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A REVIEW ON UTILIZATION OF SINGLE USE PLASTIC IN CONSTRUCTION OF FLEXIBLE PAVEMENTS

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Abstract - *Invention of plastics about 100 years ago completely changed our world and now due to increase in population and urbanization the amount of plastic generated is more than ever. The disposal of plastic waste has become a serious problem as it is non-biodegradable and causes serious environmental problems. One major way to tackle this problem is to reuse this waste plastic in the construction of flexible pavements. Plastic waste is heated to its softening point about 160 C and is coated over aggregates. This method not only enhances the properties of the mix like strength and durability but also increases the road life and water resistivity.*

The main objective of this paper is to do a comparative study of conventional bitumen and waste plastic in bitumen for determining the increase in strength by addition of waste plastics.

1. INTRODUCTION

Recent studies have revealed that plastics can stay unchanged for a period as long as 4500 years, with the current trend of the continuous rise in the global population coupled with the increase in demand for food and other necessities, as the ripple effect of fore mentioned activities has caused tremendous increase in the amount of waste generated by different households. Almost 5 % of plastic (in various forms) found in municipal solid waste is toxic in nature. [1] Even though plastic is modern day devil for present and coming generations, its use is inevitable. But though we can do away with it, it can surely be reused. [2]

In the field of civil engineering, the performance of bituminous mix used in surface coarse of roads can be improved by using treated plastic waste as an additive in the blend. Numerous studies have shown that the employment of recycled plastic, majorly polyethylene, in the making of bituminous mix led to reduction in permanent deformation in form of rutting, crazing and cracking of the pavement surface. The field tests were able to withstand the stress and it was concluded that after proper processing, plastic waste, when used as an additive, would enhance the life of roads along and would also help tackle environmental problems. [3]

2. LITERATURE REVIEW

B. G. Sreedevi (2013) [4] **–** Evaluated the results of roads laid with modified mix containing waste plastic coated aggregates; potholes are not formed easily indicating resistance towards water soaking, thereby avoiding the use of anti stripping agents. Massive consumption of waste plastics can be effectively made thereby reducing the pollution caused by burning or land filling this process is easy, cost effective and does not involve any additional machinery. There is also social benefit from this since it generates wealth from waste and as an income to rag pickers.

Reduction in voids in all types of mixes is seen. Aggregates coated with waste plastic did not showed any signs stripping after 72 hours of soaking where as ordinary bituminous mix showed 2% stripping.

L. M. B. Costa (2013) [5] **–** Stated the suitability of using different types of polymers to assess the potential using recycled polymers in asphalt mixtures for their valorization. The studied polymers were HDPE (recycled), LDPE (recycled), EVA (virgin and recycled), SBS (virgin), ABS (recycled) and crumb rubber from used tires (recycled). The characterization of the different bitumen 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 a commercially modified bitumen.

Amit Gawande (2012) [6] **–** States that the use of recycled waste plastic in pavement asphalt represents a valuable outlet for such materials. Utilization of modified bitumen with the addition of waste plastic helps in improving the Marshall stability, strength and other desirable properties of bituminous concrete mix, which improves its lifespan and pavement performance with marginal savings in bitumen usage. This process is environment friendly and the use of waste plastic in the construction of

roads also helps to consume large quantity of waste plastics which would otherwise cause disposal problem. Thus, these processes are highly relevant also providing better infrastructure.

Mahesh M. Barad (2015) [7] **–** Studied the binding properties of plastic waste with aggregates. The mixture of aggregate and plastic was compacted and then cooled. The block formed was very hard and showed compressive strength of around 130 MPa and binding strength of around 500 kg/cm^2. This shows that the polymer has good binding strength. Plastic coating increases area of contact between polymer and bitumen. The polymer coating also reduces the voids. This prevents the oxidation of bitumen by entrapped air which has resulted in reduced grooves on surface, raveling, and there is no pothole formation. The road can withstand heavy traffic than earlier and show better durability against wear and tear.

R. Manju Anand, Sathya S. (2017) [8] – Some encouraging result were found out from this study; the crushing value of aggregate compared with plastic mix aggregate decreases by 40%, which shows higher strength. Impact Value was reduced by 9%, Los Angeles Value was reduced by 21%. Penetration value of the bitumen as compared to the plastic mix bitumen shows increased value, bitumen softens 10°C less than the bitumen replaced with plastic. Stability of modified bitumen is higher than the normal bitumen by 10%.

Abdelaziz Mahrez, Mohamed Rehan Karim (2010) [9] – This paper states that the result showed an improvement in PET modified bitumen properties as the PET content increases in the binder. The recycled PET modified bitumen have lower penetration value, higher softening point and viscosity and better viscoelastic properties. The viscosity value of recycled PET modified bitumen was lower which fulfils highway requirements.

Kapil Soni , K.K Punjabi (2014) [10] – States that the results indicated that the consumption of waste polyethene in bituminous concrete mixtures shows improved property of the mixtures thus formed. The Marshall Stability test as a strength parameter shows the increased trend with a maximum increased percentage of around 35.20% as compared to the conventional mix when modified with 4.5% Polythene Waste. The waste plastic which is also a pollution threat find its use in road construction and solves the problem of pollution to some extent.

Bindu C.S, Dr. K.S. Beena (2010) [11] - Based on the study of the utilization of shredded plastic in SMA mixtures, the some findings were made. The flow value of SMA mixture with fibre was seen to be decreasing. With increase in plastic content retained Stability of SMA mixture increases. Triaxial test results show that stabilized SMA has higher cohesion and decrease in angle of shearing resistance than the conventional mixes. The stabilized SMA mix also has good strength under soaking.

Anzar Hamid Mir (2015) [12] **-** Studied the properties of waste plastic. The maintenance cost of the road will reduce and road life is increased by 2 to 3 times. The sturdiness of the roads laid out with plastic waste is more compared with the roads made with the standard mix. Less bleeding occurs during summer and resistance towards water stagnation i.e. no potholes are formed. Addition of plastic will increase the melting point of bitumen. The use of the innovative technology not only strengthens the road but also increases the road life as well quality of the road.

R. K. Yadav (2016) [13] **-** Based on the results obtained from laboratory test, the percentage air voids in the mix decrease continuously and VFB continuously increases with the addition of the plastic waste in the mix.

R. M. Subramanian and S.P. Jeyapriya[14] **-** Based on the experimental investigations done and the result obtain from the tests some conclusions were made. Crumb tyre mixed with soil improves the UCC value and show gradual decrement in CBR value, waste tyre pieces reinforced with soil showed improvement in CBR value. Aggregates in Sub-base layer of pavement when partially replaced by with tyre pieces also showed increase in the CBR value.

K.V.R. Prasad and Dr. S.P. Mahendra (2015) [15] **-** States that the use of waste plastic for road construction can save the environment and increase the service lifespan of roads. Reduce the consumption of petrochemical products. Dry process helps us to use higher percentage of plastic waste thereby reducing the necessity of bitumen by around 10% which will increase the strength and performance of the road, reduce the cost and provide employment for rag pickers. By mixing plastic with bitumen the ability of the bitumen to resist high temperature increases.

Utibe J. Nkanga, Johnson A. Joseph (2017) [16] **–** This report stated that using the modified bituminous mix with plastic waste by weight of about 5% to 15% helps the bitumen by improving its Marshal stability, strength, flow, bulk density, and also the fatigue life of the bitumen. Whereas, other desired properties in the bituminous mix also increases; this improves the durability and shows high performance rate.

3. CHARACTERISTICS OF WASTE PLASTICS

3.1 Thermal Property

A study of the thermal behavior of the polymers namely polyethylene, polypropylene, polystyrene, shows that these polymers get softened easily without any evolution of gas around 130-140 C, this has been proven scientifically. At around 350 C these polymers get decomposed releasing gases like methane, ethane etc and at 700 C they undergo combustion, producing gases like CO and CO_2. [17]

3.2 Binding Property

The molten plastics waste shows good binding property. Different raw materials like stone, granite, ceramics etc. were coated with plastics then molded into a stable product. On cooling, they were tested for compression and bending strengths. It was found that the values of the compression strength and bending strength increases which shows that the plastics can be used as a binder. [17]

4. METHODOLOGY

The properties of aggregate and bitumen are investigated by following tests:

4.1 Tests for aggregate

1. Sieve Analysis of Aggregates [IS:2386 (Part 1)]
2. Flakiness & Elongation Index [IS:2386 (Part 1)]
3. Specific Gravity & Water Absorption Test [IS: 2386 (Part 3)]
4. Aggregate Impact Value Test [IS:2386 (Part 4)]
5. Aggregate Crushing Value Test [IS:2386 (Part 4)]

4.2 Tests for Bitumen

1. Penetration Test [IS: 1203-1978]
2. Softening Point Test [IS: 1205-1978]
3. Viscosity Test [IS: 1206-1978]
4. Ductility Test [IS: 1208-1978]
5. Flash and Fire Test [IS: 1209-1978]

5. TYPES OF PROCESS FOR CONSTRUCTING BITUMEN MIX ROAD USING WASTE PLASTIC

There are two processes for the constructing road with waste plastic:

5.1 Dry Process

In this process the hot stone aggregates (170°C) is mixed with hot bitumen (160°C) and therefore the mix is employed for road laying. The aggregates are chosen on the basis of their strength, moisture absorption capacity and porosity. The bitumen is chosen on the basis of its penetration value, binding property and viscoelastic property. The aggregates when coated with waste plastic improves its quality with reference to voids, moisture absorption and soundness. The coating of plastic decreases the porosity and helps in improving the properties of the aggregate and its performance in the flexible pavement. Aggregates with porosity less than 2% are only allowed for this process.

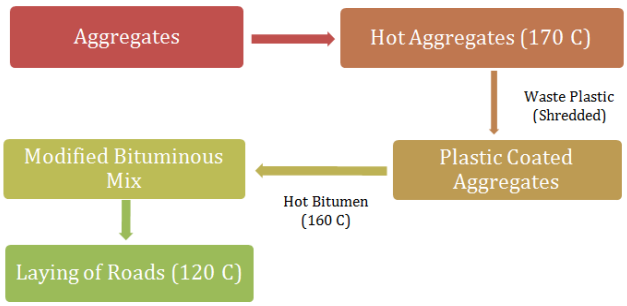

Fig -1: Flowchart for Dry Process

Advantages of Dry Process

- It improves the surface property of aggregate.
- Coating is easy and temperature required is same as road laying temp.
- Waste plastic more than 15% is possible for disposal.
- The binding property of aggregates gets doubled.
- No extra machinery or equipments are required.
- Bitumen bonding is strong than normal.
- The strength of coated aggregates is also increased.
- Higher cost efficiency is possible due to less bitumen consumption.
- After construction there is no deterioration of roads even after 5 -6 yrs.
- It is workable in all type of climatic conditions.
- There is no evolution of any kind of' toxic gases as maximum temperature is 180°C.

Disadvantages of Dry Process

- The process is applicable to waste plastic only.
- PVC should not be used for construction of roads.

5.2 Wet Process

Waste plastic is grinded and made into powder form; 6 to 8 % plastic is mixed with the bitumen. Addition of plastic in bitumen increases the melting point of the bitumen and makes the road more flexible during winters leading to its long life. Use of shredded plastic waste acts as a strong "binding agent" for bitumen which makes it last longer. The plastic waste is first melted and then mixed with

bitumen in a particular ratio. The tests done at the laboratory level proves that the bituminous concrete mixes prepared using the treated bitumen binder fulfills all the specified Marshall mix design criteria for surface course of road pavement. The Marshall Stability value of the mix increases up to 2-3 times higher value in comparison with the untreated or normal bitumen. One important result that discovered was that the treated binder could withstand adverse soaking conditions under water for extended duration.

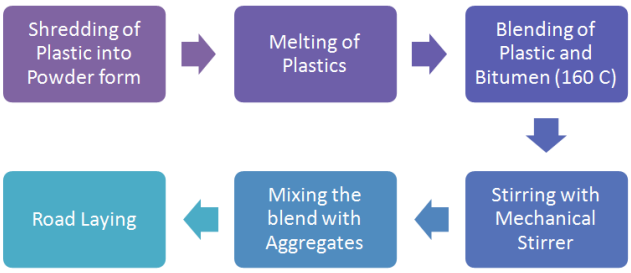

Fig -2: Flowchart for Wet Process

Advantages of Wet Process:

- This Process can be used for recycling of any type, size, shape of waste material (Plastics, Rubber etc.)

Disadvantages of Wet Process:

- This process is time consuming due to extra time and energy for blending.
- Powerful mechanical equipments are required.
- Additional cooling is required as improper addition of bitumen may cause air pockets on the surface of roads.
- Maximum % of waste plastic that can be added is around 8 %.

6. CONCLUSIONS

This review is done to learn about the different methods of disposing of plastic waste in bituminous pavement to reduce the environmental pollution and thereby also increasing the characteristics properties of the pavement. The use of waste plastic from 5-15% by weight of bitumen in the bituminous pavement helps in improving Marshall stability value, flow value, strength, bulk density along with its fatigue life. Other properties like aggregate crushing value, impact value and Los Angeles abrasion value decreases for plastic coated aggregates. Potholes are not formed easily also there is reduction in voids. Due to which the maintenance cost gets reduced and the road life increases substantially by 2-3 times making the road more durable with high performance rate. This process is eco friendly. The machinery used is easily available and does not require skilled persons. This process can be easily adopted with the co-operation of public and government bodies.

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