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Utilization of Waste Polymers for Flexible Pavement and Easy Disposal of Waste Polymers

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ABSTRACT

Solid waste management is the thrust area. Of this various waste materials, plastic waste, tyre waste and municipal solid waste are of great concern. On the other side, the road traffic is increasing. The traffic intensity is increasing. The load bearing capacities of the road are to be increased. Our present work is helping to take care of both these aspects. Plastic waste, consisting of carry bags, cups and thermocoles can be used as a coating over aggregate and this coated stone can be used for road construction. By this process a road of 1 Km length and 3.375M width of single lane can consumes 10, 00000 carry bags and the road strength is increased by 100% and there is no pot hole formation. Secondly the waste tyres are powdered and the powder is blended with bitumen and this blend is used along with plastic coated aggregate. The mix polymer coated aggregate and tyre modified bitumen have shown higher strength. Use of this mix for road construction helps to use both plastics waste and tyre waste. Once the plastic waste is separated from municipal solid waste, the organic matter can be converted into manure and used. Our paper will discuss in detail the process and its successful applications.

Keywords: waste polymers, Flexible povement

1.0 INTRODUCTION

Plastics, a versatile material and a friend to common man becomes a problem to the environment after its use. Disposal of a variety of plastic wastes in an eco friendly way is the thrust area of today's research. The authors' innovative techniques to use the waste plastics and the tyre waste for the construction of flexible pavement, for making pathway blocks, and for making laminated roofing sheets form a good solution for the waste disposal problem of both plastic waste and municipal solid waste.

2.0 CHARACTERIZATION OF WASTE PLASTICS

2.1 Thermal Study

Thermal behavior of the polymers namely PE, PP and PS is shows in Table 1.

Table 1. Thermal Behavior of Polymers

Polymer	*Solubility*		*Softening Temp in Deg.C*	*Products reported*	*Decom position Temp Deg.C*	*Products reported*	*Ignition temp. range in Deg. C*	*Products reported*
	Water	*EPT**						
PE	Nil	Nil	100-120	No gas	270-350	CH_4,C_2H_6	>700	CO,CO_2
PP	Nil	Nil	140 - 160	No gas	270-300	C_2H_6	>700	CO,CO_2
PS	Nil	Nil	110-140	No gas	300-350	C_6H_6	>700	CO,CO_2

- 5% acetic acid

2.2 Binding Property

The molten plastics waste exhibits **good binding property**. Various raw materials like granite stone, ceramics etc... were coated with plastics and then molded into a stable product. On cooling, it was tested for compression and bending strengths.

Table 2. Binding Property

Percentage of plastics coating over aggregate	*Compression Strength (Tonnes)*	*Bending Strength (Kg)*
10	250	325
20	270	335
25	290	350
30	320	390

The increase in the values of the compression strength and bending strength shows that the plastics can be used as a binder.

3.0 CHARACTERISTICS OF PLASTIC COATED AGGREGATE (USED FOR FLEXIBLE PAVEMENT)

3.1 Moisture Absorption and Void Measurement

For the flexible pavement, hot stone aggregate (170^0c) is mixed with hot bitumen (160^0c) and the mix is used for road laying. The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity as per IS coding. The bitumen is chosen on the basis of its binding property, penetration value and viscoelastic property. The aggregate, when coated with plastics improved its quality with respect to voids, moisture absorption and soundness. The coating of plastic decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement. It is to be noted here that stones with < 2% porosity only allowed by the specification.

3.2 Soundness Test

Soundness test is intended to study the resistance of aggregate to weathering action. The weight loss is attributed to the poor quality of the aggregate. The plastic coated aggregate, did not show any weight loss, thus conforming the improvement in the quality of the aggregate.

3.3 Aggregated Impact Value

A study on the effect of plastic coating was extended to study on the aggregate impact value. Aggregate was coated with 1% & 2% plastics by weight and the plastic coated aggregate was submitted to Aggregate Impact Value test and the values were compared with values for non coated aggregate.

Table 3

Percentage of Plastics	*Aggregate Impact value*
Nil	25.4
1%	21.20
2%	18.50

It is clearly observed that the coating of plastics improves Aggregate Impact Value. Coating of plastics over the stone aggregate improves the quality of the aggregate. Moreover a poor quality of aggregate can be made useful by coating with polymers.(Table 3). This in turn helps to improve the quality of flexible pavement.

3.4 Los Angel's Abrasion Test

The repeated movement of the vehicle with iron wheeled or rubber tire will produce some wear and tear over the surface of the pavement. This wear and tear percentage of an aggregate is determined with the help of Los Angeles abrasion study. Under this study the percentage of wear and tear values of the plastic coated aggregate is found to be in decreasing order with respect to the percentage of plastics (Eg. 37% without plastic, 32% with 1% plastic and 29% with 2% plastic). When the Los Angeles abrasion value of plain aggregate value is compared with the Plastic coated aggregate the values are less for polymer coated aggregate.

4.0 CHARACTERISTICS OF POLYMER MODIFIED BITUMEN

An alternate use of plastic waste is also under study where plastics is mixed with bitumen and used for preparing the mix. The mix was used to study the basic properties of bitumen like softening point, penetration point and ductility. The penetration value was decreased to a very low value and similarly the ductility. More than 3% addition of waste plastics to the bitumen results in a hard polymer modified bitumen with very poor viscoelastic property (The minimum values for a suitable bitumen P.V = 80; Ductility ≈ 50).

Table 4. Properties of Polymer Modified Bitumen

% of Plastics	*Ductility (cm)*	*Penetration (mm)*	*Softening Point (^{o}c)*
1%	64	95	54
2%	55	90	50
3%	20	80	50
5%	11	55	72
10%	7	Nil	75

On comparison it may be inferred that the use of higher percentage of plastics in polymer modified bitumen is not favorable (Table 4).

5.0 STUDY ON CRUMB RUBBER MODIFIED BITUMEN

The waste tires are made into powder by grinding into some special type of grinders. The powder is collected and it is used for modification of bitumen. The bitumen is heated to 100-120^{o}c and the powdered crumb rubber is added to the bitumen and stirred well with help of mechanical stirrer. The mix is stirred at the speed of 3000 RPM to get a homogenous mixture. The stirring is carried out for 2-3 hours. The crumb rubber blended bitumen is subjected to different tests like penetration point, ductility, softening point. Here we have taken 80/100 bitumen and it is modified with different percentage of crumb rubber powders starting from 1% to 5%.

The results of the test are given in Table 5.

Table 5. Data on Crumb Rubber Modified Bitumen

% of crumb rubber	*% of plastics*	*Ductility Values (cm)*	*Softening point (^{0}C)*	*Penetration at 25^{o}C (mm)*
1%	5	75	53	90
2%	5	72	54	88
3%	5	70	56	85
5%	5	61	58	70

6.0 FIELD STUDY

More than 1500kms length of Plastic tar road was laid by Tamil Nadu government during 2004-2006. Test road were laid at Mumbai, Pondicheery and Trivandrum. These roads are functioning well without pothole, raveling and rutting. The process requires only 30 seconds for mixing 10% of plastics. The plastic available in the near by area can be used.

6.1 Testing of the Roads

As per our discussion above the load withstanding capacity of the road is increased by a large amount. This is proved by conducting various tests on the built plastic tar roads at different places at different times. This test has been carried out with the help of National Transport Planning and Research Centre, Trivandrum. The tests show very good results some of the tests are listed below.

i) To measure the roughness of the pavement surface.
ii) To measure the resistance offered by the pavement surface against skidding of vehicles.
iii) To measure the pavement macro texture for the geometrical deposition.
iv) To assess the structural evaluation of flexible pavement for the strength of the pavement.
v) To Measure the Field Density of the road.
vi) To study the Gradation of the laid road.
vii) To carry out different tests on recovered bitumen.
viii) Examine the condition of the road (cracks, raveling, potholes, rutting, corrugation edge Break)

Table 6. Summary of Results

Road	*Year laid*	*Average Daily Traffic*	*Unevenness (mm /km)*	*Skid number*	*Texture Depth (mm)*	*Rebound Deflection (mm)*
Car Parking Road	Jan 2007	95	3200	50	0.53	0.70
Canteen Road	2004	280	3000	55	0.55	0.75
Men's Hostel Road	2005	180	3010	59	0.56	0.61
Vilachery Road	2005	1000	3250	50	0.50	0.70
Vandiyur Road	2003	600	3100	66	0.47	0.62
Bitumen Road	2003	1000	4700	55	0.90	1.55

- From the skid resistance studies of the five stretches it has been proved that the entire road was having good skid resistance values.
- From the surface texture studies of the five stretches it has been proved that the roads inside the campus and the other two outside roads have good texture values.
- From the deflection studies of the five stretches it has been proved that all the stretches are reasonably strong.
- From the bump integrator studies of the five stretches it has been proved that the unevenness index value of these three road sections are nearly to 3000 mm/km, which indicates a good surface evenness.

7. ECONOMY OF THE PROCESS AND THE PLASTIC WASTE AVAILABLE

This dry process helps to use good quantity of plastic waste in road construction. A model calculation is given in Table 7.

Table 7. Economics of the process

Size of the road	*Bitumen needed*	*Plastics needed*	*Bitumen saved*	*Cost reduced*
1kmX 3.75 m	9 tonnes	1 tonnes	1 tonnes	Rs,15,000

A model is being worked using Tirunelveli, a town in Tamil Nadu. The plastics waste collected is around 650 tonnes/ annum. The roads available are approximately 400km and their annual requirement of plastic waste to lay plastic road is more than 600 tons. So the total waste generated could be used for road laying. The life of the road is increased and hence the maintenance expenditure is reduced.

8.0 WASTE PLASTICS AND OTHER END USES

8.1 Path Way Block

Waste plastics are used to prepare pathway block using its binding property, compression strength and the bending strength. The block is good substitute for concrete block. Here the waste consumption is very high. 1 sq.m area needs 15 kg of plastics. It is also a very useful process to help to overcome the problem of waste disposal.

8.2 Plastic Laminated Roofing

Paper board, dipped in bitumen is used as black corrugated sheets for roofing. Process has been developed to coat the waste plastics on the card board. The flexibility is incorporated using specific polymer mix (process is being patent). The plastic laminated board has no water absorption compared to existing boards.

Table 8. Data on Moisture Absorption Studies

Percentage of plastics	*0%*	*1%*	*2%*	*3%*	*5%*
Moisture absorption	0.0616	0.0157	0.0063	0.0014	Nil

Using the plastics and dyes, attractive boards are prepared. A sq.m of board needs 250gm of plastics. This is again another process for the use of waste plastics.

9.0 NEED OF THE HOUR

- Segregation at the source is to be done. Domestic waste plastics need to be separated at the source and collected efficiently. This can be implemented using the Self Help Group. The Self Help Group will shred the plastic and supply for road construction. This process helps the Self Help Group to have an income of Rs 300-500 per day easily. (The cost of shredding machine is around Rs 25,000). Segregation can be improved by educating school students through awareness camps and requesting them to bring the domestic waste plastics to the school through social organization like NSS. This helps to clean the house and prevent the Waste Plastics reaches Municipal Solid Waste. This also helps to create needed Garbage culture to the next generation.
- Public houses are to be given definite instruction or order to collect the waste plastics separately. and hand over the sane to Self Help Group.
- Awareness camps should be conducted to the Engineers of City Corporation and at all society level and at educational institutions both by government and by social organizations. Instead going through the banning of plastics, it is important that needed education is to be given.
- The present use of Vinyl plastics for flex board is increasing manifold. The disposal of this flex board is again to be attended too.

10.0 CONCLUSION

The generation of waste plastics is increasing day by day. The major polymers namely polyethylene, polypropylene, polystyrene show adhesion property in their molten state. Stone aggregate is coated with the molten waste plastics. The coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate bitumen mix forms better material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics. The use of polymer coated aggregate is better than the use of polymer modified bitumen in many respects. Moreover the polymer coated aggregate helps to use Crumb rubber modified bitumen resulting in better result. In India more than 3.3 million km of road is available. If they are constructed as plastic tar road, there will be less waste plastic available on the road. The process is eco friendly. The use of waste plastics in the manufacture of pathway blocks and laminated roofing also help to consume large quantity of waste plastics. These processes are eco friendly and socially highly relevant, giving better infrastructure. Let us grow with these newer technologies.

Note: The innovation was awarded patent on 13-02-2006. The technique is being used in India for the past 3 years. Patent No: A-CH\871. Reg No: 198254, Dt. 27-06-2002

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