EFFECT OF POLYVINYL CHLORIDE(PVC) MIXED WITH BITUMINOUS MATERIALS ON PAVEMENT

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering



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Section: (20C)

Semester -Year (Spring-2024)

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DECLARATION

We hereby declare that the research reported in this thesis was performed by us as a research project in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering from Sonargaon University.

This thesis contains no material which has been accepted for the award of any other degree or diploma from any other institution. Further, to the best of knowledge and belief, the thesis contains no material previously published or written by any other person, expect when due reference is made in the text of the thesis.

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Dedicated

to

'Our Parents'

ACKNOWLEDGEMENTS

We sincere gratitude and respect to **Monirul Islam , Lecturer, Department of Civil Engineering, SU,** for his cordial and constant supervision, valuable suggestion and keen interest throughout the thesis work. His constructive comments and enormous expertise helped me in better understanding of the study.

We indebted to the **Md Robiullah (Laboratory attendants of Transportation Laboratory), Department of Civil Engineering, SU,** for assist the authors conduct the experiments required for this study.

We also like to express my gratitude to my family and friends for their sincere support and inspiration during the period of this study.

Finally, grateful to almighty Allah for giving me the strength to continue the study and bring it to the present stag

ABSTRACT

The growth in several types of industries together with population growth has resulted in enormous increase in production of varies type of waste plastic material and it is one of major environmental concerns. On other side, the road traffic and the traffic intensity is increasing; the load bearing capacities of the road should be improved. To deal with the problem, study on use of polyvinyl chloride (PVC) as partial replacement of bitumen is considered in the present work. This paper will help to take care of both those aspects.

The main objective of this study was to evaluate laboratory performance of modified bitumen mix using polyvinyl chloride(PVC) dust for flexible pavement to enhance or change in asphalt mix properties. In this study two proportion (8 & 9%) of Polyvinyl chloride (PVC) (PET and HDPE) were introduced in the asphalt mixture with a selected aggregate grading. Amount of laboratory tests such as Penetration, softening point, Specific gravity test and Flash & Fire point test has been carried out by replacing some parts of the bitumen with Polyvinyl Chloride (PVC). The results show that there is an improvement on those properties when compared to normal bitumen.

It is expected that using the output of this research, provide an economical solution and minimize the frequency of rehabilitation work by improving the performance of asphalt. It is also expected of substantially reduce volume of environmentally hazardous plastic and environmental pollution.

Study recommends contractors and local authorities to confirm using Polyvinyl Chloride (PVC) in asphalt mix with the propose percentage (7% PET and 8% HDPE by OBC weight) to improve the performance of asphalt mix. Moreover, Further studies are needed in various topics related to effective utilization and best incorporation techniques of waste materials.

Key Word:- Several Types Of Test such as Penetration Test, Softening Test, Specific Gravity and Flash & Fire Test, Modified Bitumen, Polyvinyl chloride (PVC)

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ACRONYMS

AASHTO	Association of American State Highway and Transportation officials
AC	Asphalt Concrete
ASTM	American Society for Testing and Materials
HDPE	High Density Polyethylene
HMA	Hot Mix Asphalt
LDPE	Low Density Polyethylene
MSW	Municipal solid wastes
OBC	Optimum Bitumen Content
PE	Poly Ethylene
PET	Polyethylene Terepthalate
PMB	Polymer Modified Bitumen
PP	Poly Propylene
PVC	Polyvinyl Chloride
SG	Specific Gravity
SPI	Society of the Plastics Industry
RB	Ring and Ball
TCDE	Transport Construction and Design Enterprise
VFB	Void Filled with Bitumen
VMA	Void in Mineral Aggregate

CHAPTER - 1

INTRODUCTION

1.1 Background

The management of solid waste is a growing problem in many urban areas in Dhaka today. One of the reasons for this is that during the recent decades urban areas in Dhaka have experienced a rapid urbanization due to rapid population growth and high rates of migration from rural areas. To give an indication of the situation, the urban population of the world is expected to double to more than five billion people in the next 35 years, with 90 percent of the growth taking place in developing countries.

Plastics are commonly used substances which play an important role in almost every aspect of our lives. The widespread generation of plastics waste needs proper end-of-life management. The highest amount of plastics is found in containers and packaging (like bottles, packaging, cups and other), and they also are found in durables such as tires, building materials and furniture and disposable goods. (Plastic Common Wastes & Materials).

The highway engineers are thinking about the alternative solutions to cop up with this growing challenge. The addition of polymers to enhance service properties in road paving applications was considered a long time ago and nowadays has become a real alternative. A variety of additives are used in order to obtain enhanced service properties within a wide range of temperature. A number of research works in many countries have confirmed the beneficial effects of polymer addition to bitumen.

In the construction of flexible pavements, bitumen plays the role of binding the aggregate together by coating over the aggregate. It also helps to improve the strength and life of road pavement. A common method to improve the quality of bitumen is by modifying the rheological properties of bitumen by blending with synthetic polymers like rubber and plastics. Use of plastic waste in the bitumen is similar to polymer modified bitumen.

In recent years, applications of Polyvinyl Chloride (PVC) 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. The durability of the roads laid out with Polyvinyl Chloride (PVC) is much more compared with roads with asphalt with the ordinary mix. Roads laid with plastic dust of (PVC)

mix are found to be better than the conventional ones. The binding property of plastic makes the road last longer besides giving added strength to withstand more loads. While a normal highway quality road lasts 4-5years it is claimed that plastic-bitumen roads can last up to 10 years.

Along with technical aspect, economical aspect is of course a huge driving force for the choice of technology. Different kinds of pavements have different demands on performance. From the economic aspect, it is not always better to achieve higher performance for a road. Only when the technology is cost-effective and people get the maximum benefits from it, then can it become popular. As for polymer modified bitumen, the cost is quite relevant with the dosage of the added polymer, while the polymer dosage usually has important influences on the final degree of polymer modified bitumen performance. So before constructing a road, the designers must know what the needed degree of performance for the road is and then decide to use polymer modified bitumen or not, and how much should be applied. Currently, most of the world consumption of bitumen is still base bitumen.

Use of Polyvinyl Chloride (PVC) in road construction with different method and approach is one of emerging advanced technology getting famous now days. Such technology solves not only the problem of management of municipal solid plastic of (PVC) but also it save environment pollution and bitumen cost. In most case utilization of plastic in flexible pavements has been done to increase the stability and durability of roads and reduce the cost of construction by replacing some percentage of bitumen with that of the Polyvinyl Chloride (PVC).

1.2 Statement of the Problem

The global production of plastic has continued to rise. Millions of tons of plastics were produced exponentially throughout the year. Recovery and recycling were practice but still it is not enough to consume all the plastic waste in the environment; such as landfill and water areas. In any part of the world the plastic produced or consumed per person is continued to rise together with the economy.

There are efforts in the reduction of plastic of (PVC) material in landfills. In addition to the harmful chemicals it adds to the environment such as bisphenol A, phthalates and antimony, it reduces the aesthetic value of the environment. Inadequate municipal and industrial dry waste collection will result to unmanageable waste. Much amount of these waste products will end up in open dump, waterway and everywhere. At the end of the day, these will cause environmental and health problem.

The government is importing bituminous materials from Middle East and other countries. The consumption of this bitumen is increasing as the government improves the road network. Replacing parts of this material will ease and minimize the consumption of bitumen. Plastic can be one of the waste products which can partially replace bitumen. The percentage of replacement and the increase of performance will be the aim of this research paper.

1.3 Research Objectives.

This research was conducted to answer the following objectives.

- To explore the physical and mechanical properties of Polyvinyl Chloride (PVC) with modified bitumen mix.
- To determine the effect of Polyvinyl Chloride (PVC) on capability and durability characteristics of bitumen mix.

1.4 Significance of Study

Plastics have a number of important properties which were used alone or together with other products to make a significance and expanding contribution for road construction needs. Therefore, the study has a beneficial purpose to the government and authorities to reuse of Polyvinyl Chloride (PVC) which improve the solid waste disposal problem. The study were used as a bench mark information to those scholars who want to conduct future detailed studies on utilization of Polyvinyl Chloride (PVC) for road construction and other related issues. These waste materials of (PVC) were possible to use in pavements, and this can reduce not only the cost of management of the increasing Polyvinyl Chloride (PVC) but also reduce the cost on the use of bitumen. Also this study has contribution in creating employment opportunities.

1.5 Scope and Limitation of the Study

This study was conducted to explore the idea on the use of Polyvinyl Chloride (PVC) dust in bituminous. Laboratory investigation was carried out to find whether it is viable to use waste plastic for road construction as a partial replacement of bitumen in bituminous asphalt pavement.

The present study basically focused:-

- On the study of the effect on Stability of bituminous mix with the addition of Polyvinyl Chloride (PVC) HDPE and PET.
- On the reduction of the bitumen amount by addition of Polyvinyl Chloride (PVC) (HDPE and PET) in bituminous mix.

The laboratory investigation on the bituminous mix was carried out as per the ASTM/AASHTO standard for road construction. The field application is out of the scope of work.

CHAPTER - 2

LITERATURE REVIEW

2.1 General

Over the past two decades, traffic volumes have increased, demanding from pavement engineers, stronger and long lasting pavements. New methods of pavement design are being developed to improve the performance of roads. New materials are being used to replace the old ones to improve the durability, strength, aesthetics and economy. One of the promising ways is to use plastics in bituminous road construction industry.

Plastic is a relatively cheap, durable and versatile material. Plastic products have brought benefits to society in terms of economic activity, jobs and quality of life. Plastics can even help reduce energy consumption and greenhouse gas emissions in many circumstances, even in some packaging applications when compared to the alternatives. Plastic waste also imposes negative environmental externalities. It is usually non-biodegradable and therefore can remain as waste in the environment for a very long time; it may pose risks to human health as well as the environment; and it can be difficult to reuse and/or recycle in practice. An issue of particular concern is that giant masses of plastic waste have been discovered in the North Atlantic and Pacific Oceans, the full environmental impacts of which are not yet fully understood but which cause severe damage to seabirds, marine mammals and fish.

2.1.1 Bitumen

Bitumen is a low-grade of crude oil which is composed of complex and heavy, hydrocarbons. In an oil reservoir, bitumen is a thick, viscous fluid and must be extracted from the ground. When extracting it, a lot of heat and effort must be used to upgrade it to a better product. Although bitumen is hard to extract from the ground, it can bubble naturally to the surface of the Earth in petroleum seeps. These seeps are places where fossil fuels and petroleum products leak out of the Earth instead of being trapped deep below the ground. In these seeps, bitumen, asphalt, and tar bubble up into pools. Additionally, bitumen is the main fossil fuel component of oil sands. When bitumen combines with asphalt tines a solid is formed that is useful for paving roads.

Production of Bitumen

In addition to being found naturally in seeps and the oil sands, bitumen can be produced by removing lighter fractions from crude oil during the refining process. Fractions that are removed are liquid petroleum gas, gasoline, and diesel.

Once crude oil has been extracted from the ground, the production of bitumen can begin. The crude oil is pumped from the storage tanks and through a system that increases the temperature of the crude oil to 200°C. The oil then moves to a furnace, where it is heated even higher to approximately 300°C where it is vaporized partially into a distillation column. Here, the separation of the different components of the crude oil occurs. As lighter components rise to the top, heavy components—including the bitumen—fall to the bottom of the column. This process is known as fractional distillation. Finally, the bitumen is obtained by further distilling the residue in a vacuum distillation column. This type of bitumen is known as straight run bitumen. The grade of the bitumen depends on how much volatile material remains in the distilled bitumen—with more volatiles resulting in a less pure, more liquid product.

Uses of Bitumen

Most refined bitumen is used in the construction industry. Mainly, it serves its use in paving and roofing applications. 85% of all bitumen is used as a binder in asphalt for roads, runways, parking lots, and foot paths. Gravel and crushed rock are mixed with thick bitumen, holding it together and it is then applied to roadways. 10% of the bitumen used worldwide is used in the roofing industry as its waterproofing qualities help make roofs function well. 5% of bitumen is used for sealing and insulating purposes in various building materials such as carpet tile backing and paint.

In addition to these main uses, bitumen also has many minor uses. Other examples are soundproofing, explosives, mildew protection, a binder in briquettes, a backing to mirrors, shoe soles, fence post coating and soil stabilization.

Types of Bitumen and Their Properties and Uses

The bitumen can be classified into the following grade types:

- Penetration Grade Bitumen
- Oxidized Bitumen Grades
- Cut Back Bitumen
- Bitumen Emulsion
- Polymer Modified Bitumen

Penetration Grade Bitumen

The penetration grade bitumen is refinery bitumen that is manufactured at different viscosities. The penetration test is carried out to characterize the bitumen, based on the hardness. Thus, it has the name penetration bitumen. The penetration bitumen grades range from 15 to 450 for road bitumen. But the most commonly used range is 25 to 200. This is acquired by controlling the test carried out i.e. the distillation process. The partial control of fluxing the residual bitumen with the oils can help in bringing the required hardness.



Figure 2.1: Penetration Grade Bitumen

Oxidized Bitumen

The refinery bitumen is further treated by the introduction of processed air. This will give us oxidized bitumen. By maintaining a controlled temperature, the air is introduced under pressure into soft bitumen. Compounds of higher molecular weight are formed by the reaction of this introduced oxygen and bitumen components. Thus, the Asphaltenes and the Maltenes content increases resulting in a harder mix. This harder mix has a lower ductility and temperature susceptibility.



Figure 2.2: Oxidized Bitumen

The oxidized bitumen is used in industrial applications such as roofing and coating for pipes. By this method of processing, the bitumen that has a lower penetration can be manufactured, which can be employed for paving roads.

Cutback Bitumen

These are a grade of bitumen that comes under penetration grade bitumen. This type of bitumen has a temporarily reduced viscosity by the introduction of a volatile oil. Once after the application, the volatile material is evaporated and bitumen gain its original viscosity. The penetration grade bitumen is a thermoplastic material. It shows the different value of viscosity for different temperature. In areas of road construction, it is necessary for the material to be fluid in nature at the time of laying. during surface dressing. It is also essential for the material to regain back to its original hardness and property after setting. This is ensured by cutback bitumen. The fluidity is obtained for any bitumen by raising the temperature. But when it is necessary to have fluidity at

lower temperatures during surface dressing, cutback bitumen is employed. The time for curing and the viscosity of cutback bitumen can be varied and controlled by the

- dilution of volatile oil, and
- the volatility of the oil added.

70/100 or 160/220 pen bitumen that is diluted with kerosene are the main composition of bitumen in the construction of roads. The standard tar viscometer is used to test the standard viscosity.



Figure 2.3: Cutback Bitumen

Bitumen Emulsion

This type of bitumen forms a two-phase system with two immiscible liquids. One of them is dispersed as fine globules within the other liquid. When discrete globules of bitumen are dispersed in a continuous form of water, bitumen emulsion is formed. This is a form of penetration grade bitumen that is mixed and used for laying purposes. An emulsifier having a long hydrocarbon chain with either a cationic or anionic ending is used for dispersing the bitumen globules. This emulsifier provides an electrochemical

environment. The ionic part of the chain has an affinity towards water and the bitumen is attracted by hydrocarbon part.



Figure 2.4: Bitumen Emulsion

2.1.2 Plastic Material

Plastic is an organic material manufactured from petroleum derivatives or naturally occurring. It is composed of one organic substance or more. It can be shaped into any form or shape as desired

Plastic is an organic material manufactured from petroleum derivatives or naturally occurring. It is composed of one organic substance or more. It can be shaped into any form or shape as desired. It is either synthetic or naturally occurring, that may be shaped when soft and then hardened to retain the given shape. Plastic is a polymer. A polymer is a substance made of many repeating units. The word polymer comes from two Greek words: poly, meaning many, and meros, meaning parts or units. A polymer can be thought of as a chain in which each link is the “mer,” or *monomer* (single unit). The chain is made by joining, or *polymerizing*, at least 1,000 links together. (American Chemistry Council."History of Polymers and Plastics for Teachers.")

Plastic is the general term for a wide range of synthetic or semi synthetic polymerization products. They are composed of organic condensation or addition polymers and may contain other substances to improve performance or economics.

There are few natural polymers generally considered to be "plastics". Plastics can be formed into objects or films or fibers. Their name is derived from the fact that many are malleable, having the property of plasticity.

2.1.3 Characteristics of Polymers

Polymers seem to have a limitless range of characteristics along with properties that allow them to be dyed in an endless array of colors. Their properties can be enhanced by additives. Being able to design or engineer polymers for specific applications makes plastics unique materials. Although each polymer has unique characteristics, most polymers have some general properties:

- They are resistant to chemicals.
- They are insulators of heat and electricity.
- They are light in mass and have varying degrees of strength.
- They can be processed in various ways to produce fibers, sheets, foams, or intricate molded parts.

2.1.4 Classifications of Plastic

Plastics can be classified in many ways, but most commonly by their physical properties. Depending on their physical properties, may be classified as thermoplastic or thermosetting materials.

- Thermoplastic materials:-can be formed into desired shapes under heat and pressure and become solids on cooling. If they are subjected to the same conditions of heat and pressure, they can be remolded.
- Thermosetting materials:-which once shaped cannot be softened /remolded by the application of heat.

Table 2.1 Typical Thermoplastic and Thermosetting material

Thermoplastic	Thermosetting
Polyvinyl Chloride (PVC)	Polyester

2.1.5 The Types of Thermoplastic:

Polyvinyl chloride (PVC):

Harmful and toxic if used for long time. It is commonly abbreviated PVC and used in the manufacturing of plumping pipes, bathroom curtains, toys, and transparent plastic

wraps for meat and cheese. It is widely used because of its cheap price, so it considered the most dangerous type of plastic. [1]

2.1.6 Environmental Impact of Waste Plastic

Some environmentalists state that despite recycling efforts, millions of plastic bags and water bottles take decades or centuries to decompose. Plastics are used throughout the world for a broad number of applications. However, there are many environmental concerns associated with its use. The fact that plastic is durable means it degrades slowly. In addition, burning plastic can sometimes result in toxic fumes. [2]

Aside from trying to eliminate waste plastic, its production is also costly to the environment. It takes large amounts of chemical pollutants to create plastic, as well as significant amounts of fossil fuels. Although Plastic activists argue that, plastic bags can be reused, all plastic materials find their way to landfills. Hence this is not a robust defense when it comes to the environment.

Plastic bottles are a major part of the municipal waste. They have special importance due to their low density to volume ratio. Moreover, they are chemically stable since they are non-biodegradable materials (i.e. the biodegradation process is very slow). This means that plastic waste will be visible for months or years, and waste will sit in landfill sites for years without degrading. Therefore, plastic bottles can cause a serious environmental problem.

Today, the availability of the waste plastics is enormous, as the plastic materials have become part and parcel of daily life. If not recycled, their present disposal is either by land filling or by incineration. Both these processes have certain impact on the environment.

2.2 Historical Perspective of Bitumen Modification

Bituminous binders are widely used in road paving and their viscoelastic properties are dependent on their chemical composition. 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 situation to think about some alternative ways for the improvement of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economical aspects. Bitumen can also be modified by adding different types of additives to achieve the present requirement. One of these additives is the polymers. [3]

Bitumen polymer modification has a long history. Even before refined bitumen was produced, people began to modify natural bitumen and some patents were granted for natural rubber modification. [4]

Synthetic polymers, however, were not widely used until after World War II ended. One well-known early example is neoprene (polychloroprene) latex, which began to be increasingly used for bitumen modification in North America from the 1950s Plastomers have a longer history of artificial synthesis than thermoplastic elastomers. Most of the currently popular plastomers began to be produced commercially before 1960. [5]

Bitumen polymer modification was firstly used in the roofing industry, and then the paving industry.

In 1965, a tactic polypropylene (APP), which is a by-product of isotactic polypropylene(IPP) manufacturing, was firstly used to modify bitumen for roofing in Italy and the first commercial product was marketed in 1967 .

However, it was not widely used until the early 1970s in Europe. As for the USA, it was in 1978 that Americans began to widely use modified bitumen in roofing. [6]

Bitumen polymer modification for road construction is a field extensively covered by intellectual property. A patent, relating a bituminous composition with base bitumen and polyisobutylene, was granted as early as 1940 bituminous composition. During the 1970s, researchers proved that the addition of polymers, including plastomers and thermoplastic elastomers, could improve some properties of paving bitumen, such as reducing temperature sensitivity or increasing the resistance to permanent deformation

In 1978, Chaffin reported the potential storage stability problems of bitumen modified with elastomers, but they also wrote that their field test sections constructed in Texas in 1976 were performing well. In 1983, a binder for pavement wearing courses, which comprises PE modified bitumen, was reported by Denning et al.) although it led to phase separation problems and higher manufacturing and compacting temperatures. In 1989, Reese reported the good resistance to ageing and cracking of PMB after a two-year field test in California, although they pointed out that further evaluations needed to be performed to be conclusive about the success of the modification.

By the early 1990s, increased interest in research of bitumen polymer modification was observed in many countries [7]. Researchers systematically investigated the mechanical properties, rheology, temperature sensitivity, morphology, thermal behavior, storage stability and ageing of different PMBs. Both the advantages and disadvantages of widely used PMBs were gradually found out. On the other hand, some drawbacks were proven, such as the thermal instability of some polymer modifiers and phase separation problems of some PMBs.

In June 1998, a World Road Association International Symposium on polymer modification of bitumen was held in Rome, which gave an overview of the situation at that time and encouraged the publication of a report in 1999 (World Road Association,1999). Furthermore, attempts to remove PMB's drawbacks began from the 1990s. In 1996, claimed that PP modified bitumen could be stabilized by adding polyphosphoric acid (PPA) and they believed PPA could help to improve storage stability of PMB by changing the bitumen structure from Sol to gel. After 2000, investigations regarding PMB tended to be divided into two fields:

i. continuing to deeply investigate the mechanism of polymer modification and its failure and

ii. Attempting to overcome the disadvantages of some PMBs. The first field mainly focused on the microstructure, deformation, cracking, ageing and fatigue of PMB.

Even now, there are still some academic debates in this field. For example, some researchers believe that bitumen has a heterogeneous colloid structure and PMB should be investigated as a multiphase (polymers/asphaltenes/maltenes) viscoelastic emulsion ,while some other researchers claim that bitumen is a homogeneous and continuous molecular solution based on their mutual solubility and polymers result in good effects on PMB by their partial solubility in bitumen.

2.3 Previous Studies on Plastic Modification of Bitumen:

The results of previous studies showed that the using of waste plastic in asphalt mixture improve the engineering properties such as Marshall Stability, resistant to water (measure by retained stability) and resistant to crack propagation (indicated by indirect tensile strength of modified asphalt mixes). This approach of modification also produces better binding property for the bitumen mix and increase the road life.

In recent years, research on the application of modified bitumen binders has reported lots of advantages. These advantages include improved bitumen resistance to rutting due to high viscosity, high softening point and better resilience, improved bitumen resistance to surface initiated cracks, the reduction of fatigue or reflection cracking, the reduction of temperature susceptibility, improved durability as well as the reduction in road pavement maintenance costs. A study on the thermal behaviour of polymers show that on heating at 130-160oC, plastics. As plastics are heated to a maximum temperature of 165oC, there is no evolution of harmful gas. However, when heated above 270oC, plastics get decomposed and above 750oC, they get burnt to produce noxious gases.

In their research reveal that polymer modified bitumen shows improved rheological properties for highway construction. In the construction of flexible pavements, bitumen plays the role of binding the aggregates together by coating over the aggregates. The bitumen as a binder also helps to improve the strength and life of road pavements. But its resistance towards water is poor, whereas polymer modified bitumen has better resistance to temperature and water. The above discussion reveals that the use of polymer as well as waste plastic in bitumen to improve its service properties is very common in different countries

CHAPTER - 3

RESEARCH METHODOLOGY AND MATERIAL

3.1Study Design

Laboratory type of research was carried out to evaluate the properties of modified asphalt mix with HDPE and PET Polyvinyl Chloride (PVC) with regards to suitability, economical and environmental based on ASTM, AASHTO standard. Qualitative study forwards impression of the findings whereas the quantitative study was used to describe the numerical aspects of the findings.

3.2 Source of Data

The data was collected from two sources, those primary data was collected from the laboratory investigation and secondary data was gathered from literatures review of previous studies on the subject matter, laboratory manuals and specification (ASTM, AASHTO).

3.3 Study variables

Dependent Variable:

- Polyvinyl Chloride (PVC) Modified bitumen

Independent Variable:

- Specific Gravity Test
- Penetration Test
- Flash and Fire Test
- Softening Point Test

3.4 Sampling Procedure

Sampling of bitumen was undertaken as per ASTM standard in order to determine physical characteristics. Quartering method was used to obtain sample from aggregate.

Harmful plastic waste were eliminated and Polyvinyl Chloride (PVC) dust were used to reduce the effect of the content during the sampling procedure of this research.

3.5 Data Processing and Analysis

Processing and analysis of data carried out on this study was presented and explained using tables and graphs. Analysis was based on the outstanding and present specification suggested by ASTM, and AASHTO.

3.6 Laboratory Test Procedure

This study is based on laboratory testing as the main procedure to achieve study objective. All the testing is conducted using equipment and devices available in the laboratories. Laboratory tests are divided into several stages, which begin with evaluation of the properties of used materials as aggregates, bitumen and Polyvinyl Chloride (PVC) Dust. Sieve analysis is carried out for each aggregate type to obtain the grading of aggregate sizes. After that, asphalt mixes with different bitumen contents are prepared and Softening and Penetration test is conducted to obtain optimum bitumen content. The value of the optimum bitumen is used to prepare asphalt mixes modified with various percentages of Polyvinyl Chloride (PVC) dust. Penetration Test was utilized to evaluate the properties of these modified mixes. Finally, laboratory tests results are obtained and analyzed.

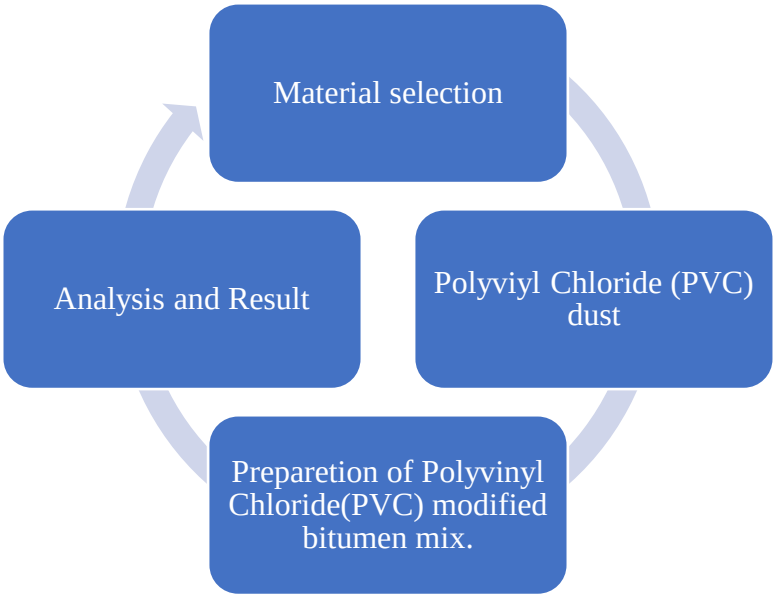


Figure 3- 1: Laboratory testing procedure.

3.7 Materials Selection

Selection of material for conventional material is very important because, various material properties can influence the performance of the mix. While selecting the materials, engineering considerations which follow the specification were applied to ensure reliable result.

The materials selected for this study were collected from different sources, from A-One Polymer Limited Company,is currently one of the largest manufactures of uPVC pipes & fittings in Bangladesh it is 81 Tongi-Kaliganj Highway Tongi and bitumen grade of 94/100 from M/s Golden Gulf Bitumen Industries it is location Plot No-B-18, Bscic industrial Estate,Kanchpur,Sonargaon,Narayanganj,Dhaka.

The materials used are as follows:-

Bituminous Binder.

- Polyvinyl Chloride (PVC) Dust plastic.

Bituminous Binder:

Bitumen holds the aggregate together in a bituminous pavement. The quality of bitumen depends on its crude source, refining process and chemical composition. The characteristics of base bitumen affect the quality improvement of the modified bitumen. In this research 80/100 penetrations grade bitumen is used.

Polyvinyl Chloride (PVC) Dust Plastic:

Polymers can be classified into two major class based on their responsive nature to heat: thermoplastic and thermo harden. The product of thermo harden polymer cannot be remolded. So this type of polymer cannot be used as modifier of bitumen. Thermoplastic polymers are recyclable. Polymers that will be used as modifier must be recyclable.



Figure 3.2: Polyvinyl Chloride (PVC) Dust.

In fact any thermoplastic polymer can be used as modifier of bitumen. So in this research, We have used good quality (PVC) and mixed with bituminous to increase the strength of the road construction.

3.8 Preparation of Polyvinyl Chloride (PVC) dust mixed.

There are many different methods for utilization of Polyvinyl Chloride (PVC) materials in bituminous mix. In this study dry process method was used for the bitumen mix in order to attain the objective of the study. After obtaining OBC, samples were prepared to evaluate the effect of adding Polyvinyl Chloride (PVC) to bituminous mixture samples by considering two proportions (8% and 9%) by the weight of OBC.

The procedure of incorporating Polyvinyl Chloride (PVC) in bituminous mix can be summarized as follows:

Polyvinyl Chloride (PVC) have to be grinded then sieved to have a granular size. Our research purpose of (PVC) dust has passed through a 100 size sieve (0.150mm).

Requisite amount of grinded of (PVC) is mixed with course aggregates. Polyvinyl Chloride (PVC) and course aggregates mix is heated at (180oC-190oC). The heating temperature and duration of aggregates were chosen based on many experimental trials to be hot enough to melt Polyvinyl Chloride (PVC) that it would stick to the aggregate surfaces and leave textured surface with good adhesion between coated aggregates.



Figure 3.3: Polyvinyl Chloride (PVC) Dust with Bitumen.

Requisite amount of bitumen is heated until it reaches 150◦C Polyvinyl Chloride (PVC) Dust are mixed with fine aggregates followed by addition of hot bitumen at OBC. All ingredients are mixed vigorously to form a homogeneous asphalt mixture.

3.9 Test Analysis

3.9.1 Specific Gravity of Semi-Solid Bituminous Materials

(AASTH DESIGNATION: T228-93)

(ASTM DESIGNATION: D70-76)

1. Scope

1.1 This method covers the determination of the specific gravity of semi-solid bituminous materials, and Plastic dust materials, by use of a pycnometer.

2. Specific Gravity

2.1 The specific gravity of semi-solid bituminous materials, Plastic dust materials, and shall be expressed as the ratio of the mass of a given volume of the material at 27°C (80.6°F) or at 17.6°C (63.68°F) to that of an equal volume of water at the same temperature, and shall be expressed thus:

Specific gravity, 27/27°C (80.6/80.6°F) or 17.6/17.6°C (63.68/63.68°F)

3.Apparatus

3.1 Pycnometer, glass, consisting of a cylindrical vessel carefully ground to receive an accurately fitting glass stopper 22 to 26 mm in diameter. The stopper shall be provided with a hole 1.0 to 2.0 mm in diameter, centrally located in reference to the vertical axis. The top surface of the stopper shall be smooth and substantially plane, and the lower surface shall be concave in order to allow all air to escape through the bore. The height of the concave section shall be 4.0 to 18.0 mm at the center. The stopped pycnometer shall have a capacity of 24 to 30 ml, and shall weight not more than 40gm.

3.2 Water Bath- Constant temperature, capable of maintaining the temperature within 0.1°C (0.2°F) of the test temperature.

3.3 Thermometers – Calibrated liquid-in-glass of suitable range with graduations at least every 0.2°F(0.1°C) and a maximum scale error of 0.2°F (0.1°C) as prescribed in ASTM Specification on E1. Thermometers commonly used are 63°F or 63°C. Any other thermometer of equal accuracy may be used.

Note-1: Other ASTM thermometers (such as the ASTM 17°C) which have subdivisions and scale errors equal to or smaller than those specified for the ASTM 63°C and 63°F may also be used.

3.4 Balance – a balance conforming to the requirements of M 231, Class B.

4. Materials

4.1 Distilled Water – Freshly boiled and cooled distilled water shall be used to fill the pycnometer and beaker.

Note-2: For the purpose of this test, freshly boiled and cooled distilled, mineralized or deionized water may be used.

5. Preparation of Equipment

5.1 Partially fill a 600 ml or larger Griffin low-form beaker with freshly boiled and cooled distilled water to a level that will allow the top of the pycnometer to be immersed to a depth of not less than 40 mm.

5.2 Partially immerse the beaker in the water bath to a depth sufficient to allow the bottom of the beaker to be immersed to a depth of not less than 100 mm, while the top of the beaker is above the water level of the bath. Clamp the beaker in place.

5.3 Maintain the temperature the water bath within 0.1°C (0.2°F) of the test temperature.

6. Calibration of Pycnometer

6.1 Thoroughly clean, dry, and weight the pycnometer to the nearest 1 mg. Designate this mass as A.

6.2 Fill the pycnometer with freshly boiled distilled water at test temperature and place the stopper in the pycnometer. Do not allow any air bubbles to remain in the pycnometer.

6.3 Allow the pycnometer to remain in the water for a period of not less than 30min. Remove the pycnometer, immediately dry the top of the stopper with one stroke of a dry towel (Note 3), then quickly dry the remaining outside area of the

pycnometer and weigh to the nearest 1 mg. Designate the mass of the pycnometer plus water as B.

Note-3: Do not redry the top of the stopper even if a small droplet of water forms due to expansion. If the top is dried at the instant of removing the pycnometer from the water, the proper mass of the contents at the test temperature will be recorded. If moisture condenses on the pycnometer during weighing, quickly redry the outside of the pycnometer (excluding the top) before recording the mass.

Note -4: Calibration should be done at the specific temperature. A pycnometer calibrated at one temperature cannot be used at a different temperature without recalibration at the temperature.

7. Procedure

7.1 Preparation of Sample- Heat the sample with care, stirring to prevent local overheating until the sample has become sufficiently fluid to pour. In no case should the temperature be raised to more than 56°C (100°F) above the expected softening point of tar, or to more than 111°C (200°F) above the expected softening point for asphalt. Do not heat for more than 30 minutes over a flame or hot plate or for more than 2 hours in an oven, and avoid incorporating air bubbles in the sample.

7.2 Pour enough sample into the clean, dry, warmed pycnometer to fill it about there fourth of its capacity. Take precautions to keep the materials from touching the sides of the pycnometer above the final level, and to prevent the inclusion of air bubbles (Note 5). Allow the pycnometer and its contents to cool to ambient temperature for a period of not less than 40 minuets, and weigh with the stopper to the nearest 1 mg. Designate the mass of the pycnometer plus sample as C.

Note – 5: If any air bubbles are inadvertently included, remove by brushing the surface of the asphalt in the pycnometer with a high “soft” flame of a Bunsen burner. In order to avoid overheating, do not allow the flame to remain in contact with the asphalt more than a few seconds at any one time.

7.3 Fill the pycnometer with freshly boiled distilled water at test temperature and place the stopper in the pycnometer. Do not allow any air bubbles to remain in the pycnometer

8. Report

8.1 Report the specific gravity to the nearest third decimal at 27/27°C (80/80°F) or 17.6/17.6°C (63/63°F)

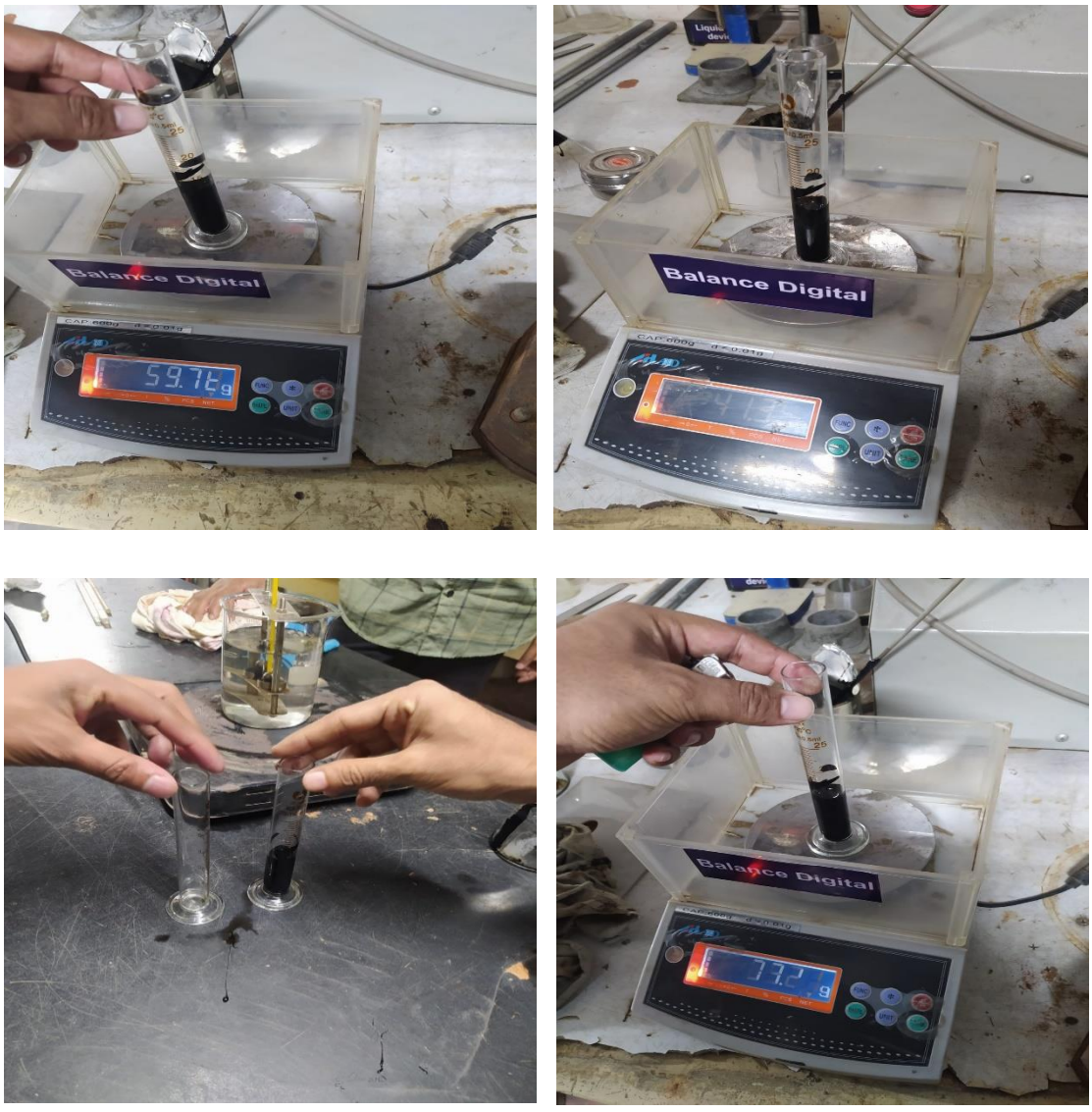


Figure 3.4: Specific Gravity Test

3.9.2 Penetration of Bituminous Materials

AASHTO DESIGNATION: T 49-93

(ASTM DESIGNATION: D 5-86)

1. Scope

1.1 This test method covers determination of the penetration of semi-solid and solid bituminous materials. Materials having penetrations below 350 can be tested by the standard apparatus and procedure described. Materials having penetrations between 350 and 500 can be determined using the special apparatus and modifications given in section .

1.2 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Reference Documents

2.1 AASHTO Standards:

T 53 Softening Point of Asphalt (Bitumen) and Tar in Ethylene Glycol (Ring-and Ball)

2.2 ASTM Standards:

C 670 Practice for Preparing Precision Statements for Test Methods for

Construction Materials

E 1 Specification for ASTM Thermometers.

E 77 Method for Verification and Calibration of Liquid in Glass Thermometers.

2.3 ANSI Standard B 46.1 Surface Texture

IP Standard Thermometers Reference Documents

3. Description of Terms

3.1 The penetration of a bituminous material is the distance in tenths of a millimeter that a standard needle penetrates vertically into a sample of the material under fixed conditions temperature, load, and time.

4. Summary of Method

4.1 The sample is melted and cooled under controlled conditions. The penetration is measured with a penetrometer by means of which a standard needle is applied to the sample under specific conditions.

5. Significance and Use

5.1 The penetration test is used as a measure of consistency. Higher values of penetration indicate softer consistency.

6. Apparatus

6.1 Penetration Apparatus – Any apparatus permitting movements of the spindle without appreciable friction and which is a accuracy calibrated to yield results in accordance with the description of the term penetration (see Section 3.1) will be at approximately 90 degrees to this surface. The spindle shall be detachable without the use of special tools, for checking its mass. When the needle is mounted in a ferrule, the mass of the moving spindle shall be 47.5±0.05 g. Regardless of the type of mounting of the needle, the total mass of the needle and spindle assembly shall be 50.0±0.05 g. Weights of 50.0±0.05 g and 100.0±0.05 g shall be provided for the total loads of 100 g and 200 g (0.9N and 2 N), depending upon the conditions of test to be applied.

NOTE – 1: The detachability of the spindle prescribed here is intended to apply to penetration apparatus acquired after January 1, 1976. Penetration apparatus acquired before January 1, 1976, may conform either to this standard or the previous standard (T 49 – 74).

6.2 Needle – The needle, shall be made from fully hardened and tempered stainless steel, grade 440 C or equal, HRC 54 to 60. It shall be approximately 50 mm (2 in.) in length

and 1.00 to 1.02 mm (0.039 to 0.04 in) in diameter. It shall be symmetrically tapered at one end to a cone.

Whose angle shall be within the range of 8.7 to 9.7 deg over the entire length from full needle diameter, and whose axis shall be coincident with the needle axis within 0.0127 mm (0.005in.) maximum runout (total indicator reading). After tapering, the point shall be ground off to a truncated cone, the smaller base of which shall be from 0.14 to 0.16mm (0.0055 to 0.0063 in.) in diameter. The truncate shall be square with the needle axis within 2 deg, and the edge shall be sharp and free from burrs.

6.2.1 When the surface texture of the tapered cone surface is measured in accordance with American National Standards Institute Standard B46.1, the surface roughness height shall be 0.2 to 0.3 µm (8 to 12µin.) arithmetic averages.

6.2.2 The exposed length of the needle when mounted in the chuck of the penetration apparatus or in a ferrule shall be approximately 40 to 45 mm (1.57 to 1.77 in.). When the needle is mounted in a ferrule, the ferrule shall be a cylindrical rod, 3.20±0.05 mm (0.126±0.002 in.) in diameter and approximately 38 mm (1.5 in.) long, made of stainless steel or brass, in which the needle shall be rigid and coaxially mounted. The weight of the ferrule needle assembly shall be 2.50±0.05 g. (A drilled hole is permissible at the end of the ferrule to control weight). Individual identification markings shall be placed on the ferrule of each needle; the same markings shall not be repeated by a manufacturer within a 3- year period.

NOTE-2: The manufacturer or commercial laboratories will certify the test needles for conformance to the permissible variations.

7. Preparation of sample

7.1 Heat the sample with care to prevent local overheating until it has become fluid. Then with constant stirring, raise the temperature of the asphalt sample not more than 100°C or 180°F above its expected softening point or the tar pitch sample not more than 56°C or

100°F above its softening point determined accordance with the Method of test for Softening Point of Bituminous Materials (Ring and Ball Method), T 53. Avoid the

inclusions of air bubbles. To reach the pouring temperature, do not heat the softened sample more than 30 minutes. Then pour it into the sample container to a depth such that, when cooled to the temperature of test, the depth of the sample is at least 10mm greater than the depth to which the needle is expected to penetrate. Pour separate samples for each variation in test conditions.

7.2 Loosely cover each container and its contents as a protection against dust, and allow to cool in an atmosphere at a temperature not higher than 30°C or 86°F and now lower than 20°C or 68°F for not less than 1-1/C hours nor more than 2 hours when the sample is in a 175 ml (1 oz) container and for not less than 1 nor more than 1-1/2 hours when the sample is in a 92 ml (1 oz) container. Then place the sample in the water bath maintained at the prescribed temperature of the test, along with the transfer dish if used, and allow it to remain for not less than 1-1/2 hours nor more than 2 h when the sample is in the 175 ml (1 oz) container, and for not less than 1 nor more than 1-1/2 hours when the sample is in a 91 ml (2 oz) container.

8. Procedure

8.1 Examine the needle holder and guide to establish the absence of water and other extraneous matter. Clean a penetration needle with toluene or other suitable solvent, dry with a clean cloth, and insert the needle in the penetrometer. Unless otherwise specified, place the 50 g weight needle, making the total load of 100±0.1g for the needle and attachment. If the tests are made with the penetration apparatus mounted with the bath, place the sample container directly on the submerged stand of the penetration apparatus. If the tests are made with the sample in the bath and the penetration apparatus outside the bath, place the containers on the self provided in the bath. In the above procedures the container shall be kept completely submerged during the complete test. If test are made using the transfer dish with the penetration apparatus outside the bath, place the sample in a dish filled with water from the bath to a depth to cover completely the same container. Then place the transfer dish containing the sample on the stand on the penetration apparatus and penetrate immediately. In each case, adjust the needle loaded with the specified weight to just make contact with the surface of the sample. Accomplish this by making contact of the actual needle point with its image reflected by the surface of the sample from a properly placed source of light (Note 4). Either note the reading of the dial or bring the pointer to zero. Then quickly release the needle for

the specified period of time and adjust the instrument to measure the distance penetrated. Observe the sample container as the needle is applied, and if any movement of the container is noted, ignore the result.

NOTE – 2: For certain types of asphalt erratic results are sometimes obtained. When this occurs, pretreat the needles by immersing them for 5 minutes in a 1 percent solution of olene acid prior to drying and running the test.

NOTE – 3: For reference tests penetration at temperature other than 27°C (80°F) should be made without removing the sample from the bath.

NOTE – 4: The position of the needle can be materially aided by using an illuminated methyl methacrylate rod.

8.2 Make at least three penetrations at points on the surface of the sample not less than 10 mm (3/8 in.) from the side of the container and not less than 10 mm (3/8 in.) apart. If the transfer dish is used, return the dish and sample to the water bath after each penetration. Before each test, clean the needle with a clean cloth moistened with toluene or other suitable solvent to remove all adhering bitumen, and then wipe with a clean dry cloth. For penetration values greater than 200, use at least three needles, leaving them in the sample until completion of the penetrations.

8.3 The needles, containers, and other conditions described in this method provide for determinations of penetrations up to 350. However, the method may be used for direct determinations up to 500 provided special containers and needles are used. The container shall be at least 60 mm in depth. The over-all volume of material in the container should not exceed 125 ml to permit proper temperature adjustment of the sample.

8.3.1 Specially made needles for such determination shall meet all the requirements of Section 6.2 for dimensions and weight except that the minimum exposed length of the needle shall be 50 mm.

The report of results obtained by this procedure shall indicate the basis of the test.

9. Report

9.1 Report to the nearest whole unit the average of at least three penetrations whose values do not differ by more than the amount shown:

Penetration	0-49	50-149	150-249	≥250
Maximum difference between highest and lowest determinations	2	4	6	8

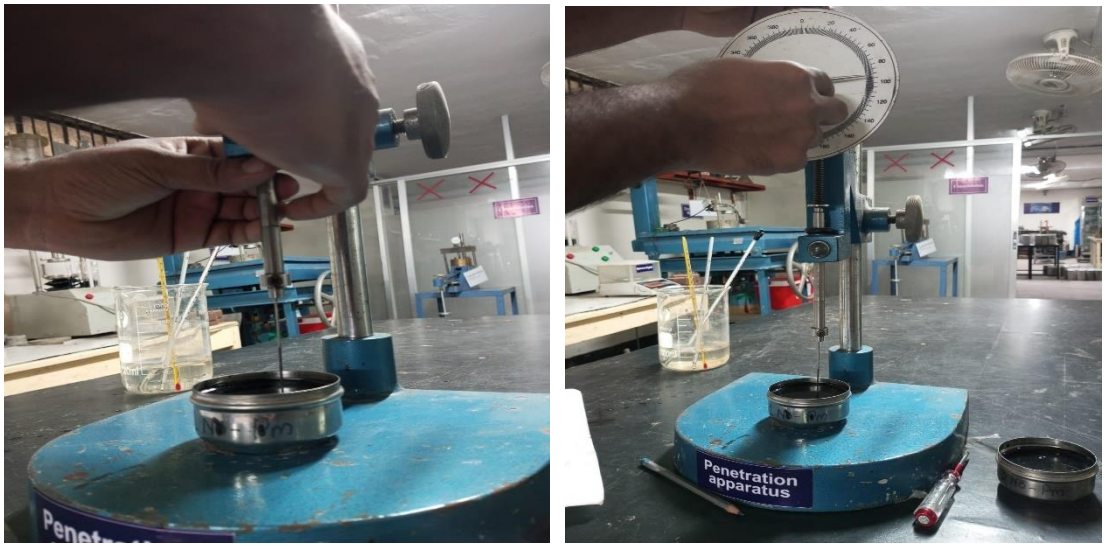




Figure 3.5: Penetration Test.

3.9.3 Softening Point of Bituminous Materials (Ring and Ball Method)

AASHTO DESIGNATION: T53-92

(ASTM DESIGNATION: D36-89)

1.Scope

The ring and ball softening point is extensively used to evaluate the consistency of bituminous binders. It is a very simple one, consisting of placing a 3/8in. diameter steel ball on a binder sample placed in a steel ring and immersed in a water bath. Heat is applied to the water and its temperature is raised until a value is reached when the test sample become sufficiently soft to allow the ball, enveloped in binder to fall down. The water temperature at which this occurs is called the ring and ball softening point.

The softening point is not a melting point; bituminous binder do not melt but instead gradually change from semi-solids to liquids on the application of heat. It is useful for determining the temperature susceptibilities of bitumen which are to be used in thick films, such as in crack filters. When two bituminous have the same penetration value, the one with higher softening point is normally less susceptible to temperature changes.

2. Referenced Documents

2.1 Standards

C 670 practice for Preparing Precision Statements for Test Methods for Construction Materials.

E 1 Specification for ASTM thermometers

T 40 Method for Sampling Bituminous Materials

T 48 Test Method for Flash and Fire Point by Cleveland Open Cup

3. Apparatus and Materials

3.1 Ring- A brass ring 15.875mm (5/8in.) inside diameter and 6.35mm (1/4in.) depth, thickness of wall, 2.38 mm(3/32in.). this ring shall be attached to a convenient manner to a brass with (Diameter 1.85mm = 0.072in.)

3.2 Ball- A steel ball 9.53mm (3/8in.) in diameter having a mass of 3.50±0.05gm.

3.3 Container- A glass vessel, not less than 8.5cm (3.34in.) in diameter and measuring 10.5cm (4.13in.) in depth from the bottom of the flare (A 600ml beaker, low form, meets this requirement).

3.4 Thermometer- ASTM Low Softening Point Thermometer having a range of -2 to +80°C or 30°to 180°F, is specified.

4. Reagents and Materials

4.1 Bath liquids:

4.1.1 Freshly boiled distilled water.

4.1.2 USP Glycerin, or

4.1.3 Ethyl Glycol, with a boiling point between 195 and 197°C (383 and 387°F)

5. Preparation of Sample

Melt and thoroughly stir the sample avoiding incorporating air bubbles in the mass, and then pour it into the ring. The ring, while being filled, should rest on a brash plate which has amalgamated to prevent the bituminous material from adhering to it. Allow the excess material to cool for 1 hr. then cut it off clearly with a slightly heated knife.

6. Procedure for Materials Having Softening Point 50°C (122°F) or Below

Fill the glass vessel to a depth of substantially 8.25cm (3.25in.) with freshly boiled, distilled water at 5°C (41°F).

6.2 Suspend the ring containing the sample in the water so that the lower surface of the filled ring is exactly 2.54cm (1 in.) above the bottom of the glass vessel and its upper surface is 5.08cm (2in.), below the surface of the water.

6.3 Place the ball in the water but on the specimen.

6.4 Suspend the thermometer so that the bottom of the bulb is leveled with the bottom of the ring and within 0.635cm (3/4in.) but not touching the ring.

Maintain the temperature of the water at 5°C (41°F) for 15min. temperature of the water at 5°C (41°F) for 15min.

6.5 With suitable force, place the ball in the center of the upper surface of the bitumen in the ring, this completing the assembly.

6.6 Apply heat in such manner that the temperature of the water is raised 5°C (9°F) each minute.

7. Softening Point

Report the temperature recorded by the thermometer at the instant the bituminous material touches the bottom of the glass vessel as the softening point. No correction shall be made for emergent stem of the thermometer.

8. Permissible Variation in Rise of Temperature

The rate of rise of temperature shall be uniform and shall not be averaged over the period of the test. The maximum permissible variation for any minute period after the first three minutes shall be 0.5°C (0.9°F). All tests in which the rate of rise in temperature exceeds these limits shall be rejected. Permissible Variation in Rise of Temperature.

9. Accuracy

The limit of accuracy of the test is 0.5°C (0.9°F).

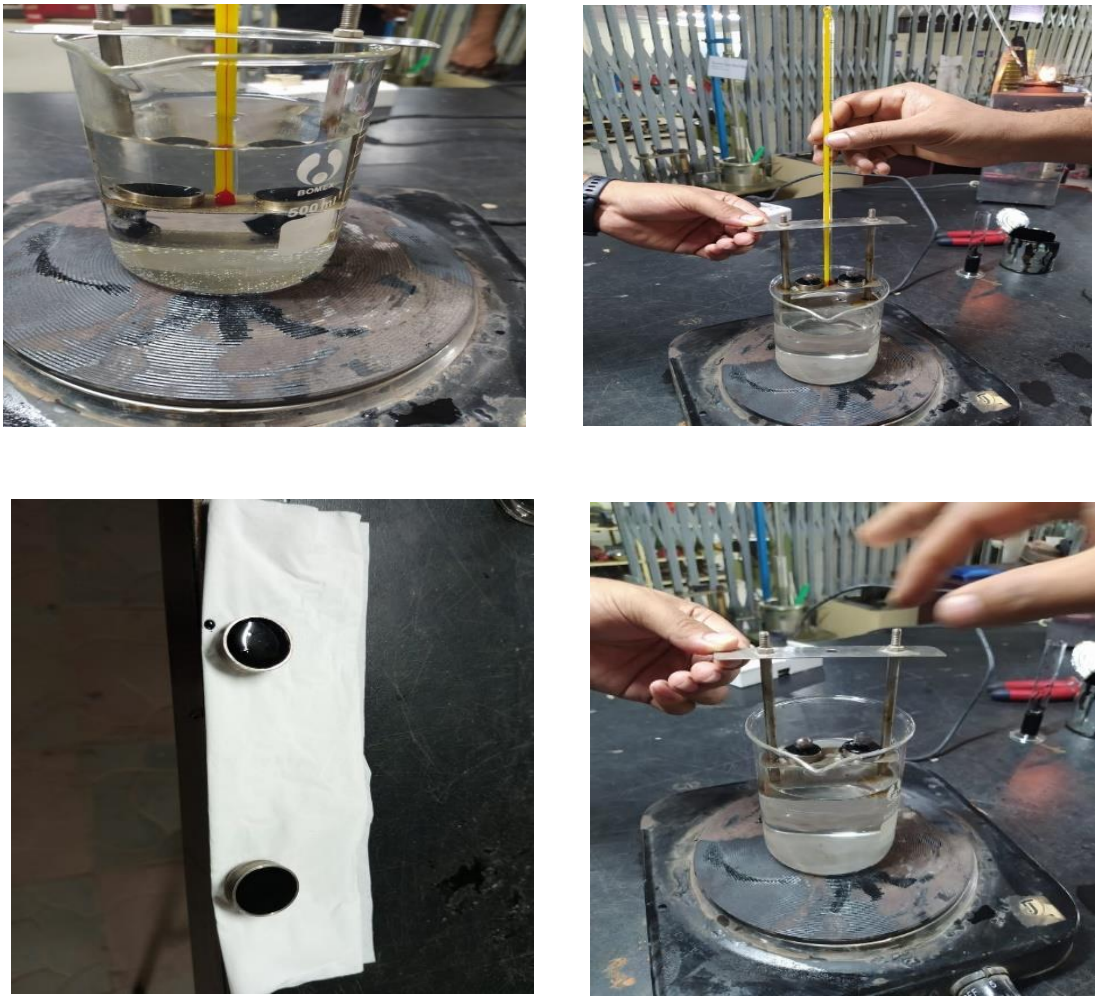


Figure 3.6: Softening Point Test

3.9.4 Flash and Fire Points of Bituminous Materials (Cleveland Open Cup Method)

AASTH DESIGNATION: T 48-91

(ASTM DESIGNATION: D 92-85)

1.Scope and Significance

This method describes a test procedure for determining the flash and fire points, Cleveland Open Cup Tester, of all petroleum products except fuel oils and those having an open cup flash below 175°F. The flash point is the temperature at which a bituminous material, during heating, will evolve vapors that will temporarily ignites or flash when

a small flame is brought in contact with them. The fire point is the temperature at which the evolve vapors will ignite and continue to burn.

To make the test, the material is heated in an open cup, and at intervals a small flame is applied near its surface. The lower temperature at which application of the test flame causes the vapors to ignite is recorded as the flash point while the temperature at which the vapors ignited and continue to burn for at least 5 seconds is recorded as the fire point. The flash and fire point test is purely a safety test. It indicates the maximum temperature to which the material can be safely heated.

2. Reference Documents

2.1 ASHTO Standards:

T73 Flash point by Pensky-Martens Closed Tester

T79 Flash point with Tag Open-Cup Tester

2.2 ASTM Standards:

E 1 Specification for ASTM Thermometers

2.3 Other Methods:

IP Method 35 Flash Point (Open) and Fire Point by Means of the Pensky Martens Apparatus

3.Apparatus and Materials

3.1 Cleveland Open Tester- The apparatus consists of the test cup, heating plate, test flame applicator, heater and support.

3.2 Shield- A shield 18in. (46cm) square and 24in. (61cm) high, is recommended but not essential.

3.3 Thermometer – ASTM thermometer having a range of 20°F to 760°F (- 6°C to +400°C).

4.Procedure

4.1 Support the tester on a level steady table in a draft free room or compartment and shield top of the tester from strong light by any suitable means.

4.2 Clean the cup with an appropriate solvent and remove all gums, carbon deposit, and oxide coating from the inside of the cup with fine steel wool until a bright metallic surface is presented.

4.3 Support the thermometer in a vertical position with the bottom of the bulb ¼ in. (0.635cm) from the bottom of the cup and above a point halfway between the center and back of the cup.

Note: The immersion line engraved on the thermometer will be 5/64in. (0.02cm) below level of the rim of the cup when the thermometer is properly positioned.

4.4 Fill the cup at any convenient temperature (Note2) so that the top of the meniscus is exactly at the filling line. When too much sample has been added to the cup, remove the excess, using a or other suitable device, however, if there is sample on the outside of the apparatus, empty, clean. Destroy any air bubbles appears on the surface of the sample.

Note -2: Viscous samples should be heated until they are reasonably fluid before being poured into the cup; however, the temperature during heating must not exceed 100°F (65°C) below the probable flash point.

4.5 Light the test flame and adjust it to a diameter of 1/8 to 1/16in. (0.08cm).

4.6 Apply heat initially so that the rate of temperature rise of the sample is 25 to 30°F (13.9 to 16.7°C) per minute. When the sample temperature is approximately 100°F (56°C) below the anticipated flash point, decrease the heat so that the rate of temperature rise for the last 50°F (27.8°C) before the flash point is 10+1°F (5.5 +0.6°C) per minute.

4.7 Starting at least 50°F(2.8°C) mark. Pass the test flame across the center of the cup, at right angle to the diameter which passes through the thermometer. With a smooth, continuous motion apply the flame either in a straight line or along the circumference

of a circle having a radius of at least 6in. (15cm). The center of the test flame must move in a plane not more than 5/6in. (0.2cm) above the plane of the upper edge of the cup. The time consumed in passing the test flame across the cup shall be about 1sec.

4.8 Record as the flash point the temperature read on the thermometer when a flash appear at any point on the surface of the sample but do not confuse the true flash with the bluish halo that sometimes surrounds the test flame.

4.9 To determine the fire point, continue heating so that the sample temperature increases at rate of 10±1°F (5.5±0.6°C) per minute. Continue the application of the test flame at 5°F (2.8°C) intervals until the oil ignites and continues to burn for at least 5sec. Record the temperature at this point as the fire point of the oil.

5. Precision

The following data should be used for judging the acceptability of results (95 percent probability).

- Duplicate results by the same operator should be consider suspect if they differ by more than the following:

Repeatability

Flash point 317°F (158°C) -Bitumen Grade.

Fire point 339° (170°C) -Bitumen Grade.

- The result submitted by one laboratory should not be considered suspect unless it differs form that of another laboratory by more than the following amounts:

Reproducibility

- Flash point 280°F (137°C)-Bitumen Grade.
- Fire point 308°F (153°C) -Bitumen Grade.



Figure 3.7: Flash and Fire Test.

CHAPTER - 4

RESULT AND DISCUSSION

Results of laboratory work were obtained and analyzed to achieve the study objectives which include studying the effect of adding different percentages of Polyvinyl Chloride (PVC) on the properties of asphalt mix and identify the optimum percent of (PVC) plastic to be added in order to modify bitumen binder.

The laboratory work results are presented in two stages. First, the results of gradation of blending Polyvinyl Chloride (PVC) plastic dust is determine to obtain asphalt binder course. Second stage, Penetration test is carried out with different types of bitumen which are (**92, 94, and 96**) and the results are analyzed. After , the following step is used to study the effect of adding different percentages of waste plastic on bituminous mix properties which are **8 & 9%** percent. Specific gravity test results for modified bituminous mixes are analyzed and finally the optimum waste plastic modifier content is obtained.

All of the tests are performed following the ASTM/AASHTO designation. In order to obtain representative results, all the tests are carried out as preciously as possible following the standards test procedures. Due to some instrumental constraint or problems a few tests may shown inconsistent results.

4.1 Material Property Test Result

4.1.1 Polyvinyl Chloride (PVC) plastic Gradation

The Polyvinyl Chloride (PVC) dust used in the research were subjected to various tests in order to assess their physical characteristics and suitability in the road construction.

Bituminous mix requires the combination of (PVC) plastic dust, having different gradations, to produce an (PVC) blend that meets gradation specifications for a particular Polyvinyl Chloride (PVC) mix. The final proportion of each Polyvinyl Chloride (PVC) material in bituminous binder materials. The proposed waste plastic gradation curve is found to be satisfying ASTM 3515 specification for bituminous binder course gradation.

4.1.2 Bitumen Property Test

In order to evaluate bitumen properties, numbers of laboratory tests were performed (such as Penetration value, Softening point, Flash & Fire and Specific Gravity).

Bitumen Penetration Test

The penetration test measures the consistency of binders. It is expressed as a distance in tenths of a millimeter that a standard needle vertically penetrates into a sample of the material under specified conditions of loading, time, and temperature. The higher value of penetration indicates softer consistency. To determine the penetration, sample should be melted properly and cooled and maintained specified temperature. The penetration is measured with Penetrometer (penetration apparatus) at standard temperature of 27ºC as per test specification of ASTM D5-80.

TABLE 4-1 PENETRATION TEST RESULT OF BITUMEN (MM)

Trial	Sample 1			Sample 2		
	A	B	C	A	B	C
Initial	0	0	0	0	0	0
Final	66	71	69	92	94	96
Penetration Value	66	71	69	92	94	96
Each trial Average	66.67			94.00		

Here, Sample 1 taken the Bitumen mixed with Polyvinyl Chloride (PVC) dust then given the value **66.67mm**. As well sample 2 test with only bitumen then given the value **94.00mm.**

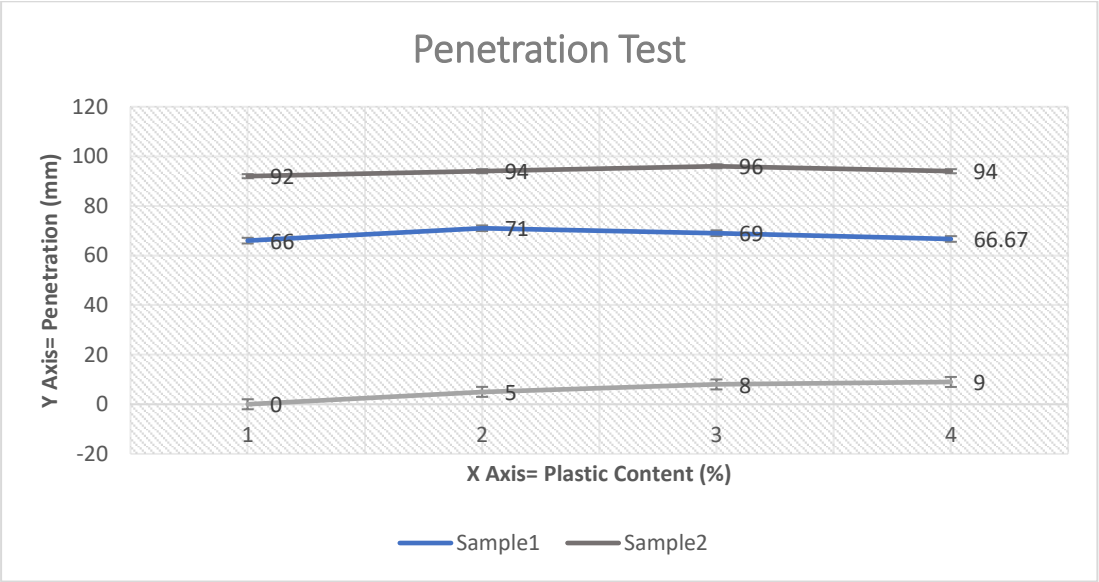


Figure 4.1: Graph of Penetration Test Value

Here is seeing this graph here is two sample. **First sample** value is lower then **sample 2**. We did three trial in this sample. We got three types of value So here can be use sample 2. Because **Sample 2** is good grading Bituminous.

Softening Point Test

The softening point test is also the measure of consistency of binder. It is the temperature at which the binder changes its semi solid state to liquid state. Temperature susceptibility of binder can be evaluated by softening point test. Between two binders having the same penetration value, one will be less susceptible to temperature which has higher softening point. Samples of bitumen loaded with steel balls are confined in brass rings suspended in a beaker of water and glycerin (ethylene glycol) at 25mm above a metal plate. The liquid is then heated at a prescribed rate. As the bitumen softens, the balls and the bitumen gradually sink toward the plate. At the moment the bitumen touches the plate, the temperature of the water is determined, and this is designated as ring and ball (RB) softening point of bitumen .Test Specification ASTMD 36-2002.

Table 4-2. Softening Point Test Result

Sample	Softening Point (oC)
Sample-1	50.60
Sample-2	48.00

Here, Sample 1 taken only Bitumen for test and Sample 2 Mixed the bitumen with Polyvinyl Chloride (PVC) dust. Both are given value show by the table.

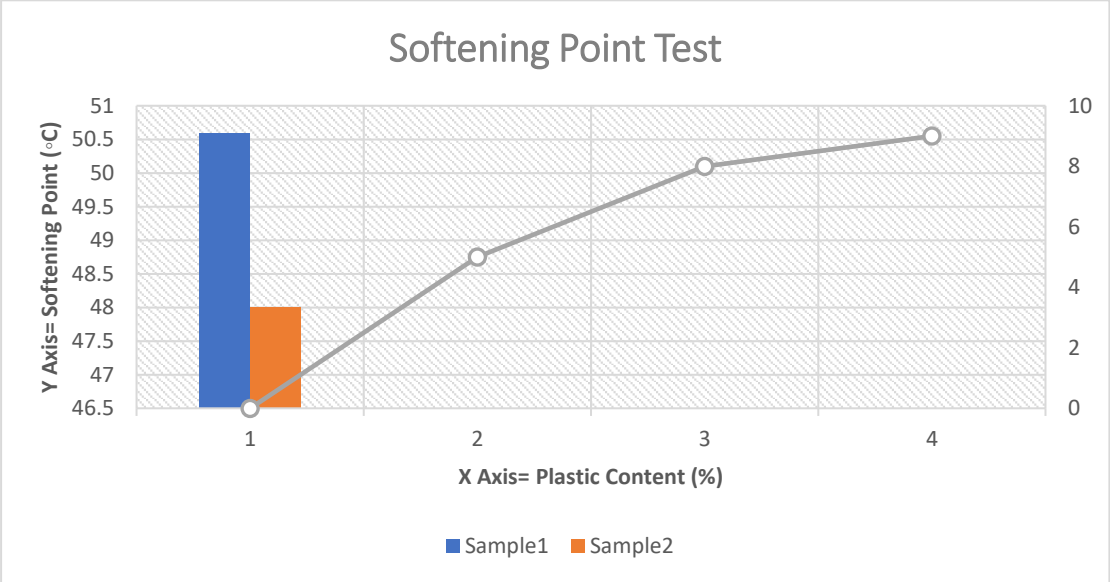


Figure 4.2: Softening Point Test

Here are used 2 types of sample. Sample 1 and sample 2. But sample 1 is better than sample 2.

Specific gravity test

The specific gravity of bituminous binder is the ratio of the mass of a given volume of the material at 25°C to that of an equal volume of water at the same temperature. The specific gravity of binder influences the bitumen absorption capacity of aggregate.

Test specification: ASTMD D70

Table 4.3: Specific Gravity Test Results- Without materials

Sample-1(Bitumen)	Weight(gm)
Weight of Pycnometer, W1	30.03
Weight of Pycnometer + Water, W2	60.02
Weight of Pycnometer + Bitumen, W3	41.35
Weight of Pycnometer +Bitumen + Water, W4	59.75

$$\textit{Specific Gravity, GS} = \frac{\mathbf{W3 - W1}}{(\mathbf{W2 - W1}) - (\mathbf{W4 - W3})}$$

$$= \frac{(\mathbf{41.35 - 30.03})}{(\mathbf{60.02 - 30.03}) - (\mathbf{59.75 - 41.35})}$$

$$= \mathbf{0.98}$$

Table 4.4: Specific Gravity Test Results- With materials

Sample-2 (Bitumen + Polyvinyl Chloride (PVC)	Weight(gm)
Weight of Pycnometer, W1	30.06
Weight of Pycnometer + Water, W2	53.79
Weight of Pycnometer + Bitumen, W3	37.14
Weight of Pycnometer +Bitumen + Water, W4	54.62

$$\textbf{\textit{Specific Gravity, GS}} = \frac{\mathbf{W3 - W1}}{\mathbf{(W2 - W1) - (W4 - W3)}}$$

$$= \frac{\mathbf{(37.14 - 30.06)}}{\mathbf{(53.79 - 30.06) - (54.62 - 37.14)}}$$

= 1.133

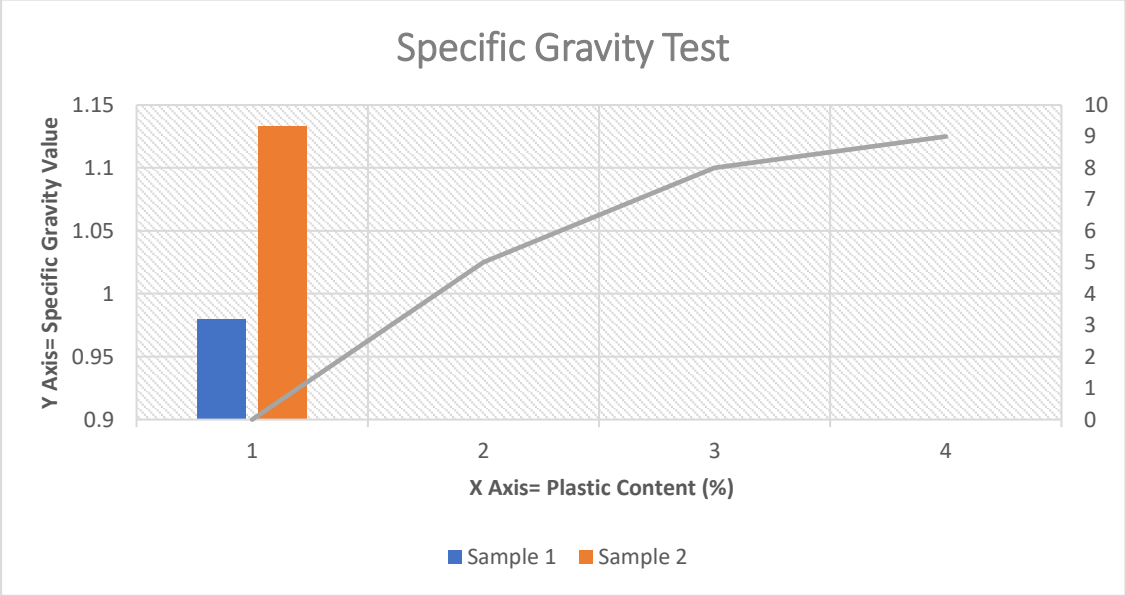


Figure 4.3: Graph of Specific Gravity Test

The Graph Shown the value sample 1 and sample 2.Sample 2 is better then sample 1.

Flash and Fire

Flash and Fire point test is conducted on bitumen to know the safe mixing and application temperature values of particular bitumen grade.

Flash Point

The Flash point of a material is the lowest temperature at which vapor of substance quickly catches fire in the form of flash under definite conditions of the test. So, at this point fire will not last longer, just a flash will appear for a fraction of second. The existence of highly volatile and inflammable materials in a particular grade of bitumen can be indicated by the Flash point.

Fire Point

The fire point of a material is the lowest temperature at which material catches fire and burns under definite conditions of test. The presence of combustible materials in a bituminous material can be indicated by the Fire point.

Table 4.5: Flash and Fire Test Without Materials

Sample- **(Bitumen)**	Flash Point	Fire Point
Sample-1	**280°C**	**308°C**

Here is the flash point of this grade of bitumen is **280°C** and Fire point of this Grade of Bitumen is **308°C.**

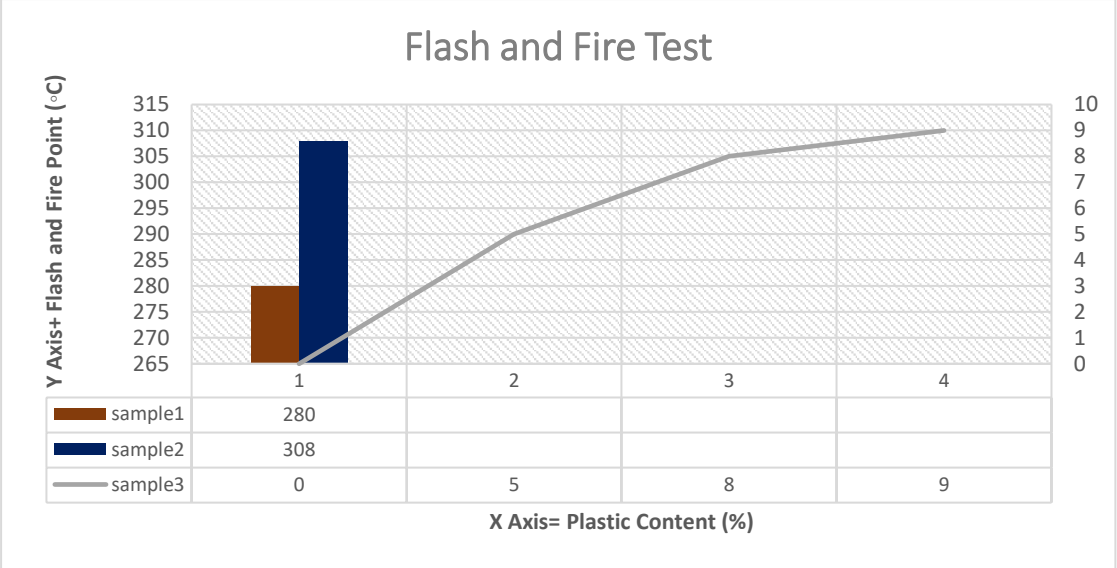


Figure 4.4: Graph of Flash and Fire Test (Sample-1)

Table 4.6: Flash and Fire Test With Materials

Sample- **(Bitumen + Polyvinyl Chloride)**	Flash Point	Fire Point
Sample-2	**280°C**	**330°C**

Here is **Sample 1** and **Sample 2** is the Flash point of bitumen Grade are given same value. As well **sample 1** and **sample 2** between the Fire point of bitumen Grade is different.

So **Sample 2** is better than **sample 1** fire point.

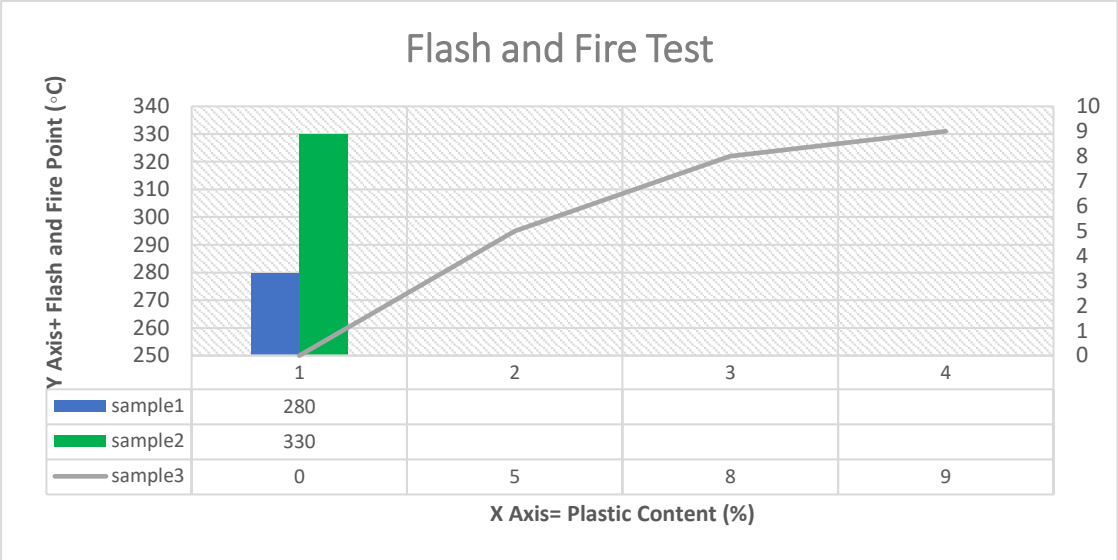


Figure 4.5: Graph of Flash and Fire Test (Sample-2)

4.1.3 Polyvinyl Chloride (PVC)

The Polyvinyl Chloride (PVC) used in this study was derived from the different types and sizes of bottles which are used to contain liquid products such as mineral water and cooking oil. Those plastics are free from dust and toxic and they are waste which were collected from households, hotels, and cafeteria and so on. They were washed and cleaned by putting them in hot water for 2-3hours. They were then dried.

The dried plastic was cut into tiny pieces of size not greater than 4.75mm. This is because when the plastic is to be added with bitumen and plastic dust it is to be ensured that the mixing will be proper. The smaller the size of the plastic, the more is the chance of good mixing.



Figure 4.6: Polyvinyl Chloride (PVC) pipe and Dust

4.1.4 Effect of Polyvinyl Chloride (PVC) on Penetration

The effect of Polyvinyl Chloride (PVC) (both PET and HDPE) on penetration is shown in Fig. 4.7 There is general trend of decreasing penetration value with increase in plastic concentration in bitumen.

This is good in one sense since it might improve the rutting resistance of the mix.

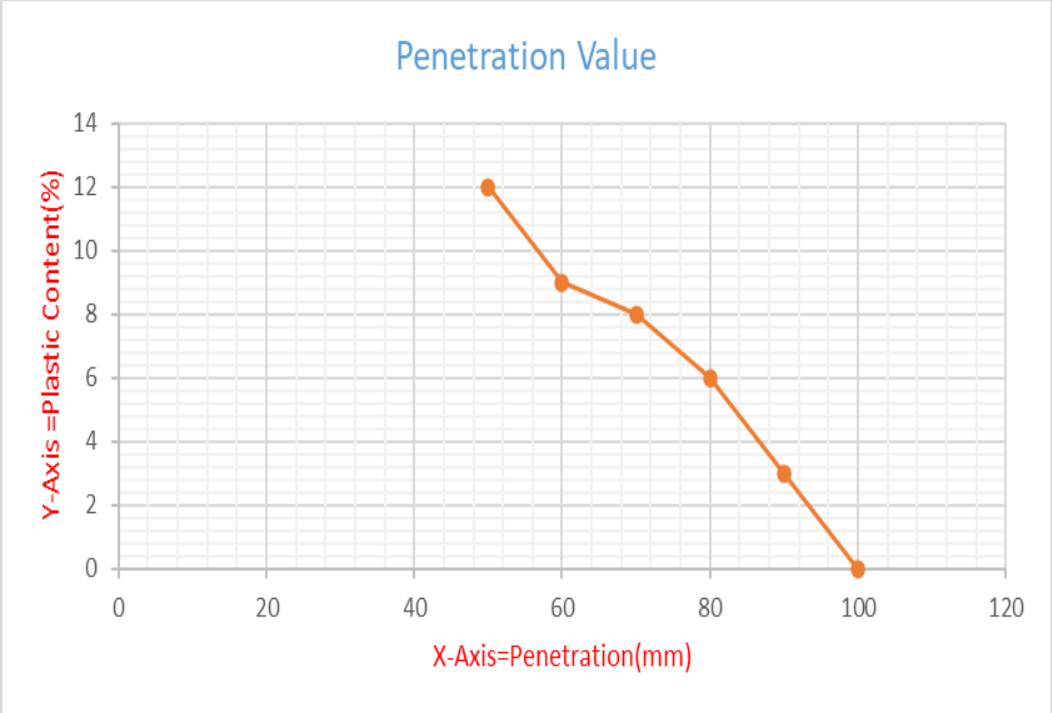


Figure 4.7: Penetration Test of PMB with different % plastic content

Figure 4-**7** shows that, the variation of penetration value with the various percentages of bitumen modified PET and HDPE decreases with the addition of both plastic. This means that the addition of (PVC) plastic dust makes the modified bitumen harder and more consistent. This is good in one sense since it might improve the rutting resistance of the mix, but on the other hand this may affect flexibility **I**n similar study identified that penetration decrease in value by plastic content increase.

4.1.5 Effect of Polyvinyl Chloride (PVC) on Softening Point

Softening Point is a measure of temperature susceptibility and a measure of flow of bitumen in service. The test was performed in accordance with ASTM D36. It is a form of consistency test that determines the melting point of bitumen and is used for control in refining operation. The test for determining softening point is called Ball-and-ring / Softening point test.

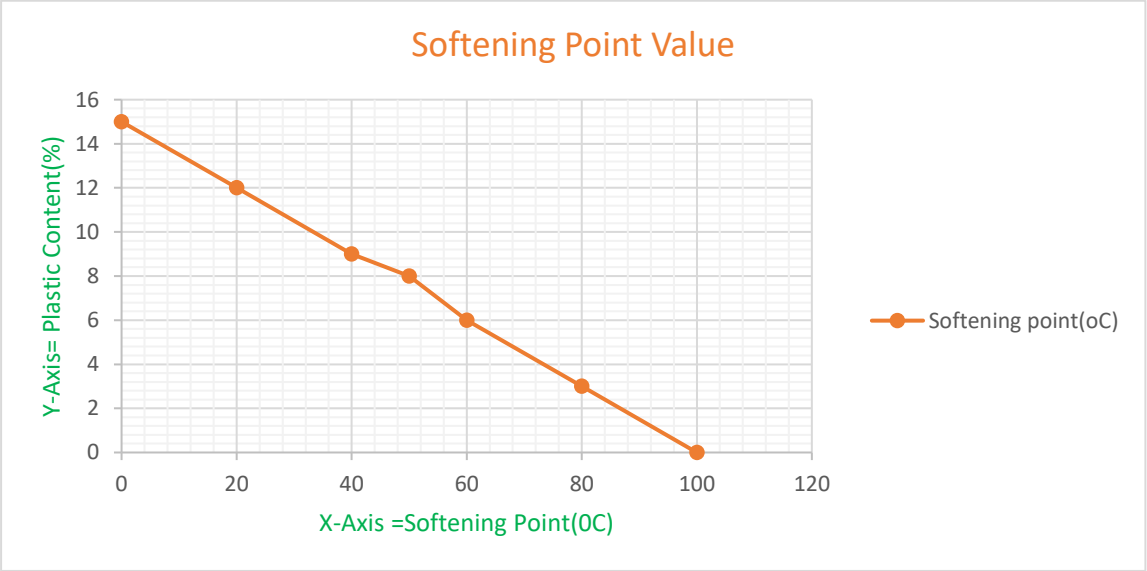


Figure 4.8: Softening Point of PMB with different % plastic content

As plastic content increases consistency of the binder, higher temperature will be required to make the modified binder soft. It can be calculated that addition of 12% waste plastic with the virgin binder, softening point has increased by about 28% (HDPE) and 24%(PET)of modified bitumen. It indicates that temperature susceptibility of binder significantly decreases with waste plastic content.

In a similar study identified that softening point increase and penetration decrease in value by plastic content incease.

CHAPTER - 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The use of such innovative technology is not only strengthened the road construction but also it will help to improve the environment and also creating a job opportunity. It is hoped that in near future we will have strong, durable and eco-friendly roads which will relieve the earth from Polyvinyl Chloride (PVC). The physical properties such as penetration decreased with the increase of Polyvinyl Chloride (PVC) Dust percentage, this means that the addition of Polyvinyl Chloride (PVC) dust makes the modified bitumen harder and more consistent. This is good in one sense since it might improve the rutting resistance of the mix. But the softening point increase with the addition of plastic additive to bitumen. This increment will alleviate the bleeding problem that characterized high tropical climate.

The experimental work while comparing the performance of conventional asphalt mixtures and plastic modified asphalt mixtures, plastic modified bitumen has increased softening point. This phenomenon indicates that the resistance of the binder to the effect of heat is increased and it will reduce its tendency to soften in hot weather. Thus, with the addition of (PVC) plastic the modified binder will be less susceptible to temperature changes.

The effect of Polyvinyl Chloride (PVC) dust on strength and stability indicates that the values of the stability and the values of flow, decrease these results indicate that the modifier HDPE & PET improves the properties of asphalt and asphalt mixture.

The optimum modifier content was found to be **8%** of (PVC) (HDPE) and **9%** of (PVC) plastic (PET).

From an environmental and economic standpoint, the use of Polyvinyl Chloride (PVC) dust , as a bitumen modifying agent may contribute to solving a waste disposal problem and to improving the quality of road pavements.

In general, this investigation not only utilizes beneficially, the waste non-degradable plastics but also provides us an improved pavement with better strength and longer life period and also create a source of job opportunity.

5.2 Recommendations

- This technology is not well understood and used in our country, therefore Government agencies like ERA and ERCC should come up with at least one comprehensive project of processing Polyvinyl Chloride (PVC) and constructing roads using the modified bituminous mix.
- The researcher believes that further studies is recommended to evaluate the effect of aging on PET and HDPE-modified asphalt binders, the effect of PET & HDPE on the fatigue behavior of the asphalt binder, and Dynamic Shear Rheometer (DSR) to study the low , medium and high temperature cracking stiffness.
- It is recommended to conduct similar studies on the wearing course layer of asphalt pavement and recommended for incorporating other waste plastic materials in asphalt mix such as plastics formed from Polypropylene (PP) and Polystyrene (PS) which widely used in construction.

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Appendix A

Physical Properties of Plastic Dust Mixed With Bituminous

Laboratory Results of Physical Properties of Aggregates Quality Test

Properties Tested	Test Result	Specification
Flash and Fire Test	280	Max308
Water Absorption Test	1.41%	Max 2%
Impact Value Test	17%	Max 24%
Los Angeles abrasion value Test	18.38%	Max 30%
Flakiness index	25%	Max 45%