A New Life for Plastic Waste as Aggregates in Bituminous Road: A Review

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***Abstract*: The idea of using waste plastics in road construction is relatively new. Laboratory tests have shown positive results when a small amount (5-10% by weight) of plastic is incorporated in bituminous mixes (asphalt), resulting in improved pavement stability, strength, and durability. However, international field experience using plastics in actual road construction is quite limited. In this review, we found examples of waste plastics being used in road construction in a few case studies in India, UK, Portugal, and South Africa. While roads constructed using waste plastics have shown good longevity and pavement performance to date, the first roads constructed using this technology are only about ten years old, so long-term outcomes are not yet clear. This review did not find any evidence discussing the maintenance of roads constructed using waste plastics. This paper reviews the work of various researchers on use of Plastic Waste as material in road construction for improving the strength of pavement.**

***Keywords:* waste plastics, pavement stability, bituminous mixes**

I. Introduction:

Plastic has slowly become an integral part of all human requirements. Plastic carry bags, packaging material, bottles, cups, and various other items have slowly replaced everything made of other material due to the advantages of plastic. Plastic is durable, easy to produce, lightweight, unbreakable, odourless, and chemical resistant.
Plastic garbage is commonly seen around the country and has started causing several problems. Plastic waste clogs drains, causing floods. It chokes animals who eat plastic bags, etc. Plastics found in fields blocks germination and prevent rainwater absorption. Recycling plastic can be done only 3-4 times and melting the plastic for recycling releases highly toxic fumes. Using plastic waste can help India, which has the world's second largest road network, in curbing road accidents deaths. Potholes, a common feature of roads in India, are responsible for one tenth of deaths that occurred in 2017 due to road accidents in the country.
The major threat to the environment is the disposal of waste plastic. In a highway, the potholes and corrugation is the major problem. Plastic pavement will be a better solution to the above stated problems. A material that contain one or more organic polymer of large molecular weight, solid in its finished state, can be plastic has high resistant to degradation. Plastic can be divided into two major categories- thermoses & thermoplastics, thermoses have high durability and strength because it solidifies irreversibly when heated, hence forth can be used primarily in construction application. Plastic is a non-degradable waste, causes green- house effect and global warming. The various experiments have been carried out whether the waste plastic can be reused productively. The various literature indicated that the waste plastic when added to hot aggregates will form a fine coat of plastic over the aggregate and such aggregates when mixed with binder is found to have higher strength, higher resistance and better performance over a period of time. Along with bitumen, use waste plastic increases its life and smoothness. It is economical and eco-friendly. Addition of plastic waste in construction of pavements reduces the plastic shrinkage and drying shrinkage. The use of waste plastic improves the abrasion & slip resistance of asphalt pavement. In India, because of hot and extremely humid climate, plastic pavements are of greatest advantage.

II. Literature review:

Most of the researches have worked in publishing their work on use of Plastic Waste as material in road construction for improving the strength of pavement. The observation, methodology, conclusions and further scope of work are used to finalise the objectives of present work. The available literature of review is as follows:

Vidula Swami, *at el*, (2012) The addition of waste plastic modifies the properties of bitumen. The modified bitumen shows good result when compared to standard results. The optimum content of waste plastic to be used is between the range of 5% to 10%.The problems like bleeding are reduce in hot temperature region. Plastic has property of absorbing sound, which also help in reducing the sound pollution of heavy traffic. The waste plastics thus can be put to use and it ultimately improves the quality and performance of road. Total material cost of the project is reduced by 7.99%.

S.Rajasekaran, *at el*, (2013), In Dry process, the aggregate is modified by coating with polymers and producing a new modified raw material for flexible pavement. Patent has been obtained for this process (Fig-2). Coating of polymers on the surface of the aggregate has resulted in many advantages and ultimately helps to improve the quality of flexible pavement. The coating of plastics over aggregate also improves the quality of the aggregate. In addition to the improvement of the quality of the road, this technology has helped to use the waste plastics obtained from domestic and industrial packing materials. This has added more value to the dry

process as this process helps to dispose 80 percentages of the waste polymers usefully by an eco-friendly method. This has already been accepted by the Central Pollution Control Board, New Delhi. They have already released a guideline on the technique of the road laying by dry process and its advantage.

Apurva J Chava , (2013), Plastic coating on aggregates is used for the better performance of roads. This helps to have a better binding of bitumen with plastic wasted coated aggregate due to increased bonding and increased area of contact between polymers and bitumen. The polymer coating also reduces the voids. This prevents the moisture absorption and oxidation of bitumen by entrapped air. This has resulted in reducing rutting, raveling and there is no pothole formation. The roads can withstand heavy traffic and show better durability. In short it can conclude that, using plastic waste in mix will help reduction in need of bitumen by around 10%, increase the strength and performance of road, avoid use of anti stripping agent, avoid disposal of plastic waste by incineration and land filling and ultimately develop a technology, which is eco friendly. Increased traffic conditions will and are reducing the life span of roads. Plastic roads are means of prevention and ultimately will be the cure. It will save millions of dollars in future and reduce the amount of resources used for construction.

Amit P. Gawande(2013), Polymer Modified Bitumen is used due to its better performance. But in the case of higher percentage of polymer bitumen blend, the blend is a more polymer dispersion in bitumen, which get separated on cooling. This may affect the properties and quality of the blend and also the road laid using such blend. Coating is easy and the temperature needed is the same as the road laying temperature. Bitumen is bonded with the aggregate by means of plastic which acts as a binder. Bitumen bonding is strong as evidenced from higher Marshall value. Coated plastics acts as binder and the added bitumen binds strongly. Waste plastic is collected, shredded and can be used in the hot mix plant to lay the roads. No new technology is involved. The existing Mini hot mix plant or Central Mix plant can be
used without any modification. The coated aggregate shows increased strength. Dry process can be practiced in all type of climatic conditions. Process can be modified by varying the percentage of plastic with respect to the environmental conditions namely, Temperature, Rain, Snow, load, etc.,No evolution of any toxic gases like dioxin as the max. temp. is only 170oC .

Adebayo Olatunbosun Sojobi, at el,(2016), Eco-friendly road construction comprises eight basic elements, namely: eco-design, eco-extraction, eco-manufacturing, eco-construction, eco-rehabilitation, eco-maintenance, eco-demolition, and socioeconomic empowerment. Our research also highlighted various waste materials which are applicable in various aspects of road construction, which include plastic wastes. For eco-friendly road construction to be embraced specially in developing countries there is a need for collaboration among all stakeholders and decision-makers in all levels of government, and support from government in terms of financial support for research and development as well as regulation, monitoring, and enforcement. Utilization of PET plastic bottle wastes could have positive environmental and economic benefits considering the potential effects of removal of several million metric tons of PET wastes from the waste stream and the potential financial savings emanating from elongated service life of roads, reduction of accidents, conservation of natural resources, and income from trading in such wastes.

Yendrembam Arunkumar Singh, et al, (2016)As compared to PCCBP, the initial construction costs for conventional flexible and rigid pavement are seen to be higher by 9% and 150% respectively. The total cost including construction and maintenance cost for 5 years of flexible and rigid pavements are higher by 43% and 141% respectively as compared to that of PCCBP. Cent percent replacement of river sand in concrete by stone dust proved to be cost cutting without significant change in the strength of the concrete. Hence, PCCBP can be a suitable alternative to the conventional flexible and concrete pavement for the construction of rural roads which is labour intensive and cost effective.

Aadesh Prafulla Patil, et al, (2017), Increasing issue of disposal of the recycled waste polymer plastic and using of natural aggregate in large scale force to study the alternative option for these issues. Executing the present work it concludes that the WPA is feasible for the replacement of the natural aggregate. The WPA has qualified all the tests prescribed by IS codes. The impact value, crushing value and abrasion value of WPA are much below to the upper limits this explains that WPA has the ability to be used in the construction of the bituminous road. Hence the suitability of the WPA as road pavement constituent is well justified

Azmat Shaikh, et al, (2017), From the study of the behavior of plastic waste modified BC, we can conclude that the modified mix possesses improved Marshall Characteristics. It is observed that Marshall Stability value increases with plastic content and we observed that the Marshall Flow value decreases upon addition of polythene i.e. the resistance to deformations under heavy wheel loads increases. From all the experiments performed we can conclude that the addition of plastic waste enhances the various properties of an ordinary bituminous road. Considering these factors we can assure that we can obtain a more stable and durable mix for the pavements by polymer modifications. This small investigation not only utilizes beneficially, the waste non-degradable plastics but also provides us an improved pavement with better strength and longer life period. This study will have a positive impact on the environment as it will reduce the volume of plastic waste to be disposed of by incineration and land filling. It will not only add value to plastic waste but will develop a technology, which is eco-friendly.

Liliana M. B. Costa, et al, (2017), Cross-linked polyethylene (PEX) waste can be partially melted into hot bitumen, modifying the final properties of the resulting binder.When incorporated into asphalt mixtures as an aggregate partial substitute, PEX reduces the density of the mixtures by about 5%, which may be an advantage in specific circumstances, namely, during transport and in the application over structural elements, like bridges. Regarding the water sensitivity test results, the introduction of PEX was not able to improve the performance of the mixture, unless increased binder content (0.5% higher) was used. Similar results were observed

in the fatigue cracking resistance tests because polyethylene based polymers are not able to improve the flexibility of asphalt mixtures in the same way as the elastomeric polymers that were used in the PMB 45/80-60 mixtures. Permanent deformation results of the mixtures with PEX were clearly better than those of the mixtures without PEX, even when higher binder contents were used. This is a result of the lower susceptibility to temperature variation of those mixtures, which can also be observed from their higher stiffness modulus and lower phase angle values. These properties are related to each other and can be seen as the main performance related improvements of incorporating PEX in asphalt mixtures. The inclusion of PEX in asphalt mixtures is a viable solution that can assure adequate performance of a road pavement, especially when high service temperatures are expected.

Mandeep Sindhu, (2018), From the investigation of the conduct of plastic waste changed BC, we can reason that the altered blend has enhanced Marshall Characteristics. It is watched that Marshall Stability esteem increments with plastic substance and we watched that the Marshall Flow esteem endless supply of polythene i.e. the protection from disfigurements under substantial wheel loads increments. From every one of the tests performed we can presume that the expansion of plastic waste upgrades the different properties of a common bituminous street. Considering these components we can guarantee that we can acquire a more steady and tough blend for the asphalts by polymer adjustments. This little examination not just uses valuably, the waste non-degradable plastics yet additionally furnishes us enhanced asphalt with better quality and longer life period. This examination will positively affect the earth as it will lessen the volume of plastic waste to be discarded by cremation and land filling. It won't just increase the value of plastic waste yet will build up an innovation, which is eco-accommodating.

Chinthayyanaidu Rudram(2018), When it is compared the dry and wet process it is most effective to use dry process why because in dry process we can use up to 15% of plastic waste and binding also more with aggregate, where as in wet process we can use only up to 10% beyond this we can't use because it requires much mechanical energy, and stability is average. Marshal stability values of dry process are much better than the wet process, so in practical situation Dry Process is more suitable.

III. Conclusion :

This review intended to find the effective ways to reutilize the plastic waste particles as aggregate modifier for flexible pavements. The use of recycled waste plastic in pavement represents a valuable outlet for such materials. Plastics will increase the melting point of the bitumen. The use of the innovative technology not only strengthened the road construction but also increased the road life as well road quality. In addition to the improvement of the quality of the road, this technology has helped to use the waste plastics obtained from domestic and industrial packing materials. This process is eco friendly and socially highly relevant and hence one of the best methods for easy disposal of Waste plastics.

REFERENCES

[1] Vidula Swami,Use of waste plastic in construction of bituminous road, International Journal of Engineering Science and Technology, Vol. 4 No.05 May 2012,2351-2355
[2] S.Rajasekaran, Reuse of Waste Plastics Coated Aggregates-Bitumen Mix Composite For Road Application – Green Method, American Journal of Engineering Research Volume-02,2013 Issue-11, 01-13
[3] Apurva J Chava, Use of plastic waste in flexible pavements, International Journal of Application or innovation in Engineering & Management,540-552
[4] Amit P. Gawande,Economics and viability of plastic road : a review, J. Curr. Chem. Pharm. Sc.: 3(4), 2013,231-242
[5] Adebayo Olatunbosun Sojobi, Recycling of polyethylene terephthalate (PET) plastic bottle wastes in bituminous asphaltic concrete, https://www.tandfonline.com/loi/oaen20,
[6] Yendrembam Arunkumar Singh, Economic Evaluation of Plastic Filled Concrete Block Pavement, International Journal of Engineering and Advanced Technology (IJEAT), Volume-5, Issue-3, February 2016,57-65
[7] Aadesh Prafulla Patil, Use of Plastic Waste in Bituminous Road, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 5 Issue V, May 2017,557-560
[8] Chinthayyanaidu Rudram, Study of Economics and Stability of Bituminous Road by using Waste Plastic, International Journal for Research in Applied Science & Engineering Technology (IJRASET),Volume 6 Issue III, March 2018,1541-1548