.

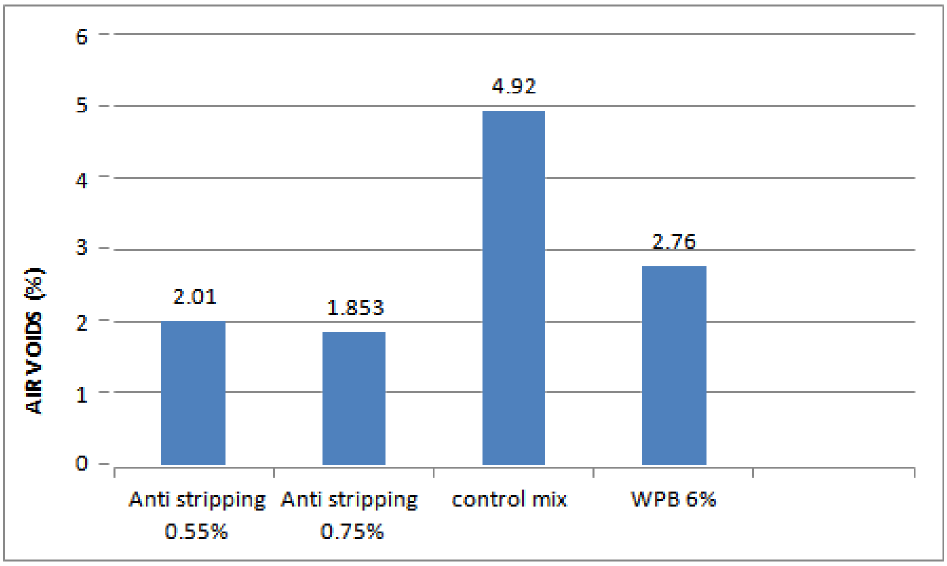

Figure 6 Comparison between Air Void results for Control Mix, Mix with various % of Anti-stripping chemical, mix with 6% WPB after 3 Freeze Thaw cycles

6.11.2. Density

The maximum Density is exhibited by Control mix i.e. 2.340. The least amount of Density is present in mix having 0.5% of anti-stripping chemical i.e. 2.303. The mix with 6% WPB has a density of 2.285. Show in fig 7.

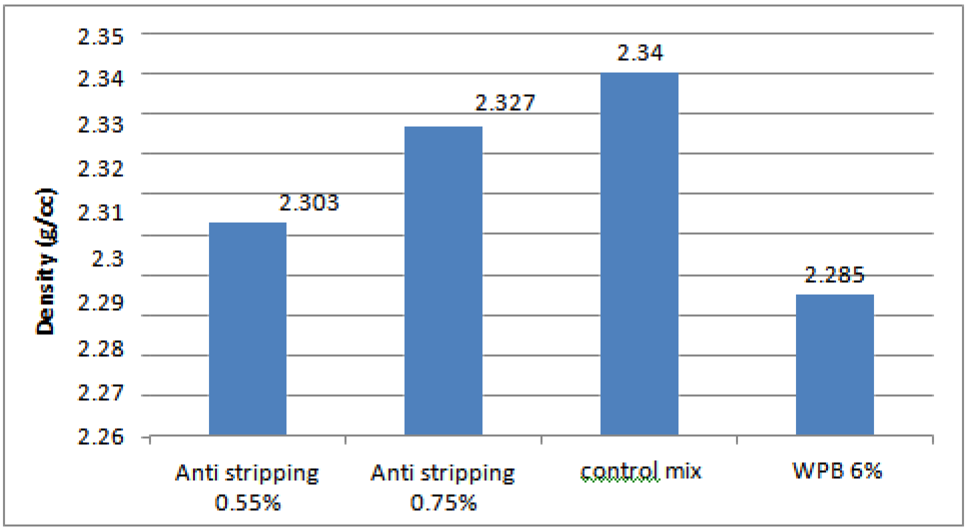

Figure 7 Comparison between Density results for Control Mix, Mix with various % of Anti-stripping chemical, mix with 6% WPB after 3 Freeze Thaw cycles

6.11.3. Stability

The maximum Marshall Stability is exhibited by mix with WPB 6% i.e. 2342 kg. The least amount of Retained Marshall Stability is shown by control mix having 1368 kg. The mixes with 0.5%& 0.75% Anti stripping chemical have Marshall Stability values equal to 1482 kg& 1658 kg respectively show in fig 8.

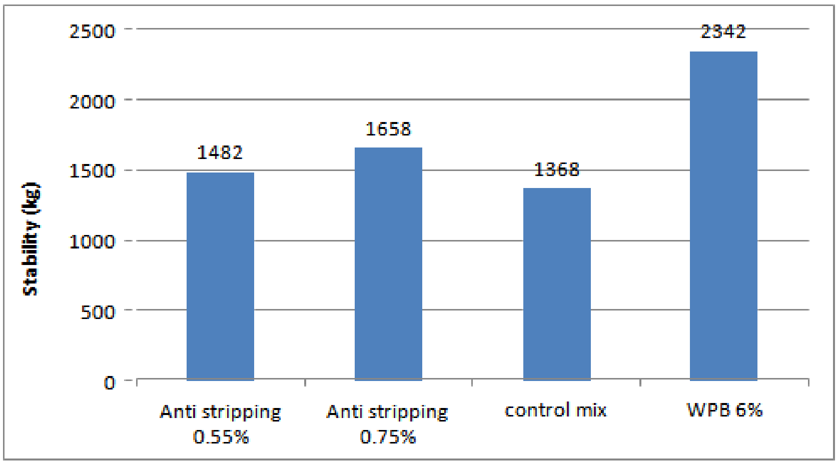

Fig 8 Comparison between Stability results for Control Mix, Mix with various % of Anti-stripping chemical, mix with 6% WPB after 3 Freeze Thaw cycles

6.11.4. Flow

The maximum Flow Value is exhibited by mix with WPB 6% i.e. 3.4mm. The least amount of Flow Value is shown by control mix having flow value 2.65mm. The mixes with 0.5% and 0.75% anti stripping chemical have Flow values equal to 2.92mm and 2.78mm respectively. Show in fig 9.

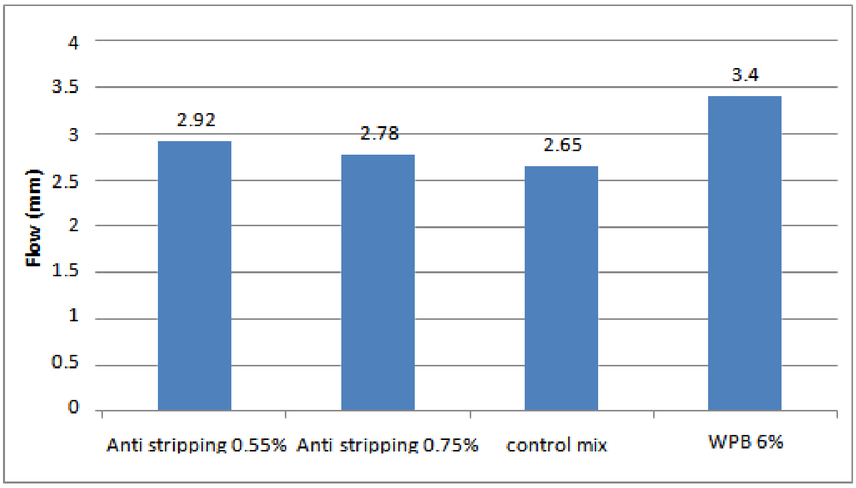

Figure 9 Comparison between Flow value results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB after 3 Freeze Thaw cycles

6.12. Observations from Marshall Stability Test results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB after 7 Freeze Thaw cycles.

6.12.1. Stability

The maximum Marshall Stability is exhibited by mix with WPB 6% i.e 2003 kg. The least amount of Retained Marshall Stability is shown by control mix having 1007 kg. The mixes with 0.5% & 0.75% Anti stripping chemical have Marshall Stability values equal to 1203 kg & 1368 kg respectively show in fig 10.

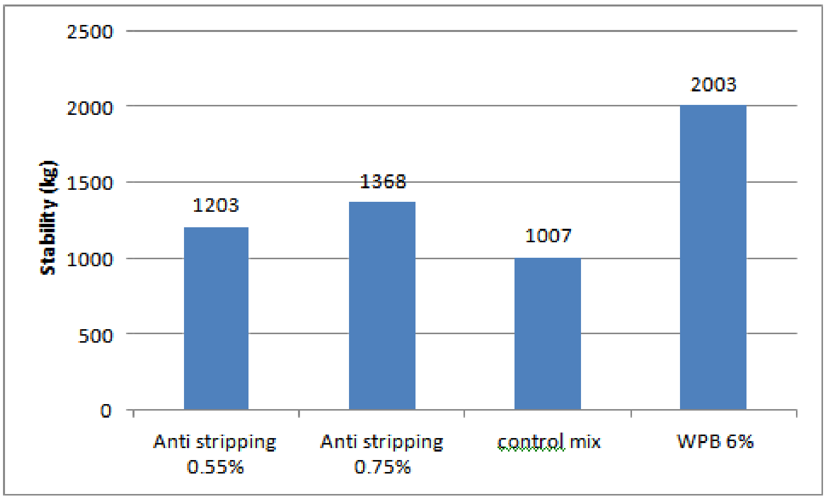

Figure 10 Comparison between Stability results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB after 7 Freeze Thaw cycles

6.12.2. Flow
The maximum Flow Value is exhibited by mix with WPB 6% i.e. 3.1mm. The least amount of Flow Value is shown by control mix having flow value 2.55mm. The mixes with 0.5% and 0.75% anti stripping chemical have Flow values equal to 2.72mm and 2.63mm respectively show in fig 11.

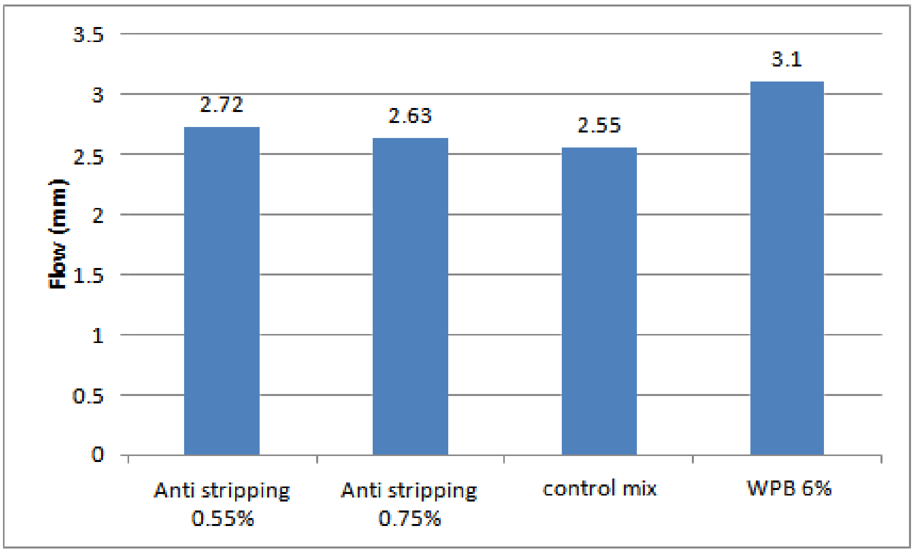

Figure 11 Comparison between Flow value results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB after 7 Freeze Thaw cycles

6.13. Observations from Marshall Stability Test results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB after 14 Freeze Thaw cycles.

6.13.1. Stability
The maximum Marshall Stability is exhibited by mix with WPB 6% i.e 1524 kg. The least amount of Retained Marshall Stability is shown by control mix having 613 kg. The mixes with 0.5% & 0.75% Anti stripping chemical have Marshall Stability values equal to 792 kg & 854 kg respectively.

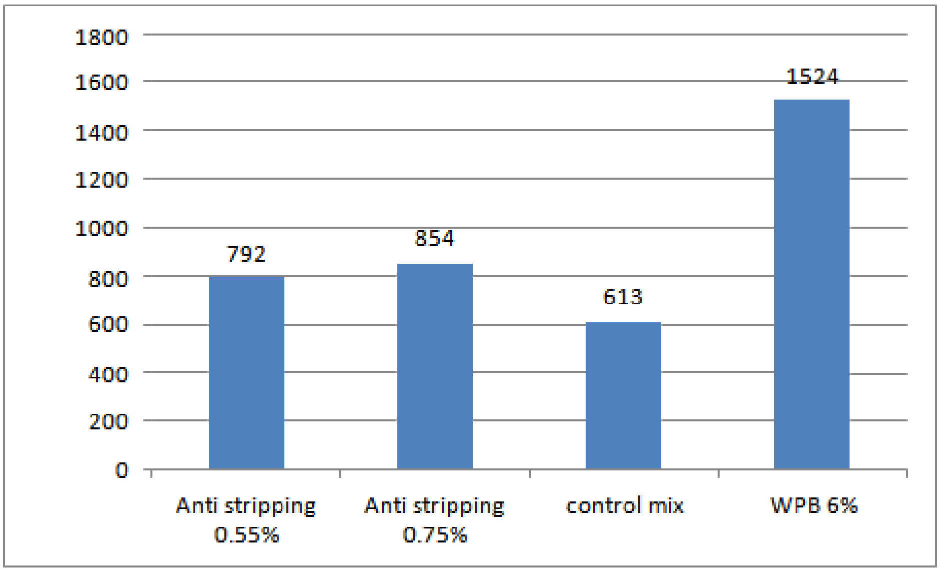

Figure 12 Comparison between Stability value results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB after 14 Freeze Thaw cycles

6.13.2. Flow
The maximum Flow Value is exhibited by mix with WPB 6% i.e. 3.1mm. The least amount of Flow Value is shown by control mix having flow value 2.55mm. The mixes with 0.5% and 0.75% anti stripping chemical have Flow values equal to 2.72mm and 2.63mm respectively. Fig13 Comparison between Flow value results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB after 14 Freeze Thaw cycles

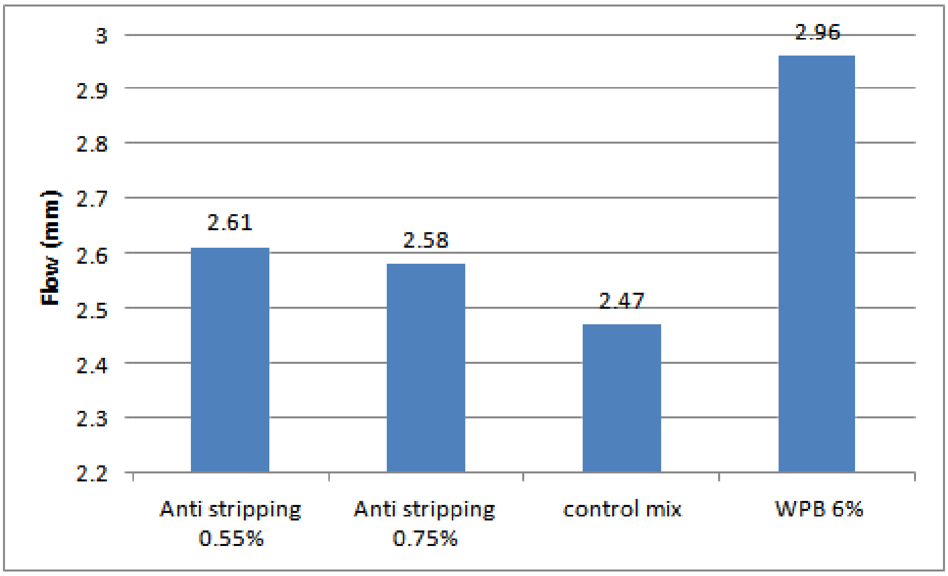

Figure 13 Comparison between Flow value results for Control Mix, Mix with various percentages of Anti-stripping chemical, mix with 6% WPB after 14 Freeze Thaw cycles

7. CONCLUSIONS

After thoroughly studying the results, Mixes having waste plastic bags can be utilized in the construction of BC pavements. Mixes with 6% WPB and 7% WPB show good results and can hence replace aggregate in virgin mixes. The optimum amount of WPB for mix in BC was found to be 6% at a bitumen content of 5.66%It was observed that after comparing the results of the mixes prepared by the addition of both Anti stripping material with Varying percentages and WPB, and the mixes containing only WPB, the latter provided better results in terms of Retained Marshall stability and Marshall Quotient. The retained stability of control mix was found to be about 75% from the Standard value whereas for mix with both anti stripping and WPB and for mix with WPB only, it was above 85%.The comparative study of the results obtained for mixes with varying percentages of anti-stripping material, mix with 6% WPB and control mix after 3,7 & 14 repeated Freeze Thaw cycles also indicate much better Stability and Marshall quotient values for Mix with 6%WPBThe Standard value for control mix was considered to be the mix prepared with a bitumen content of 5.66%. The standard for WPB was considered prepared with 5.66% binder and 6% waste plastic. After being exposed to 3 Repetitive Freeze Thaw cycles, the control mix exhibited stability values around 72% of the Standard value, the mix with 0.5% & 0.75% anti striping chemical showed stability values around 77% and 80% respectively, whereas the mix with 6%WPB showed stability values higher than 85% of the standard value. After being exposed to 7 Repetitive Freeze Thaw cycles, the control mix exhibited stability values around 53% of the Standard value, the mix with 0.5% & 0.75% anti striping chemical showed stability values around60% and 65% respectively, whereas the mix with 6%WPB showed stability values higher than 72% of the standard value. Also the mix with 6% WPB after 7 repetitive Freeze Thaw cycles exhibited similar stability values as shown by Control mix with 5.66% bitumen under ideal conditions. It is observed from the results that exposure to moisture and repetitive Freeze Thaw cycle highly affects the durability of life of pavements. Exposure to 7 Repeated Freeze Thaw cycles can reduce the strength of a pavement by 50%.By exposing the mix to 14 repetitive Freeze Thaw cycles, majority of the Stability is lost by the both Control Mix and Mix with anti-stripping chemical of varying percentages. The mix with 6% plastic waste lost around 50% of the Stability exhibited under standard conditions. But still had Stability value of over 1500 kg. The mix with 6% Plastic after 14 Freeze Thaw cycles exhibited a Stability value of about 75% as exhibited by Control Mix under Standard conditions. By subjecting the mixes to Freeze Thaw cycles and then comparing the results obtained with the Values of mixes under ideal conditions, a parameter for evaluation of strength and durability can be established in cold regions.

From the results, it can be concluded that mixes with 6% WPB have greater durability and Strength as compared to the mixes with Anti stripping chemical and also control mix. Also WPB mixes are cheaper due to easy availability of waste plastic. It was observed that control mix after being subjected to repeated Freeze Thaw cycles can lose more than 50% of its original strength; hence modification to the mix should be done by addition of 6% WPB which highly enhances the strength of the mix. The mixes with 6% WPB even after 7 Freeze exhibit stability values similar to that of control mix under ideal conditions. Thus, it can be concluded that 6% WPB should be added to the mix for use in places having low day and night temperatures.

8. REFERENCES

[1] **Ahmadinia E., Zargar M., Karim M. R., Abdelaziz M.**, "Performance evaluation of utilization of waste Polyethylene Terephthalate (PET) in stone mastic asphalt," *Constr. Build. Mater.*, vol. 36, pp. 984–989, 2012.

[2] **Awwad M.T. and Shbeeb L.**, "The use of polyethylene in hot asphalt mixtures," *Am. J. A ppl.Sci.*,vol. 4, no. 6, pp. 390–396, 2007.

[3] **BinduC. S and Beana K. S**, "Influence of Additives on the Characteristics of Stone Matrix asphalt," *Int. J. Res. Eng. Technol.*, vol. 3, no. 7, pp. 83–88, 2014.

[4] **Chavan M.**, "Use of Plastic Waste in Flexible Pavements," *International Journal of Application or Innovation in Engineering & Technology*, vol. 2, no. 4, pp. 540–552, 2013.

[5] **Gawande A., Zamare G., RengeV. C., Tayde S., and Bharsakale G.**, "An overview on waste plastic

utilization in Asphalting of roads," *J. Eng. Res.*, vol. III, no. II, pp. 1–5, 2012.

[6] **Ghorpade M. R** "A Study of Enhancement of Bituminous Mix by Use of Modifiers," *Imperial Journal of Interdisciplinary Research,* vol. 2018, no. 1, 2018.

[7] **Gundaliya P. J.,** "Utilization Of Waste Polyethylene Materials In Bituminous Concrete Mix For Improved Performance Of Flexible Pavements," *Indian Journal Of Applied Research* Vol.1 Issue 12 . pp. 2–3, September, 2012.

[8] **Herndon D.**, "Moisture Susceptibility of Asphalt Mixes Using Phosphonylated Recycled Polyethylene," 2009.

[9] **Karim R., Islam N., Sajjad M. and Habib A**. "Polyethylene, a potential solution to strength loss of bituminous pavement under water", *International symposium on geodisasters, infrastructure management and protection of world heritage sites,* pp. 204-207, 2013.

[10] **Moghaddam T. B, Karim M. R., and Soltani M.,** "Utilization of waste plastic bottles in asphalt mixture," *J. Eng. Sci. Technol.*, vol. 8, no. 3, pp. 264–271, 2013.

[11] **Rajasekaran S., Vasudevan R., Samuvel P.,** "Reuse Of Waste Plastic coated Aggregate-Bitumen Mix Composite For Road Application-Green Method," *American Journal of Engineering research* e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-02, Issue-11, pp-01- ,2013.

[12] **Sabina, Khan Tabrez A, Sangita, Sharma DK & Sharma BM**, "Performance Evaluation Of Waste Plastic/Polymer Bituminous Concrete Mix," J*ournal Of Scientific & Industrial Research* Vol. 68,Nov 2009, pp. 975-979.

[13] **Sangita, Reena, and Verinder . K,** "A Novel Approach to Improve Road Quality by Utilizing Plastic Waste in Road Construction," *J. Environ. Res. Dev.*, vol. 5, no. 4, pp. 1036–1042, 2011.

[14] **Soni K. and Punjabi K. K**, "Improving the Performance of Bituminous Concrete Mix by Waste Plastic .,"*Int. Journal of Engineering Research and Applications,* vol. 3, no. 5, pp. 863–868, 2013.

[15] **Sreedevi B. G., Salini P. N.,"**Pavement performance studies on roads surfaced using bituminous mix with plastic coated aggregates,"*Int. Journal of Engineering Research & Technology* ISSN: 2278-0181 vol. 2 issue 9, September - 2013

[16] **ThakurShivani and Duggal A. K.,** "Review on Reutilization of Plastic Waste in Paving Mixes.," *Int. J. Res. App. Sci. & Eng. Technol.,* vol. 5, no.Viii, pp. 1156–1159, 2017.

[17] **Verma S. S.,** "Roads from plastic waste," *Indian Concr. J.*, vol. 82, no. 11, pp. 43–44, 2008.