EXPERIMENTAL STUDY OF BITUMINOUS MIXES CONTAINING WASTE PLASTIC WASTE AS AN ADMIXTURE SUBJECTED TO COLD WEATHERE CLIMATE

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Abstract

This research was focused to modify and improve the performance of bitumen mixes in low temperatures region by using waste plastic bags (WPB) as an additive in pavement. Mixes with 7% WPB and 7% WPB show praising results can be used as a substitute in aggregate virgin mixes. The minimum amount of WPB for mix in bituminous concrete (BC) was found to be 7% at a bitumen content of 6.67%. The stability of control mix was found to be about 75% from the standard value, whereas for the mix with both anti-stripping & WPB and for mix with WPB only, it was more than 85%. This shows that mixes with 7% WPB have extra durability and strength in comparison to the mixes with anti-stripping chemical and controlled mix. Also, WPB mixes are economical due to the availability of plastic waste, it is noticed that control mix after being subjected to repeated freeze thawing cycles can lose greater than 50% of its original strength. Hence modification to the mixture can be done by means of addition of 7% WPB which gives the required strength.

Keyword: Performance, Mixes, Bituminous, Stability, strength.

1.0: Introduction

Use of plastic in bituminous mixes can be of importance in curtailing the extra damage to roads in cold weather conditions. Waste plastic roads were used in a few components of the us of a with a varying degree of success. Waste plastic roads have numerous advantages over ordinary roads which can be of wonderful significance in these parts of the USA. Despite the fact that a huge amount of labor has been achieved through addition of waste plastic to the bitumen mixes, little expertise approximately the performance of such mixes in harsh climatic and snowy conditions affords a broader scope to exactly achieve results on this regard and accordingly understand the advantages and de merits of the use, if any. Some applicable research and studies executed on usage of waste plastic for cold climate areas are as follows:

(Awwad and Shbeeb 2007) Claimed that the modified mixture taken into consideration to have higher balance and VMA fee in contrast with the non-modified blends and has effect without delay to the rutting protection of combinations. It changed into brought by means of their finding that editing the asphalt blend with HDPE polyethylene complements its homes greater while as compared with LDPE polyethylene. (Herndon, 2009) Examined dampness vulnerability of asphalt combination making use of phosphorylated reused polythene. They confirmed that there is a big lower in dampness susceptibility by means of addition of reused unmodified polyethylene to asphalt concrete mixtures in both the Wet Procedure and the Dry Process. According the work of (Chavan, 2013) Plastic waste was replaced in vicinity of mixture for higher overall performance of pavement. This becomes attributes in supplying an improved quantity of bitumen containing plastic as an admixture. The polymer delivered decreases the voids gift in the blend, which prevents the dampness absorption and oxidation of bitumen by captured air. They concluded that, using plastic waste in mixture will reduce quantity of bitumen by using 12%, in addition to boom the first-rate, performance and in the end increase a green innovation. The review work of (Gawande et, al., 2012) on waste plastic utilization in pavement in both wet and dry technique. It was concluded by them that modified bitumen with a content of waste plastic addition of 5-12% by weight of bitumen provides a longer life span and performance of pavement. (Ghorpade, 2018) Found out that the concurrent motion and high visitors quantity of industrial vehicles, over-burdening of vans and varieties in daily temperature of the pavement were taken into consideration as the main elements causing rutting, cracking, bleeding, shoving and potholing at the bituminous surfacing. (Ahmadinia, et, al., 2012) Conducted a sequence of laboratory take a look at to make use of massive amount of waste plastic bins as an admixture to stone mastic asphalt (SMA). Wheel monitoring, dampness weakness, bulk modulus and drain down assessments have been conducted with the special percentage of those at zero%, 3%, five%, 7%, 10% and 12% by weight of bitumen content. Their result suggests that during cooperating such waste into the combo has ended in beneficial outcome on the houses of SMA that can enhance the mixture's safety in opposition to perpetual misshaping (rutting), increment the energy of the combination, provide low binder drain down in addition to recycling the waste product as a bonus.

(Gundaliya, 2012) Suggests that the system of enhancing of bitumen with waste polythene provide higher methods in protecting the pavement from safety from splitting, pothole arrangement and rutting by using improving softening factor, hardness and diminishing stripping because of water, on this manner improving the general execution and performance of roads over a drawn out stretch of time. As indicated by using them the waste polythene used inside the mixture shapes protecting over aggregates of the blend which lessens porosity, ingestion of dampness and complements binding property. (Karim et, al., 2013) Check out the overall performance of bituminous mixture with polyethylene admixture and revealed that bitumen blends with polyethylene plays better whilst as compared with conventional bituminous combination when submerged beneath water. Also shielding the earth from infection will be a unique reward. (Soni and Punjabi 2013), Found that with using waste plastic aiming at improving the overall performance of bituminous concrete aggregate, this waste plastic changed bitumen combination gives better binding assets, balance, stiffness, thickness and impermeability to water. Their end result shows that the waste polythene used in the mixture will give lessens porosity, retention of moisture and complements binding belongings of the mixture. The bitumen adjusted with 4.5% Polythene waste is taken into consideration to be optimal indicating better performance when compared with traditional blends. (Moghaddam et, al., 2013) confirmed that the use of waste material in asphalt pavement would be promising for the benefit life of asphalt pavement and reduces ecological contamination. Their result indicates that Polyethylene Terephthalate (PET) fortified blends have higher stability value, flow, and weariness life when compared with themixtures without PET. (Rajasekaran et, al., 2013) revealedthat the reuse of waste Plastics Coated Aggregates- Bitumen Mix Composite for Road Application by Green Method. The sample showed higher Marshall Stability values ranges between 18 to 20KN and the load bearing capacity of the road is increased as well. (Sangita and Verinder, 2011) Proposed a way for managing enhancing the exceptional of pavement through using plastic waste. As it turned into indicated by means of them India spends Rs 35,000 crores a year on road development and maintenance, such as Rs 100,000 crores each year simplest to upkeep serviceability and handiest through bitumen roads continues going 2-3 instances longer, with a view to spare us Rs 33,000 crores a yr in upkeep. (Bindu and Beana 2014) Provided the end result in their studies on how the waste plastic behaves whilst introduced as a stabilizer in Stone Mastic Asphalt, the blends had been subjected to exams which consist of Marshall Stability, rigidity, compressive electricity assessments and Tri-axial tests. The result indicated that that bendy pavement of high durability and extra performance can be attained with the highest quality addition of 12% shredded plastic. (Sabina, et, al., 2009) Evaluated the comparative overall performance of properties of bituminous mixes containing plastic/polymer (PP) (10% and 15% through the weight of bitumen) with conventional bituminous blend. Extremely good improvement in houses which include Marshall Stability, Retained Stability, Indirect Tensile Strength and Rutting turned into discovered in PP modified bituminous concrete mixes. Thus, waste PP modified bituminous concrete mixes are expected to be more long lasting, much less at risk of moisture. It was revealed from the studied conducted by (Sreedevi and saline, 2013) on roads surface using bituminous mixwith plastic coated aggregates. Laboratory research suggests that the Marshall Stability fee of bituminous mixes increase through 1.5 to 2 times by using Plastic Coated Aggregates. Also, quantity of bitumen may be decreased by means of extra than 12% by using weight. (Thakur and Duggal 2017) concluded that changing the reused cloth in pavement production will enhance the overall performance of the road and decrease the construction fee of the road. (Verma, 2008) Taken into consideration that plastic expands the factor of melting of the bitumen and makes the road flexible amid winters bringing approximately its long existence.

The quantity of waste plastic to be had provides one of the first-rate to be followed for editing the content material of bitumen mixes. This could lead to a giant discount within the renovation and restore prices or even the development cost of pavement. Hence the present look at offers with enhancing the homes of modified mixes with waste plastic bags (WPB).

2.0 : Materials

For this study various materials utilized are:

VG10 binder, Plastic waste, and aggregates. Plastic waste was used in shredded form.

i. Waste plastic: the waste plastic was obtained from Chandigarh industrial estate.

ii. Cement: OPC was used for addition to the mixes. Aggregates:

iii. Aggregate: The size of aggregate utilized was 13.2 mm and stone dust was used.

3.0: Methodology

For this cause of this examine, bitumen mixes have been made the usage of Marshall Method of Design. Various materials viz: aggregates, binder, polythene, anti- stripping chemical substances. Also, most fulfilling binder content material turned into selected. The paintings executed for this study was achieved in numerous stages. Determination of Bituminous

Concrete control blend and using Waste Plastic Bags with various chances (7%, 8%). As properly as for Bituminous Concrete by utilizing anti-stripping chemical with varying probabilities (0.5%, 0.75%, and 1%) by means of the usage of Marshall Method at the same time as Repetitive Freezing and Thawing of samples with plastic having both plastic and anti-stripping chemical of varying chances (0.5%, 0.75%), and manage mix for 3, and seven days turned into also decided.

4.0 : Results and Analysis

4.1 : Properties of Various Materials Utilized in the Study

In order to meet the requirements as per MORTH (revision 5th), various types of tests were performed on thematerials. The results obtained as a result of these tests are indicated in the following table:

Table 1.0: Physical Properties of Aggregates

S/No.	Physical Properties	Values	Requirements as per MORTH
1	Specific Gravity	2.73	2.6-2.8
2	Elongation Index (%)	10.45	Max 30% (combined)
3	Flakiness Index (%)	10.85	
4	Impact Value (%)	18.3	Max 25%
5	Water Absorption (%)	0.73	Max 3%
6	Stripping Value (%)	3.54	<5%

Table 2.0 Physical Properties of Binder

Binder: The bitumen used was VG 10 grade. The results of the tests performed are given in the following table

S/No.	VG-10 Grade			Test Method
	Properties	Determined	Required	
1	Penetration	92	80-100	IS: 1203-1978
2	Softening point	43.51	40 min.	IS: 1205-1978
3	Specific gravity	1.10	0.99 min.	IS: 1202-1978

4.2 The Aggregate Grading

The Grading of different aggregates was done for obtaining virgin mix. The results are as shown in followingtable:

Table 3.0: Grading of Aggregates for Control Mix

IS SieveSize	% Passing (required)	% Passing 19mm	% Passing13.2 mm	% PassingStone dust	% Passing Cement	Grading
19mm	90-100	86.75	100	100	100	97.54
13.2mm	59-79	11.05	99.5	100	100	78.979
9.5mm	52-72	1.85	78.7	100	100	69.2
4.75mm	35-55	0.35	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	100	15.62
150mm	5-13	0	0	20.05	99.5	9.99
75mm	2-8	0	0	34.6	99	7.8

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After grading of aggregates, ratio of the blend is calculated. It was done by hit and trial method and the ratio usedwas 58:40:2

4.3 : Marshall Stability

Table 4.0: Marshall Stability Test results for Control Mix

Bitumen Content	**5.43%**	**5.70%**	**5.87%**	**6.5%**
Specific Gravity of Bitumen	1.10	1.10	1.10	1.10
Density (g/cc)	2.50	2.32	2.31	2.32
Specific Gravity of Aggregate Blend	2.36	2.36	2.36	2.36
Volume of Bitumen, Vb (%)	11.86	11.93	12.46	14.34
Volume of Aggregate, V_a (%)	80.03	79.40	78.74	78.50
Voids in Mineral Aggregate, VMA (%)	16.86	16.93	17.43	1794.
Voids Filled with Bitumen, VFB (%)	62.35	68.43	70.35	72.00
Air Voids, %	5.23	4.67	4.40	4.20
Stability, kg	1769	1890	1890	1935
Flow Value, mm	3.54	3.80	4.10	3.90.

Table 5.0: Marshall Stability Test results for 7% WPB

Bitumen Content	**5.43%**	**5.70%**	**5.87%**
Specific Gravity of Bitumen	1.10	1.10	1.10
Density (g/cc)	2.74	2.56	2.32
Specific Gravity of Aggregate Blend	2.30	2.30	2.30
Volume of Bitumen, Vb (%)	11.75	11.93	12.30
Volume of Aggregate, V_a (%)	79.70	79.86	80.43
Voids in Mineral Aggregate, VMA (%)	14.43	14.80	15.13
Voids Filled with Bitumen, VFB (%)	78.70	79.42	78.70
Air Voids, %	3.10	2.93	3.20
Stability, kg	2143	2321	2567
Flow Value, mm	4.12	4.75	4.31

Table 5.0: Marshall Stability Test results for 7% WPB

Bitumen Content	**5.43%**	**5.70%**	**5.87%**
Specific Gravity of Bitumen	1.0	1.0	1.0
Density (g/cc)	2.93	2.53	2.47
Specific Gravity of Aggregate Blend	2.30	2.30	2.30
Volume of Bitumen, Vb (%)	11.94	12.01	12.30
Volume of Aggregate, V_a (%)	80.37	81.00	82.35
Voids in Mineral Aggregate, VMA (%)	14.23	14.34	15.45
Voids Filled with Bitumen, VFB (%)	79.87	81.45	81.55
Air Voids, %	3.56	3.67	3.45
Stability, kg	2345	2458	3678
Flow Value, mm	4.21	4.34	4.41

Determination of optimum binder content After performing Marshall Stability Test, the optimum binder contentwas known to be 5.70%. The quantity of bitumen in accordance to its percentage was calculated as 72grams.

4.4 : Marshall Stability Test results for Control Mix, mix with various percentages ofAnti-stripping chemical, mix with 7% WPB of different Freeze Thaw cycles.

Table6.0: Retained Marshall Stability Test results for Control Mix, mix with various percentages of Anti-strippingchemical, mix with 7% WPB at 5.67% Bitumen content

	Anti-stripping chemical			**Control mix**	**WPB (7%)**
Parameters	0.5%	0.75%	1%		
Specific Gravity of Bitumen	1.10	1.10	1.10	1.10	1.10
Density(g/cc)	2.309	2.310	2.314	2.348	2.287
Specific Gravity of Aggregate Blend	2.30	2.30	2.70	2.70	2.70
Volume of Bitumen,Vb(%)	11.93	11.73	12.30	12.30	12.43
Volume of Aggregate,V_a(%)	80.20	80.73	81.21	81.21	82.30
Voids in Mineral Aggregate, VMA (%)	12.31	12.18	12.62	12.86	14.34
Voids Filled with Bitumen, VFB (%)	82.21	81.42	84.21	78.21	83.34
Air Voids, %	1.23	1.81	1.52	4.21	2.63
Retained Marshall Stability, kg	2321	2339	2357	1781	2423
Flow Value, mm	4.34	4.97	4.82	3.4	3.71

Table 7.0: Marshall Stability Test results for Control Mix, mix with various percentages of Anti-stripping chemical, mix with 7% WPB after 3 and 7 repeated Freeze Thaw cycles.

	3 Repeated Freeze Thaw Cycles.				**7 Repeated Freeze Thaw Cycles.**			
Parameters	**Anti-stripping chemical**		**Controlmix**	**WPB7%**	**Anti-stripping chemical**		**ntrolmix**	**VPB7%**
	0.5%	0.75%			0.5%	0.75%		
Specific Gravity of Bitumen	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Density(g/cc)	2.41	2.43	2.34	2.32	2.21	2.31	2.28	2.27
Specific Gravity ofAggregate Blend	2.30	2.30	2.70	2.30	2.30	2.30	2.70	2.30
Volume ofBitumen, Vb (%)	11.92	11.87	11.86	12.21	11.67	11.56	11.86	12.47
Volume of Aggregate,V_a (%)	81.62	81.96	82.91	82.30	81.96	82.60	82.46	82.23
Voids in Mineral aggregate,VMA (%)	13.45	12.93	12.76	12.74	13.36	12.35	12.45	15.67
Voids Filledwith Bitumen, VFB (%)	83.21	84.21	76.81	83.74	82.34	89.21	76.78	83.76
Air Voids, %	1.99	1.74	4.34	2.63	2.21	1.78	4.75	2.45
Stability, kg	1482	1658	1368	2342	1202.7	1368	1007	2003
Flow Value, mm	2.92	2.78	2.65	3.4	2.72	2.63	2.55	3.1

After being exposed to 3 Repetitive Freeze Thaw cycles, the control mix exhibited stability values around 73% 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 7%WPB showed stability values higher than 85% of the standard value. While 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 around 60% and 65% respectively, whereas the mix with 7%WPB showed stability values higher than 73% of the standard value. Also, the mix with 7% WPB after 7 repetitive Freeze Thaw cycles exhibited similar stability values as shown by Control mix with 5.67% bitumen under ideal conditions.

5.0. Conclusions

The mixes with 7% WPB have more sturdiness and Strength as compared to the mixes with each control and mixes containing anti-stripping chemical. Also, WPB mixes are fine as compared with the traditional bitumen substances due to the supply and abundance of waste plastic bag. It became located that manage mix subjected to repeated Freeze Thaw cycles loses greater than 50% of its authentic strength; as a result, amendment to the mix should be done via addition of 7% WPB which contributed in improving the electricity of the mixture. The mixes with 7% WPB at 7 Freeze thawing cycles reveals balance values much like that of manage blend under perfect conditions. Thus, it is able to be concluded that 7% WPB should be added to the mixture for the application in low-temperature region.

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