EFFECT OF WASTE POLYTHENE USE IN DIFFERENT MODIFIER BITUMEN IN FLEXIBLE PAVEMENT

A Thesis Submitted

In partial fulfillment of the requirement

For the degree of

MASTER OF TECHNOLOGY

In

Transportation Engineering

By

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2018 – 19

CERTIFICATE

This is to certify thesis entitled **"EFFECT OF WASTE POLYTHENE USE IN DIFFERENT MODIFIER BITUMEN IN FLEXIBILE PAVEMENT"** which has being carried out by Mr. MAYANK MOHAN MISHRA (Roll No. 1170465002) for partial fulfillment of requirement for the award of **MASTER OF TECHNOLOGY** (TRANSPORTATION ENGINEERING) of Babu Banarasi Das University, Lucknow, is a record of her work carried out by her under the guidance and supervision. The result embodied in this thesis has not been submitted elsewhere for award of any other degree or diploma.

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DECLARATION

I, hereby declare that the work which is being presented in the **M.Tech** Thesis Report entitled **"EFFECT OF WASTE POLYTHENE USE IN DIFFERENT MODIFIER BITUMEN IN FLEXIBLE PAVEMENT",** in fulfillment of the requirements for the award of the MASTER OF TECHNOLOGY in **Transportation Engineering (Civil Engineering)** and submitted to the Department of Civil Engineering of Babu Banarasi Das University, Lucknow (U.P.) is an authentic record of our own work carried out during the period from August 2017 to June 2019 under the guidelines of **Prof. D.S. Ray, Department of Civil Engineering**. The matter presented in this thesis has not been submitted by me for the award of any other degree elsewhere.

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ABSTRACT

The use of waste polythene is increasing week by week. The waste polythene pollutes the environment, especially where there is no garbage collection and disposal system. A large amount of plastic collected form the tourist trekking regions and housing area are discarded or burned which releases harmful gases into the environment. The waste polythene collected from domestic and industrial sectors can be used in the production of plastics coated aggregate. Waste polythene, mainly used for packing and carrying any food. It's made up of Polyethylene, Polypropylene and polystyrene. There softening point varies between 110^0C – 140^0C and if the wastes polythene is heated within this temperature range then they do not product any toxic gases but the softened waste polythene have tendency to form a film like structure over the aggregate, when it is sprayed over the hot aggregate at 160^0C – 170^0C. The Plastics Coated Aggregates (PCA) is a better raw material for the construction of flexible pavement. PCA was mixed with hot bitumen of different types and the mixes were used for road construction.

Key Words: Waste Plastics, Plastic Coated Aggregate, Bitumen, Polyethylene, Polypropylene

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MAYANK MOHAN MISHRA

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Plastic have become part of our today's lifestyle. It is used for packaging, for protecting, serving purpose, & even discharging all types of goods. With the industrial mass production of goods and plastic would be a cheaper and good constituent. Using of plastic non-biodegradable (Subjected to recent studies, plastics can stay for as long as 4200 years) product is growing speedily and leads problem in disposal of waste polythene.

Now a day, wastes polythene have been considered in pavement construction with great interest in developing countries such as India. The use of these materials in road construction is totally based on economic, technical and ecological point of view also. India has a large network of metro cities located in different parts of the country and many more are planned for future. Several metric tons waste polythene are produced every year in India.

Keeping in mind that the need for bulk use of these waste polythene in India develops specifications to enhance the use of these waste polythene in pavement construction, in which higher economic returns also possible. The use of these materials should be developed for construction of low-volume roads in different region of our country. The necessary specifications should be sort-out and attempts are to be made to maximize the use of waste polythene in different layers of the road pavement construction. Many highway agencies are doing various studies on environmental suitability and performance of agencies are doing various studies on environmental suitability and performance of agencies are doing various studies on environmental suitability and performance of water bottles which are made up of high density polyethylene has increased abnormally. These bottles are not readily biodegradable, environmental problems are created due to dumping; these are either land filled or incinerated which are not ecofriendly which pollute land and air.

On heating at 100 - 150°C, plastics such as polyethylene, polypropylene and polystyrene, soften and shows good binding properties. Blending plastic with an aggregate and bitumen results in a mix that is amenable for road laying. These roads have withstood loads due to traffic, heavy rain and variation of temperature.

1.2 BACKGROUND OF STUDY AND JUSTIFICATION

Plastics and municipal solid waste are great concern. Finding proper use for the disposed waste polythene is the need of the hour. On the other side, the road traffic also increasing, hence need to increase the load bearing capacities of the pavements. As there is increasing demand in highway construction, scientists and researchers are constantly trying to improve the performance of bitumen pavement. Asphalt concretes are widely used in pavements. Bitumen is the naturally occurring by product of crude oil. Due to increase in vehicles in recent years the road surfaces have been exposed to high traffic resulting in deformation of pavements due to excessive stress. Permanent deformation happens when pavement does not have sufficient stability, improper compaction and insufficient Pavement strength. The performance of pavement is determined by the properties of bitumen. Bitumen is a viscoelastic material with suitable mechanical and rheological properties for water proofing and protective covering for roofs and roads, because of its good adhesion properties of aggregates. One of the most important properties of bitumen mixture is its ability to resist shoving and rutting under traffic. Hence stability should be more enough to handle traffic adequately, but not more than the traffic criteria require. Low stability causes unravelling and flow of the road surface. Some improvements in asphalt properties have been achieved by selecting the proper starting crude, to make asphalt. From practical experiences it is proved that the modification of asphalt binder with polymer additives, offers several benefits. To enhance various engineering properties of asphalt many modifiers such as styrene based polymers, polyethylene based polymers, polychloroprene, Gilsonite, various oils have been used in asphalt. Plastic usage has been increased in our daily life. Because of all these there is an increased usage of plastic the disposal of plastic has become difficult. Some studies say that 15 million tons of plastic are produced in India and only 3 to 4 million tons of waste polythene are recycled. Plastics have to be disposed or else it will be hazardous to nature and environment. Thus one of the best ways of disposal of these plastics is to use in bituminous road construction by melting them.

1.3 PROJECT ACTIVTIES

The plastic wastes could be used in road construction and the field tests withstood the stress and proved that waste polythene used after proper processing as an additive would enhance the life of the pavements and we can achieve road stability, minimizing cost of the bitumen. The present study highlights the developments in using waste polythene to make plastic pavements. The rapid rate of urbanization and development has led to increasing waste polythene production. As plastic is non-biodegradable, it remains in environment for numerous years and disposing waste polythene at landfill are unsafe since toxic chemicals percolate out into the earth, and under-ground water and pollute the water bodies. Due to littering routines, insufficient waste management scheme, waste polythene disposal to be a big problem for the civic authorities, especially in the urban areas. As mentioned above, plastic disposal is one of the major problems for developing country like India, at a same time India needs a large network of roads for its smooth economic and social development. Scarcity of bitumen needs a deep thinking to ensure fast pavement construction.

At present the disposal of waste polythene has become a major waste management problem in the world. Hence in this present investigation efforts have made to identify the potential application of waste polythene in civil engineering projects. In present study the aim is to investigate the optimal use of waste polythene in bitumen for road pavement construction.

1.4 OBJECTIVE OF THE STUDY

1.4.1 GENERAL OBJECTIVES

The main objective of this experimental investigation is to provide tools to evaluate and to improve the properties of pavement using waste polythene such that it may be more confidently employed in roadways and driveways etc.

1.4.2 SPECIFIC OBJECTIVES

Keeping in view of the above point the following specific objectives have been set for study.

- To study on polymer modified asphalt mixtures to evaluate engineering properties using marshal stability.
- To study basic properties of aggregates and plain bitumen.
- To study the strength and stability characters of BC mix for 60/70 and 80/100 grade bitumen.
- To study the effect of waste polythene on strength and stability characteristics of BC mix.
- To study characteristics of bitumen.
- Study on performance of Stability characters of BC mix.
- To study Strength characteristics of waste polythene.
- Strength characteristics of BC mix.

1.5 SIGNIFICANCE OF THE STUDY

There are many significance of present study as follows.

- To develop recycled plastics with enhanced physical and mechanical properties and that are strong, chemically inert and environmental-friendly.

- To study the effects of type of reused plastics, content of recycled plastics as replacement of aggregate.
- To select the optimum mix or mixes for use in the road by comparing and standing various concrete mixes built on the performance measures in physical properties (hardened density, water absorption etc..) and mechanical performance (compressive and flexural strength, etc..).
- Increase the strength and performance of pavement.
- Creating jobs for rag pickers.
- Develop a technology, which is eco-friendly.

1.6 SCOPE OF THE STUDY

The scope of the study is to evaluate the performance of Plastic tar flexible pavement road constructed using plastic coated aggregate bitumen mix.

1.7 CONCEPT OF PLASTIC ROAD

The roads constructed using waste plastic, popularly known as Plastic Roads, are found to perform better compared to those constructed with Plastic roads mainly use plastic carry bags, disposable cups and PET bottles that are collected from garbage dumps as an important ingredient of the construction material. When mixed with hot bitumen, plastics melt to form an oily coat over the aggregate and the mixture is laid on the road surface like a normal tar road.

1.7.1 PROCESS OF PLASTIC ROAD

- Wet Process

  Waste Plastics directly mixed with hot Bitumen at 1600C since the wet process require a lot of investment and bigger plants Addition of Stabilizers and proper cooling Mechanical Stirrer is needed.

- Dry Process

Aggregate is heated to 170°C in Mini Hot Mix Plant Shredded Plastic waste is added in equal proportion. Between 2 to 3 min. shredded waste polythene will coated over the aggregate and then after hot bitumen will be mix over the waste polythene coated aggregate.

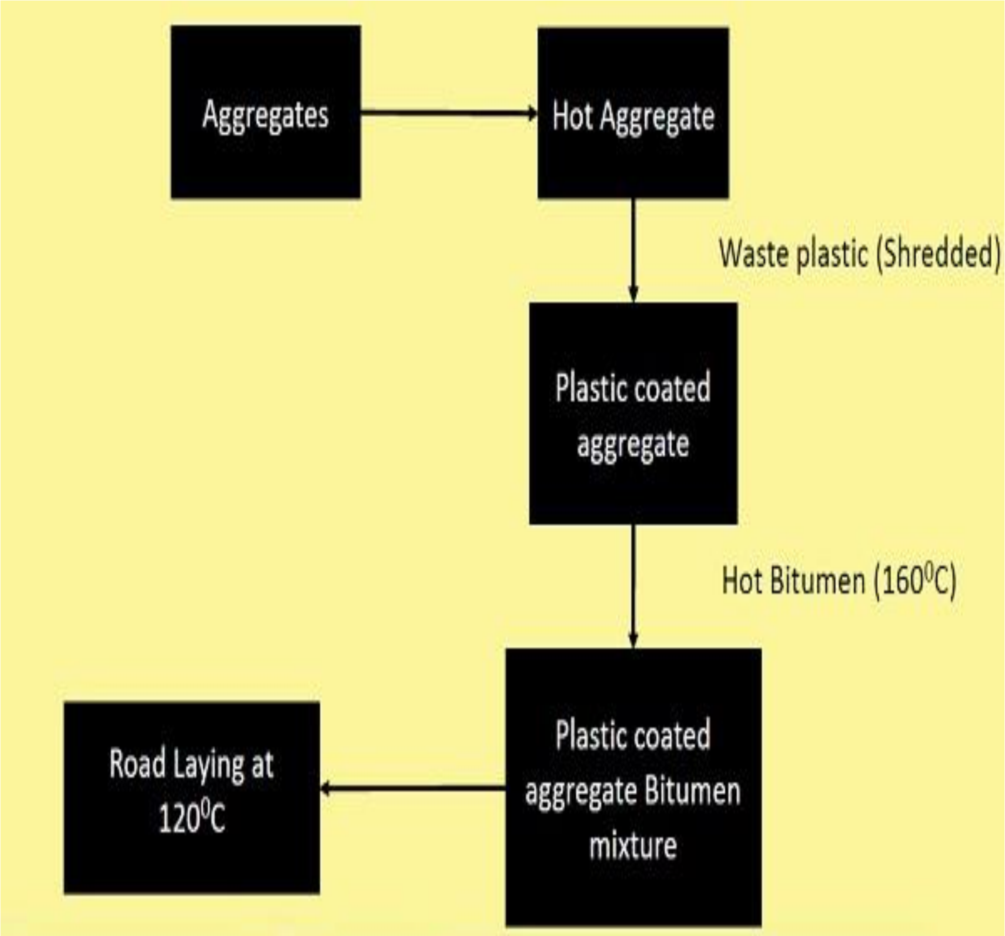

Fig. 1.1 Process of waste polythene coated aggregate bitumen Mix

1.7.2 WHY USE PLASTIC IN ROAD CONSTRUCTION

- Durable and Corrosion Resistant
- Good Binder
- Economical, Longer Life

- Maintenance Free
- Ease of Processing/ Installation
- Light Weight
- Improves Aggregate Impact Value
- Increases melting point of Bitumen

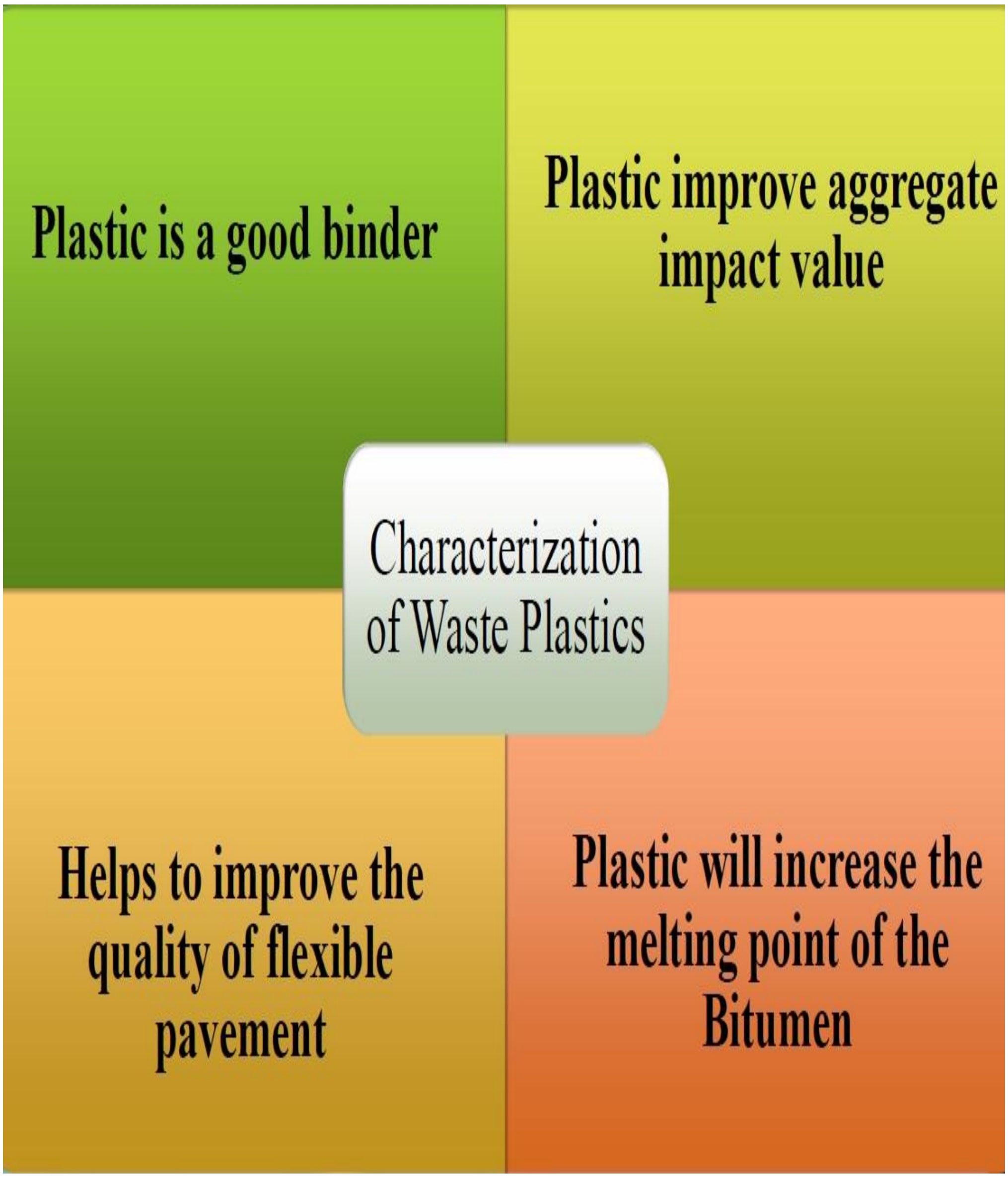

Fig. 1.2 Characterization of waste plastic

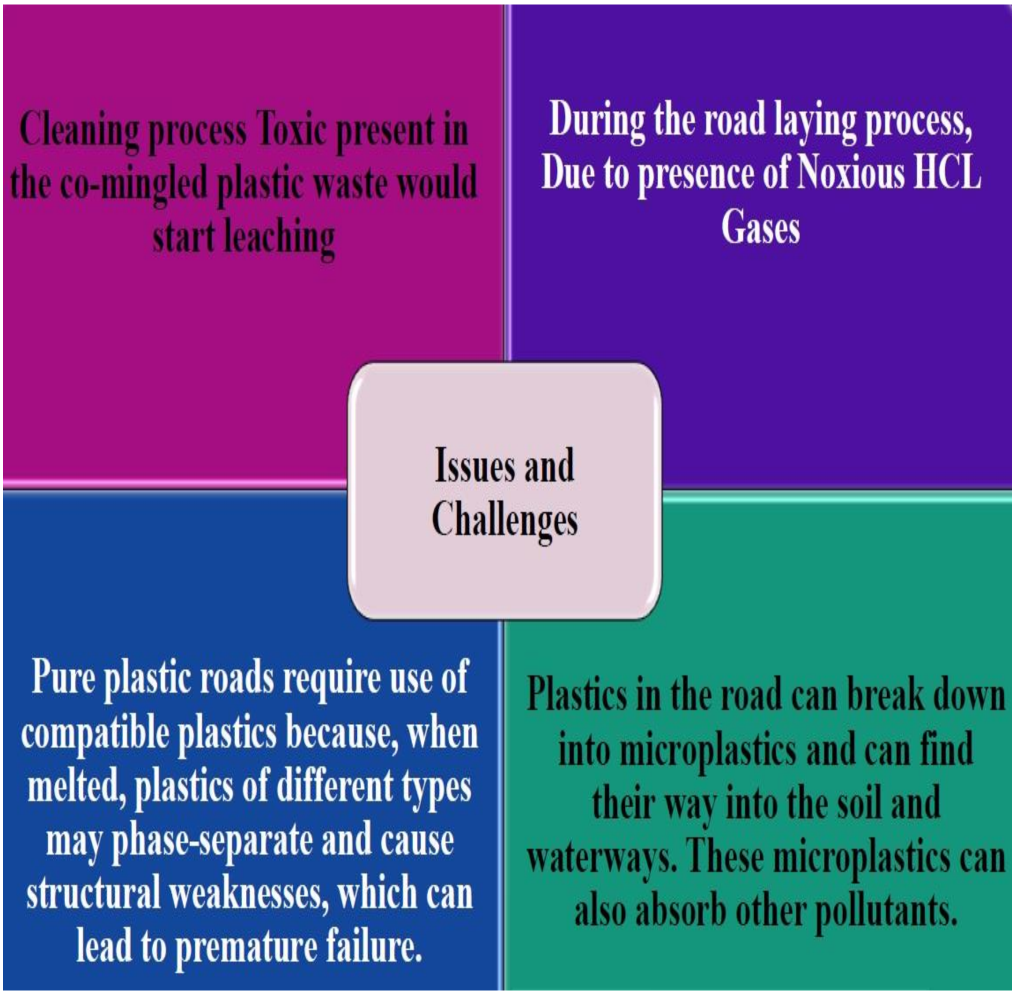

Fig. 1.3 Issues and challenge

1.7.3 ADVANTAGES AND DISADVANTAGES OF PLASTIC ROAD

1.7.3.1 ADVANTAGE OF PLASTIC ROAD

- Stronger road with increased Marshall Stability Value.
- Better resistance towards rainwater and water stagnation.
- No stripping and no potholes.
- Increase binding and better bonding of the mix.
- Reduction in pores in aggregate and hence less rutting and raveling.
- No effect of radiation likes UV.

- The strength of the road is increased by 100%.
- The load is withstanding property increases. It helps to satisfy today's need for increased road transport.
- For 1km X 3.75m road, 1 ton of plastic (10 lakh carry bags) is used, and 1 ton of bitumen is saved.
- The cost of road construction is also decreased.
- The maintenance cost of the road is almost nil.
- Disposal of waste plastic will no longer be a problem.
- The use of waste plastics on the road has helped to provide the better place for burying the plastic waste without causing disposal problem.

1.7.3.2 DISADVANTAGE OF PLASTIC ROAD

- Cleaning process- Toxics present in the co-mingled plastic waste would start leaching.
- During the road laying process- in the presence of chlorine will release noxious HCL gas.
- After the road laying- It is opined that the first rain will trigger leaching. As the plastics will merely form a sticky layer, (mechanical abrasion).
- The components of the road, once it has been laid, are not inert.

1.7.4 WASTE PLASTIC ROAD CONSTRUCTED

- The Bruhat Bengaluru Mahanagara Palike (BBMP) has used plastic on about 600 km of roads, including many thoroughfares and arterial roads.
- It uses the plastic blend in at least 25% of the road-laying works, including the present project to upgrade about 45 roads in the city.
- The plastic model was successful on major roads in Bangalore, including -:

    I. Shankar Mutt Road.

    II. K H Road.

    III. M G Road (towards Trinity Circle).

    IV. J C Nagar Road.

    V. Miller's Road and Cunningham Road.

    VI. Rajarajeshwari Junction.

CHAPTER 2

LITERATURE REVIEW

2.1 STUDIES ON WASTE POLYTHENE FOR ROAD CONSTRUCTION

2.1.1 R. MANJU et al. (MAY 2017) [41]

The waste plastic and its disposal is a major threat to the environment, which results in pollution and global warming. The utilization of plastic waste in bituminous mixes enhances its properties and also its strength. In addition, it will also be a solution to plastic disposal & various defects in pavement viz., pot holes, corrugation, ruts, etc. the waste plastic used are poly-ethylene, poly-styrene, poly-propylene. The waste plastic is shredded & coated over aggregate & mixed with hot bitumen and resulted mix is used for pavement construction. This will not only strengthen the pavement and also increases its durability. The titanium-dioxide is used as a smoke absorbent material, which will absorb the smoke from the vehicles. This innovative technology will be boon for Indian hot-humid climate. It’s economical and eco-friendly. In this paper, we have discussed about the soil properties to be considered in design of pavement, pavement design, process of construction flexible and plastic-smoke absorbent pavement.

2.1.2 T. KIRAN KUMAR et al. (2017) [45]

Bituminous Concrete (BC) is a composite material mostly used in construction projects like road surfacing, airports, parking lots etc. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which are mixed together & laid down in layers then compacted. Now a days, the steady increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature put us in a demanding situation to think of some alternatives for the improvisation of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economical aspects. Also considering the environmental approach, due to excessive use of plastics in the day to day business, the pollution to the environment is enormous. Since the plastic (polypropylene) are not biodegradable, the need of the current hour is to use the waste polypropylene in some beneficial purposes.

2.1.3 ABEY LULSEGED et al. (2016) [3]

This research paper tries to shed light on the use of PCA in asphalt mix and study the performance of PCA using different testes. Use of disposed plastics waste is the need of the hour. The studies on the thermal behavior and binding property of the molten plastics promoted a study on the preparation of plastics waste – bitumen blend and its properties to find the suitability of the blend for road construction. A modified technique was developed and the stone aggregate was coated with molten plastics and the plastics waste coated aggregate (PCA) was used as the raw material for flexible asphalt concrete. PCA showed better binding property, it had less water absorption and also the sample showed higher Marshall Stability value.

2.1.4 BRAJESH MISHRA et al. (2015) [11]

The continuous increase in road traffic in combination with insufficient maintenance due to paucity of funds has resulted in deterioration of road network in India. To improve this process there are several types of measures which are proven to be effective, like securing adequate funds for proper maintenance, effective and improved roadway design, use of better quality materials and use of effective and modern construction techniques. During last three decades in many countries around the world it has been tested that modification of the bituminous binder with polymer additives enhances the properties and life of asphalt concrete pavements. The present investigation was carried out to propose the use of plastic coated aggregate (PCA) in bituminous mix of flexible pavements in order to improve their performance and also to give a way for safe disposal of plastic wastes to provide a solution to threat of environmental pollution as well. There are two processes available for mixing of waste plastic in bituminous mixes namely wet and dry process. In this study the dry process was used for bituminous concrete mixes. The Marshall method of mix design was adopted using 80/100 grade bitumen to find the optimum bitumen content. Marshall Specimens were prepared at bitumen content ranging from 4% to 6% with an increment of 0.5% by weight of aggregates and with waste plastic content of 0%, 6%, 8%, 10%, 12%, 14% and 16% by weight of optimum bitumen content. Marshal stability, Flow value, Marshal Quotient, Air voids (Vv), Voids in mineral aggregates (VMA), Voids filled with bitumen(VFB), and striping value were determined and compared with conventional aggregates (without plastic) bituminous concrete mixes. Comparison was also made by testing the physical properties of conventional and plastic coated aggregates (PCA). It was found that there was a considerable improvement in the properties of aggregates and bituminous mix leading to provide longer life and better pavement performance. The use of waste plastic in bituminous concrete mix thus contributes to construction of green roads and solves the problem of its safe disposal as well.

2.1.5 YOUCEF GHERNOUTI et al. (2014) [49]

The study present the partial replacement of fine aggregate in concrete by using plastic fine aggregate obtained from the crushing of waste plastic bags. Plastic bags waste was heated followed by cooling of liquid waste which was then cooled and crushed to obtained plastic sand having finesse modulus of 4.7. Fine aggregate in the mix proportion of concrete was replaced with plastic bag waste sand at 10%, 20%, 30% and 40% whereas other concrete materials remain same for all four mixes. In fresh properties of concrete it was observed from the results of slump test that with increase of waste content workability of concrete increases which is favorable for concrete because plastic cannot absorb water therefore excessive water is available. Bulk density decreases with increase of plastic bags waste. In harden state, flexural and compressive strength were tested at 28 days and reductions in both strengths with increasing percentage of plastic bag waste sand in concrete mix. Plastic waste increases the volume of voids in concrete which on other hand reduce the compactness of concrete simultaneously speed of sound in concrete is also decreased. Strength reduction in concrete mix was prime concern; however they recommend 10 to 20% replacement of fine aggregate with plastic aggregate. Use of admixtures to address the strength reduction property of concrete with addition of plastic aggregate is not emphasized.

2.1.6 A. J. CHAVAN et al. (MAY 2013) [5]

Disposal of waste materials including waste plastic bags has become a serious problem and waste plastics are burnt for apparent disposal which cause environmental pollution. Utilization of waste plastic bags in bituminous mixes has proved that these enhance the properties of mix in addition to solving disposal problems. Plastic waste which is cleaned is cut into a size such that it passes through 2-3mm sieve using shredding machine. The aggregate mix is heated, and the plastic is effectively coated over the aggregate. This plastic waste coated aggregate is mixed with hot bitumen and the resulted mix is used for road construction. The use of the innovative technology will not only strengthen the road construction but also increase the road life as well as will help to improve the environment. 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. In my research work I have done a thorough study on the methodology of using plastic waste in bituminous mixes and presented the various tests performed on aggregates and bitumen.

2.1.7 S. RAJASEKARAN et al. (2013) [44]

Waste plastics both by domestic and industrial sectors can be used in the production of asphalt mix. Waste plastics, mainly used for packing are made up of Polyethylene Polypropylene polystyrene. Their softening varies between 110oC – 1400C and they do not produce any toxic gases during heating but the softened plastics have tendency to form a film like structure over the aggregate, when it is sprayed over the hot aggregate at 1600C. The Plastics Coated Aggregates (PCA) is a better raw material for the construction of flexible pavement. PCA was then mixed with hot bitumen of different types and the mixes were used for road construction. PCA -

Bitumen mix showed improved binding property and less wetting property. The sample showed higher Marshall Stability value in the range of 18-20KN and the load bearing capacity of the road is increased by 100%. The roads laid since 2002 using PCA-Bitumen mixes are performing well. A detailed study on the performances of these roads shows that the constructed with PCA –Bitumen mix are performing well. This process is eco-friendly and economical too.

2.1.8 R L RAMESH et al. (2008) [42]

They have used waste plastic of low density poly ethylene as replacement to coarse aggregate to determine its viable application in construction industry and to study the behavior of fresh and harden concrete properties. Different concrete mix were prepared with varying proportions (0%, 20%, 30% & 40%) of recycle plastic aggregate obtained by heat treatment of plastic waste (160-200 centigrade) in plastic granular recycling machine. A concrete mix design with 1: 1.5: 3 proportions was used having 0.5 water/cement ratio having varying proportion of plastic aggregate as replacement of crushed stone. Proper mixing was ensured and homogeneous mixture was prepared. A clear reduction in compressive strength was reported with increase in percentage of replacing plastic aggregate with crushed aggregate at 7, 14 and 28 days of casted cubes (80% strength achieved by replacing waste plastic up to 30%). The research highlights the potential application of plastic aggregate in light weight aggregate. Their research was narrowed down to compressive strength of concrete with no emphasis given to flexural properties of concrete. They suggest future research scope on plastic aggregate with regard to its split tensile strength to ascertain its tensile behavior and its durability aspects for beams and columns.

2.1.9 MOHAMMAD T. AWWAD et al. (2007) [40]

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.

2.1.10 ZAINAB Z. ISMAIL et al. (2007) [50]

They have conducted comprehensive study based on large number of experiments and tests in order to determine the feasibility of reusing plastic sand as partial replacement of fine aggregate in concrete. They conducted tests on concrete samples for dry/fresh density, slump, compressive and flexural strength and finally toughness indices on room temperature They have collected waste plastic from plastic manufacture plant consist of 80% polyethylene and 20% polystyrene which was crushed (varying length of 0.15-12mm and width of 0.15-4mm). Concrete mix were produce with ordinary Portland cement, fine aggregate (natural sand of 4.74mm maximum size), coarse aggregate (max size below 20mm) and addition of 10%, 15% and 20% of plastic waste as sand replacement. Their test results indicate sharp decrease in slump with increasing the percentage of plastic, this decrease was attributed to the presence of angular and non-uniform plastic particles. In spite of low slump however, the mixture was observed with good workability and declared suitable for application. Their tests also revealed the decrease in fresh and dry density with increasing the plastic waste ratio; however increase was reported in dry density with time at all curing ages. Decrease in compressive and flexural strength was observed by increasing the waste plastic ratio which can be related to decrease in adhesive strength between plastic waste particles with cement. However, load-deflection curve of concrete containing plastic waste showed the arrest of propagation of micro cracks which shows its application in places where high toughness is required. The study has shown good workability in spite of low slump but w/c content kept constant in all samples. They should have reduced the water content in order to improve the strength when workability was not an issue.

2.1.11 R. VASUDEVAN et al. (2007) [46]

He is investigated that 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 plastics. Use of plastic bags in road help in many ways like Easy disposal of waste, better road and prevention of pollution.

2.1.12 MINAKSHI SINGHAL et al. (MAY 06) [39]

Flexible pavements with bituminous surfaces are widely used. Due to increased traffic intensity of roads, overloading of commercial vehicles and temperature variation of pavements due to climatic changes leads to formation of various distresses like rutting, shoving, bleeding, cracking and potholing of bituminous surfacing. Due to high temperature, bitumen becomes very soft in summer and brittle in winter. Also, in a developing country like India, roadway construction is taking place at a very high pace which require large demand of construction material that too eco-friendly and economical. Several Studies have revealed that properties of bitumen and bituminous mixes can be improved/ modified with addition of certain additives and the bitumen premixed with these additives/modifiers is known as “modified bitumen”. The present study aims for use of modified bitumen by using plastic waste for road construction. The paper includes details of literature and methodology of using modifiers in bitumen and aims to provide highway construction in an eco-friendly and economical way. The modified bitumen mix shows better binding property, stability, density and more resistant to water.

2.2 CLASSIFICATION OF PLASTIC

There are two groups of plastics:-

1. Thermoplastic 2. Thermosets

2.2.1 THERMOPLASTIC

Thermoplastic are those plastics which gets soften when heated. They can be easily recycled and used again to manufacture additional products.

- Thermoplastic make up 80% of the plastic produced today.
- Linear polymers and branched polymers are example of thermoplastic.

Table 2.1 Examples of Thermoplastic

Type of plastic	Uses
High density polyethylene(HDPE)	Used in piping, Automobile fuel tanks, Bottles, Toys.
Low density polyethylene(LDPE)	Used in plastic bag, Cling films, flexible containers.
Polyethylene Terephthalate(PET)	Used in bottle, Carpets, Food packaging.
Polypropylene(PP)	Used in food containers battery cases, Bottle crates, Automotive parts and fibers.

2.2.2 THERMOSET

Thermoset are those plastic which cannot be heated and if they are heated, they become hard. Thermoset cannot be remoulade like thermoplastics. Thermoset are valued for their durability and strength.

- Thermoset make up the remaining 20% of plastics produced.
- They are hardened by curing and cannot be re-melted and therefore difficult to recycle. They are sometimes ground and used as a filler material.
- Cross-linked polymers (two or more joined by side chains) are thermosets.

Table 2.2 Examples of Thermoset

Type of plastics	Uses
Polyurethane(PU)	Used in coating, Finished, Gears, Diaphragms, Cushions and Car seats.
Epoxy	Used as adhesives, In sports equipment, Electrical and Automotive equipment etc.
Phenolics	Used in ovens, Automotive parts, Circuit boards etc.

2.3 PLASTIC FACT FILE

- It is estimated that 100 million tons of plastic are product each year.
- More than 20,000 plastic bottle are needed to obtain 1 ton of plastic.
- The world's annual consumption of plastic material has increased from around 5 million tons in the 1950's to nearly 100 million tones today.
- In India, the consumption of plastic has more than doubled since 1995-2000 from about 1.8 million tones to about 5 million tones today.
- Plastic consumption is growing about 4% every year in Western Europe.
- Plastic packaging total 42% of total consumption and very little of this is recycled.
- One ton of plastic is equivalent to 20,000 two litter drinks bottles or 120,000 carrier bags.
- Plastic make up around 7% of the average household dustbin.

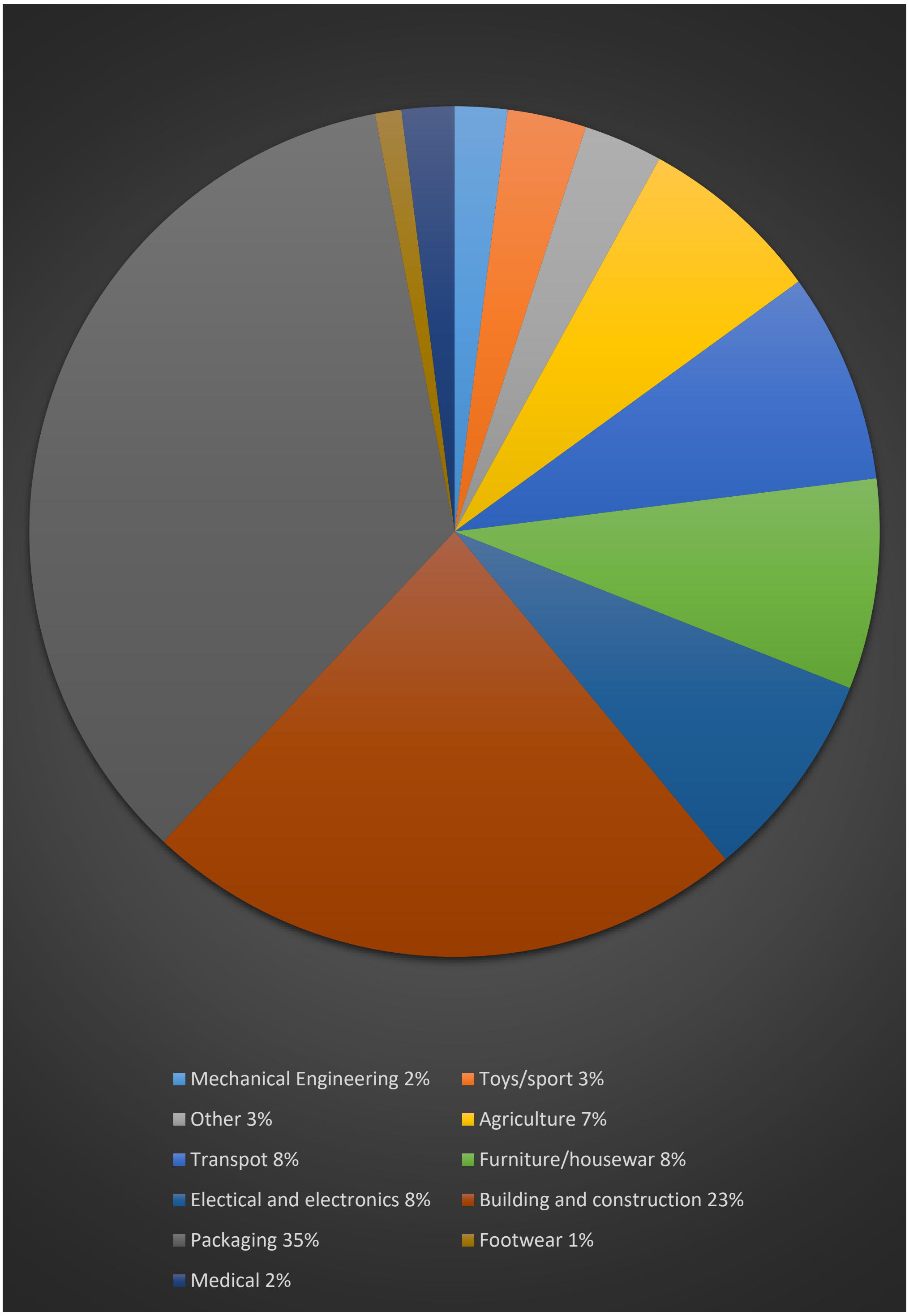

Fig. 2.1 Pie Chart Showing the Plastic Utilization in Various Sectors

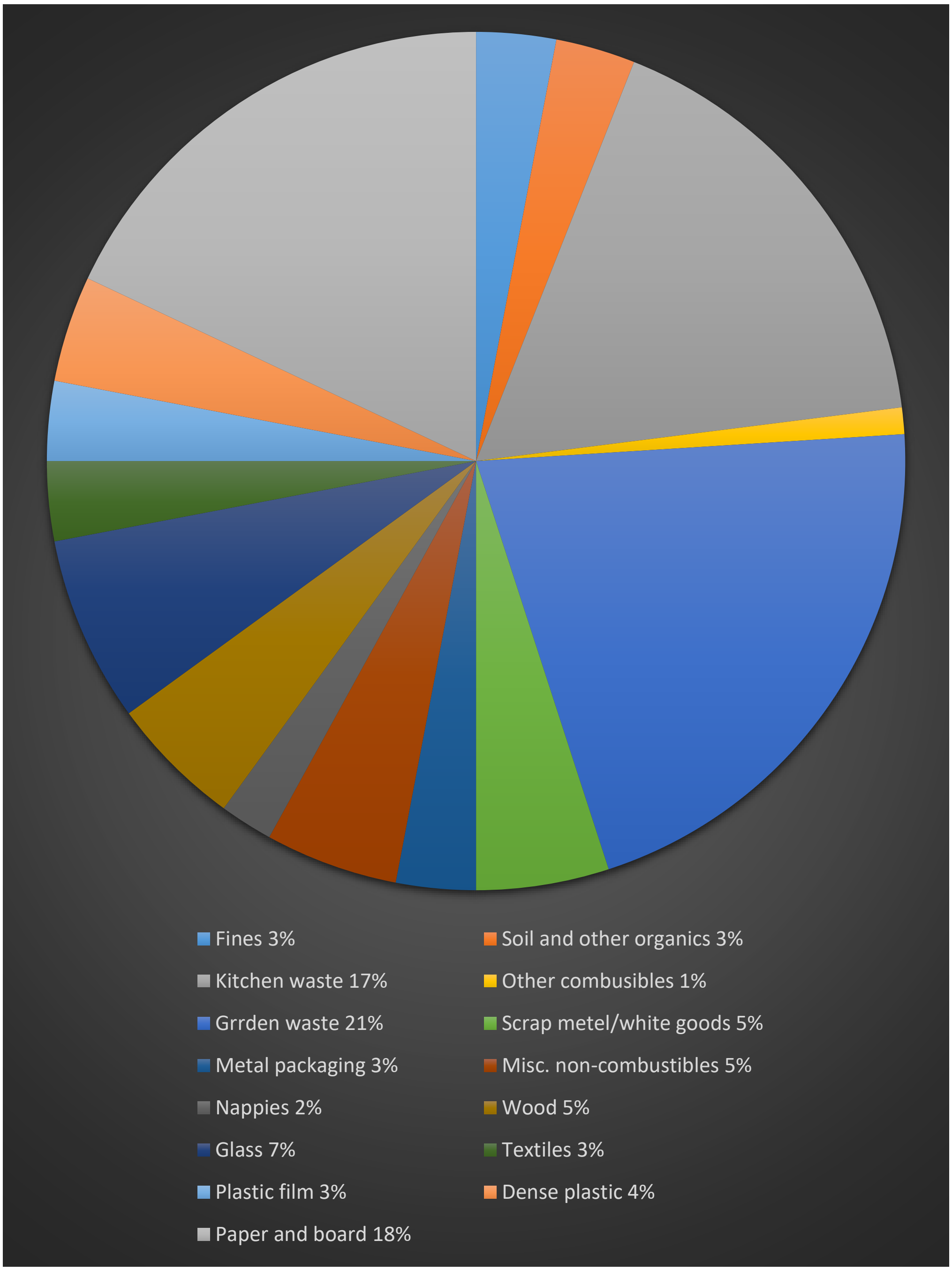

Fig. 2.2 Chart Showing the Household Waste Composition

2.4 BENEFITE OF PLASTIC

The considerable growth in plastic use is due to the beneficial properties of plastics they include:

- Light weight than competing materials, reducing fuel consumption during transportation.
- Extreme durability.
- Extreme versatility and ability to be tailored to meet very specific technical need.
- Resistance to chemicals, water and impact.
- Good safety and hygiene properties for good packaging.
- Excellent thermal and electrical insulation properties.
- Relatively inexpensive to produce.

2.5 SOURCES OF GENERATION OF WASTE POLYTHENE

The production and consumption of the plastic is increasing all over the world due to its benefits. And the generation of waste polythene is also increasing at the same rate which is causing a major problem to the world. There are various type of sources which are producing the waste polythene. There sources are classified as below:

Table 2.3 Sources of Generation of waste polythene

Sources	Waste polythene generated
Household	• Carry bags • Bottles • Containers • Trash bags
Health and Medicare	• Disposable syringes

	• Glucose bottles • Blood and euro bags • Intravenous tubes
Hotel and Catering	• Packaging Items • Mineral water bottles • Plastic plates, Glasses, Spoons
Air/Rail Travel	• Mineral water bottles • Plastic plates, Glasses, Spoons • Plastic bags

These sources are producing waste polythene in huge amount, improper disposal of waste polythene can cause the problem like breast cancer, reproductive problem in humans and animals, genital abnormalities etc.

2.6 LITTER

Litter can be as small as a sweet wrapper, large as a bag of rubbish or it can mean lots of items scattered about (Cousteau, 2003). ENCAMS describes litter as “Waste in wrong place cause by human agency”. In other words, people make litter. Litter is an important environmental issue. It is amazing that 90% of people identify litter as a major environmental problem and yet people still litter. Carelessly discarded garbage effects every member of society. It cause harm to people and animal, damages our waterway, costs us money and suggests that we do not care for our environmental.

Fig. 2.3 Littered Waste Polythene in an Open Plot

2.6.1 SOURCES OF LITTER

There are primary sources of litter:

- Pedestrians dropping garbage in the street or gutters.
- Motorist discarding garbage out of windows.
- Uncovered loads. Items that are not secure can easily be blown out of the trailers and cause roadside littering.
- Household refuse disposal and collection.
- Animal scavengers and the wind can dislodge unsecured items placed out on the corner for collection.
- Commercial refuse and disposal. Poorly secured commercial reuse can easily become litter.

- Construction projects. Litter can come from uncontrolled building waste and workers lunch time reuse.
- Entertainment events. Events create a large amount of litter, which can overflow onto neighboring areas when measures to control it are not carefully planned.
- Illegal dumping.
- Intentional or habitual littering, for reason such as laziness or acts of rebellion.

2.6.2 EFFECT OF LITTER

Litter can cause a whole range of problem for everyone in the community.

- Litter discarded in the streets and parks can travel through the storm water system to our bays and oceans, where it can cause harm to wildlife.
- Litter costs money. Removing litter form the environment costs everyone money.
- Litter is a threat to public health. Litter attracts vermin and is a breeding ground for bacteria. Items such as broken glasses and syringes can be a health hazard in public place.
- Litter can be a fire hazard. Accumulation litter and carelessly discarded cigarette butts are potential fire hazards.
- Litter look bad. Litter negatively affect the image of place, especially tourist locations.
- Litter can harm or kill wildlife. Waste polythene can choke or suffocate birds and marine life. Carelessly discarded containers can trap small mammals.

Fig. 2.4 An Illegally Dumped Refrigerator Floating in an Irrigation Canal

2.6.3 WHAT'S THE SOLUTION?

There are a number of simple ways to help prevent littering.

- Use garbage cans properly if provided. Make sure that waste is going in the garbage can, not beside it.
- Pick up garbage, do not flush it away. Sweep paved area and pick up all the garbage, rather than housing it down into gutters and drains. All the garbage in gutters works its way into the water.
- Always place waste in the most appropriate place.
- Use a reusable cloth bag while shopping, or choose cardboard boxes instead of plastic bags whenever possible.

2.7 METHODS OF REDUCING THE WASTE POLYTHENE

There are two ways by which we can reduce the amount of waste polythene to a great extent.

These are:

(1) Recycling of polythene

(2) Use of waste polythene in road construction

2.7.1 RECYCLING OF POLYTHENE

Recycling of polythene is the process of converting the waste polythene into value-added fuel products (Bandopadhyay et al, 2004).

2.7.1.1 POLYTHENE FOR RECYCLING

Not all polythene are recyclable. There are 4 type of polythene which are commonly recycled:

- Polyethylene (PE) – both high and low density polyethylene.
- Polypropylene (PP)
- Polystyrene (PS)
- Polyvinyl chloride (PVC)

A common problem with the recycling polythene is that polythene are often made up of more than one kind of polymer or there may be some sort of fiber added to plastic to give added strength. This can make recovery difficult.

There are basically 4 different ways of recycling of polythene (Zadgaonkar, 1904). These are:

- **Primary Recycling -** Conversion of waste polythene into products having performance level comparable to that of original product made from virgin plastic
- **Secondary Recycling -** Conversion of waste polythene into product having less demanding performance that the original material.
- **Tertiary Recycling –** The process of producing chemicals / fuels / similar products from waste polythene.
- **Quaternary Recycling –** The process of recovering energy from waste polythene by inciration.

Zadgaonkar's invention deals with the **Tertiary Recycling.** Her work involved use of post-consumer waste of polythene and other polymeric material to product fuel at a cheaper cost.

The process consists of two step:

(1) <u>Random De-polymerization</u>

- Loading of waste polythene into the reactor along with the catalyst system.
- Random De-polymerization of the waste polythene.

(2) Fractional Distillation

- Separation of various liquid fuels by virtue of the difference in their boiling point.

2.7.1.2 UNIQUE FEATURES OF THE PROCESS AND PRODUCT OBTAINED

- All type of waste polythene can be used (PP, PS, PET and PVC) can be used in the process without any cleaning operation.
- Bio-medical plastic can be used.
- About 1 liter of fuel is produced from 1 Kg of waste polythene.
- Any possible Dioxin formation is ruled out during the reaction involving PVC waste.
- This is a unique process in which 100% waste is converted into 100% value-added product.
- The process does not create any pollution.

2.7.1.3 PALSTIC MANUFACTURING AND RECYCLING UINT

Table 2.4 List of Plastic Manufacturing and Recycling units

Sr. No.	Name of SPCBs/UTs	No. of Units	No. of Registration Granted	Comments/ Suggestion
1	Andhra Pradesh	150	121	Less than 20 micron carry bags are banned. Littering of plastics carry bag is banned in public places, Levy of penalties against the violators of recycling

				Norms (vide Notification dated 30.03.2011) Mass Awareness programmer are organized.
2	Andmans & Nicobar Islands	Nil	Nil	Recycled Plastics Rule published vide Notification No. 25, Date 5.2.2011
3	Assam	10	Nil	Criteria shall be developed for other plastics product such as ropes, sheets, soap case etc.
4	Arunachal Pradesh	Nil	Nil	
5	Bihar	-	-	Inventory not completed. Rules disseminated through public Notices.
6	Chandigarh	20	-	Notified vide Notification No. DC/MA/2011/187/dated 14.09.2011
7	Chhattisgarh	32	11	Inter-state movement of Sub-standard Carry bags/materials etc.
8	Delhi	147	147	Non-Biodegradable Act, 2001 has been brought

				out to manage waste plastic.
9	Gujarat	365	41	
10	Goa	16	-	Notification has been brought out and thickness of plastics carry bags has been raised to 40 microns regardless of D punch or handle type.
11	Haryana			Inventory not completed recycled plastics rule notified.
12	Himachal Pradesh	13	10	Recycled plastics rule Notified on 26.11.1998.
13	Jharkhand	-	-	Rules disseminated through public Notices.
14	J&K	-	-	Recycled plastic rule notified.
15	Karnataka	302	Nil	Public Notices issued. Free for registration, involvement of municipality, Reuse of plastic waste in Road, Inter-state movement of substandard carry bags/ material etc.

16	Kerala	193	10	Recycled Plastic rule Notified. Govt. of Kerala has formulated action plan for waste plastic management.
17	Lakshadweep	Nil	Nil	Import of carry bags/ plastics material for carrying of foodstuff is prohibited vide Notification dated 17.07.1998.
18	Madhya Pradesh	179	83	
19	Maharashtra	-	-	Recycled plastics rule Notified/
20	Mizoram	Nil	Nil	Mass awareness Programmes have been organized stating the ill effects of polythene bags.
21	Meghalaya	1	Nil	Interstate movement of substandard plastics carries bags, material.
22	Manipur	-	-	
23	Nagaland	4	4	Less than 20 micron poly carry bags are prohibited vide notification 12.11.2003.

24	Orissa	14	2	District collectors have to be strengthened/ pursued for strict vigilance, and provisions of confiscation/ seizure, penal action should be in Rule.
25	Pondicherry	56	2	Usage of polycarry bags for food stuff banned. Penal provisions should be made, virgin/ Recycled plastic carry/ containers should not be used for foodstuffs.
26	Punjab	-	-	Vide order dated 02.11.2000. Usage of polycarry bags for food stuff banned.
27	Rajasthan	-	-	Vide circular No. 01.06.2000. Usage of polycarry bags for food stuff banned.
28	Sikkim	-	-	Usage of polycarry bags for food stuff banned.
29	Tamil Nadu	588	45	Proposed that Govt. of India to evolve plastic waste processing technologies such as

				reuse in road construction etc.
30	Tripura	Nil	Nil	The manufacture, sale, distribution and use of virgin and recycle plastic bags and containers are prohibited vide direction issued by Tripura SPCB date 01.09.2003.
31	Utter Pradesh	-	-	Inventory not yet completed. Usage of polycarry bags for food stuff banned.
32	West Bengal	-	-	Draft plastic rules notified.

2.7.2 REUSE OF WASTE POLYTHENE IN ROAD CONSTRUCTION

2.7.2.1 PASTIC AS BINDER AND MODIFIER

Waste polythene on heating soften around 130^0C – 140^0C. A study using thermogravimetric analysis has shown that there is no gas evolution in the temperature range of 130^0C – 180^0C. Moreover the softened plastic have a binding property. Hence, the molten plastic materials can be used as a binder and or they can be mixed with binder like bitumen to enhance their binding property. This may be a good modifier for the bitumen, used for road construction.

2.7.2.2 PROCESS OF ROAD LAYING USING POLYMER -AGGREGATE – BITUMINOUS MIX

The study of using waste polythene in road construction was performed by Central Pollution Control Board. The waste polythene (bags, cups, and thermocoles) made out of PP, PE and PS were separated, cleaned if needed and shredded to small pieces. The aggregate was heated to 170^0C in the mini hot mix plant and the shredded waste polythene was added, it got softened and coated over the aggregate. Immediately the hot bitumen (160^0C) was added and mixed well. As the polythene and the bitumen were in the molten state, they get mixed and the blend is formed at the surface of the aggregate. It was observed that addition of waste polythene up to 10 – 15 % by weight of bitumen resulted into higher value of softening point and lower value of penetration, which are appreciable improvements in the properties of the binder. The mixture was transferred to the road and the road was laid. Then this technique was extended to central mixing plant too.

2.7.3 LIST OF ROAD LAID USING WASTE PLASTIC

Table 2.5 Roads Laid Using the Waste Plastics

	Process	**Blend Composition**	**Date**
TCE	Polymer Blending with Bitumen	5 % PE	23^{rd} March-02
Kovilpatti	Polymer Blending with Metal and the Mixing with Bitumen	10 % PE	4^{th} October-02
	Polymer Blending with		

Madurai	Metal and the Mixing with Bitumen	15 % PE	5th October-02
Salem	Polymer Blending with Metal and the Mixing with Bitumen	10 % PE	15th October-02
Komarapalayam	Polymer Blending with Metal and the Mixing with Bitumen	10 % Mixture	15th October-02
Chennai	Polymer Blending with Metal and the Mixing with Bitumen	12 % Mixture	22nd Novermber-02
Trichy	Polymer Blending with Metal and the Mixing with Bitumen	10 % Mixture	10th January-03
Salem	Polymer Blending with Metal and the Mixing with Bitumen	10 % Mixture	17th April-03

Erode	Polymer Blending with Metal and the Mixing with Bitumen	10 % Mixture	7th May-03
Theni	Polymer Blending with Metal and the Mixing with Bitumen	10 % Mixture	10th May-03
Nagercoil	Polymer Blending with Metal and the Mixing with Bitumen	10 % Mixture	16th May-03
Madurai – Kombadi	Polymer Blending with Metal and the Mixing with Bitumen	10 % Mixture	-

CHAPTER 3

MATERIAL ANALYSIS

3.1 BASIC RAW MATERIALS

The materials used are as follows.

(1) Aggregates

(2) Bituminous Binder

(3) Waste Polythene

3.1.1 AGGREGATES

There are various types of mineral aggregates used to manufacture bituminous mixes can be obtained from different natural sources such as glacial deposits or mines and can be used with or without further processing. The aggregates can be further processed and finished to achieve good performance characteristics. Industrial by-products such as steel slag, blast furnace slag, fly ash etc. sometimes used by replacing natural aggregates to enhance the performance characteristics of the mix. Aggregate contributes up to 90-95 % of the mixture weight and contributes to most of the load bearing & strength characteristics of the mixture. Hence, the quality and physical properties of the aggregates should be controlled to ensure a good pavement. Aggregates are of 3 types:

3.1.1.1 COARSE AGGREGATE

The aggregates retained on 4.75 mm sieve are called as coarse aggregates. Coarse aggregate should be screened crushed rock, angular in shape, free from dust particles, clay, and vegetation’s and organic matters which offer compressive and shear strength and shows good interlocking properties. In present study, stone chips are used as coarse aggregate with specific gravity 2.75.

Fig. 3.1 Coarse Aggregate

3.1.1.2 FINE AGGREGATE

Fine aggregate should be clean screened quarry dusts and should be free from clay, loam, vegetation or organic matter. Fine aggregates, consisting of stone crusher dusts were collected from a local crusher with fractions passing 4.75 mm and retained on 0.075 mm IS sieve. It fills the voids in the coarse aggregate and stiffens the binder. In this study, fine stones and slag are used as fine aggregate whose specific gravity has been found to be 2.6 and 2.45.

Fig. 3.2 Fine Aggregate

3.1.1.3 FILLER

Aggregate passing through 0.075 mm IS sieve is called as filler. It fills the voids, stiffens the binder and offers permeability. In this study, stone are used as filler whose specific gravity has been found to be 2.7 and 2.3.

3.1.2 BITUMINOUS BINDER

Bitumen acts as a binding agent to the aggregates, fines and stabilizers in bituminous mixtures. Bitumen must be treated as a visco-elastic material as it exhibits both viscous as well as elastic properties at the normal pavement temperature. At low temperature it behaves like an elastic material and at high temperatures its behavior is like a viscous fluid. Asphalt binder VG30 is used in this research work. Grade of bitumen used in the pavements should be selected on the basis of climatic conditions and their performance in past. It fills the voids, cause particle adhesion and offers impermeability.

Fig. 3.3 Bitumen VG 30

3.1.3 WASTE POLYTHENE

Stabilizing additives are used in the mixture to provide better binding property. Now-a day's polypropylene, polyester, mineral and cellulose are commonly used as fibers. In this present study polyethylene, Polypropylene and is used as stabilizing additive to improve performance characteristics of pavement.

Fig. 3.4 Waste Polythene

3.2 MATERILAS USED

3.2.1 AGGREGATE

For preparation of bituminous mixes (DBM) aggregates as per MORTH grading as given in Table 3.1 respectively, a particular type of binder and polyethylene, Polypropylene in required quantities were mixes as per Marshall Procedure. The specific gravity of aggregate are given in Table-3.2.

Table 3.1 Gradation of Aggregates for DBM

Sieve size (mm)	Percentage passing	Spec. Limit of % Passing
40	100	100
25	97.8	85-100
20	73.78	71-95
12.5	61.7	58-82
10	55	52-72
4.75	37	35-50
2.36	35	28-43
0.6	20	15-27
0.3	18	7-21
0.15	10	5-15
0.075	4	2-8

Table 3.2 Specific gravity of aggregates

Types of aggregates	Specific gravity
Coarse	2.75
Fine	2.6
Filler	2.7

3.2.2 BITUMEN

One conventional commonly used bituminous binder, namely VG 30 bitumen was used in this investigation to prepare the samples. Conventional tests were performed to determine the physical properties of these binders. The physical properties thus obtained are summarized in Table 3.3.

Table 3.3 Physical Properties of Binder

Test	**Test Result**
Penetration value test at 25^0C	69 mm
Softening point test	52^0C
Ductility test at 27^0C	93 cm
Flash point test	230^0C
Fire point test	250^0C

3.2.3 WASTE POLYTHENE

In present study polyethylene and Polypropylene is used as stabilizing additive. The polyethylene packets were collected, they were washed and cleaned by putting them in hot water for 3-4 hours. They were then dried.

3.2.3.1 SHREDDING

The dried polyethylene packets were cut into thin pieces of size 2 mm maximum. This is because to maintain uniformity in size of polyethylene in mix. When the polyethylene is to be added with aggregate it is to be ensured that the mixing will be proper. The smaller the size of the polythene, the more is the chance of good mixing.

Specific Gravity of polythene was found as 0.905.

Fig. 3.5 Waste Polythene Used

Fig 3.6 Shredded Waste Polythene

3.3 PREPARATION OF PLASTIC COATED AGGREGATE

Cleaned and dried wastes polythene (e.g.: disposed carry bags, films, cups and thermocoles) is shredded into small pieces (2 mm to 4 mm size). PVC (Polyvinyl Chloride) is not suitable for this process. Aggregate is heated upto 160^0C to 170^0C. Shredded waste polythene is added to the hot aggregate mix. The waste polythene gets softened and coated over the surface of the aggregate within 10 sec. to 30 sec. Hot Bitumen (heated up to a maximum of 160^0C to 170^0C to ensure good binding) is added immediately and the contents are mixed well. When cooled to 110^0C to 120^0C can be used for road. As the waste polythene are heated to a maximum temperature of 160^0C to 170^0C, there is no evolution of any gas. When heated above 270^0C, the plastics get decomposed and above 750^0C they get burnt to produce noxious gases.

Fig. 3.7 Preparation of Plastic Coated Aggregate

3.4 EXPERIMENTAL WORK ON RAW MATERIAL

The experimental works carried out in this present investigation. It involves mainly 2 processes. i.e.

- Preparation of Marshall samples
- Tests on samples

Prior to these experiments, the specific gravity of polythene used was calculated as per the guidelines provided in ASTM D792-08.

3.4.1. DETERMINATION OF SPECIFIC GRAVITY OF POLYTHENE

The procedure adopted is given below:

1) The weight of the polythene in air was measured by a balance. Let it be denoted by "a".
2) An immersion vessel full of water was kept below the balance.
3) A piece of iron wire was attached to the balance such that it is suspended about 25 mm above the vessel support.
4) The polythene was then tied with a sink by the iron wire and allowed to submerge in the vessel and the weight was measured. Let it be denoted as "b".
5) Then polythene was removed and the weight of the wire and the sink was measured by submerging them inside water. Let it be denoted as "w".

The specific gravity is given by:-

$$s = a / (a + w - b)$$

Where:-

a = apparent mass of specimen, without wire or sinker, in air.

b = apparent mass of specimen and of sinker completely immersed and of the wire

Partially immersed in liquid.

w = apparent mass of totally immersed sinker and of partially immersed wire.

From the experiment, it was found that:-

a = 19 gm, b = 24 gm, w = 26 gm.

s = 19 / (19+26-24) = 19/21 = 0.90476

Take s = 0.905.

3.4.2 TEST ON BITUMEN

3.4.2.1 PENETRATION TEST

The penetration of bitumen is defined as the distance in tenth of a millimeter that a standard needle will penetrate into the bitumen under a load of 100 gm applied for five second, at 25^0C. The softer the bitumen, the grater will be the penetration. Penetration test is the most commonly adopted test on bitumen to grade the material in terms of its hardness. Depending upon the climatic condition, bitumen of different penetration grades are used, in warmer regions lower penetration grades and in colder regions bitumen with higher penetration value is used.

In this test, bitumen is softened ta a pouring consistency between 82^0C to 110^0C. The sample material is thoroughly stirred to make it homogeneous and free from air bubbles. The sample material is then poured into the containers to a depth at least 15 mm more than the expected penetration. The sample containers are allowed to cool in the atmosphere for one hour. Then it is placed in temperature controlled water bath at a temperature of 25^0C for a period of one hour. A standard needle is then allowed to penetrate into the surface for 5 second under the correct loading. This is done by means of an instrument known as penetrometer. This test is standardized by IS: 1203-1978.

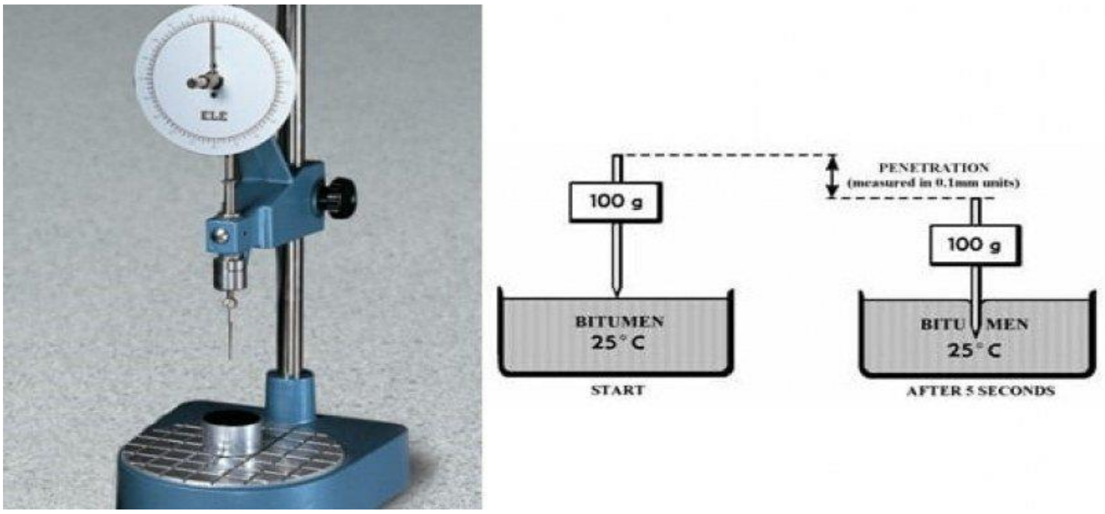

Fig. 3.8 Penetration Test

3.4.2.2 SOFTENING TEST

The softening point is the temperature at which the substance attains a particular degree of softening under specified condition of test. The softening point of a bitumen binder is the temperature at which a disc of the binder softens sufficiently to allow a steel ball, initially placed on the surface, to fall through the disc and a prescribed distance. It is usually determined by Ring and Ball test. Softening point essentially is a temperature at which binders have an equal viscosity. Bitumen with higher softening point may be preferred in warmer place.

In this test, two brass rings are filled with hot bitumen and allowed to cool in air for 30 minutes. The excess bitumen is trimmed and the rings are placed in supports. At this time, the temperature of water is kept at 5^0C for 15 minutes. The temperature of water is raised at uniform rate of 5^0C per minute with a controlled heating unit, unit the bitumen softens and touches the bottom plate by sinking of balls.

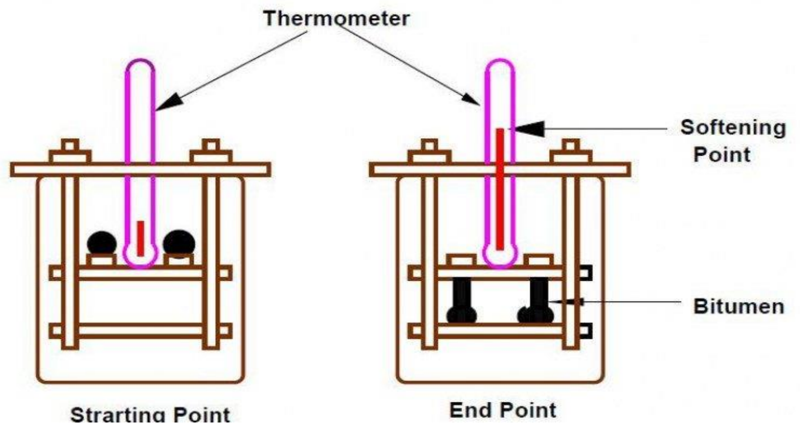

Fig. 3.9 Softening Test

3.4.2.3 DUCTILITY TEST

In the flexible pavement construction where bitumen binder are used, it is important that the binder form ductile thin film around the aggregates. This serves as a satisfactory binder in improving the physical interlocking of the aggregate bitumen mixed. Under traffic load the bituminous pavement layer is subjected to repeated deformation and recoveries. The binder material which does not possess sufficient ductility would crack and thus provide pervious pavement surface. Ductility test is carried out on bitumen to test property of binder.

The ductility is expressed as the distance in centimeters to which a standard briquette of bitumen can be stretched before the thread breaks. The bitumen sample is heated and poured in the mould assembly placed on a plate. The sample along with the moulds are cooled in air and then in water bath maintained at 27^0C. The mould assembly containing the sample is replaced in water bath of the ductility testing machine for 85 to 95 minutes. The sides of the mould are removed, the clips hooks in the machine and the pointer is adjusted to zero. The distance up to the point of breaking of the thread is reported in centimeters as the ductility value.

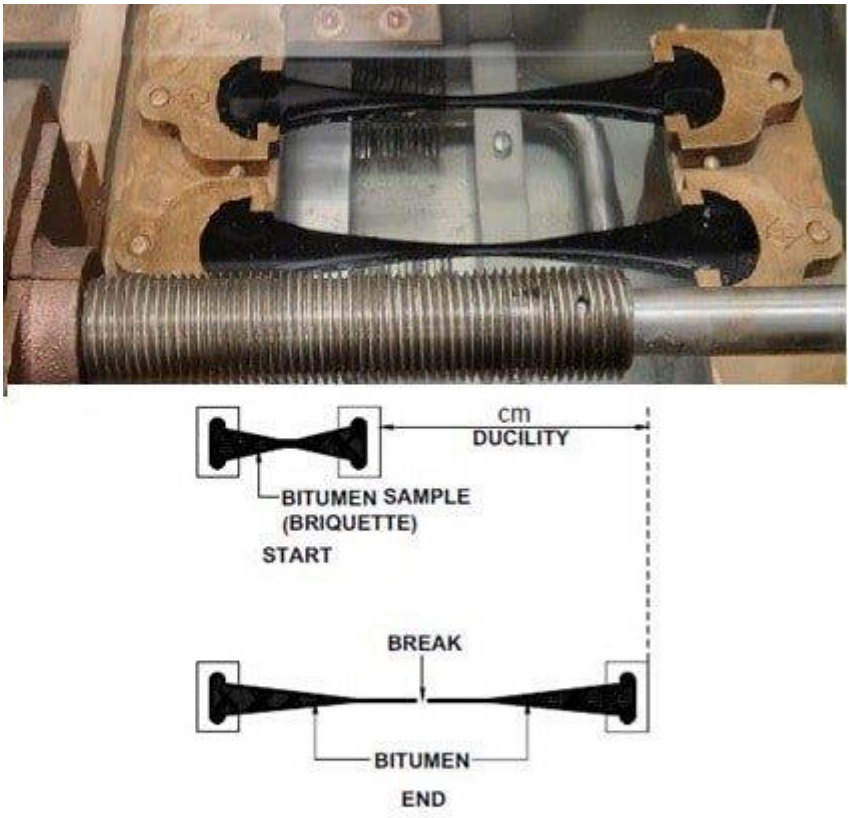

Fig. 3.10 Ductility Test

3.5 SAMPLE PREPARATION

3.5.1 MARSHALL SAMPLING MOULD

The specifications of the Marshall sampling mould and hammer are given in table 3.4.

Table 3.4 Dimensions of Marshall Sampling mould & Hammer

APPARATUS	VALUE	WORKING TOLERANCE
MOULD		
Average internal diameter, mm	101.2	± 0.5
HAMMER		
Mass, kg	4.535	± 0.02
Drop Height, mm	457	± 1.0
Foot diameter, mm	98.5	± 0.5

Fig. 3.11 Marshall Sampling Mould

Fig. 3.12 Marshall Hammer

3.5.2 MIXING PROCEDURE

The mixing of ingredients was done as per the following procedure (STP 204-8).

1) Required quantities of coarse aggregate, fine aggregate & mineral fillers were taken in an iron pan.
2) This was kept in an oven at temperature 1600C for 2 hours. This is because the aggregate and bitumen are to be mixed in heated state so preheating is required.
3) The bitumen was also heated up to its melting point prior to the mixing.
4) The required amount of shredded waste polythene was weighed and kept in a separate container.
5) The aggregates in the pan were heated on a controlled gas stove for a few minutes maintaining the above temperature.
6) The waste polythene was added to the aggregate and was mixed for 2 minutes.
7) Now bitumen was added to this mix and the whole mix was stirred uniformly and homogenously. This was continued for 15-20 minutes till they were properly mixed which was evident from the uniform Colour throughout the mix.
8) Then the mix was transferred to a casting mould.
9) This mix was then compacted by the Marshall Hammer. The specification of this hammer, the height of release etc. are given in Table – 4.1.
10) 75 no. Of blows were given per each side of the sample so subtotal of 150 no. of blows was given per sample.
11) Then these samples with moulds were kept separately and marked.

Fig. 3.13 Mixing of Mixture

Fig. 3.14 Pouring of Mixture

Fig. 3.15 Tamping

Fig. 3.16 Prepared Specimen

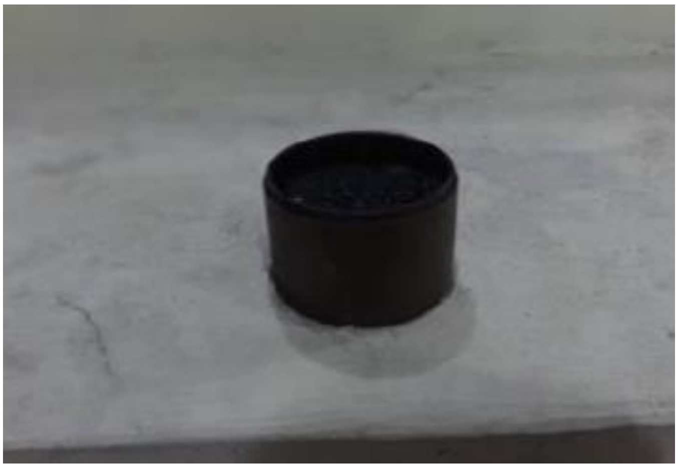

Fig. 3.17 24 Hours Cooling

Fig. 3.18 Marshall Sample

3.6 SAMPLE CALCULATION

3.6.1 AT 0% WASTE POLYTHENE (POLYETHYLENE)

(1) Bitumen Content = 5 %

Stability = 920 Kg, Flow Value = 3.6 mm

$$Gt = \frac{100}{\left(\frac{63.65}{2.71}\right) + \left(\frac{26.6}{2.63}\right) + \left(\frac{4.75}{3.15}\right) + (5/1.01)} = 2.50$$

$$Gb = \frac{1196}{1196 - 691} = 2.37$$

$$Vv\ \% = \frac{100(2.50 - 2.37)}{2.50} = 5.2$$

$$Vb\ \% = 5 \times \frac{2.37}{1.01} = 11.73$$

VMA % = 16.93

$$VFB\ \% = \frac{100\ \times 11.73}{16.93} = 69.28$$

(2) Bitumen Content = 5.5 %

Stability = 1110 Kg, Flow Value = 3.75 mm

$$Gt = \frac{100}{\left(\frac{63.315}{2.71}\right) + \left(\frac{26.46}{2.63}\right) + \left(\frac{4.725}{3.15}\right) + \left(\frac{5.5}{1.01}\right)} = 2.48$$

$$Gb = \frac{1198}{1198 - 696} = 2.39$$

$$Vv\ \% = \frac{100\ \times (2.48 - 2.39)}{2.48} = 3.36$$

$$Vb\% = 5.5\ \times \frac{2.39}{1.01} = 13.01$$

VMA % = 16.64

$$VFB\ \% = \frac{100\ \times 13.01}{16.64}\ 78.18$$

(3) Bitumen Content = 6%

Stability = 873, Flow Value = 4.00 mm

$$Gt = \frac{100}{\left(\frac{62.98}{2.71}\right) + \left(\frac{26.32}{2.63}\right) + \left(\frac{4.7}{3.15}\right) + \left(\frac{6}{1.01}\right)} = 2.46$$

$$Gb = \frac{1197}{1197 - 694} = 2.38$$

$$Vv\ \% = \frac{100\ \times (2.46 - 2.38)}{2.46} = 3.25$$

$$Vb\ \% = 6\ \times \frac{2.38}{1.01} = 14.13$$

VMA % = 17.38

$$VFB\ \% = \frac{100 \times 14.13}{17.38} = 81.3$$

3.6.2 At 0% WASTE POLYTHENE (POLYPROPLENE)

(1) <u>Bitumen Content = 5 %</u>

Stability = 950 Kg, Flow Value = 3.00 mm

$$Gt = \frac{100}{\left(\frac{48.45}{2.71}\right) + \left(\frac{40.85}{2.63}\right) + \left(\frac{5.7}{3.15}\right) + \left(\frac{5}{1.01}\right)} = 2.49$$

$$Gb = \frac{1196}{1196 - 685} = 2.34$$

$$Vv\ \% = \frac{100\ \times (2.49 - 2.34)}{2.49} = 6.02$$

$$Vb\ \% = 5\ \times \frac{2.34}{1.01} = 11.58$$

VMA % = 17.6

$$VFB\ \% = \frac{100\ \times 11.58}{17.6} = 65.80$$

(2) Bitumen Content = 6 %

Stability = 1150 Kg, Flow Value = 3.30 mm

$$Gt = \frac{100}{\left(\frac{47.94}{2.71}\right) + \left(\frac{40.42}{2.63}\right) + \left(\frac{5.64}{3.15}\right) + \left(\frac{6}{1.01}\right)} = 2.45$$

$$Gb = \frac{1194}{1194 - 687} = 2.35$$

$$Vv\ \% = \frac{100\ \times (2.45 - 2.35\ )}{2.45} = 4.08$$

$$Vb\ \% = 6 \times \frac{2.35}{1.01} = \ 13.96$$

VMA % = 18.04

$$VFB\ \% = \frac{100\ \times 13.96}{18.04} = 77.38$$

(3) Bitumen Content = 7 %

Stability = 1060 Kg, Flow Value = 3.95 mm

$$Gt = \frac{100}{\left(\frac{47.43}{2.71}\right) + \left(\frac{39.99}{2.63}\right) + \left(\frac{5.58}{3.15}\right) + \left(\frac{7}{1.01}\right)} = 2.41$$

$$Gb = \frac{1196}{1196 - 680} = 2.32$$

$$Vb\,\% = 7 \times \frac{2.32}{1.01} = 16.08$$

VMA % = 19.81

$$VFB\,\% = \frac{100 \times 16.08}{19.81} = 81.17$$

Table 3.5 Result of Marshall Test of Dense Bitumen Macadam (Polyethylene)

Bitumen (%)	**Waste Polythene (%)**	**Stability (Kg)**	**Flow (mm)**	**Air Voids (%)**	**Bulk Density (gm/cm^3)**	**VMA (%)**	**VFB (%)**
5	0	920	3.60	5.2	2.37	16.93	69.28
5.5	0	1110	3.75	3.63	2.39	16.64	78.18
6	0	873	4.00	3.25	2.38	17.38	81.3
5	3	1250	3.45	4.84	2.36	16.50	70.66
5.5	3	1590	3.62	3.25	2.38	16.19	79.93
6	3	1145	3.95	2.86	2.35	16.91	83.08
5	6	1720	3.20	4.82	2.35	16.41	70.63
5.5	6	2210	3.45	3.06	2.375	15.95	80.81
6	6	1976	3.78	2.88	2.36	16.85	82.91
5	9	2418	2.90	4.69	2.335	16.2	71.05
5.5	9	2840	3.10	2.88	2.36	15.67	81.62
6	9	2670	3.40	2.49	2.35	16.43	84.80
5	12	2090	2.95	4.51	2.33	15.97	71.76
5.5	12	2465	3.18	2.69	2.355	15.43	82.57
6	12	2250	3.50	2.51	2.33	16.25	84.55
5	15	1738	2.98	4.45	2.32	15.93	71.56
5.5	15	2194	3.25	2.53	2.34	15.13	83.48
6	15	1840	3.60	2.44	2.322	16.11	84.85

Table 3.6 Marshall Test Result of Dense Bitumen Macadam (Polypropylene)

Bitumen (%)	Waste Polythene (%)	Stability (Kg)	Flow (mm)	Air Voids (%)	Bulk Density (gm/cm^3)	VMA (%)	VFB (%)
5	0	950	3.00	6.02	2.34	17.6	65.8
6	0	1150	3.30	4.08	2.35	18.04	77.38
7	0	1060	3.95	3.73	2.32	18.01	81.17
5	3	1495	2.80	6.65	2.34	17.22	67.19
6	3	1730	3.10	3.28	2.36	17.27	81
7	3	1547	3.50	3.17	2.324	19.24	83.52
5	6	2060	2.50	5.28	2.33	16.78	68.53
6	6	2495	2.7	3.10	2.36	16.99	81.74
7	6	2238	3	2.94	2.31	18.87	84.42
5	9	2585	2	4.89	2.33	16.37	70.13
6	9	3160	2.25	2.5	2.34	16.33	84.69
7	9	2890	2.8	2.42	2.33	18.46	85.89
5	12	2100	2.12	4.73	2.315	16.12	70.65
6	12	2752	2.36	2.5	2.33	16.24	84.60
7	12	2460	3.1	2.14	2.29	17.88	86.24
5	15	1830	2.2	4.60	2.30	16.02	70.92
6	15	2370	2.49	2.43	2.31	16.11	85.06
7	15	2010	3.25	2.01	2.275	17.35	86.54

Table 3.7 Indirect Tensile Strength of Dense Bitumen Macadam (Polyethylene)

Waste Polythene (%)	Optimum Bitumen Content (%)	Load (Kg)	Indirect Tensile Strength at 25^0C (Kg/cm^2)
0	5	910	8.98
3	5	1163	11.48
6	5	1595	15.74
9	5	1842	18.17
12	5	1484	14.64
15	5	1035	10.21

Table 3.8 Indirect Tensile Strength of Dense Bitumen Macadam (Polypropylene)

Waste Polythene (%)	Optimum Bitumen Content (%)	Load (Kg)	Indirect Tensile Strength at 25^0C (Kg/cm^2)
0	5	1005	9.92
3	5	1356	13.38
6	5	1610	15.89
9	5	1950	19.25
12	5	1509	14.90
15	5	1250	12.34

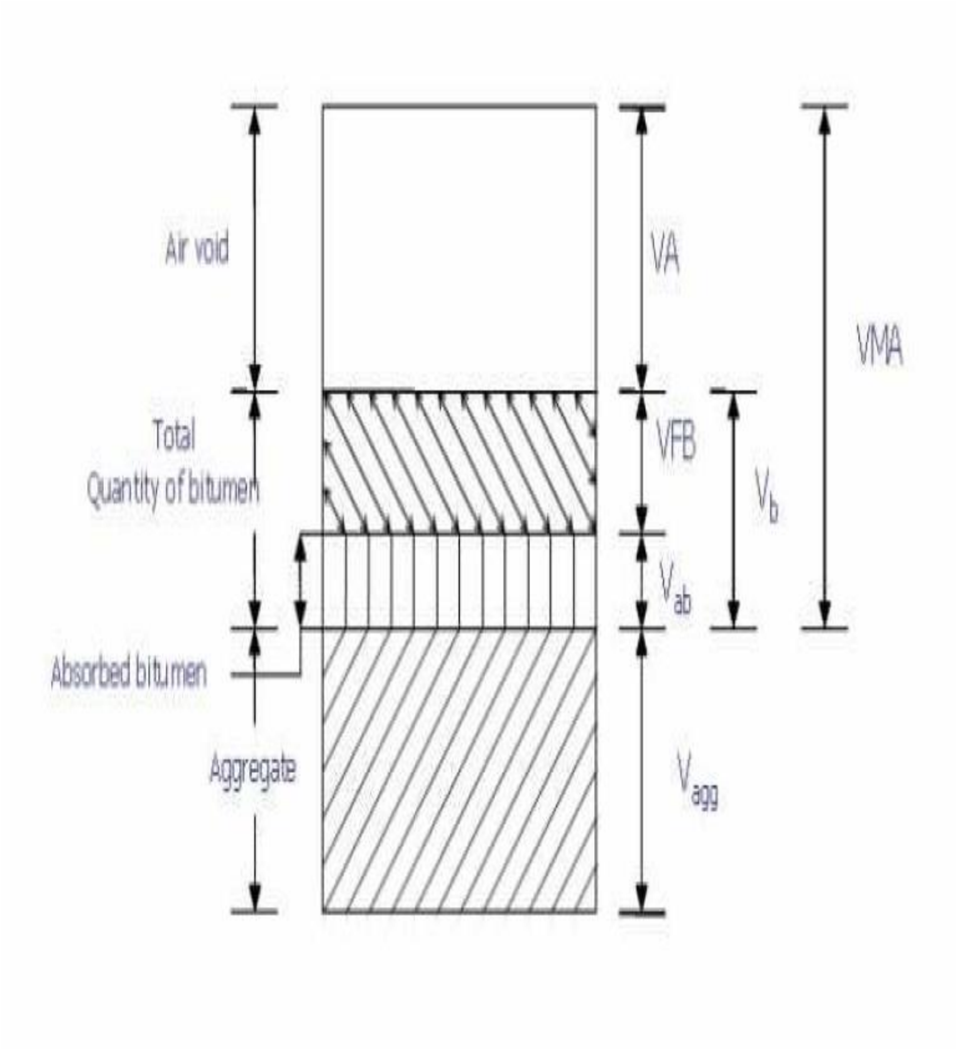

Fig 3.19 Phase Diagram Mix Volumetrics

(Chakroborty & Das, Principles of Transportation Engineering)

3.7 VOIDS ANALYSIS

For analysis of voids, the samples were weighed in air and also in water so that water replaces the air present in the voids. But by this process some amount of water will be absorbed by the aggregates which give erroneous results. Hence 1st the samples were coated with hot paraffin so that it seals the aggregate-bitumen mix completely and checks the absorption of water into it.

CHAPTER 4

ANALYSIS OF RESULT

4.1 PLOTTING CURVES

4 curves were plotted. i.e.

- Marshall Stability Value v/s Waste Polythene Content.
- Marshall Flow Value v/s Waste Polythene Content.
- Air Voids (Vv) v/s Waste Polythene Content.
- Voids Filled with Bitumen (VFB) v/s Waste Polythene Content.

For each % of polythene, 3 samples have been tested. So the average value of the 3 were taken. The mean values are shown in Table - 5.1 and Table – 5.2

4.1.1 PLOTTING CURVES FOR POLYETHYLENE

Table 4.1 Data for Plotting Curves (Polyethylene)

Waste Polythene (%)	Optimum Bitumen Content (%)	Stability (Kg)	Flow (mm)	% Air Voids (Vv)	Voids Filled With Bitumen (VFB)
0	5	1100	3.73	3.78	77
3	5	1575	3.58	3.5	77.8
6	5	2140	3.39	3.48	78.14
9	5	2810	3.05	3.18	80
12	5	2392	3.11	3.00	80.69
15	5	2128	3.18	2.28	81.25

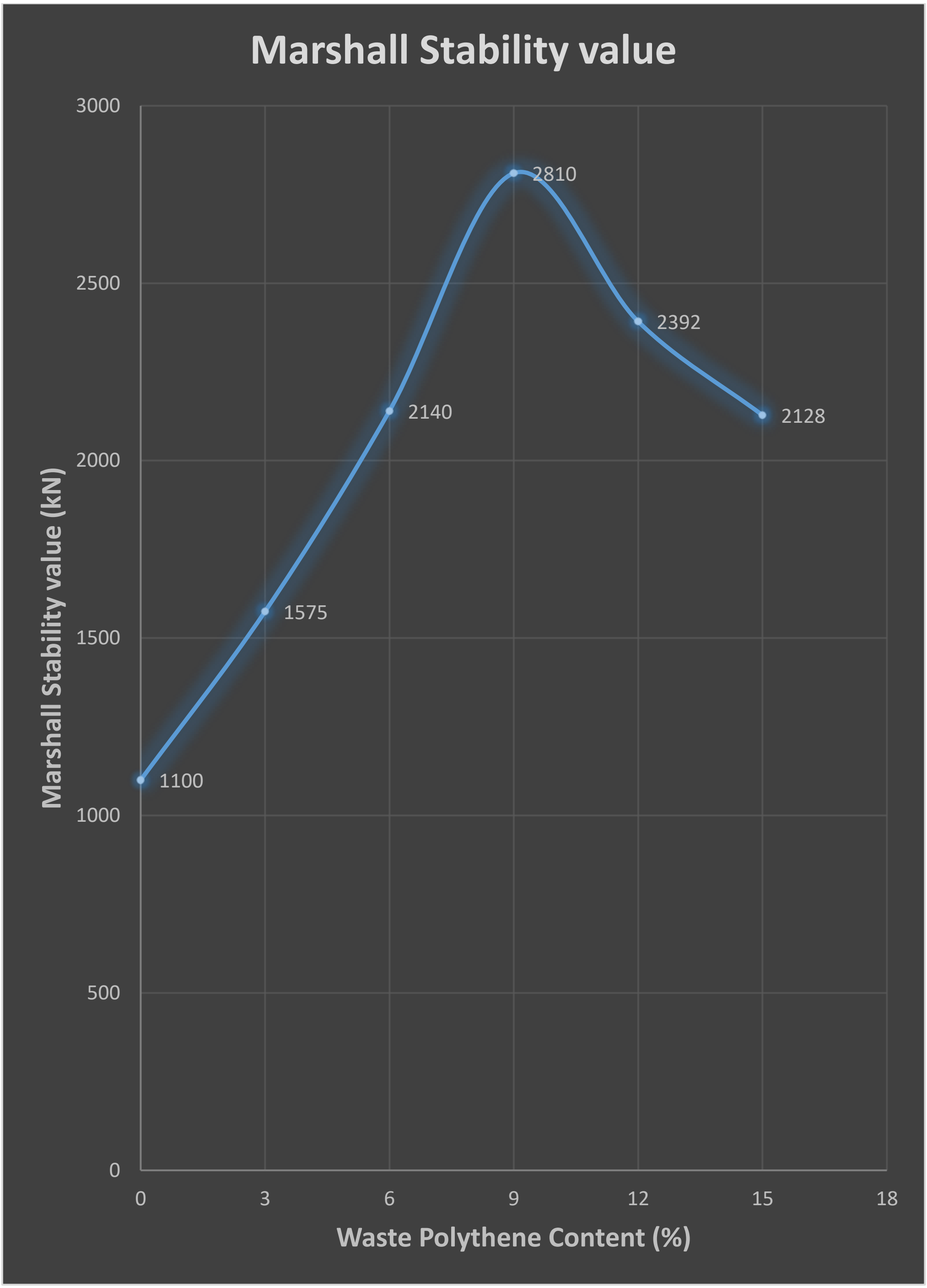

Fig. 4.1: Marshall Stability Value V/S Polythene Content

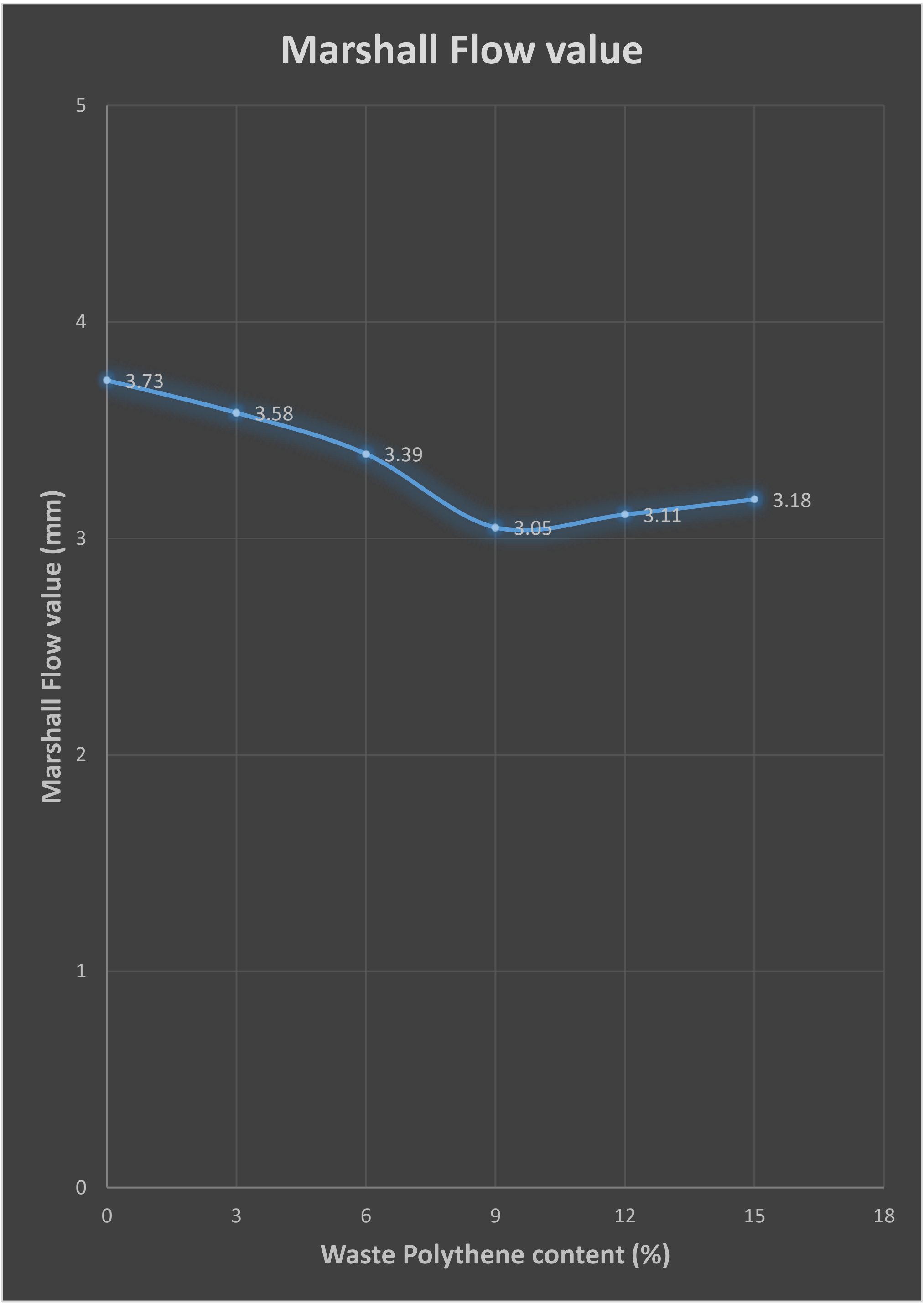

Fig. 4.2: Marshall Flow Value V/S Polythene Content

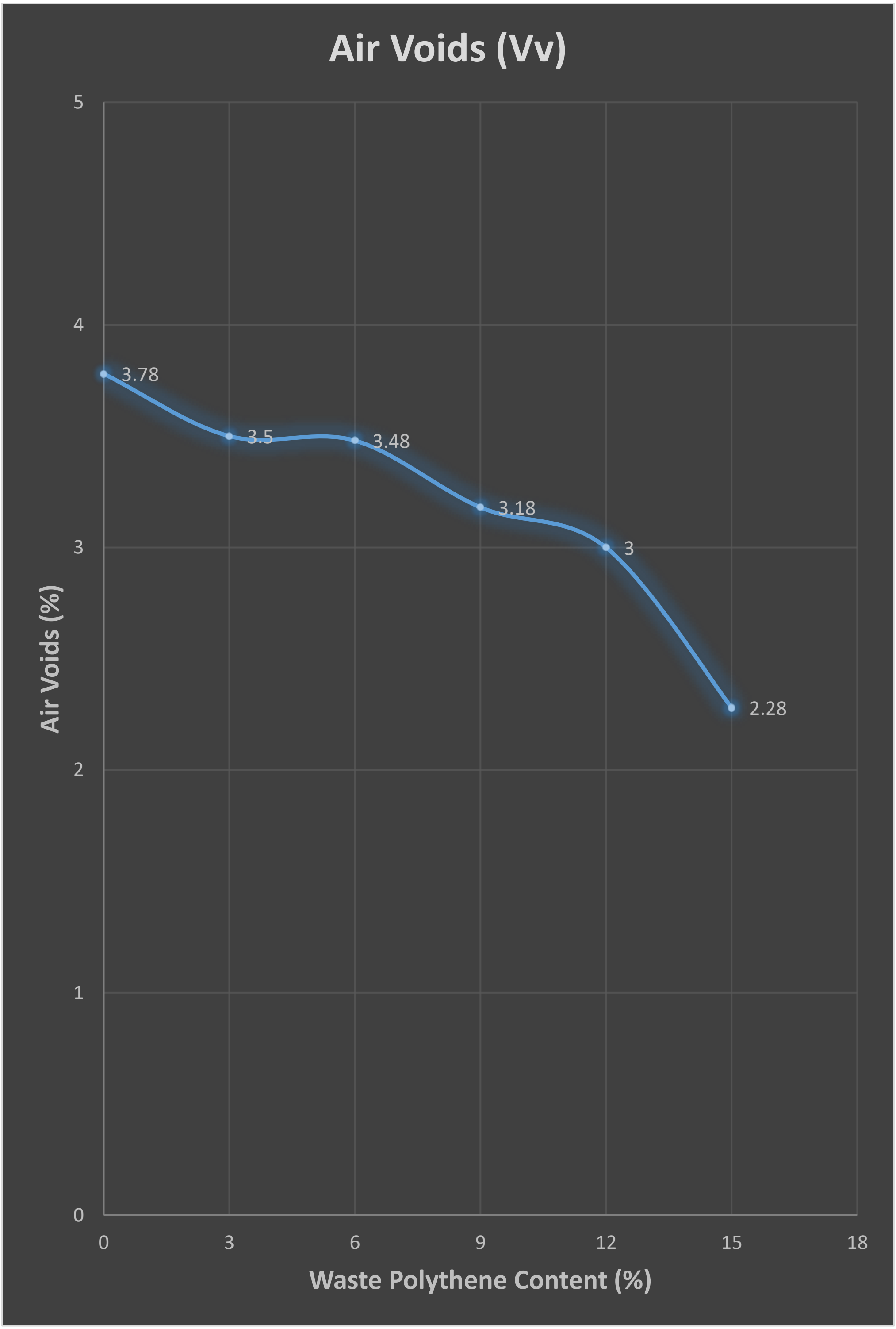

Fig. 4.3: Air Voids V/S Polythene Content

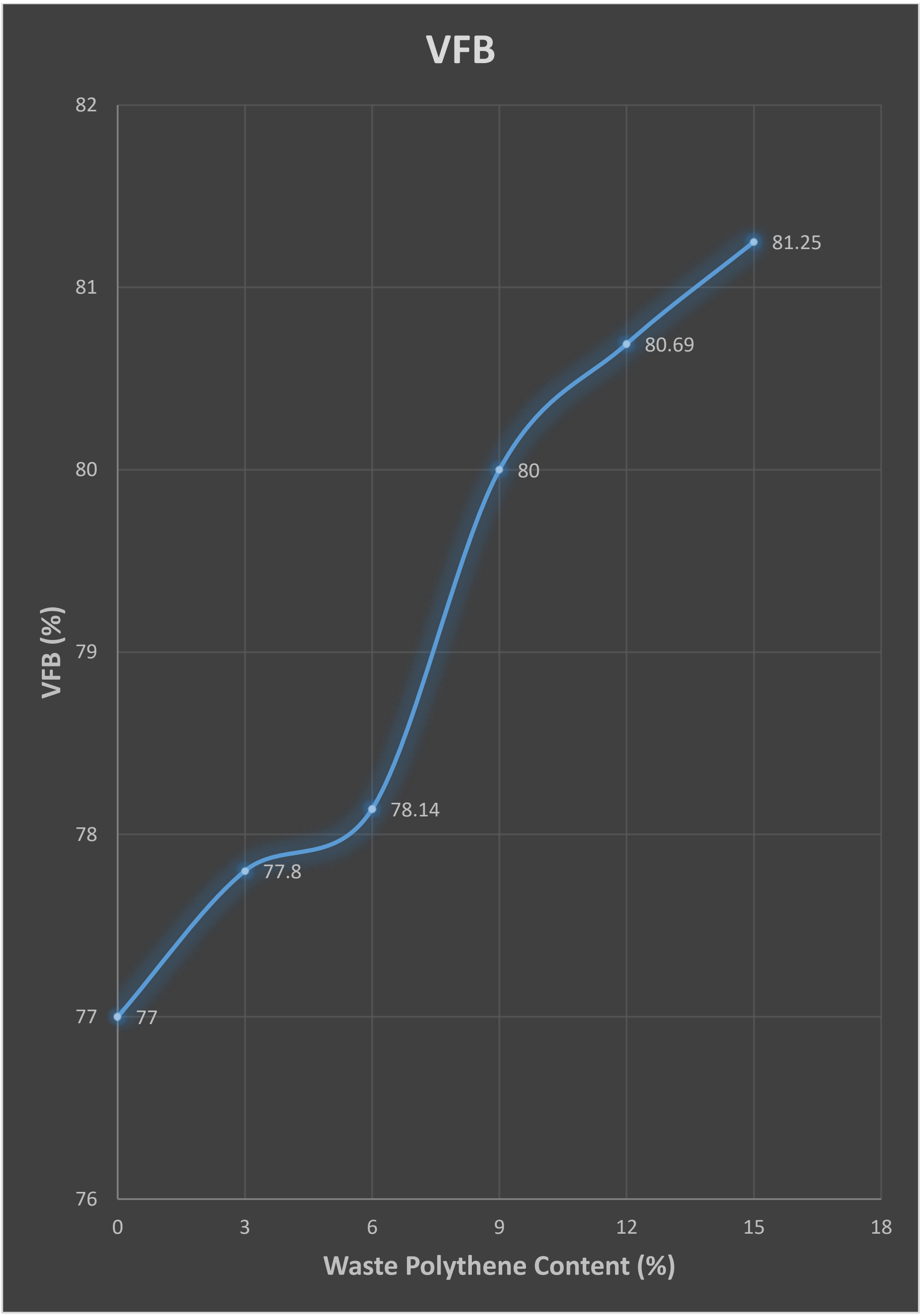

Fig. 4.4: VFB V/S Polythene Content

4.1.2 PLOTTING CURVES FOR POLYPROPYLENE

Table 4.2 Data for Plotting Curves (Polypropylene)

Waste Polythene (%)	Optimum Bitumen Content (%)	Stability (Kg)	Flow (mm)	% Air Voids (Vv)	Voids Filled With Bitumen (%)
0	5	1155	3.31	3.88	77.32
3	5	1724	3.06	3.54	79.48
6	5	2441	2.68	3.20	80.02
9	5	3094	2.19	2.84	82.3
12	5	2640	2.25	2.98	81.25
15	5	2238	2.38	3.08	80.77

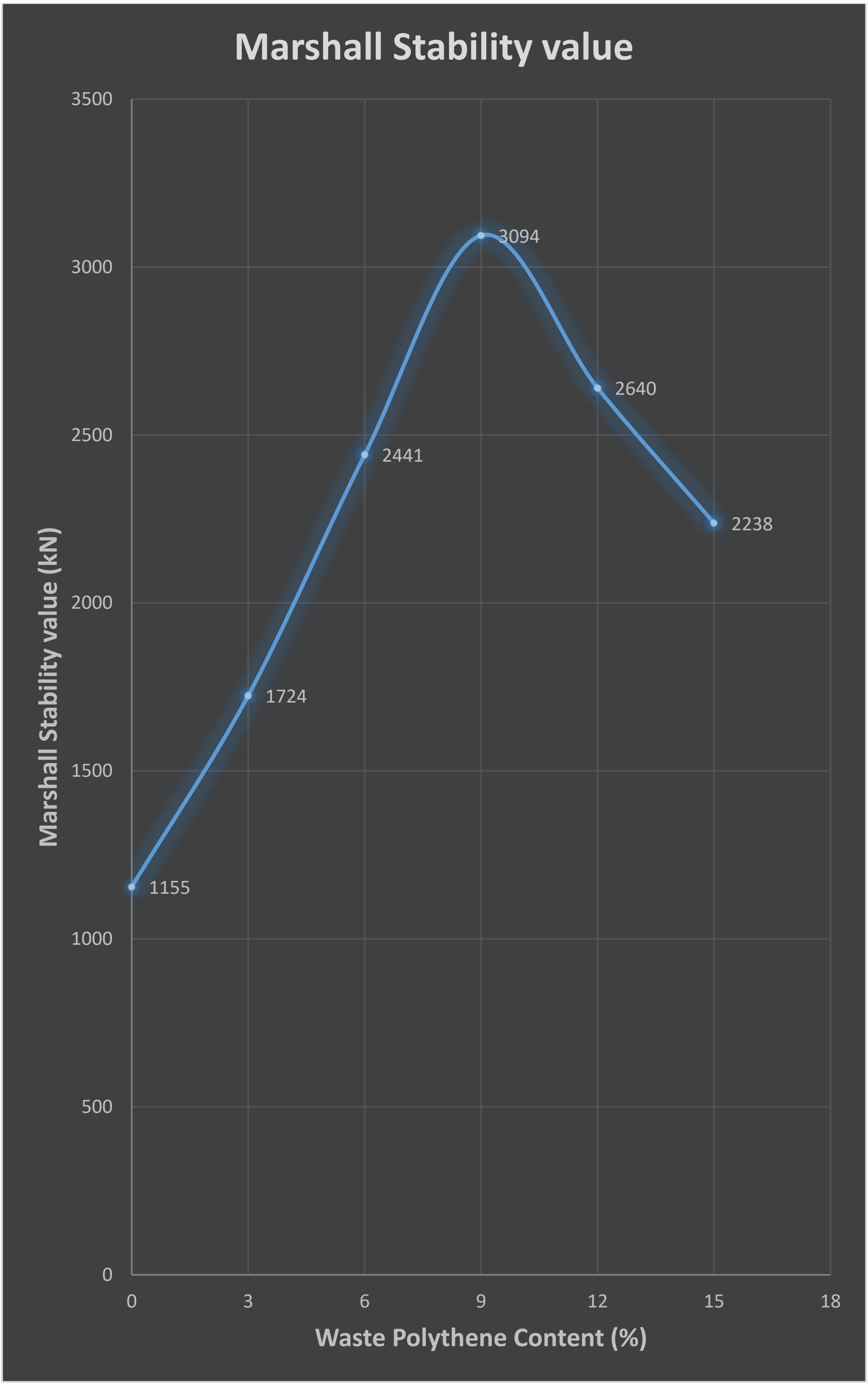

Fig. 4.5: Marshall Stability Value V/S Polythene Content

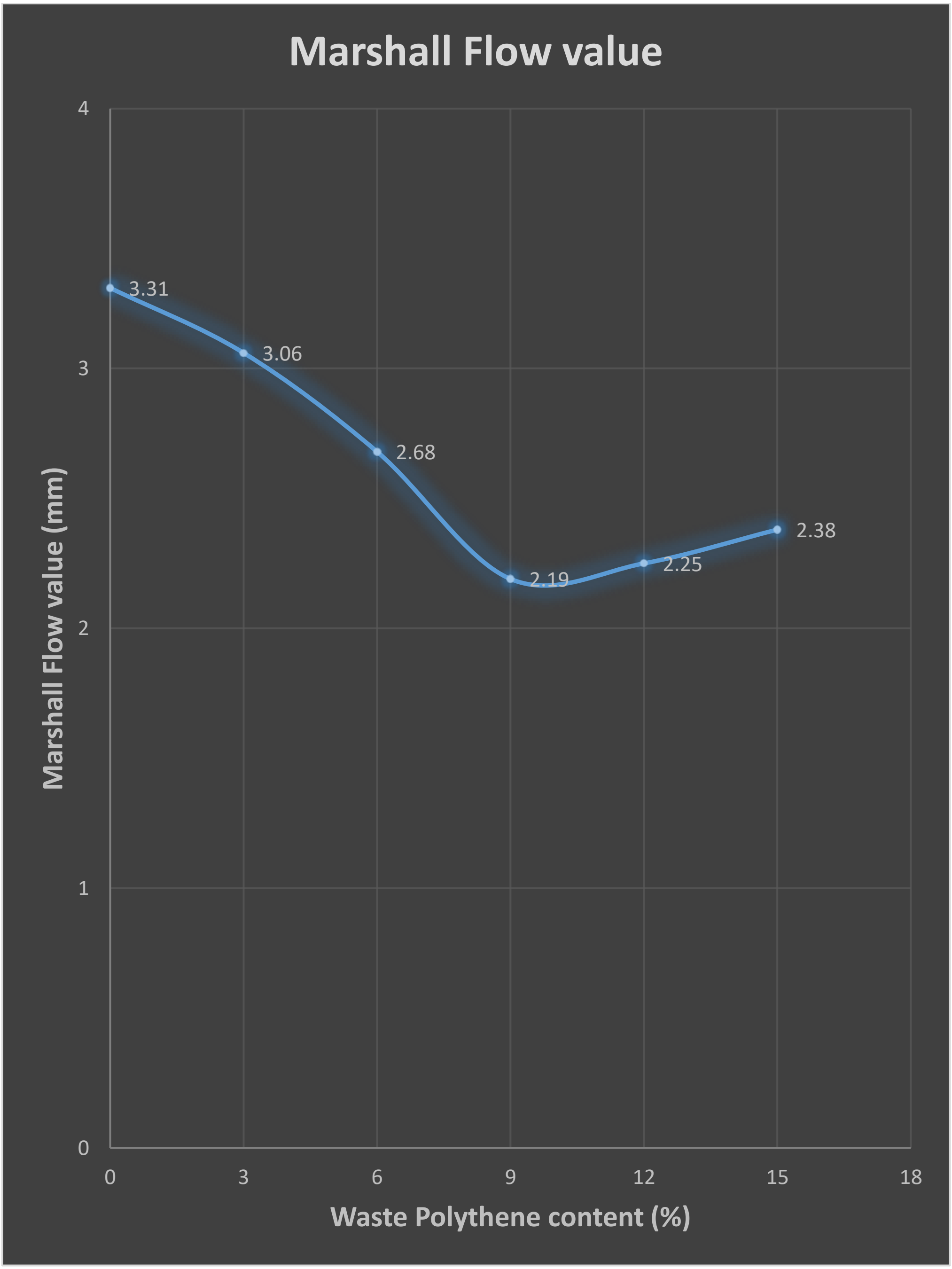

Fig. 4.6: Marshall Flow Value V/S Polythene Content

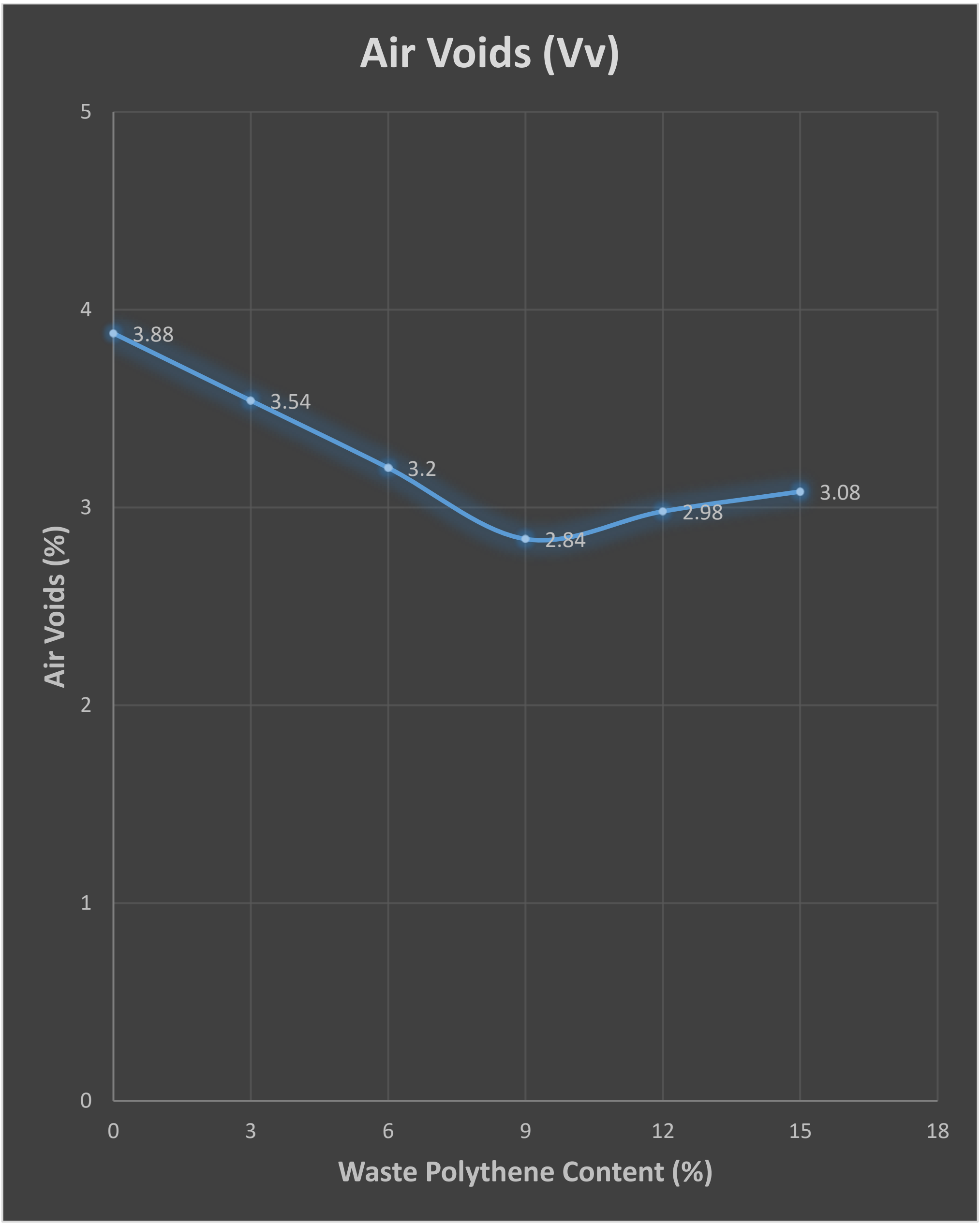

Fig. 4.7: Air Voids V/S Polythene Content

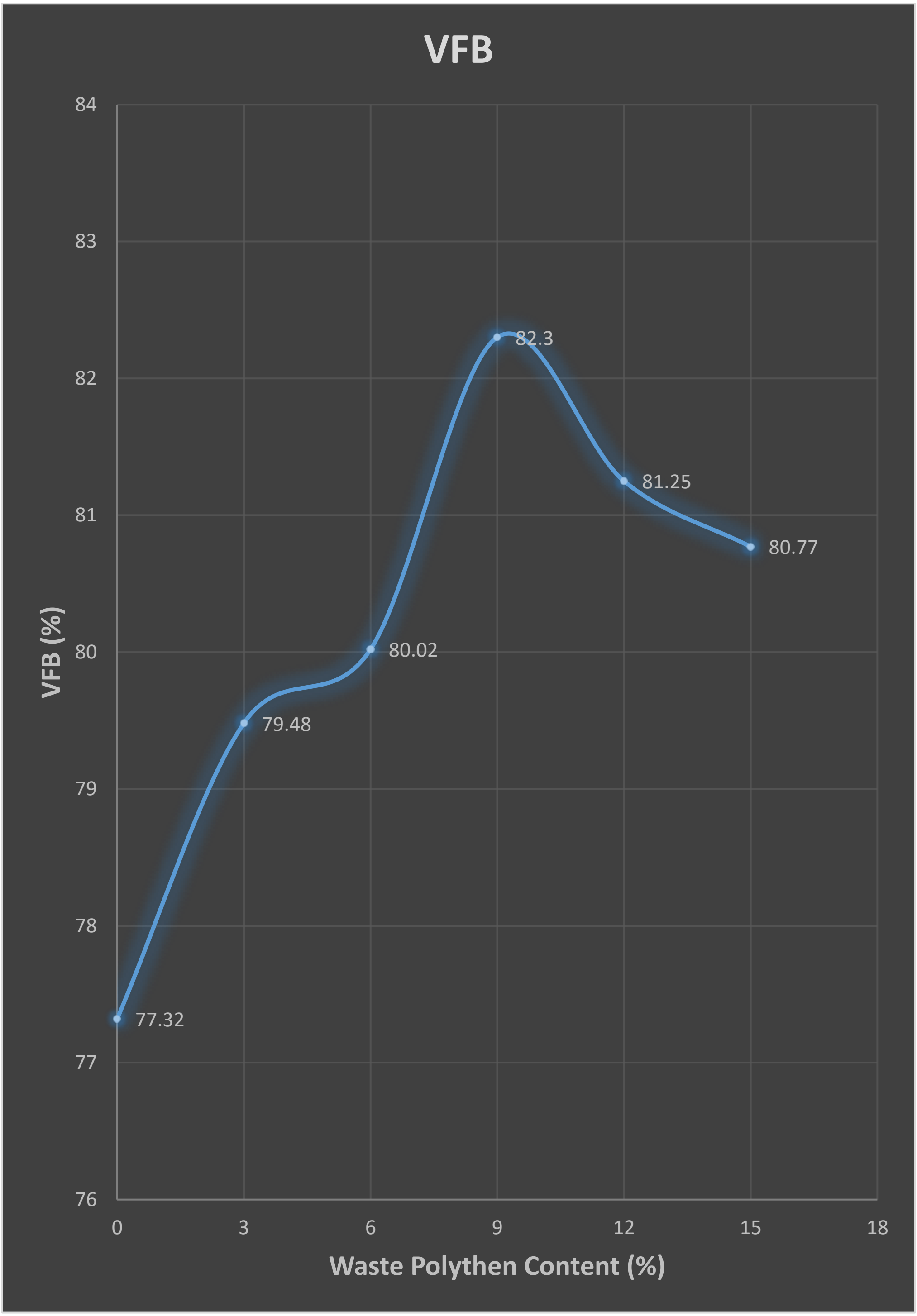

Fig. 4.8: VFB V/S Polythene Content

4.2 COST ANALYSIS (DBM)

Cost Estimation of waste polythene Road construction:-

- **Making 1Km. Normal bitumen road:-**

Total Wt. of mix (as per data book) = 450 tones

Wt. of bitumen (as per data book) = 5% of total wt. of mix

= 23 tones

Wt. of aggregate = 450 – 23 = 427 tones

Cost of bitumen for 1 Kg. is 36 Rs/-.

1 kg. = 36 Rs/-

1 tone = 36 x 1000 = 36,000 Rs/-

23 tones = 23 x 36,000 = 828,000 Rs/-

Total Cost of bitumen for 1 Km. road is 828,000 Rs/-

- **Making 1Km. Waste Polythene Coated aggregate Road:-**

Total Wt. of mix (as per data book) = 450 tones

Wt. of bitumen (as per data book) = 5% of total wt. of mix

= 23 tones

Adding waste polythene (according to test) = 9% of bitumen = 2.1 tones

Sr. No.	**Particulars**	**Approx. Rate (Rs./Kg)**
1	Waste Polythene	0
2	Collection of polythene	2
3	Transportation	2
4	Cleaning / Shredding	3
5	Labor Charger	4
6	Machinery Charges including electricity / Maintenance	2
	Total	13

Cost of waste polythene for 1Kg. is 13 Rs/-

1 Kg. = 13 Rs/-

1 tones = 13 x 1000 = 13,000 Rs/-

2.1 tones = 13,000 x 2.1 = 27,500 Rs/-

Total cost of waste polythene for 1 Km. road is 27,500 Rs/-

- **Required bitumen in waste polythene coated aggregate road:-**

Required bitumen in waste polythene road = (Wt. of bitumen) –

(Adding waste polythene)

= (23 tones) – (2.1 tones)

= 20.9 ≅ 21 tones

Cost of 21 tones bitumen = 21 x 36,000

= 756,000 Rs/-

Saving cost of bitumen in 1 Km. of waste polythene coated aggregate road

= 828,000 – 756,000

= **72,000 Rs/-**

Total saving cost in bitumen is 8% to 9%.

CHAPTER 5

CONCLUSIONS

5.1 GENERAL

From the study of the behavior of Waste polythene it was found that the modified mix possesses improved Marshall Characteristics as mentioned below.

It is observed that Marshall Stability value increases with polyethylene content upto 9% and thereafter decreases. We observe that the Marshall Flow value decreases upon addition of Waste polythene i.e. the resistance to deformations under heavy wheel loads increases. Also the values of the parameters like VMA, VA, VFB are within the required specifications.

Considering these factors we can assure that we can obtain a more stable and durable mix for the pavements by Waste Polythene modifications. This small investigation not only utilizes beneficially, the waste non-degradable Polythene but also provides us an improved pavement with better strength and longer life period.

Waste Polythene modified pavements would be a boon for India's hot and extremely humid climate, where temperatures frequently rises past 50°C and torrential rains create heavy leaving most of the roads with heavy distresses. This adversely affects the life of the pavements. The Waste Polythene modified bitumen show improved properties for pavement constructions. This also can reduce the amount of plastics waste which otherwise are considered to be a threat to the hygiene of the environment.

In this modification process Waste Polythene is coated over aggregate. This increases the surface area of contact at the interface and ensures better bonding between aggregate and bitumen. The polymer coating also reduces the void spaces present in the mix. This prevents the moisture absorption and oxidation of bitumen by entrapped air. The road can withstand heavy traffic and show better service life. This study will have a positive impact on the environment as it will reduce the volume of Waste Polythene to be disposed of by incineration and land filling. It will not only add value to Waste Polythene but will develop a technology, which is eco-friendly.

However, it is recommended that more research regarding the topic should be done and more trial sections should be laid and their performance should be studied.

5.2 Future Scope of Plastic Road

As the population increases, the solid waste also increases proportionally. The best alternative is the usage of waste as construction material assuring a good disposal. As this method is economic the practice would be on satisfactory extent aiding the future generations for a good solid waste management.

The main scopes of plastic roads are:-

- **Economic in terms of bitumen: -** The shredded plastic in form of polymer covers the aggregates and thus occupies a larger portion of the road reducing the quantity of bitumen needed.
- **Efficient management of non-biodegradable waste: -** Plastic is a harmful and non-biodegradable waste responsible mainly for land pollution. Utilizing it for road construction will result in its efficient management.
- **Easy process without any new machinery: -** It is a simple and easy technique which does not involve any complex or new machinery.
- **Enhanced durability: -** The addition of plastic to bitumen will help in improving the strength and durability of the pavement.

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Study of waste polythene used in flexible pavement

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ABSTRACT

Waste polythene which is increased week to week becomes messed of the waste polythene it turns pollutes the environment, especially where there is no garbage collection system existed. A large amount of plastic comes into the tourist trekking regions and housing area are discarded or burned which is released harmful gases into the environment and air. The waste polythene collected from domestic and industrial sectors can be used in the production of plastics coated aggregate. Waste polythene, mainly used for packing and carrying any food. It's made up of Polyethylene, Polypropylene, and polystyrene. There softening point varies between 110 degree Celsius – 140 degree Celsius and if the wastes polythene is heated thesis temperature range then they do not produce any toxic gases but the softened waste polythene have tendency to form a film like structure over the aggregate, when it is sprayed over the hot aggregate at 160 degree Celsius – 170 degree Celsius. The Plastics Coated Aggregates (PCA) is a better raw material for the construction of flexible pavement. PCA was mixed with hot bitumen of different types and the mixes were used for road construction.

Keywords— *Waste plastics, Plastic coated aggregate, Bitumen, Polyethylene, Polypropylene, Polystyrene*

1. INTRODUCTION

The continuous growth rate of the population of India has resulted in an overall count of around 1.35352 Billion people which represents almost 18% of the world's total population according to google. Plastics is a material which easily changes his shape and a friend to common man. This time Plastic is everywhere in today's lifestyle. In recent years, applications of plastic wastes have been considered in road construction with great interest in many developing countries. The use of these materials in road making is based on technical, economic, and ecological criteria. Several million metric tons of plastic wastes are produced every year in India. Plastics waste constitutes a significant portion of the total municipal solid waste (MSW) generated in India. However, the end-of-life plastics can be recycled into a second life application but after every thermal treatment, degradation of plastics takes place to a certain extent. To evaluate the performance of the built roads using plastics waste coated aggregate (PCA) bitumen mix and also to generate a database for evolving Standards by Indian Road. Disposal of a variety of plastic wastes in an eco-friendly way is the thrust area of today's research. The waste plastics used for the construction of flexible pavement material which would give better stability, durability, resistance and strength to the road as compared to the conventional material made road. Plastic wastes consisting of mainly Polyethylene, Polypropylene and Polystyrene from items such as carry bags, cups, and thermocouples and packaging films is a major problem for their disposal. In this study, the plastic wastes were shredded into a small size, i.e. 2 mm to 4 mm, molten and thereafter coat over hot aggregate at 160ºC. Several roads have been built in this manner using Waste polythene-coated aggregate - bitumen. Bitumen is a useful binder for flexible pavement. Different grades of bitumen like 60/70, 80/100 are available on the basis of their penetration values.

2. LITERATURE REVIEW

R. Manju (MAY 2017) the waste plastic and its disposal is a major threat to the environment, which results in pollution and global warming. The utilization of plastic waste in bituminous mixes enhances its properties and also its strength. In addition, it will also be a solution to plastic disposal & various defects in pavement viz., potholes, corrugation, ruts, etc. the waste plastic used are poly-ethylene, polystyrene, polypropylene. The waste plastic is shredded & coated over aggregate & mixed with hot bitumen and the resulted mix is used for pavement construction. This will not only strengthen the pavement and also increases its durability. The titanium-dioxide is used as a smoke absorbent material, which will absorb the smoke from the vehicles. This innovative technology will be boon for Indian hot-humid climate. It's economical and eco-friendly. In this paper, we have discussed the soil properties to be considered in the design of pavement, pavement design, process of construction flexible and plastic-smoke absorbent pavement.

R.Vasudevan (MAY 2015) Infers that the addition of natural or synthetic polymers to bitumen is known to impart enhanced service properties. By adding small amounts of polymers to bitumen, the life span of the road pavement is considerably increased and the purpose is to achieve desired engineering properties such as increased shear modulus and reduced plastic flow at high temperatures and/or increased resistance to thermal fracture at low temperatures.

Saiyed Farhana (MAY 2015) they conclude that the specific gravity of these aggregates ranges from 1.5 to 2.7 and the marble chips are extremely durable. They also reported that replacement of marble chips to aggregates had a beneficial effect on the mechanical properties such as crushing strength and stripping value.

A. J. Chavan (May 2013) Disposal of waste materials including waste plastic bags has become a serious problem and waste plastics are burnt for apparent disposal which causes environmental pollution. Utilization of waste plastic bags in bituminous mixes has proved that these enhance the properties of the mix in addition to solving disposal problems. Plastic waste which is cleaned is cut into a size such that it passes through 2-3mm sieve using shredding machine. The aggregate mix is heated, and the plastic is effectively coated over the aggregate. This plastic waste coated aggregate is mixed with hot bitumen and the resulted mix is used for road construction. The use of innovative technology will not only strengthen the road construction but also increase road life as well as will help to improve the environment. 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. In my research work, I have done a thorough study on the methodology of using plastic waste in bituminous mixes and presented the various tests performed on aggregates and bitumen.

Minakshi Singhal (May 06) Flexible pavements with bituminous surfaces are widely used. Due to increased traffic intensity of roads, overloading of commercial vehicles and temperature variation of pavements due to climatic changes leads to the formation of various distresses like rutting, shoving, bleeding, cracking and potholing of bituminous surfacing. Due to high temperature, bitumen becomes very soft in summer and brittle in winter. Also, in a developing country like India, roadway construction is taking place at a very high pace which requires large demand for construction material that too eco-friendly and economical. Several Studies have revealed that properties of bitumen and bituminous mixes can be improved/ modified with the addition of certain additives and the bitumen premixed with these additives/modifiers is known as "modified bitumen". The present study aims for the use of modified bitumen by using plastic waste for road construction. The paper includes details of literature and methodology of using modifiers in bitumen and aims to provide highway construction in an eco-friendly and economical way. The modified bitumen mix shows better binding property, stability, density and more resistant to water.

3. MATERIALS USED

3.1 Waste plastic

The waste polythene used like bottles, bags, wrappers etc. collected from the residential area and domestic area. The consumption of plastics has increased from 4000 tons/annum (2001) to 4 million tons/annum (2009) and it is expected to rise 8 million tons/annum during the year 2017. Nearly 50 to 60% of the total plastics are consumed for packing. Once used plastic materials are thrown out. They do not undergo bio-decomposition.

Table 1: Different types and sources of waste plastic

Types	Sources
Polyethylene (PE)	Water Bottle, Carry Bag, Milk Pouches etc.
Polypropylene (PP)	Bottle Cap, Detergent Wrappers etc.
Polystyrene (PS)	Clear egg pack, Disposable cups, Protective Packaging etc.

3.2 Aggregates

The aggregate grading is used for all testing is taking form IRC: 94-1986.

Fig. 1: Aggregates

3.3 Bitumen

The bitumen 60/70 gradient is used for all tests.

Fig. 2: Bitumen

4. PREPARATION OF WASTE POLYTHENE - AGGREGATE-BITUMEN MIX

Cleaned and dried wastes polythene (e.g.: disposed carry bags, films, cups and thermocouples) is shredded into small pieces (2 mm to 4 mm size). PVC (Polyvinyl Chloride) is not suitable for this process. Aggregate is heated up to 160°C to 170ºC. Shredded waste polythene is added to the hot aggregate mix. The waste polythene gets softened and coated over the surface of the aggregate within 10 sec. to 30 sec. Hot Bitumen (heated up to a maximum of 160°C to 170ºC to ensure good binding) is added immediately and the contents are mixed well. When cooled to 110ºC to 120°C can be used for the road. As the waste polythene are heated to a maximum temperature of 160°C to 170ºC, there is no evolution of any gas. When heated above 270°C, the plastics get decomposed and above 750°C they get burnt to produce noxious gases.

Fig. 3: Preparation of waste polythene aggregate- bitumen mix

5. PERFORM TESTS

Tests will be performed on the materials:

5.1 Following the tests have been performed on bitumen:

(a) Penetration value test: In the performing of the bitumen penetration test, the value will become 69mm.

(b) Ductility test: In the performing of the bitumen ductility test, the value will become 82mm.

(c) Flash and Fire point test: In the performing of the bitumen flash and fire point test, the value of flashpoint will become 230^0C and the value of fire point will become 250^0C.

(d) Softening point test: In the performing of the bitumen softening point test, the value will become 52^0C in around 5 to 6 min.

5.2 Following the tests will be performed on aggregate

(a) Aggregate impact value test
(b) Water absorption test
(c) Specific gravity test

5.3 Marshall Test

(a) Six Marshall Stability samples will be prepared out of which three will be with the plastic of varying percentage
(b) And three samples without plastic waste.
(c) Marshall Stability test will be performed on all of the samples prepared.

6. CONCLUSION

By using waste-polythene coated aggregate in road construction, helps to:

- Use a higher percentage of waste polythene.
- Reduce the need for bitumen.
- Increase the strength and performance of the road.
- Avoid the use of anti-stripping agents.
- Avoid the disposal of waste polythene by burning and landfilling.
- Generate jobs for rag pickers. The ability of the aggregate to resist weather conditions is improved.
- As plastics are added to the aggregates, moisture absorption ability of aggregates decreases, resulting in better resistance to rain.
- Higher resistance to rain and waterlogging.
- Reduced the need for bitumen by around 10% to 15%.
- Increase the strength and performance of the road.
- Contribute to eco-friendly technology.

7. REFERENCES

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[4] Bindu C, Dr.K.S.Beena," Waste plastics as a stabilising additive in Stone Mastic Asphalt", International Journal of Engineering and Technology, Vol.2 (6) pp.379-387, 2010.
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Effect of waste polythene use in different modifier bitumen in flexible pavement

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ABSTRACT

The use of waste polythene is increasing week by week. The waste polythene pollutes the environment, especially where there is no garbage collection and disposal system. A large amount of plastic collected from the tourist trekking regions and housing area are discarded or burned which releases harmful gases into the environment. The waste polythene collected from domestic and industrial sectors can be used in the production of plastics coated aggregate. Waste polythene, mainly used for packing and carrying any food. It's made up of Polyethylene, Polypropylene, and polystyrene. Their softening point varies between 110 degree Celsius to 140 degree Celsius and if the wastes polythene is heated within this temperature range then they do not produce any toxic gases but the softened waste polythene have tendency to form a film like structure over the aggregate, when it is sprayed over the hot aggregate at 160 degree Celsius to 170 degree Celsius. The Plastics Coated Aggregates (PCA) is a better raw material for the construction of flexible pavement. PCA was mixed with hot bitumen of different types and the mixes were used for road construction.

Keywords— *Waste plastics, Plastic coated aggregate, Bitumen, Polyethylene, Polypropylene, Polystyrene*

1. INTRODUCTION

The population of India has reached around 1.35352 billion due to the continuously increasing growth rate. It constitutes around 18 % of the world's total population. Plastics is a substance which can easily change its shape and very useful to the common man. Today we are surrounded by plastic. In recent years, the study of waste polythene has been done in the construction of the road within many developing countries. The application of these materials in the construction of the road is based on technical, economic, and ecological criteria. Millions of metric tons of waste polythene are produced every year in our country. The total Municipal Solid Waste (MSW) generated in India mostly constitutes waste polythene. However, some plastics can be recycled into a second life application but at the cost of degradation of plastic. In order to evaluate the performance of the constructed road using waste polythene coated aggregate (PCA) bitumen mix and also to make database for evolving Standards by Indian Road. Disposal of a variety of plastic wastes in an eco-friendly way is the most important part of today's research. The waste polythene which used for the construction of flexible pavement material would give better stability, durability, resistance and strength to the road when it is compared with the conventional material made road. An item such as carry bags, cups and thermocouples and packaging films are made up of Polyethylene, Polypropylene and Polystyrene disposal of such item is a major problem. In our study, the waste polythene was shredded into small size, 2 mm to 4 mm, molten and thereafter coat over hot aggregate at 160ºC. Numerous roads have been built by this method of using Waste polythene-coated aggregate - bitumen. Bitumen is an important binder for flexible pavement. Different grades of bitumen like 60/70, 80/100 are available on the basis of their penetration values.

2. LITERATURE REVIEW

R. Manju (May 2017): The waste plastic and its disposal is a major problem for the environment, which results in pollution and global warming. Using waste polythene in bituminous mixes improves its characteristics and also its strength. It will also be the right solution to plastic disposal & other defects in pavement viz., potholes, corrugation, ruts, etc. the waste plastic which can be used are polyethene, polystyrene, polypropylene. It is shredded and coated over aggregate & then it is mixed with hot bitumen and the resulted mix is used for the construction of pavement. Along with strengthening the pavement, it will also increase its durability. The titanium-dioxide is used to absorb the smoke from the vehicles. This innovative technology will be very using full for Indian hot-humid climate. It's economical and eco-friendly. In this paper, we have also discussed the properties of soil which are to be considered in the design of pavement, pavement design, and process of construction of flexible and plastic-smoke absorbent pavement.

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3. MATERIALS USED

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3.2 Aggregates

The aggregate grading is used for all testing is taking form IRC: 94-1986.

Fig. 1: Aggregates

3.2 Bitumen

The bitumen 60/70 gradient is used for all tests.

Fig. 2: Bitumen

4. CONCEPT OF PLASTIC ROAD

The roads constructed using waste plastic, popularly known as Plastic Roads, are found to perform better compared to those constructed with Plastic roads mainly use plastic carry bags, disposable cups and PET bottles that are collected from garbage dumps as an important ingredient of the construction material. When mixed with hot bitumen, plastics melt to form an oily coat over the aggregate and the mixture is laid on the road surface like a normal tar road.

4.1 Wet process

Waste Plastics directly mixed with hot Bitumen at 160^{0}C since the wet process require a lot of investment and bigger plants Addition of Stabilizers and proper cooling Mechanical Stirrer is needed.

4.2 Dry-process

Aggregate is heated to 170°C in Mini Hot Mix Plant Shredded Plastic waste is added in equal proportion.

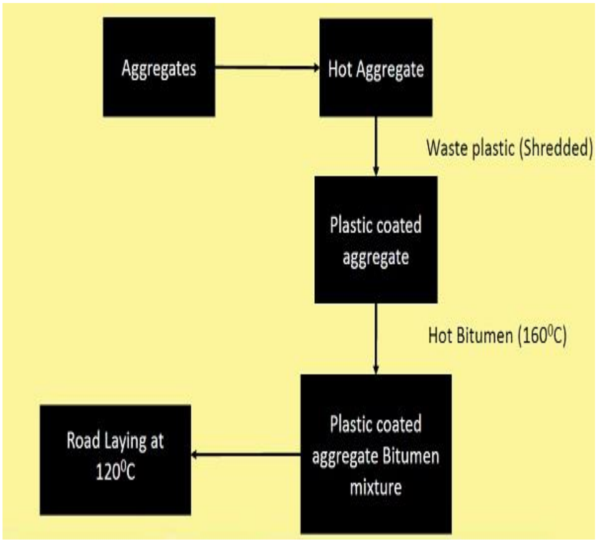

Fig. 3: Complete process of plastic

5. PREPARATION OF WASTE POLYTHENE-COATED-AGGREGATE-BITUMEN MIX

Cleaned and dried wastes polythene (e.g.: disposed carry bags, films, cups and thermocouples) is shredded into small pieces (2 mm to 4 mm size). PVC (Polyvinyl Chloride) is not suitable for this process. Aggregate is heated up to 160°C to 170^{o}C. Shredded waste polythene is added to the hot aggregate mix. The waste polythene gets softened and coated over the surface of the aggregate within 10 sec. to 30 sec. Hot Bitumen (heated up to a maximum of 160°C to 170^{o}C to ensure good binding) is added immediately and the contents are mixed well. When cooled to 110^{o}C to 120°C can be used for road. As the waste polythene are heated to a maximum temperature of 160°C to 170^{o}C, there is no evolution of any gas. When heated above 270°C, the plastics get decomposed and above 750°C, they get burnt to produce noxious gases.

Fig. 4: Preparation of waste polythene aggregate- bitumen mix

6. PERFORM TESTS

Tests will be performed.

6.1 Following the tests have been performed on bitumen

Table 2: Physical properties of binder

Test	Test Result
Penetration value test at 25^{0}C	69 mm
Softening point test	52^{0}C
Ductility test at 27^{0}C	93 cm
Flash point test	230^{0}C
Fire point test	250^{0}C

6.2 Following the tests will be performed on aggregate

Table 3: Specific gravity of aggregates

Types of aggregates	Specific gravity
Coarse	2.75
Fine	2.6
Filler	2.7

Table 4: Gradation of aggregates for DBM

Sieve size (mm)	Percentage passing	Spec. Limit of % Passing
40	100	100
25	97.8	85-100
20	73.78	71-95
12.5	61.7	58-82
10	55	52-72
4.75	37	35-50
2.36	35	28-43
0.6	20	15-27
0.3	18	7-21
0.15	10	5-15
0.075	4	2-8

6.4 Marshall Test

Plotting Curves Data For Polyethylene

Table 5: Data for Plotting Curves (Polyethylene)

Waste Polythene (%)	Optimum Bitumen Content (%)	Stability (Kg)	Flow (mm)	% Air Voids (Vv)	Voids Filled With Bitumen (VFB)
0	5	1100	3.73	3.78	77
3	5	1575	3.58	3.5	77.8
6	5	2140	3.39	3.48	78.14
9	5	2810	3.05	3.18	80
12	5	2392	3.11	3.00	80.69
15	5	2128	3.18	2.28	81.25

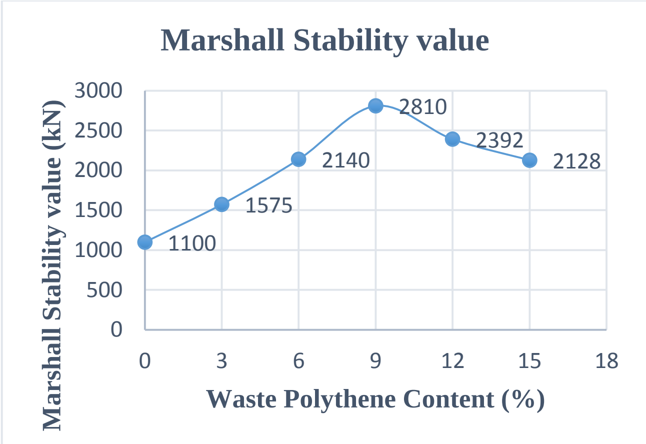

Fig. 5: Marshall Stability Value V/S Polythene Content

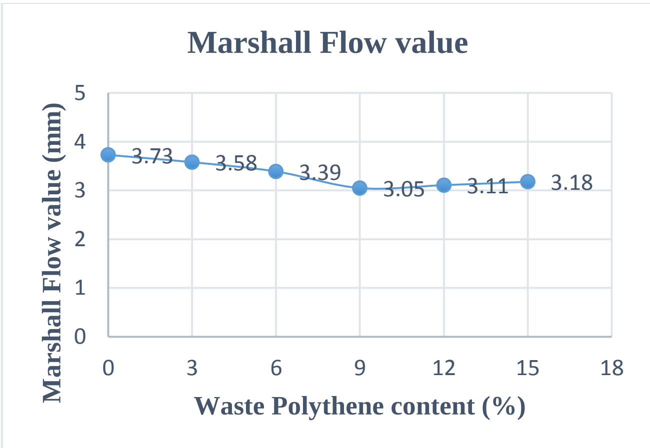

Fig. 6: Marshall Flow Value V/S Polythene Content

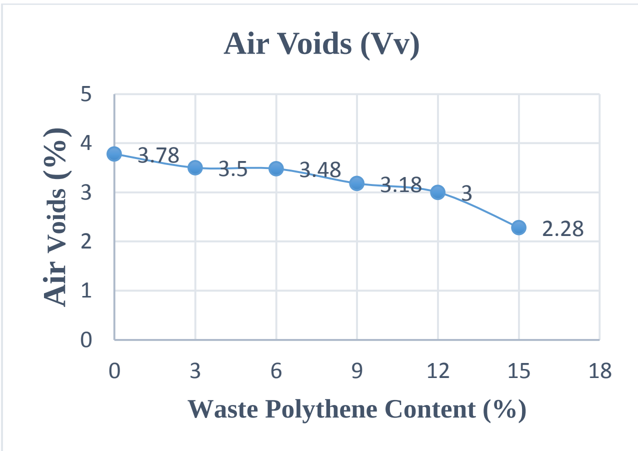

Fig. 7: Air Voids V/S Polythene Content

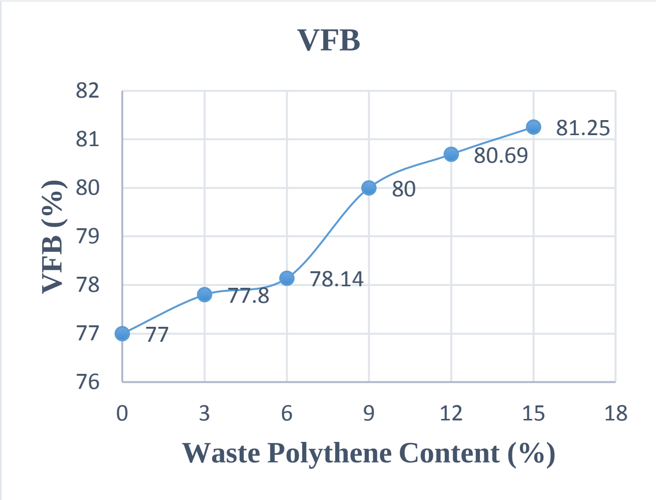

Fig. 8: VFB V/S Polythene Content

Table 6: Data for Plotting Curves (Polypropylene)

Waste Polythene (%)	Optimum Bitumen Content (%)	Stability (Kg)	Flow (mm)	% Air Voids (Vv)	Voids Filled Wit Bitumen (%)
0	5	1155	3.31	3.88	77.32
3	5	1724	3.06	3.54	79.48
6	5	2441	2.68	3.20	80.02
9	5	3094	2.19	2.84	82.3
12	5	2640	2.25	2.98	81.25
15	5	2238	2.38	3.08	80.77

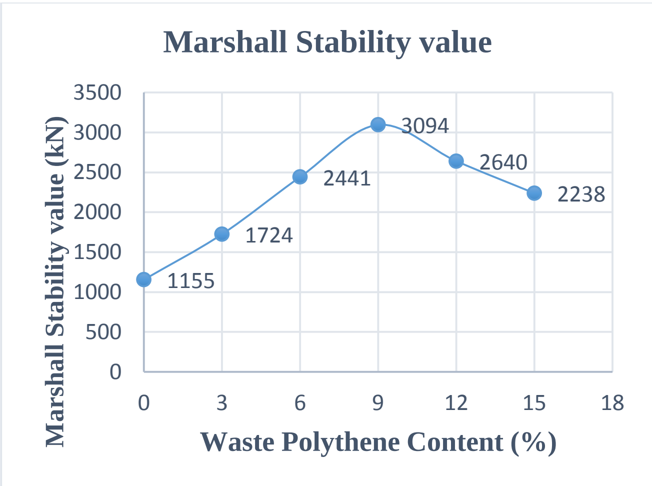

Fig. 9: Marshall Stability Value V/S Polythene Content

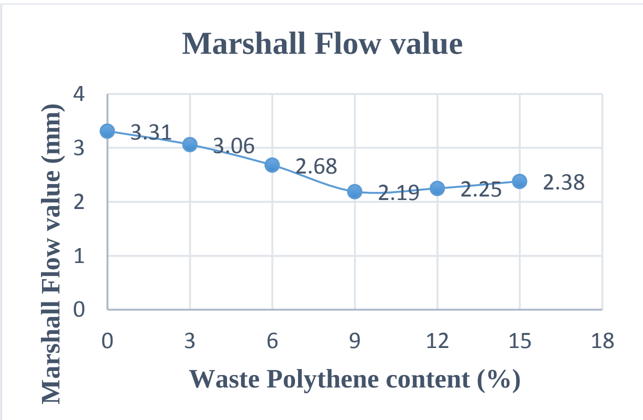

Fig. 10: Marshall Flow Value V/S Polythene Content

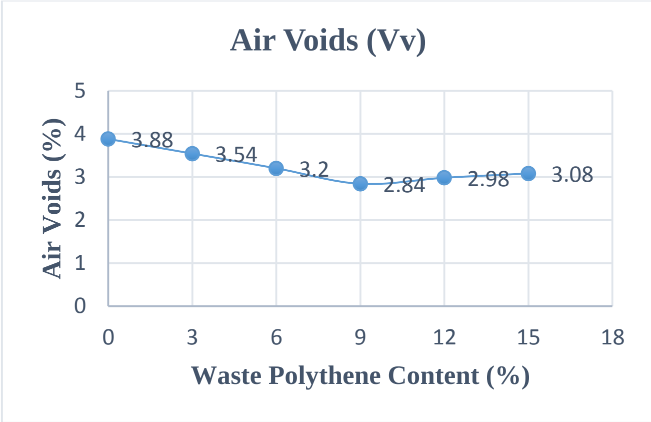

Fig. 11: Air Voids V/S Polythene Content

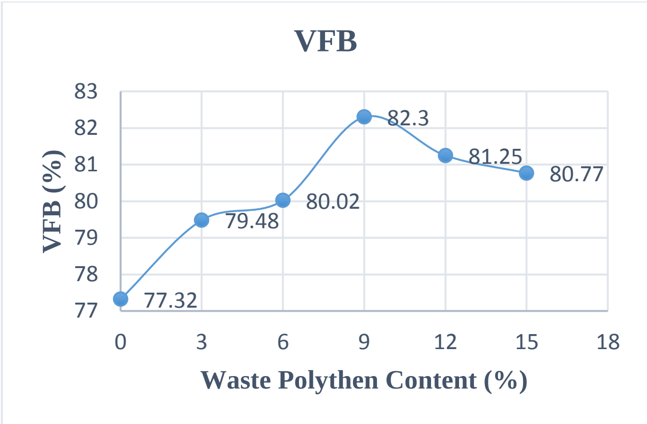

Fig. 12: VFB V/S Polythene Content

7. COST ANALYSIS (DBM)

Cost Estimation of waste polythene Road construction:

•

- **7.1 Making 1Km. Normal bitumen road**

Total Wt. of the mix (as per data book) = 450 tones
Wt. of bitumen (as per data book) = 5% of total wt. of mix = 23 tones.

Wt. of aggregate = 450 – 23 = 427 tones
Cost of bitumen for 1 Kg. is 36 Rs/-.
1 kg. = 36 Rs/-

1 tone = 36 x 1000 = 36,000 Rs/-

23 tones = 23 x 36,000 = 828,000 Rs/-

Total Cost of bitumen for 1 Km. road is 828,000 Rs/-

- **7.2 Making 1Km. Waste Polythene Coated aggregate Road:**

Total Wt. of the mix (as per data book) = 450 tones
Wt. of bitumen (as per data book) = 5% of total wt. of mix = 23 tones
Adding waste polythene (according to test) = 9% of bitumen = 2.1 tones

S no.	Particulars	Approx. Rate (Rs./Kg)
1	Waste Polythene	0
2	Collection of polythene	2
3	Transportation	2
4	Cleaning / Shredding	3
5	Labor Charger	4
6	Machinery Charges including electricity / Maintenance	2
	Total	13

Cost of waste polythene for 1Kg. is 13 Rs/-
1 Kg. = 13 Rs/-
1 tones = 13 x 1000 = 13,000 Rs/-
2.1 tones = 13,000 x 2.1 = 27,500 Rs/-

Total cost of waste polythene for 1 Km. road is 27,500 Rs/-

7.3 Required bitumen in waste polythene coated aggregate road

Required bitumen in waste polythene road = (Wt. of bitumen) – (Adding waste polythene) = (23 tones) – (2.1 tones) = 20.9 ≅ 21 tones

Cost of 21 tones bitumen = 21 x 36,000 = 756,000 Rs/-

Saving cost of bitumen in 1 Km. of waste polythene coated aggregate road = 828,000 – 756,000 = 72,000 Rs/-

Total saving cost in bitumen is 8% to 9%.

8. CONCLUSION

By using waste-polythene coated aggregate in road construction, helps to:

- Using a higher percentage of waste polythene.
- Reduce the need for bitumen.
- Increase the strength and performance of the road.
- Avoid the use of anti-stripping agents.
- Avoid the disposal of waste polythene by the burn and land filling.
- Generate jobs for rag pickers. The ability of the aggregate to resist weather conditions is improved.
- As plastics are added to the aggregates, the moisture absorption ability of the aggregates decreases, resulting in better resistance to rain.
- Higher resistance to rain and waterlogging.
- Total saving cost in bitumen is 8% to 9%.
- Increase the strength and performance of the road.
- Contribute to eco-friendly technology.

9. REFERENCES

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6. Thesis Preparation Guide was referred to for preparing the thesis. [ ]YES [ ]NO
7. Specification regarding thesis format have been closely followed. [ ]YES [ ]NO
8. The contents of thesis have been organized based on the guideline. [ ]YES [ ]NO
9. The thesis has been prepared without resorting to plagiarism. [ ]YES [ ]NO
10. All sources used have been cited appropriately. [ ]YES [ ]NO
11. The thesis has not been submitted elsewhere for a degree. [ ]YES [ ]NO
12. All the corrections have been incorporated [ ]YES [ ]NO
13. Submitted 3 hard bound copies plus one CD. [ ]YES [ ]NO

(Signature of the Candidate)

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6. Thesis Preparation Guide was referred to for preparing the thesis. [ ]YES [ ]NO
7. Specification regarding thesis format have been closely followed. [ ]YES [ ]NO
8. The contents of thesis have been organized based on the guideline. [ ]YES [ ]NO
9. The thesis has been prepared without resorting to plagiarism. [ ]YES [ ]NO
10. All sources used have been cited appropriately. [ ]YES [ ]NO
11. The thesis has not been submitted elsewhere for a degree. [ ]YES [ ]NO
12. All the corrections have been incorporated [ ]YES [ ]NO
13. Submitted 3 hard bound copies plus one CD. [ ]YES [ ]NO

(Signature of Supervisor)

Name: …………………………….

(Signature of the Candidate)

Name: ………………………………..

Roll No.: ……………………………..

Enrollment No.: ……………………...