UTILIZATION OF PLASTIC WASTE IN ROAD CONSTRUCTION

A literature review submitted in partial fulfilment of the requirements for the degree of Master of Science in Chemistry.

BY

NIKITA BABAN NAIK

UNDER THE GUIDANCE OF

Dr. DIPTESH NAIK

SCHOOL OF CHEMICAL SCIENCES

GOA UNIVERSITY, TALEIGAO, PANAJI-GOA 403206

APRIL 2022

DECLARATION

I declare that the literature review titled "**UTILIZATION OF PLASTIC WASTE IN ROAD CONSTRUCTION**" has been carried out by me in the Chemistry Department, School of Chemical Sciences, Goa University. The Information derived from the literature has been duly acknowledged in the text and a list of references is provided.

CERTIFICATE

I certify that the literature review titled: Utilization of plastic waste in road construction ” has been successfully completed under the guidance of Dr. Diptesh Naik during the year 2021-2022 in the partial fulfilment of the requirements for the degree of Master of Science in Chemistry.

Dr. Diptesh Naik	Dr. Vidhyadatta Verenkar
(Project Guide)	(Dean of SCS, Goa University)

AKNOWLEDGMENT

There is no good work done which comes without efforts; but those efforts cannot be obtained without proper guidance. So, in these few humble lines I take this opportunity to express my profound gratitude to the people who have made invaluable contribution during the course of completion of the literature review in time.

First of all I would like to thank my guide; **Dr. Diptesh Naik** or giving me an opportunity to work under his guidance; for his patience and invaluable help and assistance during the course of work on this literature review. I am also very much grateful to our respected Dean **Dr. Vidhyadatta Verenkar** for his support and for providing us the opportunity to work in the School of Chemical Sciences.

No acknowledgements would be complete without giving thanks to our Family and Friends. Finally with silent words we thank God for the energy, health and life so far and in future.

INDEX

ABSTRACT

The review focusses on waste plastic coated aggregate is mixed with hot bitumen and resulted mixture was used for road construction. This innovative technology will strengthen the road construction and also increase road life as well as help to improve the environment. Plastic road are boon for India's hot and extremely humid climate, where temperature frequently cross 50 degree Celsius and torrential rains create lots of damage, leaving most of the roads with big potholes (hollow in the road surface)[1]**. In this research work study is done on methodology of using plastic waste in bituminous mixes and presented various tests performed on aggregates and bitumen.**

ITNRODUCTION

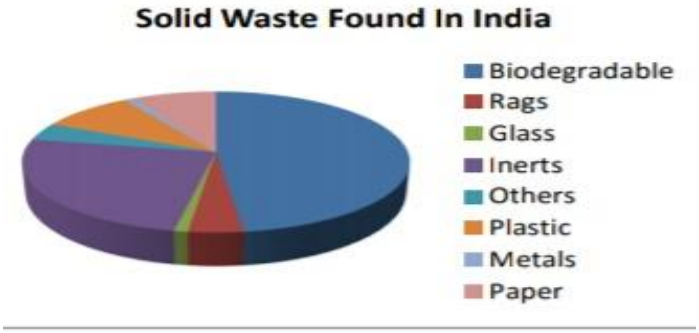
Plastic is a material consisting of any of a wide range of synthetic or semi synthetic organics that are malleable and can be molded into solid objects of diverse shapes. The world first fully synthetic plastic was bakelite, invented in New York in 1907 by Leo Baekeland who name it PLASTICS[2].

Plastics themselves contribute to approximately 10 percentage of discarded waste. Many kinds of plastics exist depending on their precursors and the method for their polymerization. Depending on their chemical composition, plastics and resins have varying properties related to contaminant adsorption and absorption. Polymer degradation takes much longer as a result of saline environments and the cooling effect of the sea[3]. Every year, around 500 billion bags are used worldwide. 1 million bags are being haphazardly disposed every minute and are damaging environment. Precious little has been recycle, re-use and disposal of non-biodegradable plastic waste. Plastic bag are difficult and costly to recycle and therefore mostly end up on landfill sites but by this it take 450 years to photo degrade or to change in typically undesirable properties. Therefore several state government including Delhi had ban the use of plastics bags[4]. But if are concern about conservation of energy then plastic bags is the best option for packing. Plastic is actually a good invention if we disposed plastic waste properly and reuse it by innovate waste. LDPE, PP, PS FPP, PET, PVC are different type of polymer plastic waste collected from a solid waste and now become a mega cumbersome for segregation and recognized to be a major environmental constrain in our country. Rubbers and plastic are causing trouble to the components for land filling and non-biodegradable product[5].

Any nation progress is directly dependent on infrastructure. India is on the threshold of a major forward thrust in the field of transportation infrastructure. Over the past two decades (a period of ten years) traffic volumes have increased, demanding from pavement stronger and long lasting pavements. New methods of pavement design are being developed to improve the durability, strength, nature beauty and economy[6].

In the state like goa frequented by tourists and lead to heavy consumption of plastics water bottle has result of trash on beaches and damaging marine life. India’s cows

also eat this plastics bag and as a result die after certain years. 3,000 cows died in Lucknow in 2000, then city investigated and found the plastic bags in their stomachs. The plastics bags had been ingested as the animals grazed and block the dump sites[7]. Plastic is a cheap moldable, and corrosion resistant material, making them easily manufactured into a wide range of products. As a result, this material has become a dependable stable in our everyday lives, supplying items ranging from grocery bags to take out containers to straws. Plastic pollution is the accumulation of plastic objects and particles in the earth environment that adversely affects humans, wildlife and their habitat. The chemical structure of most plastic renders them renders them resistant to many natural processes of degradation and as a result they are slow to degrade[8]. Together these two factors allow large volumes of plastic to the enter the environment as mismanaged waste and for it to persist in ecosystem.



Pie chart showing Municipal Solid Waste in India

The amount of plastic waste produced increased during COVID-19 due to increased demand for protective equipment and packing materials.

Today, the availability of the waste plastics is enormous, as the plastic materials have become part and parcel of daily life. If not recycled or not use again, then their present disposal is either by land filling or by incineration means the process of destruction of plastic waste. Both these processes have certain impact on the environment[9]. Marshall (Several properties are subjected to a mortgage and one of them in sold, free from encumbrance and required to satisfy the debt from other subject) properties of bituminous mixes have been found when plastic waste are incorporated into them. we found plastics in different forms, almost 5% municipal solid waste, which is toxic in nature[10]. It is common sight in both urban and rural areas to find empty plastic bag

and type of plastic packing material littering the roads as well as drains. Plastic biodegradability creates stagnation of water and associate hygiene problems. In order to solve such problem research has been carried out whether this waste plastic can be reuse productivity. The experimentation at several institutes indicated that the plastics, when plastic added to hot aggregate (mixture) will form a fine coat of plastic over the aggregate and when this aggregate mixed with the binder is found to give higher strength ,increase the strength, higher resistance to water and increase performance of the road over a period of time. Use of more plastic reduce the need of bitumen by 10%. the variation Marshall properties of for mixes containing different amount of plastic waste are studied[11].The main purpose of this paper is to discuss and review plastic as packing material and hurdles of incorporation postconsumer plastic waste in urban and rural areas. The plastic waste utilization for construction of roads this technology is use in Bombay, Bangaluru Calcutta, and Delhi in India. Plastic modified bituminous road surfacing will be first of its kind in Haryana state. Test report show improvement in engineering properties such as retained stability, Marshall stability, and tensile strength of modified bituminous mixes with comparison to unmodified Coated bituminous mix.

The plastic waste contain major polymer are namely polypropylene, polyethylene and polystyrene show adhesion (ability to stick to something) property in molten state. Plastic modified bitumen forms better material for flexible pavement construction as mixes show higher Marshall stability value and suitable Marshall Coefficient. Thermal behaviour and binding property promotes study on preparation of plastic waste bitumen blend and it's properties to find suitability of blend for road construction. It also increases the strength and performance of the road. Plastic wastes increases the melting point of bitumen[10].

According to Dr. R. Vasudevan, Dean ECA and Professor, Department of Chemistry, Thiagarajar College of Engineering, Madurai, waste plastic replaces the 10% to 15% of bitumen, and thereby saves approximately Rs.35000 to Rs.45000 per kilo meter of a road constructure[7]. Inclusion of plastic waste in road construction can eliminates the road surface cracking and shrinkage and reduces drying shrinkage to some extent. Waste plastic helps to improving the superficial rub and move easily and smoothly to resistance of flexible pavement. The conversion of waste plastic into useful chemical products. The fraction of a liquid produced by the thermal degradation process

(damaging chemical structure using high temperature) of plastics waste, containing about 29% naphtha chemical, was subjected to thermal reactions[5]. The used of waste plastic material which has low -density polyethylene (LDPE-2), high -density polyethylene (HDPE-4), polystyrene (PS-6) and propylene PP5. Plastic waste was first converted to slurry, and then thermal liquefaction (broken down fragments produced hydrolysis) was done at 370–420°C of slurry followed by distilling, recovering and condensing[2]. In this way we help sustainable development and recycling plastics in developing countries like India. Study indicates that due to poor awareness and facilities, most of the plastics wastes, are disposed in unauthorized dumping sites or burned[12].

The rapid rate of urbanization in India has led to increasing plastic waste generation or plastic pollution. Plastic pollution is the accumulation of plastic objects and particles example - plastic bottles, bags and microbeads .Plastics that act as pollutants are categorized by size into micro, or macro debris. Plastic are inexpensive and durable making them very adaptable for different use[13]. Chemical structure of most plastic renders them resistant to many natural processes of degradation and as a result they are slow to degrade. In this context, research has been carried out to contribute to the development of efficient policy approaches on plastic waste in India. Few policies have been enforced by the government to address the acute problem of littering in the country. the analysis has revealed that on plastic waste the existing policies have not been able to address the issues of littering, primarily because these not attempted to provide a long-term solution to the problem[3].

In the case of PET (Polyethylene terephthalate) the lack of legislation to manage the rising. .consumption has been identified as the key problem. Based on the analysis a few policy recommendations have been made that could assist decision makers in their efforts to develop a comprehensive plan of action for plastic waste management[11]. The purpose of this project is to investigate the possibility of using Polyethylene Terephthalate it is the most common thermoplastic polymer resin of the polyester family and is used in fibres for clothing, containers for liquids and foods, and thermoforming for manufacturing, and in combination with glass fibre for engineering resins.as polymer additives in Bituminous mix (it is a coal has a composition of about 84.4 % carbon, 5.4% hydrogen, 6,7% oxygen, 1.7% nitrogen and 1.8 % sulphur, on a

weight basis. The chemical processes during coalification must remove most of the oxygen and much of the hydrogen, leaving carbon, a process called carbonization[14].

Bituminous mixture is blends of aggregates with different gradations, filter type and content and hardness with bitumen of different grades and quantities. The characteristics of PET-modified bituminous mix is obtained by fix mixing temperature, was investigated. The binders were prepared by mixing the PET in bitumen[14].

By the weight of optimum bitumen with penetration grade bitumen at temperature of Minimization of waste material is important aspect of the modern growth and development initiatives. Plastic bags and bottles use are very common. Plastic is use in various industries and domestic application. Use of plastic waste is major problem due to non -biodegradable nature of plastic. The plastic can be used as feedstock for ethanol like products. It can be used for road construction[15]. Plastic waste cleaned then cut and aggregate mixture is heated and plastic is coated over the aggregate. The plastic coated aggregate is mixed with hot bitumen mixture and resulted mixture was used for road construction. This innovative technology will strengthen the road construction and also increase road life as well as help to improve the environment. Plastic road are boon for India’s hot and extremely humid climate, where temperature frequently cross 50 degree Celsius and torrential rains create lots of damage, leaving most of the roads with big potholes (hollow in the road surface)[1]. In this research work study is done on methodology of using plastic waste in bituminous mixes and presented various tests performed on aggregates and bitumen.

LITERATURE REVIEW

- Plastic waste is flexible for use and open up a solution for the disposal issues. The research works are going on in the area of use of plastic waste in bituminous for road construction. Dr. R. Vasudevan investigated that plastics coating help to reduce porosity, improves soundness and absorption of moisture. The plastics polymer coated aggregate bitumen mixture forms better road material for flexible pavement construction and mixture shows higher Marshall Coefficient and suitable Marshall Stability value. The use of plastics waste for construction of road is best methods for disposal or reuse of plastics waste. Use of plastic bags or material in road construction help in many ways such as disposal of waste in easy way, prevention of pollution and better road. Dr. R.Vasudevan and S. Rajasekaran, stated that polymer bitumen blend is a better binder compared to plain bitumen. Blend help to decreased Penetration value with a suitable ductility and increase softening point. They suggested that plastic waste like carry bags, cups and other utilized of plastic can be used as a coating over aggregates and then coated stone used for construction of road.[8]
- This research paper help to solve two main problems in Ghana. They are firstly disposed of plastics solid waste which is major problem in cities and towns and secondly, potholes on roads because of excessive traffic and heavy weight. The effect of blending waste thermoplastic polymers such as Polypropylene PP and High density polyethylene (HDPE) in AC-20 graded bitumen of different composition of waste plastic. Then plastics was shredded and blended with the bitumen in shear mixer at a temperature between 160°C– 170°C. Parameters like penetration, softening point and viscosity tests were done to determine resulting changes from base bitumen. To study the chemical functionalities present in bitumen composition we use FTIR spectroscopy. The properties of unmodified bitumen were found to enhance with changes recorded in the rheological properties of the polymer modified bitumen (PMB). The polypropylene polymer shown profound effect on compatibility with slight linear increment in viscosity and homogeneity , softening and penetration values as against relatively high changes for modified bitumen.[1]

- The plastic waste in municipal solid waste (MSW) is day by day increase due to increase in urbanization, population, development activities and changes in life style and because not proper disposal of plastic waste become a serious problem globally due to non-biodegradability. Plastics should disposed scientifically to reduce air, soil and water pollution. Plastic waste partially replaced the conventional material to improve desired mechanical characteristics for particular road mix. In this paper developed techniques to use plastic waste for road construction. In modified plastic road making process of bitumen and bitumen is used as binder. And bitumen plastic mixture is made then use on a top layer coat for flexible pavement. The plastic waste modified bitumen mix show better stability, binding property, density and water proofing property.[5]
- Because of seasonal change in temperature it show lots of seasonal effect on asphalt behaviour because of its viscoelastic nature. The behaviour of asphalt binder, among which rutting and fatigue cracks are very common this is due to the failure of flexible pavement. This study show, Low Density and High Density Polyethylene and Crumb rubber were used to base bitumen. The basic perimeters used to evaluate the behaviour of the binder are complex modulus (G*) and phase angle (δ) obtained from Dynamic Shear Rheometer (DSR). It was concluded by Dynamic Shear Rheometer that High Density Polyethylene (HDPE), Low Density Polyethylene (LDPE), and Crumb Rubber (CR) modified binder showed significant improvement in rheological properties of the binder. Recycling plastic wastes in this innovating way contribute to solving environmental problems in the Kingdom of Saudi Arabia. [13]
- Plastic waste materials include low density polyethylene (LDPE) grocery bags, PET, etc. are disposed by landfilling's method and leading to environmental pollution because of very slow degradation nature of polymeric materials. Waste plastic materials can improve the desired properties of bituminous mix for construction and flexible pavements. This project include, various proportions of polymeric materials blended with bituminous mix were characterized. Strength and performance of modified plastics road were tested through Marshall, stability test, extraction test, sieve analysis, water absorption tests and bulk density. The results showed that bitumen and plastic blend has higher Marshall, stability of range 14.03 to 14.80 KN compared to normal

bituminous mix sample which has a value of 11.35 KN. This road showed higher void air, lower bulk density and Marshall flow than the simple bituminous mix.[11]

- Important steps taken to increase life of the bituminous pavements by addition of waste plastics. Flexible pavement subjected to the problems such as cracking, rutting and other failures due to repeated traffic loads. We have used waste International Journal of Pure and Applied Mathematics Special Issue 1148 materials for plastic as a replacement material of bitumen in percentage of 5&10%, 10&15%, 15&20%, 20&25% respectively. Lignin act as a binding material for asphalt. By mixture proportions which determined by series of tests such as ductility, viscosity, penetration, and softening point.[20]
- This paper help to explain that by use of coating aggregate with plastic waste polymer has many advantages and ultimately helps to improving flexible pavement quality and also improve aggregate quality. This technology helps in plastic waste disposal obtained from industrial packing and domestic materials.[1]
- Utilization of plastic waste in bituminous mixes has proved that these enhance the properties of mixture in and also solve disposal problems. Cleaned plastic waste is cut into a small size using shredding machine. Then aggregate mixture is heated and plastic is effectively coated over the road. This technology help to strengthen the road construction and increase the road life indirectly help to improve the environment. The pieces of rubber is use to study the effect as a partial substitute in bitumen. Bitumen is binding materials used in roads construction and prices of bitumen is also increase day by day and by use of plastic waste cost decrease. Objective of this study is to reduce the quantity of bitumen used and replaced with pieces of rubber. And many efforts have undertaken to improve quality of existing bitumen. Bitumen grade with addition of various pieces of rubber per cent content. When in mixture we add of pieces of rubber in the mixture can improve the capability of the mixture pave flexible. [11]

- Use of plastic waste materials and rubber in road construction is increasing to reduce environmental pollution. Due to increase in population and changes in life style the plastic waste increase in municipal solid waste. Need of roads with better quality and engineering design because of number of vehicles increases. Comparison is carried out between the use of plastic waste such as PET bottles and crumb rubber in bitumen concrete mixes that has better ability to modify bitumen mix to use it for road construction.[11]
- Reusing of waste plastic materials may become a possible for pavement construction purpose. This help in all three factor such as environmental, economic, and social benefits. This research promote is the use of RAP materials in addition of neat bitumen at various types of highway. This help to described Optimum Bitumen Content (OBC) using Marshall Mix Design method at various ratio of bitumen and plastic content. This investigation also determine the bitumen content present in RAP, Marshall Mix Design and finding out the water proofing capacity of bituminous mixture in terms of retained stability at OBC. The aggregates of pavement falls for continuously graded mix and binder content present in RAP is 1.37%. The OBC was found as 4.92% and at OBC, the retained stability was found as 77.2%. Marshall Mix Design properties at OBC samples are in specified limit according to Marshall Mix Design criteria for a new pavement construction. From this we can concluded that waste plastic materials with the addition of neat bitumen can be reused as bituminous modified roads.[11]
- Disposal of plastic waste become a major problem due to their non-biodegradability. If we not disposed plastic waste in scientific way then it create air, ground and water pollution. We can replaced the plastic waste in conventional material to improve specifics desired mechanical characteristics for road mix. In this paper developed a techniques to utilise the plastic waste for construction purpose of roads. In this modified road making process bitumen is used as binder. This bitumen can be modified with plastic pieces and bitumen mix is made. This can be used on a top layer coat of flexible pavement. Modified bitumen mix with plastic waste show better density, stability, binding property, and show water proofing character.[18]
- Several types of flexible pavement distress occur due seasonal change. Distress like cracking and rutting behaviour of asphalt binder. High Density and

Low Density Polyethylene and Crumb rubber were used as additions to base bitumen (PG 64-10). Complex modulus (G*) and phase angle (δ) obtained from Dynamic Shear Rheometer (DSR) this are some basic perimeters used to evaluate the behaviour of binder in respect to distress. We concluded that Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), and Crumb Rubber (CR) modified binder and a show significant improvement in rheological properties of binder. Recycling municipal plastic wastes will help to solve International Journal of Pure and Applied Mathematics Special Issue 1151 environmental problems in the Kingdom of Saudi Arabia caused by the piling up of these wastes.[11]

- Asphalt concert material is then investigated using semi crack circular specimen of 50 mm radius and 63 mm thickness. As asphalt concrete mixtures modifiers in research by 10% of weight of bitumen. CaCo3 was add to crumb rubber modified heated bitumen by modification level of 5%, 10%, 15%,20% and 25%. Result shows that crumb CaCo3nano com-posited can be use as asphalt modifier and improve both Penetration and softening point for all modified bitumen. The mechanical properties and fracture resistance modified asphalt concrete mixtures with 15% crumb rubber have higher than unmodified mixtures by 34.2% and it is appear modified mixtures with 15% crumb rubber have two times higher Critical Energy Release Rate than unmodified mixtures that means the mixtures is more resistance to fracture. [12]
- The International Conference on Nano materials and Material Engineering (2017): The paper explains that as we add plastic waste Rheological properties of Bitumen were changed. Plastic waste helps to improve performance of road pavement and also reduces the rutting effect.[1]
- Used processed plastic bags as an additive in asphalt concrete mixes. The properties of this modified bitumen were compared to that of ordinary bitumen. It was noted that penetration and ductility values, of modified bitumen, was decreasing with the increase in the proportion of the plastic additive.[17]
- Polyethylene as one sort of polymers is used to investigate the potential prospects to enhance asphalt mixture properties. The objectives also include determining the best type of polyethylene to be used and its proportion. Two types of polyethylene were added to coat the aggregate High-Density Polyethylene (HDPE) and Low-Density Polyethylene (LDPE). The results

indicated that grinded HDPE polyethylene modifier provides better engineering properties. The recommended proportion of the modifier is 12% by the weight of bitumen content. It is found to increase the stability, reduce the density and slightly increase the air voids and the voids of mineral aggregate.[4]

- Roadways are consider to be the most important elements of infrastructure and play an essential role in our daily lives. In road pavement construction, the use of plastic waste and rubber in the modification of bitumen binder is consider as a smart solution for sustainable development by reusing waste materials. It is conclude that crumb rubber modifier (CRM) could be one of alternative polymer materials to improving bitumen binder performance properties of hot mix asphalt. This study aims is to discuss the findings from some of studies, on the use of plastic waste and crumb rubber in asphalt pavement.[11]
- The disposal of waste plastic bags has become a serious issues and waste plastics are burnt which lead to environmental pollution. Utilization of plastic waste material in bituminous mixes help to improve the properties of mix and also solve disposal problems. Plastic waste is first clean then is cut into a size of 2-3mm using shredding machine. The aggregate mixture is heated and the plastic is coated over the aggregate. Then the plastic waste coated aggregate is mixed with hot bitumen and the resulted mix is used for road construction. This innovative technology will strengthen the road construction and also increase road life and help to improve the environment. In this research work thorough study the various tests performed on aggregates and bitumen to use of plastic waste in road construction.[9]
- Finding alternative methods for disposing plastic waste becoming a major research issue. High density polyethylene waste is mixed with cement to produce plastic cement, and replacing sand by fine polyethylene waste with different percentage based on the properties of product. This experiments were done by using plastic waste of polyethylene packages which include bottle and food crates in range of 10% to 80% by volume as a short reinforcement structure. The results show the possibility to produce plastic cement from plastic waste and Portland cement by using 60% and 40%, respectively help to decrease the density, increased ductility, and workability improved, due to this produce lightweight materials.[19]

PROBLEM STATEMENT

The debate on the use and abuse of plastics can be go on without yielding the result of innovative use of plastic.

Plastic is a good invention if we disposed it properly and then we can use the plastic waste in different way. The plastic waste could be used in road construction and it's proved that plastic in bitumen (is a complex hydrocarbons) enhance the life of road by protective covering for roofs, waterproofing and good adhesion properties to aggregates[10].

OBJECTIVES

The objective of the study is to modified bitumen and mixes by using "Polyethylene terephthalate" as an additive for modification of bitumen and for its potential application in bituminous binder courses.

To recognize how much of plastic waste we can add to the bitumen for getting required strength and smoothness and to solve the disposal problem of waste plastics.

The scope of the study included the following

1 Determination of mechanical properties of bituminous mixes prepared with varying percentages of waste PET.
2 Stability comparison of conventional and modified bituminous mixes.
3 Determination of OBC to find the improved flow values and stability.
4 Determination of physical properties of aggregates, bitumen and filler.

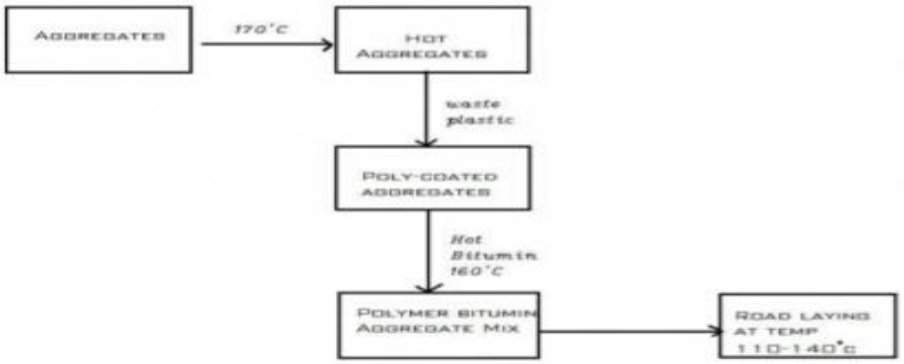
SCOPE OF THE WORK

Day by day expanding populace and industrialization, request are of different improvement projects, development of sustainable constructions, building and streets have become significant for proficient and ideal plan comprehension by considering the of road surface is of prime significance.

- To use squander materials as an asphalt fixing (as bitumen modifier).

- To limit a dangerous atmospheric devotion, ozone depleting substances and contamination.

MATERIAL AND METHODOLOGY



Flow chart for process of Mixing and Placing

We clean the plastic waste and remove the non-plastic things then go through the process of mixing plastic in asphalt roads. After that we perform some test like specific gravity, water absorption, shape tests, crushing and abrasion and impact test are conducted as per MORTH standard (Ministry of Road Transport and Highways)[8]. The procedure followed to determine mechanical properties of mixes are as per Marshall method. Marshall specimens with varying percentages of bitumen content was use to find Optimum Binder Content.

The procedure is repeated for various percentage of waste PET and results are used to study VG30 viscosity grade Bitumen is used. Coarse aggregates of 9.5mm and 6mm size, angular, hard, BT metal and dust is used in different proportion to satisfy MORTH specification. The apparent specific gravities are found under 9.5mm aggregate- 2.81 6 mm aggregate 2.82 Fine aggregate (Dust) 2.80 To study the effect of mixing plastic waste in bituminous mixes. The following methods was adopted The plastic waste such as carry bags, PET bottles, Polythenes etc. was collected and shredded to size passing through 2.36 mm sieve and Retained on 600 micron sieve. The shredded (cut) plastic waste was mixed in the hot aggregates. Normal mix were prepared with bitumen contents of 4.5 percent, 5 percent, 5.5 percent and 6 percent. Using Marshall test the Optimum Bitumen Content (OBC) was found out. Plastic contents of 6%, 8%,10%, 12%, and 14% by weight of bitumen were prepared through dry process by adding plastic to hot aggregates. Marshall test was conducted on plastic modified mix to study different parameters[10].

Preparation of design mix

1 plain bituminous mix

Bitumen is oily, black and viscous material that is a naturally-occurring organic by product of decomposed organic materials. Also known as tar or asphalt. Throughout prehistory and throughout the world bitumen was mixed with other materials to use as a sealant, incense, building mortar adhesive and decorative application also use in waterproofing canoes and other water transport. A good design of bituminous mix is expected to result in a mix which is adequately 1) durable 2) resistive to fatigue and permanent deformation 3) strong 4) environment friendly 5) economical and so on[7]

2 Selection of mix constituents

Aggregates and binder are two main constituents of bituminous mix. Bitumen is a by-product of crude oil.

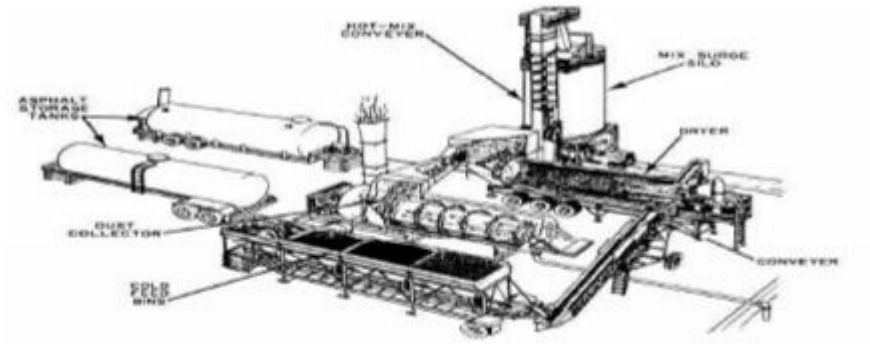
MIXING PROCEDURE AT HOT MIX PLANT

Step 1: Waste plastic bags, bottles are cut into a size between 2.36 mm and 4.75 mm using shredding machine. Care should be taken that PVC waste should be eliminated before it proceeds into next step.

Step 2: Then the mixture is heated to 1650 C and then transfer to mixing chamber. The bitumen mix is also heated up to a maximum of 1600 C. this is done so as to obtain good binding and to prevent weak bonding. During this the temperature monitoring is very important.

Step 3: At the mixing chamber, the shredded plastics waste is added over a hot aggregate. It gets coated uniformly over the aggregate within 30 to 45 seconds. It made oily coated look to the aggregate.

step4: Plastic waste is mixed with hot bitumen. Then this final resulted mix is used for laying roads. The road laying temperature is between 110C to120C. The roller used should be of 8 – ton capacity.



Hot Mix Plant

MIXING BY CENTRAL MIXING PLANT (CMP)

Using central mixing plant the dry process can be carried out. The shredded plastic is added along with the aggregate in the moving belt and carries plastic object's and then it is transferred into the hot cylinder. The aggregate is coated with plastic first and then with the bitumen. The mixer prepared is then loaded in the dipper lorry and transported for road laying. CMP helps in better control of temperature and better mixing of the material and therefore helping to have a uniform coating.

DATA COLLECTION AND ITS ANALYSIS (EXPERIMENTAL INVESTIGATION)

The Investigation of plastic waste materials aggregates and bitumen requires various field test and lab tests. This part is divided into three main sections. First section presents the physical requirement of bitumen and aggregates. Second section presents plastic waste properties. Third section presents how to prepare plastic waste materials for shredding on aggregates. It is a flexible pavement laid investigation designed of roads. The experimental investigations was done at Central Lab of Ajwani Infrastructure Pvt. Ltd., Maske Wasti at Rawet.

i) Aggregate

The aggregates are bound together either by cement or by bituminous material. When rock dust mixed with water forms slurry which acts as binding medium in some cases. The aggregates may be classified into artificial aggregates and nature aggregates. Natural aggregates are further classified as coarse aggregates consisting of gravels or crushed rock aggregates and dust or sand aggregates.

ii) Bitumen

Bitumen is a coal has a composition of about 84.4 % carbon, 5.4% hydrogen, 6,7% oxygen, 1.7% nitrogen and 1.8% sulphur, on a weight basis.

The bitumen used in the study is tested for its desirable properties for satisfactory performance of a road material. Bitumen is used as binders in road constructions. Bitumen is derived from residue left by the refinery to make pure substances from naturally occurring asphalt (a thick black substance making for road constructions). American Society of Testing Materials give a definition for bitumen as “Mixtures of hydrocarbons of natural or pyrogenous origin, or combination of both, frequently accompanied by their non-metallic derivatives, which may be in solid, liquid, gaseous, or semi-solid and which are completely soluble in carbon disulphide.” Bitumen found in natural state known as asphalt and contains more numbers of solid mineral. When

petroleum crude is refined in a refinery, bitumen are separated by fractional distillation in order to decreasing volatility.

Heavier grade cut backs, rapid setting emulsions or heavier grade tars may also be used. The grade of basic bitumen is altered by mixing with diesel oil or by controlled refining or other oils. For dressing WBM Water Bound Macadam base course, bitumen quantity needed ranges from 17 to 195 kg per 10 m2 areas and 10 to 12 kg per 10 m2 area on top surfacing. The second coat surface dressing quantity of bitumen needed ranges from 10 to 12 kg per 10 m2 area. The content of bitumen in mixture should be 4% of weight to total mixture. The paving bitumen available in India and classified into two categories: Assam petroleum denoted a Paving bitumen as A-type and designated a grades A35, A90, etc. Other sources denoted paving bitumen as S-type and designated as grades S35, S90, etc. Some important properties for selection of bitumen are: Viscosity of bitumen should be sufficient at time of mixing and compaction. It is achieved by heating prior to mixing and by use of cut backs and emulsion. Bitumen should not strip off from aggregate in presence of water. In all season bitumen should be durable. It should not become too soft during summers and should not develop cracks during winters. Bituminous material for road construction is obtained by destructive distillation of organic matters like coal shale, wood etc.

Determination of OBC

To determine the mechanical properties of the bituminous mixes we adopted by Marshall Method of mix design and to determine the optimum binder content, Marshall Specimens are prepared of different bitumen content varying from 3.5-6.0% of blended aggregates at specific interval of 0.5%. The Marshall flow Value, stability value, Unit Weight, VFB and Vv are evaluated. Based on the graphs obtained optimum Binder Content is decided.

Cut-back bitumen:

The asphaltic bitumen is mix with volatile solvents to improve its work ability of material. The solvent evaporated and leaving behind particles together. This cutback bitumen is classified into rapid, medium and slow curing depending upon type of solvent used.

Emulsions:

Emulsion is a mixture of two immiscible liquids. Asphalt gets broken up into minute drop in water in presence of emulsifiers. It improves that work ability of bitumen at normal temperature in the liquid form. Bitumen.

iii) PLASTIC MATERIAL

Cleaning and Shredding of plastic 200 mm plastic

Plastics material are classified by their chemical structure of polymer's backbone and side chains. These are classified as silicones, halogenated plastics, acrylics, polyesters, silicones, and polyurethanes. Its also be classified based on synthesis process, such as polyaddition, condensation, and crosslinking. Types of plastics are thermoplastics and thermosetting polymers.

Thermoplastics plastic can be moulded again and again and not show any change in the chemical composition when heated. Examples are polystyrene, polyvinyl chloride, propylene, polyethylene, and polytetrafluoroethylene. The organic chemistry of polymer defined properties of plastics. Which include hardness, oxidation, resistance to heat, organic solvents, density, and ionizing radiation.

Types of Plastics

Polyvinyl chloride LDPE, PET polyethylene terephthalate HDPE, polypropylene PS, high-density polyethylene PVC, low-density polyethylene, PP polystyrene Plastics this are durable and required lots of time to degrade. Chemical bonds of plastic make it

durable make equally resistant to natural processes of degradation. The biggest environmental harm from plastic that nurdles, which are the raw material for plastics to made. They are tiny pre-plastic pellets and it kill large numbers of birds and fish. Prior to ban the use of CFCs (chlorofluorocarbon) in extrusion of polystyrene. The polystyrene production contributed to the depletion of the ozone layer. Non-CFCs are currently used in the extrusion process for plastic deformation by application of a force. Thermoplastics can be melted and reused, the thermoset plastics ground up and used as filler, with time the purity of material tends to degrade with each

Classification of Plastic Waste:

a) Polyethylene: The plastic waste available in form of carry bags are best example of low density poly-ethylene LDPE, these plastic bags are very thin and easily available. High density poly-ethylene HDPE type of waste plastic is also available in the form of carry bags and easily available in market.

b) Polypropylene: This plastic available in the form of plastic bottles and mat sheets, etc. and also available in the form of carry bags or solid plastic it's depend upon need and use of the industries.

Determination of OPC

Optimum Plastic Content is determined by adding waste PET in percentages of 2-10% of bitumen at an interval of 2% for the Optimum Binder Content. The Marshall Stability value, Flow Value, Unit Weight, Vv and VFB are evaluated. Based on the Marshall Stability vs % PET graph, the Optimum Plastic content is determined.

BENEFITS OF MODIFIED BINDED

• It helped to resistance the surface-initiate cracking because of high binder content.

• Due to improved quality pavemented it lowered the pavement maintenance costs.

• Eco-friendly method of construction, and helps to maintaining balance in environment.

•Due to higher binder contented it improve resistance to fatigue and cracks.

• Due to higher viscosity and softening it improved resistance to rutting.

• It helped in managing hazardous waste.

• Reduced tyre noise due to increased binder film thickness and opening texture.

• It helped to educed construction time on site.

• Due to improved quality it helped to lower pavement maintenance costs.

• Due to contrast between pavement and stripping it increase visibility at night time.

RESULT AND DISCUSSION

Without adding plastic waste and by adding plastic waste of 6% to 14% weight of bitumen in the mix Marshall specimen were prepared. The Marshall parameters are summarized in table II. The variation of stability, density, flow value, voids fill bitumen, air voids and optimum binder content is shown below.

Table – I

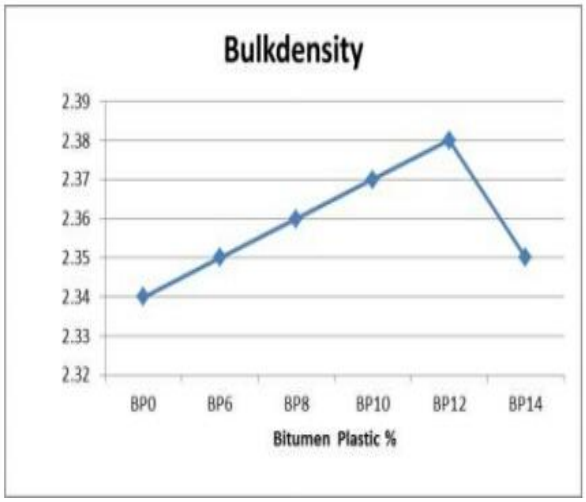
Grading of aggregate

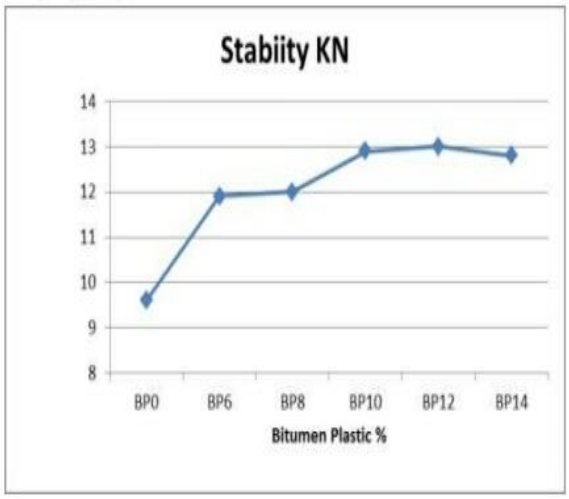
IS Seive Size (mm)	% passing by weight				Combined grading A : B : C : D 40 : 30 : 28 : 2	Specified Limit as Per MORTH
	9.5 mm (A)	6 mm (B)	Dust (C)	Filler (D)		
9.5 mm	82	100	100	100	92.8	90-100
4.75 mm	6.5	36	100	100	43.4	35-51
2.36 mm	0	5	98	100	30.9	24-39
1.18 mm	0	0	59	100	26.7	15-30
300 u	0	0	46	100	13.8	9-19
75 u	0	0	10	2 %	3	3-8
Pan			110			

Table -II

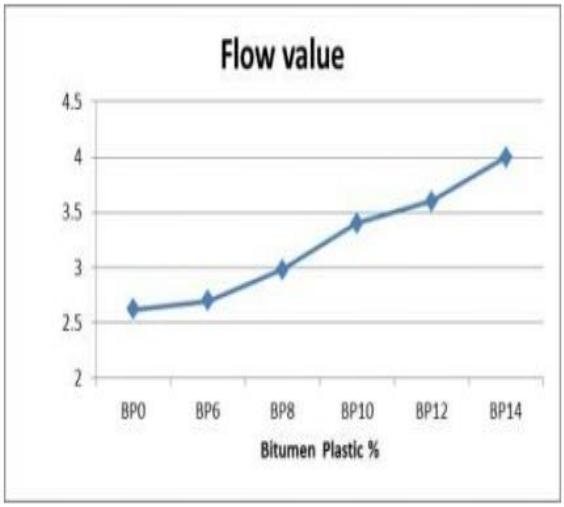
Marshall Parameters for SDBC using plastic waste in different proportions

Bitumen mix	Optimum binder content (OBC)	Stability (kg)	Flow (mm)	Unit weight (g/cc)	Air voids (%)	VFB (%)
BP0	5.5	9.6	2.62	2.34	4.2	71.9
BP6	5.7	11.9	2.7	2.35	4.0	72.0
BP8	5.67	12.0	2.98	2.36	4.0	74.5
BP10	5.6	12.9	3.4	2.37	3.9	74.8
BP12	5.4	13.0	3.6	2.38	3.3	75.0
BP 14	5.2	12.8	4.0	2.35	3.2	75.9

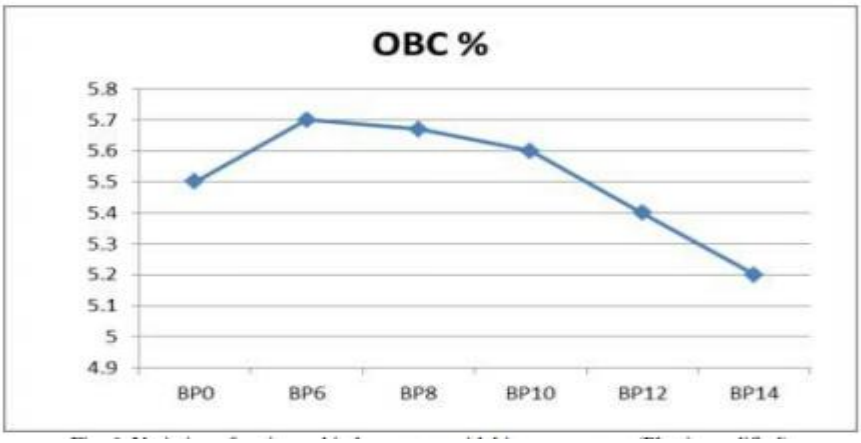




Variation of Unit Weight and Stability with plastic modified bitumen content



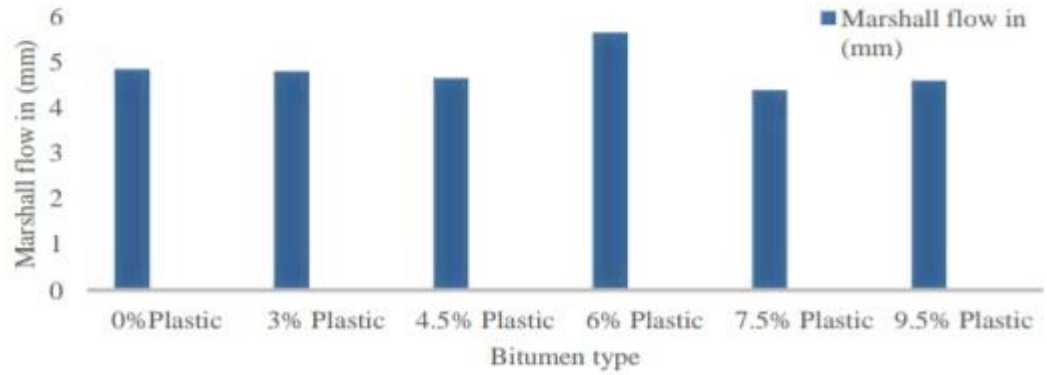
Variation of Air Voids and Flow plastic modified bitumen content



Variation of Optimum Binder Content with plastic modified bitumen content

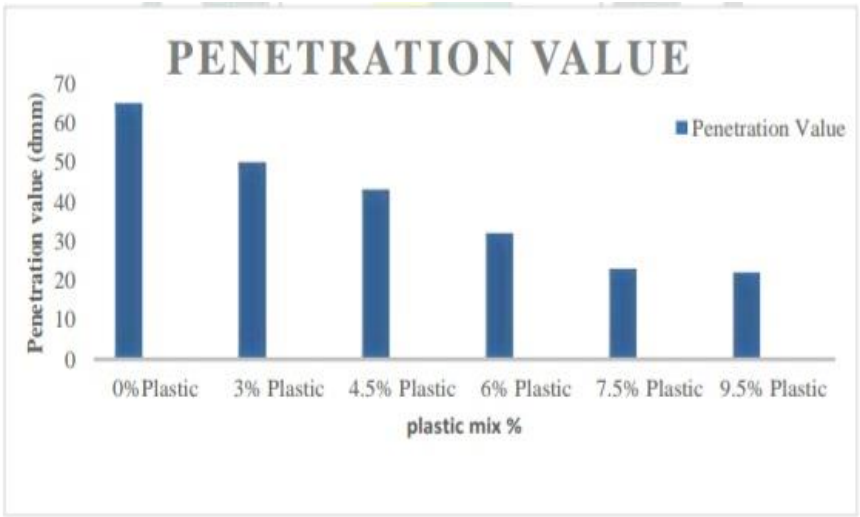
A) MARSHALL STABILITY TEST

This test is made to analysed the consequences of normal bitumen example and with Plastic modified bitumen example with fluctuating % of plastic blended. Unique %age of bitumen and the example was tried in Marshall Testing Machine and three example different example were use. Optimum Bitumen content (OBC) is determined with reference to normal of % bitumen for which Marshall Stability, Thickness is most extreme and 4% air void bitumen content.



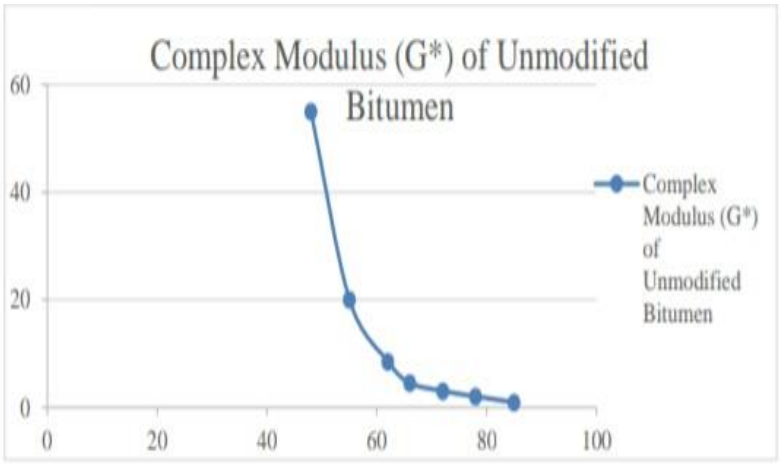
B) PENETRATION TEST

The different level of plastic (%) was added to bitumen. This test showed variety of entrance esteem with different rate of plastic adjusted in bitumen and it introduced that consistency increments with growth of plastic.



C) SOFTNING POINT

The different level of plastic was added to bitumen. The test showed variety of more relaxes point with different rates of plastic modified bitumen. This made softening point makes increments with rising measure of plastic substance (%).



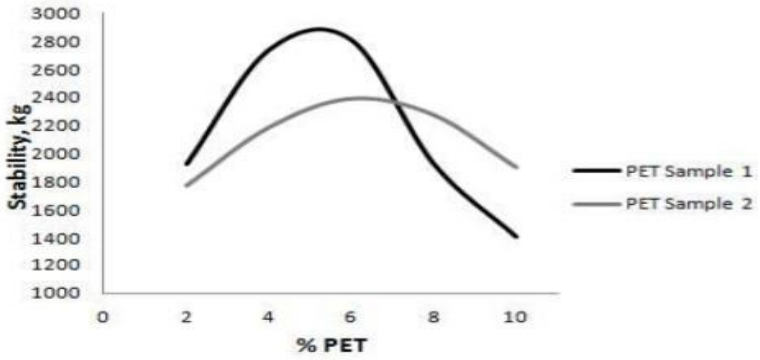
CONCLUSION

The problem of waste plastics can be reduce by reuse of plastic. Plastic waste can be used for synthesis of useful product such as ethanol. Reuse of plastic waste for road construction is widely investigated area. The potential of roads constructed with plastic waste mixed bitumen was found to be more as compare to constructed without plastic.

Plastic waste coating help for better performance of roads by providing better binding of bitumen by increasing bonding and increase area of contact between plastic waste polymers and bitumen. This coating also helped to reduces the voids and prevents adsorption of moisture and oxidation of bitumen by interstitial air. This has resulted in reducing rutting and there is no hole formation.

This project help to investigates the viability of bituminous mixture using PET as an additive plastic waste polymer

1. By the addition of polymer the Marshall Stability value increased is nearly 75.76% for PET sample 1 and for PET sample 2, it is nearly 44.85%.



Graph showing the stability due to PET sample 1 (2900kg PET) and sample 2 (2900kg PET)

2. Indicates that as plastic waste content increases. Marshall stability increases up to 5.3% because of plastic waste content is 2900kg for sample 1 and percentage increase in stability value 75.76% as compared to the mix without plastic. This is because of plastic waste content helped to enhanced interlocking of aggregates.

3. This helped to conclude that as plastic content increases the stability increases up to 6.3% plastic content and the Marshall stability value with 6.3% waste plastic is 2390kg for sample 2 and the percentage increase in stability value has been found to be 44.85% as compared to the mix without plastic.

4. With plastic waste content density increase up to 7%.

5. With the increase in percentage of PET the flow value is also increase.

Some important points which are drawn from study:

1. Aggregate value of the control specimen was 5.43% and now reduce to 4.91 % for PP8 and 4.26% for PP10. Reduction in the value was 10% for PP8 and 22% for PP10. This shows how toughness of aggregate mixture was increased to face impacts.

2. The crushing value was reduced from 19.2% to 13.33% and 9.82% for PP8 and PP10 respectively. Value reduced by 30% for PP8 and 48% for PP10. Strong aggregates means low aggregate crushing, as the crushed fraction is low.

3. Aggregate increases the specific gravity from 2.45 control specimen to 2.7 for PP8 and 2.85 for PP10 because of plastic coating.

4. Stripping Value or ratio of uncovered area was reduced from 8% for control specimen to nil for PP8 and PP10. From this we indicate coated aggregate are more suitable for bituminous construction than plain aggregates.

5. Now the road has waterproofing property and therefore water absorption is reduced to nil for PP8 and PP10.

6. Coating of plastic waste polymer over aggregate help to increased abrasion value

All this indicates hardness of aggregate and we conclude that using plastic waste in mixture it will help to reduce the in need of bitumen by around 10% and increase the strength and performance of road and also avoid use of anti-stripping agent and avoid disposal of plastic waste by land filling, incineration which ultimately harm the environment, but by this way we take care of disposal and develop a technology which is eco-friendly. By this way we save money and resource amount which required for construction of road.

REFERENCE

[1] D. C. Rahi, R. Chandak, and A. Vishwakarma, “Utilization of liquid plastic waste in bitumen for construction of roads,” *AIP Conf. Proc.*, vol. 2158, no. September, 2019, doi: 10.1063/1.5127134.

[2] D. Baltime and J. Darnell, “Task History Initiating Search,” pp. 1–2, 2021.

[3] Y. Prasad, K.V. R.; Mahendra, S., P., Dr.: Kumar, N., S., Dr; G., S., Rakesh; V., Vijay; P., B., “Study on Utilization of Waste Plastic in Bituminous Mixes for Road Construction Study on Utilization of Waste Plastic in Bituminous Mixes for Road Construction,” *Int. Conf. Futur. Innov. Dev. Civ. Eng.*, no. April 2013, pp. 1–7, 2013.

[4] Ahmed Trimbakwala, “Plastic Roads Use of Waste Plastic in Road Construction,” *Int. J. Sci. Res. Publ.*, vol. 07, no. 04, pp. 2903–2908, 2017.

[5] J. Shrikrishna Atre, “a Review on Studies and Research on Use of Plastic, Its Hazards and Safe Disposal,” *Int. J. Adv. Res.*, vol. 9, no. 10, pp. 1218–1222, 2021, doi: 10.21474/ijar01/13669.

[6] P. S. Rajput and R. K. Yadav, “Use of Plastic Waste in Bituminuous Road Construction,” *Int. J. Sci. Technol. Eng.*, vol. 2, no. 10, pp. 509–513, 2016, [Online]. Available: www.ijcaonline.org

[7] Ahmed Trimbakwala, “Use of waste plastic in road construction” Indian Highways,” *Int. J. Sci. Res. Publ.*, vol. 7, no. 4, pp. 31–32, 2017.

[8] A. Raut, S. W. Dhengare, A. L. Dandge, and H. R. Nikhade, “Utilization of Waste Plastic Materials in Road Construction,” *J. Adv. Res. Mech. Civ. Eng. (ISSN 2208-2379)*, vol. 3, no. 3, pp. 01–12, 2016, doi: 10.53555/nnmce.v3i3.321.

[9] A. Zheltobriukh, I. Kopynets, V. Kaskiv, and O. Sokolov, “Use of industrial waste in road construction,” *Dorogi i Most.*, vol. 2020, no. 21, pp. 110–119, 2020, doi: 10.36100/dorogimosti2020.21.110.

[10] M. Chavan, “Use of Plastic Waste in Flexible Pavements,” *Ijaiem.Org*, vol. 2, no. 4, pp. 540–552, 2013, [Online]. Available: http://www.ijaiem.org/Volume2Issue4/IJAIEM-2013-04-29-095.pdf

[11] A. Gawande, G. Zamare, V. C. Renge, S. Tayde, and G. Bharsakale, “AN OVERVIEW ON WASTE PLASTIC UTILIZATION IN ASPHALTING OF ROADS Address for Correspondence,” *J. Eng. Res.*, vol. III, no. II, pp. 1–5, 2012.

[12] S. Simha and L. Kumar, “Use of plastic waste in flexible pavement construction,” *Open Access Int. J. Sci. Eng. ISSN 2456-3293*, vol. 2, no. 10, pp. 107–110, 2019.

[13] M. Kalpana and D. Surendaran, “Utilisation of Waste Plastic in Bituminous Roads-A Review,” *Int. J. Pure Appl. Math.*, vol. 119, no. 17, pp. 1143–1155, 2018, [Online]. Available: http://www.acadpubl.eu/hub/

[14] B. Li, “Reference Detail,” pp. 1–2, 2022.

[15] A. M. Babalghaith *et al.*, “A systematic review of the utilization of waste materials as aggregate replacement in stone matrix asphalt mixes,” *Environ. Sci. Pollut. Res.*, pp. 1–2, 2022, doi: 10.1007/s11356-022-19447-w.

[16] V. Patel, S. Popli, and D. Bhatt, “Utilization of Plastic Waste in Construction of Roads,” *Int. J. Sci. Res.*, vol. 3, no. 4, pp. 161–163, 2012, doi: 10.15373/22778179/apr2014/56.

[17] A. Shaikh, N. Khan, F. Shah, D. Shukla, and G. Kale, “Use of Plastic Waste in Road Construction,” *Int. J. Adv. Res. Dev.*, vol. 2, pp. 14–19, 2017, [Online]. Available: www.ijarnd.com

[18] R. Article, “A Review on Studies and Research on Iron Removal,” *J. Sainstek*, vol. V, no. 1, pp. 2–5, 2016.