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ECO-SUSTAINABLE PAVEMENT: AN EXPERIMENTAL EXPLORATION OF EMPLOYMENT OF WASTE PLASTIC AS A PARTIAL SUBSTITUTION FOR BITUMEN

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Abstract
This research is about studying how bituminous mix behaves and performs. Bituminous mix is a combination of coarse and fine aggregates, bitumen and filler material. This study modifies the traditional bituminous mix by adding polymer to it, i.e. plastic. This research focuses on sustainability by reducing the use of naturally obtaining materials and utilizing waste materials which can harm the environment. There are specific guidelines for bituminous mixes outlined in IRC: 29-1988 specification for bituminous mix (Asphalt mix) for road pavement and the Ministry of Road Transport and Highway Authority in India (MORTH). Everything in this research study follows the instructions mentioned in IRC and MORTH. Bituminous mixes are used in the top layer of flexible pavements. Bituminous binders are commonly used in the road construction industry. Pavement with hard surfaces is generally divided into two main types: flexible pavement and rigid pavement.

Keywords: Bitumen, pavement, plastic, bituminous mix.

Introduction
The amount of people living in cities is more. Therefore, there is more development and the lifestyles of people are changing. This has resulted in the increasing amount of plastic waste in regular trash, i.e. municipal solid waste. This is causing a lot of plastic to end up as litter everywhere. To deal with this, this study explored using some of this plastic waste instead of the usual materials to make roads.

Aim and objective of the study
The aim of the current study is to utilize the waste plastic generated by the mankind in bituminous road pavement and reduce the harmful effects on the environment as well as the human society. To accomplish this aim, the current study focuses on the following objectives:
1. To minimize the load on municipal treatment systems by using the waste plastic in bituminous pavements.
2. To check the optimum amount of waste plastic that can be used as the replacement.
3. To make the pavement non porous to prevent the formation of potholes.
4. To enhance the life of the pavement.
5. To increase the performance of the pavement and resistance to wear and tear.

Literature review
Using a mix of polymer and bitumen as a binder for roads is better than using just ordinary bitumen. This combination has a higher softening point, lower penetration value and right amount of flexibility. When it is used in road construction, it can handle higher temperatures and heavy loads. Coating the mixture with plastic makes it less porous, reduces moisture absorption and improves its strength. Asphalt containing plastic creates a stronger material for making flexible pavements. This mix also has a higher marshal stability value. So, using plastic waste in flexible pavement is a great way to easily get rid of plastic waste. [1]
Instead of just throwing away plastic, a smart way can be found to use it. This not only solves the problem of disposal, but also helps the environment by reducing pollution. It turns out that plastic works well as a binder used for flexible pavements. This clever approach can help the pavements

handle higher temperatures better, preventing cracks and reducing the chances of rainwater penetration causing potholes. These pavements also show better resistance to crushing and abrasion. [2]
When certain types of plastics and polymers are mixed with bitumen, modified bitumen is obtained. These plastics can come from recycled waste, natural sources, or other suitable materials. When more polymer is added, bitumen becomes harder and its penetration value is decreased. [3]

Methodology

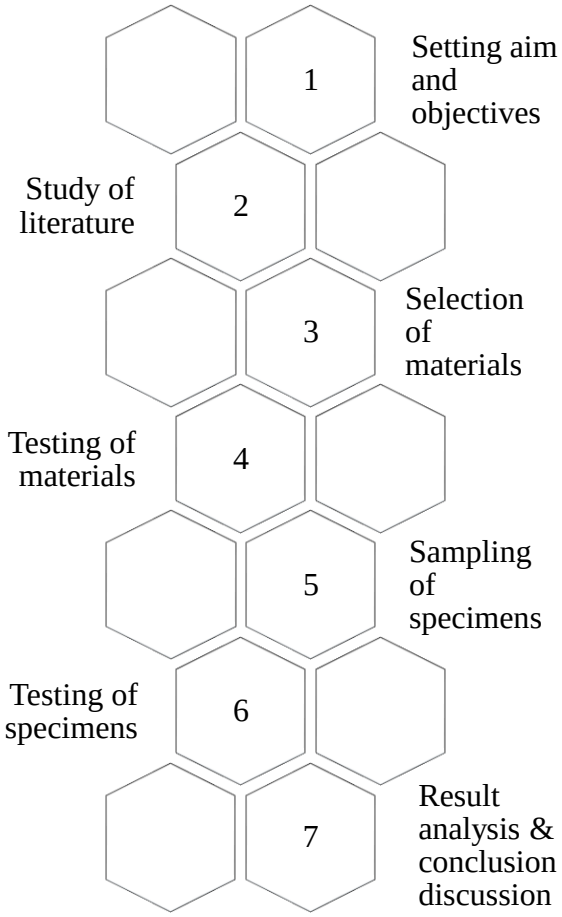

Figure 1. Order of methodology

Experimental Analysis
5.1. Selection of materials: The following materials were selected for the experimental exploration of the study:
5.1.1. Plastic: Waste plastic including single use plastic bags, bottles, wrappers, etc.
5.1.2. Aggregates:
Size – 6 mm, 10 mm, 20 mm, and rock dust
Tests for 20 mm aggregates: Water absorption (IS:2386 Part III-1963) – 14%
Aggregate Impact Value (IS:2386 Part IV-1963) – 13.9
Aggregate Crushing Value (IS:2386 Part IV-1963) – 17.4
5.1.3. Bitumen:
Penetration Value (IS:1203-1978) – 46 mm (Penetration grade 40-60)
Ductility Value (IS:208-1978) – 56.33 mm (Minimum 50 mm)
Softening Point Value (IS:1205-1978) – 58.4º C
Flash Point Value (IS:1209-1978) – 239.67 º C
Fire Point Value (IS:1209-1978) – 252.33 º C

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Viscosity Value – 3739.98 Poise (Viscosity grade 40)
Specific Gravity Value (ASTM D70) – 1.015

5.2. Preparation of specimens: The following steps were involved in the preparation of specimens:
The ingredients were sampled in the following quantities:
Total weight of sample = 1200 gm
Aggregates = 1146 gm (95.2 %)
In which,
Dust = 456 gm (38 %)
6 mm aggregates = 300 gm (25 %)
10 mm aggregates = 234 gm (19.5 %)
20 mm aggregates = 156 gm (13 %)
Bitumen = 54 gm (4.5 %)
Waste plastic = 4.32 gm (8 % of weight of bitumen)
The following steps were involved in the preparation of specimens:

1. The specimens were prepared using the dry process of making bituminous mix.
2. Total 7 number of specimens were prepared out of which one specimen was of traditional mix, i.e. 0% of waste plastic.
3. The other specimens included 2%, 4%, 6%, 8%, 10% and 12% waste plastic by the weight of bitumen respectively.

5.3. Testing of specimens: All the specimens were tested using the Marshall Stability method.

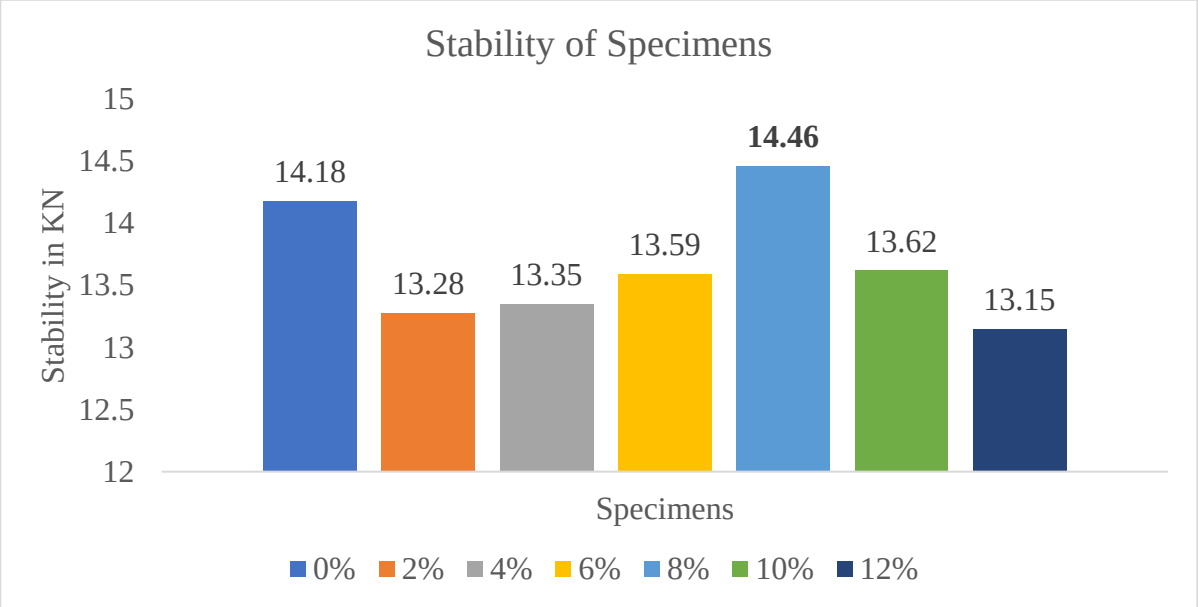

Figure 2. Comparison of the stability of specimens with different percentage of waste plastic in bitumen

Table 1. Marshall Stability (ASTM-D1559) observation readings of the specimen containing 8% waste plastic by the weight of bitumen

Sample no.		1	
% bitumen by weight of mix		Pb	4.5
Specimen no.		1	
Specimen height		mm	60.23
	In air	A	1024.1

Wt. of specimen (g)	In water	B	566.1
	SSD in air	C	1027.1
Volume of specimen		D = (C - B)	461
Bulk sp. Gravity of specimen		Gmb = (A / D)	2.221
Max. sp. Gravity of specimen		Gmm = Pmm / [(Ps / Gse) + (Pb / Gb)]	2.607
VIM (%)		VIM = [(Gmm - Gmb) / Gmm] x 100	14.82
VMA (%)		VMA = 100 - [Gmb x (100 - Pb) / Gsb]	24.46
VFB (%)		VFB = (VMA - VIM) / VMA x 100	39.41
Stability	Proving ring reading	F	230
	Marshall stability (KN)	G = (F x CF)	15.06
	Correction factor	H	0.96
	Corrected stability (KN)	I = (G x H)	14.46
Flow (mm)			2.5

Result Analysis and Discussion

1. According to the marshal stability test procedure, the stability of the specimens with 0%, 2%, 4%, 6%, 8%, 10% and 12% turned out to be 14.8 KN, 13.28 KN, 13.35 KN, 13.59 KN, 14.46 KN, 13.62 KN and 13.15 KN respectively.
2. The results show an increase in the stability when 2%, 4%, and 6% waste plastic was added in the mix.
3. It reaches its highest value when 8% waste plastic is added in the mix.
4. The stability decreases when the percentage of waste plastic by the weight of bitumen in the mix exceeds 8%.

Conclusion

1. The optimum content of bitumen content was found out to be 4.5%.
2. It is concluded that up to 8%, use of waste plastic in the bituminous mix has improved the results.
3. This study suggests a partially reliable alternative to the conventional materials used in the construction of bituminous pavements.
4. It is seen that use of waste plastic as a modifier is a good choice which also enhances the performance of roads.
5. It can also be concluded that the formation of potholes and seepage of water can be prevented by using waste plastic in bituminous mixes.

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