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SUITABLITY STUDY OF LOW DENSITY POLYETHYLENE WASTE PLASTIC FOR BITUMEN MODIFICATION

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Abstract

The objective of this study was modification of bitumen by using low density polyethylene. This production process was carried out in wet process. There are different types of modifier. We have used low density Polyethylene (LDPE). And it's commonly used for packaging, protecting and many other applications. However disposal of waste plastic bags (WPB) in large quantities constitutes an environmental problem, as they considered non-biodegradable materials. Hence, there is a real need to find useful applications for these growing quantities of wastes. In this study, Waste Plastic Bags (WPB) as one form of polymers is used to investigate the potential prospects to enhance asphalt mixture properties. After preparing raw material bitumen was heated at 85℃ and waste plastic pieces are added slowly to the hot bitumen temperature around 160℃-170℃. By using different proportion of plastic. The mixture stirred well using mechanical stirrer for about 20-30 minutes.

The research investigates the properties of bitumen modified with used low density polyethylene. basic tests used as penetration, softening point, flash and fire point were carried out by using shredded waste plastic which varied from 0%to 8% by weight of 80/100 penetration grade bitumen using wet mix method. As we obtain from result, as the content of plastic waste increase from 1 to 8% the rheological properties have been improved Penetration value decrease with addition of 8% plastic while increasing in softening point, flash and fire point were obtained, with the corresponding value of 61mm, 340℃ and 380℃ respectively. When the Penetration value decreases it indicates the hardness of the bitumen. And an increasing the percentage of plastic (LDPE), the marshal stability values increases till it reaches at 4 % LDPE content; then it started to decline steeply at higher LDPE content and marshal flow values are decreased due to the resistance to deformation under heavy wheal loads increase.

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List of Acronyms

LDPE low density polyethylene

HDPE high density polyethylene

PE polyethylene

PP Polypropylene

WPB waste plastic bag

MSW municipal solid waste

PMB polymer modification binder

HMA hot mix asphalt

OBC optimum bitumen content

ERA Ethiopian road Authority

CHAPTER ONE

1. INTRODUCTION

Plastic is everywhere in today's lifestyle. The leading problem is what to do with the plastic waste. Plastic is one of the daily increasing useful and hazardous materials. At the time of need, plastic is found to be very useful but after its use, it is simply thrown away, creating all kinds of hazards. The quantum of plastic waste in municipal solid waste (MSW) is expanding rapidly. It is estimated that the rate of expansion is double for every 10 years. This is due to rapid growth of population, urbanization, developmental activities and changes in life style which leading widespread littering on the landscape. They are non-biodegradable and also researchers have found that the plastic materials can remain on earth for 4500 years without degradation, Hence, these waste plastics are to be effectively utilized. Today, it is impossible for any vital sector to work efficiently without usage of plastic starting from agriculture to industries. Thus we cannot ban the use of plastic but the reuse of plastic waste in building constructions, industries are considered to be the most practicable applications. Polymers have been used to modify the physical and mechanical properties of bitumen (asphalt binder) since the 19th century. Since polymers, such as plastic, rubber, have elastic nature, they are capable of increasing the binding property of the bitumen when mixed in the proper proportion. On the other hand the road traffic is growing with time hence there rises a need to increase the load bearing capacities of roads .the roads in Ethiopia are wearing out due to many reasons; such as quality, climatic effects, over loading, etc.. Before finishing the presumed service life. The application of polymer modified bitumen for asphalting of roads can possibly minimize those pavement distress, of which, rutting, low temperature cracking, load associated fatigue cracking, stripping, and hardening are the most common since the polymer modified roads showed superior resistance to environmental stresses in countries where the technology have been implemented. Then use of waste plastic in hot bituminous mixes too enhances pavement performance, protect environment and provide low cost road.

1.2Problem statement

80% of plastic end up in landfill, which takes thousands of years to decompose. In our country there is no proper solid waste disposal and management of plastic waste. This is due to the inability of plastic materials to biodegrade and its subsequent persistence in the environment. This improper disposal of plastic may causes blocking of water movement channels its cause wide spread of diseases like malaria and cholera. And also it can cause many other diseases. Under these circumstances, an alternative use of these plastic wastes is required. So, this study meant to alleviate the problem by modifying bitumen from such materials. On the other hand, in our country most roads are unpaved and many paved roads going for long periods without maintenance. When the road age became increase, it surface will be fragile and less resilient in carrying the load. This leads to defects which consequently allow water to percolate to the underlying layers causing effectual road failure. Road failures causes traffic jams for long hours; loss of time for drivers and passengers and also increased air pollution from gas emissions. Use of modified bitumen would result in road pavements with longer design life. Using locally available admixtures to modify bitumen would give an additional benefit to the local economy in the long run. When such a material is a waste or a by-product, the benefits are even higher as this helps to maintain the environment and provide a beneficial use of the waste. And also Ethiopian government bring out a lot of money for buying bitumen for asphalt pavement so replacement of bitumen by plastic decrease foreign currency.

1.3 Objectives

1.3.1 General objective:

Suitability Study of low density polyethylene for bitumen modification

1.3.2 Specific objectives:

- ✓ To compare the properties of LDPE polymer-modified bitumen with conventional bitumen in order to ascertain its usefulness in bituminous pavement construction in cold region.
- ✓ To determine the optimum mix proportions of LDPE waste plastics in the modification of bitumen.
- ✓ To assess the blending effect of LDPE waste plastic mixing ratio on the physical property of bitumen.

1.4 Significance of the study

Modification of bitumen from locally available solid waste LDPE plastics have a significant usage in waste reduction which is dumped in cities and towns due to this unpleasant sceneries, flooding due to blocking of sewer, diseases caused by like cholera and malaria together with soil degradation may reduce and also These modified mixes are expected to present better physical and mechanical properties than the conventional asphalt mix. And also when we replace small portion of bitumen by plastic it can be reduce foreign currency

Generally it used as

- To reduce of the environmental and health hazards of waste plastics.
- To Proper and effective reuse of waste plastic materials.
- To improve the mechanical and physical properties of asphalt mix.
- To improve performance of asphalt roads as well as to extend their service life.
- To reduce foreign currency

1.5. Scope of the project

The study focused on the modification of bitumen using Shredded LDPE Waste Plastic Bags. The penetration test, ductility test, softening point test, and specific gravity tests were carried out to determine the quality of the modified bitumen. Marshall Stability test was used in determining, stability and flow of the briquette.

The following were the limitation of the study

i. This study is limited; it’s only in the case of cold region.
ii. Study the possibility of using LDPE waste plastic, as low price asphalt additive, in order to improve the performance of bitumen; i.e. other waste plastic types weren’t assessed in this project.
iii. Analyzing the outcomes of LDPE waste plastic addition for asphalt mix in wet processing.
iv. The lab tests made on those different samples of LDPE waste plastic-bitumen mixtures were performed in the Civil and COTM Engineering lab.

CHAPTER TWO

2 LITERATURE REVIEW

2.1Back ground of the study

Bitumen obtained from crude oil distillation. For thousands of years, it has been used to provide water proofing and protective coverings for roof and roads. it is a complex of high-boiling or non-boiling components. These components do not change during the distillation process of crude oil, which is the reason they are still present in bitumen in their original unaltered form as in crude oil. Therefore, bitumen, like crude oil, is a natural product. As far as its chemical composition is concerned, we must realize that for any type of bitumen, as with any type of crude oil, we do not yet know completely know it. This can be explained by the fact that each type of bitumen is composed of a large number of different groups of hydrocarbons that have an average molecular weight of 600 to 1000 g/mol as well as a relatively high proportion of non-hydrocarbons. Bitumen is a complex chemical mixture of molecules that are predominantly hydrocarbons (carbon: 82 to 88%, hydrogen: 8 to 11%) with a small amount of structurally heterocyclic species and functional groups containing sulfur, nitrogen, and oxygen atoms.it also contains minor quantities of metals such as vanadium, nickel, iron, magnesium, and calcium, which occur in the form of inorganic salts and oxides or in porphyrin structures. The chemical composition of bitumen is extremely complex.

Bituminous binders have been widely used in construction applications, mainly for flexible road pavement, water proofing, roofing, joint sealant, etc. a binder must remain flexible enough to with stand sadden stresses without cracking at low temperature during winter, but must also resist the permanent deformation or viscous flow at high in service temperatures. In that way, bitumen should resist stresses due to traffic loads and low temperatures in pavement application as well as extension and construction in roof construction. In order to achieve the desired mechanical properties, bitumen is modified mainly by using virgin polymers in order to change their natural rheological properties.

2.2Bitumen production

2.2.1Preparation of Road Bitumen from Petroleum

The refining of petroleum is most complex procedure producing a tremendous range of products from the simplest hydrocarbon gas methane to the hardest bitumen with constituents of molecular weight of the order of several thousands.

The preparation of different forms of bitumen for road purposes from petroleum

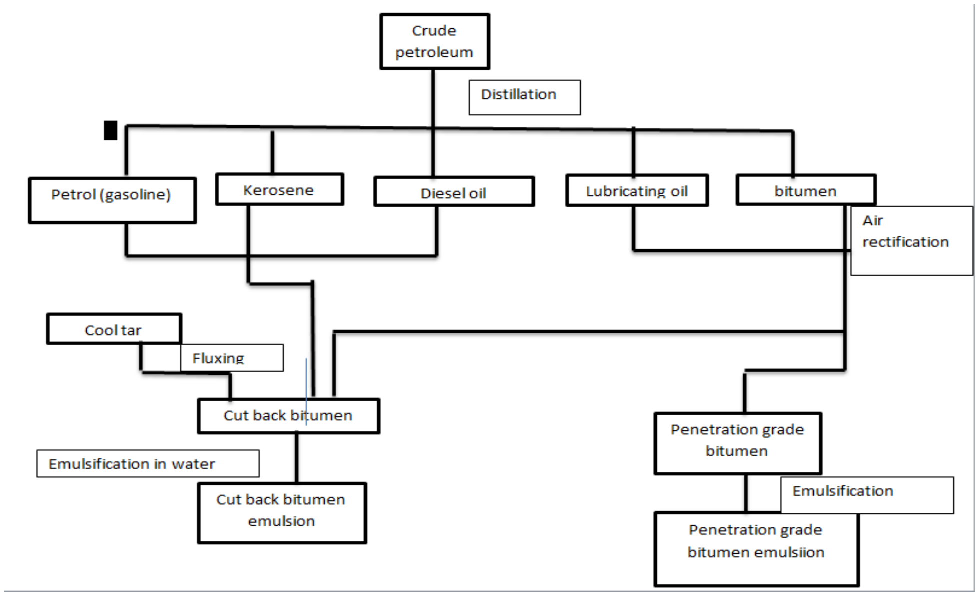


Figure 2.1preparation of bitumen

a) Distillation of Petroleum

Bitumen is produced from selected crude oils by a process of concentration by distillation. The distillate is obtained in the desired boiling point ranges by condensation in a fractionating column. It is first to heat the crude oil to a temperature lower than 350°C under atmospheric pressure to drive off light fractions such as gasoline, kerosene and gas oil. Further heating above 400°C is necessary to drive off heavier oils. Refining of the topped crude is carried out by use of reduced pressures and steam injection in the fractionating column. The incoming crude is pumped through a continuous pipe-still similar to that used in tar distillation plants, where it is raised to desired temperature (between 200 and 400° C). It is then injected into a fractionating column where at the reduced pressure volatile components flash into vapors. The vapors are condensed into fractions of decreasing boiling point by condensation at points at higher levels in the fractionating column. A flow diagram representing the distillation of topped oil in a modern refinery.

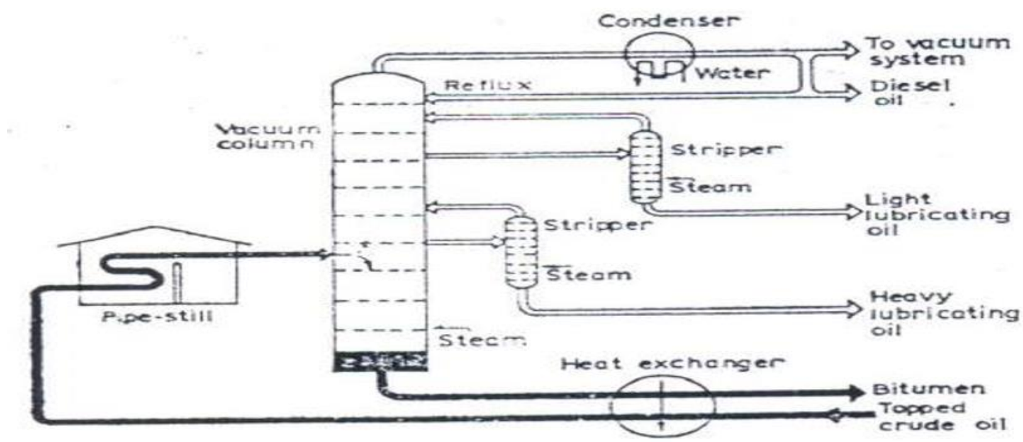


Figure 2.2Bitumen production

b) Air-Rectification of Refinery Bitumen

Bitumen produced by straight steam-refining from crude oils may be deficient in the components of high molecular weight which are insoluble in heptanes, asphaltenes fractions. It is common practice to increase the asphaltene content by oxidation of the hot straight-run bitumen by a current of air blown through it. These are bitumen of high softening point produced by an oxidation by air-blowing at high temperatures. The oxidation is more extensive and the blown bitumen has rubbery qualities required for certain industrial purposes and not used as binders for road aggregates.[22]

Chemical Constitution of Bitumen

Bitumen although formed from distillation process causes some changes which is closely related in chemical nature to its primary source i.e., the crude petroleum oil. Bitumen is completely soluble in carbon-di-sulphide but most of them divide the bitumen soluble in carbon-di-sulphide into three fractions:

a) **Carbenes**: fraction insoluble in carbon tetrachloride.

b) **Asphaltenes:** fraction insoluble in light aliphatic hydrocarbon solvent such as petroleum ether.

c) **Maltenes**: fraction soluble in light aliphatic hydrocarbon solvent

The molecular weight of asphaltene fraction is estimated between 1800 and 1,40,000 and maltenes have molecular weight between 370 and 710.

The hydrocarbons in petroleum are of four basic forms:

a) Saturated aliphatic groups or paraffins

b) Naphthenic groups or cycloparaffins

c) Aromatic ring compounds

d) Aliphatic groups with olefin double bonds

Aliphatic group normally does not present in road bitumen. The approximate proportions of the other three groups in the molten groups can be obtained from modified Waterman analysis. Many properties of bitumen, particularly the non-Newtonian flow properties suggest that bitumen is a colloidal system. The colloidal nature of bitumen is due to the presence of asphaltenes in association with high molecular weight material from the maltenes fraction, form a disperse phase. This complex is normally referred as ‘micellar phase’.[22]

2.3Types of bitumen

There are different forms of bitumen

Cutback bitumen

Cut back is a free flowing liquid at normal temperatures and is obtained by fluxing bitumen with suitable solvents. The viscosity of bitumen is reduced substantially by adding kerosene or any other solvent. Cutback has been used in tack coat applications. In some situations preference is given to use liquid binders such as cutback bitumen. In cutback bitumen Suitable solvent is used to lower the viscosity of the bitumen. From the environmental point of view also cutback bitumen is preferred. The solvent from the bituminous material will evaporate and the bitumen will bind the aggregate. Cutback bitumen is used for cold weather bituminous road construction and Maintenance. The distillates used for preparation of cutback bitumen are naphtha, kerosene, diesel, oil and furnace oil. There are different types of cutback bitumen Like rapid curing (RC), medium curing (MC), And slow curing (SC).RC is recommended for Surface dressing and patchwork. MC is recommended For premix With less quantity of fine aggregates.SC is used For premix with appreciable quantity of fine aggregates.[22]

Bitumen Emulsion.

Bitumen emulsion is a free flowing liquid at ambient temperatures. Bitumen emulsion is a stable dispersion of fine globules of bitumen in continuous water phase. Dispersion is obtained by processing bitumen and water under controlled conditions through a colloidal mill together with selected additives. The use of proper quality emulsifiers is essential to ensure that the emulsion has stability over time and also that it breaks and sets when applied on aggregates/road surface. It is chocolate brown free flowing liquid at room temperature the bitumen content in the emulsion is around 60% and the remaining is water. When the emulsion is applied on the road it breaks down resulting in release of water and the mix starts to set. The time of setting depends upon the grade of bitumen. Three types of bituminous emulsions are available, which are Rapid setting (RS), Medium setting (MS), And Slow setting (SC).Bitumen Emulsions are ideal binders for hill road construction. Where heating of bitumen or aggregates are difficult. Rapid Setting emulsions are used for surface dressing work. Medium Setting emulsions are preferred for premix jobs and patch repairs work. Slow setting Emulsions are preferred in rainy season. Bitumen Emulsions can be of two types cationic & anionic. Anionic bitumen emulsions are generally not used in road construction as generally siliceous aggregate is used in road construction. Anionic bitumen emulsions do not give good performance with siliceous whereas cationic bitumen emulsions give good performance with these aggregates. Therefore, cationic bitumen emulsions are far more popular than anionic bitumen emulsions.[11],[22]

Bituminous primers

In bituminous primer the distillate is absorbed by the road surface on which it is spread. The absorption there for depends on the porosity of the surface. Bitumen primers are use full on the stabilized surfaces and water bound macadam base courses. Bituminous primers are generally prepared on road sites by mixing penetration bitumen with petroleum distillate.[22]

Modified Bitumen

Certain additives or blend of additives called as bitumen modifiers. Bitumen treated with these modifiers is known as modified bitumen. Investigations have revealed that properties of bitumen and bituminous mixes can be improved, by improving bitumen physical properties without changing its chemical nature .Modified Bitumen is bitumen with additives. These additives help in further enhancing the properties of bituminous pavements. Pavements constructed with Modified Bitumen last longer which automatically translates into reduced overlays. Pavements constructed with Modified Bitumen's can be economical if the overall lifecycle cost of the pavement is taken into consideration [11]

2.4Bitumen grade

Penetration Grade

Bitumen 80/100: The characteristics of this grade confirm to that of S 90 grade of IS-73-1992. It is suitable for low volume roads. This type of bitumen is thinner material & is used in tropical regions. It is having lower softening point

Bitumen 60/70: This grade is harder than 80/100 and can withstand higher traffic loads. The characteristics of this grade confirm to that of S 65 grade of IS73-1992. It is presently used mainly in construction of National Highways & State Highways. These are semi viscous material having moderate softening point.

Bitumen 30/40: This is the hardest of all the grades and can withstand very heavy traffic loads. Bitumen 30/40 is used in specialized applications like airport runways and also in very heavy traffic volume roads in coastal cities in the country. These are the thicker material having higher softening point & these are used in high temperature regions

2.5Properties of bitumen

2.5.1) Viscosity The viscosity of the bitumen at the time of mixing and compaction should be adequate. This is achieved by heating the bitumen and aggregate prior to mixing or by use of cutbacks or emulsions of suitable grade. [22]

2.5.2) Temperature Susceptibility The bituminous material should not be highly temperature susceptible. During the hottest weather of the region the bituminous mix should not become too soft or unstable. During cold weather the mix should not become too hard and brittle, causing cracking. The material should be durable. [22]

2.5.3) Adhesion Property

Bitumen has excellent adhesive qualities provided the conditions are favorable. However in presence of water the adhesion does create some problems. Most of the aggregates used in road construction possess a weak negative charge on the surface. The bitumen aggregate bond is because of a weak dispersion force. Water is highly polar and hence it gets strongly attached to the aggregate displacing the bituminous coating. The factors influencing aggregate bitumen adhesion are plenty and some of the factors influencing this property are as below:

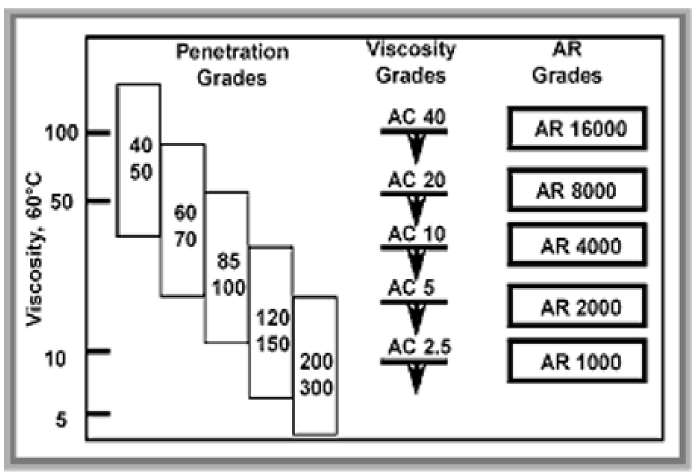


Figure 2.3adhesion property

2.5.3.1External*:* Rainfall, Humidity, Water pH, Presence of salts, Temperature, Temperature cycle, Traffic, Design, Workmanship, Drainage

2.5.3.2Aggregate: Mineralogy, Surface texture, Porosity, Dirt, Durability, Surface area, Absorption, Moisture content, Shape, Weathering

2.5.3.3 Bitumen: Rheology, Constitution

2.5.3.4 Mix: Void content, Permeability, Bitumen content, Bitumen film thickness, Filler type, aggregate grading, and Mix type. [11]

2.5.4. Bitumen –A Visco-Elastic Material

The properties of Bitumen can be defined in terms analogous to the Modulus of Elasticity of solid materials. In case of solids, Modulus of Elasticity E is defined by Hooke's law Bitumen is a Visco-elastic material. At high temperatures it behaves like a liquid & hence liquid flow properties like Viscosity are exhibited. However, at low temperatures bitumen behaves like a solid and hence solid properties like stress & strain become relevant. Similarly, for shorter loading time bitumen behaves like a solid whereas for longer loading times bitumen behaves like a liquid. The properties that bitumen exhibits in the intermediate temperature range and loading time are of great relevance as this range is very long and bitumen is handled in this temperature range most of the times. It has thermoplastic nature, (stiff when cold liquid when hot[11]

2.6Background of Bitumen modification

Ancient inhabitants directly used the natural bitumen which is usually in the earth's surface [9]. In the early 1900s, refined bitumen was first produced by refining crude oil in the USA [17]. Since then, the world consumption of bitumen has increased rapidly, most of which was used in road construction. According to a joint publication of Asphalt Institute and Eurobitumen in 2011, the current world consumption of bitumen is approximately 102 million tons per year, 85% of which is used in various kinds of pavements [2]. In fact, the chemistry composition of produced bitumen is very complex and variable; and the properties of produced bitumen are closely related to the crude oil sources and the refinery processes. By selecting good crude oil or proper refinery processes, some good bitumen properties can be obtained. However, the limited oil resources for producing good-quality bitumen and the lack of effective control actions during refinery, as well as the driving force of earning the maximum economic benefits, made industries pay more attention on bitumen modification [26]. Additionally, pavement industry has developed rapidly all over the world during the last few decades, especially in developing countries. Following the rapid development, increased traffic load, higher traffic volume, and insufficient maintenance led to many severe distresses (e.g. rutting and cracking) of road surfaces. The harsh reality was demanding more on bitumen quality. In order to obtain bitumen with enhanced quality, an increasing number of investigations also began to focus on bitumen modification. Among all attempted or investigated modification methods of bitumen, polymer modification has been one of the most popular approaches.

2.6.1 Polymer modification

Polymer modified binders (PMBs) are made up of a bituminous binder and a small amount of added polymer (typically up to 5 wt% but more usually 3–4 wt%). is the incorporation of polymers in bitumen by mechanical mixing or chemical reaction [24]. Depending on the type and concentration, the polymer additive changes the properties of the binder resulting in (among other changes): greater elastic recovery, higher softening point, greater viscosity, greater cohesive strength and greater ductility [27]; By the 1980s, new polymers were being developed for bitumen modification and were being used in both Europe and in the US [27] There are two main families of polymers currently used in road applications plastomers and elastomers. plastomers (e.g. polyethylene (PE), polypropylene (PP), ethylene-vinyl acetate (EVA), ethylene-butyl acrylate (EBA)) and thermoplastic elastomers (e.g. styrene-butadiene-styrene (SBS), styrene-isoprene-styrene (SIS), and styreneethylene/butylene-styrene (SEBS)) [10].plastomers were reported to lead to some improved properties of bitumen, such as higher stiffness at high temperatures, higher cracking resistance at low temperatures, better moisture resistance or longer fatigue life [20]. In [9], an extensive summary was given that an effective polymer modification results in a thermodynamically unstable but kinetically stable system in which the polymer is partially swollen by the light components of bitumen. Some important factors, including the characteristics of the bitumen and the polymer themselves, the content of polymer and the manufacturing processes, determine the final properties of polymer modified bitumen (PMB) [24,6].

Elastomers impart both viscous and elastic properties to the bitumen binder [3] Elastomer modified bitumens exhibit greater recovery upon unloading than the original bitumen. Some polymers are also used in combination. For example, polyethylene (PE) is often used in conjunction with elastomers such as poly butadiene (PBD) in order to prevent or retard segregation of the dispersed PE particles (Morrison et al 1994). Other specialist polymer types such as epoxy resin modified binders find niche application in bridge deck surfacing for example, but are used in relatively small quantities due to the high costs.

Table 2-1types of modifier

Synthetic Polymers		**Natural Rubber**	**Crumb Rubber**
Plastomeric Thermoplastics	Low Density Polyethylene(LDPE)	Latex Powder	Crumb Rubber without additives
	Ethylene Vinyl Acetate (EVA)		
	Ethylene Butyl Acetate (EBA)		
	Ethylene Ter Polymer (ETP)		
Elastomeric Thermoplastics	Styrene Isoprene Styrene (SIS)	Rubber Powder	Crumb Rubber with additives
	Styrene Butadiene Styrene Block Copolymer (SBS)		

2.6.2 Advantages of Modified Bitumen

The advantages of using modified bitumen are as follows**:** [22]

1. Lower susceptibility to daily and seasonal temperature variations

2. Higher resistance to deformation at high pavement temperature

3. Better age resistance properties

4. Higher fatigue life for mixes

5. Better adhesion between aggregates and binder

6. Prevention of cracking and reflective cracking.

Hot Mix Asphalt

Hot-Mix Asphalt (HMA) is the most widely used paving material around the world. It's known by many different names: HMA, asphaltic concrete, plant mix, bituminous mix, bituminous concrete, and many others. It is a combination of two primary ingredients aggregates and asphalt binder. Aggregates include both coarse and fine materials, typically a combination of different size rock and sand. The aggregates total approximately 95% of the total mixture by weight. They are mixed with approximately 5% asphalt binder to produce HMA. By volume, a typical HMA mixture is about 85%aggregate, 10% asphalt binder, and 5% air voids. Additives are added in small amounts to many HMA mixtures to enhance their performance or workability. Because asphalt concrete pavement is much more flexible than Portland cement concrete pavement, asphalt concrete pavements are sometimes called flexible pavements. [8]

2.7Basic raw materials

It’s proven that the addition of certain polymer additive to asphalt mix can improve the performance of road pavement. The addition of polymers typically exhibits improved durability, greater resistance to permanent deformation in the form of rutting and thermal cracking. Besides, it increases stiffness and decreased fatigue damage. Waste plastic bags (WPB) which is mainly composed of Low Density Polyethylene (LDPE) has been found to be one of the most effective polymer additives which would enhance the life of the road pavement and also solve many environmental problems . Basic materials in hot mix asphalt (HMA) Aggregate, Bitumen, Waste Plastic

2.7.1 Aggregates

Aggregates (mineral aggregates) are hard, inert materials such as sand, gravel, crushed rock, slag, or rock dust. Properly selected and graded aggregates are mixed with the asphalt binder to form HMA pavements. Aggregates are the principal load supporting components of HMA pavement. Because about 95% of the weight of dense-graded HMA is made up of aggregates, HMA pavement performance is greatly influenced by the characteristics of the aggregates. Aggregates in HMA can be divided into three types according to their size:

Coarse aggregates: are generally defined as those retained on the 4.75-mm sieve.

Fine aggregates: are those that pass through the 4.75-mm sieve and are retained on the 2.36-mm sieve.

Mineral filler: is defined as that portion of the aggregate passing the 2.36-mm sieve. They are also referred to as mineral dust or rock dust - consists of very fine, inert mineral with the consistency of flour, which is added to the hot mix asphalt to improve the density and strength of the mixture. It shall be incorporated as part of the combined aggregate gradation .The fillers may be cement or fly ash.

Road aggregate characteristics

Table 2-2road aggregate characteristics

Color	Black>gray>white
Strength	Need to be good
Surface roughness	More preferred
Porosity	2% tolerance
Moisture absorption	2% tolerance

2.7.2 Bitumen used as a binder

Table 2-3physical property of bitumen 80/100 grade

Characteristic	Test method	Unit.	Min	Max.
Specificgravity@25℃	IS: 1202-1978	gm/cm^3	1.01	1.05
Penetration(0.1mm) @25℃	IS: 1203-1978	Mm	80	100
Softening point	IS: 1205-1978	℃	42	52
Ductility @25℃	IS: 1208-1978	Cm	100	

2.7.3 Waste plastics

A plastic is a type of synthetic or man-made polymer; similar in many ways to natural resins found in trees and other plants. . Plastics have been used in packaging, automotive and industrial applications, medical delivery systems, artificial implants, other healthcare applications etc**.**The world's annual consumption of plastic materials has increased from around 5 million tons in the 1950s to nearly100 million tons in 2001 [21]

Plastic offer advantages Good insulation for cold, heat and sound saving energy and reducing noise pollution, lightness, resilience, resistance to corrosion, colour, fastness, transparency, ease processing, low density, , good mechanical properties, good chemical resistance, excellent thermal and electrical insulating properties and low cost (in comparison to other materials) etc. The plastic constitutes two major category of plastics based on physical properties; (i) Thermoplastics and (ii) Thermo set plastics. The thermoplastics, constitutes 80% and thermo set constitutes approximately 20% of total postconsumer plastics waste generated .In a thermoplastic material the very long chain – like molecules are held together by relatively weak Van der Waals forces. In thermosetting types of plastics the molecular are held together by strong chemical bonds making it quite rigid materials and their mechanical properties are not heat sensitive [14]Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Moreover, the softened plastics have a binding property. Hence, the molten plastics 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. The use of plastic waste helps in substantially improving the abrasion and slip resistance of flexible pavement. [18]

2.8Properties of low density polyethylene (LDEP)

1. LDEP melting point 105 to 115℃
2. Density 0.910-0.940g/cm^3
3. Chemical resistance

- Good resistance to alcohols, dilute alkalis and acids
- Limited resistance to aliphatic and aromatic hydrocarbons, mineral oil

4. Temperature resistance up to 80℃ continuously and 95℃ for shorter times.
5. very low water absorption
6. Good insulation for cold, heat and sound saving energy and reducing noise pollution''

7. Durable and corrosion resistant[16]

Table 2-4 types of plastics and their major applications

Type of plastic	Description	Some uses for virgin plastic	Some uses for recycled plastic
Polyethylene terephthalate(PET)	Clear tough plastic, may be used as a fiber	Soft drink and mineral water bottles	Clear film for packaging, carpet fibers, fleecy jackets
Low density polyethylene (LDPE)	Soft, flexible plastic, milky white, unless a pigment is added	Lids of ice-cream containers, garbage bags, and garbage bins	Film for builders, industry, packaging and plant nurseries
High density polyethylene(HDPE)	Very common plastic, usually white or colored	Crinkly shopping bags, freezer bags, and milk	Compost bins, detergent bottles, crates, and mobile rubbish bins
Polypropylene (PP	Hard, but flexible plastic	Ice-cream containers, potato crisp bags, stools and chairs	Compost bins, kerb side recycling crates, and worm factories
Polystyrene (PS)	Rigid, brittle plastic. May be clear, glassy	cheap, transparent kitchen ware, light fittings, bottles, toys, and food containers	Clothes pegs, coat hangers, and video/CD boxes

2.9The bitumen Test

Bitumen is subjected to various tests before it is used as a binder in road construction to determine its suitability as a binding material. The following tests are usually conducted to evaluate different properties of bituminous materials.

1. Penetration test –Most Commonly use technique for evaluating the consistency of bitumen in a specific temperature. Rather than a measure of quality it is a mean of classification. We examine the consistency of sample of bitumen by determining the distance in 10th of mm that a standard needle perpendicularly penetrates the bitumen sample under specified conditions of temperature, time and load by using penetrometer.

An indirect method of measuring viscosity is the measure of penetration of a standard needle under standard conditions of load, time & temperature. The penetration value obtained is represented in 80-100 or 80/100 grade bitumen at standard consistence and it range from 20-225mm. In cold region bitumen with High penetration value is used. In warm region low penetration value is used ex. 30/40 grade. The factors which affect the Penetration test is test temperature, needle size and weight and period of cooling

2, Softening point-This test is conducted using Ring and ball apparatus. The principle behind this test is that softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test. A viscosity material like bitumen or tar doesn't have a well-defined softening point. However a std test determines the temperature at which a std ball will pass through a disc of bitumen contained in ring.

The softening point is range between 35℃ to 75℃. The liquid water is used for bitumen having softening point less than 800℃ and Glycerine is for softening point more than 800℃. Higher softening point indicates lower temperature Susceptibility and in warm climate. The factors which affect the softening points are quality and type of liquid used, weight of ball, distance between bottom of the ring and bottom base plate and rate of temperature.

3, **Ductility test-** It is an empirical test which measure1the bitumen cohesive strength. This test involves a sample retained at a constant temperature of 27 ℃ in water bath. Continuous tensile forces with constant rate are applied at sample. Ductility is measured as the length of sample brakes. Ductility gives the cohesive strength of bitumen which reflects material fatigue strength. Material having greater ductility is material of choice to endure repeated loads in a better manner.

In flexible pavement construction it is important that the binders form ductile thin film around the aggregate. This serves as a satisfactory binder in improving the physical interlocking of the aggregate bitumen mixes. Under traffic loads the bitumen 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. The test is believed to measure the adhesive property of bitumen and its ability to stretch. The ductility of a binder is an indication of its elasticity & ability to deform under load & return to original condition upon removal of the load. A material which doesn't possess adequate ductility would crack under a load. This is unsatisfactory since water can penetrate into the surfacing through there cracks. The factors which affect the ductility is pouring and test temperature, dimension of briquette mold, rate of pulling and period of cooling.

4, Viscosity Test:

Viscosity is the property of a fluid that determines the resistance offered by the fluid to a shearing force under laminar flow conditions, it is thus the opposite of fluidity. The determination of viscosity is generally done by efflux viscometers. They work on common principles, though they differ in detail. The liquid under test is poured to a specified level into a container surround by water or oil bath providing temperature control at the base of the container is a small orifice with a simple valve control on opening valve, the time in seconds is recorded for a stated quantity of liquid to discharge into a measuring liquid below.

5, Specific gravity test: In most applications bitumen is weighed, but finally in use with aggregate the bitumen content is converted on volume basis. Hence determine of specific gravity value is required for conversion of weight to volume. Specific gravity of a binder doesn't influence its behavior but all the same, its value is needed for mix design. Specific gravity of bitumen varies from 0.97 to 1.02 .There are two methods to test the specific gravity of bitumen Pycno meter method and Balance method

6 Heat stability test

When a bituminous binder is heated continuously it starts emitting volatile vapors above a certain temperature and these volatile vapors can momentarily catch fire in form of flash and continued heating get fired

The flash point of bitumen is that temperature at which it gives off vapors, which ignites in the pressure of a flame, but don't continue to burn. The flame point is an induction of critical temperature at & above which suitable precautions should be taken to eliminate fire hazards.

Fire point test: If heating is continued beyond the flash point, the vapors ignite in the pressure of a flame & continue to burn indicating the fire point temperature. There is no standard method to determine the spontaneous ignition temperature, which can only broadly indicate.

Loss on heating test: The effect of heat on a bituminous binder is the loss of volatile constituents. This loss causes the binder to harden. Thus one method of testing the desirable property of a binder is to find out the loss on heating. This is achieved by an accelerated heating test a 50gm sample is weight is taken and maintained at a temperature of 1600℃ for 5hours. Then it expressed as a percentage of loss in original weight is determined.

7. Solubility test: It has already been indicated that all bitumen are substantially soluble in CS2. This is one of the points that define bitumen. Hence any impurity in bitumen in the form of inert minerals, carbon, salts etc. could be quantitatively analyzed by dissolving the samples of bitumen in any of the two solvents.

Thin film oven test: In this test, a sample of bitumen is subjected to hardening conditions as would be expected during hot mixing operations this method is then used for identify short term aging or hardening of bitumen. [22]

2.10Processes for manufacturing bitumen mix road using waste plastic

Waste plastic is made powder and varying percent plastic is mixed with bitumen. Plastic increase the melting point of the bitumen and makes the road flexible during winters resulting in its long life. By mixing plastic with bitumen the brittleness overcomes and elastic nature enhances. The plastic waste is melted and mixed with bitumen in a particular ratio. There are two important processes used for bitumen mix flexible pavement, they are

2.10.1 Dry Process

For the flexible pavement, hot stone aggregate (170°C) is mixed with hot bitumen (160°C) and the mix is used for road laying. The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity as per IS coding. The bitumen is chosen on the basis of its binding property, penetration value and viscous-elastic property. The aggregate, when coated with plastics improved its quality with respect to voids, moisture absorption and soundness.

In this process the shredded plastics are poured over the heated aggregates, thus forming plastic coated aggregates which are then mixed with hot bitumen to form plastic coated aggregate bitumen mixture for laying roads. The coating of plastic decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement.

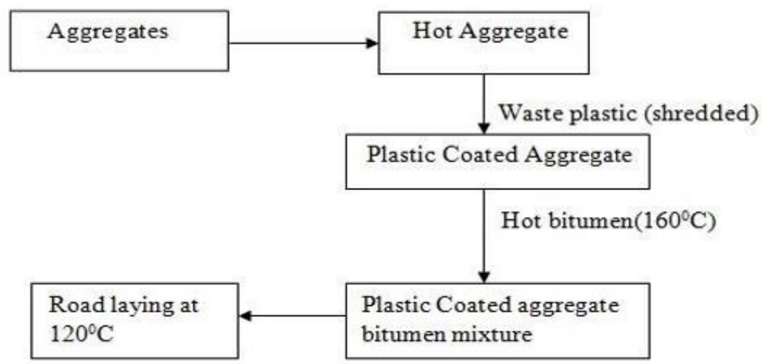


Figure 2.4dry process

2.10.2Wet Process:

These are the method used for formation of polymer based modified bitumen, in which the waste polymer directly added with bitumen and heated up to temperature of 170℃ so that proper blend is to be formed with proper dispersion of waste polymer into bitumen, then the hot mix is then cooled up to 120℃ into another chamber, which is then added to the aggregate in paddling chamber. The mix is to be cooled because when hot mix poured on aggregate then there are chances to form air pocket into small gap of aggregate and chances in lower the strength of rods and chances of rutting of roads. After addition of modified bitumen at 110℃ on aggregate, it is then laid on the road and then spreader material is compacted by 8 ton roller. [1]

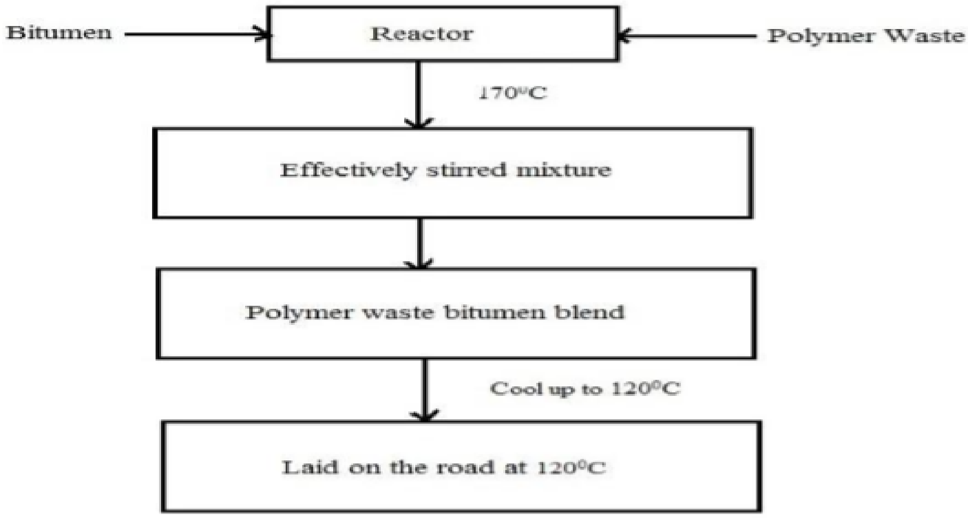


Figure 2.5wet process

The rate of mixing is affected by the following:

- Temperature of the binder (higher temperatures provide a quicker reaction),
- The surface characteristics of the plastic used (rougher surface reacts quicker)
- The size of the waste plastic particles (smaller particles swell quicker but lesser)
- The period, blend is kept at the reaction temperature (longer time, greater reaction). The main and important process in bitumen modification using wet process is blending of polymer sand bitumen. It requires proper blending technique to ensure a required quality of blend.

CHAPTER THERR

3MATERIAL AND METHODS

3.1. Materials

Chemicals used

- Benzene- to clean test apparatus
- Water -to wash waste plastic

Equipment's/instruments used in laboratory

Analytical balance - to measure the samples

Plastic bag -temporary storage

Pan -to mix the samples

Stove - to heat the samples

Thermo meter - to read the temperature

Standard penetrometer - For Penetration Test

Ring Ball Point Apparatus - For Softening Test

Pensky Martens Apparatus- For Flash and Fire Point Test

Water -to wash waste plastic

3.2Methodology

- **Collection and Segregation process** Waste plastics (low density poly ethylene) were collected from primary and secondary collection then the collected Plastics were sorted.

Figure 3.1collection of waste plastic

- **Cleaning and drying process** the separated waste plastics were cleaned by soap and water and dried by using sun light.

Figure 3.2Washing and drying of waste plastics

- **Size reduction** The dried low density Polyethylene carry bags waste cut into a size between 2.36 mm and 4.75mm using shredding machine (scissors) This is because when the low density poly ethylene was added with bitumen it was ensured that the mixing was proper. The smaller the size of the low density poly ethylene, the more is the chance of good mixing.

Figure 3.3Size reducing waste plastics

- **Preheat-** the bitumen is to be heated to a maximum of 85℃to have good binding and to prevent weak bonding. (Monitoring the temperature is very important)

Figure 3.4melting of bitumen

- These plastic pieces are added slowly to the hot bitumen temperature around 160℃-170℃. The mixture stirred well using mechanical stirrer for about 20-30 minutes. Polymer-bitumen mixtures of compositions can be prepared and used for carrying out various tests.

Sample test preparation.

In this study, different samples were used to determine the optimum plastic content .The shredded plastic waste was mixed in the hot bitumen. Normal mix specimens were prepared with plastic contents of 1%, 2%, 4%, 6% and 8%. A single sample weighs 250gm. and mass calculations will be making based on that

Table 3-1 sample composition

Samples	Percentage of waste Plastic (%)	Mass of waste plastic (gm.)	Bitumen Mass(gm.)
1	1	2.5	247.5
2	2	5	245
3	4	10	240
4	6	15	235
5	8	20	230

Figure 3.5bitumen and plastic mix

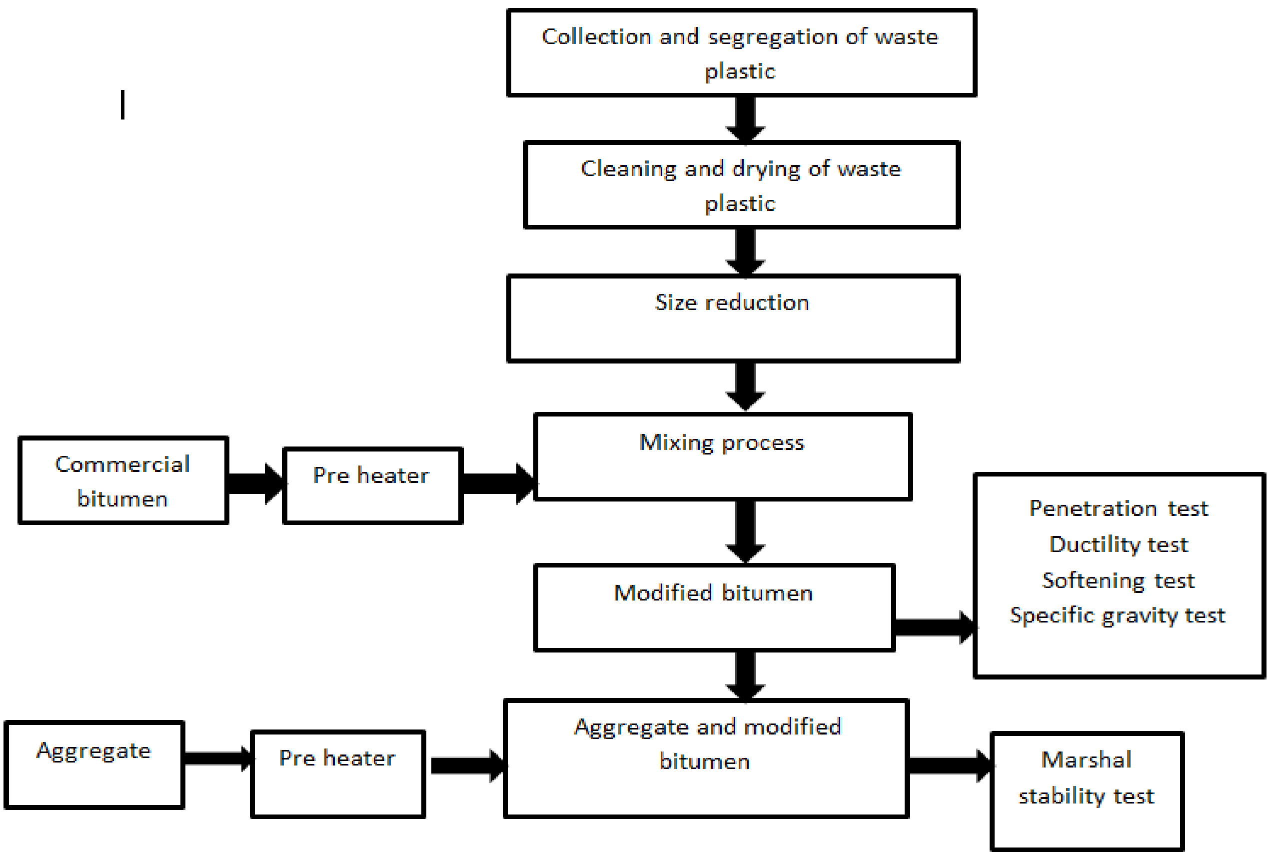


Figure 3.6Overview of the process for modified bitumen

3.3 Collection method of plastic

We have to use both primary and secondary collection methods

Primary collection is the collection of waste from the point where it is placed by the person or employee. |Payment is Volume based rate

Secondary collections are taken from the transfer station to the final plant site.

The employee collect waste from different waste generators, mainly the households, hotel and restaurant, commercial institutions and the purpose of the containers is to function as municipal collection stations, and the containers are therefore located on open spaces near the main roads in the city, where the households and other generators deliver their waste to the containers

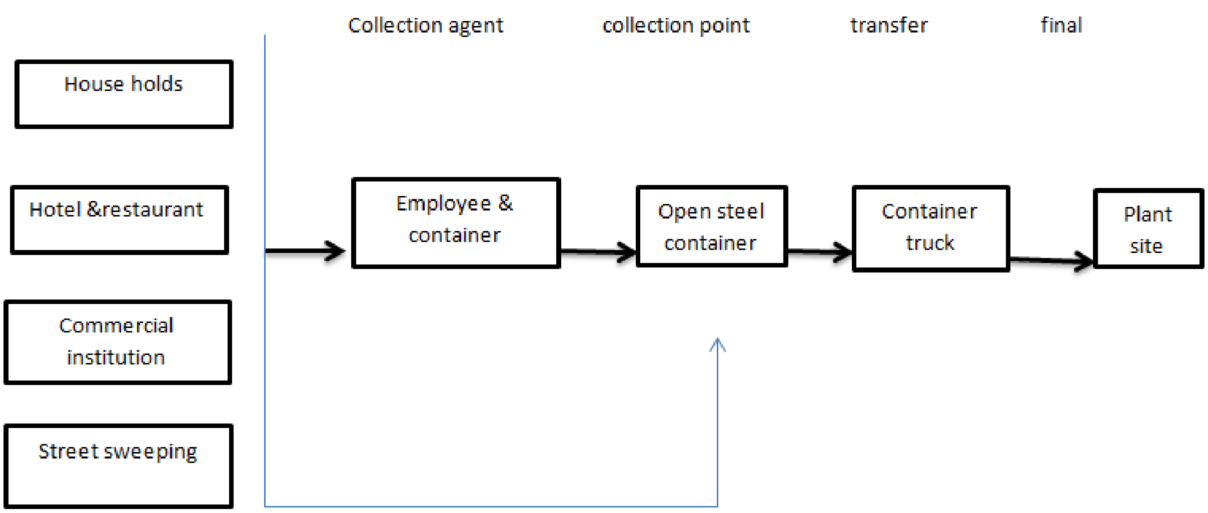


Figure 3.7 overview of collection method

3.4Characterization of modified bitumen

3.4.1 Penetration test – Most Commonly use technique for evaluating the consistency of bitumen in a specific temperature. Rather than a measure of quality it is a mean of classification. We examine the consistency of sample of bitumen by determining the distance in 10th of mm that a standard needle perpendicularly penetrates the bitumen sample under specified conditions of temperature, time and load by using penetrometer.

Theory – Determining the hardness or softness of the bitumen sample by gaging the depth in 10th of mm to which a standard needle penetrate perpendicularly in 5 seconds

Procedure-

- The sample was heated till it becomes liquefied while stirring thoroughly to remove unwanted air bubbles. The temperature of oven should not exceed the 90°C above the softening point (35-45°C). So, the maximum heating shouldn't exceed 135°C.
- The sample was Poured in a container .The specimen depth should be 10mm or more.
- It was cooled in atmospheric temperature at 15 - 30°C for 45- 90 min and then the water bath was used to retain the temperature of the sample.
- The sample was placed in such a way that the needle of penetrometer should slightly touch the sample surface.
- While starting the stop watch was allowed the needle to penetrate the sample freely for interval of 5 second.
- the dial reading was Recorded. (Taken at least three reading).

Figure 3.8penetration test

3.4.2 Softening point test-This test is conducted using Ring and ball apparatus. The principle behind this test is that softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test.

Procedure

- Material was heated up to (75 to 100) Celsius beyond it softening point.
- It was stirred till it is completely liquefied and most of bubble and water are removed.

- The ring was placed on metal plate which is coated with mixer of glycerin and dextrin to avoid it from stinking on the plate.
- The sample was poured in the mold till the sufficient level.
- The excess sample was removed after cooling it for 30 minutes in room temperature by using warmed sharp knife
- All the apparatus was gathered such as rings, thermometer and ball and assemble it in standard form.
- The water bath contained distilled water at room temperature and filled the bath above 50mm from the upper surface of the ring.
- Freshly boil distilled water were in the water bath.
- The top surface of bottom plate of support or bottom of bath and bottom of the ring has a difference of 25mm in between.
- Bath temperature was maintained at 5 °C for 15 minutes than placed the balls in the ring at the center.
- the heat of the bath was increased while stirring the liquid so that temperature was rises at uniform rate of 5+0.5 c per minute until the sample is soften and it allow the ball to pass through the ring

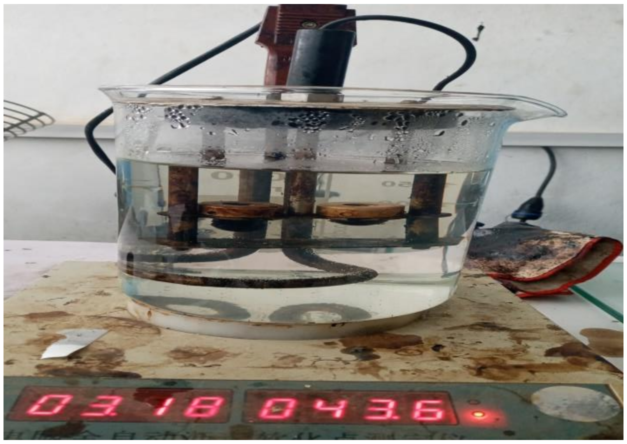


Figure 3.9 softening point

3.4.3Flash point of a material is the lowest temperature at which vapor of substance quickly catches fire in the form of flash under definite condition of test. so at this point fire will not last longer, just a flash will appear for a fraction of second.

Procedure

1. The bitumen was heated to above its softening point generally 75 ℃ to 100℃ and stir this softened bitumen thoroughly to remove air bubbles.
2. The cap was filled with softened bitumen up to the filling mark provided on the cup. placed the lid and close the cup
3. Other accessories like thermometer and flame exposure are suitably fixed in their respective positions. Now let up the flame and set the size of flame to 4mm in diameter
4. The bitumen getting heated and preferred rate of heating was 5℃ to 6℃per minute.
5. Stirring of sample was simultaneously done along with heating using stirrer device.
6. The rate of stirring was approximately 60 revolutions per minute.
7. the thermometer was Observed carefully and when the temperature is 17℃ below the actual flash point (175℃)lit up the time flame
8. The test flame size was 4mm diameter and carries it close to the heating sample.
9. The test flame applied for every 1℃ rise from this point and remember during application of test flame the stirring should be stopped.
10. the sample was catches the flame and forms flash, note town the temperature at that point which if flash point of the bitumen.

3.4.4 Fire Point: The lowest temperature at which the application of test flame causes the bitumen to fire and burn at least for 5 seconds.

Procedures

1) the sample was heated further with the same previous rate and apply the test was applied flame for every 2℃ rise when the material catches the fire and burns at least for 5 seconds, note the temperature at this pint which is the fire point of the bitumen.
2) The experiment was repeated for 2 more times and the average of the three readings should be taken as flash point and fire point of the given sample.

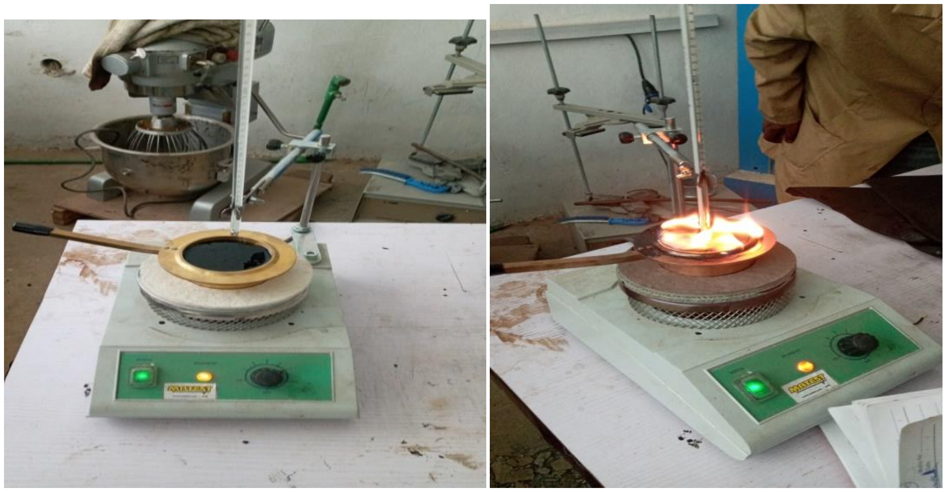


Figure 3.10 fire and flash point test

3.5 Aggregate and modified bitumen characterization

This test had to be carried out to determine the Optimum Binder content for BC mixes. The properties incorporate with the test are:

Marshall Stability Value (S) and Marshall Flow Value (F)

3.5.1Marshal stability test

This test involves measuring of resistance to plastic deformation of specimen cylindrical in shape. It is the most common test among all and is used on routine basis for road construction.

Principle- This test determines the load sustained by the sample at 50.8 mm/minutes rate of loading. Till failure is occurred the load is applied and max load is labeled as stability. Attached dial gauge measure sample plastic flow due to the loading while load is applied on the sample. The flow value is noted at same time when max load is noted at increment of 0.25mm

Procedure-

- Required quantities of coarse aggregate, fine aggregate & mineral fillers were taken in a pan and kept in an oven at temperature 160℃ for 2 hours. Preheating was required because the aggregates and bitumen were mixed in heated state.
- The required amount of shredded modifier was weighed and kept in a separate container.

- The aggregates in the pan were heated on a controlled gas stove for a few minutes maintaining the above temperature. Then the polyethylene was added to the aggregate and was mixed for 2 minutes.
- Bitumen was heated at 140℃.
- It was mixed them nicely and carefully and transferred the material to the mold container arranged.
- Blow of 75 was applied with standard hammer (45cm, 4.86kg) on the top side of the sample and inverse the sample and again apply 75 blows. then the mold was leaved with sample to cool for few minutes.
- the sample was taken out from the mold by slightly pushing it and mark the sample and leave it cure overnight at room temperature.
- Different sample were prepared similarly with varying quantities of bitumen content.
- The mold was kept in water bath for 30 min at temperature of 60 ℃ before conducting the test.
- The stability value of the sample was noted from the Marshall Stability apparatus.

Figure 3.11aggregate mix and compact

3.5.2. Marshall Flow Value

It is defined as the deformation undergone by the specimen at the maximum load where the failure occurs. During the loading, an attached dial gauge measures the specimen's plastic flow as a result of the loading. The flow value was recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load was recorded. Two readings were taken from the dial gauge i.e. Initial reading (I) & final reading (F) The Marshall Flow Value (f) is given by $f = F – I$

CHAPTER FOUR

4 RESULTS AND DISCUSSIONS

4.1. Results

Table 4-1numerical and experimental value of 80/100 grade bitumen

Property	Numerical Value	Experimental value(0% LDPE)
Penetration mm	0.8-10	9.8
Softening ℃	42-52	44.8
Flash point ℃	250 min	310
Marshal stability in KN	8 min	10
Marshal flow in mm	3-7	3.5

4.1.1Penetration Test result

It is one of the most bitumen control test for grades of bitumen. It measures the consistency or hardness of bitumen. Figure 4.1 shows the variation in penetration values with various percentages of LDPE used in bitumen. Penetration value of bitumen modified with plastic decreases in relation to the control bitumen (bitumen with 0% plastic content). This decrease in the value of penetration for LDPE modified bitumen was influenced or caused by the presence of LDPE. The value of penetration for the modified bitumen decreases as the proportion of LDPE introduced increases as compared with the bitumen with no LDPE content. When the content plastic waste is increased from 1% to 8 %, the penetration value became decreases gradually from 98 to 65. Hence the decrease in the penetration value of modified bitumen is good suggesting that the presence of LDPE will reduce rutting susceptibility of bituminous mix. However, this may have consequent effect on the flexibility of bitumen by making bituminous material much stiffer.

Therefore the first two samples 1 and 2 can be compromised, both samples can be applied to make good quality asphalt mix maintaining the quality of 80/100 grade bitumen.

For the remaining samples has lower penetration, sample 4 and 5 they can be used in areas with warm climatic condition since lower penetration grade bitumen is recommended for cold areas to avoid unwanted softening during warm days. .

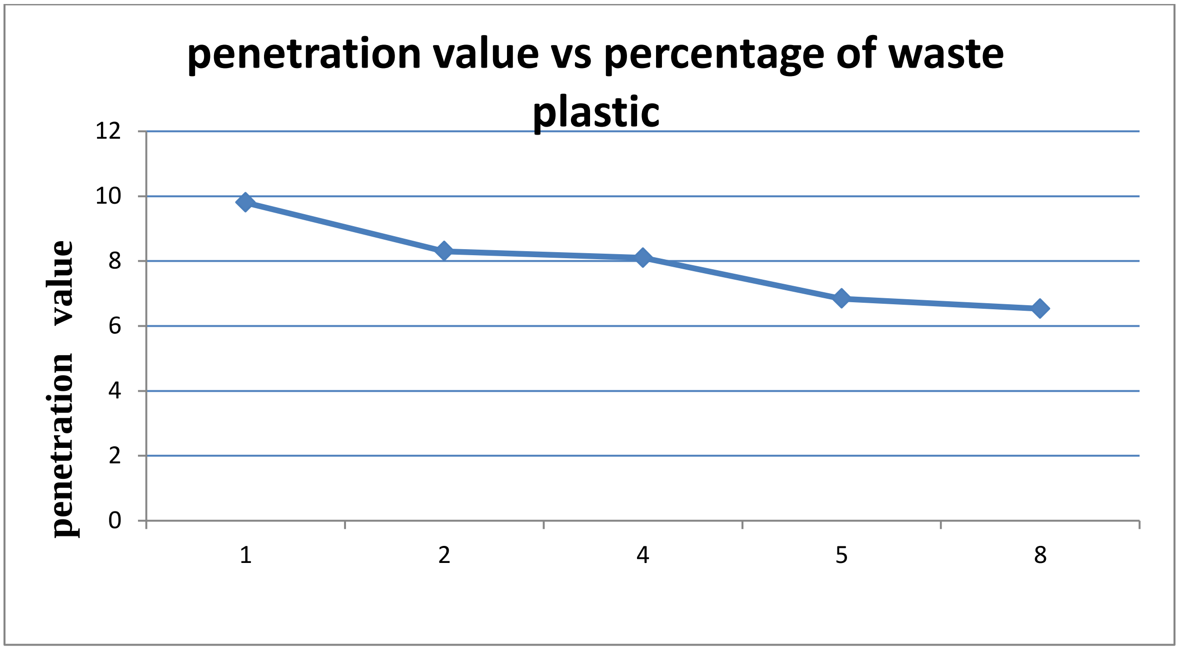


Figure 4.1 penetration result

4.1.2 Softening Points

Figure 4.2 observed the softening point of plastic modified bitumen its indicates that the addition of plastic into bituminous material will increase its softening point value. For bitumen 80/100 penetration grade, it can be seen that when plastic waste content increase from 1 to 8% the softening point also increase from 45 to 61%.

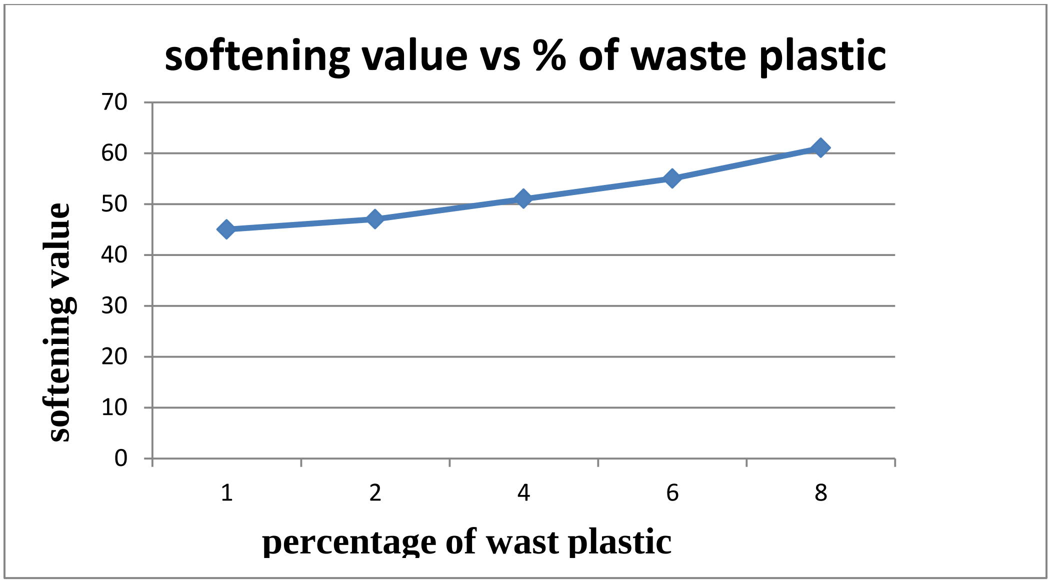


Figure 4.2 softening result

Based on the graph of softening point it can be illustrated that when the softening point is increasing resistance of the bituminous binder to the effect of heat will increase which in turn will reduce the tendency of bitumen to bleed or softening in hot weather and the adverse effect of temperature on bituminous material will reduce. Similarly, the rate of rutting will decrease due to the increase in the stability and softening point of bitumen. Higher softening point of plastic modified bitumen will ensure that they will not flow during service.

Therefore the higher the plastic contents in bitumen, the higher the softening point hence the lesser the temperature susceptibility.

4.1.3Flash and fire

At high temperatures depending upon the grades of bitumen materials leaves out volatiles. These volatiles are susceptible for to catch fire which is cause explosion or hazardous. Hence, it is essential to qualify this temperature for each bitumen grade. At extreme temperature bitumen can release enough vapor to increase the volatile concentration to a point where it ignites (flash) when exposed to a spark or open flame. For safety reason the flash point of bituminous compound is tested under control. The fire point which occurs after flash is the temperature at which the material will sustain combustion.

It is observed from graphs of Figure 4.3and4.4 when increase the portion of plastic in bitumen, the flash and fire point also increase.it can be proved that when the content of plastic waste is increased from 1% to 8 %, the flash and fire point increase gradually from 320℃ to 340℃ and 330℃ to 380℃ respectively. It means that plastic waste has a great effect on increasing the flash and fire point and the highest value obtained at 8% corresponding to 340℃. The result of the Fire point of modified bitumen increases from 1% to 8% with the highest value of 380 ℃at 8%.

The increase in the flash point and the fire point of the plastic modified bitumen can be attributed to the difference in the ignition temperature of the two materials mixed i.e. plastic and bitumen as plastic ignites at higher temperature. This signifies that inclusion of plastic content into bituminous mix will likely reduce associated fire hazard.

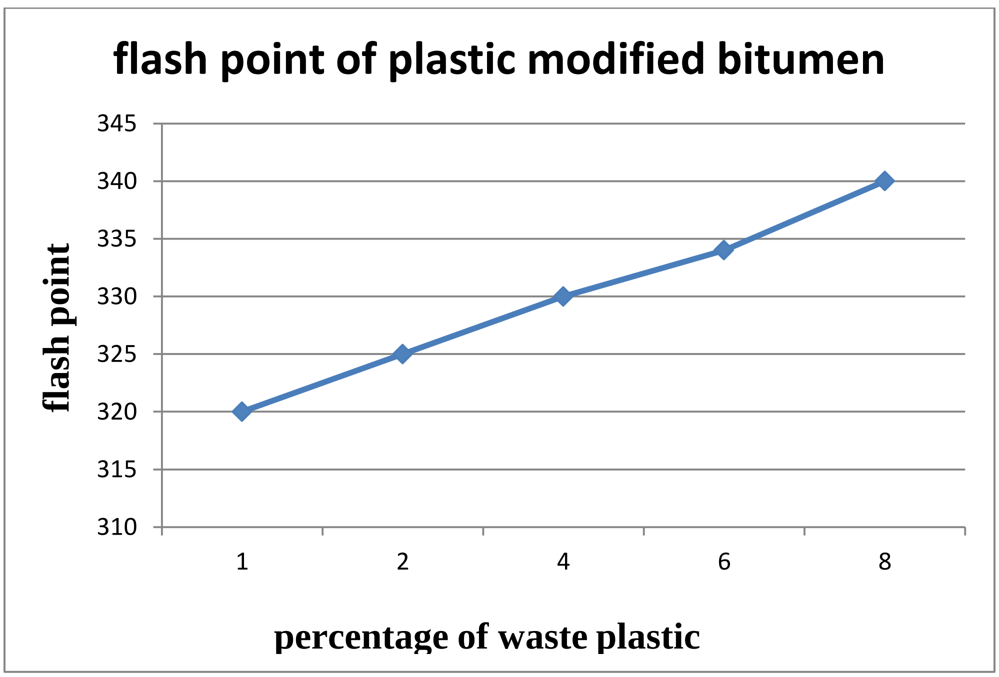


Figure 4.3 flash point result

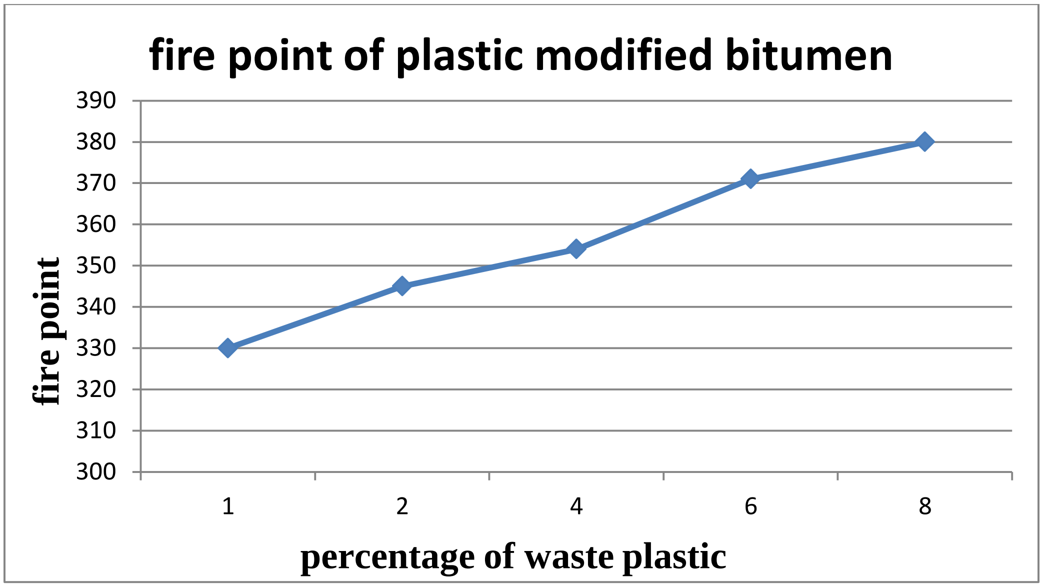


Figure 4.4 fire point result

4.1.4Marshal stability test

For our investigation we used standard specification total aggregate and bitumen mix 1200g and from this mix 5% bitumen and 95% pure aggregate.so

From this investigation the LDPE content increase the marshal stability of modified asphalt mix also increases till 4% of waste plastic content (LDPE) then it started to decline steeply at higher LDPE content.

The improvement of stability in LDPE modified asphalt mixes can be explained as a result of the better adhesion developed between bitumen and LDPE coated aggregates due to intermolecular bonding, these intermolecular attractions enhanced strength of Asphalt mix, which in turn help to enhance durability and stability of the asphalt mix. ERA recommended that the standard limit of stability is minimum 8and so based on the below graph .The maximum stability value is found nearly 13KN at LDPE content around 4%. Above this percent of plastic the stability value became below the standard and the surface of the road became swell up and decline steeply.

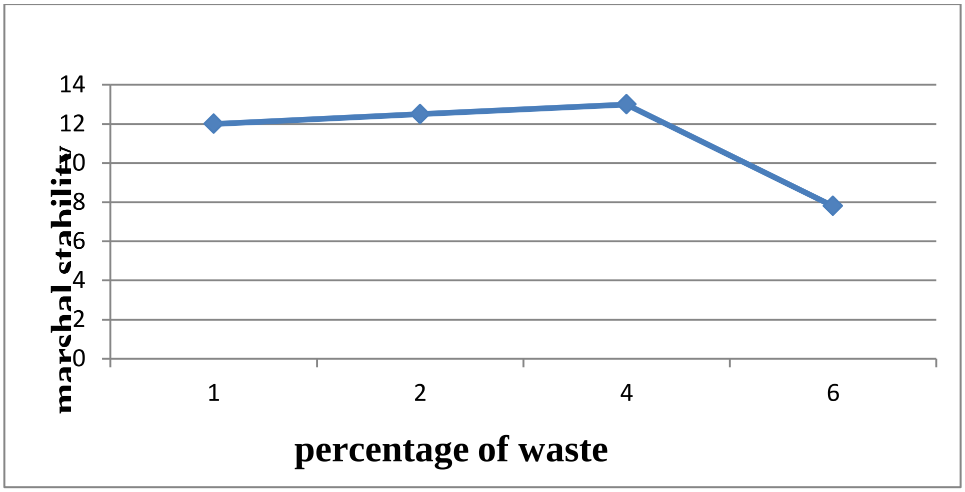


Figure 4.5marshal stability test

4.1.5Marshal flow test

When addition of LDPE increases the marshal flow decrease this indicate that the resistance to deformation under heavy wheal loads increase. For high way road the ERA recommended that the standard limit of flow is 3.5-4.5.based on the below figure the first three samples attain the standards of Flow.

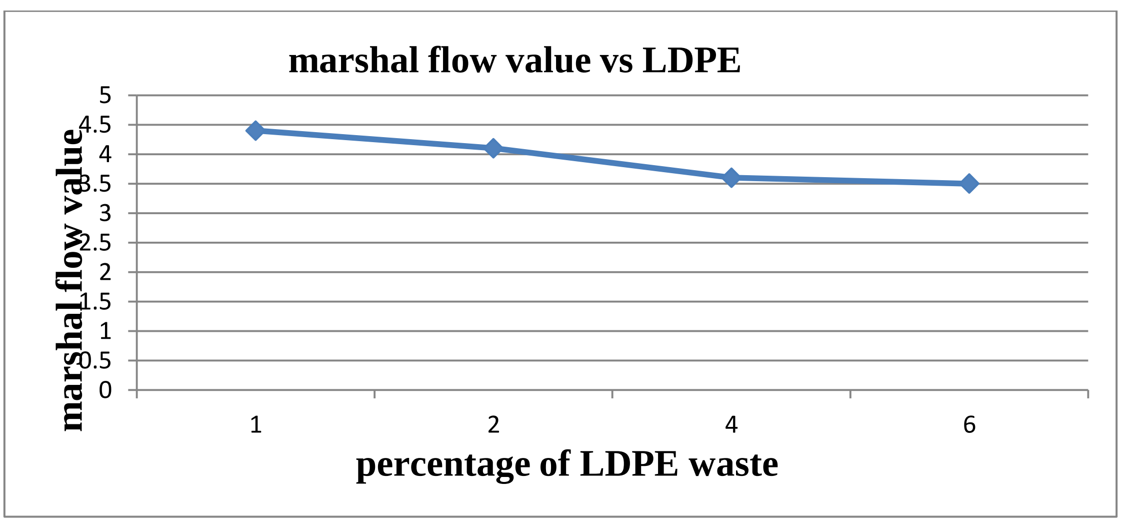


Figure 4.6marshal flow test

CHAPTER FIVE

5 MATERIAL AND ENERGY BALANCE

5.1. Material Balance

The main objective of material balance on bitumen modification is to determine the amount of Output, loss. And to determine the length of asphalt road that can be constructed.

The basis for material balance on each unit operation can be taken from our laboratory experiment and based on the data of Addis Ababa city administration, waste management sector,

Let consider this material balance done for 1% of waste plastic.

Basis

- 300 working days/year and24 working hours per day.
- The process is batch process
- 6 batch/day and 4hour/batch
- It is Steady state condition
- Amount of asphalt mix =1ton
- Waste plastic percentage=1%
- Requirements can be determined as follows:
  - Aggregate Content=95%
  - OBC = 5%

Experimental result

Wight of bitumen + waste plastic = 500g

WP = 1 %(500g) = 5g

Weight of bitumen = 500-5=495 g

Waste plastic content = 1 % weight of OBC

For one ton of asphalt mix the required amount of bitumen /ton of asphalt mix

OBC*(100% - % of WP)*1 ton

5 %*(100%-1%)*1ton =49.5kg/ton of asphalt mix

For one ton of asphalt mix the required amount of aggregate /ton of asphalt mix

=Aggregate content *1 ton

95%*1ton=950kg/ton of asphalt mix

Required weight of WP material per ton of asphalt mix =

OBC % x WP % x 1 ton= 1 % x 5 % x 1ton=0.5kg/ton of asphalt mix

According to the data of Addis Ababa city administration, waste management sector City of Addis Ababa generates a solid waste of 0.4kg/c/day means 146 kg/cap/year. More than 200,000tons are collected each year. About 550t/day, 80% of the total waste collected.

Sources of Waste Generated

- 76% households
- 18% institutions ,commercial, factories, hotels,
- 6% is street sweeping

It is estimated that only 65% of the waste generated in the city is collected, 5% recycled, 5% composted the remaining is simply dumped on open sites, drainage channels, rivers and valleys as well as on the streets (UN, 2010).

And when we see the physical composition of solid waste plastic waste takes only 2.9 %.

According to 2008 E.C estimation the city has a population of 3,384,569.and 65% of the waste generated in the city is collected.

Solid Waste collected within a year =3,384,569pp.*146 kg/cap/year*65%=879,987.94 kg/day

Waste plastic available will be =879,987.94 kg/day*2.9%=25,519.65kg/day

Assumption

- From those 25,519.65kg/day plastic waste, LPDE takes 60%.
- assume that 30% of the collected waste can be utilized =

Therefore LPDE waste =25,519.65kg/day*60%=15,311.79kg/day

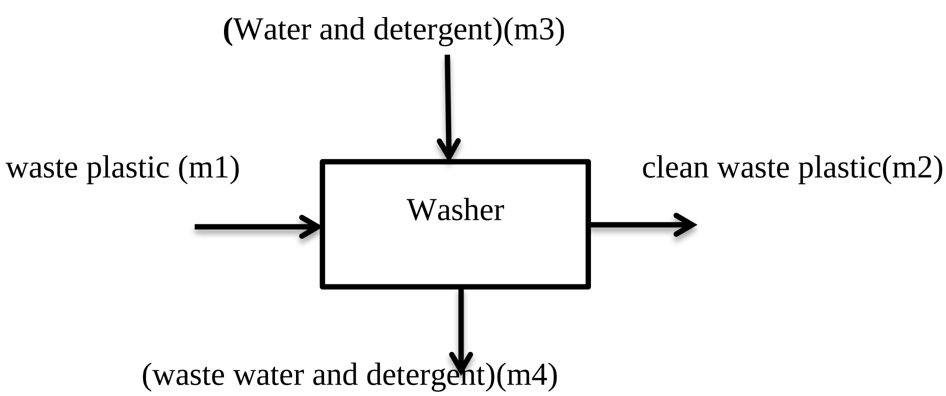
Final LDPE input=15,311.79kg/day*25%=**3,827.947kg/day**

5.1Material balance on major unit operations

According to the law of conservation of mass, mass can't be created nor destroyed. In its general form it can be written as;

Mass flow in the system = Mass leaving the system + Mass accumulated in the system

1. Material balance on washing tank



Mass in + generation = mass out +consumption +accumulation

Mass in = mass out=m3=m4

Final LDPE input=3828kg/day

Wight loss of plastic 2%

m2=98%m1

m2=0.98*3828= 3752kg

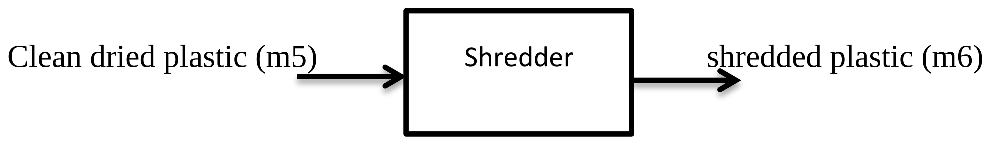
2. Material balance on dryer

Efficiency of dryer=99.5%

m5=99.5%m2

0.995*3752=3732kg

3, Material balance on shredder



Optimum size Efficiency of shredder ŋ =85%.the remaining 15%fined plastic

M4=0.85*3731=3171.5kg/day

According to the above basis for 5g waste plastic require 495g bitumen, so we can calculate how much bitumen is required for a given waste plastic

5g = 495g

3171 = ?

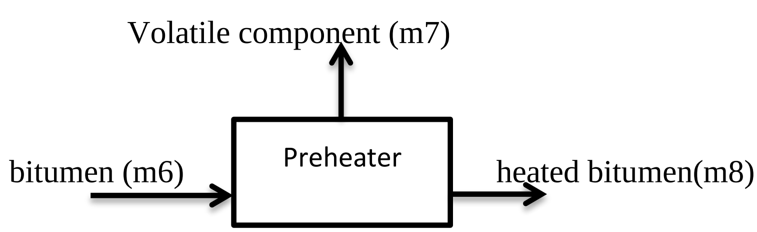
$$\frac{3171kg/day*495g}{5g}$$=313,929kg/day

4. Material balance on heater

Loss of heat on bitumen=0.2 %(max)

Therefore: - the amount lost by heating can be determined as

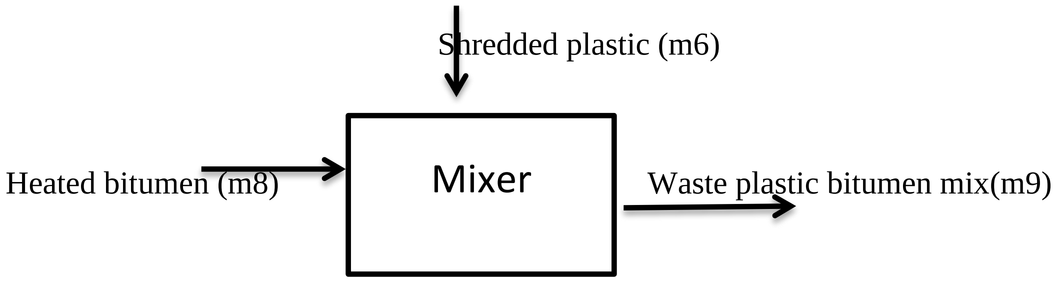
0.002*313,929kg/day=627,858kg/day



m8=m6-loss

313,929-627.8=313,301kg/day

5, material balance on mixer



M9=m6+m8

Waste plastic bitumen mix 313,301+3171.5=316,472kg/day

6, Material balance on Pre- Heater

In order to calculate the amount of aggregate required to be mixed with this waste plastic bitumen mix, take the assumption of conventional asphalt mix ratio of aggregate-to bitumen. Mass of aggregate material per ton of asphalt mix (950 kg)…for 49.5 kg bitumen for1ton how much aggregate required for 313,301 kg bitumen

49.5kg = 950kg

313,301kg = ?

$\frac{950*313,301}{49.5}$ =6,012,847

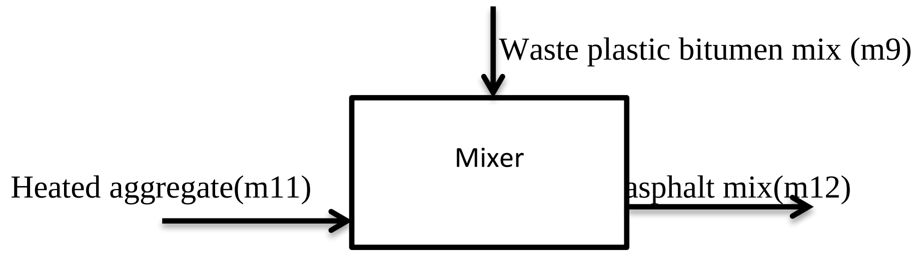
Aggregate required = 6,012,847 kg/day aggregate

Mass in + generation = mass out +consumption +accumulation

Mass in = mass out

m10=m11=6,012,847

7, material balance on mixer



Mass in + generation = mass out +consumption +accumulation

Mass in = mass out

m11+m9=m12

6,012,847+316,472=6,329,319

Asphalt production on daily basis =6,329,319kg/day

For section of road to be covered by asphalt mix, produced by waste plastic modified bitumen, take the following basis:

Width (W) = 10 m

Asphalt layer with 6 cm or 0.06m depth (D)

Density of modified asphalt mix (ρ) = 2.346 g/cm3 = 2.346 ton/m3

Length (L) = to be determined on daily basis

Therefore, we can determine the length of asphalt road that can be constructed as

V = L*W*D

L = M/ (W*D*ρ)

$$L=\frac{6{,}329{,}319 kg/day}{2346 kg/day*10m*0.06m}=4{,}496.5m$$

Therefore, 4.49 km road can be constructed using the daily generated waste plastics

5.2 Energy balance

Energy Balance on Major Unit Operation

i. **Shredder**

Power consumption: 18 kW

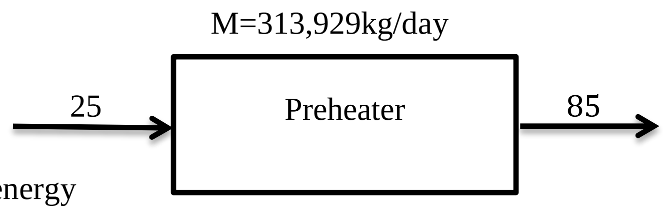
Energy requirement= power*working days*working hours

18kw*300days/yr*24hrs/day=129,600kwh/day

ii. Pre-Heater

The energy balance was performing based on the material balance results.

The basic of the calculation is



From conservation of energy

Energy in +energy generation=energy out +energy consumption +energy accumulation

Energy in =energy out

The required energy is calculated as

$Q = m\ Cp\ \Delta T$

Where

Q= required energy

M= capacity of the plant in kg = 313,929kg/day

Cp= specific heat capacity of the bitumen Cp=2.093kj/kgk

ΔT is temperature change of the bitumen

$Q = m\ Cp\ \Delta T$

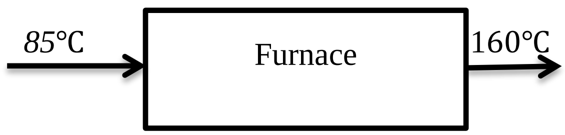
ΔT=T final-T initial 85℃-25℃=60℃

(313,929kg/day)*(2.093 KJ/kgk)*(60℃)=39,423,203kj/day=39.42MJ/day

Then, the annual energy requirement of the pre heater, assuming 300working days, will be

Q_{annual}=39.42MJ/day*300days/yr=11,826MJ/yr

ii. Furnace with Agitator



From conservation of energy

Energy in +energy ~~generation~~=energy out +energy ~~consumption~~ +energy ~~accumulation~~

Energy in =energy out

$Q= m(Cp_1X_1+Cp_2X_2)\ \Delta T$

Where

Capacity of the plant in kg =(316,472kg/day)

Cp_1specific heat of bitumen(2.093kj/kgk)

Cp_2specific heat of plastic (2.1 kj/kgk)

X_1 mass fraction of bitumen

X_2 mass fraction of plastic

Since $X_1+X_2=1$ and from basis of 500g is mass of a mixture with 495g bitumen and 5 g plastic

$X_1=\frac{495}{500}=0.99$

$X_2=\frac{5}{500}=0.01$

$\Delta T=T$ *final*-T *initial* 160℃-85℃=75℃

$Q= m(Cp_1X_1+Cp_2X_2)\ \Delta T$

=(316,472kg/day)*(2.093kj/kgk*0.99)+(2.1 kj/kgk*0.001)75℃

49,231254kj/day=49.23mj/day=2.05mj/hr

For 24 hr and 300 working days,

2.05mj/day *300days/yr*24hr/day=14,769MJ/Yr

CHAPTER SIX

6. SIZING OF MAJOR EQUIPMENTS

Assumption

- All tanks are 10% safety factor.
- Sizing of equipment is depending on the material balance calculated on the above section.
- Basis : one day

Sizing of dried plastic storage tank

Material of construction carbon steel

Material handled waste plastic

Density of plastic : $0.923 g/cm^3 = 923 kg/m^3$

Required mass per day 3828kg/day

Density $= \frac{mass}{\text{volume}}$

The required volume of storage tank is for 7 days

Volume waste plastic$= \frac{3828 kg/day}{923 kg/m3} = 4.147\ m^3$

$4.147\ m^3 * 7 = 29.02\ m^3$

If the number of storage tank is 3

$29.02 m^3/3 = 9.67\ m^3$

Vvessel$=9.67\ m^3 * 1.1 = 10.64\ m^3$

Sizing of bitumen storage tank

Material of construction carbon steel

Material handled bitumen

Density of bitumen: $1.035 kg/dm^3 = 103.5 kg/m^3$

Required mass per day 313,929kg/day

Density $= \frac{mass}{\text{volume}}$

$=\frac{313,929 kg/day}{103.5 kg/m3}$=3033.1m^3/day

Required volume of vessel Vv_{essel}=3033*1.1=3336 m^3/day

The bitumen may be stay for around one week or 7 days, so that the total volume of vessel required for one week is 23,354m^3

Sizing of mixer

Material of construction carbon steel

Material handled bitumen and plastic

Type of agitator top entering

Density 821 kg/m^3

Mass of mixing material 316,472kg/day

V of slurry = mass of slurry/density

$=\frac{316,472\text{kg/day}}{821\text{ kg/m3}}$=385 m^3

If the mixer 85% is full the volume of the tank

20 batches are operated per day, so that the volume of mixture per batch is 19.2 m^3. Vvessel=19.2m^3/0.85= = 22 m^3 including 10% safety factor

=22 m^3*1.1=24.2 m^3

Sizing /design of agitator in the mixer

Assume Length to diameter ratio. I.e. L/d=2, L= 2D

Volume of the tank/mixer= 24.2m^3

V=$\frac{\pi D2}{4}$*L

24.2m^3=$\frac{\pi * D2 * 2D}{4}$

D=2.48 m and L=4.97 m

Diameter of agitator = 0.8*Dv=0.8*4.82 = 3.98 m

Pump for delivering bitumen

Type	centrifuge pump
Operating condition	
Head	4m
Slurry to be	bitumen
Density	103.5kg /m3
Temperature of liquid	25℃
Materials of construction	carbon steel
Capacity	0.004m^3/s

Dryer for drying plastic

Material of construction	carbon steel
Density of plastic:	923kg/m^3
Required mass per day	3751.4kg/day

Density =$\frac{mass}{\text{volume}}$

$\frac{3751.4kg/day}{923kg/m3}$=4.06 m^3

V=4.06 m^3*1.1=4.46 m^3/day

V = $\pi r^2 h$, let assume h = 3r

V= πr^3=4.46 m^3/day

r=1.12m,h=3r =3*1.12=3.37m

A = $2\pi r^2 + 2\pi rh$

$(2\pi*(1.12m)^2)+(2\pi*1.12m*3.37m)$

A=31.59m^2

Sizing of washer

Basis:- the volume of the tank required is equal to the volume of the material it holds.

V = Vplastic + V_{H2O} + Vdetergent

$V=\frac{mplastic}{\rho plastic}+\frac{mwater}{\rho water}+\frac{mdetergent}{\rho detergent}$

$V=\frac{3828kg/day}{923kg/m3}+\frac{30000kg/day}{1000kg/m3}+\frac{200kg/day}{900kg/m3}$

$V=34.3m^{3/}day$

Required volume of vessel $V_{vessel}=34.3m^{3/}day*1.1=37.83m^{3/}day$

CHAPTER SEVEN

7 PRELIMINARY ENGINEERING ECONOMIC ANALYSIS

Total Capital Investment

Total Capital Investment = Fixed Capital Investment + Working Capital Investment For this case, capital investment items are calculated based on the purchased equipment cost of the plant. Fixed capital cost = *f* (purchased equipment cost)

Table 7-1total purchased cost

	Equipment	Quantities	construction Material	Capacity	Unit cost($)	Total Cost$)
1	Plastic storage tank	3	Stainless steel	$10m^3$	19948	59844
2	Bitumen storage tank	1	Stainless steel	$23354m^3$	1,495212	1,495212
3	Washer tank	1	Stainless steel	$37.8m^3$	124,763	124,763
4	Dryer	1	Stainless steel	$31m^2$	50051	50051
5	Shredder	1	Stainless steel	0.5kg/s	6156	6156
6	Sieve	2		$1.7m^2$	1180	2360
7	Preheater	1	Stainless steel	200kw	50618	50618
8	Mixer with agitator	1	Stainless steel	$24.2m^3$	54197	54197
9	Pump	5	Carbon steel	$0.004m^3/s$	6116	30580
	Total					**1,873771**

Data Sources: http://www.mhhe.com/engcs/chemical/peters/data/ and use rating equipment cost by scaling

Estimation of fixed capital investment

Table 7-2fixed capital investment

Direct cost (DC)	**Percentage (%)**	**Estimated cost(in dollar)**
Purchased equipment	E	**1,873771**
Purchased equipment installation	30%E	562,131
Instrumentation and control	13%E	243,590
Piping (installed	31%E	580,869
Electrical(installed	10%E	187,377
Building (including service)	22%E	412,229
yard improvement	12%E	224,852
Service facilities	42%E	786,983
Land	6%E	112,426
A. Total direct cost (TDC)		**4,984,228**
Indirect cost (IC)	**Percentage (%)**	**Estimated cost(in dollar)**
Engineering and Supervision	20%E	374,754
Construction expenses	12%E	224,852
Contractor's fee	5%E	93,688
Contingency,	10%E	187,377
B. Total indirect cost		**880,671**

Total fixed capital investment (FCI) = direct cost + indirect cost

FCI =$4,984,228+$880,671=5,864,899

Total capital investment (TCI) = fixed capital investment + working capital investment

In most plants working capital investment takes (10-20) % of total capital investment. In this plant it is assumed to be 15% of total capital investment

TCI = FCI + WCI, But WCI = 15%TCI

TCI = FCI + 0.15TCI

TCI =FCI/ (1-0.15)

TCI=5,864,899/(1-0.15)= $6,899,881

WCI=0.15TCI

0.15*$6,899,881=1,034,982

Total production cost Estimation

Total production cost = Manufacturing cost + General expense

1, Manufacturing cost = direct production cost + fixed charge + plant overhead cost

A. **Fixed charge**: (10-20% total production cost)

1. Depreciation = 10% of FCI for machinery ,

Depreciation =0.1*5,864,899=$586,489

2. Local taxes: (1-4% of FCI) and consider the local taxes of 3% of FCI.

Local taxes =0.03*5,864,899=$175,946

3. Insurances: (0.4-1% of FCI) and consider the assurance 1% of fixed capital cost

0.01*5,864,899=$58,648

Fixed charge =depreciation + local taxes + insurance

=$586,489+$175,946+$58,648 =$821,084

B, direct production cost 60% total cost investment

Let, the total product cost be 'X'

1. Raw materials: (10-50% of total production cost) and consider the cost of raw materials 30% of total production cost,

Raw material cost =$0.30*X

2. Operating labor (OL):(10-20%of total production cost) and consider the cost of OL=15% of total production cost.

OL=$0.15*X

3. Direct supervisory and clerical labor (DS &CL): (10-25% of OL) and consider the cost for DS &CL =20% of OL DS &CL

=0.2*0.15*X=$0.03*X

4. Utilities :(10-20% of total production cost) and consider the cost of utilities= 17% of total production cost Utilities cost

=$0.17*X

5. Maintenance and repair (M & R): (2-10% of FCI) and consider the M & R cost=7%FCI

M &R =0.07*5,864,899=$410,542

6. Operating supplies :(10-20% of M&R or 0.5-1% of FCI) and consider 1% of FCI

= $0.1*5,864,899=$586,489

7. Laboratory charges: (10-20% of OL) and consider to be 15% Laboratory charges

=$0.15X*0.15X=0.0225X

Thus direct production cost

(DPC) =$($0.30*X+$0.15*X+$0.03*X+$0.17*X+$410,542+$586,489+0.0225X)

=997,031+0.6725X

Plant overhead cost

Plant overhead cost = (50-70% of operating cost, supervision, and maintenance or 5-15% of total product cost), Consider the plant overhead cost 5% of total product cost

Plant overhead cost= $0.05*X.

Manufacture cost= Direct production cost + Fixed charges + plant overhead cost

=$821,084 +997,031+0.6725X +$0.05*X.

=1,818,115+0.7225X

General expense = Administrative costs + Distribution and selling costs

1) Administrative costs: (2-6% of total production cost) and consider 2% of total production cost Administrative costs

   =0.02*X

2) Distribution and selling costs: (2-20% of total production cost) in this includes costs for sales offices, salesmen, shipping, advertising. And consider it to be 3% Distribution and selling costs

=0.03*X

General expenses=0.02*X+0.03X=0.05X

Total product cost(X) = manufacture cost + general expenses

Total product cost(X)= 1,818,115+0.7225X+0.05X=1,818,115+0.8225

(1-0.8225)X=1,818,115

Total expense X=$10,242,901

Gross earning/income

Income =unit selling price* Quality of product manufactured

Let Selling price $3/kg and produce 5,000,000kg/yr

Annual revenue=$3/kg *5,000,000kg/yr. =$15,000,000

Gross annual profit = Annual revenue –Total production cost

$15,000,000-$10,242,901=$4,757,099

Gross income including depreciation = Gross income-depreciation

Depreciation= (FCI-salvage value, Vs)/life period

Let service life 15 years.

DCP= $\frac{FCI-salvage\ value}{service\ life}=\frac{FCI-Vs}{n}$

$=\frac{5,864,899}{15}$=390,993

Gross income including depreciation $4,757,099-390,993=4,366,105

Let the Tax rate be 35 %(common in Ethiopia)

Net profit=Gross income including depreciation (1-Tax rate)

=4,366,105 (1-0.35)

Net profit=$2,837,968

Percent rate of return

The yearly profit divided by the total initial Investment necessary represents Return on Investment. Taking the risk factor Mar = 12%, to be the plant feasible RoI>Mar (must).

Net income =$2,837,968

Total capital investment (TCI) = $6,899,881

-Rate of return, % ROR=$\frac{net\ income}{TCI}$

=$$\frac{2,837,968}{\$6,899,881}$=41%> 12% it is acceptable

Payback period

The minimum length of time theoretically necessary to recover the original fixed capital investment in the form of cash flow is called payback period.

Assume 15 years Project service life and we use straight line method to calculate depreciation.

Dep= $\frac{FCI-salvage\ value}{service\ life}=\frac{FCI-Vs}{n}$

$=\frac{5,864,899}{15}=390,993$

Payback period= $\frac{FCI}{dep+net\ profit}$

$\frac{5,864,899}{390,993+2,837,968}=1.81$

=1.81 year < 5 year, it is acceptable

CHAPTER EIGHT

8. SITE SELECTION AND PLANT LAYOUT

8.1 plant location

When it has been decided to plant a factory it is most important to select a suitable site or location to house the factory. To selecting a site, owner must consider technical, commercial and financial aspects. The geographical area of the plant has a strong influence on the success or failure of the plant. In other words, it has a crucial effect on the profitability of the plant, and the scope of future expansion. Therefore, a plant should be located where minimum cost of production, as well as distribution could be obtained, amongst other factors.

There are a number of considerations concerning the choice of site locations for the production of modified bitumen with in the country. Some of these are general considerations whilst others relate directly to the process and its requirements.

Generally, the following list contains a few of the important considerations. Site selection criteria

- The raw materials should be easily available
- Distance from bitumen market must be also considered
- climatic and atmospheric conditions are governing factor
- There should be good transport facilities for bringing raw material and sending finished product
- Skilled and cheap laborers should be available near the plant site.
- Availability of power and fuel were very influencing in olden days to day
- The market should be near the factory for the quick service to the customers and easy transportation.
- A good working environment is preferable for the worker
    - ❖ **Therefore, the plant should be established in Addis Ababa**

8.2Plant layout

Plant layout is Physical arrangement of equipment and facilities within a plant to ensure a smooth flow of work, material, people and information

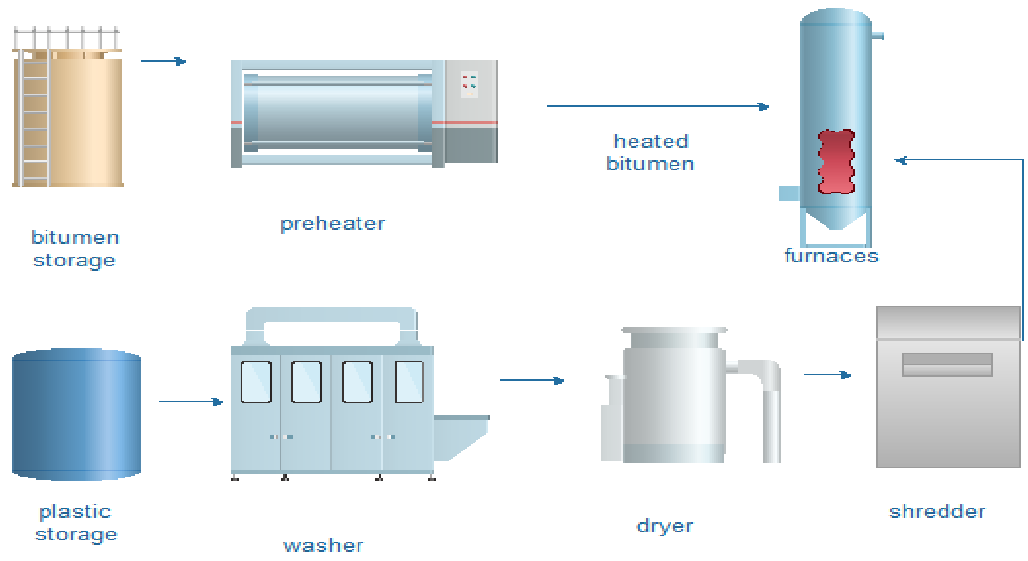


Figure 8.1product plant layouts

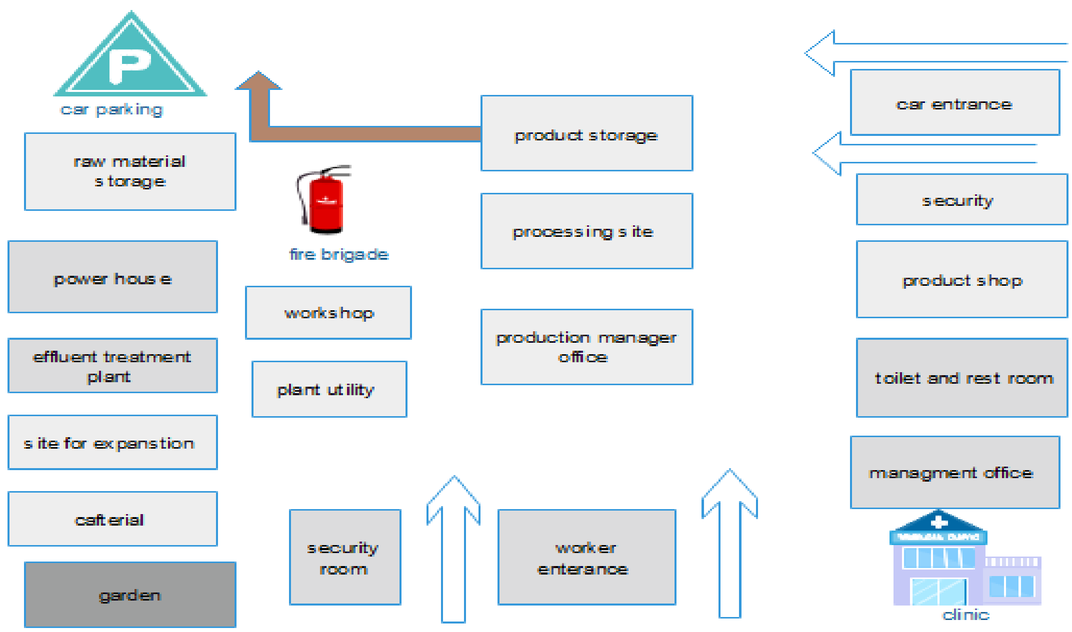


Figure 8.2process plant layout

CHAPTER NINE

9, CONCLUSION AND RECOMMENDATION

9.1conclusion

Plastics will increase the melting point of the bitumen. The use of the innovative technology not only strengthened the road construction but also increased the road life as well as will help to improve the environment and also creating a source of income. Based on the laboratory test results, the bitumen mixture containing plastic produced high resistance to permanent deformation and was found to be highly resistant to rutting. The result of the penetration, flash and fire point, and softening point test show a decrease in the consistency and increased in the resistance of the material to temperature changes. As the content of plastic waste increase from 1 to 8% the rheological properties have been improved. There is an increase in the softening point and decrease in penetration and ductility values. Decrease in penetration value which indicates the hardness of the bitumen, by increasing the percentage of plastic (LDPE), the marshal stability values are increased and marshal flow values are decreased. All the Modified specimens are fulfilled the minimum stability criteria Therefore, the use of waste plastic at 4% optimum mixture content is hereby recommended. Also, the use of plastic in bitumen will contributes to the reuse of waste plastic thereby enhancing the protection of the environment. Therefore from the environment and economic point of view the use of waste plastic in the development of modified asphalt is an interesting alternative.

9.2. Recommendation

Based on the current investigation the following recommendations are forwarded:

- The combination of wet and dry process is recommended , part of the plastic waste is coated on aggregate for improvement of impact and crushing strength of aggregate by applying dry process and remaining part of plastic waste is mixed in bitumen by applying wet process therefore the total loading of plastic waste can be increased as well as the improvement in mechanical properties will occurred
- Further research is recommended studies in detail marshal stability test to maximize the quality of bitumen
- Detailed economic feasibility studies in the production process is recommended

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10, Reference

1. *Akhilesh Yadav1, Ruchi an effectChandrakar2 Construction of plastic roads: An effective way to utilize wastes*
2. *Asphalt Institute; Eurobitume. The bitumen industry - A global perspective (2nd Edition). Lexington, Kentucky: Asphalt Institute; Brussels, Belgium: Eurobitume; 2011.*
3. *Awwad, MT and L Shbeeb (2007) The use of polyethylene in hot asphalt mixtures. American Journal of Applied Sciences 4, no.6: 390–396*
4. *B. Brûlé, Y. Brion, A. Tanguy. Paving asphalt polymer blends: Relationship between composition, structure and properties. In: Asphalt Paving Technology 1988: Journal of the Association of Asphalt Paving Technologists; 1988 February 29-March 2; Williamsburg, Virginia. St. Paul, Minnesota: Association of Asphalt Paving Technologists; 1988: 41-64.*
5. *B. Sengoz, G. Isikyakar. Analysis of styrene-butadiene-styrene polymer modified bitumen using fluorescent microscopy and conventional test methods. Journal of Hazardous Materials 2008; 150(2): 424-432.*
6. *D.O. Larsen, J.L. Alessandrini, A. Bosch, M.S. Cortizo. Micro-structural and rheological characteristics of SBS-asphalt blends during their manufacturing. Construction and Building Materials 2009; 23(8): 2769-2774.*
7. *Ehinola, Felode, & Jonathan, 2012).=Olugbenga A. Ehinola, Olugbenga A. Falode& G. Jonathan (2012). Softening Point and Penetration Index of bitumen from parts of Southwestern Nigeria. Original Scientific Paper 319-323*
8. *FransisHveem " Hveemstabilometer" 1927*
9. *G. Polacco, J. Stastna, D. Biondi, L. Zanzotto. Relation between polymer architecture and nonlinear viscoelastic behavior of modified asphalts. Current Opinion in Colloid & Interface Science 2006; 11(4): 230-245.*
10. *G. Polacco, S. Berlincioni, D. Biondi, J. Stastna, L. Zanzotto. Asphalt modification with different polyethylene-based polymers. European Polymer Journal 2005; 41(12): 2831-2844.*
11. *hp bitumen handbook*
12. *Lesueur D. (2009). The Colloidal Structure of Bitumen: Consequences on the Rheology and on the Mechanisms of Bitumen Modification. Advances in Colloid and Interface Science,145, 42–82*

13. M. Panda, M. Mazumdar. Engineering properties of EVA-modified bitumen binder for paving mixes. Journal of Materials in Civil Engineering 1999; 11(2): 131-137.
14. N.Thirugnanasambantham1,P.Tharun Kumar2, .R.Sujithra3, R.Selvaraman4, P.Bharathi5 ManufacturingAndTesting Of Plastic Sand Bricks
15. Nicholls, 1998; read and Whiteoak, 2003 the shell bitumen hand book
16. NitinDutt Sharma1, Anupam Sharma2 Utilization of Waste Plastic in Flexible Pavement
17. P. Morgan, A. Mulder. The Shell bitumen industrial handbook. Surrey: Shell Bitumen; 1995.
18. P.B.Rajmane Prof. A.K.GuptaProf.D.B.Desai Effective Utilization of Waste Plastic In Construction Of Flexible Pavement For Improving Their Performance
19. Roberts F.L, Kandhal. P.S, Brown. E.Ray, Lee. D, 1991.
20. S. Tayfur, H. Ozen, A. Aksoy. Investigation of rutting performance of asphalt mixtures containing polymer modifiers. Construction and Building Materials 2007; 21(2): 328-337.
21. Siddique R. , Khatib J., Kaur I., "Use of recycled plastic in concrete: A review", Waste Management 28 (2008) , 1835–1852
22. Vinod.B.R, Asst.Professor Department of Civil Engg,BMSIT&M, Bangalore PAVEMENT MATERIALS AND CONSTRUCTION
23. Whiteoak D., 1990).=Whiteoak D. (1990). Shell Bitumen Handbook. RiversdellHause, (6Edn), Shell Bitumen UK=Roberts F.L, Kandhal. P.S, Brown. E. Ray, Lee. D,& Kennedy. T.W. (1991). HMA materials, mixture design and construction. Mary Land NAPA Research and Education Foundation
24. X. Lu. On polymer modified road bitumens [doctoral dissertation]. Stockholm: KTH Royal Institute of Technology; 1997.
25. X.G. Dong, Q.F. Lei, W.J. Fang and Q.S. Yu: Thermochim. Acta Vol. 427 (2005), p. 149.
26. Y. Becker, M.P. Méndez, Y. Rodríguez. Polymer modified asphalt. Vision Tecnologica 2001; 9(1):39-50.
27. Yildirim, Y (2007) Polymer modified asphalt binders. Construction and Building Materials 21, no.1: 66–72.

Appendixes

1. PENETRATION TEST RESULT

Sample	Plastic Content in %	Testing Temperature	Penetration Average Value
1	1.0	25℃	98
2	2.0	25℃	83
3	4.0	25℃	81
4	6.0	25℃	68
5	8.0	25℃	65

2, SOFTENING TEST RESULT

Sample	Plastic Content in %	Softening Average Value
1	1.0	45
2	2.0	47
3	4.0	51
4	6.0	55
5	8.0	61

‘

3, FLASH POINT TEST RESULT

Sample	Plastic Content in %	flash point value
1	1.0	320
2	2.0	325
3	4.0	330
4	6.0	334
5	8.0	340

4, FIRE POINT TEST RESULT

Sample	Plastic Content in %	Fire point value
1	1.0	330
2	2.0	345
3	4.0	354
4	6.0	371
5	8.0	380

5. MARSHAL SABLITY TEST RESULT

Sample	Plastic Content in %	Marshal stability(KN)
1	1.0	12
2	2.0	12.5
3	4.0	13
4	6.0	7.8

6, FLOW TEST RESULT

Sample	Plastic Content in %	Initial reading in mm(I)	final reading in mm(F)	Marshal flow value (f) in mm
1	1.0	0	3.1	4.4
2	2.0	0	3.9	4.1
3	4.0	0	4.4	3.6
4	6.0	0	4.9	3.5

Marshal stability test apparatus