TO STUDY THE PERFORMANCE OF BITUMEN WITH MODIFIED BINDERS (LDPE)

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MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

BY

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DECLARATION

I, Shakir Hussain Bhat (11208490), hereby declare that this thesis report entitled **"To study the performance of bitumen with modified binders (LDPE)"** submitted in the partial fulfillment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

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CERTIFICATE

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ABSTRACT

Number of both business and private vehicle utilizing bituminous roads increments extensively day by day, which not only demands good pavement surfaces but also desirable roads which can provide safe and economical journey. To meet the demands of challenging vehicle growth bitumen needs to be modified with modified binders, which leads to construction of pavements with higher resistance to various deformations and could also boost the economy of the country. The utilization of this innovative technology (polymer modified with bitumen) upgrades the quality of roads as well as supports road life. Additionally this innovation proves vital in hot, humid and extreme freezing temperate regions where temperature crosses 50°c and precipitation, snowfall is generally basic. While during modification the prime heed should be paid towards the cost of modification and also modifier should be related to its effect on environment. All the polymers utilized till date enhance the properties of bitumen yet has certain impediments, keeping every one of those constraints in view modifier utilized as a part of this study polyethylene (LDPE). The morphology and designing properties of bitumen adjusted with LDPE were explored with the assistance of different tests like penetration test, ductility test and softening point test. The outcomes got are very practical. With expanding rate of LDPE, properties like penetration and ductility continues diminishing while softening point continued to be increaing. The content of modified binder LDPE was increased as 2%, 4%, 6% and 8%. On initial three perceptions comes about accomplished were obviously yet on 8% expansion comes about accomplished were same as accomplished on flawless bitumen. Which demonstrated LDPE rate ought to be constrained to 6% to accomplish advantageous outcomes. To learn most sparing and long living roads.

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CHAPTER 1

INTRODUCTION

1.1TOPIC OVERVIEW

There are distinctive method for transportation, among all these street transportation is one of the crucial means and most generally utilized one for transportation of merchandise and ventures all through the world. In Ancient circumstances Romans firstly executed the idea of planning and development of streets that later changed to black-top innovation. This change from easy to cutting edge innovation prompts to the development of agreeable streets all through the world. Extensively asphalts can be separated into two i.e. adaptable and unbending asphalts. Adaptable asphalt involves different layers which are sub-base, street base and wearing course, these layers are comprised of bitumen and totals while unbending asphalts are normally built with strengthened cement and are not utilized for transportation reason often.

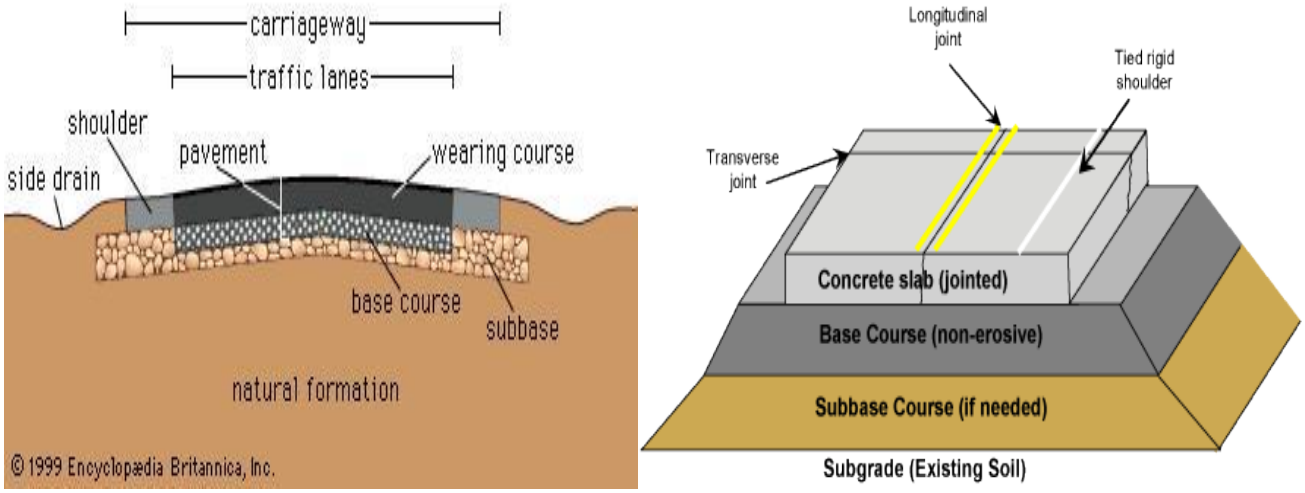

Figure 1.1 cross section of flexible and rigid pavement

Surface roads are very often and are mostly constructed with the use of bitumen binders .the reason only behind the large use of bitumen is that it is the material of the choice and meets the major requirements for example low initial cost ,phased development , and ready availability. With the rapid progress in every aspect it becomes mandatory to extend road network even to difficult environs. Due to increasing heavy traffic loads, engineers in almost every part of the world have become increasingly aware about the up gradation of bituminous binder modification

of binders is being done to overcome the various problems regarding flexible pavements. Some of the usual and common problems faced are mentioned below.

1. Development of greater potential against fatigue cracking due to repeated loads (needs elasticity for fatigue)

2. Heavy traffic flow to be carried in tropical and sub-tropical locales, with greater variations in temperature and extreme tyre pressure of heavy vehicles needs capability to resist the permanent deformation or rutting

3. One of the most usual and common failure in case of flexible pavement is low temperature cracking this is the result of shrinkage or thermal contraction under freezing Conditions of bituminous pavement. At low temperature bituminous mixes with greater stiffness modulus are very much temperature susceptible which leads to thermal cracking. To restrain this type of failure to minimal we do make use of polymer modified binders. These modified binders not only have low stiffness but also had a great ability of stress relaxation even at freezing temperature of pavement surface.

Different types of modified binders are needed which can minimize these daily rising problems to a large extent to have most durable pavements. Several types of modified binders with bitumen are used currently; among all these the most common are polymers. Polymers used for modification are Styrene Butadiene Styrene (SBS), ethylene followed by others such as Crumb Rubber, Styrene Butadiene rubber (SBR), Ethylene Vinyl Acetate (EVA) and Polyethylene (Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE)). Due to their relatively low cost and excellent engineering properties these polymers are blended with bitumen to attain the best possible results. The engineering properties of bitumen are influenced to a large extent by addition of modifiers. This latest technique of modification not only results in more suitable bituminous binder at low service temperature but also provides enhanced viscoelastic properties at high service temperature. With the help of this advanced technique deformation in pavement is reduced to minimal possible range. More improved viscoelastic properties are obtained by virtue of this advanced technique of modification.

1.1.1POLYETHYLENE

It is a consumer polymer coming to us in various forms like polymer films, containers, pipe, toys etc. Being lighter in weight it requires less transportation and installation cost. Which is one of the note worthy advantages of it. Working on ethylene at high pressure in 1935 a British chemist Eic Fawcett and his fellow members came with solid form of ethylene called as ethylene. Apart from its various uses it plays an important role in transportation engineering for example pipes of polyethylene are used for drainage purposes. Other than this polyethylene does suits best for its use as modified binder with bitumen.

1.1.2Types of polyethylene

All the types of polyethylene have same basic repeating units (─CH2─CH2 ─) but due to differences in chemical structures they exhibit different properties and hence have different applications. The main important properties which differentiate these polymers from one other are molecular weight (MW), molecular weight distribution (MWD), degree of large chain.

According to ASTM standards on the basis of density polyethylene are divided into four types which are tabulated below according to their densities.

Table 1.1 Classification of polyethylene by density

PE TYPE	**DENSITY(gm/cm3)**
LOW	0.910-0.925
MEDIUM	0.926-0.940
HIGH	0.940-0.959
HIGH DENSITY HOMOPOLYMER	0.960 and above

1.1.3 Low Density Polyethylene and its properties

Low-density polyethylene (LDPE) is a thermoplastic produced using the monomer ethylene. It was the primary review of polyethylene, delivered in 1933 by Imperial Chemical Industries (ICI) utilizing a high weight prepare by means of free radical polymerization. Its fabricate utilizes a similar technique today. The EPA gauges 5.7% of LDPE (reusing number 4) is reused. In spite of rivalry from more cutting edge polymers, LDPE keeps on being an essential plastic review. In 2013 the overall LDPE showcase achieved a volume of about US$33 billion.

Figure 1. 2 LDPR branching structure.

1.1.4 Properties:

LDPE is defined by a density range of 0.910–0.940 g/cm3. It is not reactive at room temperatures, except by strong oxidizing agents, and some solvents cause swelling. It can withstand temperatures of 80 °C continuously and 95 °C for a short time. Made in translucent or opaque variations, it is quite flexible and tough.

LDPE has more branching (on about 2% of the carbon atoms) than HDPE, so its intermolecular forces (instantaneous-dipole induced-dipole attraction) are weaker, its tensile strength is lower, and its resilience is higher. Also, because its molecules are less tightly packed and less crystalline due to the side branches, its density is lower.

1.1.5 Applications:

- It is commonly used in manufacturing of toys, films, bottles, and processing equipment's.
- It is also used for the purpose of insulation in wires and cables.
- It is also having good applications in green buildings these days.
- Used for drainage purposes in the form of pipes in highways.
- It is also used as modified binder with bitumen.

1.1.6 Advantages:

- Being lighter in weight it has less transportation and installation cost.
- It is having good resistance towards moisture.
- It is having good chemical resistance also.
- It is the material of choice in temperature ranges from -4o c to 90 c.

- It can be processed by all thermoplastic methods.

1.1.7 Disadvantages:

Irrespective of having all these advantages LDPE is having few disadvantages also which are discussed below:

- It is having high thermal expansion.
- It has also poor weathering resistance.
- It is very difficult to bond when subjected to stress cracking.

1.2 NEED FOR STUDY

To provide pavement with good resistance against various failures for example rutting, thermal cracking etc. Bituminous mixtures are normally designed with high coarse aggregate content, fines and modified binders. Irrespective of this advancement, pavement deformation is increasing at a detrimental rate. Road traffic is increasing at an extra pace since from last 20 years. This increase plays a significant role in deteriorating the pavements which demands binders that can with stand this increasing traffic. Structural failure either in flexible or in rigid pavement for example rutting and cracks (thermal cracks) have always been matter of great concern in highway construction.

RUTTING **THERMAL CRACKS**

Figure 1.3 a

Figure 1.3 b

Pavement using polymer modified bitumen as a binder shows its greater resistance to thermal cracking, rutting, and stripping and temperature susceptibility. Bitumen being flexible at room

temperature with density of 1gm/cm3 but at stumpy temperature it becomes brittle and at higher temperature it flows like a fluid. To make bitumen less susceptible to these temperature variations it is required to blend with modified binders. Which can to some extent make bitumen to resist these temperature changes. Method of production of bitumen and type of method used while mixing modifiers with bitumen also had great effect on the properties of the mixture. For production and use of bitumen mix with various modifiers there are different conditions. On addition of binders and change of method of production bitumen shows different properties and performance also changes over a great extent. Utmost care should be taken while choosing a modifier. Proper dosage also needs great attention so that almost all requirements and minimum cost are achieved. In other words there is need to meet the roadside conditions with appropriate type of modifier to be used.

As PG system was introduced the use of bitumen increased significantly.Although the use of bitumen also increased prior to super paver technology. This is because some of the PG grades with wide range of maximum and minimum temperature, unmodified or neat bitumen for example PG64-22 which matches the properties and performance of India's VG-20 is one of the most common paving bitumen used over large parts of the world. This grade is the mixture of two grades which are PG 64 -22 and PG 76 -22 and can't be produced without the use of modified binder. Most commonly used modified binders are polymers. Polymers simply refer to a large molecule which are the result of chemically reacting of many small molecules bound together either in small chains or in clusters. When polymers as binders are mixed with bitumen both the properties and performance of the bitumen changes over a large extent with the result of which maximum requirements and low cost are achieved to desired extent. Most commonly two types of polymers are used as modified binders which are plastomers and elestomer as the name suggests former can be stretched like rubber ,after application of force it stretches as force is released it regains its shape. Elestomer add only little strength to bitumen. While on the other hand plastomers add higher strength to withstand against heavy traffic loads

1.3 OBJECTIVES OF THE STUDY

- To investigate and analyze the properties and performance of bitumen when incorporated with different percentages of High Density Polyethylene as a modifiers.
- During mixing to analyze the negative effect of aging on modified binders.

- To investigate the direct tensile strength of bituminous mixes when mixed with modified binder High Density Polyethylene
- To compare the economic implication with the use of modified binders (HDPE) and standard mixtures.
- To investigate the stability of modified binders with bitumen while storage and also to analyze the morphology of the mixture.
- To determine the binding properties of bitumen mixed with ethylene vinyl acetate by checking the micro structure analysis of the modified bitumen homogeneity.

1.4 IMPORTANCE OF THE STUDY

The basic aim of the study is to assess the performance of the bitumen mixed with modified binder (HDPE). By doing so we will be able to reduce or minimize various pavement defects for example Rutting, Fatigue cracking, low temperature thermal cracking. Since from years rutting is the major problem in pavements especially in flexible pavements the major cause behind the failure is heavy traffic loads and high tyre pressure. To overcome this problem it is need of hour to look for the bituminous mixes which can withstand the problem quit easily for this we need modified binders with higher stiffness and adequate elasticity at higher service temperature. Other defect named as fatigue cracking is also one of the defects of great concern the defect is caused by increased heavy vehicle traffic and repeated loads to overcome this problem binders with lower stiffness and higher elasticity at immediate service temperature are required. Last but not least defect is thermal cracking which is one of the most dominating defects especially in flexible pavements the defects occurs usually at low service temperature, unmodified bitumen cannot cope with the range extreme minimum and maximum temperature. So to overcome this problem we require binders with low stiffness at low temperature and high stiffness with high temperature. To overcome all these rising issues regarding the defects in flexible pavement it is important to blend the bitumen with those mixtures which could at least have a great check over these defects so that the pavement life would be more and cost of maintenance would be less.

1.5 SCOPE OF THE STUDY

As problems are faced while using neat bitumen, to reduce these problems to minimal amount. Therefore the future scope relies on how much these modified binders reduce problems in

pavement construction. Which not only leads to long livings pavements but also most economical projects? The study involves the use of modified binder (LDPE) with bitumen and extensive laboratory testing.

1.6 APPROACH AND METHODOLOGY

Literature review

Case study

Data collection

Data analysis

Data interpretation

1.7 STUDY SYENTHESIS

- Chapter one contains introduction.
- Chapter two contains review of literature.
- Chapter three contains data collection.
- Chapter four contains discussion on results and to find the conclusion and future scope.

CHAPTER 2

LITERATURE REVIEW

Polymer alteration of bitumen has a long history. So it is viewed as vital to edify the historical backdrop of improvement and utilization of changed folios in different created and creating nations to give legitimate learning and their back ground of utilization. Licenses for adjusting bitumen with regular and engineered polymers were allowed as right on time as 1843. In 1950s neoprene latex in North America was presented and was principally utilized as a part of western United States and Canada. Different sorts of changed folios containing plastomers and elastomers by US expressway powers were advanced for utilize. A number of these elastomers and plastomers were advanced independent of knowing there organization. Since there were no determinations accessible. This prompt to disarray in practicing altered bitumen innovation. Errand 31 appeared to dispose of this uncertain circumstance under which certain determinations were said which gave accentuation on polymer alteration of bitumen and its utilization. This undertaking was the aftereffect of joint exertion of American Association Of State Highways and Transportation Officials (AASHTO), the Associated General Contractors (AGC) and the American Road and Transport Builder Association (ARTBA). Polymer adjusted folios being of various sorts (elastomers and plastomers) in fact it was never conceivable to have basic details for every one of them. Put basically oranges can't be contrasted and apples. Keeping every one of these determinations into thought these adjusted covers were ordered into various classifications as indicated by their details (AASHTO 1992). AASHTO created three separate guide determinations.

There rise a requirement for creating execution based determinations for all street clearing bitumen folios which could gave an idea of mixing the sort of adjustment or refining process. At that point soon five year Strategic Highway Research Program (SHRP) was produced from 1987 to 1992 giving the reviewing of bituminous fasteners according to their execution. This five year program was completely in light of the designing principals. This purported super clear execution reviewing framework comprises new bitumen tests and some specific details with notable components which are clarified beneath.

- Rather than the experience measured physical properties by super pave bitumen tests are directly related to field performance by engineering principles.

- For first time long tenure bitumen aging test was introduced, which imitate aging of bitumen between 5-10 years.
- These tests and guidelines should be so designed to have minimum bituminous pavement distresses which include rutting, fatigue cracking and thermal cracking. Usually these stresses occur at high temperature, intermediate temperature and low temperature respectively.
- Latest equipments were developed to perform these tests and used for testing the bitumen only for the purpose that entire range of pavement temperature should be considered experienced at the project site.
- These tests and specifications should cover the both modified and unmodified bitumen mixes.

2.1 POLYMERS USED AS MODIFIED BINDERS

The term polymer is the combination of two words poly meaning many and monomer meaning molecules. Polymers are formed by chemically reacting these small molecule. These molecules may be formed in long chains or in clusters. The chemical structure and the arrangement between these monomers is a prime factor to decide various chemical and physical properties of a certain polymer. When polymers are blended with bitumen, then polymer used is the main components governing both the physical and chemical properties of the mixture. Polymer droplets can also be emulsified in water with bitumen this water based emulsion is commonly known as latex. The best example of water based emulsion is SBR latex. This was the only reason that surface dressing (chip seals) and slurry seals were the first paving applications. This application took advantage of this latest technique (modification). Same monomers or different monomers may lead to formation of polymers. If two or more different monomers are used to make a polymer then the resulting polymer is called as random or block copolymer. For production of such polymers (block copolymer) a monomer of one polymer chemically reacts with block of another monomer. One of the best examples of such polymer is SBS which is the result of chemical reaction of block of polystyrene with block of polybutadiene and another block of polystyrene. The case is totally different in random polymer. In case of random polymer, the monomers are randomly mixed with polymer chain for example styrene butadiene rubber (SBR). Even though

as SBR, SBR is composed of same monomers but its random orientation gives it different physical properties.

2.2 CRUMB RUBBER MODIFIED BITUMEN (CRMB)

Zaniewski and Pumphrey; & McGennis et al.,(1994) concluded that the Crumb rubber is produced by so called wet process. This procedure incorporates the expansion of scrap elastic to hot bitumen as piece elastic is blended completely with bitumen then the blend is mixed mechanically till homogeneous blend of bitumen and morsel elastic is not accomplished. Instead of a compound procedure the response amongst elastic and bitumen is a dissemination procedure. This dispersion procedure makes contribution of ingestion of sweet-smelling oils from bitumen. The procedure of arrangement of CRMB itself prompts to increment in consistency Due to the retention of oil elastic molecule swell which prompts to increment in thickness as talked about before.

Principle source from which morsel elastic is gotten are truck tires and car tires or both. Truck tires contain more characteristic rubber when contrasted with car tires rate shifts from 18-20% and 9-10% separately. Nearness of common elastic influences the properties both physical and concoction of CRMB essentially over an awesome degree. Contingent upon the source every parcel of scrap elastic have distinctive substance organization notwithstanding when conveyed with same wellspring of bitumen may display diverse properties

As already examined amid the day and age when interstate architects in the US were attempting to comprehend complex polymer altered bitumen (PMB) frameworks. With the consequence of which they accompanied another slightest comprehended idea of adjusted fastener the folio was morsel elastic altered bitumen. In US CRMB is just called as Asphalt-Rubber (AR) fastener. Elastic from disposed of tires is granulate to extreme fineness or scrap before adding to bitumen to get the best blend of morsel elastic adjusted bitumen.

Becker et al., (2001) In 1960 Charles MC Donald was the first specialist who created or gave the idea of elastic altered bitumen. Till 1991 utilization of CRMB was not a typical practice. At that point later US congress commanded the utilization of CRMB in 50 states through focal enactment. This was just in light of the reason that the asphalts in which CRMB was utilized gave the enhanced execution when contrasted with the asphalts which made us of other altered fasteners. This political choice made by US congress was not acknowledged by both Asphalt

industry and state thruway divisions. In any case, in disdain their resistance it was by and by. From 1991-1995 all the 50 states amid the command utilized CRMB as a part of all the bituminous clearing ventures till the order was canceled. After this the vast majority of the states suspended the utilization of CRMB in bituminous clearing blends. For this there were the three essential reasons which are talked about underneath

1. Development of state wide infrastructure consisting of strategically placed blending terminals or on site blending units were required for the use of CRMB as CRMB must be used as soon as possible as it starts deteriorating just after 6 hours of production.

2. From the production to end use the quality control requirements are too much difficult because of the following reasons.

- With bitumen crumb rubber tries to get separated and tends to settle down
- Being very much vulnerable to degradation ,DE vulcanization and depolmerization takes place if its use is delayed which results in losing its most important properties like viscosity etc.

3. Many of the states like Arkansas, Minnesota, Nevada, Washington and Wisconsin have reported the weak performances of the pavements constructed with CRMB and cost effectiveness was also one of the serious concern.

In present time among all the 50 states in US CRMB is utilized just as a part of 4 expresses that too just on routine premise rest of the 46 states don't indicate insignificant enthusiasm for utilizing the CRMB as a part of building up the vital frameworks and actualizing the important quality control program to guarantee compelling utilization of CRMB .

Being much defenseless against high temperature, the piece elastic starts to corrupt. In the event that CRMB is kept up at high temperatures for delayed timeframe as meager as 6 hours prompts to diminish in consistency from its objective esteem.

In contrast with a routine blend without elastic, there is increment in element soundness (DS) of elastic changed black-top blend. Then again there is diminishing in disappointment solidness modulus (FSM) of elastic changed black-top blend. It could be finished up with the announcement that the expansion of tire elastic in black-top blend with the assistance of dry process. The marvel

could lead to incredible change in properties like imperviousness to perpetual misshapening at high temperature and warm breaking at low temperature 600 and 100 individually.

C E G Justo & A Veeraragavan et al., (2002) An exploration directed on scrap elastic gives that marshal security has demonstrated augmentation to a substantial degree. The most extreme esteem was accomplished at 25% expansion of piece elastic. With this the thickness of blend likewise demonstrated an incredible augmentation when contrasted with 60/70 flawless review of bitumen. Beneath given the table uncovers the aftereffect of studies which presume that the execution of adjusted bitumen could touch the immense change regardless of this reality of utilizing waste material as modifier. Prepared plastic packs utilized as an added substance with bitumen was concentrated on by transport architects of Bangalore University to think about the execution of bitumen fasteners. The study included differing rate of handled plastic sacks to the heaviness of bitumen. The rate was differed from 0-12% by weight. The blend was warmed first and mixed mechanically. The properties of blend were contrasted with the normal blend. It was unmistakable that the properties like malleability and infiltration esteem continues diminishing on expanding rate of handled plastic. While softening point was recorded to increment.

Table 2.1: Results of SDBC mix for varying percentages of Crumb Rubber

S no	Crumb rubber%	Bitumen%	Marshal stability (Kg/mm)	Flow value (mm)	Bulk density (gm/cc)	Air voids % VV	VMB	VFB %
1	8	5	1065	3.10	2.23	3.87	14.99	74.12
2	10	5	1190	3.62	2.24	3.86	15.03	74.25
3	12	5	1180	3.76	2.26	3.98	15.24	73.25

Mashan et al., (2011) demonstrated that the entrance continues diminishing on expanding grouping of elastic at various blend state of rubber treated bitumen fastener. Which specifically or in a roundabout way prompts to all the more hardened and thick cover. Concentrate additionally uncovered that mixing properties of bitumen blend got influenced, as it were, on option of piece elastic. Higher the focus was included more critical changes were watched. This concentrate likewise uncovered that changing folio content from any other person to elastic, makes bituminous blend then as a material of decision particularly in those zones where temperature changes are so sudden.

2.3 LOW DENSITY POLETHYLENE (LDPE)

Atul kumar vaidya et al., (2016) concluded from his work that Marshal Stability values and stream estimation of Dense Bituminous Mix increment because of expansion of LDPE. It has been watched that altered blend demonstrates better marshal strength esteem at 8% LDPE however VFB surpasses the constraining quality, so the ideal dosage of LDPE is chosen as 6%. His outcomes additionally reasoned that the LDPE Modified Bitumen blend indicates better Marshal Stability esteem (1445 kg) than normal (60/70 review) bituminous blend (1263 kg). The test were performed to locate the ideal cover content with 6% LDPE changed blend. The Optimum cover content in his work diminished to 5% with ideal measurements of LDPE (6%) in contrast with common bituminous blend (5.5%). The Marshall's blend configuration directed on DBM utilizing LDPE gives comes about according to MORTH proposals, show the adequacy of the LDPE in Bituminous Concrete blend, since in satisfactory range.

Noor Zainab Habib et al., (2010) has studied that the rheology of 80 penetration bitumen was unequivocally influenced by the expansion of thermoplastic copolymers as saw by the consequences of infiltration, softening point and viscosity. From all the test outcomes it was uncovered that LLDPE &PP changed bitumen demonstrates minimum variety in entrance and softening point in contrast with HDPE altered bitumen, when the grouping of polymer is kept beneath 3% which might be because of the development of thermodynamically stable structure which may offer resistance regarding rutting, exhaustion and temperature powerlessness when explored at later piece of this study. The sharp diminishing in the infiltration estimation of virgin bitumen at 0.5% convergence of polymer in the mix demonstrates that even at lower centralization of the polymer in mix quickly improves the hardness of the PMB, which might be because of the development of scattered polymer organize as the viscoelastic conduct of virgin bitumen was firmly affected by polymer focus, temperature and entrance review of the bitumen. The non-Newtonian conduct was watched for virgin bitumen, which was significantly influenced by the expansion of polymer in the mix as they as they showed thixotropy. Polypropylene with straight structure included powder shape to the base bitumen was less demanding to mix to create homogenous mix as saw by the direct diminishing in infiltration, increment in softening point and increment in thickness, along these lines exhibiting the consistent development of stable inner structure. HDPE and LLDPE displayed both thixotropic and viscoelastic conduct at all centralization of polymer in the mix. HDPE demonstrated shear thickening conduct at shear

rate around 2000 1/sec to 3000 1/sec., which might be because of agglomeration of HDPE molecule at higher temperature of 135ºC and may offer better imperviousness to rutting.

B Malpas et al.,(2010) concluded that Ethylene monomers leads to the formation of thermoplastic known as low density polyethylene. It was produced in 1933 by imperial chemical industry by virtue of high pressure process through free radical polymerization. LDPE was the first grade of polyethylene. It is having numerous applications among which the important are packing, foils, trays, and plastic bags both for food and nonfood purposes. Below given are some unique characteristics of LDPE.

Maximum temperature: 80

Hardness: sd55

Minimum temperature: -50

UV: resistance poor

Autocalvable: no

Tensile strength: 700psi

Specific gravity: 0.92

Translucent

Excellent flexibility

Flynn et al., (1993) studied that the vital utilization of LDPE is in asphaltic asphalts. From basic need sacks reused polyethylene is utilized as a part of such asphalts which prompts to utilize lasting disfigurement as low temperature warm splitting and rutting asphalt surfaces.

Garcla Morales et al 2004 &Habib et al., (2011) has sudied that the rheology of 80 pen bitumen was unequivocally influenced by the expansion of thermoplastic copolymers as saw by the consequences of infiltration, softening point and viscosity. From all the test outcomes it was uncovered that LLDPE &PP changed bitumen demonstrates minimum variety in entrance and softening point in contrast with HDPE altered bitumen, when the grouping of polymer is kept beneath 3% which might be because of the development of thermodynamically stable structure which may offer resistance regarding rutting, exhaustion and temperature powerlessness when explored at later piece of this study. The sharp diminishing in the infiltration estimation of virgin bitumen at 0.5% convergence of polymer in the mix demonstrates that even at lower centralization of the polymer in mix] quickly improves the hardness of the PMB, which might be because of the development of scattered polymer organize as the viscoelastic conduct of

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Kennedy et al., (1994) found that at a precise recurrence of 10 radians for each second testing a bitumen test is proportional to a movement speed of 100 km/hr. for diminishing pace of stream under 100km/hr bring down frequencies could be utilized to assess different properties and practices of altered bitumen under changing movement conditions.

Abdel Aziz Mahrez and Mohammad Rehan Karim et al., Another exploration was made to bolster all the past studies which expresses that on expansion of LDPE the altered bitumen gets to be distinctly stiffer, harder, and predictable. Given underneath is the figure demonstrating the consistency of LDPE changed bitumen diminishes as the LDPE content increments in the blend. It was likewise one of the noteworthy changes that 10-40% diminishment in infiltration esteem was recorded with expansion of 2%, 4%, 6% and 8% of LDPE into bitumen

2.4 PLASTIC AS MODIFIED BINDER

At a center of transportation engineering Bangalore University study was conducted which made utilization of handled plastic packs as an added substance in various extents changing from 0-12% by weight of bitumen with warmed bitumen. The review furnish with the conclusion that the expansion of plastic around 8.8% aides fundamentally in enhancing the properties like solidness, quality, weakness life and other alluring properties under antagonistic climate conditions and substantial activity loads. The expansion of plastic likewise made this thing clear that mixing of plastic with bitumen prompts to spare no less than 0.4% of bitumen by weight of the blend. For handy applications to be assessed utilizing plastic as a modifier a 1000m extend of

street was taken in Tamil nadu in which handled plastics was utilized as an adjusted cover. The review was led under a plan " 1000 km plastic tar street "" it was assessed that the execution of street extend was agreeable even in antagonistic climate conditions and overwhelming movement volume. Same system was rehashed in Karnataka there it likewise gave acceptable outcomes. In previously mentioned states the development of these asphalt were altogether done under the direction of Indian street congress under the supervision of specialists from Bangalore college, CRRI and some IIT specialists additionally Besides these developments we are not with standard details on the utilization of waste plastic material in street development as a modifier. This allowed to put this thing in notice of Indian street congress (IRC). This activity was taken by NRRDA to put this proposition forward to the same in which it was said that rules ought to be there which ought to concentrate on this thing how to utilize plastic as a modifier fastener to lead the most traditional and practical tasks.

2.5 EFFECT OF WAX ON BITUMEN CHARECTERISTICS

Maccorone et al., (1994) study was carried on a sample of bitumen mixed with varying percentage of wax from 1-5% showed the result of an increasing softening point and decreasing penetration values. These things were also noteworthy that at high temperature viscosity of binder gets decreased while on mid-range temperature it was recorded to increase with increasing concentration of wax. As consistency of bitumen mix may be defined as the measure of its susceptibility to temperature changes and resistance to flow which has a great affect ob ability and resistance to various deformations in form of rutting and low temperature thermal cracking of the mixture. This study also revealed that the consistency gets affected significantly by addition of sasobit wax(S). Penetration, softening point, and viscosity were also measured by using brook field viscometer. A study was conducted on cold mixed bitumen based on the use of foamed bitumen and very high binder content emulsion. They mentioned in their study that worldwide side acceptance was gained on the use of cold mixes for road construction. They also made it clear that these systems are energy efficient and ecofriendly. The reason that motivated them to mention these things in their study was that cold mixes don’t release hydrocarbons and their production requires very less amount of fuel.

Edward et al., (2006) studied rheological properties of bitumen grade 60/120 were investigated at various temperature on addition of commercial wax. The study focused with low temperature

effects which can have a great influence on thermal cracking resistance of bituminous mix. The study also mentioned that the type of bitumen grade is also the governing factor regarding the rheological properties other than the type and quantity of additive used.

2.6 ETHYLENE VINYL ACETATE AS MODIFIED BINDER (EVA)

Pedro Partal, Francisco j.Navorra et al.,(2004) explored that change of bitumen with ethylene vinyl acetic acid derivation (EVA) holds great in calm zones where the material is utilized for surface covering reason. At the point when 5% of EVA by weight of bitumen was included it accomplished the consistency esteem at 1350c which make its simple application on streets. While on expansion of 9% of EVA by weight of bitumen it accomplished a substantial consistency which makes it troublesome for preparing at a similar temperature. In this review relationship amongst consistency and microstructures of EVA changed bitumen was additionally kept in thought. These connections were looked at by different trials did in slender and Rheometer and photomicrographs which were taken utilizing microscopy framework while the specimen was sheared. Utilizing four sharp edge propeller mixes of bituminous review and waste plastic (EVA) were handled in an open blender. Different tests like rheological test, differential examining Calorimetry (DSC) and microscopy uncovered that the execution of bituminous blend improved over an awesome degree on expansion of EVA as a modifier which prompted to the conclusion that utilization of EVA is most appropriate being more conservative and ecofriendly.

2.7 HIGH DENSITY POLYETHYLENE AS MODIFIED BINDER (HDPE)

Sisan Hinislioglu, Hatice Nur Aras & Osman Unsal Bayrak et al., (2005) came with the interesting conclusions which are enumerated below.

- There was 3-21% increment in stability while flow value decreased from 17-25%.
- It was also concluded that HDPE modified bituminous mix provide better resistance against the permanent deformation because of higher stability, lower flow and lower softening point.
- There was 34% decrease in permanent strain by addition of 2% of HDPE.
- On addition of HDPE it was also found that mix had higher creep stiffness values than control mix.
- After 15 minutes of addition it was observed that creep stiffness value were higher as expected.

- It was also concluded that mix added with HDPE is more suitable in the regions where temperature changes are sudden.
- Stiffness modulus of mix increased by 52% which increased 38% of total cost of HDPE modified bitumen by using 2% of HDPE.

M.S.Ranadive and A.B.Tapase et al., (2012) led by these two entitled as change of adaptable asphalts with the assistance of adjusted cover (HDPE). Bitumen utilized as a part of this review was given by pune city organization (PMC). The review of bitumen utilized was 60/70 infiltration review. The outcomes got from both dry and wet example blend indicated half upgrade in elasticity in Comparison to ordinary blend when 8% of altered fastener was included. This review additionally demonstrated that bitumen with expanded rate of cover has higher steadiness and marshal remainder (MQ). Which gives blend a superior imperviousness to changeless twisting. One of the critical consequences of the review was that keeping every single other parameter inside point of confinement it was watched that on the expansion of 10% of HDPE there was 25.57% augmentation in steadiness.

***Abdel Aziz Mahrez and Mohammad Rehan Karim et al., (*2010)** study was led in which bitumen 80/100 entrance review was utilized with this polyethylene (HDPE) in powdered frame with thickness and softening purpose of 1370kg/cm3 and 260oc separately as a changed cover. Different physical tests, for example, infiltration, softening point, consistency utilizing Brookfield viscometer were performed likewise rheological properties were measured with the assistance of element shear Rheometer test. It was watched that with expanding rates of HDPE diminishing infiltration qualities were recorded while on expanding rate of HDPE softening point likewise gets expanded. At lower temperatures more viscosities were seen as looked at higher temperature. Comes about additionally demonstrated that polyethylene changed bitumen satisfied the SHRP prerequisites. Bring down stage point and higher complex modulus were additionally seen in adjusted bitumen than flawless bitumen. found that ideal rate of PVC, plastic packs, novolac was 4% and HDPE was 5% which was added to bitumen test. The expansion of these rates prompt to improvement of kinematic viscosity,stabilty, solidness, guide elasticity furthermore prompt to diminishment in entrance values. There was seen diminish in rigidity and strength if these added substances were included with expanded rate. While stream values demonstrated certain augmentation. Among every one of these added substances the base estimation of stream was gotten when HDPE was utilized as adjusted fastener took after by

waste plastic sacks. Then again the greatest elasticity was accomplished when plastic sacks were utilized as added substances then taken after by HDPE. Toward the end their review accompanied the outcome that among all these adjusted covers utilized, the best appropriate are HDPE and plastic sacks.

Shirish N. Nemade and Prashant V. Thorat et al., (2013) led examine in which utilized bitumen 60/70 review which was acquired from Kothari manufacturers Akola. Test of bitumen was mixed with polyethylene (HDPE) in its powdered frame with shifting rates. It was watched that expansion of HDPE prompts to increment in softening purpose of bitumen. Which makes the asphalt more adaptable particularly amid winters which at last prompts to longer existence of the asphalt. Mixing of test with HDPE likewise demonstrated as contrasting option to defeat weakness of bitumen.

EslamMagdy Mohammed Deef- Allah and Ahmad Mohamady et al., (2014) as indicated by there study in Egypt the bitumen was mixed with various modifiers like poly vinyl chloride (PVC), high thickness polyethylene(HDPE),plastic packs and novolac.

Maccorone et al.,(1994) tests were carried on an example of bitumen blended with differing rate of wax from 1-5% demonstrated the consequence of an expanding softening point and diminishing infiltration values. These things were likewise significant that at high temperature consistency of folio gets diminished while on mid-extend temperature it was recorded to increment with expanding convergence of wax. As consistency of bitumen blend might be characterized as the measure of its helplessness to temperature changes and imperviousness to stream which has an awesome influence on capacity and imperviousness to different distortions in type of rutting and low temperature warm breaking of the blend. This review likewise uncovered that the consistency gets influenced fundamentally by expansion of sasobit wax(S). Infiltration, softening point, and thickness were additionally measured by utilizing stream field viscometer. A review was directed on icy blended bitumen in view of the utilization of frothed bitumen and high folio content emulsion. They specified in their review that overall side acknowledgment was picked up on the utilization of cool blends for street development. They additionally made it clear that these frameworks are vitality proficient and ecofriendly. The reason that inspired them to say these things in their review was that cool blends don't discharge hydrocarbons and their creation requires less measure of fuel.

Mahrez & Karim et al., (2010) In one of the reviews to reflect three unmistakable streams, three one of a kind frequencies were picked. The three unmistakable streams were free stream, lessening free stream, overpowering stream. In this learn at various mid and high temperatures dynamic shear Rheometer was used to evaluate the component mechanical properties for perfect and LDPE balanced bitumen.

Table 2.3 : Conventional test results of base and modified bitumen

Prop.e.rties	B 160/220	B 160/220 + i-LDPER, wt.%				
Penetration 25 c ,0,1mm	195.5	158.2	133.3	117.7	68.4	63.5
Softening point	38.7	41.1	43.4	51.0	59.5	67.8
Ductility, cm	103	88	81	72	63	53
Penetration index	-0.73	-0.59	-0.38	1.53	1.77	3.13

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CHAPTER 3

MATERIALS AND METHODS

3.1 Material used

For this study neat bitumen VG30 from unknown source and aggregates with maximum size of 20 mm were used. Low density polyethylene (LDPE) in pallet form was used as a modified binder with varying percentages.

3.2 Tests performed on aggregates

Various tests were conducted on aggregates which include aggregate grading test, crushing value test and loss angels' abrasion test. These tests were performed to determine and analyze the results about utility of road aggregates in terms of crushing value and abrasion value. These all the three tests were performed keeping IRC guidelines under consideration. Tests with the calculated results are discussed below.

3.2.1 Aggregate crushing value test

3.2.1.1 Objective

The principal mechanical properties required in stones are

- Under the roller during construction aggregates should have adequate resistance to crushing.
- Under mixed traffic conditions these should have adequate resistance to surface abrasion
- To resist crushing under traffic wheel loads aggregates should be strong enough. Weak aggregates leads to pavement failures.

3.2.1.2 Apparatus used

a) Cylindrical measure with internal diameter 115mm and height 180mm

b) Steel tamping rod with diameter 16mm and length 450mm to 600mm

c) Balance with 3kg with accuracy up to 1gm

d) Compressive testing machine which should be capable of applying loads of 40 tones.

e) Is sieve of size -12.5mm, 10mm and 2.36mm

3.2.1.3 Sample preparation:

Coarse aggregate passing 12.5mm IS sieve and retained on a10mm. IS sieve and heated at 100 to 110°C for 4 hours and cooled to room temperature. The quantity of aggregate shall be such that the depth of material in the cylinder, after tamping shall be 10 cm. The appropriate quantity may be found conveniently by filling the cylinder. Measure it in three layers of approximately equal depth, each layer being tamped 25 times with the tamping rod and finally leveled off using the tamping rod as straight edge, care being taken in the case of weaker materials not to break the particles. The weight of the material comprising the test sample shall be determined (weight A) and the same weight of sample shall be taken for the repeat test.

3.2.1.4 Procedure

- Put the cylinder in position on the base plate and weigh it (W). Put the sample in 3 layers ,each layer being subjected to 25 strokes using the tamping rod, care being taken in the case of weak materials not to break the particles and weigh it (W1)
- Level the surface of aggregate carefully and insert the plunger so that it rests horizontally on the surface, care being taken to ensure that the plunger does not jam in the cylinder.
- Place the cylinder with plunger on the loading platform of the compression testing machine.
- Apply load at a uniform rate so that a total load of 40T is applied in 10 minutes.
- Release the load and remove the material from the cylinder.
- Sieve the material with 2.36mm IS sieve, care being taken to avoid loss of fines
- Weigh the fraction passing through the IS sieve (W2).

3.2.2 Los Angeles abrasion value test

3.2.2.1 Objective

I. To determine the suitability of aggregates for use in road construction.

II. To evaluate the Los Angeles abrasion value for given sample of aggregates.

3.2.2.2 Apparatus used

As per Is: 2386(part iv) 1963 following apparatus are required

Los Angeles abrasion testing machine, Abrasive charge-Cast iron or steel balls, 1.70mm sieve, balance of capacity 10kg, oven, Tray.

3.2.2.3 Procedure

- The prepared sample is placed in the abrasion-testing machine.
- A specified number of steel spheres are then placed in the machine and the drum is rotated for 500 revolutions at a speed of 30 - 33 revolutions per minute (RPM).
- The material is then separated into material passing the 1.70 mm (No. 12) sieve and material retained on the 1.70 mm (No. 12) sieve.
- Dry the sample in an oven.
- Calculate %age loss due to Abrasion by calculating the difference between the retained material (larger particles) compared to the original sample weight. The difference in weight is reported as a percent of the original weight and called the "percent loss".

3.3 Tests performed on neat and modified bitumen

Bitumen is a mixture of organic liquids, highly viscous in nature, having sticky characteristics mainly used for paving roads. Almost 90% of total produced bitumen is used in paving road surfaces. To determine the appropriate use of bitumen there are various tests performed on bitumen. Being very important component in construction of roads. Bitumen has to go through these tests to ensure its quality use.

3.4 Sample preparations

By temperance of dissolve mixing method different examples of flawless and changed bitumen were readied. Around 200gms of bitumen were warmed till it accomplishes liquid qualities. Test was warmed at around 750c to 1000c. Differing rates of LDPE were included physically. While adding ceaseless mixing was done to accomplish homogeneous blend. On arranged examples observational tests like malleability test, entrance test and softening point tets were performed. Every one of these tests were performed concurring the details gave by IRC to get attractive outcomes for utilization of changed bitumen.

3.4.1 Ductility test

3.4.1.1 Objective

To measure the ductility of given sample of bitumen and to determine the suitiblity of bitumen for its use in road constructions

3.4.1.2 Apparatus used

Briquette mould, water bath (maintained at 270c), testing machine, thermometer.

3.4.1.3 Procedure

Firstly the bitumen is heated up.

- After heating the bitumen is poured in to a mould kind of assembly.
- Then the bitumen is being cooled in air in a water bath at 27°C.
- Then the sides of the mould are being removed, the clips are hooked and the pointer is then set to zero.
- Then the two clips are pulled apart @50 mm per min.
- Then the ductility value is calculated.
- The ductility value is the distance up till the time where thread tends to break.

3.4.2 Penetration test

3.4.2.1 Objective

It gives the softness or hardness of bitumen by measuring the depth in tenth of millimeter to which a needle of penetrometer will penetrate vertically in 5 seconds.

3.4.2.2 Apparatus used

Container, needle, stop watch, water bath, penetrometer, thermometer.

3.4.2.3 Procedure

- Firstly, the bitumen is being heated up to 75℃ to 100°C.
- Then the bitumen gets poured into a container and then in a temperature control water bath at a temperature of about 25℃ for about an hour.
- Then after pouring the bitumen is then taken out and the needle is arranged in order to make contact with upper surface of the sample.
- Then the dial is arranged to zero.
- After adjusting the needle is released for about 15 seconds.
- Then the last reading is taken with the help of dial gauge.
- Normally three readings are taken out and then the average of these is taken in order to find the penetration of the bitumen.

3.4.3 Softening point test:

3.4.3.1 Objective:

This is the standard method to test bitumen for its softening point (IS: 1205-1978).

3.4.3.2 Apparatus used

Ring and ball apparatus, steel balls, brass ring, support, thermometer, bath with stirrer.

3.4.3.3 Procedure

- In the brass ring the bitumen sample is suspended in the liquid.

- Then the liquid temperature is heated at the rate of 5°C per min.
- Then the temperature is noted where the softened bitumen touches the metal which is being placed just below the ring
- This temperature will be called as softening point of the bitumen

3.4.4 Marshal stability test

3.4.4.1Objective

This test is done to determine the Marshall stability of bituminous mixture as per ASTM D 1559. The principle of this test is that Marshall Stability is the resistance to plastic flow of cylindrical specimens of a bituminous mixture loaded on the lateral surface. It is the load carrying capacity of the mix at 60°C and is measured in kg.

3.4.4.2 Apparatus used

Mould assembly having diameter as 10 cm and height being 7.5 cm, Simple extractor, compaction pedestal and a hammer, Breaking head, Loading machine, Flow meter, water bath, thermometer.

3.4.4.3 Procedure

- Firstly, three compacted samples are being made foe each binder content.
- Then selection of appropriate grading is being done.
- Then determination of each proportion sixe is being taken.
- Specific gravity of the aggregate being taken is being calculated.
- Then the various stability tests are being performed
- Calculations are being done like the percentage of voids filled with bitumen in bitumen.
- Then the optimum binder content is being taken out.

3.4.4.4 Preparation of sample:

- Firstly the various aggregates like the course, fine aggregates and the filler materials properly proportioned in accordance with the standard.
- Then the required amount of mix is taken in order to have a compacted specimen having thickness 63.5mm, 1200 gram of aggregates, and filler material so as to produce the desired amount of thickness,
- The aggregates are heated at the temperature of 175°C to 190°C.
- The bitumen is being heated to a temperature of 121°C to 138°C and then first trail of the bitumen is being added to aggregate and then these are mixed thoroughly.
- Then the mix is being placed in mould and then compaction is being done.
- Then after few minutes the mould is being extracted using a simple extractor.

3.4.4.5 Combined GradatioN:

Table 3.4. showing cpmbined gradation

With respect to sieve analysis values the above combined gradation of aggregates is done by trial and error method. Number of trials was done and the combined gradation of aggregates satisfies the limits as per IRC 111-2009 specifications

The total weight of the aggregate used is 1200g. Modified bitumen is prepared using different percentages of modifier as LDPE waste.

Sl. No	Aggregate	Percentage	Weight taken (g)
1.	11.2mm	18	216
2.	6.7mm	50	600
3.	Dust	32	384
Total		100	1200

Table 3.5: showing percentage of aggregates

Size of Aggregate		%	13.2 mm	9.5 mm	4.75 Mm	2.36 mm	1.18 mm	300 micron	75 Micron
11.2mm	% passed		100	70.90	0.30	0.00	0.00	0.00	0.00
	Design mix %	18	18.00	12.76	0.05	0.00	0.00	0.00	0.00
6.7mm	% passed		100	100	22.40	1.70	0.00	0.00	0.00
	Design mix %	50	50.00	50.00	11.20	0.85	0.00	0.00	0.00
Dust	% passed		100	100	100	96.20	75.80	41.90	12.40
	Design mix %	32	32.00	32.00	32.00	30.78	24.26	13.41	3.97
Combined grading		100	100	94.76	43.25	31.63	24.26	13.41	3.97
IRC 111 - 2009 specification			100	90 - 100	35 - 51	24 - 39	15 – 30	9 - 19	3 – 8

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Aggregate crushing value test

Total weight of the sample (A) = 4.1kg

Weight of sample passed through 2.36mm sieve after load application (B) =0.48kg

Aggregate crushing value =B/A×100

=0.48/4.1×100

Aggregate crushing value =11.70

For cement concrete pavement it should not exceed 30% and for wearing coarse it should not exceed 40%.

4.2 Los Angeles abrasion value test

Weight of aggregate sample (W1) = 2.5kg

Weight of aggregate sample retained (W2) = 1.575

Weight passing 1.70mm Is sieve =W1-W2

=0.925kg

Los Angeles abrasion value = (W1-W2)/W1×100

=2.5-1.575/2.5×100

Los Angeles abrasion value =37%

4.3 Ductility test

Figure 4.4: various steps involved in ductility test

Table 4.6: Ductility values (cm).

Reading	Neat Bitumen	2% LDPE	4%LDPE	6%LDPE	8%LDPE
Ist reading	38	36	32	29	39
Second Reading	41	38	35	27	42
Ductility value (cm)	39.5	37	33	28	41.5

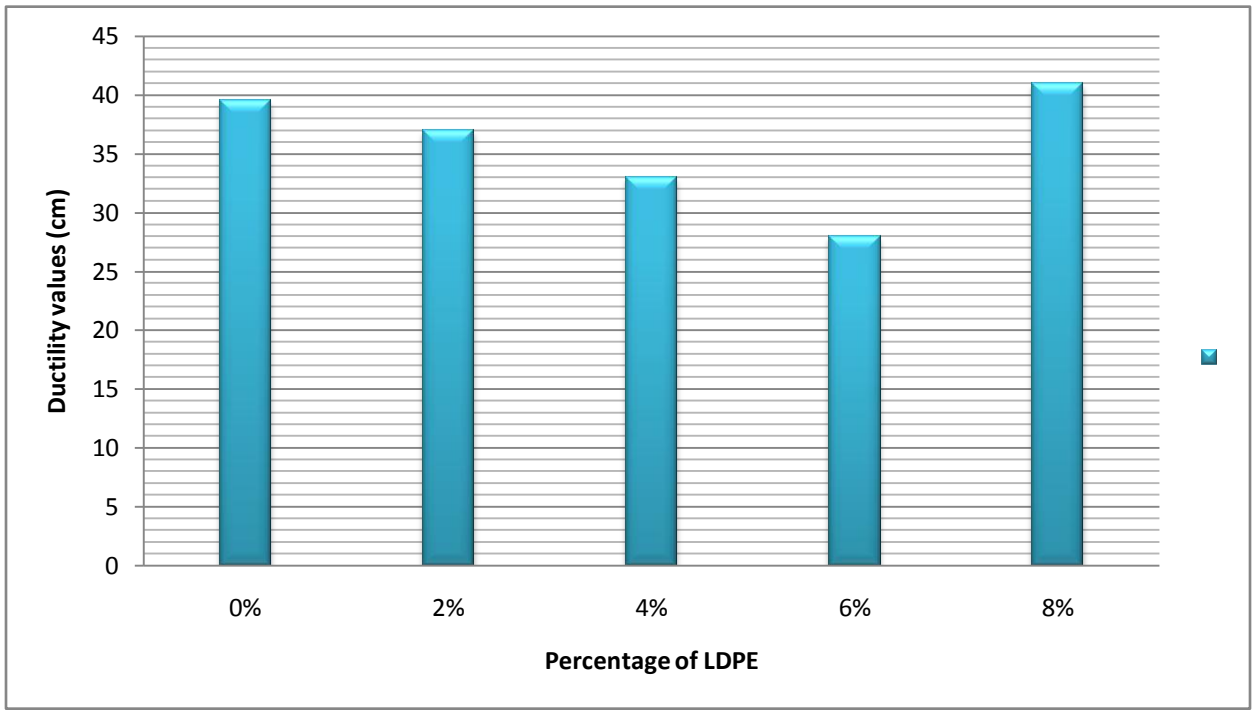

Figure 4.5: Ductility of modified bitumen with varying percentage of LDPE

4.4 Penetration test

Figure 4.6:various steps involved in penetration test

Table 4.7: penetration of modified bitumen with varying percentages of LDPE

Neat bitumen	Initial reading	Final reading	Penetration	Mean (P)
Test 1	200	265	65	= 65.333
Test 2	265	328	63	
Test 3	328	396	68	
2% LDPE				
Test 1	200	259	59	= 56.00
Test 2	259	312	53	
Test 3	312	368	56	
4% LDPE				
Test 1	200	249	49	
Test 2	249	302	53	=54.33
Test 3	302	359	61	

6% LDPE				
Test 1	**200**	**247**	**47**	
Test 2	**247**	**296**	**51**	**= 48.66**
Test 3	**296**	**344**	**48**	
8% LDPE				
Test 1	**200**	**270**	**70**	**=58.66**
Test 2	**270**	**321**	**51**	
Test 3	**321**	**376**	**55**	

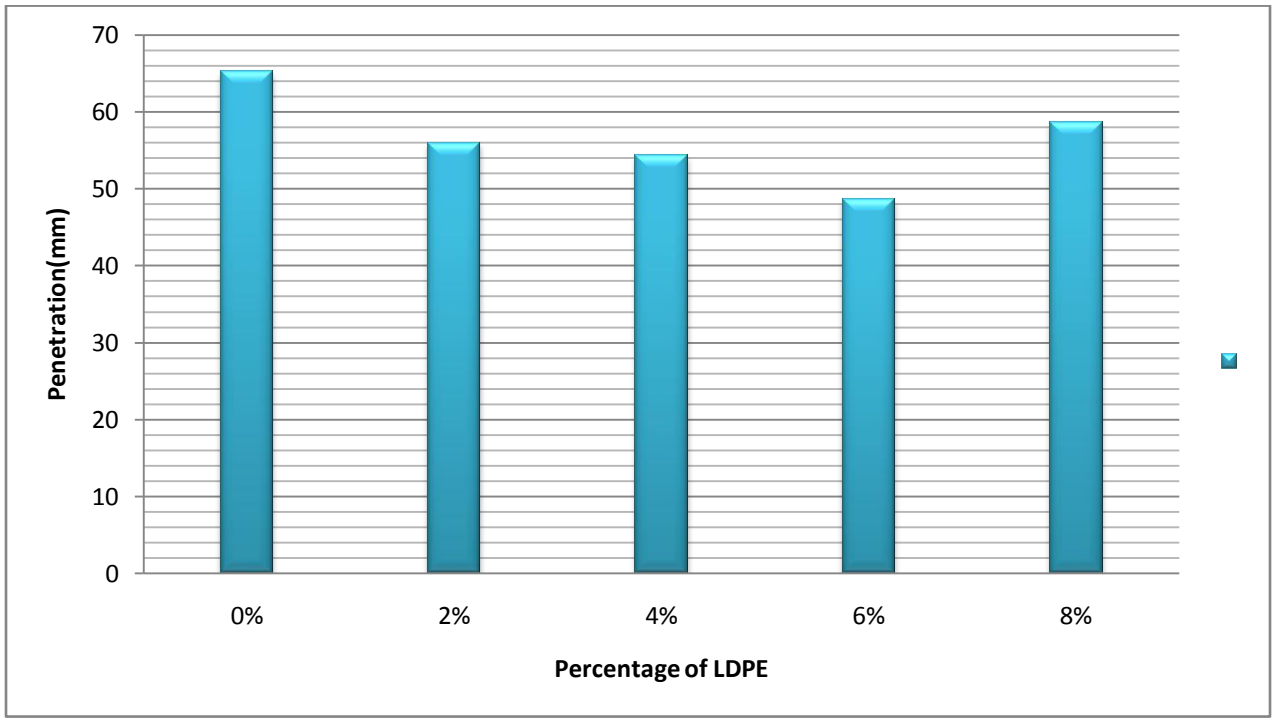

Figure 4.7:Penetration of modified bitumen with varying percentage of LDPE

4.5 Softening point test

Table 4.8: Softening point values for modified bitumen with varying percentages of LDPE

Temperature when ball touches bottom	2%LDPE	4%LDPE	6%LDPE	8%LDPE
Ist reading	54	56	56	51
2nd reading	51	54.4	57	49.5
Softening point ^{0}c	52.5	55.2	56.5	50.25

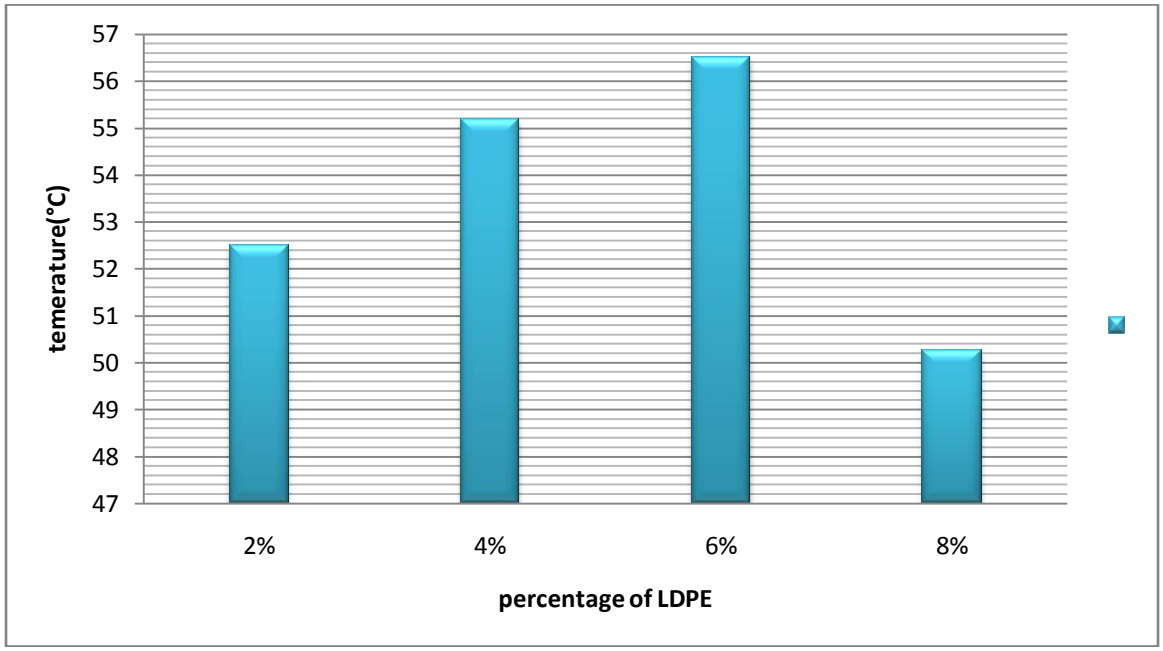

Figure 4.8: softening point of modified bitumen with varying percentage of LDPE

4.6 Marshal stability test

The Marshall stability and flow values for the raw bitumen are shown in table. The values of stability and flow are the representation of 5 samples prepared with 4.5%, 5%, 5.5%, 6% and 6.5% respectively and optimum binder content is obtained.

Table 4.9:Results of BM Mix using VG-30 Grade Unmodified bitumen

S. No.	Bitumen content	Marshal stability values	Flow Value	Bulk Density Of the mix	Air Void	VMA	VFB

		S	F	G_m	V_v		
	%	KN	mm	Gm/cc	%	%	%
1	4.5	9.53	4.05	2.15	6.63	12.7	66.9

S. No.	Mix	Stability Value (kN)	Flow Value (mm)	Bulk Density (g/cc)	Air Voids (%)	VMA (%)	VFB (%)
1	Unmodified bitumen	9.67	4.06	2.17	5.26	14.40	68.8
2	B + 8 % LDPE	10.89	3.72	2.21	4.67	16.10	73.5

2	5.0	9.67	4.06	2.17	5.26	14.4	68.8
3	5.5	9.53	4.19	2.16	4.94	13.8	67.2
4	6.0	9.25	4.30	2.15	4.73	13.0	65.1
5	6.5	8.93	4.31	2.14	4.31	12.3	61.1

Table 4.10 variation of stability, flow, bulk density, air voids,VMA and VFB values with LDPE.

3	B + 10 % LDPE	13.79	3.58	2.52	3.12	18.70	76.2
4	B + 12 % LDPE	13.51	3.01	2.45	3.24	18.60	70.1
5	B + 14% LDPE	11.20	2.99	2.34	3.31	17.20	67.2

4.6.3 Variation of Stability Values of Mixes

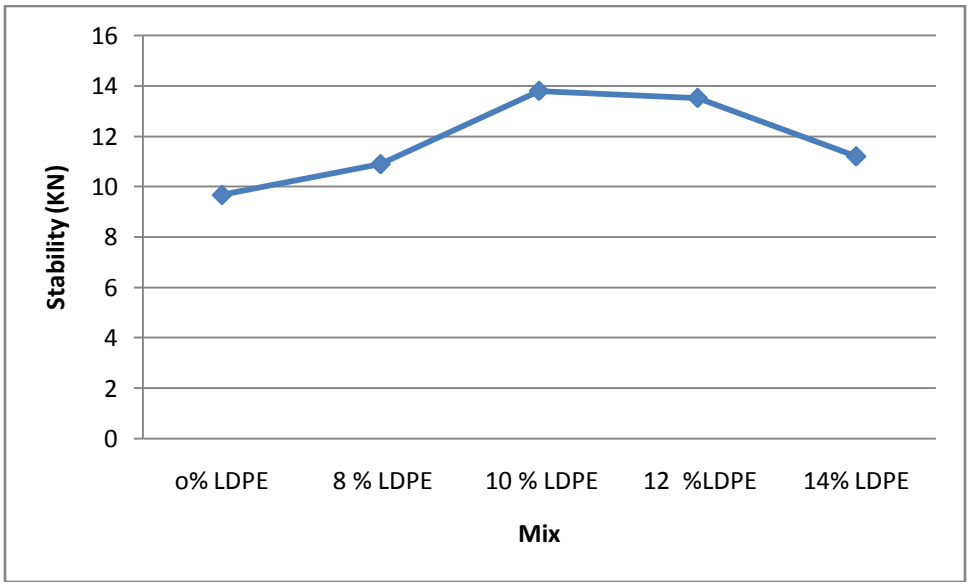

Figure 4.9 showing stability values.

4.6.4 Variation of Flow Values of Mixes;

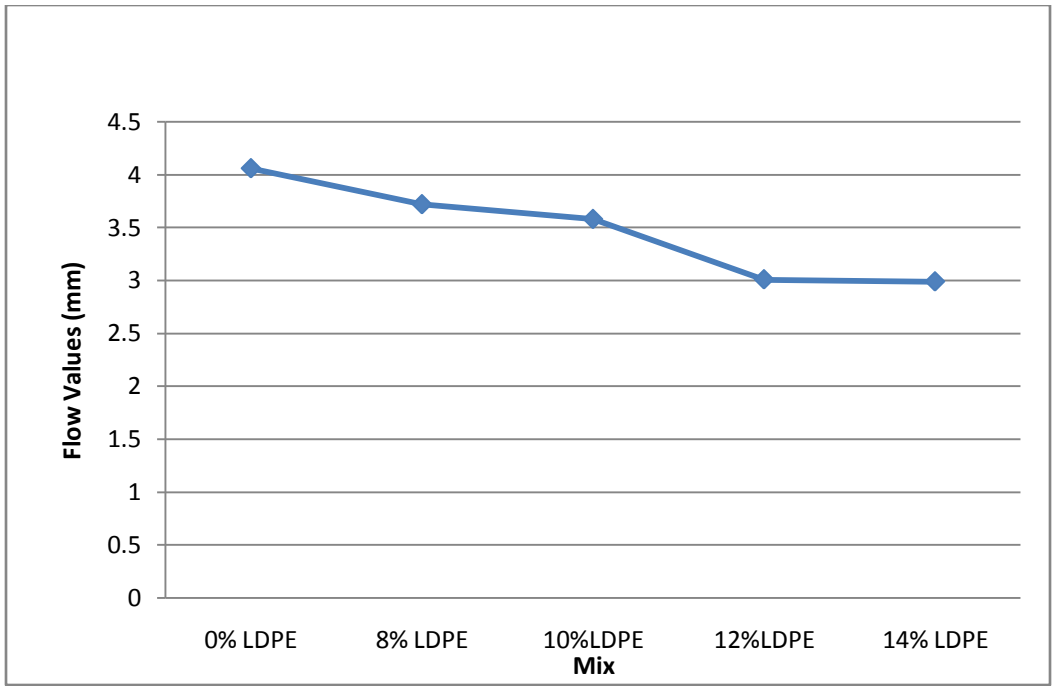

Figure 4.10 showing flow values.

CHAPTER 5

CONCLUSIONS AND FUTURE SCOPE:

- The results of this study concluded that addition of LDPE waste has improved the properties of penetration, ductility and softening temperature of the modified bitumen. As the stiffness of the material is improved,
- It is capable of taking high load and increase the resistance to pavement ruts. Therefore, the durability of the pavement is improved by the use of waste material that also helps to use the waste in an efficient manner.
- On the basis of the analysis of results obtained in the present investigations, the following conclusions were drawn:
- The optimum bitumen content (OBC) for conventional BM Grade VG30 mixes was found to be 5%. For BM mixture with Grade VG30 the most significant percentage of LDPE was obtained 6 to 7 %.
- The addition of plastic waste reduces the air voids which prevents the moisture absorption and oxidation of bitumen by entrapped air. This has resulted in enhancement of Marshall Stability value.
- The flow value of mix was decreasing with increase in the waste content in the mix from 8 to 14%. The bulk density of the mix was also increasing with increase in the LDPE content.

REFERENCES

1. ASTM D 1559, "Test Method to carry Out Penetration''. American Society of testing And Materials.
2. Abdel.Aziz Mahrez and Mohamed Rehan Karim (2010). "Rheological Evaluation of Bituminous Binders Modified with Waste Plastic Material''.
3. Bureau of Indian Standards, Paving bitumen – specification (Third Revision) IS 73:2006, July 2006.
4. Bureau of Indian standards, "Indian standard Method for Determination of Striping value of Road Aggregates ''. IS: 6241-1971(Reaffirmed 1998).
5. Bureau of Indian standards, "Indian standard Method for Determination of methods of testing Bituminous material, Determination of Penetration IS 1203-1978 (First Revision).
6. Habib.N.Z, Kamaruddin, I., Tan, M. (2010). "Rheological Properties of Polyethylene and Polypropylene Modified Bitumen".vol:4, no: 12, 2010.
7. Haider Habeeb Aodah, Yassir N. A.Kareem, Satish Chandra. (2012). "Performance of Bituminous mixes with different aggregate gradation and binder''.pp 2049-3444, vol 2.
8. John.P.Zaniewski and Micheal.E.Pumphrey. (1994). "Evaluation Performance graded asphalt binder equipment and testing protocol".vol:3:125-128.
9. Moises .Garcia-Morales, Pedro. Patel, Franciso.J.Novora. (2004). "The Rheology Of Recycled EVA/LDPE Modified Bitumen.vol:43:482-490
10. M.S.Ranadive1 and A.B.Tapase (2012). "Improvement in strength in flexible pavement: an experimental approach".vol:56:129-138.
11. Shirish.N.Nemade and Prashant.V.Thorat (2013). "Utilization of polymer waste for modification of bitumen in road construction". PP198-213.

12. Shivangi.Gupta and A.Veeraragavan. (2010). “Fatigue behavior of polymer modified bituminous concrete mixtures”. P no. 548.

13. Sinan. Hinislioglu, Hatice. Nur. Aras and Osman.Unsal.Bayrak. (2005). “Effects of high density polyethylene on the permanent deformation of asphalt concrete”.vol:12.pp.456-460.

14. Suleiman.Arafat.Yero and Mohd.Rosli.Hainin.(2012). “Evaluation of bitumen properties modified with additives”.vol:13.

15. Xiaohu. Lu. Ulf.Isacsson, Jonas. Ekblad. (1998). “Low temperature properties of SBS modified bitumen”.vol:11.pp405-414.

16. Zhu.j, Birgison.b. Kringson. N. (2014). “Polymer modification of bitumen: advances and challenges”. European polymer journal,.Vol:54:18-38.