Potential use of Waste Plastic as an Effective Construction Material in Bituminous Pavement

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Abstract: Now days, the population growth, industrialization, consumerism and technological development have led to uncontrollable accumulation of waste. Proper waste disposal is of great importance in both rural and urban areas. Many of the wastes produced today will remain in the environment for many years leading to various environmental concerns. Plastic which is toxic in nature is found to be nearly 5% in Municipal Solid Waste (MSW). A major problem nowadays is the disposal of plastic wastes. These wastes are non biodegradable in nature causing environmental pollution and hygiene problems. In this study bitumen and aggregates are coated with various percentage of waste plastic (0 %, 4 %, 8 %, and 12 %) replacement. And various laboratory tests are done on these samples. It has been observed that, the optimum replacement of waste plastic to bitumen without changing the properties is 12%.

Keywords: Waste Plastic, Marshall Stability, Unit weight, Flow value, Bitumen Content.

1.1 INTRODUCTION

Now-a-days disposal of different wastes produced from different Industries is a great problem. These materials pose environmental pollution in the nearby locality because many of them are non-biodegradable. Traditionally soil, stone aggregates, sand, bitumen, cement etc. are used for road construction. Natural materials being exhaustible in nature, its quantity is declining gradually. Also, cost of extracting good quality of natural material is increasing. Concerned about this, the scientists are looking for alternative materials for highway construction, and industrial wastes product is one such category. If these materials can be suitably utilized in highway construction, the pollution and disposal problems may be partly reduced. In the absence of other outlets, these solid wastes have occupied several acres of land around plants throughout the country. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of these industrial wastes in road making, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low volume roads in different parts of our country. The necessary specifications should be formulated and attempts are to be made to maximize the use of solid wastes in different layers of the road pavement. Post construction pavement performance studies are to be done for these waste materials for construction of low volume roads with two-fold benefits: (a) it will help clear valuable land of huge dumps of wastes; (b) it will also help to preserve the natural reserves of aggregates, thus protecting the environment. Plastics are user friendly but not eco-friendly as they are non-biodegradable generally, it is disposed by way of

land filling or incineration of materials which are hazardous. Plastic is versatile material and a friend to common man becomes a problem to the environment after its use. The better binding property of plastics in its molten state has helped in finding out a method of safe disposal of waste plastics. Road surface with neat bitumen can cause bleeding in hot climate, may develop cracks in cold climate, possess fewer loads bearing capacity and can cause serious damages because of higher axle load in present conditions due to rapid infrastructure development. Useful life of bituminous overlays has reportedly declined 7- 8 from average life of 5-6 years in the past to about 3-4 years at present as compared to average pavement life (5-6 years) in abroad. India has to raise transportation system to a higher level both in terms of length and quality. This study presents the use of waste in hot bituminous mixes to enhance pavement performance, protect environment and provide low cost roads. Polymer and plastic modified bitumen, often abbreviated as modified bitumen is obtained with the incorporation of selected thermoplastics and shredded plastic from discarded waste, natural plastic or any other suitable elastomers in bitumen.

1.2 POTENTIAL OF PLASTIC TAR ROAD IN DEVELOPING COUNTRIES

The Waste plastic roads absorb very less amount of heat compared to the ordinary flexible & rigid pavements. The durability of the roads laid out with shredded plastic waste is much more compared with roads with asphalt with the ordinary mix. Roads laid with plastic waste mix are found to be better than the conventional ones. The binding property of plastic makes the road last longer besides giving added strength to withstand more loads. While a normal 'highway quality' road lasts four to five years it is claimed that plastic-bitumen roads can last up to 10 years. Rainwater will not seep through because of the plastic in the tar. So, this technology will result in lesser road repairs. And as each km of road with an average width requires over two tonnes of polyblend, using plastic will help reduce non-biodegradable waste. The cost of plastic road construction may be slightly higher compared to the conventional method. However, this should not deter the adoption of the technology as the benefits are much higher than the cost. 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. Already, a kilometer long test-track has been tested in Karnataka using this technology. The government is keen on encouraging the setting up of small plants for mixing waste plastic and bitumen for 25 road construction. It is hoped that in near future we will have strong, durable and eco-friendly roads that will relieve the earth from all type of plastic-waste

1.3 OBJECTIVES OF THE STUDY

Basic intention is to efficiently utilize the waste plastic in constructive way so that it can be beneficial to society.

Main objectives of current project work are:

1. To identify the optimum proportion of waste plastic to be added in the bitumen mix for getting the required strength.

2. To compare the experimented results with the conventional pavement details and perform the economic analysis.
3. To prepare statistical model for optimum utilization of plastic waste.
4. To improve the volumetric properties of BC mix design
5. To utilize waste plastic in bituminous mixes

1.4 LITERATURE ON WASTE PLASTICS

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.

AJIM S. SUTAR et al experimentally investigated the use of low density polyethylene (LDPE) in bituminous road construction. The present study deals with the use of waste plastic as coating over aggregates. The properties of aggregates by coating plastic are evaluated. In this study Laboratory studies were carried out at the Centre for Transportation Engineering of Bangalore University, in which the plastic was used as an additive with heated bitumen in different proportions (ranging from zero to 12% by weight of bitumen) The results of the laboratory investigations indicated that, the addition of processed plastic of about 8.8% by weight of bitumen, helps in substantially improving the stability, strength, fatigue life and other desirable properties of bituminous concrete mix, even under adverse water-logging conditions. The additions of 8.0% by weight of processed plastic for the preparation of modified bitumen results in a saving of 0.4% bitumen by weight of the mix or about 9.6% bitumen per cubic meter of BC mix.

H. K. SHARMA studied about the utilization of Waste Plastic in Construction of Pavement. The aim of paper is to analyze & study how the waste plastic will be effectively utilized in construction of pavement as a binder material for replacing the content of bitumen and in detail process & its successful application In an Indian city solid waste management is the thrust area. Of this various waste materials, plastic waste and municipal solid waste are of great concern. On the other side, the road traffic is increasing, traffic intensity is increasing. The load bearing capacities of the road are to be increased. Plastic waste can be used as a coating over aggregate and this coated stone can be used for road construction. The mix polymer coated aggregate have shown higher strength. Use of this mix for road construction helps to use plastics waste.

Sasane Neha et al studied about the application of waste plastic as an effective construction material in flexible pavement. The research methodology in this study has adopted various tests to investigate the results on aggregate, bitumen and plastic and aggregate-bitumen-plastic mix. The tests conducted were water absorption, aggregate impact, loss Angeles and aggregate crushing test [is: 2386 (part 4)-1963] for aggregates and softening point, penetration test and ductility test [is: 1203-1978] for bitumen. For mixing the ingredients of road mix, dry process was adopted. In this process, waste plastic is mixed with aggregates and blends of polymer modified aggregate are prepared by mixing bitumen in it. These blends are later tested in laboratory and required optimum results are obtained. This paper includes the results of the various laboratory tests conducted on bitumen, aggregate and bitumen-aggregate plastic mix. it shows that with the increase of waste plastic in bitumen increases the properties of aggregate and bitumen. And use of waste plastic in flexible pavements shows good result when compared with conventional flexible pavements.

Bhageerathy K. P studied the use of Biomedical Plastic Waste in Bituminous Road Construction. In this work, the use of medical plastic waste in the form of shredded syringes in road construction is tested. The main objective of the study was to investigate the performance of the bituminous mix modified with bio-medical plastic waste and to compare it with the normal mix. Medical plastic waste was collected from IMAGE (Indian Medical Association Goes Eco-friendly), Palakkad, Kerala, India. As part of the study, the properties of Plastic Coated Aggregates (PCA) were determined. The results showed improved properties for PCA when compared to normal aggregates. The properties of both the mixes were tested by conducting creep test and indirect tensile stiffness modulus test. On the basis of the experimental results obtained, it is found that mixes prepared with biomedical plastic waste has shown better properties compared to the conventional bituminous mixes. Hence, the biomedical plastic waste can be disposed off judiciously by incorporating it in bituminous mixes.

Mercy Joseph Poweth et al studied the use of plastic waste in road construction. This study discussed the suitability of plastic waste materials for pavement construction. The waste is mixed in different proportions to the soil sample and their influences on geotechnical properties were studied. The results of the tests indicated that plastic alone is not suitable for pavement subgrade. When quarry dust was added along with soil plastic mix, it maintains the CBR value within the required range. First phase of studies were on the soil-plastic mixes. From the standard compaction test it was observed that as the proportion of plastic increased, the maximum dry density was decreasing. Hence another waste with maximum density was mixed with soil-plastic waste and again the standard proctor test was carried out. In addition to the above two waste, another locally available tyre was also mixed and the same test was done. From these various tests different optimum soil-waste samples were obtained and CBR tests were carried out.

Pankaj P.Shedame et al experimentally studied on the bituminous Concrete Containing Plastic Waste Material. This study deals with study on the various test performed on aggregates, bitumen and methodology of using plastic waste in bituminous mixes. This threat has emphasized the need to find appropriate solutions for effective plastic waste management. Rapid growth of infrastructure in road construction needs natural resources. In recent year escalation of prizes of natural resources, so that required reuse of waste material in road construction. Now-a-days disposal of different wastes (plastic waste) produced from different Industries is a great problem. In recent years, applications of industrial wastes have been considered in road construction with great interest in many industrialized and developing countries. Reuse of wastes material is a very simple but powerful concept.

1.5 MARSHAL STABILITY TEST

In marshal stability test, the deformation of specimen of bituminous mixture is measured when the same load is applied. This test procedure is used in designing and evaluating bituminous paving mixes. The marshal stability of mix is defined as a maximum load carried by a compacted specimen. The following results of Marshal Stability test are shown in Table 1.

Table 1: Marshall Stability test

Sr. No	Mix	Binder Content	Plastic Waste (%)	Marshall Stability (KN)	Flow (mm)	Marshall Density (g/cc)	Percentage Air Voids (%)	Percentage voids filled with Bitumen, VFB (%)
1.	Mix 1	4 %	0 %	11.38911	3.259815	2.173548	5.942583	62.97923
2.	Mix 2	5 %		12.26986	3.512907	2.241376	4.980836	66.27954
3.	Mix 3	6 %		13.04938	3.583772	2.543061	4.373417	67.6766
4.	Mix 4	7 %		12.16863	3.765998	2.147226	3.604019	73.43696
5.	Mix 5	4 %	4 %	12.44197	3.320557	2.269722	5.719862	61.60241
6.	Mix 6	5 %		13.04938	3.563525	2.368934	4.677126	63.64739
7.	Mix 7	6 %		14.01113	3.796369	2.404367	4.282304	65.75311
8.	Mix 8	7 %		12.47234	3.857111	2.040928	3.583772	71.10852
9.	Mix 9	4 %	8 %	12.90765	3.381299	2.150263	5.54776	59.46632

10.	**Mix 10**	**5 %**		13.18099	3.604019	2.281871	4.596137	61.06586
11.	**Mix 11**	**6 %**		14.69954	3.887482	2.444861	4.262057	63.7385
12.	**Mix 12**	**7 %**		12.56345	3.958347	2.383107	3.52303	65.33804
13.	**Mix 13**	**4 %**	**12 %**	13.80866	3.462288	2.248463	5.274422	53.50349
14.	**Mix 14**	**5 %**		14.09212	3.786245	2.450936	4.57589	56.65195
15.	**Mix 15**	**6 %**		16.03586	3.887482	2.788053	3.745751	57.26949
16.	**Mix 16**	**7 %**		14.93238	4.039336	2.595704	3.512907	60.96462

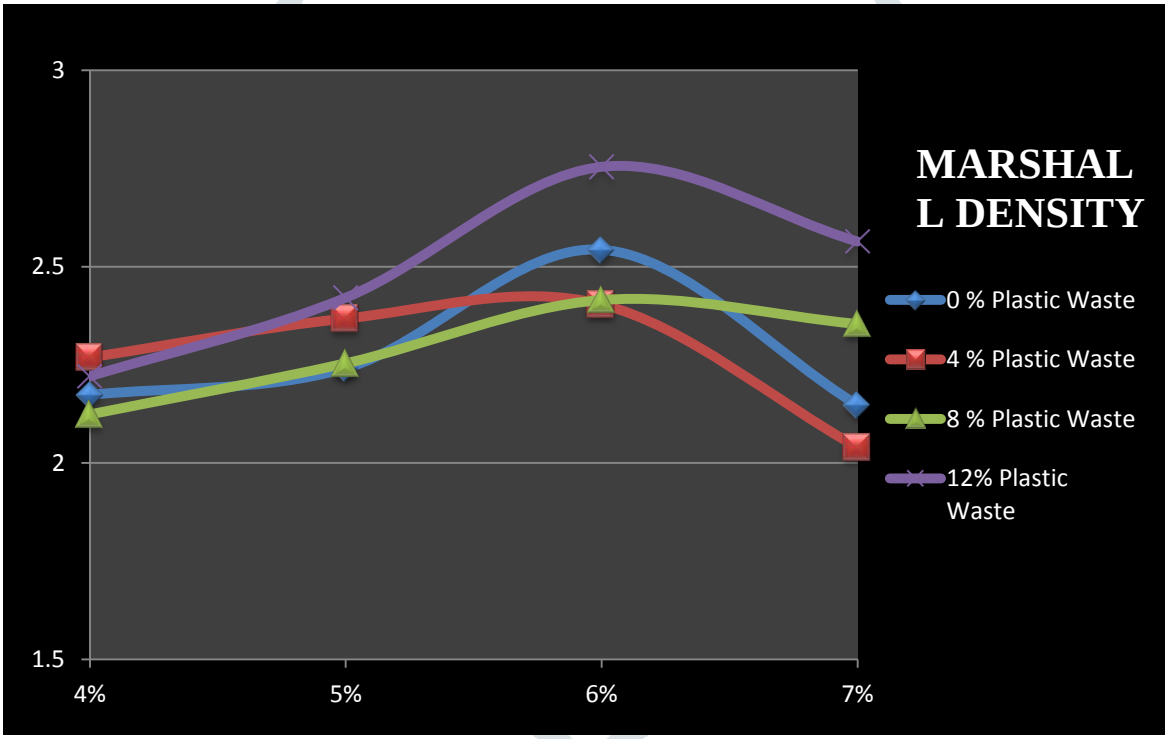

Figure 1: Variation of Marshall Density With %age of Plastic waste

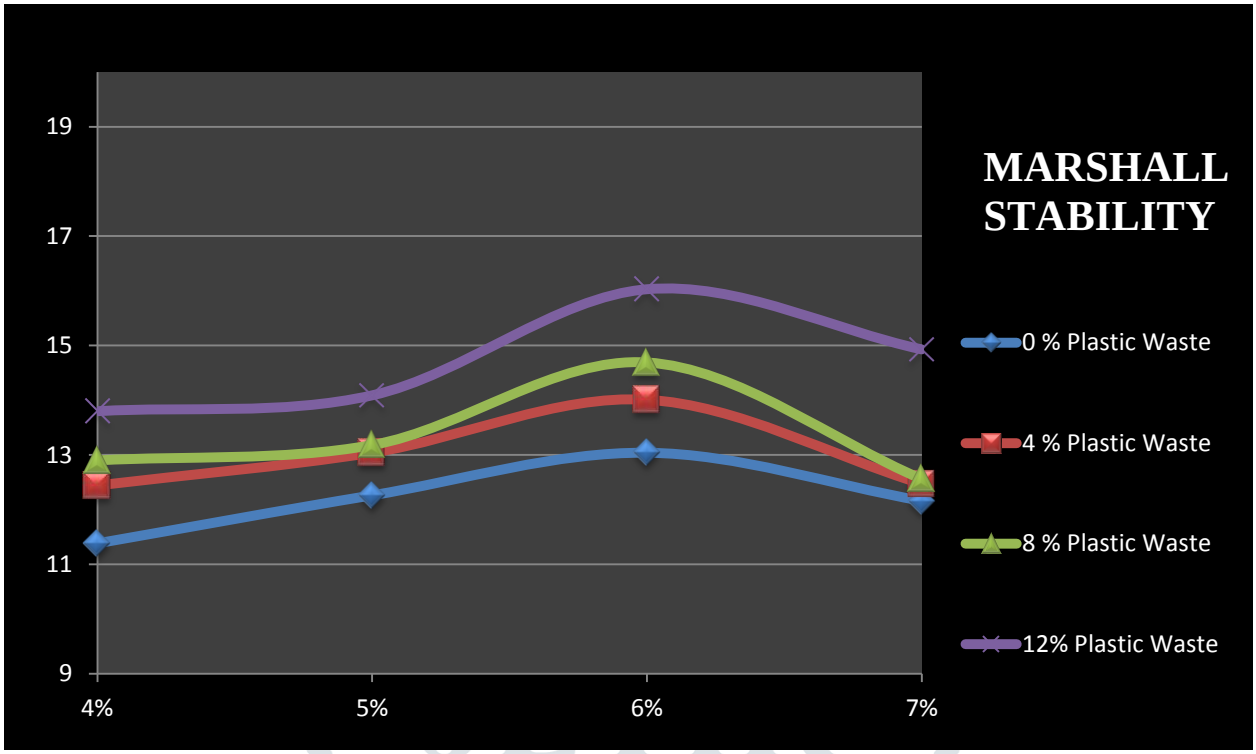

Figure 2: Variation of Stability With %age of Plastic waste

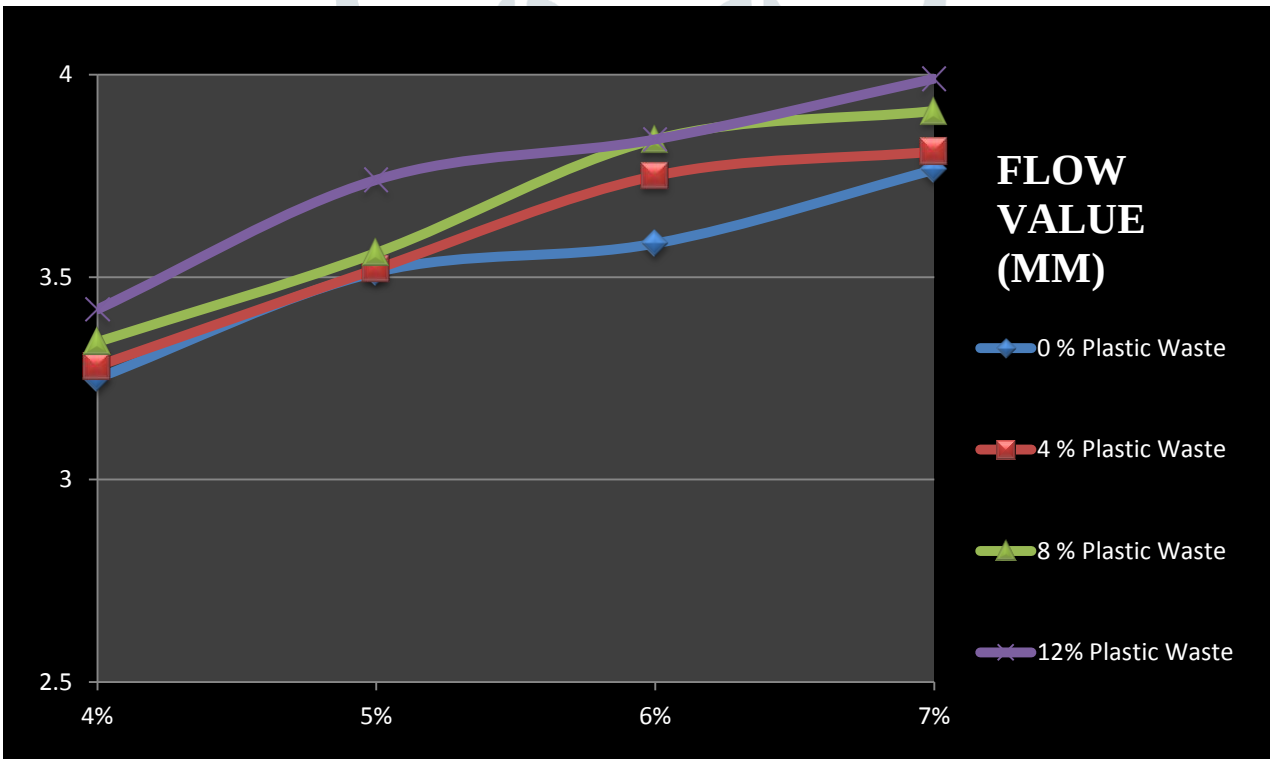

Figure 3: Variation of Flow Value With %age of Plastic waste

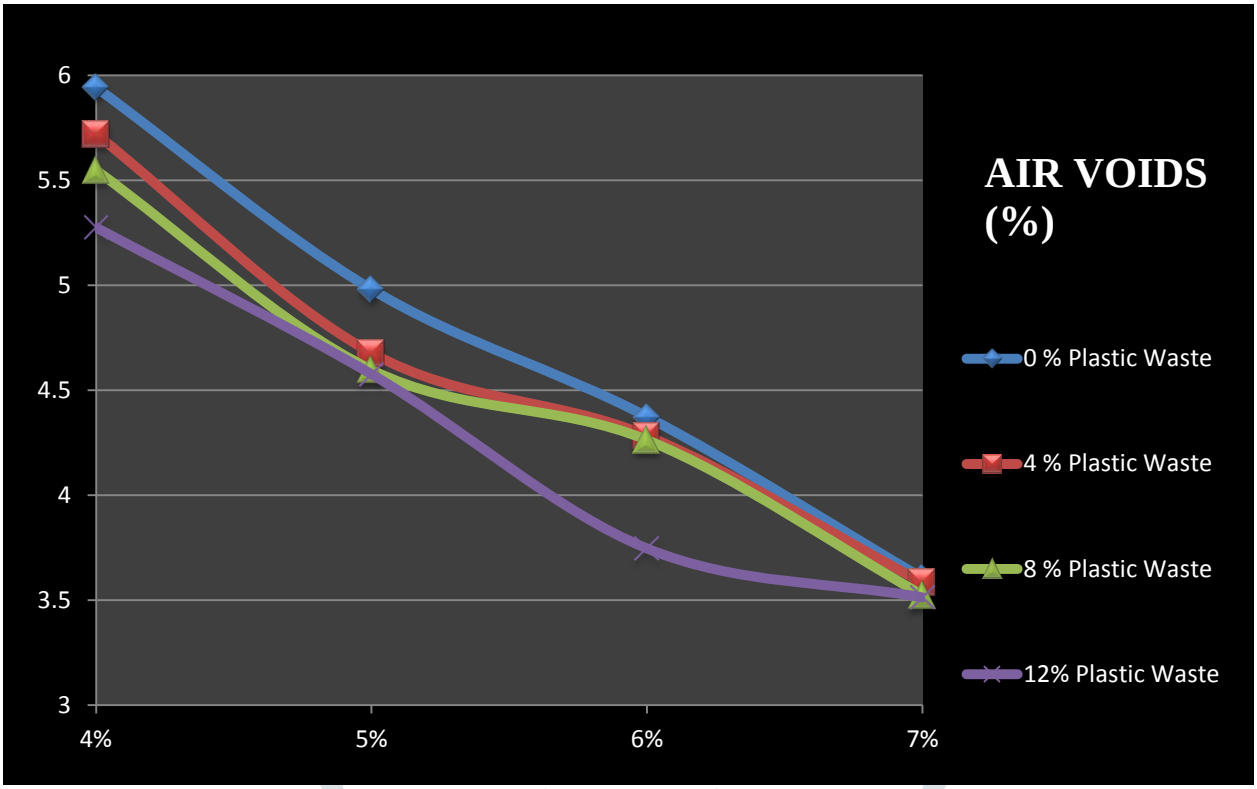

Figure 4: Variation of Air Voids With %age of Plastic waste

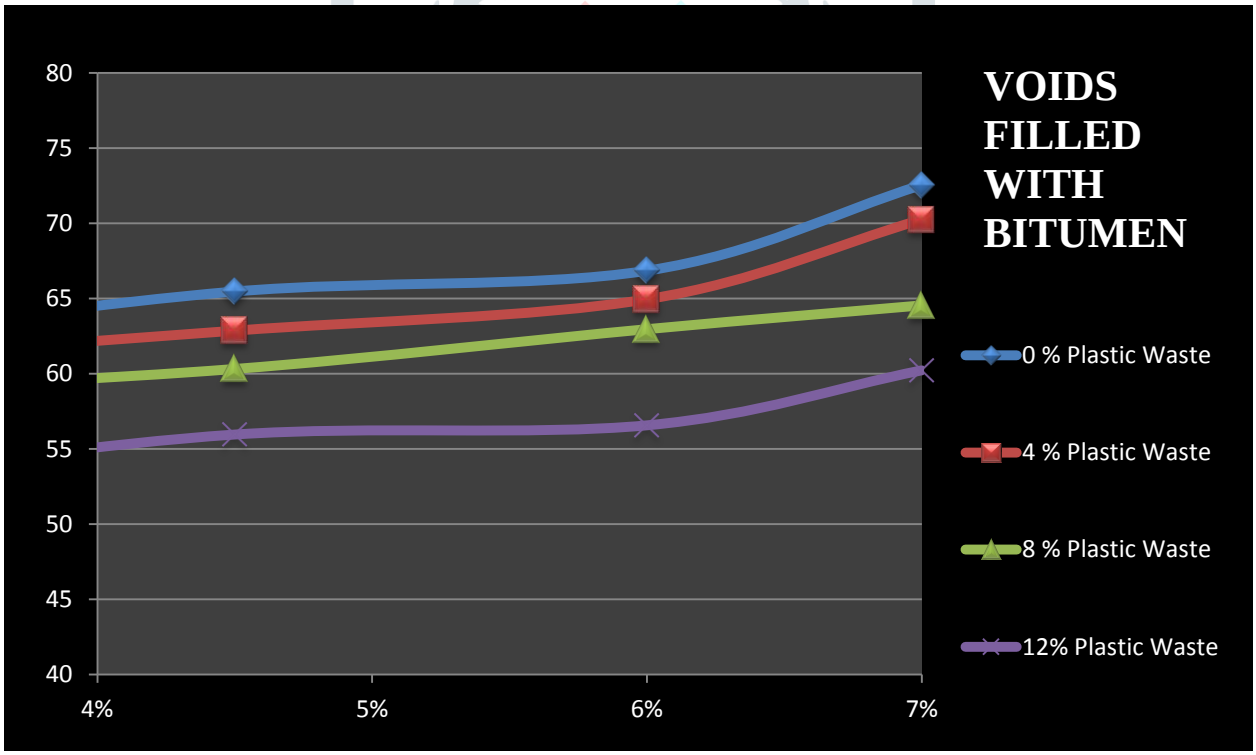

Figure 5: Variation of Voids filled with bitumen with %age of Plastic waste

CONCLUSION

After conducting laboratory tests on bitumen binder and mixtures with different polymer content and after analyzing the data and comparing the results, the following conclusions are drawn:-

1. The result shows that with increase of waste plastic in bitumen increases the properties of aggregate and bitumen.
2. The optimum use of plastic can be 12 % of bitumen based on Marshal Stability test.
3. The modified bitumen shows good result when compared to standard results.
4. For all modified binders prepared, the penetration values decrease as waste plastic ratio increases whilst, softening point values increase as waste plastic ratio increases.
5. The coating of aggregates with waste plastic reduces the absorption of moisture.
6. By using waste commodity plastics in binder modification carries the advantage of a cheap, technologically effective means of enhancing conventional binder performance and offers an alternative way to manage plastic waste.
7. This has added more value in minimizing the disposal of plastic waste is the eco-friendly technique.
8. The use of modified bitumen with the addition of processed plastic of about 12 % by weight of bitumen helps in substantially improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous concrete mix, resulting which improves the longevity and pavement performance with marginal saving in bitumen usage.
9. The waste plastic bitumen mix forms better material for pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient.
10. The use of waste plastics for pavement is one of the best methods for easy disposal of waste plastics.

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