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Application of Waste Plastic as an Effective Construction Material in Flexible Pavements

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Abstract: Preservation of road infrastructure requires a systematic approach for the good performance of roads keeping in mind the future condition and maintenance scenarios. Now-a-days pavements are subjected to various kinds of loading which affects the pavement performance condition that causes various distresses. These distresses include rutting, fatigue cracking, and temperature cracking. Looking forward to the environmental condition, complete ban on plastic cannot be made. Thus, using of plastic as an innovative technology not only strengthened the road construction but also increase the road life. This paper includes the results of the various laboratory tests conducted on bitumen, aggregate and bitumen-aggregate plastic mix. In my research work I have done a thorough study on the methodology of using plastic waste in bituminous mixes and presented the various tests performed on aggregates and bitumen.

Keywords: Plain Bituminous Mix, Waste Materials, Modified HMA, Mix Constituents.

I. 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. Today, for the developing countries, Flexible pavements are one of the most important infrastructures. Any damage to this may cause lots of inconvenience to the traffic which ultimately will affect the future scenario of countries. Now-a-days it is been observed that due to increase in axel load and traffic intensity the capability of the bituminous binders is been reduced causing bleeding in hot climate, cracks in cold climate, rutting and pot holes. This makes an essentiality in modification of bitumen binder to meet the increasing demand of axel loads and traffic intensity.

A. Problem Statement

The plastic wastes could be used in road construction and the field tests withstood the stress and proved that plastic wastes used after proper processing as an additive would enhance the life of the roads and also solve environmental problems. The rapid rate of urbanization and development has led to increasing plastic waste generation. As plastic is no biodegradable in nature, it remains in environment for several years and disposing plastic wastes at landfill are unsafe since toxic chemicals leach out into the soil, and under-ground water and pollute the water bodies.

B. Objectives

Main motto is to efficiently utilize the waste plastic in constructive way so that it can be beneficial to society however main objectives of current project work are:

- To mix the waste plastic with the bitumen in hot mix plant efficiently.
- To coat the aggregates with the waste plastic materials
- To check the properties of bituminous mix specimen due to coating of waste plastic materials
- To compare the properties of bituminous mix specimen with the properties of coated aggregates.
- To utilize the plastic waste and to reduce its impact on environment.

C. Disposal of Plastics

The present-day disposal of plastic waste, especially Municipal Solid Waste containing plastics, is carried out by 1. Land filling and 2. Incineration.

II. LITERATURE REVIEW

A. Polymer Modified Seal Coats

The paper on “Evaluation of polymer modified chip seal coats” by Llyod D.Coyne(1987) describes the use of modification of the Vialit Drop Test and Surface Abrasion test for the evaluation of polymer modified asphalt emulsion chip seal coats. The modified Vialit Drop Ball test was used to evaluate the setting characteristics of the seal coats. The surface abrasion test was used to evaluate the durability of the seal coats.

B. Testing And Evaluation of Large Stone Mixes

Prithvi S. Kandhal(1989) has presented a paper on “Testing and Evaluation of Large Stone Mixes Using Marshall Mix

Design Procedures". The premature rutting of heavy duty asphalt pavements had been increasingly experienced in recent years primarily due to high pressure truck tires and increased wheel loads. The use of large size stone (maximum size of more than one inch) in the binder and base courses found to minimize or eliminate the rutting of heavy duty pavements.

C. Non-Destructive Testing of Asphalt Pavements

Non-destructive testing provides ideal means to test pavement structure in a rapid and convenient manner. The paper on "Nondestructive testing of asphalt pavements for structural condition evaluation" by Amit Goel and Animesh Das (2008) describes that estimation of layer modulii and thickness values are direct indicators of structural strength of pavement.

D. Rubber Modified HMA

Freddy L. Roberts, Prithvi S. Kandhal, E. Ray Brown and Robert L. Dunning, report on "Investigation & Evaluation of Ground Tire Rubber in Hot Mix Asphalt" to National Centre for Asphalt Technology, Auburn University, Alabama, report 89-03: August 1989. A blend of reclaimed ground tire rubber reacted with asphalt cement at elevated temperature was used as a binder in various types of bituminous construction, 29 rehabilitation and maintenance.

III. MATERIALS

A. Waste Materials & By-Products In Road Construction

The pivotal thrust of utilizing waste materials into road construction field is diminishing the detrimental repercussions of processing natural materials on the environment, to alleviate the burden on authorities in both developing and developed countries in providing landfills and setting provisions for such wastes, and to reaffirm the commitment of the industry towards better road services and riding quality. Besides, the scarcity of the natural resources is also an intuitive rationale that underpins utilizations. Several experimental and research studies have been dedicated to investigating potential incorporating of waste materials in road construction field. Many pieces of research have proven a success in reusing and recycling of some compositions of these waste materials in pavement structures and others are still undergoing comprehensive research studies to further shed the light on what can be gained from their recycling into pavement constructions. Due to some stringent knowledge and shortage of funding for in-depth analysis of utilizing some waste materials in the utmost beneficial way, the waste material is a core problematic issue to governmental institutions and transportation legislation authorities in several parts of the world.

IV. PREPARATION OF DESIGN MIX

A. Plain Bituminous Mix

Bitumen is a black, oily, viscous material that is a naturally-occurring organic by-product of decomposed organic materials. Also known as asphalt or tar, bitumen was mixed with other materials throughout prehistory and throughout the world for use as a sealant, adhesive, building mortar, incense, and decorative application on pots, buildings, or human skin. The material was also useful in waterproofing canoes and other water transport. A good design of bituminous mix is expected to result in a mix which is adequately (i) strong (ii) durable (iii) resistive to fatigue and permanent deformation (iv) Environment friendly (v) economical and so on.

B. Selection of Mix Constituents

Binder and aggregates are the two main constituents of bituminous mix. This section discusses some of the issues involved in selection of binder and aggregates.

Binder: Generally, binders are selected based on some simple tests and other site-specific requirements. These tests could be different depending of the type of binder viz. penetration grade, cutback, emulsion, modified binder etc. For most of these tests, the test conditions are pre-fixed in the specifications. Temperature is an important parameter which affects the modulus as well as the aging of binder. Superpave specifications [Superpave 1997, 2001] suggest that these acceptability tests are to be carried out at the prevalent field temperatures, not in a laboratory specified temperature. This is an important consideration because, binder from two different sources may show same physical properties at a particular temperature, but their performances may vary drastically at other temperatures. In Superpave specifications, therefore, only the acceptable test values are recommended, and not the test temperatures. The temperature values are found out from the most prevalent maximum and minimum temperatures at the field at a given probability level.

Aggregate: Number of tests is recommended in the specifications to judge the properties of the aggregates, e.g. strength, hardness, toughness, durability, angularity, shape factors, clay content, adhesion to binder etc. Angularity ensures adequate shear strength due to aggregate interlocking, and limiting flakiness ensures that aggregates will not break during compaction and handling.

Various Mix Design Approaches: There is no unified approach towards bituminous mix design, rather there are a number of approaches, and each has some merits are demerits. Table-1 summarizes some of the important bituminous mix design approaches are as follows:

- Mix design method
- Recipe method
- Empirical mix design method
- Analytical method
- Volumetric method
- Performance related approach
- Performance based
- Approach

The recent emphasis on bituminous mix design is on performance related and performance-based approaches. The requirement of a good mix design has changed from time to time. gives some idea of how the mix design requirements have changed from past to present.

TABLE I: Requirements Of Bituminous Mix Design

Past	Present
Stability	Stiffness
Durability	Permanent deformation
Economy	Fatigue
	Temperature susceptibility
	Low temperature cracking
	Moisture susceptibility
	Freeze-thaw
	Permeability
	Economical
	Environment friendly
	Workability
	Economy

Some of the above requirements are sometimes mutually conflicting. For, example, the higher is the bitumen content; the better is the fatigue life, provided all the other parameters are kept unchanged. But with the increase of bitumen content, the resistance to rutting may decrease. Increase in bitumen content not accompanied by adequate amount of air voids will result in the fall of stability of the mix, the chances of bleeding will increase. The only way to increase bitumen content keeping sufficient air voids (VA) is by maximizing VMA and suitably gradation can be designed. Heavy duty bituminous pavements are composed of bituminous binder course and wearing course, for example, Dense Bituminous Macadam (DBM) and BC , as per Indian specification. Same grades of bitumen are generally used for construction of these layers. Generally same grades of bitumen are used for construction of these layers. Stiffer grade of bitumen has higher value of stiffness, and it causes lesser stains to the pavement layers and also it is expected to show lesser rutting. On the other hand, higher fatigue life as observed for bituminous mixes with softer grade of bitumen, indicates greater longevity of the pavement against fracture. It can be shown computationally that if a pavement is constructed with softer grade of bitumen at the lower layer, and harder grade at the top layer, the pavement is expected to last longer, than a pavement constructed with same grades for both the layers – this technique is known as rich-bottom pavement construction [Harvey et. al. 1997, Monismith 2001] in other countries.

C. Coated Bituminous Mix

The generation of waste plastics is increasing day by day. The major polymers are namely polyethylene, polypropylene, polystyrene show adhesion property in their molten state. The plastic coated aggregate bitumen mix and plastic modified bitumen forms better materials for flexible pavement construction as the mixes shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for flexible pavement is one of the best methods of easy disposal of waste plastics. The use of polymer coated aggregate is better than the use of polymer modified bitumen in many aspects. The studies on the thermal behavior and binding property promoted a study on the preparation of plastic waste-bitumen blend and its properties to find the suitability of the blend for road construction. Following procedure can be adopted for using plastic in road construction

D. Mixing Procedure At Hot Mix Plant

Step I: Plastics waste like bags, bottles made out of PE and PP cut into a size between 2.36 mm and 4.75mm using shredding machine. Care should be taken that PVC waste should be eliminated before it proceeds into next process.

Step II: The aggregate mix is heated to 1650C and then it is transferred to mixing chamber. Similarly, the bitumen is to be heated up to a maximum of 1600C. This is done so as to obtain a good binding and to prevent weak bonding. During this process monitoring the temperature is very important.

Step III: At the mixing chamber, the shredded plastics waste is added over the hot aggregate. It gets coated uniformly over the aggregate within 30 to 45 seconds. It gives an oily coated look to the aggregate.

Step IV: The plastics waste coated aggregate is mixed with hot bitumen. Then this final resulted mix is used for laying roads as shown in Fig1. The road laying temperature is between 110^{o}C1200C. The roller used should be of is 8-ton capacity.

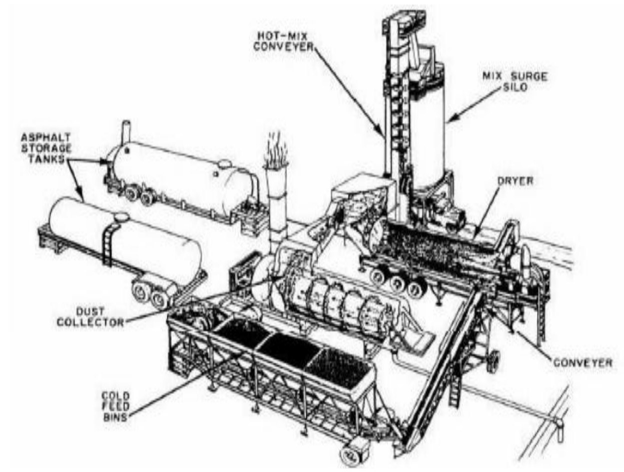

Fig.1. Hot Mix Plant.

E. Mixing By Mini Hot Mix Plant

Step I: Plastic waste made out of PE, PP and PS cut into a size between 2.36mm and 4.75mm using shredding machine.

Step II: Similarly, the bitumen is to be heated to a maximum of 1600C to have good binding and to prevent weak bonding. (Monitoring the temperature is very important)

Step III: At the mixing chamber the shredded plastic waste is to be added to the hot aggregate. It gets coated uniformly over the aggregate within 30 Secs, giving an oily look Plastic coated aggregate is obtained.

Step IV: Hot bitumen is then added over the plastic-coated aggregate and the resulting mix is used for road construction. The road laying temperature is between 1100C to 1200C. The roller used is 8-ton capacity.

F. Mixing By Central Mixing Plant (CMP)

The dry process can also be carried out using central mixing plant. The shredded plastic is added along with the aggregate in the conveyor belt. This is transferred into the hot cylinder. There aggregate is coated with plastic first and then with the bitumen. The mixer so prepared is then loaded in the dipper lorry and transported for road laying. CMP helps to have better control of temperature and better mixing of this material thus helping to have a uniform coating.

V. DATA ANALYSIS

Investigation of plastic waste materials aggregates and bitumen requires various field test and lab tests as explain in previous chapter. This chapter presents material which is collected from site given below for plastic coated aggregates in detail. The present chapter divided into three main sections. First section presents the physical requirement of aggregates and bitumen. Second section presents the properties of plastic. Third section presents the preparation plastic waste materials for shredding on aggregates

A. Aggregates

The aggregates are bound together either by bituminous materials or by cement. In a few cases, the rock dust itself when mixed with water forms slurry which acts as a binding medium. The aggregates may be classified into natural and artificial aggregates. The natural aggregates again are classified as coarse aggregates consisting of crushed rock aggregates or gravels and fine aggregates or sand.

TABLE II: Aggregate of 20mm, 10 Mm, Stone Dust And Lime As Filler

Sr. No	Test	Permissible values
1.	Abrasion Test a. Using Los Angeles machine (max b. Aggregates impact test (max)	 35% 30%
2.	Stripping test (max)	25%
3.	Water absorption (expect in the case of slag) max	1%
4.	Soundness test: Loss with sodium sulphate 5 cycles (in case of slag only) max	12%
5.	Weight unit or Bulk density (in slag only)	1120 per m^3

B. Bitumen

Bitumen is used as binders in pavements constructions. Bitumen may be derived from the residue left by the refinery from naturally occurring asphalt. As per definition given by the American Society of Testing Materials bitumen has been defined as "Mixtures of hydrocarbons of natural or pyrogenous origin, or combination of both, frequently accompanied by their non-metallic derivatives, which may be gaseous, liquid, semi-solid or solid, and which are completely soluble in carbon disulphide." Bitumen found in natural state known as asphalt contains large quantities of solid mineral matter. When petroleum crude is refined in a refinery, they are separated by fractional distillation in the order of decreasing volatility. On distillation of the residual bituminous residue, straight-run bitumen is obtained. This bitumen is known as penetration grade bitumen or steam refined petroleum bitumen. The paving bitumen available in India is classified into two categories:

- Paving bitumen from Assam petroleum denoted as A-type and designated as grades A35, A90, etc.
- Paving bitumen from other sources denoted as S-type and designated as grades S35, S90, etc. Important properties of bitumen are:
- Viscosity of bitumen should be adequate at the time of mixing and compaction.
- It is achieved by heating prior to mixing and by use of cutbacks and emulsion.
- In presence of water bitumen should not strip off from aggregate.
- Bitumen should be durable in all seasons.
- It should not become too soft during summers and develop cracks during winters.

Road Tar: This bituminous material is obtained by the destructive distillation of organic matters such as wood, coal shale etc. In the process of destructive distillation, the carbonation results in the production of crude tar which is further refined by distillation process

Cut-back Bitumen: The asphaltic bitumen is very often mixed with comparatively volatile solvents to improve the workability of the material. The solvent gets evaporated leaving behind the particles together. This cutback bitumen is classified into slow, medium and rapid curing depending upon the type of solvent used.

Emulsions: An emulsion is a mixture of normally two immiscible liquids. Asphalt gets broken up into minute globules in water in the presence of the emulsifiers. It improves the workability of bitumen or asphalt. As a result of emulsification, asphalt is available at normal temperature in the liquid form

Bitumen: 60/70, 80/100 grade bitumen.

C. Plastic Material

Plastics are usually classified by their chemical structure of the polymer's backbone and side chains. Some important groups in these classifications are the acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be classified by the chemical process used in their synthesis, such as condensation, polyaddition, and crosslinking. There are two types of plastics: thermoplastics and thermosetting polymers. Thermoplastics are the plastics that do not undergo chemical change in their composition when heated and can be moulded again and again. The properties of plastics are defined chiefly by the organic chemistry of the polymer. such as hardness, density, and resistance to heat, organic solvents, oxidation, and ionizing radiation.

Types of Plastics:

- PET, polyethylene terephthalate
- HDPE, high-density polyethylene
- PVC, polyvinyl chloride
- LDPE, low-density polyethylene
- PP, polypropylene
- PS, polystyrene

Plastics are durable and degrade very slowly; the chemical bonds that make plastic so durable make it equally resistant to natural processes of degradation. Thermoplastics can be remelted and reused, and thermoset plastics can be ground up and used as filler, although the purity of the material tends to degrade with each reuse cycle. There are methods by which plastics can be broken back down to a feedstock state.

Classification of Plastic Waste:

- Polyethylene
- Polypropylene

This plastic may be available in the form of carry bags or solid plastic it's depend upon the use and need of the industries. It is available in the form of plastic bottles and mat sheets etc.

D. Preparation Of Plastic Waste Material

The use of plastic materials such as carry bags, cups, etc. is constantly increasing. The consumption of plastics has increased from 4000 tons/annum to 4 million tons/annum and it is expected to rise 8 million tons/annum during the year 2010. Nearly 50 to 60% of the total plastics are consumed for packing.

Details of Shredding Machine:

- Agglomerator
- Specification of Agglomerator

E. Plastic Waste Blending Materials

- Preparation of blend
- Characterization of blend
- Separation Test (IRC-SP: 53-1999)
- Characterization of Plastic Waste-Bitumen

F. Blend for Flexible Pavement

Preparation of Plastic-Waste Coated Aggregate: The aggregate are heated to around 1700C; the plastic waste shredded to the size varying between 2.36mm and 4.75mm. This shredded plastic waste is added over hot aggregate with constant mixing to give a uniform distribution. The plastic get softened and coated over the aggregate. The hot plastic waste coated aggregates are mixed with hot bitumen 60/70 or 80/100 grade (1600C) as shown in Fig2. For shredding of solid plastic waste of poly-propylene 'scrap grinding machine' is used. In this process, a solid plastic waste cut in small pieces with the help of with two rotating and one fixed blades. This whole process gives output in per hour rate. Following are the Specifications of Scrap Grinder

- Output 7.5Kg/hr.
- Length of rotor-200mm
- Length of blade-200mm
- No. of blades rotating-2Nos.
- Fixed blade-1No.
- Motor-3HP,900RPM

Fig.2. Shredding Machine Blade.

VI. RESULTS AND DISCUSSION

A. Aggregate Impact Value

The coating of plastics improves Aggregate Impact Value, thus improving the quality of the aggregate. Moreover, a poor quality of aggregate can be made useful by coating with polymers. It helps to improve the quality of flexible pavement. This shows that the toughness of the aggregate to face the impacts. Its range should be less than 10% as shown in Fig.3.

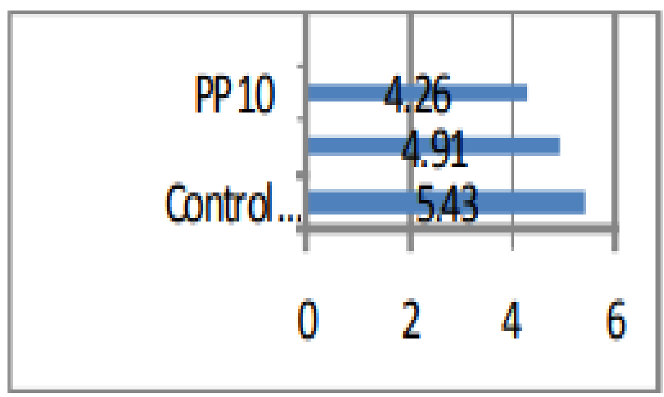

Fig.3. Comparison of Aggregate Impact Value Test Results.

B. Aggregate Crushing Value

The aggregate with lower crushing value indicate a lower crushed fraction under load and would give a longer service life to the road. Weaker aggregate would get crushed under traffic load. It is clearly seen from Table- that plastic-coated aggregates shows the lower crushing value and which can be withstand to traffic load more efficiently than the plain aggregates. The results show that the aggregates are within the range according to ISS. Its range should be less than 30-35%, as shown in Fig.4.

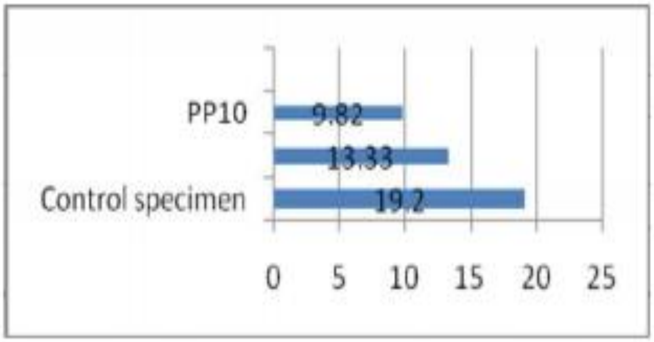

Fig.4. Comparison of Aggregate Crushing Value Test Results.

C. Specific Gravity

The specific gravity of an aggregate is an indirect measure of its strength as shown in Fig.5. The more specific gravity the more is the strength. The value of specific gravity of plain aggregate is less as compare to that of plastic coated aggregate. Since aggregates having low specific gravity are generally weaker than those with higher specific gravity values, the results say that the specific gravity of the aggregates are increased increasing its strength. Its range should be within 2.5-3.0%

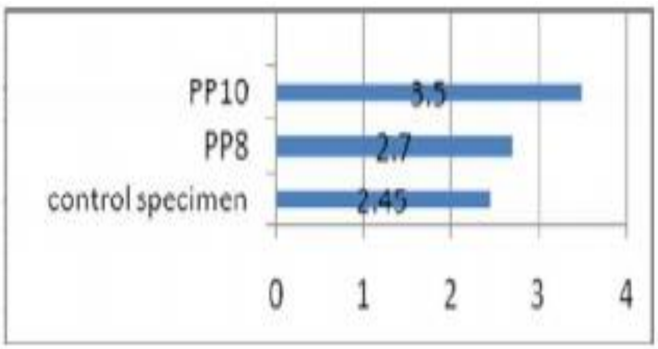

Fig.5. Comparison of Specific Gravity Test Results.

D. Stripping Value

Stripping value gives the effects of moisture upon the adhesion of bituminous film to the surface particles of the aggregate. The plastic coating to aggregates gives the nil value of stripping. It indicates that the aggregates are more suitable for bituminous road construction than plain aggregates. The results obtained of the control specimen are within the range of the IRC standards whereas coating of the aggregate reduces the affinity of the aggregate towards water. Its range should be less than 25% as shown in Fig.6.

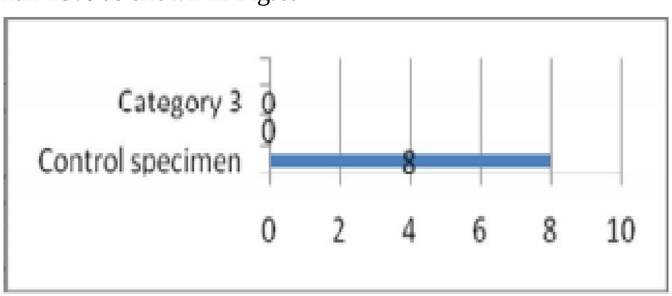

Fig.6. Comparison Of Stripping Value Test Results.

E. Water Absorption

The aggregate is chosen also on the basis of the moisture absorption capacity. The aggregate when coated with plastics improved its quality with respect to moisture absorption. The coating of plastic decreases the moisture absorption and helps to improve the quality of the aggregate and its performance in the flexible pavement. The results show that the moisture absorption of the aggregate is within the range of IRC specifications which reduced to nil due to coating. Its range should be less than 10%.

F. Los Angeles Abrasion Value

The repeated movement of the vehicle will produce some wear and tear over the surface of pavement. This test gives that wear and tear in percentage. Under this study the percentage of wear and tear values of plastic coated aggregate is found to be in decreasing order with respect to the percentage of plastics as shown in Fig.7.

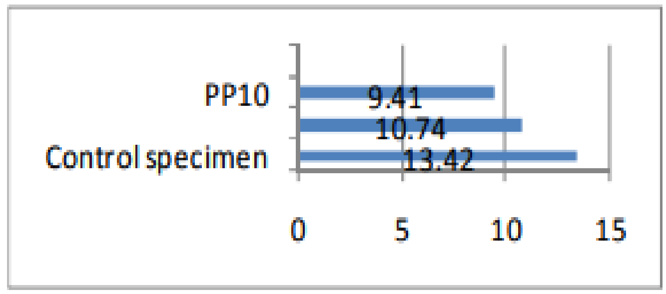

Fig.7. Comparison Of Los Angeles Test Results.

TABLE III: Observations For Tests On Bitumen

PROPERTIES	NORMAL BITUMEN	5% PLASTIC ADDED BITUMEN	7% PLASTIC ADDED BITUMEN	9% PLASTIC ADDED BITUMEN
STABILITY(KN)	17.77	7.7	8.24	6.42
AIR VOIDS(%)	3.27	2.46	2.28	2.66
FLOW(%)	4.16	6.41	5.04	6.26
VFB(%)	74.93	65.19	71.6	66.23
SPECIFIC GRAVITY	1.02	0.99	0.97	0.93

TABLE IV: Results of Tests On Bitumen

Test	Result	Ranges
Ductility Test	77.50 cm	Min 40
Penetration value	63 mm	60-70 mm
Viscosity value	50.1 sec	-
Softening Point	48.25^{0}C	45-600C
Flash Point Test	280^{0}C	>65^0-175^{0}C
Fire Point Test	302^{0}C	

TABLE V: Modified Bitumen Marshall Stability Test

PROPERTIES	NORMAL BITUMEN	5% PLASTIC ADDED BITUMEN	7% PLASTIC ADDED BITUMEN	9% PLASTIC ADDED BITUMEN
STABILITY(KN)	17.77	15.20	18.58	18.70
AIR VOIDS(%)	3.27	3.08	3.76	3.22
FLOW(%)	4.16	3.72	3.71	4.26
VFB(%)	74.93	77.48	77.54	74.89
SPECIFIC GRAVITY	1.02	1.04	1.05	1.03

TABLE VI: Values For LDPE

Test	NORMAL BITUMEN	5% PLASTIC ADDED BITUMEN	7% PLASTIC ADDED BITUMEN	9% PLASTIC ADDED BITUMEN	Range
Ductility(kn)	71	52	47	42	MIN 75
Softening point(°C)	47	53	54	55	47-80
Flash point(°C)	180	173	175	177	180-185
Firepoint (°C)	186	180	183	184	185-190

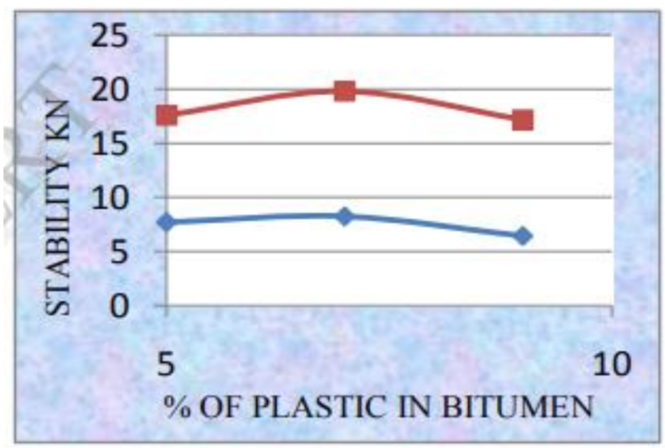

Fig.8. Bitumen% Vs Flow Values.

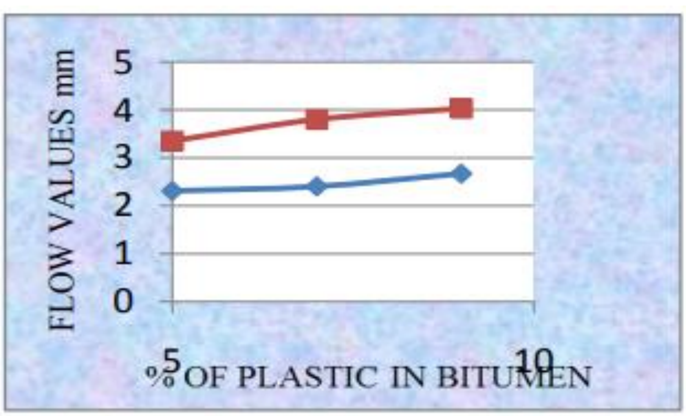

Fig.9. Bitumen %Vs Bulk Specific Gravity (kg/m^3).

G. Comparison of Tests Results

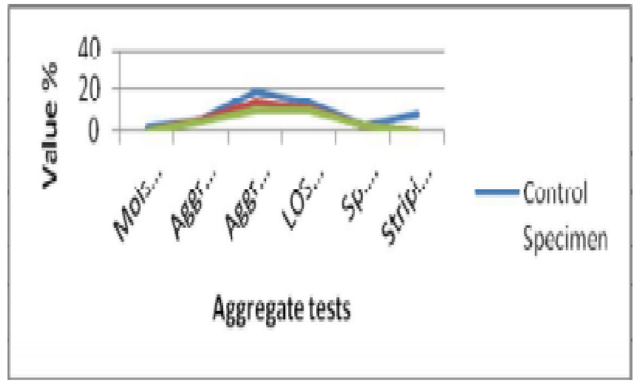

Fig.10. Comparison of Aggregate Test Results.

The above fig.10 shows the comparison of test results. It is evident from the figure that the use of polymer gives better results as compared to plain bitumen. Also higher percentage of polymer content gives lower values of impact, crushing, abrasion. The percentage of moisture content and the stripping value is nil in plastic coated aggregate

VII. CONCLUSION

Plastic coating on aggregates is used for the better performance of roads. This helps to have a better binding of bitumen with plastic wasted coated aggregate due to increased bonding and increased area of contact between polymers and bitumen. The polymer coating also reduces the voids. This prevents the moisture absorption and oxidation of bitumen by entrapped air. This has resulted in reducing rutting, ravelling and there is no pothole formation. The roads can withstand heavy traffic and show better durability. Following are some points which are drawn from the study:

- Aggregate Impact value of control specimen was 5.43%. It reduced to 4.91% for PP8 and 4.26% for PP10. Reduction in value was 10% for PP8 and 22% for PP10. This shows that the toughness of the aggregate was increased to face the impacts.
- Crushing Value was reduced from 19.2% to 13.33% and 9.82% for PP8 and PP10 respectively. Value reduced by 30% for PP8 and 48% for PP10. Low aggregate crushing value indicates strong aggregates, as the crushed fraction is low.
- Specific Gravity of the aggregate increases from 2.45 for control specimen to 2.7 for PP8 and 2.85 for PP10 due to plastic coating.
- Stripping Value was reduced from 8% for control specimen to nil for PP8 and PP10. This shows that coated aggregate are more suitable for bituminous construction than plain aggregates.
- Water Absorption is also reduced to nil for PP8 and PP10 from 1.7% for control specimen.
- Los Angeles Abrasion Value of the control specimen was found to be 13.42%. Coating of polymer over aggregate for PP8 increased abrasion value by 19.97% and 29.88%for PP10. This indicates the hardness of the aggregate.

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