

Characterization of flexible pavements by using plastic waste: A review paper

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ABSTRACT

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In our Experimental work, we present the application of scrap plastic substances as a partial substitution of bitumen to enlarge an alter binder, for preparing the bituminous concrete mix. To reproduce with the area, situation, “Marshall stability analysis” was accomplish on the specimen prepared by imperfect substitute “Most appropriate bitumen content” with scrap (4%, 6%, 8%, 10%, 12%, 14% and 16%) and after that they are coated with recycled coarse aggregates of size 5-20 mm which enhance the properties of bituminous mix for the longer life and better pavements performance. The stability and flow value of Marshall is 6-8%. Therefore, the utilization of scrap in the bituminous concrete mix, thus contributed to establishment of green roads and solve, the issues of its safe dumping as well.

INTRODUCTION

Plastic is throughout in today’s way of life and its scrap is a wider complication. The result is non-decomposable due to which these substances cause environmental pollution and complication such as breast cancer, human and animal complications and complications disorders. We can use scrap flexible pavements in such a way that they get cover on top of the surface of the aggregate by heating (140°C - 160°C) because scrap like polypropylene, polyethylene, polystyrene were utilized in PET bottles, scrap glasses, handbags, and other apparatus etc relieves up to 160°C [1]. Modifying polymer bitumen is one of the major flexible pavements plants. For road construction, it shows good effects and scrap can find its utilization in this procedure and this can help to deal with the difficulties of pollution. The best unbreakable property of plastic in its fluent state helped to find a safe scrap metal disposal procedure.

India has as elevator transit order at a large size. Since the introduction of the road, the modified bitumen component has effects and plastic waste can be used in this method, which can help solve pollution problems. The best bonding property of plastic scrap in its fluid condition helped to find a system if the safe disposal of plastic scrap. It is easily made and waterproof and cheap too. As the banned coveralls of upholstery for a long time, fly ash has been widely used and it has the highest strength of the bitumen combination to destroy. The fly ash was described accessibility to work as a bitumen enlarger in the sum to the filler vacuum [2].

India has become third largest client of plastic in the world with the utilization of around 15 millions used for stuffing substances which are frequently thrown and left to refuse the adjoining. The waste plastic

which is not recoverable gets combined with domestic waste and creates the in disposing difficulty of metropolitan waste. There are two methods of disposing of municipal waste, padding or carbonization[3].The utilization of scrap plastic helps in greatly up the erosion and creep resistance of adaptable pavements and collaborative allow to get values of snatch durability the required limits whereas plastic scrap fulfill is on the far side half-hour by weight of combine. If the compatible blend duration and blend temperature don't seem to be on condition that for bitumen change mix, modified hydrocarbon cannot manifest realistic presentation in place, therefore unseasonable failures can occur. Therefore, the zone unit ignores compatible direct synchronization, compatible temperature and modified content for all polymers with a brand. All this has to be taken into account, while losing and giving birth to roads has to be done dupery plastic waste. The plastic route would be a network in India combine the ease of occurrence the world of all variations of plastic scrap [4]. Bituminous mixtures consist of alloying aggregates, filling and best backrest mixed in a hot mixing plant and applied to hot straight results in an upper type of aesthetic pavements. Well group aggregates and alloy filler material cause high density when combined with large volumes of bitumen. The amount of aggregates in the asphalt smelting normally 90-95% by weight and 75-85% by volume and they are first of all answers for the load shifting size of the pavement. These mixtures show great robustness and its entity is around 6-8 years old. A magnificent group of substances and 3-5% air voids are responsible for creating them highly impervious. Due to good interlacing, high density and high flexibility, it can carry a heavy bulk vehicle and axle load. The escalation that drops and is observed reduces the constraints on the cover below. Due to the high degree of dominance in the classified supply of substances and the workbook completion, a good level is obtained without skidding

The substances are used as follows:

1. Aggregates
2. Bituminous Binder
3. Mineral Filler
4. Plastic scrap material

Aggregates: aggregates having enough toughness, rigidity, toughness, specific gravity and shape were selected and the specified test on regular aggregates and plastic covered aggregate was discharged. Mineral Filler: Filler shall contain lastly splitting substances such as rock dust or hydrated lime or cement. The utilization of hydrated lime is uplifted because of its better anti-stripping and anti-oxidant effects. It is added to the hot mix asphalt, to increase the solidity and magnify the toughness of the mixes. The span of stuffing is shown in table below.

Table 1: Grading requirement of mineral filler

Is sieve size in mm	Cumulative % by weight of total aggregate passing
0.6	100
0.3	95-100
0.075	85-100

Bitumen: the bitumen utilization in the demonstration was 80/100 grade and was trial in the laboratory for basic trial, perception, ductility, softening point, specific gravity and viscosity.

Modifiers (plastic Waste): The procedure of scrap plastic bags from the refused of nearer area in the grate form was used as supplement. The grate scrap plastic was cut into pieces of equal sizes processed through 2.36 mm IS sieve hold on to 600 micron IS sieve. Thickness between 10 micron- 30 micron.

Table-2 Properties Of waste Plastic

Property	Values
Range	2.36 mm-600 micron
Bulk weight	0.95
Melting temperature °c	130-160

Thermo gravimetric scanning has shown that there is no gas progression in the temperature size of 130-180.c. Also the softened plastic having a indissoluble effect. There is no unified approach towards bituminous mix design, rather there are a number of approaches, and each has some merits are demerits. Table-3 summarizes [RILEM 17 1998] some of the important bituminous mix design approaches are as

follows: Mix design method Recipe method Empirical mix design method Analytical method Volumetric method Performance related approach Performance based Approach .The recent emphasis on bituminous mix design is on performance related and performance based approaches. The requirement of a good mix design has changed from time to time. Table-3 gives some idea of how the mix design requirements have changed from past to present.

Past	Present
Stability	Stiffness
Durability	Permanent deformation
Economy	Fatigue
	Temperature susceptibility
	Low temperature cracking
	Moisture susceptibility
	Freeze-thaw
	Workability
	Permeability
	Economical
	Environment friendly

Table-3 Requirements of Bituminous Mix

Some of the above requirements are sometimes mutually conflicting. For, example, the higher is the bitumen content; the better is the fatigue life, provided all the other parameters are kept unchanged. But with the increase of bitumen content, the resistance to rutting may decrease. Increase in bitumen content not accompanied by adequate amount of air voids will result in the fall of stability of the mix, the chances of bleeding will increase [6].

LITERATURE REVIEW

- Prasad (2013) by utilization of 2, 4, 6, 8, 10% of PET density gets increases and flow value also increases, Marshall solidity value with 5.3% disposal in 29110 Kg and the percentage rise in solidity value has been establish to be 75.76% as compared to the mix without plastic [7].
- Soni & Punjabi (2013) the utilization of waste polythene in bituminous concrete mixture is established. The waste polythene swallowed in the mix will get cover over

aggregates of the mixture and decrease in porosity, absorption of wetness and enhance binding property, the bitumen change with 4.5% polythene waste shows good execution as differentiate to other mixes [8].

- Kazami & Govardhana Rao (2015) waste matter of polythene were collected 5 to 11% were mixed with bitumen 60/70 grade. The studies positively showed that the waste plastic material could be include as a binding agent for the construction of road low density polyethylene to expanse of 95% specimen was establish to be the most productive unbreakable quantity [9].
- Soyal (2015) states that inclusion 1%, 2%, 3%, 4%, 5% by weight of prepared plastic for the preparation of alter bitumen. The outcome 4% polythene waste is reveal better execution as contrast to other combination. Marshal solidity value rise with 4% polythene junk [10].
- Rokdey (2015) in this investigation plastic will rise the melting point of the bitumen and also this inventive technology not only reinforce the road construction but also improves the road life. By using plastic coating over aggregate compressive strength and bending strength is improved [11].
- S.A (2016) marshal stability was lead for divergent percentage of bitumen on ordinary aggregate and plastic coated aggregate. Plastic cover aggregate enhance water immersion, stripping value and soundness. When used for road construction it can hold out against higher temperature [12].
- Rajput (2016) in this investigation the grate plastic waste is mixed in hot aggregate and the plastic modified mix is produce using 6, 8, 10, 12, and 14% plastic by weight of bitumen. The consequences by strengthen the percentage of waste plastic in to the mix the marshal stability merit is increased, and maximum stability is creator for the mix carrying 12% plastic by weight of the bitumen, at 14% plastic content the stability value has dropped [13].
- Afroz Sultana.SK, et al., states that The behavior of asphalt cement in service is governed by their initial engineering

properties as well as by the mechanical and environmental conditions to which they are subjected. Under these situations, it is essential to modify the asphalt cement using modifiers to improve its engineering properties. On the other hand, the environmental problem such as disposal of waste plastic is major concern. To overcome the problems the modifiers (waste plastic) are used. Among various types of modifiers, polymers are probably the most promising. Afroz Sultana.SK concluded that, □ Aggregate Impact value of control specimen was 5.75%. It reduced to 4.91% for PP8 and 4.2% for PP10. Reduction in value was 22% for PP10. This shows that the toughness of the aggregate was increased to face the impacts. □ Crushing Value was reduced from 19.25% to 12.25% and 9.70% for PP8 and PP10 respectively. Value reduced by 30% for PP8 and 50% for PP10. Low aggregate crushing value indicates strong aggregates, as the crushed fraction is low. □ Water Absorption is also reduced to nil for PP8 and PP10 from 1.7% for control specimen.

- Sukaina Kazmi, et al., states that the Utilization of plastic materials is ubiquitous in some form or other; more so in the form of carry bags made out of polyethylene (PE), polypropylene (PP), or polyethylene terephthalate (PET) in view of their convenience, light weight and their availability in plenty. they are not easily degradable, and take pretty long time which is of the order of 100-500 years . This causes a heavy burden on the environment to degrade them. One of the approaches is to go for land filling while the other is to dump them into sea; both are not practicable. Hence, the use of plastics (particularly PE) has received wide criticism all over the world. Hence, efforts have been consistently made to find out the alternatives to dispose off the used plastic bags and materials. Sukaina Kazmi concluded that, The use of the innovative technology not only strengthened the road but also increased the road life as well as will help to improve the environment and also creating a source of income. In short we 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 Gawande (2012) - The quantum of plastic waste in municipal solid waste (MSW) is increasing due to increase in population, urbanization, development activities and changes in life style which leading widespread littering on the landscape. Thus disposal of waste plastic is a menace and become a serious problem globally due to their non-biodegradability and un aesthetic view. Since these are not disposed scientifically & possibility to create ground and water pollution. This waste plastic partially replaced the conventional material to improve desired mechanical characteristics for particular road mix. In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement¹¹. This waste plastic modified bitumen mix show better binding property, stability, density and more resistant to water.
- Rishi Singh Chhabra (2014) - In the highway infrastructure, a large number of originates materials and technologies have been invented to determine their suitability for the design, construction and maintenance of these pavements. Plastics and rubbers are one of them. Also considering the environmental approach, due to excessive use of polythene in day to day business, the pollution to the environment is enormous. The use of plastic materials such as carry bags, cups, etc. is constantly increasing day by day¹⁰. Since the polythene are not biodegradable, the need of the current hour is to use the waste polythene in some beneficial purposes. The use of these materials as a road construction proves eco-friendly, economical and use of plastic gives strength in the sub-base course of the pavement.

- ATHIRARPRASAD (2015) [2] The use of waste materials like plastics and rubber in road construction is being increasingly encouraged so as to reduce environmental impact. Plastics and rubbers are one of them. The plastic waste quantity in municipal solid waste is growing due to increase in population and changes in life style. Similarly most tiers, especially those fitted to motor vehicles, are manufactured from synthetic rubber. Disposal of both is a serious problem. At the same time, continuous increase in number of vehicles emphasizes on need of roads with better quality and engineering design. This waste plastic and rubber can be used to moderately replace the conventional material which is bitumen to improve desired mechanical characteristics for particular road mix. In the present study, an evaluation is carried out between use of waste plastic like PET bottles and crumb rubber (3%, 4.5%, 6%, 7.5%, 9% by weight of bitumen) in bitumen concrete mixes to analyze which has better ability to modify bitumen so as to use it for road construction.
- NUHA S. MASHAAN (2012) [3] Roadways are considered one of the most important elements of infrastructure and they play an essential role in our daily lives. In road bitumen construction, the use of crumb rubber in the amendment of bitumen binder is considered as a smart solution for sustainable development by reusing waste materials. It is believed that crumb rubber modifier (CRM) could be one of the alternate polymer resources in improving bitumen binder performance properties of hot mix asphalt. This study aims to present and discuss the conclusions from some of the studies, on the use of crumb rubber in asphalt pavement.
- M.S. RANADIVE ET AL.(2015) [4] An attempt has been made that the specimen of 8 percent waste polymer modified bitumen (WPMB) mix show 50 percent enhanced tensile strength compared to conventional mix and more resistance to water damage. The tests are conducted on the bituminous specimens to know the stability, flow value, bulk density, percent air voids, and per cent V.M.A. and presented. The Maximum density of compacted specimen is observed at 5.5%bitumen content for all the proportions of plastic. And there is a sudden increase in stability when the natural aggregates are coated with plastic which is water resistant.
- P.K. Jain et al.(2012) [5] They observe that the Stability, rutting and retained stability of bituminous mixes and modulus values are better and also less susceptible to moisture. Waste plastic modified bituminous surfacing are more durable and offer improved performance. The optimum quantity of plastic waste is 0.4% by weight of mixture 8% by weight of bitumen.
- Bindu C.S, et al.,states that the polymer bitumen blend is a better binder compared to plain bitumen. Blend has increased Softening point and decreased Penetration value with a suitable ductility. The coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate bitumen mix forms better material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastic. Some encouraging results were reported in this study that there is possibility to improve the performance of bituminous mixes of road pavements. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Softened plastics have a binding property. Hence, it can be used as a binder for road construction. Bindu C.S concluded that, Based on this study of the utilization of shredded plastic in SMA mixtures, the following findings were made: □ The

Marshall Stability value of stabilized SMA was found to be 17kN, which is higher than the prescribed value of 6.2 kN and the percentage increase in stability value has been found to be 64% as compared to the conventional mix. The shredded plastic was effective in preventing excessive drain down of the SMA mixtures (i.e. bleeding phenomenon) and at 10% plastic content the drain down reduces to 0.09%.

- Mrs. Vidula Swami, et al., states that, various activities like packing consume almost 50-60% of the total plastics manufactured. There has been tremendous increase in the consumption of plastic raising from 4000 tons/annum (1990) to 4 million tons annum (2009) and it is still expected to rise upto significant level of 12 million tons/annum by 2016. It becomes hard to recover useful substances from plastic waste since rubber compound in tyre because compounds like black carbon, zinc oxide, process oil, and sulphur are present in vulcanized stage. The process of retarding produces tyre crumb as its by-product. Hence, before applying new rubber the old tread of tyre is buffed to produce crumb. The reclaim process is not environmentally friendly unless expensive scrubbers and effluent treatment plants are installed. Mrs. Vidula Swami concluded that. 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%. □ Total material cost of the project is reduced by 7.99%.
- Sasane Neha, et al., states that the concept of using plastic in flexible pavement has been done since several years ago in India. Plastic has played a very vital role in increasing the strength of bitumen as well as aggregate.

The use of waste plastic in road construction as an effective way to reutilize the plastic waste. Properly selected and graded aggregates are mixed with bitumen to form hot mix asphalt (HMA) pavements. Aggregates are the principal load supporting components of HMA pavement. Sasane Neha, concluded that, It shows that with the increase of waste plastic in bitumen increases the properties of aggregate and bitumen. The optimum use of plastic can be done up to 10%, based on Marshall Stability test.

- ABEY LULSEGED, et al., states that Today, where a transport system covers vast amount of the infrastructure industry, finding economical, durable and environmentally friendly AC mix is the main concern of engineers and researchers. Hence, till this time in order to find strong and durable asphalt concrete pavement engineers use basically aggregate, bitumen and filler materials. As a result, finding construction materials that best withstand the worst environmental conditions fulfilling all the requirement of strength, flexibility, cost effectiveness, durability and environmentally friendly is the main issue. Thus, this research focuses on minimizing such costs and increase the durability of the pavement by using waste plastics as one construction material. Abey Lulseged concluded: The result of the tests using plastic-coated aggregates clearly demonstrates that the abrasion value in Los Angeles has changed significantly.; the aggregate crushing value doesn't show any significant change. On the other hand; the plastic coated aggregates have shown to have a better resistance to water absorption as the results are indicating, the plastic coated aggregate has a very small to negligible water absorption property.

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CONCLUSION

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.

On our previous studies we can conclude that, using plastic waste in mix will help reduction in need of bitumen by varying around 10%-15%, 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. And also show that the stability increases with increasing bitumen content and thereafter decreases. The optimum bitumen content was found to be 6% to 8%.

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.

The use of the innovative technology not only strengthened the road but also increased the road life as well as will help to improve the environment and also creating a source of income. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. It is hoped that in near future we will have strong, durable and eco-friendly roads which will relieve the earth from all type of plastic-waste.

The use of waste plastics in the manufacture of roads and laminated roofing also help to consume large quantity of waste plastics. Thus, these processes are socially highly relevant, giving better infrastructure.