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EXPERIMENTAL STUDY OF BITUMEN PAVEMENT WITH USE OF PLASTIC WASTE

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Abstract: The quick rise of many sorts of industries, as well as the rapid growth of the population, has resulted in a massive increase in waste pollution. Plastic waste is one of the several types of pollution that has become a severe concern. When mixed with bitumen, the plastic waste improves the mechanical qualities of the bitumen, especially road mix bitumen. Plastic blend bitumen has been proved in laboratory tests to be a better binding material. Marshall must control plastic waste in bitumen at various percentages (0, 2, 4, 6, and 8%). The stability test is used to imitate field conditions. The goal of this research is to determine the optimal percentage of bitumen that can be added by plastic garbage.

The use of waste plastic in bituminous mixes has demonstrated that the mix's qualities are improved, and disposal issues are alleviated to some extent. Using a shredding machine, the cleaned plastic waste is broken into pieces small enough to fit through a 2.36 mm sieve. After heating the aggregate mixture, the plastic is efficiently covered over the particles. To make the task mix formula, these plastic waste coated aggregates are blended with hot bitumen. The employment of modern technologies will not only boost road building, but will also increase road life and assist to minimize pollution in the environment. The purpose of this research is to look into the usage of waste plastic as a modifier for semi-dense bituminous mix. Plastic waste is mixed with hot aggregate, and the plastic modified mix contains 0%, 2%, 4%, 6%, and 8% plastic by weight of bitumen. It has been discovered that adding 6% plastic waste to the mix raises the Marshall stability value. The addition of plastic waste to the bituminous mix increases the other Marshall parameters as well.

Keywords: VG40 bitumen, plastic waste, Marshall stability test.

I. INTRODUCTION

According to recent studies, plastics can stay unchanged for as long as 4500 years on earth with increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by each household. Plastic in different forms is found to be almost 5% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas to find empty plastic bags and other type of plastic packing material littering the roads as well as drains. Due to its biodegradability, it creates stagnation of water and associated hygienic problems in order to contain this problem experiments have been earned out whether this waste plastic can be reused productively. Many research works indicated that the waste plastic. when added to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate. when mixed with the binder is found to give higher strength, higher resistance to water and better performance over a period of time.

Waste plastic such as carry bags. disposable cups and laminated products like chips. aluminium foil and packing material used for biscuits. chocolates, and milk and grocery items can be used for surfacing roads.

Use of plastic along with the bitumen in construction of roads not only increase its life and smoothness but also makes it economically sound and environment friendly. Plastic waste is used as modifier of bitumen to improve some of bitumen properties roads that are constructed using plastic waste are known as plastic roads and are found to perform better compared to those construction with conventional bitumen.

Under this circumstance, an alternate use for the waste plastics is the need of the hour. In this study to the Marshall properties of bituminous mixes have been found when plastic wastes are incorporated into them. Plastic in different forms is found to be almost 5% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas to find empty plastic bags and other type of plastic packing material littering the roads as well as drains. Due to its biodegradability, it creates stagnation of water and associated hygiene problems. In order to overcome this problem research has been carried out whether this waste plastic can be reused productively. The experimentation at several institutes indicated that the waste plastic, when added to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength, higher resistance to water and better performance over a period of time.

Use of higher percentage of plastic waste reduces the need of bitumen by 10%. It also increases the strength and performance of the road. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes.

Flexible pavement:

Flexible pavement will transmit wheel load stresses to the lower layers by grain-to-grain transfer through the granular structure. Flexible pavement consists of four layers that are subgrade with existing soil, sub base, base course, surface course or pavement course or wearing course. Mix design is the process of choosing optimum content of stabilized various ingredients of the pavement. The general principle of mix design is that the mixture should provide satisfactory performance when constructed in the desired position of sub-grade. Design proportions of ingredients are generally based on analysis of the effect of various proportions on selected properties of mix. Before the design of pavement check the properties of aggregates. In this report mainly the hydrated lime is added in bitumen so the properties of bitumen are safe or not by different methods.

Plastic waste as construction material:
The debate on the use of and abuse of plastics vis-a-vis environmental protection can go on. without yielding results until practical steps are initiated at the grassroots level by everyone who is in a position to do something about the plastic wastes could be used in road construction on the field tests withstood the stress and proved that plastic wastes used after proper processing as an additive would enhances the life of the roads and also solve environmental problems. The present write-up highlights the developments in using plastic wastes to make plastic roads. The rapid rate of urbanization and development has led to increase plastic waste. As plastic non-biodegradable in nature. it remains in environment for several years and disposing.

Plastic waste at land fill is unsafe since toxic chemicals leach out into the soil, and underground water and pollute the water bodies. Due to littering habits, in adequate waste management system infrastructure, plastic waste disposal continues to be major problem for the civic authorities, especially in the urban areas. As stated above. plastic disposal is one of the major problems for developing countries like India.

DIFFERENT TYPE OF WASTE PLASTIC (POLYMER) AND ITS ORIGIN:

Table 1. Types of Plastic Waste

Type of waste plastic (polymer)	Origin
Low density polyethylene (LDPE)	bags, sacks, bin lining and squeezable detergent bottles etc
High density polyethylene (HDPE)	bottles of pharmaceuticals, disinfectants, milk, fruit juices, bottle caps etc
Polypropylene (PP)	bottle cap and closures, film wrapping for biscuits, microwave trays for ready-made Meals etc.
Polystyrene (PS)	yoghurt pots, clear egg packs, bottle caps.
Foamed Polystyrene	food trays, egg boxes, disposable cups, protective packaging etc
Polyvinyl Chloride (PVC)	mineral water bottles, credit cards, toys, pipes and gutters; electrical fittings, etc

II.METHODOLOGY

Collection of samples:

Bitumen (VG40):

Bitumen is a black or dark coloured solid or viscous cementitious substance having an adhesive property. And it consists chiefly high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt. And also, it is a semi-solid hydrocarbon product produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process. Bitumen is used as binders in pavements constructions.

Aggregates :

Aggregate is a broad category of course to medium grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. The aggregate serves as reinforcement to add strength to the overall composite material. In this project, we have used Aggregates of Grading II with sieve specification 20mm, 9.5mm, 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm, 0.15mm, 0.075mm.

Plastic Waste :

Waste plastics heating soften at around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Moreover, the softened plastics have a binding property. Hence, the molten plastics materials can be used as a binder and/or they can be mixed with binder like bitumen to enhance their binding property. This may be a good modifier for the bitumen, used for road construction.

Figure 1. HDPE waste

TESTS REQUIRE FOR KNOWING PROPERTIES AGGREGATE AND BITUMEN :

Following tests were conducted to investigate the properties of the aggregate as well as bitumen.

TESTS ON AGGREGATES:
These below methods can be used to determine the aggregates properties like toughness, Crushing strength, Hardness, Sp.gravity, elongation.
1. Impact test [IS2386 (PART-IV)-1963]
2. Crushing test [IS2386 (PART-IV)-1963]
3. Water absorption test [IS2386 (PART-III)-1963]
4. Specific gravity test [IS2386 (PART-III)-1963]

5. Los Angeles abrasion test [IS2386 (PART-IV)-1963]
6. Shape test [IS2386 (PART-I)-1963]

TESTS ON BITUMEN:

These below methods can be used to determine the bitumen properties like ductility, hardness, softening point.

1. Ductility test (IS1208-1978)
2. Penetration test (IS1203-1978)
3. Softening point test (IS1205-1978)
4. Stripping test

Figure 2. Ductility testing of Bitumen

III. RESULTS & DISCUSSION

In this section, the results of various tests conducted on various materials were presented in the form of tables and graphs**.** Discussion of result is also provided**.**

Results for aggregates (AS PER IRC27-1967)

Table 2. Results for aggregates

S.NO	Test name	Obtained value%	Permissible limit %
1	Impact test	24	30
2	Crushing test	26	30
3	Abrasion test	21.6	30
4	Sp. gravity test	2.75	2.5-3.0
5	Water Absorption test	1.78	2
6	Shape test(flakiness)	13.8	15
7	Shape test(elongation)	12.4	15

Results for bitumen (USE CRMB60 AS PER IS154622004):

Discussion: The above aggregate results show with in the permissible limits. Hence it is suitable for road construction.

Table 3. Results for bitumen with 0% addition of plastic waste

S.NO	Test name	Obtained value	Permissible value (IS15462-2004)
1	Ductility test(cm)	78cm	≮50cm
2	Penetration test(mm)	37mm	< 50mm
3	Softening point test(°c)	52°c	35°c to 70°c ≮ 40°c
4	Stripping test(%)	5%	Max.25%

Discussion: The above results show the Ductility, Penetration, softening point are within the limits.

Table 4. Results for bitumen with 2% addition of plastic waste

S.NO	Test name	Obtained value
1	Ductility test(cm)	79.5
2	Penetration test(mm)	35
3	Softening point test(°c)	54

Discussion: The comparison of this test results shows the properties of bitumen improved by 2% addition of plastic waste than the plain bitumen.

Table 5. Results for bitumen with 4% addition of plastic waste

S.NO	Test name	Obtained value
1	Ductility test(cm)	82
2	Penetration test(mm)	33.5
3	Softening point test(°c)	55

Discussion: The comparison of this test results shows the properties of bitumen improved by 4% addition of plastic waste than the plain bitumen.

Table 6. Results for bitumen with 6% addition of plastic waste

S.NO	Test name	Obtained value
1	Ductility test(cm)	83.5
2	Penetration test(mm)	31
3	Softening point test(°c)	57

Discussion: The comparison of this test results shows the properties of bitumen improved by 6% addition of plastic waste than the addition of 4% plastic waste.

Table 7. Results for bitumen with 8% addition of plastic waste

S.NO	Test name	Obtained value
1	Ductility test(cm)	81
2	Penetration test(mm)	33
3	Softening point test(°c)	56

Discussion: The comparison of this test results shows the properties of bitumen reduced by 8% addition of plastic waste than the addition of 6% plastic waste.

Result for Marshall Stability Test with Graph:

Table 8. Results for Marshall Stability test

Bitumen mix	Stability, kg	Flow value, mm	Unit weight, (Gram/cc)	Air voids (%),	VFB (%),
Bitumen+0%plastic	1792.30	2.50	2.52	3.84	85
Bitumen+2%plastic	2269.70	2.70	2.55	4.24	83.97
Bitumen+4%plastic	2390.25	3.00	2.57	4.33	83.65
Bitumen+6%plastic	2439.85	3.30	2.61	4.48	83.23
Bitumen+8%plastic	2314.65	3.20	2.56	4.33	83.7

Discussion: The above results that are evident from that use of plastic waste gives the better results than the plain bitumen. The 6% plastic waste gives maximum stability value and high flow value than the other percentages shown in above graph.

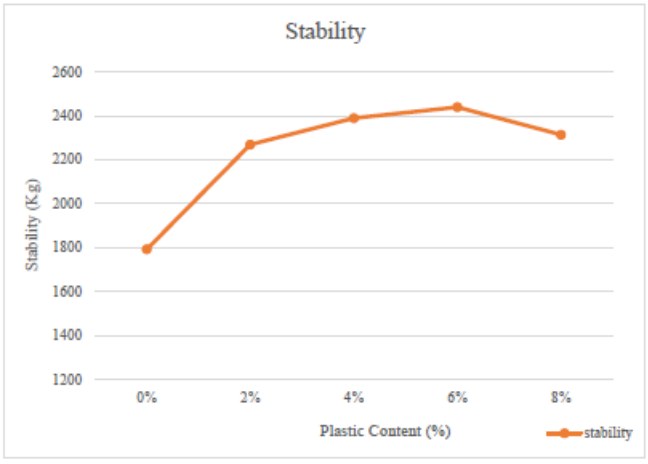

Figure 3. Plotting curve between plastic waste(%) vs Stability(kg)

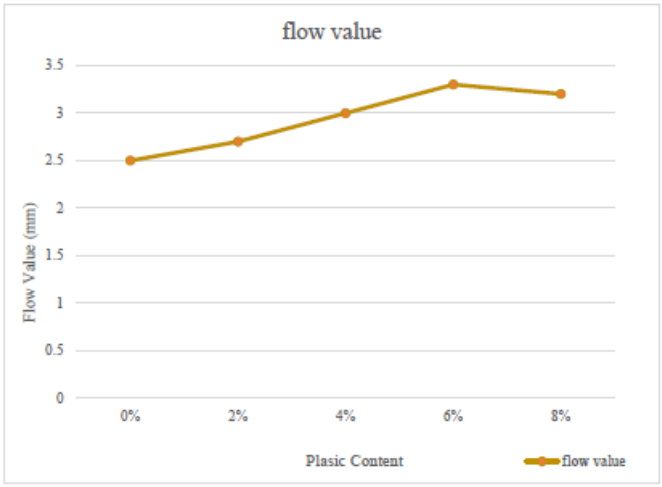

Figure 4. Plotting curve between plastic waste (%) vs flow value (mm)

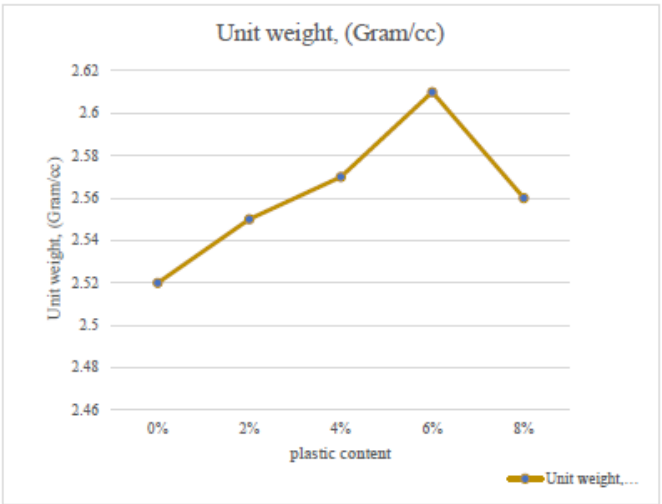

Figure 5. Plotting curve between plastic waste (%) vs Unit weight, (Gram/cc)

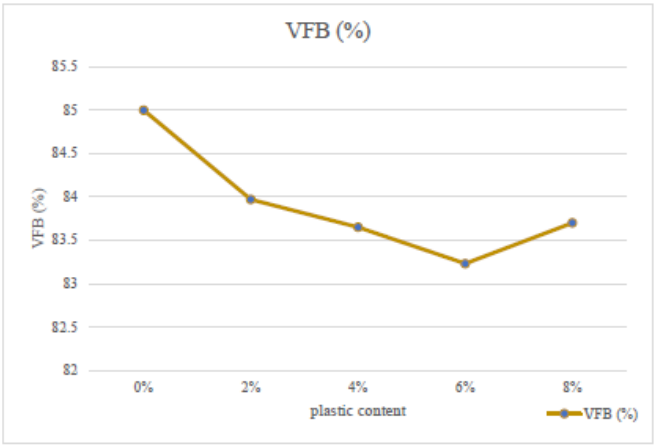

Figure 6. Plotting curve between plastic waste (%) vs VFB (%)

IV. CONCLUSIONS

Plastic Mix on Aggregate Is Used for Better Performance of Roads. This Helps to Have a Better Binding of Bitumen with Plastic Waste Mix on Aggregate Due to Increased Bonding and Increased Area of Contact Between the Polyethylene Terephthalate(Pet) In Plastic Waste and Bitumen. The Plastic Mix Also Reduces the Voids. This Prevents the Moisture Absorption of Bitumen by Entrapped Air. This Has Reducing , Rutting , Ravelling and There Is No Pothole Formation. This Roads Can Withstand Heavy Traffic and Show Better Durability.

Following are some points which are drawn from the study :

1. The aggregate impact test revealed that the value of the control specimen was 24 percent. This demonstrates that the aggregate's toughness was improved to withstand the impacts.
2. The crushing value of the control specimen was 26%.As the crushing fraction is low, the low aggregate crushing value implies strong aggregates.
3. Because of the mixing plastic, the specific gravity of aggregate increases from 2.75 for the control specimen to 2.80.
4. Plastic waste is mixed with hot aggregate, and the plastic modified mix contains 0%, 2%, 4%, 6%, and 8% plastic by weight of bitumen. It has been discovered that adding 6% plastic waste to the mix raises the Marshall stability value. The addition of plastic waste to the bituminous mix increases the other Marshall parameters as well.
5. Los Angeles and water absorption the control specimen's abrasion value was discovered to give the hardness of the aggregate.

In short, we can conclude that, using plastic waste in mix will help reduction in need of bitumen by around 6% increase the strength and performance of road, avoid use of anti-stripping agent, avoid disposal of plastic waste by incineration and land filling and ultimately develop a technology, which is eco-friendly. Increased traffic condition will and are reducing the life spans of roads. Plastic roads are means of prevention and

ultimately will he the cure. It will save millions of dollars in future and reducing the amount used for construction.

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11. IS codes: • IRC 27-1967 specification for road aggregates

• IS 2386(PART-IV)-1963 for Impact Test

• IS 2386(PART-IV)-1963 for Crushing test

• IS 2386(PART-IV)-1963 for Los Angeles Abrasion Test

• IS 2386(PART-I)-1963 for Shape test

• IS 2386(PART-III) for sp. gravity and water absorption test

• IS 1208-1978 for Ductility test

• IS 1205-1978 for Softening point test

• IS 1203-1978 for Penetration test

• IS 6241-1971 for Stripping value test

• IRC 111-2009 for Marshall stability test

