International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.6., 2015
(Nov.-Dec.,)

RESEARCH ARTICLE

ISSN: 2321-7758

PERFORMANCE OF POLYETHYLENE WASTE ON THE EFFECT OF CBR VALUES OF GRAVEL AND CLAY IN ROAD CONSTRUCTION

S.P.KANNIYAPPAN[1], T.D.RAMADASAN[1], N.RISHINATH[2], C.LAVANYA[1]

[1]Assistant Professor, Adhiparasakthi Engineering College, Melmaruvathur, Tamilnadu, India

[2]Assistant Professor, Adhiparasakthi College of Engineering, Kalavai, Tamilnadu, India

S.P.KANNIYAPPAN

ABSTRACT

The cost of construction of flexible pavements depends on thickness of the pavement layers. Thickness of pavement mainly depends on the subgrade. By suitable improvement to the strength of the subgrade, considerable saving in the scarce resources and economy can be achieved. Because of the lightweight, easy handling, non-breakable and corrosion free nature, POLYETHYLENES (PE) have surpassed all other materials in utility. But polyethylene waste has been a matter of concern to environmentalists as it is non-degradable. In this Project, an attempt has been made to study the improvement of California bearing ratio (CBR) value of soils stabilized with waste polyethylene bags. This alternative material is mixed in different proportions to the gravel and clay to determine the improvement of CBR value .The use of the polyethylene bags absorbed to have a significant impact on the strength and economy in pavement construction, when these are available locally in large quantities. In this paper we have discussed about that, how this polyethylene improves the CBR value when added in gravel and clay.

I. INTRODUCTION

Plastic is everywhere in today's lifestyle. The disposal of plastic wastes is a great problem. These are non-biodegradable product due to which these materials pose environmental pollution and problems like cancer, reproductive problems in humans and animals, genital abnormalities and even a decline in human sperm count and quality. In recent years, applications of plastic wastes have been considered in road construction with great interest in many developing countries. Several million metric tons plastic wastes are produced in India every year. If these materials can be suitably utilized in highway road construction, the pollution and disposal problems may be partly reduced. The possible use of these materials should be developed for construction of low-volume roads in different parts of our country. A review of various plastic wastes for use in the construction of roads has been discussed in this paper.

In developing countries having a predominantly rural population, the need for constructing large networks of village roads, market roads and other district roads cannot be over emphasized. With severe constraints in the allocation of funds for roads, the need for using new low cost materials suitable for prevailing local conditions, has assumed immediate importance. Disposal of solid waste has emerged has a major environment problem.

Plastics have become omnipresent in our daily life through various application in fact its light weight, easy handling and corrosion free nature has made it the material of the century. In discriminate use of plastics and disposal of plastics waste are posing environmental problems the plastic waste cannot be sent to landfill, as it is non-biodegradable and it cannot be incinerated, the best method of disposing solid waste are re-cycling and reuse. Reuse of solid waste is not only an avenue for reduction of waste quantities but also an economically attractive proposition for waste disposal, which is also source of pollution, can be avoided to large extent through recycling, reuse but the materials such as polythene covers and bags cannot be recycled. Hence in this investigation an attempt has been made to study reuse of polyethylene waste in road construction.

The debate on the use and abuse of plastics environmental protection can go on, without yielding results until practical steps are initiated at the grassroots level by everyone who is in a position to do something about it. 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 present write-up highlights the developments in using plastics waste to make plastic roads.

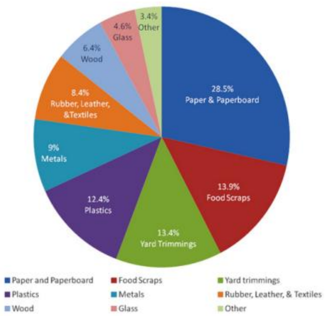


Fig.1. Percentage value of waste generation

II. PLASTICS 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.

Plastic roads mainly use plastic carry-bags, disposable cups and PET bottles that are collected from garbage dumps as an important ingredient of the construction material. When mixed with hot bitumen, plastics melt to form an oily coat over the aggregate and the mixture is laid on the road surface like a normal tar road.

III. METHODOLOGY

The specific objective of the work is incorporation of polyethylene waste in the stabilization of two typical sub grade soils via, gravel and clay used in road construction. Used polyethylene grocery bags were collected and compressed into sheets of different thickness using compression molding machine. The polyethylene bags were compressed at 80 degree in sheets of different thickness. Different thickness sheets were obtained by varying the no. of waste polyethylene grocery bags placed in the compression molding machine. The compressed polyethylene sheets cut in to different shapes(square &rectangle),sizes(1cm x1cm, 2cm x 2cm, 3cm x 3cm,4cm x 4cm, 4cm x 2.25cm and 5cm x 1.8cm) and thickness(0.5mm,1.0mm&1.5mm) the optimum moisture content of gravel and clay were determined by proctor compaction test and same moisture content was maintained throughout the study. For different size of polyethylene pieces, optimum percentage has been found for both gravel and clay. After arriving an optimum percentage of polyethylene pieces, optimum size of polyethylene pieces were arrived for both gravel and clay.

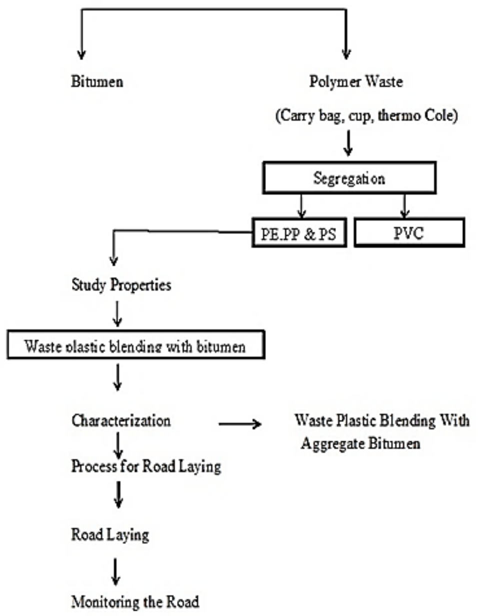
A. Basic Process

Waste plastic is ground and made into powder; 3 to 4 % plastic is mixed with the bitumen. Plastic increases the melting point of the bitumen and makes the road retain its flexibility during winters resulting in its long life. Use of shredded plastics wastes acts as a strong "binding agent" for tar making the asphalt last long. By mixing plastic with bitumen the ability of the bitumen to withstand high temperature increases. The plastic waste is melted and mixed with bitumen in a particular ratio. Normally, blending takes place when temperature reaches 45.5°C but when plastic is mixed, it remains stable even at 55°C. The vigorous tests at the laboratory level proved that the bituminous concrete mixes prepared using the treated bitumen binder fulfilled all the specified Marshall mix design criteria for surface course of road pavement. There was a substantial increase in Marshall Stability value of the BC mix, of the order of two to three times higher value in comparison with the untreated or ordinary bitumen. Another important observation was that the bituminous mixes prepared using the treated binder could withstand adverse soaking conditions under water for longer duration.

B. Preparation of Polymer-Aggregate Bitumen Mix

1) Cleaned and dried plastic wastes (e.g.: disposed carry bags, films, cups and thermo Cole) with a maximum thickness of 60 microns is shredded into small pieces (2.36 mm - 4.75 mm size). PVC is not suitable for this process.
2) Aggregate is heated to 165°C in a mini hot mix plant.
3) Shredded plastic is added to the hot mix. The plastic gets softened and coated over the surface of the aggregate giving an oily look in 30 - 60 sec.
4) Hot Bitumen (heated up to a maximum of 160°C to ensure good binding) is added immediately and the contents are mixed well.
5) The mix, when cooled to 110 - 120°C can be used for road laying using 8 ton capacity road roller. As the plastics are heated to a maximum temperature of 165°C, there is no evolution of any gas. When heated above 270°C, the plastics get decomposed and above 750°C they get burnt to produce noxious gases.

c. Flow Chart showing method for construction



D. Properties of the Mix

Coating of plastic over aggregate to the tune of 10 - 15% by weight of bitumen improves the binding properties of the mix:

1) Higher softening point and lower penetration point due to interlinking of polymer molecule with bitumen.
2) Lesser moisture absorptive capacity due to coating of plastics at the surface.
3) Better ductility, higher Marshall Stability value.
4) Better stripping value (No stripping on soaking in water for 72 hrs.)
5) High compressive strength (>100mpa) and high flexural strength (>450 Kg/cm with respect to the binding property)

IV. ECONOMICS OF ROAD CONSTRUCTION

Laying of Bitumen Road –Indian Roads Congress (IRC) Specifications, there are different types of bitumen roads. They are, Dense Bituminous Macadam, Bituminous Macadam. These roads differ in 3-ways i.e,

1. Composition of the aggregate;
2. Type of bitumen used
3. Thickness of layer.

Bitumen is a useful binder for road construction. Different grades of bitumen like 30/40, 60/70, and 80/100 are available on the basis of their penetration values and these grades can be used as IRC Specifications. Waste plastics (10% in place of bitumen) can be used for these different types of bitumen roads. The technology of road laying is very much the same as prescribed by the Indian Roads Congress (Section 500, IV revision) Specifications. A detailed description of the material required for laying of Semi Dense Bituminous Concrete (SDBC) 25 mm road (on existing road) is described below:

A. Materials

For 1000m x 3.75m (25mm) Road:

1) 11.250 tons (60/70 grade) bitumen needed
2) Shredded Plastics Required, 10% by weight (passing through 4.74mm sieve &retainin 2.36 mmsieve).
3) Bitumen replaced (saved) by 10% Plastics : 1.125 tons
4) Actual Bitumen Required : 10.125 tons
5) Aggregate (11.2mm) : 70.875 m^3
6) Aggregate (6.7mm) : 43.125 m^3
7) Aggregate Dust : 23.625 m^3

B. Cost

The total cost including material as mentioned above, labor charge etc. is approximately 5.00 lakh, and however, the cost may be different from place to place and have to be calculated accordingly.

The cost break-up is given below:

1) Collection of littered plastics : Rs. 0.50 lakh
2) Cost of shredder and other equipment : Rs. 0.50 lakh
3) Laying of road with material, labor,etc.:Rs. 4.00 lakh
4) Total : Rs. 5.00 lakh

V. COMPARISON

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 as shown in fig.2. 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 tons of polyblends, 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. The government is keen on encouraging the setting up of small plants for mixing waste plastic and bitumen for road construction. It is hoped that in near future we will have strong, durable and eco-friendly roads which will relieve the earth from all type of plastic-waste.

Fig.2. Comparison of Plastic Road with Conventional Road

VI. PROPERTIES OF CLAY AND GRAVEL

The Engineering properties of the materials such as clay and gravel are tested and their results were listed in table 1.

TABLE 1 ENGINEERING PROPERTIES OF MATERIALS

Sl. No	Engineering properties	Clay	Gravel
1	Dry density	121.87 N/m^2	22.02 N/m^2
2	Optimum moisture content	9.25%	8.75%
3	Liquid limit	24%	-
4	Plastic limit	11%	-
5	Plasticity index	13%	-
6	Specific gravity	2.21	2.45

VII. EFFECT OF POLYETHYLENE WASTE ON CBR VALUES OF GRAVEL

Initially a size of 2cm x 2cm and a thickness of 1mm of polyethylene waste pieces were selected, and CBR tests were conducted as per the standard procedure for every 2% increase of polyethylene waste in the gravel sample. The results clearly shows an increase in CBR value for adding 2% polyethylene pieces by weight of gravel, and then decreased gradually for 4% & 6%. Now the 2% polyethylene waste taken as optimum percentage and the size of piece is varied. The CBR values for different proportion of polyethylene waste mixed with gravel are represented in table 2.

TABLE 2 THE CBR VALUES FOR DIFFERENT PROPORTION OF POLYETHYLENE WASTE MIXED WITH GRAVEL

Polyethylene waste	**CBR%**		
Size / %	**1cm x 1cmx 1mm**	**2cm x 2cm x 1mm**	**3cm x 3cm x 1mm**
0	10.56	10.56	10.56
2	10.71	11.23	11.12
4	-	10.90	-
6	-	10.41	-

The above result shows there is a decrease in the CBR values above 2% of polyethylene waste and the graph for various sizes and percentages of waste polyethylene are shown in fig 3.

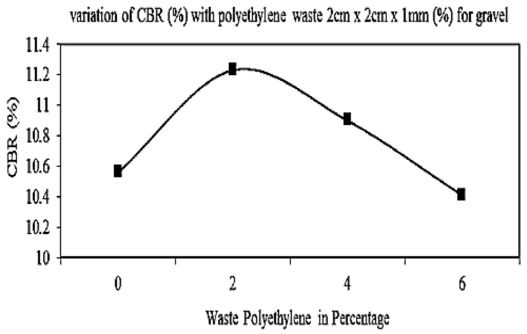


Fig.3. The Variation of CBR (%) with Polyethylene Waste (%) 2cm x 2cm x 1mm for Gravel

VIII. EFFECT OF POLYETHYLENE WASTE ON CBR VALUES OF CLAY

Initially a size of 2cm x 2cm and a thickness of 1mm of polyethylene waste pieces were selected and CBR tests were conducted for every 2% increase of polyethylene waste on the clay sample. The results indicated an increase in the CBR value up to 4% of polyethylene waste and then decreased gradually for 6% and 8%. Now the 4% of waste polyethylene was taken as optimum % and the sizes of waste polyethylene pieces were varied. The sizes of 1cm x 1cm, 3cm x 3cm, 4cm x 4cm, 4cm x 2.5cm and 5cm x 1.8cm of waste polyethylene pieces were tried. The optimum size obtained was 3cm x 3cm. though the optimum size of the waste polyethylene was obtained as 3cm x 3cm, the optimum % of polyethylene is varied.

The results clearly shows an increase in CBR value up to 4% of waste polyethylene and then decreased to 6% and 8% even though, the polyethylene pieces of 3cm x 3cm, 4cm x 2.25cm and 5cm x 1.18cm have same surface area, i.e. 9cm^2, the square size i.e. 3cm x 3cm has improved CBR value of soil compared to the other two sizes.

Later, the waste polyethylene of thickness 0.5mm and 1.5mm was tried. The results indicate that there is a lower CBR values for both 0.5mm and 1.5 mm when compared to 1.0mm thickness waste polyethylene.

The CBR values for different proportions of polyethylene waste mixed with clay are represented in table 3 and 4.

TABLE 3THE CBR VALUES FOR DIFFERENT PROPORTIONS OF POLYETHYLENE WASTE MIXED WITH CLAY

Poly ethyl ene waste	**CBR (%)**					
Size / %	**1 x1 cm**	**2 x 2 cm**	**3x 3 cm**	**4x4 cm**	**4x 2.25 cm**	**5x 1.8 cm**
0	-	3.63	3.63	-	-	-
2	-	8.26	10.84	-	-	-
4	11	17.39	20.31	16.11	16.55	15.45
6	-	16.25	19.65	-	-	-
8	-	9.32	-	-	-	-

TABLE 4 THE CBR VALUES FOR DIFFERENT PROPORTIONS OF POLYETHYLENE WASTE MIXED WITH CLAY

Polyethylene waste	CBR (%)	
size / %	3cm x 3cm x 0 .5 mm	3cm x 3cm x 1.5 mm
4	13.82	18.84

The above result shows there is a decrease in the CBR values above 4% of polyethylene waste and the graph for various sizes and percentages of waste polyethylene are shown in fig 4.

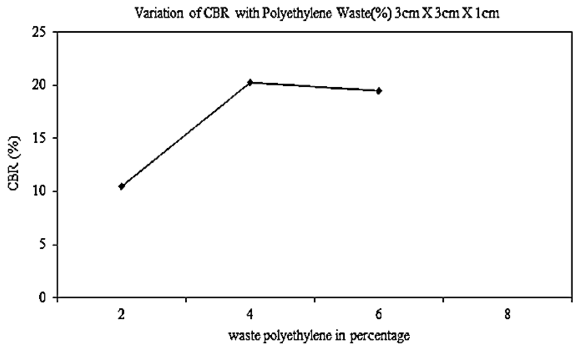


Fig.4.The Variation of CBR (%) with Polyethylene Waste (%) 3cm x3cm x 1mm for Clay

Due to increase in CBR value from 3.63% to 17.39% the thickness of pavement above the subgrade shall reduce from 39cm to 17cm as shown in fig5.

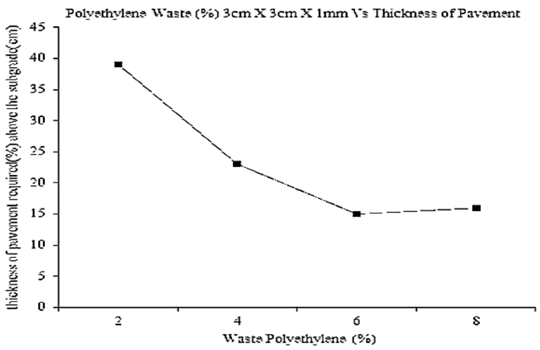


Fig.5. Polyethylene waste (%) 3cm X 3cm X 1mm Vs. Thickness of Pavement

IX. CONCLUSION

As the performance of pavement is dependent on the strength of subgrade and sub-base, the improvement in CBR value by adding polyethylene waste on clay and gravel is studied and the following conclusion are derived:

1. The reuse of polyethylene bags a significant impact on strength and economy in pavement construction, if these are available locally in large quantities.
2. The improvement in CBR values is more in clay stabilized with polyethylene waste than in gravel stabilized with polyethylene waste, where the increase is only 10%.
3. By using these compressed polyethylene waste bags in subgrade, the thickness required above the subgrade can be reduced by about 60%.

REFERENCES

[1]. S.Rajasekaran, R.vasudevan, SamuvelPaulraj, *"Reuse of Waste Plastics Coated Aggregates-Bitumen Mix Composite for Road Application-Green Method"*, American Journal of Engineering Research, Vol.2, Issue11, April'13.

[2]. AfrozSultana.Sk, K.S.B.Pr, *"Utilization of Waste Plastic as aStrngth Modifier in Surface Course of Flexible and Rigid Pavements"*, Vol. 2, Issue4, July-Aug'2012.

[3]. Mahesh M Barad, *"Use of Plastic in Bituminous Road Construction"*, Journal of Information, Knowledge and Research in Civil Engineering, Vol. 3, Issue 2, Nov'14.

[4]. R.Vasudevan, S.Rajasekaran, S.Saravanavel, *"Reuse of Waste plastics for Road Laying"* Indian Highways, (Journal of Indian Roads Congress) Vol. 34. Issue 7, July 2006.

[5]. Mahabir Panda and MayajitMuzumdar, *"Development and Evaluation of a Bituminous Paving Binder Containing Reclaimed Polyethylene waste"*, Indian Highways, Indian Roads Congress, New Delhi, Vol. 25(5), 1997.

[6]. King, G.N., Muncy, H.W., and Prudhome, J.B., *" Polymer Modification: Binder's Effect on Mix Properties"*, Proceedings of the Association of Asphalt Paving Technologists(AAPT), Vol. 55 , 1986 pp 519-540.

[7]. IS 2720 (Part xvi), *Determination of CBR soil*.

Vol.3., Issue.6., 2015 (Nov.-Dec.,)

[8]. IRC: 37 *Guidelines for the design flexible pavements*

[9]. IS 2720 (Part v), *Determination of Liquid limit, Methods of tests for soils.*

[10]. IS2720 (Part vii), *Determination of Dry density, water content.*