International Journal of
Civil Engineering (IJCE)
ISSN(P): 2278-9987; ISSN(E): 2278-9995
Vol. 4, Issue 5, Aug - Sep 2015, 17-24

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

UTILIZATION OF PLASTIC WASTE TO IMPROVE THE PROPERTIES OF AGGREGATES USING DRY PROCESS

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ABSTRACT

The plastic waste has been increasing day by day due to increase in population, urbanization, industrialization, changes in the life style, and socio-economic conditions. The disposal of plastic waste is a menace and become a serious problem worldwide due to its non-biodegradability and unaesthetic view. It is need of the hour to use plastic waste for construction of flexible pavement to minimize the bitumen consumption, protect the environment, manage the plastic waste and improve the properties of the aggregates. Dry process is the most advanced technique in which plastic waste is used to coat the aggregates. The plastic coated aggregates exhibit improved soundness & specific gravity, less abrasion & impact value and extra resistant to water than that of plain aggregates. In this paper, the use of plastic waste in flexible pavement by using dry process has been examined and the properties of the plastic coated aggregates have been compared with the plain aggregates.

KEYWORDS: Aggregates, Dry Process, Environment Protection, Improved Properties, Non-Biodegradable, Plastic Waste

INTRODUCTION

The increased use of plastic products as packaging application in the recent years have augmented the quantity of plastic in the solid waste stream to manifolds. Plastic is a non-biodegradable material and can remain on earth for 4500 years without degradation. It is not possible to ban use of plastic but we can reuse the plastic waste effectively for coating the aggregates for construction of flexible pavement. The aggregates coated with plastic show improvement in the properties than that of plain aggregates. The use of plastic waste in flexible pavement helps to minimize the requirement of bitumen up to great extent, helpful in its proper management; thus protects the environment [1].

LITERATURE REVIEW

In India, the concept of utilization of plastic waste in construction of flexible pavement has been done since 2000. In flexible pavement, bitumen plays the role of binding the aggregate together by coating over the aggregate, improve the strength and life of road but its resistance towards water is poor. Considerable research has been carried out to determine the suitability of plastic waste modifier in construction of bituminous mixes. The plastic waste can be used either to modify the bitumen in wet process i.e. plastic is added to the heated bitumen and mechanical mixing is done so as to get modified bitumen. While in dry process plastic waste is mixed with heated aggregate and bitumen is then mixed with the plastic coated aggregate to get the modified bituminous mix. Many research works have been carried out for the plastic modified bituminous mixes using wet process while a few researches are carried for the plastic modified bituminous mixes with dry process. Sunil Bose *et al*. (2005) reported that the use of waste plastic of 8% by weight of bitumen helps in substantially

improving the stability, fatigue, indirect tensile strength and reduced water damage of bituminous mixes under adverse water logging conditions. Therefore, the life of the flexible pavement using the waste plastic is expected to increase considerably in comparison to the use of conventional bituminous mix. The plastic waste materials will be put to use in road construction industry, resulting in improved road pavements and also relief from the waste plastic materials being littered all around urban areas.

Vasudevan *et al*. (2004) reported that waste plastic could replace about 8% by weight of bitumen. Stripping test conducted after mixing operation proved that adhesion of the plastic waste-aggregate-bitumen was excellent. Plastic waste could be successfully mixed with aggregates and bitumen at hot mix plant and the condition of the road when properly laid was good. Vasudevan *et al*. (2006) reported that though plastic modified bitumen improves the quality of the roads, the process of using the plastic for the blending decides the strength of the bonding. Coating plastic waste over aggregates gives better strength than blending it with bitumen. The aggregate, when coated with plastic improved its quality with respect to voids, moisture absorption and soundness. Dry process is definitely better process than wet process. They also reported that plastic will not leach out after laying the road using plastic-aggregate-bitumen mix [2, 3].

PROBLEMS WITH PLASTIC WASTE

The disposal of plastic waste is a menace and become a serious problem globally. The main problems with plastic waste are as follows:

- Non-biodegradable
- Un-aesthetic to view
- Cause land and water pollution
- Need reasonable space for disposal
- Can choke the drains & drainage channels
- Can be eaten by animals causing their illness & death
- Cause health hazards like genital abnormalities, reproductive problems, etc.

GENERATION OF PLASTIC WASTE IN INDIA

India has the lowest (6-7 kg) per capita per year consumption of plastic than that of world (24 kg) and consequently the plastic waste generation is also very low. The total plastic consumption (or plastic waste generation) in India during last decade has been shown in table 1 [4].

Table 1: Plastic Consumption in India (In Tonnes)

Sr. No.	Year	Plastic Consumption in India (in Tonnes)
1.	1996	61,000
2.	2000	3,00,000
3.	2001	4,00,000
4.	2007	85,00,000

PLASTIC WASTE CLASSIFICATION

Plastics can be classified in many ways, but most commonly by their physical properties. Plastics may also be

classified according to their chemical sources like Cellulose Plastics, Synthetic Resin Plastics, Protein Plastics, Natural Resins, Elastomers, Fibers, etc. But depending on their physical properties may be classified as thermoplastic (like Polystyrene, Polypropylene, Poly Vinyl Chloride, etc.) and thermosetting (like Bakelite, Epoxy, Polyester, etc.) materials. Thermoplastic materials can be formed into desired shapes under heat and pressure and become solids on cooling. Thermosetting materials which once shaped cannot be softened/ remolded by the application of heat.

Most of thermoplastics on heating soften at temperature between 110-140^{o}C. The Thermo-gravimetric analysis of thermoplastics has proven that there is no gas evolution in the temperature range of 130-180^{o}C and beyond 180^{o}C gas evolution and thermal degradation may occur. Thus the waste plastic can easily be blended with the bitumen as the process for road construction at temperature in the range of 155-165^{o}C [5].

PLASTIC WASTE AND ITS SOURCE

The sources of plastic waste are shown in table 2. The plastic confirming to HDPE, LDPE, PET and polyurethane shall only be used in flexible pavement. The PVC should not be used for road construction as they produce toxic gases and cause health hazards [6].

Table 2: Plastic Waste and its Source

Plastic waste	Origin/ Source
High Density Polyethylene (HDPE)	Carry bags, bottle caps, house hold articles, etc.
Low Density Polyethylene (LDPE)	Carry bags, sacks, milk pouches, bin lining, cosmetic and detergent bottles, etc.
Polyethylene Terphthalate (PET)	Drinking water bottles, etc.
Polypropylene (PP)	Bottle caps and closures, wrappers of detergent, biscuit, wafers packets, microwave trays for readymade meal, etc.
Poly Vinyl Chloride (PVC)	Mineral water bottles, credit cards, toys, pipes and gutters; electrical fittings, furniture, folders and pens, medical disposables, etc.
Polystyrene (PS)	Yoghurt pots, clear egg packs, bottle caps. Foamed Polystyrene: food trays, egg boxes, disposable cups, protective packaging, etc.

DRY PROCESS

In dry process the aggregates are heated to around 160-170^{o}C in the central mixing plant. The requisite percentage of shredded plastic waste (2 to 4 mm size) to the weight of bitumen is mixed with aggregates for 30 to 40 sec for uniform coating at their surface. After that the plastic coated aggregates mixed with hot bitumen at temperature (155-165^{o}C) to produce plastic-bitumen-aggregate mix which can be used for road laying (Figure 1) [7, 8].

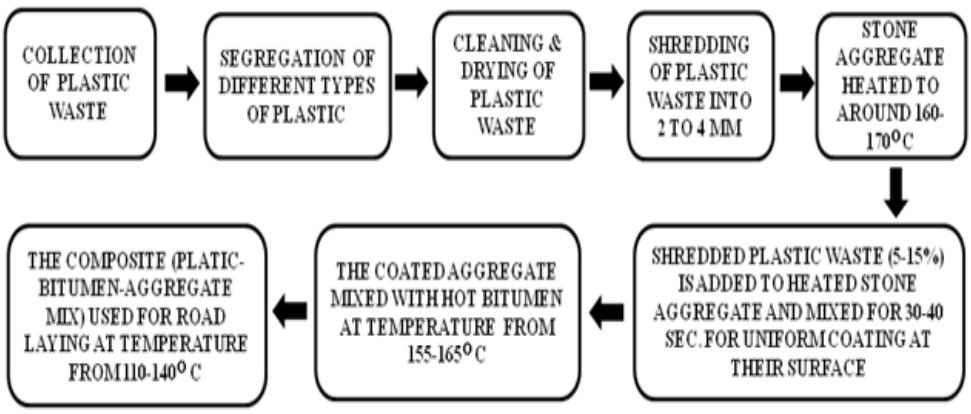

Figure 1: Flow Diagram of Dry Process

The aggregate used for dry process has been chosen on the basis of its strength, porosity & moisture absorption capacity and the bitumen has been chosen on the basis of its binding property, penetration value and visco-elastic property. The aggregate, when coated with plastic improved its quality with respect to voids, moisture absorption and soundness. The coating of plastic decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement. It is to be noted here that stones with porosity less than 2% can only be allowed by the specification for this process.

Advantages of Dry Process

- Plastic is coated over stone aggregate and thus improve the surface property of aggregate.
- No additional mechanical set up is required for this process.
- As replacing bitumen to 15%, higher cost efficiency is possible.
- The coated aggregate show increased strength and binding property.
- Bitumen bonding is stronger than normal.
- Flexible films of all types of plastic can be used.
- Can be practiced in all type of climatic conditions.
- No evolution of any toxic gases as maximum temperature is 180ºC.
- The penetration of water is reduced due to plastic-bitumen-aggregate mix which resists stripping and hence no pothole formation takes place on roads.
- Waste plastic-bitumen blend shows higher softening temperature. This increase will reduce the bleeding of bitumen during the summers.

  There is no observable demerit either in this process or in the road characteristics.

Comparison of Properties of Plastic Coated Aggregate with Plain Aggregates

The aggregates coated with 3%, 6% and 8% plastic by weight of bitumen were tested and their properties had been compared with the plain aggregates as discussed below [9, 10].

AGGREGATED IMPACT VALUE

The aggregate impact value (AIV) indicates a relative measure of resistance of aggregate to impact, which has a different effect than the resistance to gradually increasing compressive stress. The AIV should not normally exceed 30% for aggregates to be used for wearing course of pavements. Plastic coated aggregates show decrease in AIV than the plain aggregates as shown in Figure 2.

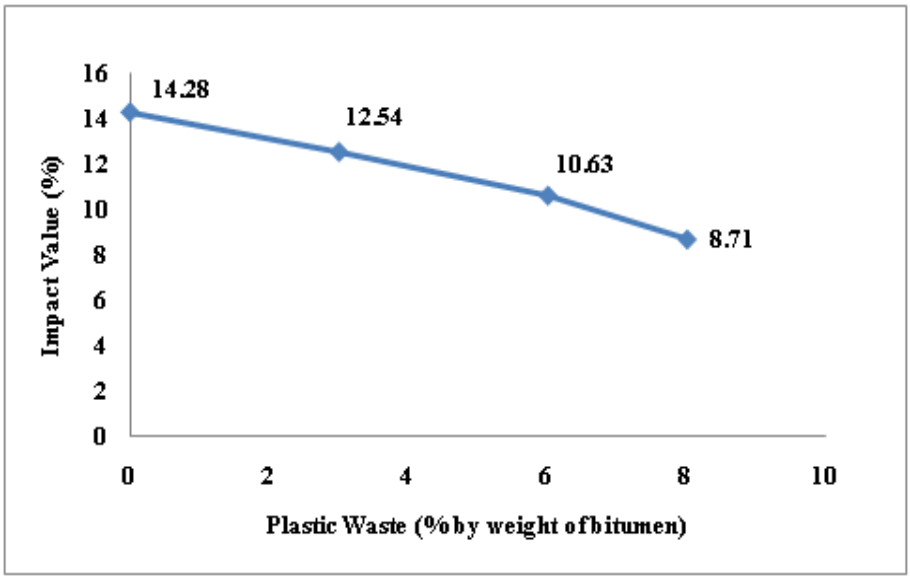

Figure 2: Results of Aggregate Impact Value Test

LOS ANGELES ABRASION TEST

Due to the movements of traffic the road aggregates used in the surface course are subjected to wearing action at the top. This wear and tear percentage of an aggregate is determined with the help of Los Angeles abrasion test. The abrasion value should be less than 30% for aggregates to be used for wearing course of pavements. Plastic coated aggregates show decrease in abrasion value than the plain aggregates as shown in Figure 3.

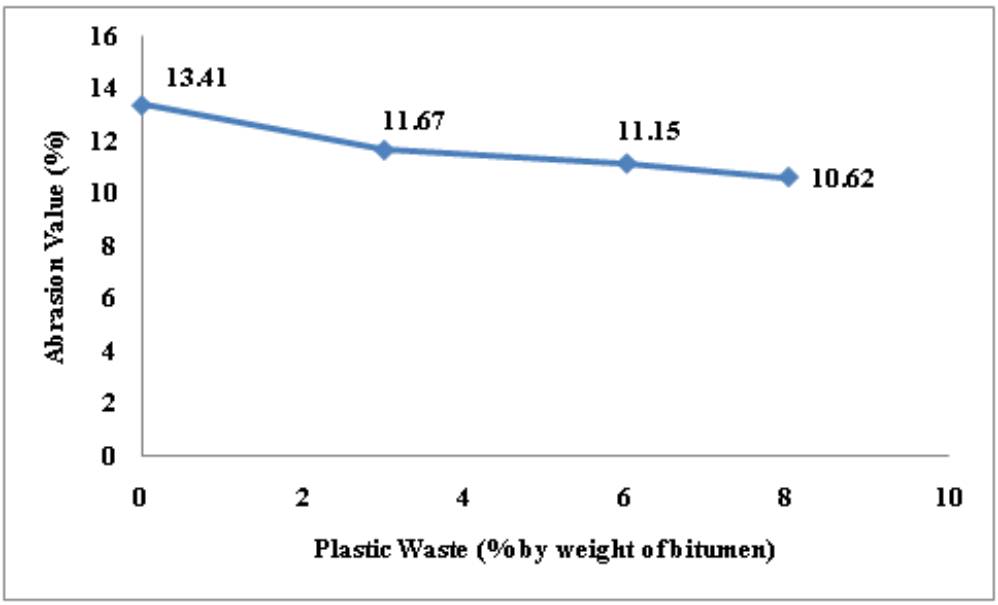

Figure 3: Results of Los Angeles Abrasion Test

SPECIFIC GRAVITY

The specific gravity of an aggregate is considered to a measure of the quality or strength of a material. Stones having low specific gravity values are generally weaker than those having higher values. Plastic coated aggregates show increase in specific gravity than the plain aggregates as shown in Figure 4.

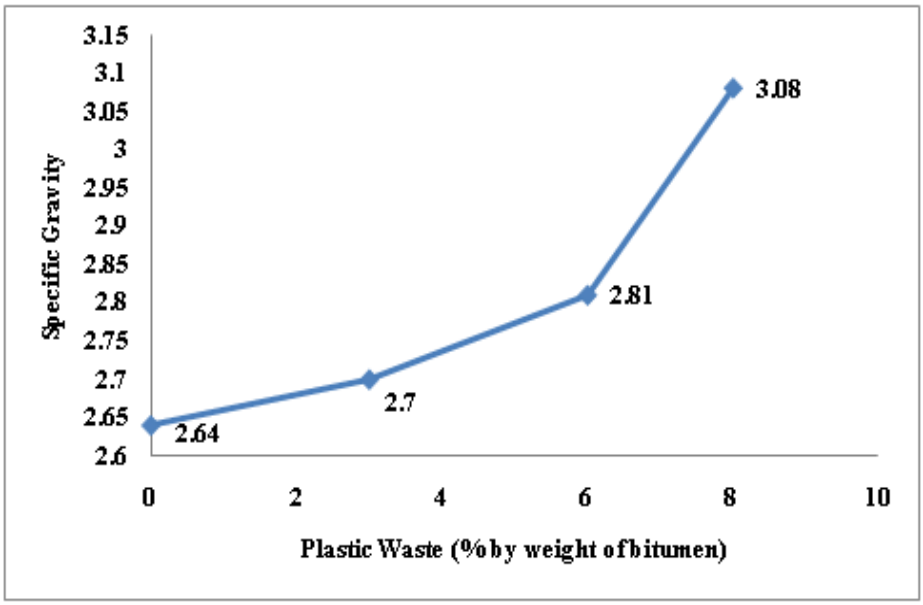

Figure 4: Results of Specific Gravity Test

MOISTURE ABSORPTION

The aggregates having higher water or moisture absorption value are porous and thus weak. Plastic coated aggregates show less moisture absorption than the plain aggregates as shown in Figure 5.

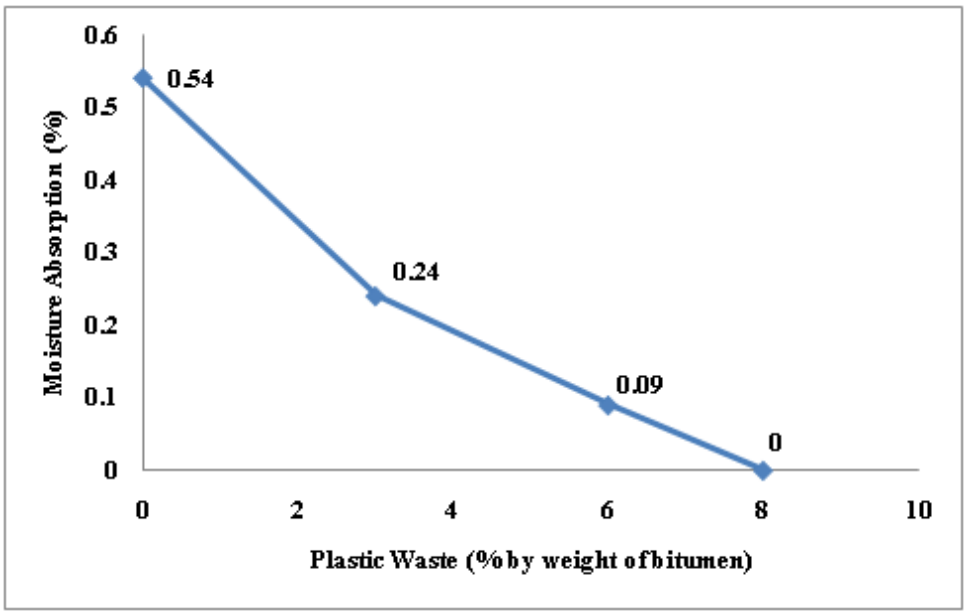

Figure 5: Results of Moisture Absorption Test

SOUNDNESS TEST

Soundness test is intended to study the resistance of aggregates to weathering action. The weight loss is attributed to the poor quality of the aggregate. The loss in the weight of aggregates tested with sodium sulphate after 10 cycles should not exceed 12%. The weight loss of plastic coated aggregates is observed to be negligible (Figure 6).

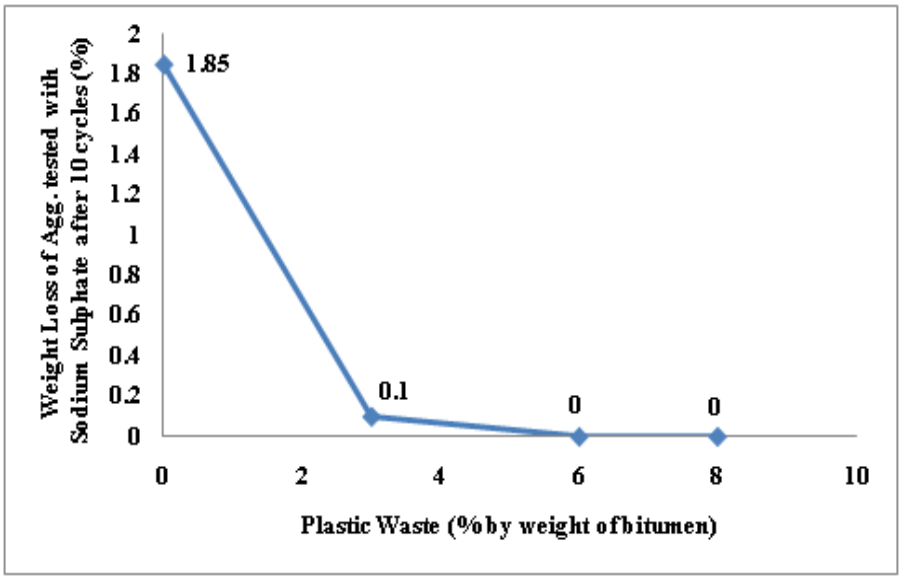

Figure 6: Results of Soundness Test

CONCLUSIONS

The plastic waste has now been utilized efficiently by using dry process for construction of flexible pavement and thus helps in resolving the problem of its disposal. The use of plastic waste in roads is a substitute to the bitumen up to great extent and improves the properties of the aggregates thus enhance the life of road. Government should take initiative to enforce the use of plastic waste in road construction using dry process.

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