# PERFORMANCE EVALUATION OF UTILIZATION OF WASTE POLYETHELENE TERAPHTHALATE AS A ASPHALT MODIFIER IN ASPHALT CONCRETE MIX

[1]Mehmood Rashid, [2]Er Mohit Bajaj

[1]M.Tech. Scholar in GEC Panipat,
[2]Assistant Professor in Chandigarh University

***Abstract*: The road network system consist of different classes of roads with different traffic loads experienced by the road. Most importantly, the C class and D class roads undergo a very low traffic load compared to the other types of national highways. However, virgin raw materials are used in the construction of pavements regardless of the traffic load faced by the pavement. Asphalt is the product of a mixture of binders, aggregates and filler. It is used both for construction and maintenance of the road, pavements and sometimes even parking areas. The primary objective of this study is to evaluate optimum bitumen content and the characteristic of recycled polyethylene terephthalate (PET) as partial fine aggregate replacement in asphalt mixtures for road pavements by determining the rutting, fatigue and stiffness properties. This paper reports the strength behaviour of concrete containing polyethylene terephthalate (PET) aggregate.**

***Keywords*: Asphalt, Polyethylene terephthalate (PET), Aggregates, Bitumen**

## 1.0 INTRODUCTION

Increasing urbanization and industrialization have contributed for increased plastic generation. Safe disposal of waste plastic is a serious environmental problem. They pose a threat to the environment essentially due to the lack of an efficient collection and disposal system, as they are non-biodegradable. Plastics are most commonly used in the form of carry bags, packaging material, containers etc. Due to accumulation of plastic wastes as they are non- biodegradable, some of them are non-recyclable pose a serious threat to the environment. The consumption of plastic has grown substantially all over the world in recent years and this has created huge quantities of plastic-based waste. Plastic waste is now a serious environmental threat to the modern way of living. In Portugal, post-consumer packaging accounts for almost 40% of total domestic waste and it is therefore an important source for the recycled materials market**1**. In a typical Portugal municipality about 10-14% of all generated waste is plastic1. Plastic waste cannot be dumped in landfills because of its bulk and slow degradation rate. Recycling plastic waste to produce new materials like aggregate in concrete could be one of the best solutions for disposing of it, given its economic and ecological advantages. The European aggregates demand is 3 billion tons per year, representing a turnover of around €20 billion. Some 90% of all aggregates are produced from natural resources. The other 10% come from recycled aggregates (6%), and marine & manufactured aggregates (2% each). Naturally, the use of waste materials as aggregate in concrete production will reduce the pressure on the exploitation of natural resources. The best way of disposal of waste plastic is its recycling to the maximum extent and many developed countries have recycled waste plastics to manufacture various products. Plastics are generally classified into two categories; thermoplastic and thermosetting materials. Polyethylene terephthalate (PET) is a thermoplastic that is commonly utilized in the food and beverage industry for beverage bottles, water bottles, disposable dishes, and plastic containers. Plastics are durable and degrade very slowly hence disposing them in landfills is an accumulation problem. Studies have revealed that waste plastics have great potential for use in bituminous construction as its addition in small doses, about 5-10%, by weight of bitumen helps in substantially improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous mix, leading to improved longevity and pavement performance. The use of waste plastic thus contributes to construction of green roads.

## 1.1 ADVANTAGES OF PLASTIC ASPHALT ROAD

The threat of disposal of plastic will not solve until the practical steps are not initiated at the ground level. A well-constructed Plastic Tar Road will result in the following advantages:

- Increased road strength (increased Marshall Stability Value)
- Better resistance to water and water stagnation
- No stripping and have no potholes
- Increased binding and better bonding of the mix
- Increased load withstanding property
- Decreased consumption of bitumen
- Reduced pores in aggregate and hence less rutting and raveling
- Better soundness property
- Reduced maintenance cost of the road
- Increased life span of the road
- Decreased plastic leaching
- No effect of radiation( like UV)

### 1.2 POLYETHYLENE TEREPHTHALATE (PET)

Polyethylene terephthalate (PET) is the most commonly used thermoplastic polyester. It is often called just "polyester," which often causes confusion, because polyester resins are thermosetting materials. PET is a transparent polymer, with a good mechanical properties and good dimensional stability under variable load. Moreover, PET has good gas barrier properties and good chemical resistance. Above mentioned properties of PET caused its wide application in the form of bottles, thermally stabilized films (e.g. capacitors, graphics, film base and recording tapes etc.) and electrical components. PET is also used for production of fibers for very wide range applications in textile industry. PET belongs to thermoplastics with excellent physical properties. It constitutes is around 18% of the total polymers produced worldwide and over 60% of its production is used for synthetic fibers and bottles, which consume approximately 30% of global PET demand.

**Figure 1: POLYETHYLENE TEREPHTHALATE (PET)**

## 2.0 LITERATURE REVIEW

**Vasudevan et al.** studied the utilization of waste polymers at production of flexible pavements. In presented studies, authors coated the stone aggregates with molten waste plastics. They concluded that the coating of aggregates with plastics reduced the porosity, absorption of moisture and improved soundness. They found that the use of waste plastics for flexible pavement was one of the best methods for easy disposal of waste plastics. Data analysis proved that grinded HDPE polyethylene modifier provided better engineering properties. The recommended proportion of the modifier was 12% by weight of asphalt content. It was also found to increase the stability, reduce the density and slightly increase the air voids and the voids of mineral aggregate.

**Fuentes-Auden et al.**studied on the effect of PE on the modified asphalt Properties. They have concluded that PE incorporation in the asphalt should not exceed 5%, otherwise the resulting viscosity would reduce the process ability of the mixture. Addition of recycled PE promotes better resistance to rutting, cracking and to thermal fatigue.

**García-Morales et al.** studied the modification of asphalt with recycled EVA led. In their work, concentrations which were studied ranged from 0 to 9% wt. The results have also indicated that the recycled EVA has increased the binder viscosity at higher service temperatures, with consequent benefits on road performance, such as resistance to rutting. However, the asphalt viscosity at the production and application temperatures demonstrated to be sufficiently low for its adequate use in pavements even at concentrations as high as 9%.

**Costa et al.** aimed to evaluate the possible advantages of modifying the asphalt binder with different plastic wastes: HDPE, LDPE, EVA, ABS and CR (crumb rubber), in order to improve the properties of the resulting asphalt binders. The performance of modified binders with recycled polymers was compared with that of the conventional asphalt and the one of a commercial modified binder. The characterization of the different asphalts modified with 5% of each one of the studied polymers demonstrated that it is possible to obtain similar properties, or even better, than those of commercial modified asphalt. In fact, it was observed that: SBS, HDPE and EVA are the most promising polymers to increase the softening point of the modified binder; HDPE and EVA are the polymers with higher influence in the penetration test results, SBS, EVA and CR (elastomers) presented the best performance in relation to resilience; all modified asphalts, excluding those with ABS and CR, only reach the proper viscosity to produce asphalt mixtures near or above 180 °C, including the commercial asphalt; HDPE, LDPE and EVA have a good dispersion in the asphalt, whereas SBS, ABS and CR are difficult to be melted in the asphalt. This phenomenon was related with viscosity of used modifiers, which were affecting on their flowability dispensability in asphalt matrix.

**Swami et al.** investigated that the total material cost of the project is reduced by 7.99% with addition of plastic to bitumen between the ranges of 5% to 10%. They concluded that by modification of bitumen the problems like bleeding in hot temperature regions and sound pollution due to heavy traffic are reduced and it ultimately improves the quality and performance of road.
**Pareek et al.** carried out experimental study on conventional bitumen and polymer modified binder and observed a significant improvement in case of rutting resistance, indirect tensile strength and resilient modulus of the bituminous concrete mix with polymer modified bitumen. They also concluded that Polymer modified bitumen results a high elastic recovery (79%) and better age resistance properties (The loss in weight on heating in thin film oven is 6 times higher as compared to conventional bitumen of 60/70).
**Sangita et al.** suggested a novel approach to improve road quality by utilizing plastic waste in road construction. According to them India spends Rs 35,000 crores a year on road construction and repairs, including Rs 100,000 crores a year just on maintenance and roads by bitumen modification lasts 2-3 times longer, which will save us Rs 33,000 crores a year in repairs, plus reduced vehicle wear and tear.
**Prusty** studied the behaviour of BC mixes modified with waste polythene. He used various percentages of polythene for preparation of mixes with a selected aggregate grading as given in the IRC Code. Marshall Properties such as stability, flow value, unit weight, air voids are used to determine optimum polythene content for the given grade of bitumen (80/100) in his study. Considering these factors he observed that a more stable and durable mix for the pavements can be obtained by polymer modifications.

## 3.0 PREPARATION OF MARSHALL SAMPLES

Bitumen is a black, oily, viscous material that is a naturally-occurring organic byproduct of decomposed organic materials. Also known as asphalt or tar, bitumen was mixed with other materials throughout prehistory and throughout the world for use as a sealant, adhesive, building mortar, incense, and decorative application on pots, buildings, or human skin. The material was also useful in waterproofing canoes and other water transport. The mixes were prepared according to the Marshall procedure specified in ASTM D1559. For SMA, BC, and DBM mixes the coarse aggregates, fine aggregates and filler were mixed with bitumen and polyethylene according to the adopted gradation. The percentage of PET added in mixes is varied from 1.5 % to 7.5 % with a variation of 1.5 %. Here Optimum Binder Content (OBC) and optimum polyethylene content (OPC) was found by Marshall Test.

**Table 1: Marshall Properties of Specimens with PET**

| PET Content (%) | Unit Weight (kg/m$^3$) | Stability (KN) | Flow Value (mm) | Air Void VA (%) | VMA % |
|---|---|---|---|---|---|
| 0 % | 2.12 | 65.3 | 2.41 | 7.2 | 21.3 |
| 1.5 % | 2.26 | 72.3 | 2.56 | 6.8 | 19.8 |
| 3 % | 2.32 | 81.2 | 2.64 | 6.1 | 18.4 |
| 4.5 % | 2.41 | 95.4 | 2.78 | 5.8 | 17.2 |
| 6% | 2.49 | 93.2 | 2.84 | 5.5 | 16.2 |
| 7.5 % | 2.56 | 82.1 | 2.74 | 4.5 | 15.7 |

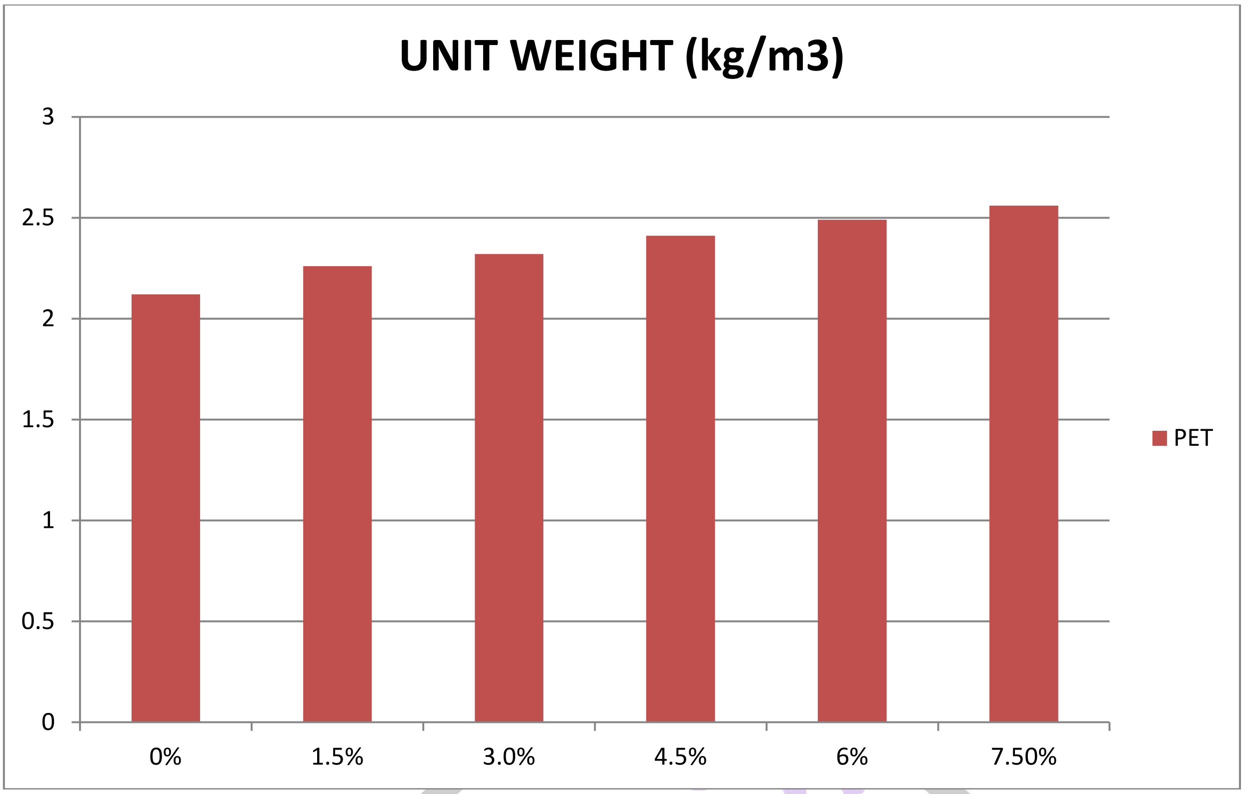


**Figure 2: Variation of Unit Weight With %age of PET**

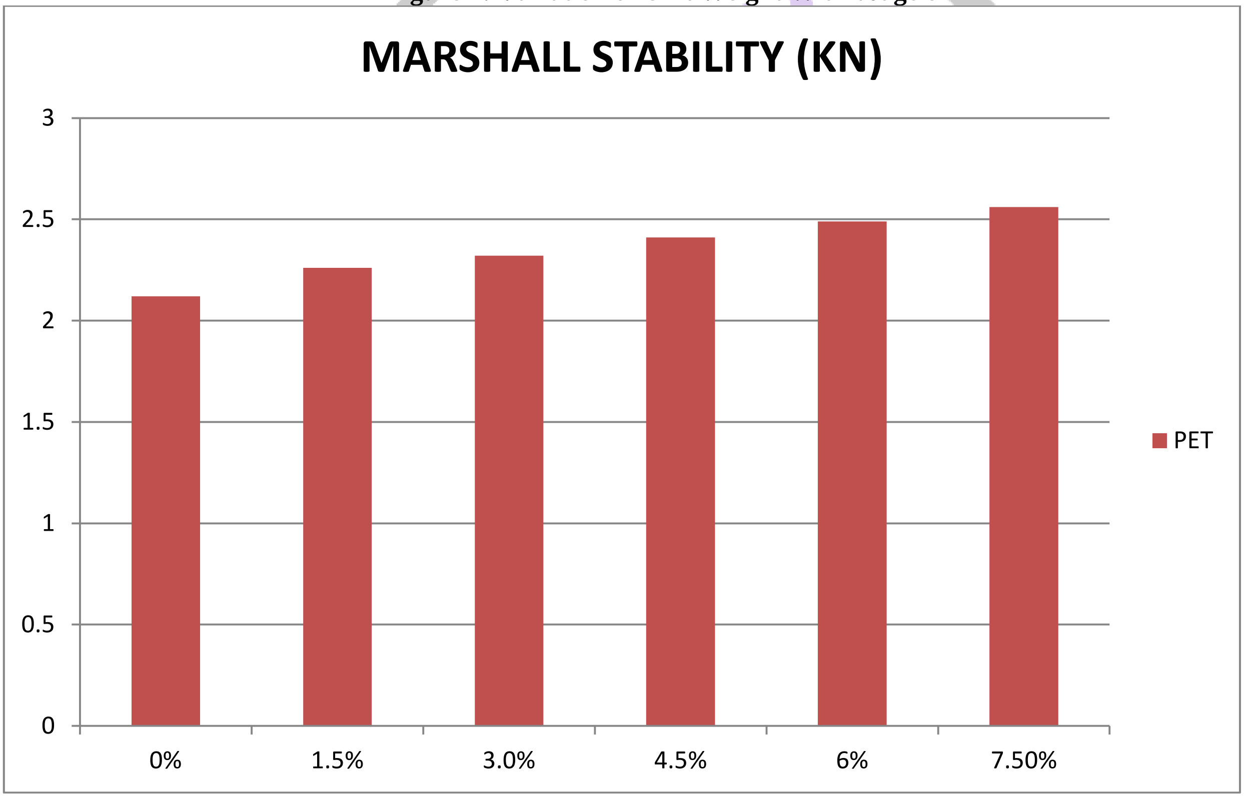


**Figure 3: Variation of Stability With %age of Bitumen**

**CONCLUSION**

**1.** Stability and flow also increase with increasing plastic aggregate content.

**2.** The performance properties of the SMA mixtures containing waste PET show the acceptable trends and could satisfy the standard requirements.

**3.** In asphalt mixes, density and percent voids increased with increasing plastic aggregates content.

**4.** Literature studies proved that improvements of road pavement asphalt and also building concretes in terms of performance in the first and reinforcement in the second are both can be attained by the addition of little amounts of a number of different polymer binders.

**5.** It is observed that the penetration values of plain bitumen decrease on increase of the PET content .The results also show that the addition of PET makes the modified bitumen harder and more consistent than plain bitumen which results in improvement in the rutting resistance of the mix.
**6.** The addition of PET kept the ductility values close from the minimum range of ASTM specifications of 100 cm.

**REFERENCES**

[1] Europe Plastics – the Facts 2014/2015: An analysis of European latest plastics production, demand and waste data, Brussels, Belgium: Plastics Europe, 2013.
[2] R. Siddique, J. B. Khatib, and K. Inderpreet, "Use of recycled plastic in concrete: A review," Waste Management, vol. 28, pp. 1835–1852, 2008.
[3] P. M. Subramanian, "Plastics recycling and waste management in the US," Resource, Conservation and Recycling, vol. 28, pp. 253–263, 2000.
[4] K. Ramadevi and R. Manju, "Experimental investigation on the properties of concrete with plastic PET (bottle) fibres as fine aggregates," International Journal of Emerging Technology and Advanced Engineering, vol. 2, no. 6, p. 42, 2012.
[5] SengozB. and Isikyakar G.," Evaluation of the properties and microstructure of SBS and EVA polymer modified bitumen", Construction and Building Materials 22 1897–1905, 2008.
[6] Zubeck H., Raad L. and Ryer, P.E., "Constructability of Polymer-Modified Asphalts and Asphalt-Aggregate Mixtures in Alaska", March, vol. 24, 1999.
[7] Al- Ghannam K.A.A., "Study on the Rheological Properties of Asphalt, Effect of Modification Process on the Homogeneity of the System" PHD. Thesis, College of Education Chemistry Dept, University of Mosul, 1995.
[8] Al-Hadidy A.I., "Evaluation of Pyrolisis Polypropylene Modified Asphalt", Al-Rafidain Engineering, vol.14, no.2, 2006.
[9] Naskar, T.K, Chaki and K.S Reddy, (2010); Effect of waste plastic as modifier on thermal stability and degradation kinetics of bitumen/w plastics blend. Thermochimica Acts 509 (2010) 128–134.