A STUDY ON EFFECTIVE USE OF PLASTIC WASTE IN FLEXIBLE PAVEMENTS

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ABSTRACT

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. 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. We have used LDPE, Polypropylene, HDPE and Polystyrene to carry out the required comparison between different plastic used. Waste plastic is heated and melted; 3 to 4 % plastic is mixed with the bitumen. The durability of the roads laid out with molten plastic waste is much more compared with roads with asphalt with the ordinary mix. The use of the innovative technology not only strengthened the road construction but also increased the road life as well as will help to improve the environment and also creating a source of income.

KEYWORDS: Low density polyethylene (LDPE), High density polyethylene (HDPE), plastic, aggregate.

INTRODUCTION

Plastic being a non-biodegradable element cause prodigious effect on the environment. A closer understanding of the harmful effects of plastic will empower us to improve their toxic footprint. But with this project we can reduce its impact on the environment and enhance the use of plastic vividly. Plastics are not inherently bad, and they have many redeeming ecological features; in fact, many of the techniques we utilize in our designs involve targeted use of plastic products. This technology is getting replicated very fast in Jharkhand, after the plastic road laid at Jamshedpur city on 30th November 2011. Many counties like Nigeria, Australia, Kenya etc. and the Indian cities like Ranchi, Bokaro,

Dhanbad and Giridih have also learnt this technology from Jusco, A Tata Enterprise by the expert and Environmentalist Mr. Gaurav Anand. Mr. Anand, a disciple of Dr. R. Vasudevan is also involved in promoting this technology for the mankind for free.

OBJECTIVES OF STUDY

Main motto of the study is to increase the pavement strength and make the environment eco-friendly from plastic. Main objectives are:

1. To check how the plastic bonds with the bitumen and aggregate to improve pavement strength.
2. To compare the characteristics of blend of various grades of bitumen and different types of plastic.
3. To get accurate results regarding the mix.
4. To bring out the best suitable blend of bitumen and plastic for flexible pavement.

LITERATURE REVIEW

The concept of using waste plastic in bitumen concrete play a very important role in increasing the strength of bitumen as well as aggregate. The addition of waste plastic in bitumen improves the stability, strength, life and other desirable properties of bitumen concrete pavement. Similarly, that the waste plastic use in bitumen concrete blend is a better binder compared to plain bitumen. The concept of utilization of waste plastic in the construction of pavement has shown better resist to water which reduces the stripping of bitumen from aggregate and effective way to utilize the plastic waste. Aggregate is one of the most important materials used for bitumen concrete pavement construction. Properly selected graded aggregates are mixed with bitumen and waste plastic to form hot mix bitumen concrete pavements. Aggregates are the load supporting components of bitumen concrete pavement. According to size of the waste plastic pieces pass through 4.75mm sieve and retaining at 2.36mm sieve was collected used in bitumen concrete is very well known as the binders in pavement construction . It is one of the major highway construction materials.

PLASTICS ROADS

Plastic roads are the ones which use plastic as superior material which hikes the binding properties of the flexible pavement. The plastic roads include transition mats to ease the passage of tires 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. A Bangalore-based firm and a team of engineers from R. V. College of Engineering, Bangalore, have developed a way of using plastic waste for road construction and it has

been carried out by KK Industries pvt.Ltd popularly known to be Bangalore's KK process. 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.

BASIC PROCESS

Waste plastic is ground and made into powder or shredded, 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 plastic waste 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. 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 i.e., it is water resistant for a long period.

MATERIALS USED

BITUMEN:

The properties of bitumen are sticky, black and highly viscous liquid or semi-solid, in some natural deposits. It is residue or by-product of fractional distillation of raw petroleum. Bitumen composed primarily of highly condensed polycyclic aromatic hydrocarbons, containing 95 percent of carbon and hydrogen. The bitumen used for the present work is of 30/40 & 60/70 penetration grade.

AGGREGATE:

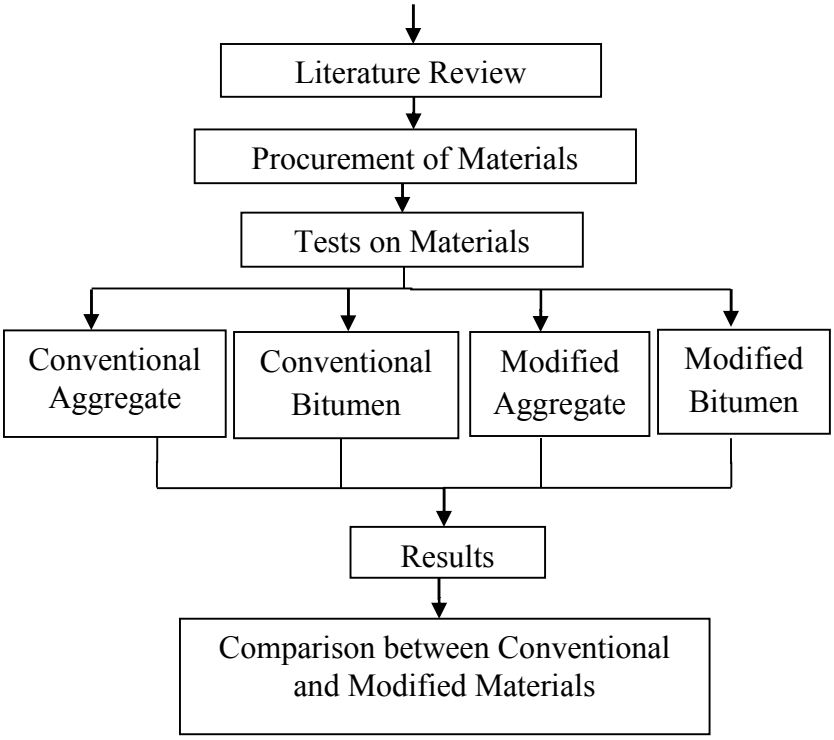
Aggregate forming the main skeleton of pavement should be tested against their suitability as a pavement construction material. Aggregate of size 20mm, 12mm, 10mm is used for present work.

PLASTIC:

The waste plastic is shredded and can easily be mix with the bitumen as the process for road construction by heating bitumen and waste plastic (that passes through 4.75mm sieve and retaining at 2.36mm sieve) in the range of 155-165°C. The Plastic used in this comparison areCompressed Polyethylene, LDPE and Polypropylene.

METHODOLOGY

Objectives of the study



PREPARATION OF POLYMER AGGREGATE BITUMEN MIX

The cleaned and dried plastic wastes (e.g.: disposed carry bags, films, cups and thermocole) with a maximum thickness of 60 microns is shredded into small pieces (2.36 mm - 4.75 mm size). The aggregate is heated to 165°C in a mini hot mix plant and 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. Then hot Bitumen (heated up to a maximum of 160°C to ensure good binding) is added immediately and the contents are mixed well.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 but when heated above 270°C, the plastics get decomposed and above 750°C they get burnt to produce noxious gases. PVC is not suitable for this process.

TESTS FOR AGGREGATE:

Specific Gravity & Water Absorption Test [IS: 2386 (Part 3) 1963]

Aggregate Impact Value Test [IS: 2386 (part 4) 1963]

Aggregate Crushing Value [IS: 2386 (Part 4) 1963]

Los Angeles abrasion test [IS: 2386 (Part IV)–1963]

TESTS FOR BITUMEN

Softening Point Test [IS: 1205-1978]

Ductility Test [IS:1208-1978]

Viscosity Test [IS:1206 -1978]

Specific Gravity & Water Absorption:

The specific gravity of an aggregate is an indirect measure of its strength. 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%.

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 1%.

Aggregate Impact Value:

The coating of plastics improves Aggregate Impact Value, thus improving the quality of the aggregate. Moreover apoor 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%.

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 graph 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%.

Los Angeles abrasion test:

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. When the Los Angeles abrasion value of plain aggregate value is compared with the plastic coated aggregates the values are less for coated aggregates. The results obtained are within the range hence can be used for the construction. Its range should be less than 35%.

Softening Point of Bitumen:

Softening point is the temperature at which the substance attains a particular degree of softening under specified conditions of test. It was observed that with increase in plastic content the value of softening value increases. The value of softening point shows the bitumen is susceptible to temperature or not.

Ductility of Bitumen:

The ductility of bituminous material is the distance in centimeters to which it will elongate before breaking when a briquette specimen of the materials is pulled at a specified speed and at specified temperature.

Viscosity Value of Bitumen:

Viscosity is defined as inverse of fluidity. Viscosity thus defines the fluid property of bituminous material. The degree of fluidity at the application temperature greatly influences the ability of bituminous material to spread, penetrate into the voids and also coat the aggregates and hence affects the strength characteristics of the resulting paving mixes.

COMPARISON TABLES

Table 1For 30/40 grade bitumen & 20mm, 25mm, 40 mm aggregate

TESTS	LDPE	CP	PP	IS CODE-RANGE
Specific Gravity	2.86	2.74	2.72	
Aggregate impact(%)	5.7	3.78	1.9	30-45
Aggregate crushing(%)	21.65	15.52	5.3	30-45
Water absorption(%)	0.19	0.25	0.23	
Los Angeles abrasion(%)	34.24	27.33	10.5	30-50
Softening(^{0}c)	52.5	85.4	68.3	55-60
Viscosity(sec)	220.12	425.65	302.6	>295
Ductility(cm)	45.5	42	40	40-45

LDPE: Low Density Polyethylene, CP: Compressed Polyethylene, PP: Polypropylene

Table 2 For 60/70 grade bitumen & 20mm,25mm,40 mm aggregate

TESTS	LDPE	CP	PP	IS CODE-RANGE
Specific Gravity	2.86	2.74	2.72	
Aggregate impact (%)	5.7	3.78	1.9	30-45
Aggregate crushing(%)	21.65	15.52	5.3	30-45
Water absorption(%)	0.19	0.25	0.23	
Los Angeles abrasion(%)	34.24	27.33	10.5	30-50
Softening(^{0}c)	78.3	86.8	80	49-56
Viscosity(sec)	269	440.5	324.1	>295
Ductility(cm)	41	44	42	53

LDPE: Low Density Polyethylene, CP: Compressed Polyethylene, PP: Polypropylene

Table 3 Comparison of conventional & plastic roads

TESTS	CONVENTIONAL ROADS		PLASTIC ROADS					
			30/40			60/70		
			LDPE	CP	PP	LDPE	CP	PP
Specific Gravity	2.027		2.86	2.74	2.72	2.86	2.74	2.72
Aggregate impact(%)	18.51		5.7	3.78	1.9	5.7	3.78	1.9
Aggregate crushing(%)	31.15		21.65	15.52	5.3	21.65	15.52	5.3
Water absorption(%)	0.47		0.19	0.25	0.23	0.19	0.25	0.23
Los Angeles abrasion(%)	41.6		34.24	27.33	10.5	34.24	27.33	10.5
GRADE	30/40	60/70	52.5	85.4	68.3	78.3	86.8	80
Softening(^{0}c)	46.1	49.9						
Viscosity(sec)	60.53	55	220.12	425.65	302.6	269	440.5	324.1
Ductility(cm)	37.5	52	45.5	42	40	41	44	42

LDPE: Low Density Polyethylene, CP: Compressed Polyethylene, PP: Polypropylene

COMPARISON GRAPHS:

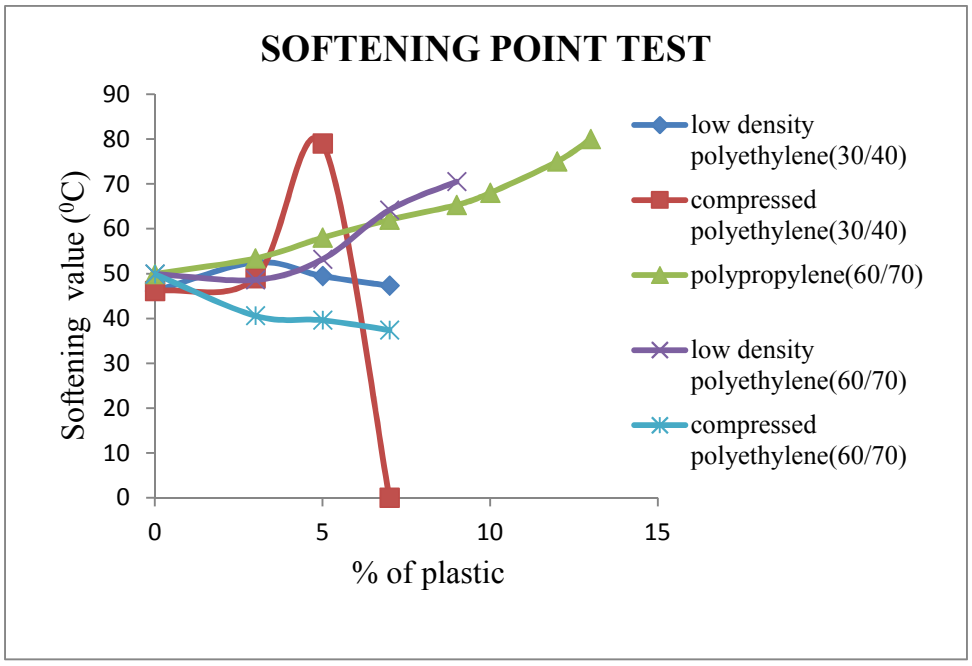


Figure 1 Softening point value versus % of plastic

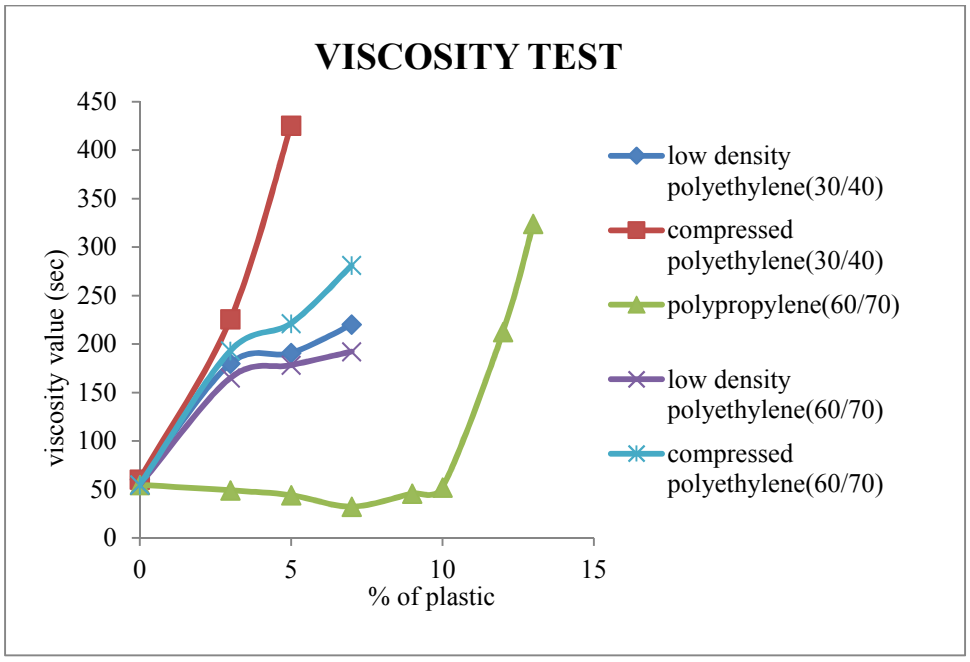


Figure 2 Viscosity value versus % of plastic

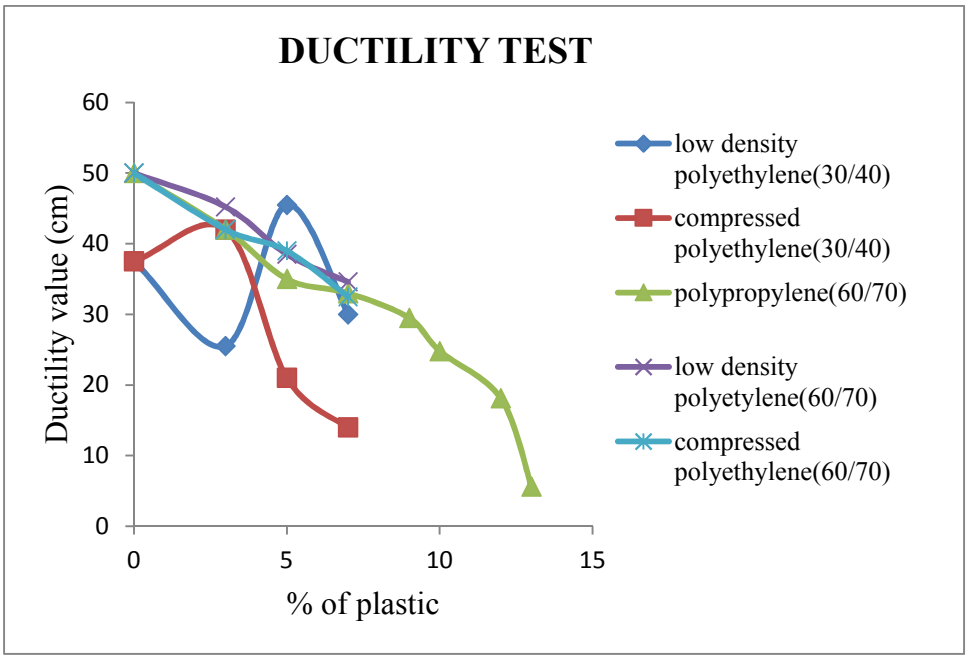


Figure 3 Ductility value versus % of plastic

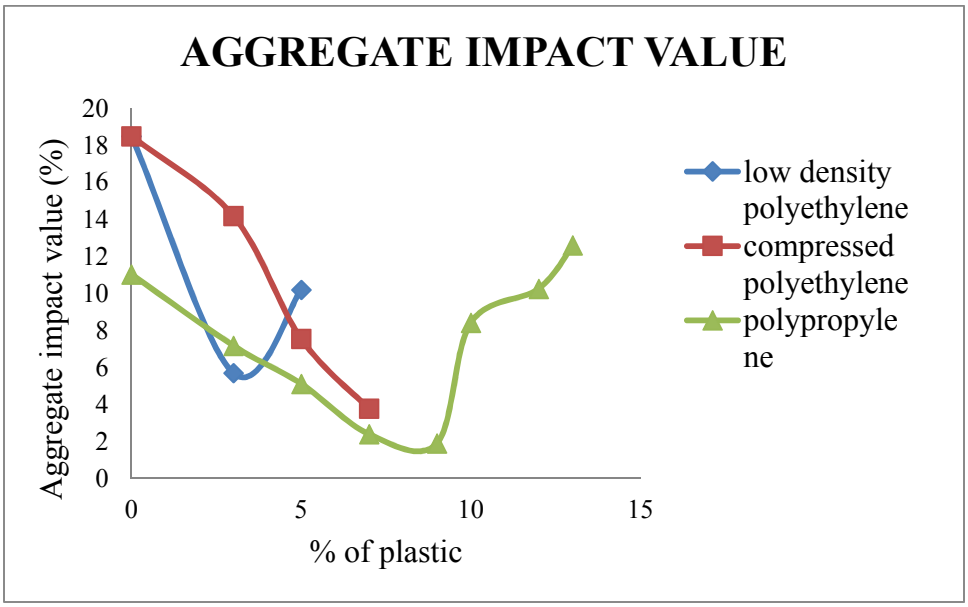


Figure 4 Aggregate impact value versus % of plastic

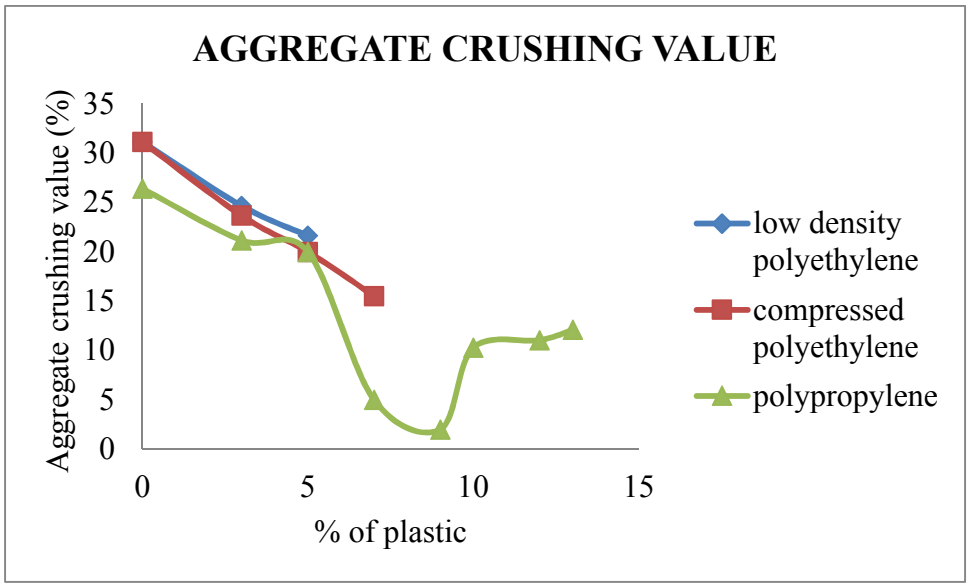


Figure 5 Aggregate crushing value versus % of plastic

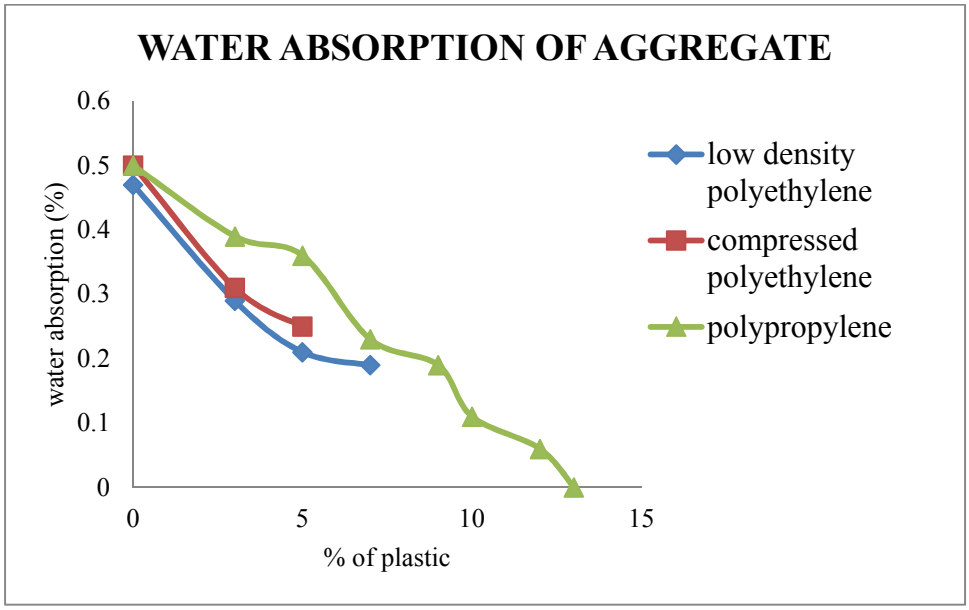


Figure 6 Water absorption value versus % of plastic

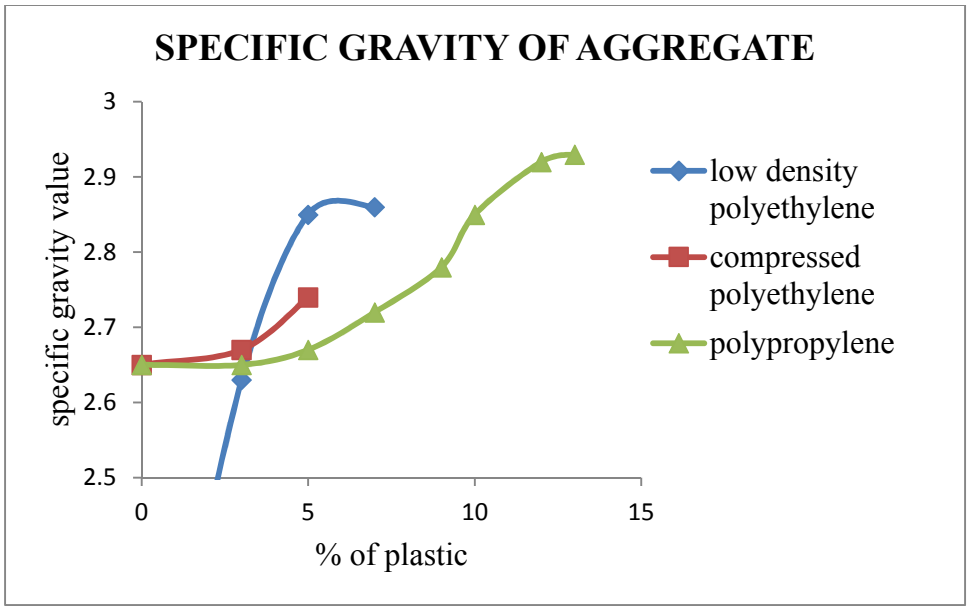


Figure 7 Specific gravity value versus % of plastic

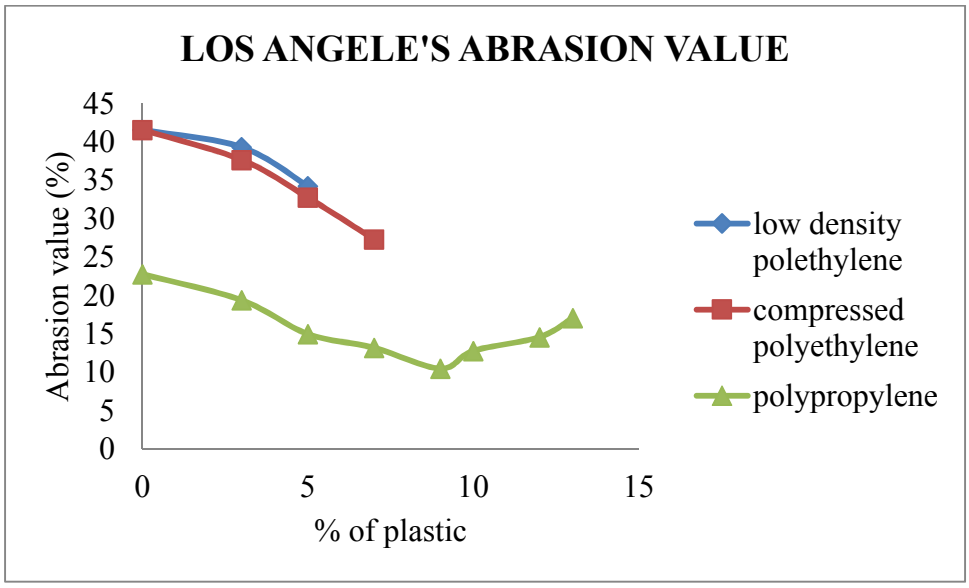


Figure 8 Abrasion value versus % of plastic

Table 4 Comparison for 30/40 and 60/70 grade bitumen test values

TESTS	MODIFIED ROADS						PREFERRED	SIGNIFICANCE
	30/40			60/70				
	LDPE	CP	PP	LDPE	CP	PP		
Specific Gravity	More			More			LDPE	Specific gravity is directly proportional to strength.
Aggregate impact(%)			More			More	LDPE	Aggregate impact value gives the relative strength of aggregates against impact loading. Lesser value of impact value shows high strength and high value of impact shows weak materials
Aggregate crushing(%)			More			More	PP	Aggregate crushing value gives the relative strength of aggregates against crushing loading. Lesser value of crushing value shows high strength and high value of crushing shows weak materials
Water absorption (%)	More			More			LDPE	Aggregates should be low water absorption capacity and high value of water absorption shows the aggregate consists flakey and weak materials
Los Angeles abrasion(%)			More			More	PP	For an aggregate to perform satisfactory in pavement, it must be

								sufficiently hard to resist the abrasive effect of traffic over long period of time. The soft aggregates will be quickly ground to dust, whilst the hard aggregates are quite resistant to crushing effect
Softening (^{0}c)		More			More		CP	Softening point has particular significance for materials to be used as joint and crack fillers. Higher softening point ensures that they will not flow during service. Higher the softening point, lesser the temperature susceptibility. Bitumen with higher softening point is preferred in warmer places.
Viscosity (sec)		More			More		CP	At high fluidity or low viscosity, bitumen binder simply lubricates the aggregate particles instead of providing an uniform film thickness for binding action. Low

								fluidity or high viscosity does not enable the bitumen to coat the entire surface of aggregate in the mix easily and also resists the compactive effort and resulting mix is heterogeneous in character
Ductility (cm)	More				More		LDPE &CP	Bitumen with low ductility value may get cracked especially in cold weather.

LDPE: Low Density Polyethylene, CP: Compressed Polyethylene, PP: Polypropylene

CONCLUSION

From the experimental results conducted on the waste plastic, aggregate and bitumen we can concluded that,

1. The optimum value of plastic waste added from the experimental results is 10% by weight

2. Adding of plastic waste in the bitumen resulted in increase in the properties of bitumen and aggregate

3. Reduces the quantity of bitumen up to 9-10 % by weight and reduces the cost of construction of flexible pavement.

4. By using waste plastic in the construction of flexible pavement we can reduce the impact on the Environment.

REFERENCES

1. Sasane Neha .B et al.(2015). “Application of waste plastic as an effective construction material in flexible pavement.” International Research Journal of Engineering and Technology (IRJET), Volume 02,Issue 03,1943-1948.
2. Gawande, A., Zamare, G., Renge, V. C., Tayde, S., and Bharsakale.G.(2016), "An overview on waste plastic utilization in asphalting of roads” Journal of Engineering Research and Studies, 3(2), 01-05.
3. A Study on Use of Waste Plastic Materials in Flexible Pavements by BrajeshMishra , Ravi Shankar Mishra.
4. Use of Plastic Waste in Road Construction by Shweta N. Rokdey, Sevagram P. L. Naktode, Sevagram M. R. Nikhar.
5. APPLICATION OF WASTE PLASTIC AS AN EFFECTIVE CONSTRUCTION MATERIAL IN FLEXIBLE PAVEMENT SasaneNeha.B, GaikwadHarish, Dr. J R Patil and Dr. S D Khandekar.
6. Information by Ministry of Road Transport and High Ways, Manual for construction and supervision of Bituminous works, New Delhi, November 2001.
7. Use of Waste Plastic in Flexible Pavements-Green Roads by YashMenaria, RupalSankhla.