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Modification of Bituminous Pavement with Use of Plastic Waste: A Review Paper

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ABSTRACT-

India generates 1,88,000 tons of garbage every day. Plastic Waste in different forms is found to be almost 9% to 12% 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. Roads using plastic waste have been constructed through simple process innovation in various states like Tamil Nadu, Karnataka, Himachal Pradesh and to a lesser degree in Goa, Maharashtra and Andhra Pradesh. The concept of "Use of Plastic Waste in Road Construction" was implemented in 2001 as a solution to the serious problem of disposal of Plastic Waste in India. The utilization of plastic waste in bituminous mixes

Key Words: Plastic waste ,Strength ,bituminous

1. INTRODUCTION

Plastic pollution has become one of the most pressing environmental issues, as rapidly increasing production of disposable plastic products overwhelms the world's ability to deal with them. Plastic pollution is most visible in developing Asian and African nations, where garbage collection systems are often inefficient or non-existent. But the developed world, especially in countries with low recycling rates, also has trouble properly collecting discarded plastics.

Plastic trash has become so ubiquitous it has prompted efforts to write a global treaty negotiated by the United Nations.

Plastic is a polymeric material-that is, a material whose molecules are very large, often resembling long chains made up of a seemingly endless series of interconnected links. Natural polymers such as rubber and silk exist in abundance, but nature's "plastics" have not been

implicated in environmental pollution, because they do not persist in the environment

Today, however, the average consumer comes into daily contact with all kinds of plastic materials that have been developed specifically to defeat natural decay processes-materials derived mainly from petroleum that can be moulded, cast, spun, or applied as a coating. Since synthetic plastics are largely non-biodegradable, they tend to persist in natural environments.

Given the global scale of plastic pollution, the cost of removing plastics from the environment would be prohibitive. Most solutions to the problem of plastic pollution, therefore, focus on preventing improper disposal or even on limiting the use of certain plastic items in the first place.

Plastic is the most widely used material in present times, because of its cheap price and its durability. As plastic is a non-biodegradable material it takes around thousands of years to degrade. Since the disposal of waste plastic is the major concern nowadays in India. New

effective waste management option needs to be considered especially on revcling concepts

This project presents the result of investigation to study performance of bituminous pavement with plastic waste mixed with bitumen.

Bitumen plays an important role in binding the aggregate together by coating over the aggregate thereby imparting strength to the road. However, due to poor resistance towards water and high costs involved, there is a demand for high quality bitumen at low costs. This can be accomplished by modifying the rheological properties of bitumen by using additives such as

plastic or rubber

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Financial benefits resulting from the implementation of plastic roads and the resulting longevity of roads are key drivers for the roll out. Launching a savings programme to be initiated by the Finance Ministry of the state ensuring a saving range of ₹ 26,000 - 60,000 per lane kilometre from the cost of bitumen. Capacity building measure maybe financed through departments such as urban and rural development, public works, livelihood mi ssions and corporate social responsibility funds. In states that are financially distressed, 10% of road length can be reduced from the total annual outlay for road construction in the state to enable the plastic roads programme. Formation of a multi-action environmental fund may be considered by the state in the roll out. The experience in pioneering states has been very encouraging. The outcomes have reduced the risks to public health from large dumps of waste plastic. Using this waste in roads has been of benefit to road construction, improving the quality and lifetime of the roads. The benefits have been realised and demonstrated for numerous communities in the pioneering states. A well planned and executed programme in a given state would have the potential

2. REVIEW OF THE LITERATURE

The development of modified bitumen (MB) roofing began in Europe. Its use spread throughout the world; MB roofing is the fastest growing type of roofing on the market today. Because of the various types of modifiers, reinforcing, and surface treatments used, the performance characteristics of the MB products available are almost unlimited. When one combines these products with the diverse methods of installation and the way of attachment or nonattachment to the roofing base, it becomes apparent that the selection of an MB may be difficult. Prof. Justo et al [2002] has recognized that the penetration and ductility standards of the plastic modified bi tumen reduced by increasing the plastic additives limited to 12% by weight. The softening point of the modified bitumen increased by adding plastic additives ranges 8.0% by weight. In 2004 stated that the fatigue lifespan of bituminous concrete mixes with plastics modifier is expressively more than that of plain bituminous concrete mixes used. After in2007 has found that earlier an enhancement in various strength characteristics once it was related with conventional mix.In 2008 it showed an earlier study to test the strength and durability properties of plastic roads. Plastic polythene, disposable plates and PET cups are together from garbage dumps as a vital constituent of the building material. When it mixed with presence of warm bitumen and plastics liquefy to make an oleaginous coat on the aggregate and the mix is put over the road surface similar a normal tar road. Later on in 2009 found that during heavy traffic and dangerous climate conditions, evolving with modified bituminous mix may also help in attaining improved performance and better life, with decreasing vehicle operating costs. Athira R Prasad et al The use of waste materials like plastics and rubber in road construction is being increasingly encouraged so as to reduce environmental impact. Plastics and rubbers are one of them. . The plastic waste quantity in municipal solid waste is increasing due to increase in population and changes in life style. .Similarly most tires, especially those fitted to motor vehicles, are manufactured from synthetic rubber.Disposal of both is a serious problem. At the same time, continuous increase in number of vehicles emphasizes on need of roads with better quality and engineering design. This waste plastic and rubber can be used to partially replace the conventional material which is bitumen to improve desired mechanical characteristics for particular road mix.In the present study, a comparison is carried out between use of waste plastic like PET bottles and crumb rubber (3%, 4.5%,6%,7.5%,9%by weight of bitumen) in bitumen concrete mixes to analyse which has better ability to modify bitumen so as to use it for road construction. Ahmad K. Jassim et al Disposal of plastic waste in environment is considered to be a big problem due to its very low biodegradability and presence in large quantities. Therefore, finding alternative methods of disposing waste by using friendly methods are becoming a major research issue. In this research, high density polyethylene waste is mixed with Portland cement to investigate the possibility to produce plastic cement, and study the effect of replacing sand by fine polyethylene waste with different percentage on the properties of product. The experiments were done by using the waste of polyethylene packages include bottle and food crates in the range of 10% to 80% by volume as a short reinforcement structure. The results show that there is a possibility to produce plastic cement from polyethylene waste and Portland cement by using 60% and 40%, respectively. In addition, their density was decreased, ductility increased, and the workability improved, which lead to produce lightweight materials. Nuha S. Mashaan et al Roadways are considered one of the most important elements of infrastructure and they play an essential role in our daily lives. In road pavement construction, the use of crumb rubber in the modification of bitumen binder is considered as a smart solution for sustainable development by reusing waste materials. It is believed that crumb rubber modifier (CRM) could be one of the alternative polymer materials in improving bitumen binder performance properties of hot mix asphalt. This study aims to present and discuss the findings from some of the studies, on the use of crumb rubber in asphalt pavement. Pratiksha Singh Rajput et al Pratiksha Singh Rajput et al studied the effect of Plastic Waste on Properties of Road Aggregate. This study investigates the use of waste plastic for the modification of properties of road aggregates.The shredded plastic waste was thoroughly mix with heated aggregates forming a layer on the surface of the aggregates .These plastic waste coated aggregates are tested for impact value, crushing value, specific gravity and water absorption. It has been found that there is significantly improvement in the properties of plastic coated aggregates. The use of plastic waste in the construction of flexible pavement is one of the best methods for the safe disposal and better performance of the bituminous mix, if plastic coated aggregates are used Prof. S.A Dawale et al Prof.Dawale S.A studied the use of waste plastic coated aggregates in bituminous road construction. This study deals with the investigations of the use of waste plastic for coating of aggregates in the bituminous road construction. This paper presents the use of plastic which is collected from municipal solid waste for coating aggregates in bituminous road construction. Marshall Properties, impact values, specific gravity, abrasion test, water absorption, soundness and stripping value of the waste plastic coated aggregates were determined. Therefore it is necessary to utilize the wastes effectively with technical development in each field. Use of this waste mix for road construction helps to use plastics waste. Once the plastic waste is separated from municipal solid waste, the organic matter can be converted into manure and used. Rishi Singh Chhabra et al In the highway infrastructure, a large number of originates materials and technologies have been invented to determine their suitability for the design, construction and maintenance of these pavements. Plastics and rubbers are one of them. Also considering the environmental approach, due to excessive use of polythene in day to day business, the pollution to the environment is enormous. The use of plastic materials such as carry bags, cups, etc. is constantly increasing day by day.Since the polythene are not biodegradable, the need of the current hour is to use the waste

polythene in some beneficial purposes. The use of these materials as a road construction proves eco-friendly, economical and use of plastic gives strength in the sub-base course of the pavement

3. OBJECTIVES

The basic goal is to effectively use waste plastic in a constructive way that benefits society, however the current project's main goals are as follows:

●To find out the properties of bituminous mix by plastic waste

●To design the qualities of a specimen of bituminous mix.

●To find out the cost expenditure and strength benefits with analysis of bituminous mix

●To check whether the modification of bituminous pavement by mean of plastic waste is economical or not

●To compare the experimental results to traditional pavement details and conduct a cost-benefit analysis.

●To compare strength of normal aggregate, bitumen and modified aggregate and bitumen

4. PROPOSED METHODOLOGY

1Background.

2Data collection.

3Technology: Innovation and Process.

4 Testing on aggregate.

5Testing on bitumen and plastic mixed bituminous.

6Testing on mix of aggregate and ideal plastic mixed bituminous.

7 Final result of testing on samples.

1. BACKGROUND:-

In this chapter we discuss about the various methods adopted. All the methods of modification of bituminous pavement by using plastic waste is to be discussed with proper explanation and representation.

2. DATA COLLECTION:-

Various material required for bituminous pavement or used for testing in our project such as aggregate, bitumen are collected from various construction sites of NHAI at NH 6. The material collected are most suitable for bituminous pavement according to their strength and requirement. As this materials used for construction of national highways we assured that this materials fulfilling our requirements of quality, strength, etc. We use plastic to make plastic coated aggregate and modified bitumen is Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE). It is generally used by us in daily life in the form of Carry bags, Sacks, Milk pouches, bin lining, cosmetic and detergent bottles, bottle caps, house hold articles etc. According to study plastic waste like Polyethylene Terephthalate (PET), Polypropylene (PP), Polystyrene (PS), Polyvinyl Chloride (PVC) is not suitable for construction as compared to Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE).

3. Technology: Innovation and Process:-

The quantum of plastic waste is estimated to be roughly 10 thousand tons per day (TPD). The two major categories of plastics are (i) Thermoplastics and (ii) Thermosetting plastics. The Thermoplastics include Polyethylene Terephthalate (PET), Low Density Poly Ethylene (LDPE), Poly Vinyl Chloride (PVC), High Density Poly Ethylene (HDPE), Polypropylene (PP), Polystyrene (PS) etc. and are recyclable. Thermosetting plastics constitute alkyd, epoxy, ester, melamine formaldehyde, phenolic formaldehyde, silicon, urea formaldehyde, polyurethane, metallised and multilayer plastics etc. A mismanagement of plastics waste is a threat to the environment in the following ways 1.Drains are choked and public places become filthy due to the littered plastics 2.The emission of polluting gases due to burning of garbage containing plastics may cause air pollution. 3.Garbage mixed with plastics hinders the waste processing facilities may be a cause of issues in landfill operations. 4.Some unhygienic hazards to the environment are being caused by recycling industries operating in non-conforming areas.

4. Testing on aggregate:-

i. Aggregate crushing test

ii. .Los Angeles abrasion test

iii. Impact test

i. Aggregate Crushing Test:-

The strength of the coarse aggregate may be assessed by aggregate crushing test. The aggregate crushing value provides a relative measure of resistance to crushing under gradually applied compressive load. To achieve a high quality of pavement, aggregates possessing high resistance to crushing or low aggregate crushing value re preferred.

Sample calculation:- 1.Weight of plastic coated aggregate (W1) = 3600 gm 2.Weight of fraction passing through 2.36mm sieve (W2) = 603 gm 3.Aggregate crushing value = W2/W1 X 100 = 603/ 3600 X100 = 16.75 %

ii. Aggregate Abrasion Tests:-

Due to the movements of traffic, the road stones used in the surface course are subjected to wearing action at the top. Hence road stones should be hard enough to resist the abrasion due to traffic. Abrasion tests are carried out to test the hardness property of stones and to decide whether they are suitable for the different road construction works. The abrasion test on aggregate may be carried out using any one of the following three tests Los Angeles abrasion test Deval abrasion test Dory abrasion test However Los Angeles abrasion test is preferred as the test results have been correlated with pavement performance. Los Angeles Abrasion Test:- The principle of Los Angeles abrasion test is to find the percentage wear due to the relative rubbing action between the aggregate and steel balls used as abrasive charge. Pounding action of these balls also exists during the test and hence the resistance to wear and impact is evaluated by this test.

Sample calculation:- 1.Weight of aggregate (W1) = 5000 gm 2.Weight of retained on 1.7 mm sieve (W2) = 4335 gm 3. Aggregate abrasion value = (W1 - W2) / W1 X 100 = 5000-4335)/ 5000 X100 = 13.30 %

iii. Aggregate Impact Test:-

The test is designed to evaluate the toughness of stone or the resistance of the aggregates to fracture under repeated impacts is called impact test. The aggregate impact test is commonly carried out to evaluate the resistance to impact of aggregates and has been standardised by ISI. The aggregate impact value indicates a relative measure of aggregate to impact, which has a different effect than the resistance to gradually increasing compressive stress. The aggregate impact value should not normally exceed 30% for aggregate to be used a wearing course of the pavements. The maximum permissible value is 35% for bituminous macadam and 40% for water bound macadam base course.

Sample calculation:- 1.Weight of plastic coated aggregate (W1) = 1000 gm 2.Weight of fraction passing through 2.36mm sieve (W2) = 245 gm 3.Aggregate impact value = W2/W1 X 100 = 245/ 1000 X 100 = 24.5 %

5. Testing on bitumen and plastic mixed bituminous:-

i. Bitumen penetration test ii.Softening point test iii.Ductility test Sample preparation – 1 kg of bitumen was heated in oven until it converts in to fluid condition and plastic waste (< 2mm size) was slowly added and the fluid is mixing simultaneously and the temperature was kept between 180 to 200 Ɉ. The percentage of plastic waste used was 2%, 4%, 6%, 8% and 10% by weight of bitumen. The mixing was continuing until the bitumen and plastic liquid was homogenous. Bitumen penetration test:- Penetration test is to determine the hardness of the bitumen. The penetration of a bitumen is the distance in tenths of millimetre that a standard needle will penetrate into the bitumen under a load of gm applied for seconds at 250 C. Penetration value indicates the softness of bitumen (higher the penetration softer is the bitumen). For test initial value set to 00mm. hence final value is our penetration value in mm. According to IRC, bitumen grades 60/70 and 80/100 is suitable for bituminous macadam and penetration macadam. Hence this sample of the modified bitumen is suitable for road construction. Bitumen Softening point test:- The principle behind this test is that softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test. Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of this test. The test is conducted by ring and ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid like water or glycerine at a given temperature. A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of C minute. Temperature is noted when the softened bitumen touches the metal plate which is at a specified distance below. Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates. For test initial value set to 00C.

Sample calculation:-

1. Temperature at which ball 1 drop = T1 = 460C 2. Temperature at which ball 2 drop = T2 = 480C 3. Average temperature = (T1+T2)/2 = (46+48) / 2 = 47 0C Bitumen Ductility Test:- Property of bitumen which allows it to undergo deformation or elongation is called ductility of bitumen. The ductility of bitumen is measured by the distance in Cm (centimetre), to which the bitumen sample will elongate before breaking when it is pulled by standard specimen at specified speed and temperature. The ductility test gives a measure of adhesive property of bitumen and its ability to stretch. In flexible pavement design, it's necessary that binder should form a thin ductile film around aggregate so that physical interlocking of the aggregate is improved. For test initial value set to 00mm. hence final value is our ductility value in mm.

●Testing on mix of aggregate and bitumen:-

We can make bituminous pavement by using waste plastic by two methods.

1. Dry method

2. Wet method

As we perform test on plastic coated aggregate for dry method and on plastic mixed bitumen for wet method. After that we take testing on block of pavement made by dry and wet method with our best proportion, which we find out in initial stages by performing various tests on aggregate and bitumen sample

Marshall Stability test: - Bituminous concrete mix is commonly designed by Marshall Method. This test is extensively used in routine test programmes for the paving jobs. The stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature of 600C. The flow is measured as the deformation in units of 0.25 mm between no load and maximum load carried by the specimen during stability test (flow value may also be measured by deformation units of 0.1 mm). This test attempts to get the optimum binder content for the aggregate mix type and traffic intensity.

Test for plain bitumen sample:-

Sr. No	Bituminous content(%)	Weight in air(g)	Weight in water (g)	SSD Weight(g)	Stability of modified bitumen (KN)	Flow(mm)	Diameter(mm)	Height(mm)
1	5	1275	765	1285	14.30	3.12	100	63
2	5	1270	758	1278	14.15	3.45	100	65
3	5	1280	770	1288	15.10	3.10	100	62
Mean					14.51	3.22		

Test for dry method sample :-

Sr. No	Bituminous content(%)	Weight in air(g)	Weight in water (g)	SSD Weight(g)	Stability of modified bitumen (KN)	Flow(mm)	Diameter(mm)	Height(mm)
1	5(10%plastic)	1270	755	1278	15.98	3.10	100	66
2	5(10%plastic)	1260	751	1266	15.86	3.20	100	64
3	5(10%plastic)	1265	753	1270	15.93	3.15	100	63
Mean					15.92	3.15		

Test for wet method sample :-

Sr. No	Bituminous content(%)	Weight in air(g)	Weight in water (g)	SSD Weight(g)	Stability of modified bitumen (KN)	Flow(mm)	Diameter(mm)	Height(mm)
1	5(10%plastic)	1272	756	1280	15.59	3.10	100	66
2	5(10%plastic)	1280	761	1285	15.70	3.09	100	64
3	5(10%plastic)	1276	758	1282	15.66	3.15	100	63
Mean					15.65	3.11		

Final result of testing on pavement samples:-

We perform Marshall Stability test on samples made with plain bitumen and modified bitumen (with dry and wet method). As we tested these sample by Marshall Stability test we know that pavement made with modified bitumen with 10% of waste plastic gives us a good stability. There is a two method

for plastic road construction 1. Dry method and 2.wet method we observed that we get better result with dry method of construction. This method is simple as compared to wet method.

6. RESULTS AND DISCUSSIONS

●The crushing value reduces from 23.32 to 14.22 for normal and plastic coated aggregate. The value was reduced by 40%. Lower the aggregate crushing value higher is the strength.

●The Abrasion value reduces from 13.30% to 10.57% for normal and plastic coated aggregate. The abrasion value plastic coated aggregates were 21% less than the normal aggregates.

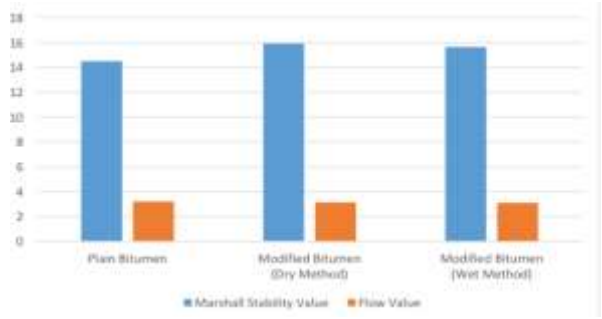
●The impact value reduces from 22.3 to 20.2 for normal and plastic coated aggregate. The aggregate impact value of plastic coated aggregate was reduced by 9% than the normal aggregate. It's the higher toughness of plastic coated aggregates.

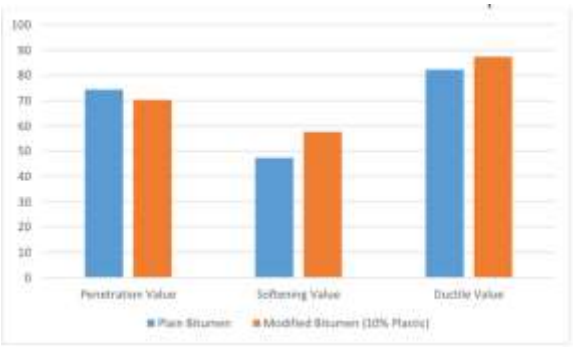
●The penetration value reduces from 74.33 to 70.33 for normal bitumen and modified bitumen. The penetration value of bitumen is higher than the bitumen mixed with the plastic.

●The softening value increases from 47.33 to 57.66 for normal bitumen and modified bitumen. The bitumen softens approx. 100C l ess than the bitumen replaced with plastic.

●The softening value increases from 82.33 to 87.33 for normal bitumen and modified bitumen. The modified bitumen is more ductile than the plain bi tumen.

●The stability of modified bitumen (10% bitumen replaced by plastic) is higher than the normal bitumen. We observed that we get better result with dry method of construction.





7. CONCLUSION

●The plastic mixed with bitumen and aggregates is used for the better performance of the roads. ●The polymer coated on aggregates reduces the voids and moisture absorption and increase the strength of aggregate than normal aggregate.

●This results in the reduction of ruts and there is no pothole formation.

●The plastic pavement can withstand heavy traffic and are durable than flexible pavement.

●The use of plastic mix will reduce the bitumen content by 10% and increases the strength and performance of the road.

●The use of smoke absorbent material (titanium di-oxide) by 10% of polymer content can reduce the vehicular pollution.

●There is no adverse effect of addition of waste plastic in bituminous pavement.

●As result we conclude that dry method is mostly suitable and feasible for plasticpavement construction.

●Modification of bituminous pavement by mean of plastic waste is economicalfor construction and maintenance.

●Modification is pavement by mean of plastic waste is nature friendly.

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