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Experimental behaviour of roads by using plastic waste.

Comportamiento experimental de carreteras mediante el uso de residuos plásticos.

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ABSTRACT

The use of plastic and related materials is increasing exponentially due to tremendous growth in population, urbanization and changed life style leads to widespread littering of plastic on the landscape. Disposal of waste plastic is a serious problem globally due to their non-biodegradability and hazardous to human health's, since these are not disposed scientifically and thus, create ground and water much polluted. If this curse to mankind in the form of waste plastic which can be used as a boon for mankind by using it as additives in road construction, it will proved to be a best solution over worst road condition. In the present paper, techniques have been developed to use plastic waste for construction of bituminous roads and flexible pavements to be discussed. In general bitumen is used as binder in road construction. Binding properties of this bitumen can be modified by blending it with waste plastic pieces. It can be used for construction purpose.

Keywords: Bitumen, Coarse Aggregate, Ductility Test, Flash and Fire Point test, Plastic Waste.

RESUMEN

El uso de plástico y materiales relacionados está aumentando exponencialmente debido al tremendo crecimiento de la población, la urbanización y el cambio de estilo de vida conduce a una gran cantidad de basura plástica en el paisaje. La eliminación de residuos plásticos es un problema grave a nivel mundial debido a su no biodegradabilidad y peligro para la salud humana, ya que estos no se eliminan científicamente y, por lo tanto, crean suelos y aguas muy contaminados. Si esta maldición para la humanidad en forma de plástico de desecho que puede usarse como una bendición para la humanidad al usarlo como aditivos en la

construcción de carreteras, demostrará ser la mejor solución en las peores condiciones de la carretera. En el presente trabajo, se han desarrollado técnicas para utilizar residuos plásticos para la construcción de carreteras bituminosas y pavimentos flexibles que se discutirán. En general, el betún se utiliza como aglutinante en la construcción de carreteras. Las propiedades aglutinantes de este betún se pueden modificar mezclándolo con residuos de plástico. Se puede utilizar para fines de construcción.
Palabras clave: Betún, Agregado grueso, Ensayo de ductilidad, Ensayo de punto de inflamación y fuego, Residuos plásticos.

INTRODUCTION

The threat of disposal of plastic will not solve until the practical steps are not initiated at the ground level. It is possible to improve the performance of bituminous mix used in the surface course of roads. Studies reported in the use of recycled plastic, mainly polyethylene, in the manufacture of blend indicated reduced permanent deformation in the form of ruts, reduced cracks and cracking in the pavement surface. 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 flexible pavement made of plastic waste of 8% and 10% was taken into consideration and obtained the results as 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 [1]. Flexible pavements made from A5% and 10% (PP), 10% (PE FOAM) , 5% and 10% (LDPE) [2]. Various studies [3-6] are being carried out to improve the quality of bitumen used in bituminous road construction. One of the results of such studies is to use polymer-modified bitumen.

MATERIALS AND METHODS

Coarse Aggregate: the size of 12mm – 20mm range are used in this research work and the results of the aggregate from various test such as aggregate impact value, aggregate crushing value and specific gravity are shown in table – 3.

Bitumen: The grade of straight run bitumen is chosen depending upon the climatic conditions of the region in which surface dressing is to be constructed. In most parts of India 80/100 and 180/200 grades bitumen is used. Heavier grade cut backs, rapid setting

emulsions or heavier grade tars may also be used. In this research work, we used the bitumen grade of 60/70.

Fig 1 – Coarse Aggregate and bitumen

Plastics types used in this research work: The various types of plastic resins were Polyethylene terephthalate (PET, PETE); Density polyethylene (HDPE) and (LDPE); Vinyl (Poly vinyl chloride or PVC); Polytetrafluoroethylene (Teflon) and Polystyrene (Styrofoam)

Waste Plastic bottles, LDPE/HDPE bags, Wrappers are collected from the nearby houses and apartments and from the dump yards. The collected plastic wastes are dried for 48hrs and were taken to nearby shredded garage. From the garage we obtained shredded plastics of size less than 4.75mm about 30% and much fined particles less than 2.36mm about 70%.

Fig 2 –Processing Waste Plastic

Bitumen Mix: The collected bitumen was heated at a temperature of 160 – 170 ◦ C and 20% of shredded plastic waste of size less than 2.36mm was added during the heating of the bitumen itself. Then the bitumen mixes is formed in different shapes according to the testing and apparatus required. The penetration test, specific gravity test, ductility test, softening point and flash & fire point tests were conducted for the bitumen mixed with plastic waste.

Plastic roads: Plastic use in road construction is not new. It is already in use as PVC or HDPE pipe mat crossings built by cabling together PVC (polyvinyl chloride) or HDPE (high-density poly-ethylene) pipes to form plastic mats. The plastic roads include transition mats to ease the passage of tyres up to and down from the crossing. Both options help protect wetland haul roads from rutting by distributing the load across the surface. But the use of plastic-waste has been a concern for scientists and engineers for a quite long time. Recent studies in this

direction have shown some hope in terms of using plastic-waste in road construction i.e., Plastic roads. An initial study was conducted in 1997 by the team to test for strength and durability.

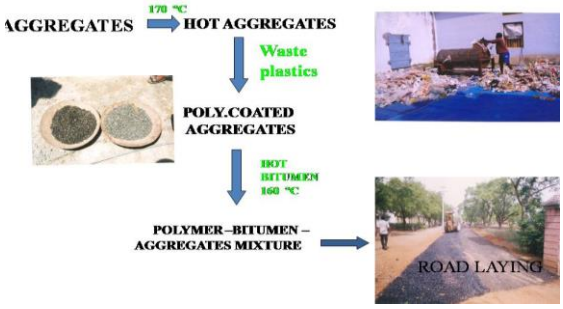

Fig 3 – Waste plastics coated aggregate – bitumen mix

Experimental work: the experimental work for the research carried on soil, coarse aggregate, Bitumen mixed with shredded plastic waste in dry state. Various types of waste plastic are collected, analysed as per their type and sent for storage. These segregated wastes are then cleaned and dried to remove impurities from them. Then cut into a size of 1.18-4.36 mm using shredding machine, (PVC waste should be eliminated). The aggregate mix is heated to 165^{o} C (as per the HRS specification) and transferred to mixing chamber. Similarly the bitumen is to be heated up to a maximum of 160^{o} C (HRS Specification) to have good binding and to prevent weak bonding. (Monitoring the temperature is very important). 20% percentage of shredded plastic waste is been mixed with bitumen and the results were compared.

- Tests carried out on soil
  - Sand replacement method
  - Core cutter method
  - Specific gravity of soil
- Tests carried out on Coarse Aggregates
  - Specific gravity test
  - Aggregate crushing value test
  - Aggregate Impact value test
- Tests carried out on Bitumen mixed with Shredded Plastic Waste
  - Specific gravity test
  - Penetration test

The material is heated between 75-100^{o}C. The mix was stirred continuously to remove air bubbles and water, and filtered through IS Sieve 30. The sample is poured in the cup and left cooling and then it is placed in the penetration apparatus for testing. With pressing the

button, needle penetrates the sample for 5seconds and noted the needle penetrated which is shown in the table – 4.

Ductility test: the material is heated between 75-100^{o}C. The mix was stirred continuously to remove air bubbles and water, and filtered through IS Sieve 30. The mix is cooled for 30 minutes. Experiment is carried and the final breaking point of the bitumen mix is noted, the result are shown in table – 4.

Fig 4 – Penetration and Ductility Test

- Softening point test

The material is heated between 75-100oC. The mix was stirred continuously to remove air bubbles and water, and filtered through IS Sieve 30. The mix is cooled for 30 minutes and the excess material was removed with the help of a warmed, sharp knife. The mix was filled in the rings and assembled in position with the beaker filled with boiled distilled water at a temperature of 5.0 ± 0.5 °C per minute. With the help of a stirrer, stir the liquid and apply heat to the beaker at a temperature of 5.0 ± 0.5 oC per minute. The heat was applied until the material softens and allows the ball to pass through the ring. The final temperature is recorded and mentioned in the table – 4.

- Flash and Fire point test

The material is heated between 75-100^{o}C. The mix was stirred continuously to remove air bubbles and water, and filtered through IS Sieve 30 and the sample is filled into the cup up to the filling mark and it is then placed into the water bath. The thermometer is inserted to measure the temperature in both high and low range as per requirement and also to stir it.

RESULTS AND DISCUSSION

The above mentioned tests were done in this research work. From penetration test and ductility test we observed that the bitumen mixed with shredded plastic waste is more penetrated and more ductile. The test results for the various materials are as shown in the following tables.

- Results obtained from soil test

SAND REPLACEMENT TEST RESULTS

Table 1 – Sand replacement (Stage 1 – Calibration of Unit weight of sand) test results

S.No	Data (Calibration of Unit Weight of Sand)	Soil sample
1	Volume of the calibrating container, V (cm^3)	1708.10 g/cm^3
2	Weight of SPC + sand, W_1 (g)	8.733kg
3	Weight of sand required to fill the conical portion on a flat surface, W_2(g)	8.010kg
4	Weight of SPC + sand (after filling calibrating can), W_3 (g)	5.984kg
5	Weight of sand required to fill the calibrating container, $W_c = (W_1-W_2-W_3)$ (g)	0.728kg
6	Unit weight of sand, $\gamma_{sand} = (W_c)/V$ (g/cm^3)	1.10g/cm^3

Table 2 – Sand replacement (Stage 2 – Determination of Density of soil) test results

S.No	Data (Determination of Density of Soil)	Soil sample
1	Weight of the excavated from the pit (W) (g)	1.295kg
2	Weight of sand + SPC, before pouring, W_1 (g)	8.73kg
3	Weight of SPC after filling the hole & conical portion, W_4 (g)	4.488kg
4	Weight of sand in the pit, $W_p = (W_1-W_4-W_2)$ (g)	0.771kg
5	Volume of sand required to fill the pit, $V_p=W_p/\gamma_{sand}$ (cm^3)	700.9kg
6	Wet unit weight of the soil, $\gamma_{wet}=W/V_p$ (g/cm^3)	1.847g/cm^3

Field density of soil by sand replacement method, ρ= 1.847 g/cm^3

a. CORE CUTTER METHOD TEST RESULTS

Bulk unit weight (γ_b) of the soil using the following relationship, $\gamma_b = (W_2-W_1)/V$ ={(2.547-0.94)/1021.01} =1.569 g/cm^3

b. SPECIFIC GRAVITY TEST OF SOIL RESULTS – 2.38

- Results obtained from coarse aggregate test

Table 3 – Test results on Coarse Aggregate

S.No	Test conducted on Coarse Aggregate	Results obtained
1	Specific gravity Test	2.71
2	Aggregate Crushing Value	31.65%
3	Aggregate Impact Test Value	14.37%

- Results obtained from Bitumen mixed with Shredded Plastic Waste

Table 4 – Test results on Bitumen mixed with Shredded Plastic Waste

S.No	Test conducted on Bitumen mixed with Shredded Plastic Waste		Results obtained	
			For bitumen	For bitumen mixed with Plastic waste
1	Penetration test		64.756mm	71.3mm
2	Ductility test		75 cm	79cm
	Specific gravity test			
3	I)	Solids and Semi Solids	2.45	2.41
	II)	Liquids	3.45	3.24
4	Softening point test		48.5 º C	43.2 º C
	Flash and Fire point test			
5	I)	Flash point	166ºC	156ºC
	II)	Fire point	215ºC	206ºC

From the above tables we obtained the result for the bitumen mixed plastic waste and then it is compared with the conventional bitumen mix, the following were the comparison charts.

Comparison charts of Bitumen mix and shredded plastic mix

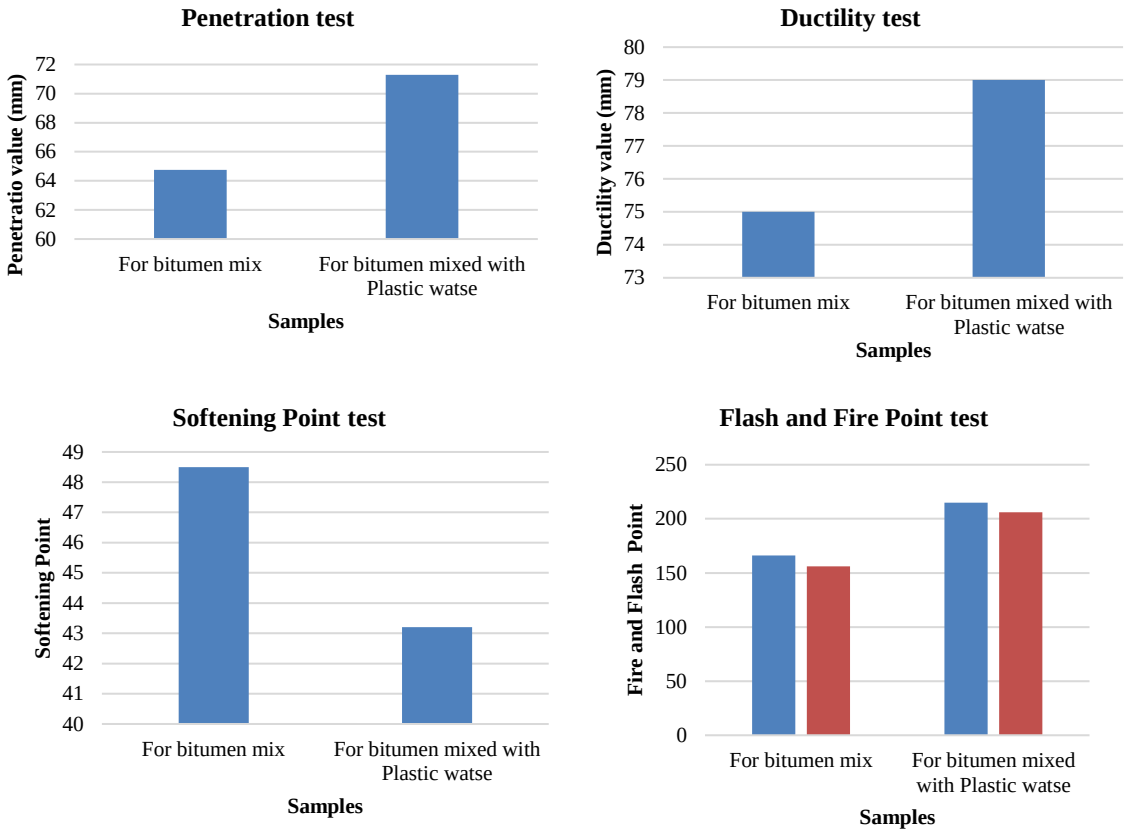

Fig 5 – Comparison chart on Bitumen mix and Bitumen mixed with Shredded Plastic Waste

Comparison chart bituminous roads between ordinary bituminous roads (OBR) and waste plastic roads (WPR)

Tab 5 – Comparison chart on OBR and WPR

S.No.	Properties	Bitumen mix	Bitumen mixed with Plastic waste
1	Binding property	Good	Better
2	Softening point	Less	More
3	Penetration value	More	Less
4	Tensile strength	Less	More
5	Rutting	More	Less
6	Seepage of water	Yes	No
7	Durability	Good	Better

From this bitumen mixed with shredded waste plastic gives better performance. The tensile strength of the bitumen mixed with shredded waste plastic is 5% more than the ordinary bitumen mix. The bitumen mixed with shredded waste plastic is less softens than the ordinary bitumen mixes and the seepage of water is very less due to the softening of the material sample. Due to their high tensile strength, we recommend that there may be no potholes and it leads to less cracking. From this study we conclude that the shredded plastic waste can be replaced with 20% of the bitumen which may be increased in future.

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