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EFFECT OF COPOLYMER ADDITIVES ON THE BINDING PROPERTIES OF BITUMEN MIX

Rakesh Kumar[1] and Devender Kumar[2]

[1,2]Department of Civil Engineering, OM Starling Global University, Hisar, India.

Abstract

Plastics are widely utilised materials that play an important part in everyday life. The use of this non-biodegradable commodity is fast expanding, as is the accumulation of plastic garbage. Due to the paucity of landfills, disposing of waste plastic is a severe challenge in the current circumstances. Poor disposal procedures have made them a major source of environmental and natural disasters. The goal of this study is to determine the viability of employing recycled High Density Polyethylene (HDPE) and recycled Poly-Ethylene Terephthalate (PET) as bitumen modifiers to improve the properties of the resulting binder for use in Bituminous Concrete (BC) mix building. The modified mix was made by replacing part of the bitumen binder with varied quantities of HDPE (4%, 6%, respectively) and PET (6 percent , 8 percent). The dry technique, i.e. plastic coating of aggregates, was used to combine HDPE and PET. The Marshall Stability of HDPE and PET modified bituminous concrete is significantly increased, up to 52 percent. The addition of HDPE and PET in the mix has a brilliant good influence on the qualities of BC mix, and it can increase the re-use of plastic waste, according to test results.

Keywords: *Bituminous concrete, High Density Polyethylene, Poly-Ethylene Terephthalate, Marshall Stability.*

Introduction

Plastic trash is a widespread issue around the world. Many of those countries are dealing with the same issues that our own country, India, is dealing with. Plastic is a fairly prevalent material utilised in numerous things in India, and as a result, it generates a large amount of garbage among us. After use, the majority of plastic materials become garbage. Plastic garbage accounts for roughly 6.3 million tonnes of waste in India each year. Delhi is the first to generate plastic waste, producing 700 TPD of plastic waste. According to a study, the average generation of garbage as plastic material accounts for 6.9% of total municipal solid waste in our country. There is a great deal of variety in the generation of plastic debris in different cities across India. It accounts for roughly 10% and 6% of total municipal solid trash in Delhi and Mumbai, respectively. Plastic plays a significant role in everyday life, and it is difficult to imagine the world without it. Because of its slow decomposition rate, plastic can be regarded a non biodegradable substance, and hence waste plastic collection is a prevalent concern around the world. It could be reduced by properly managing solid waste management. Plastic containers, bags, bottles, spoons, and a variety of other plastic product packaging materials are used in everyday life. The numerous polymers indicated by (Al-Hadidy et al., 2009) are formed from plastic and so can be used to reduce the impact of waste generation by reusing in diverse fields such as pavement and concrete design.

According to certain research, adding polymers to bituminous mixtures is one of the most effective ways to improve the quality of paving roads. Wet and dry processes for adding polymer to bituminous mixtures are the most common (Costa et al., 2013) [2]. Polymer is mixed with bitumen in the wet process, and aggregates are coated with polymer before bitumen is added in the dry process. In this case, though, aggregate coating was applied.

The advantages of using polymers in road paving were discovered in the study. The author has described the several sorts of processing that it goes through to become a polymer (Costa et al., 2013). In the wet method, bitumen is employed as a polymer mixer, whereas in the dry process, aggregate is coated before bitumen is mixed. The goal of this research is to learn more about the benefits of employing polymers like PET and HDPE. These Bitumen mix substitutes improve a variety of pavement qualities.

Materials and Methods

Roads that have been surfaced with an asphalt blend are known as flexible roads. A 95 percent fine and coarse aggregate blend is employed, along with a little amount of filler and binder. Aggregates of various sizes according to MORTH, bitumen, stone dust as a filler, and human hair as an addition are utilised in this project. The following is a list of the materials that were used:

- Aggregates (Fine and Coarse)
- Filler (Fine sand)
- Binder (Bitumen)
- HDPE
- PET

Marshall Stability Test will be done using human hair as an additive. Marshall Test has following properties:

- ❖ Stability
- ❖ Flow Value
- ❖ Percentage of volume of voids
- ❖ Unit weight
- ❖ Percentages of volume filled with bitumen

And finally optimum bitumen content will be observed against controlled concrete mix.

Specimen preparations

1200 gm of aggregates and fillers were used to pack Marshall samples. As stated in the preceding sections, the current investigation used two trial gradations. In the first trial, 5 bitumen contents were achieved to generate the various blends, ranging from 3 to 4 percent with a 0.5 rise. Because the results of the first experiment were unsatisfactory, grading of trial 2 was implemented. Throughout trial two, specimens were collected with binding material quality ranging from "4.5 to 6.5 percent."

For sample preparation, aggregates were heated to a temperature of 190 degrees Celsius. The bitumen was heated to a temperature of 125 degrees Celsius. The warmed aggregates and binding agent were completely combined at a temperature of around 155 °C. The mixture was placed to a pre-heated mould and compressed using a 4.5 kg weight rammer, which delivered 75 blows from a height of 457 mm to each side of the sample, resulting in a compacted thickness of 63.5 mm. For each substance in the trial's binder, three comparisons were created. The produced samples were cooled to room temperature and installed into the Marshall test machine, where they were submerged in water - bath C for 30 to 40 minutes before being analysed. The Marshall evaluation will primarily focus on samples with a diameter of 101.6 mm and a thickness of 63.5 mm. The thickness of each sample was measured, and the Marshall Stability results were corrected by applying correction factors for samples thicker than 63.5 mm.

Results and Discussion

MORTH and IRC standards have specified the Marshall Stability Test (MST) and mix design procedure for testing compacted specimens of bituminous mixes in India. MMD is used to design BC mix in experimental work with modified bituminous concrete. Combination aggregates and VG30 grade bitumen were used to create the mix. The modified mix was created by partially replacing the bitumen binder with varying quantities of HDPE (4%) and PET (6%). (6 percent, 8 percent).

It is possible to acquire the OBC and other Marshall features of the control mix. Following the calculation of OBC, partial binder replacement was carried out using several compositions as described in the preceding chapter (binary mix and tertiary mix) to determine the best proportion of binder replacement.

The MST was carried out on each of the BC mix specimens. For each specimen, the values of Marshall parameters are calculated, and the average of these specimens with various bitumen contents is presented. The next Marshall graphs show different levels of bitumen content.

I. Stability Curve

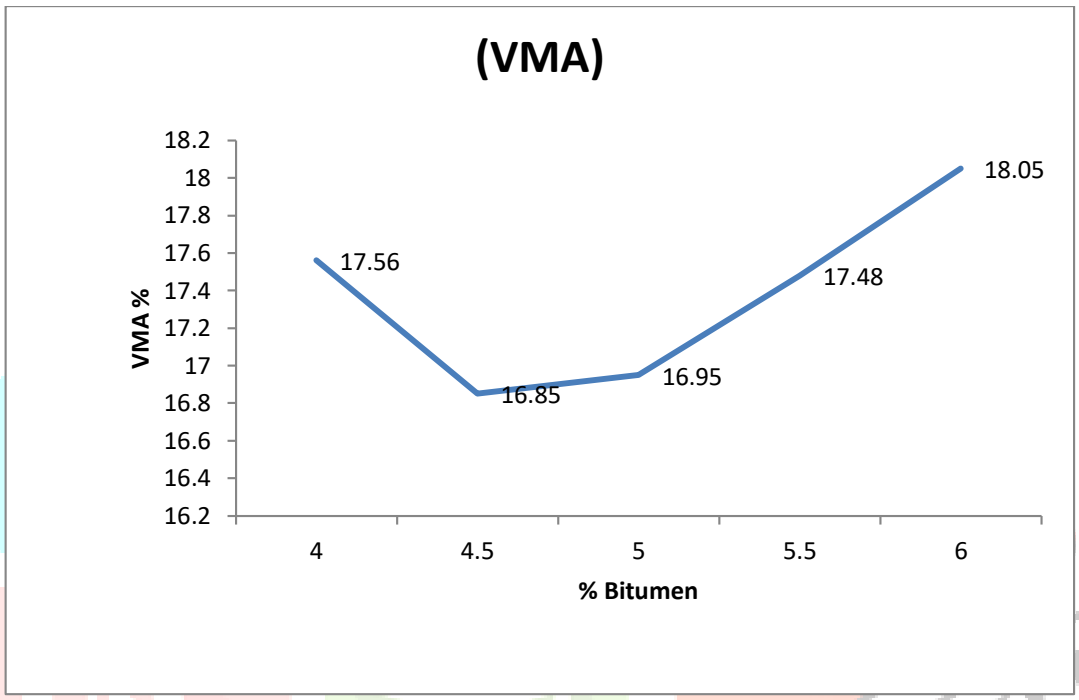
II. Flow value Curve

III. Percentage air voids (Vv) Curve

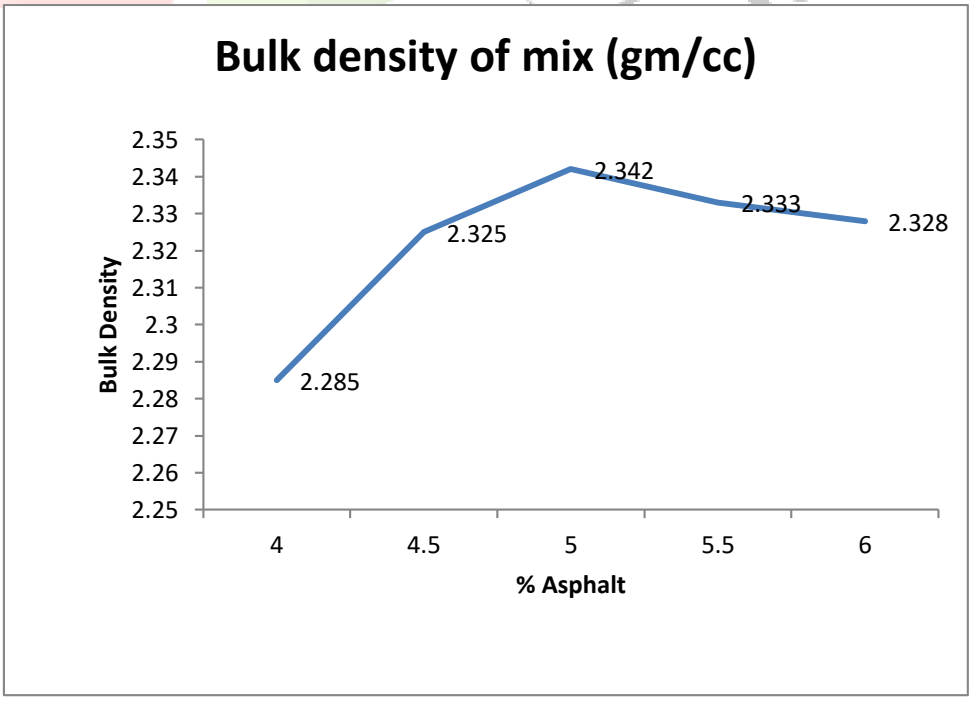
IV. Voids filled with bitumen (VFB) Curve

V. Voids in mineral aggregates (VMA) Curve

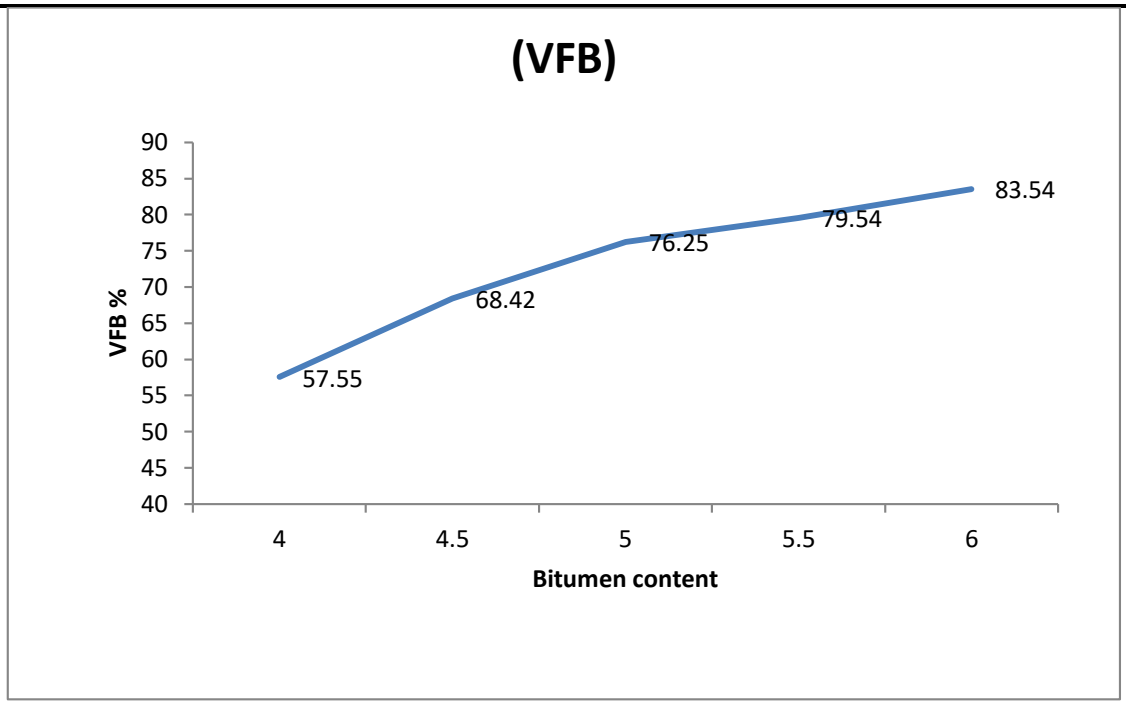
VI. Bulk specific gravity or density (Gm)



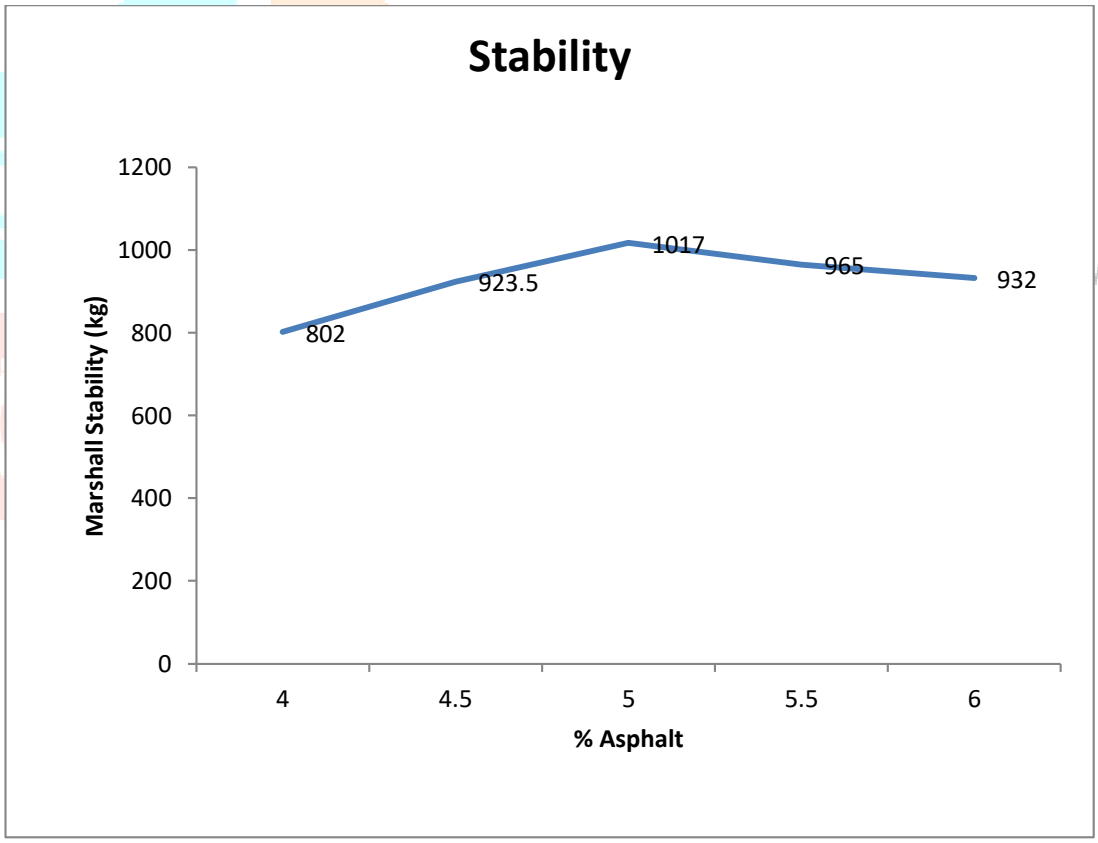
Graph 4.1: VMA vs Bitumen %



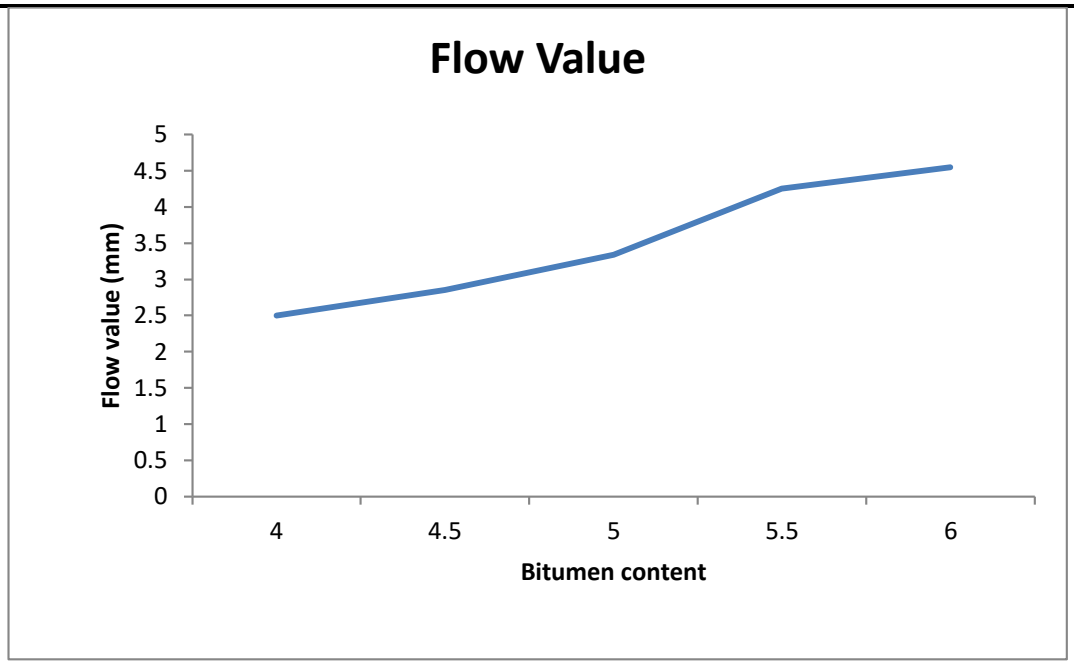
Graph 4.2: Bulk Density vs % asphalt



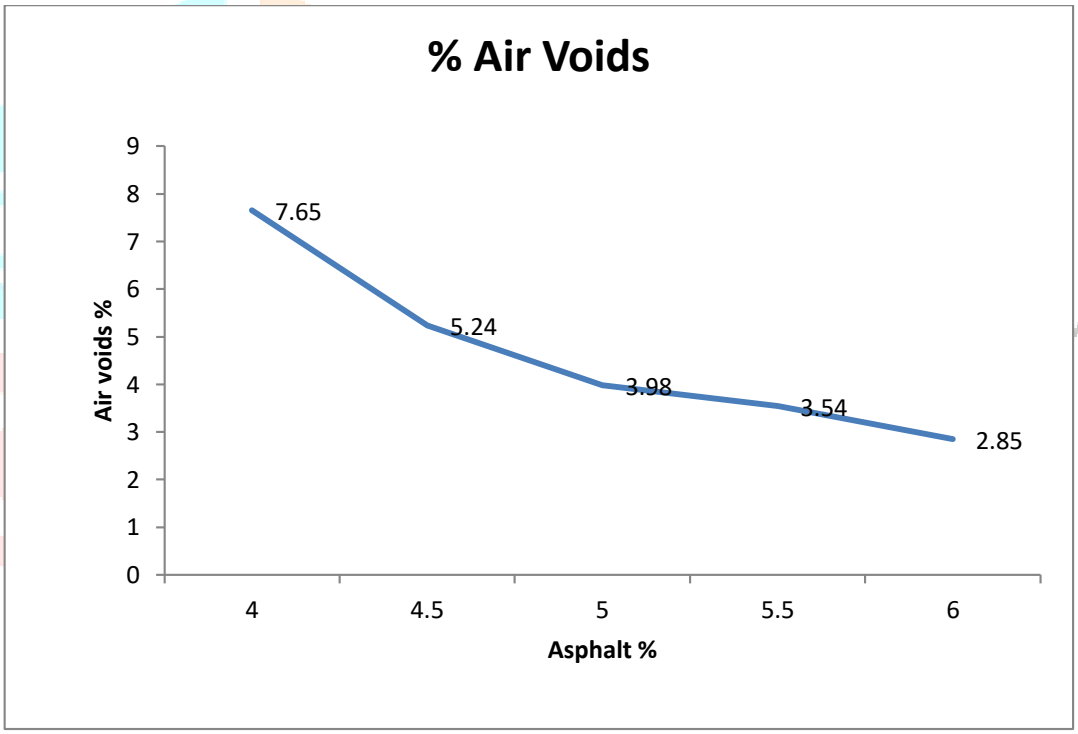
Graph 4.3: VFB vs Bitmen %



Graph 4.4: Stability vs asphalt %



Graph 4.5: Flow value vs % bitumen



Graph 4.6: Air voids vs asphalt %

The obtained optimum bitumen content from Marshall Graph is calculated as,

Binder content corresponding to max stability = 5.5 %

Binder content corresponding to max density = 5.5%

Binder content corresponding to 4% air voids = 5.45%

Optimum bitumen content = (5.5 + 5.5 + 5.45)/3 = 5.483 (rounded to 5.5%).

Conclusions

This experimental analysis work studies the practicability of using PET and HDPE to prepare bituminous mix for surface course as a choice to minimize adverse effect on environment caused due to plastic waste and their disposal. Based on laboratory test results on plastic coated aggregates, conventional bituminous concrete mix, modified BC mix, the following conclusions summarized below:

- The test results shows impressive improvements in standard properties of plastic coated aggregates than plain aggregates such as impact and crushing value get decreased.
- The OBC was obtained 5.5% by weight of mix and 4%HDPE and 8% PET by weight of OBC was found as optimum replaceable bitumen content for modification of BC mix.
- Marshall Result shows that by using 4%HDPE and 8%PET modified bituminous concrete specimen have highest stability value compared to conventional BC specimen. Stability value raised by 62%. The trend of stability value shows that stability value increases with plastic content up to 12% and thereafter decreases. Therefore use of higher percentage plastic waste for modification not preferred.

References

- "Highway Engineering" by S.K. Khanna and C.G. Justo.
- A. Gawande, G. Zamare, V, C. Renge, S. Tayde, and G. Bharsakale, "An overview on Waste Plastic Utilization in Asphalting of Roads," J. Eng. Res., vol. III, no. II, pp. I-5, 2012.
- A. L Al-Hadidy and T. Yi-qiu, "Effect of polyethylene on life of flexible pavements," Constr. Build. Mater, vol. 23, no. 3. pp. 1456-1464, 2009.
- AASHTO Designation: T245. (2004). "Standard method of test for resistance to plastic flow of bituminous mixtures using Marshall Apparatus".
- ASTM, E. 303-93 (2003). "Standard Method for Measuring Frictional Properties Using the British Pendulum Tester". Annual book of ASTM Standards, Road and Paving Materials.
- D. Cascy, C. McNally, A. Gibney, and M. D. Gilchrist, "Development of a recycled polymer modified binder for use in stone mastic asphalt," Resour, Conserv. Recycl., vol. 52, no. 10, p. 1167–1174, 2008.
- G. D. Airey, T. M. Singleton, and A. C. Collop, "Properties of Polymer Modified Bitumen after Rubber-Bitumen Interaction," J. Mater. Civ Eng., vol. 14, no. 4, pp. 344- 354, 2002.
- IRC, SP. "Guidelines on the use of polymer and rubber modified bitumen in road construction." Specifications of Indian Roads Congress, India. vol. 53, 2002.
- IRC: 111. (2009). "Specification for dense graded bituminous mix". In Indian Road Congress.
- IS: 1202, "Methods for Testing Tar and Bituminous Materials: Determination of specific gravity," Bureau of Indian Standards, New Delhi, India, 1978.
- IS: 1203, "Methods for Testing Tar and Bituminous Materials: Determination of Penetration," Bureau of Indian Standards, New Delhi, India, 1978.
- IS: 1208, "Methods for Testing Tar and Bituminous Materials: Determination of Ductility," Bureau of Indian Standards, New Delhi, India, 1978.
- IS: 2386- Parts 1 to 5, (1997). "Indian Standard Methods of Test for Aggregate for Concrete Bureau of Indian Standards", New Delhi.
- IS: 73. (2013). "Indian Standard Specification for Paving Bitumen" Bureau of Indian Standards. New Delhi.

- Jabarin, Saleh A. "Polyethylene terephthalate chemistry and preparation." Polymeric Materials Encyclopedia, vol. 4, pp. 6079-6085, 1996.
- L A. Al-Dubabe, H. L A.-A. Wahhab, I. M. Asi, and M. F. Ali, "Polymer Modification of Arab Asphalt," J. Mater. Civ. Eng, vol. 10, no. 3, pp. 161-167, 2002.
- L. Bottenbruch. "Engineering Thermoplastics: Polycarbonates, Polyacetals Polyesters, and Cellulose Esters." Hanser/Grander Publications Inc, 1996. 65.
- L. M. B. Costa, H. M. R. D. Silva, J. R. M. Oliveira, and S. R. M. Fermandes, "Incorporation of waste plastic in asphalt binders to improve their performance in the pavement, "Int. J. Pavement Res. Technol., vol. 6, no. 4, Pp. 457-464, 2013.
- M Sulyman, J. Haponiuk, and K. Formela, "Utilization of Recycled Polyethylene Terephthalate (PET) in Engineering Materials: A Review," Int. J. Environ. Sci. Dev. vol. 7, no. 2, pp. 100-108, 2015.
- M. Attaelmanan, C. P. Feng, and A. H. Ai, "Laboratory evaluation of HMA with high density polyethylene as a modifier," Constr. Build. Mater, vol. 25, no. 5, pp. 2764- 2770, 2011.
- M. T. Awwad and L. Shbeeb, "The use of polyethylene in hot asphalt mixtures," Am. J. Appl. Sci., vol. 4, no. 6, pp. 390-396, 2007.
- MORTH (Ministry of Road Transport and Highways). (2013). "Specifications for toad and bridge works". In Indian Road Congress. New Delhi, India.
- N. Kulolu, "Effect of Astragalus on Characteristics of Asphalt Concrete," J. Mater. Civ. Eng., vol. 1I, no. 4, pp. 283-286, 2002.
- R. Vasudevan, R. Velkennedy, A. Ramalinga Chandra Sekar, and B. Sundarakannan, "Utilization of waste polymers for flexible pavement and easy disposal of waste polymers," Int. J. Pavement Res. Technol., vol. 3, no. 1, pp. 34 42, 2010.
- Ramadevi, K., and R. Manju. "Experimental investigation on the properties of concrete with plastic PET (bottle) fibres as fine aggregates." Int. J. of emerging Technol., and Adv. Engineering, vol.2, no, 6, pp. 42-46, 2012.
- S. Gupta and K. H. Wei, "Encapsulation Technology and Techniques in Self-Healing Concrete," J. Mater. Civ. Eng., vol. 25, no. October, pp. 864-870, 2016.
- S. Hinislioglu and E. Agar, "Use of waste high density polyethylene as bitumen modifier in asphalt concrete mix," Mater. Lett, vol. 58, no. 3-4, pp. 267-271, 2004.