# MODIFICATION OF BITUMEN USING FLY ASH

**Submitted in partial fulfillment of the requirements**

**Of the degree of**

**MASTER OF TECHNOLOGY**

**In**

**CIVIL ENGINEERING**

**By**

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# DECLARATION

I, **Hage Mobing** (1151196), hereby declare that this thesis report entitled **"MODIFICATION OF BITUMEN USING FLY ASH"** submitted in the partial fulfilment 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.

**Date:** **Hage Mobing**

**Place:**

# CERTIFICATE

Certified that this project report entitled "**MODIFICATION OF BITUMEN USING FLY ASH**" submitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara , carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

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Signature of Student

Hage Mobing

# ABSTRACT

Basis of these thesis was to find out the change in the physical properties of the bitumen by modifying it with the help of fly ash. In these different percentage of fly ash is used to modify the bitumen. Various physical tests were conducted on virgin and modified bitumen to evaluate its physical properties. Marshall Test was conducted on bituminous mix prepared using modified and unmodified bitumen and the effects were analyzed and compared.

These study show that increase in the percentage of fly ash improves the physical properties of virgin bituminous mix when using as filler. Further it also shown that increase in the percentage of fly ash improves Marshall Stability & flow values in the bituminous mix.

# TABLE OF CONTENTS

**Description** **Page Number**


**DECLARATION** ..... **II**

**CERTIFICATE** ..... **III**

**ACKNOWLEDGEMENT** ..... **IV**

**ABSTRACT** ..... **V**

**TABLE OF CONTENT** ..... **VI**

**LIST OF FIGURES** ..... **VIII**

**LIST OF TABLES** ..... **IX**

**CHAPTER 1 - INTRODUCTION** ..... **1**

**1.1 GENERAL** ..... **1**

**1.2 Objectives of the study** ..... **2**

**1.3 Scope of the study** ..... **2**

**1.4 Thesis overview** ..... **2**

**CHAPTER 2 - LITERATURE REVIEW** ..... **3**

**2.1 General** ..... **3**

**2.1.1 Evolution of road surface** ..... **3**

**2.1.2 Recent times** ..... **3**

**2.2 Previous research** ..... **5**

**CHAPTER 3 - MATERIAL CHARATERIZTION** ..... Error! Bookmark not defined.

**3.1Material** ..... **8**

**3.1.1 Bitumen** ..... **8**

**3.1.2 Types of bitumen** ..... **8**

**3.1.2.1 Based upon Penetration Grade** ..... **8**

**3.1.2.2 Industrial grade bitumen:** ..... **8**

**3.1.2.3 Cutback..... 9**

**3.1.2.4 Bitumen Emulsion:..... 9**

**3.1.2.5 Modified Bitumen..... 9**

**3.2 Fly ash..... 9**

**3.2.1 Production of Fly ash..... 9**

**3.2.2 Chemical composition of Fly ash..... 10**

**CHAPTER 4 - EXPERIMENT AND OBSERVATION..... 11**

**4.1 Penetration Test:.....**Error! Bookmark not defined.

**4.2 Ductility test:..... 14**

**4.3 Softening point test:..... 18**

**4.4 Marshall test:..... 21**

**CHAPTER 5 - CONCLUSION AND FUTUE SCOPE..... 26**

**REFERENCES..... 27**

# LIST OF FIGURES


| FIGURE No. | DESCRIPTION | PAGE No. |
|---|---|---|
| 4.1 | Penetrometer | 11 |
| 4.2 | Penetration Test Setup | 12 |
| 4.3 | Ductility Testing Machine | 14 |
| 4.4 | Mold made of brass | 16 |
| 4.5 | Softening Point Test Setup | 19 |
| 4.6 | Marshall Stability Apparatus | 21 |

# LIST OF TABLES


| TABLE No. | DESCRIPTION | PAGE No. |
|---|---|---|
| 3.1 | Chemical composition of Fly ash | 10 |
| 4.1 | Penetration Value | 13 |
| 4.2 | Ductility Value | 17 |
| 4.3 | Softening point Value | 20 |
| 4.4 | Bituminous mix gradation | 22 |
| 4.3 | Correction factors for Marshall Stability value | 23 |
| 4.3 | When fly ash is mixed directly with bitumen | 24 |
| 4.4 | When fly ash is used as filler in bituminous mix | 24 |

# INTRODUCTION

## Chapter 1

### 1.1 GENERAL

There are different means of transportation, among all this road transportation is one of the vital means and most commonly used one for transportation of goods and services throughout the world.Today road network has become one of the essential backbones for the movement from place to place as it provides a good access for the commuters to travel to their desired place. Road network has been adopted long ago by the people when other modes of transport were not even invented. From last 50 years road transportation has expanded for providing services to both passengers and goods. This is considered as one of the vital means of transportation.

For a strong and stable economy good roadway infrastructure is necessary. Along with the other development activities road infrastructure is developing at a very fast rate in India. Today highway transportation has high speed, high load, high traffic density and channelized traffic, so as a result pavements are subjected to different types of distress such as fatigue cracking, rutting, raveling and so on and also the life span of roads laid with conventional bituminous mixes has decreased due to the increase in the traffic growth and overloading of vehicles. Which lead to the reduction in the riding quality, thereby resulting in exorbitant vehicle operating costs and frequent maintenance interventions as a result of the premature failure of pavements. In an ever growing economy like India providing durable roads has always been a problem. The problem mainly arises due to diverse climate, terrain condition, rainfall intensities and soil characteristics. Huge sum of investment can be saved if the road network is designed with accurate and precise techniques. This shall also result in better performance of service highway. So it becomes even more important to look into the various alternatives that can be used in order to develop & improve the quality of the pavements and overcome the problem of pavement failures. Modification of bituminous is one of the adequate methods that is being analyzed and extensively studied over the past few year.

## 1.2 Objectives of the study

- To examine and analysis the properties and performance of bitumen when incorporated with fly ash.
- To investigate direct tensile strength of bitumen when mixed with fly ash as a modified binder.
- To investigate the stability of modified binders with bitumen while storage

## 1.3 Scope of the study

To meet above objectives the scope of the project will be formulated as follows:

- Material Characterization i.e. evaluating physical properties of virgin binder of viscosity grading (VG 30).
- To find out various Marshall characteristics (like stability, flow, air voids) of bituminous mix prepared from both virgin and modified bitumen.

## 1.4 Thesis overview

The thesis has been structured into five chapters counted as: Introduction, literature review, Material characterization, experiment & observation and conclusion.

**Chapter 1** of the thesis is the introduction to the thesis and it presents the problem statement for the present study, objectives and details of the scope of the report selected. **Chapter 2** discusses summary of review of literature and concepts addressed in this work. **Chapter 3** presents the details of material and **Chapter 4** show the test which have been conducted in this current work and finally **Chapter 5** present the conclusion and future scope of this project

# LITERATURE REVIEW

## Chapter 2

## 2.1 General

### 2.1.1 Evolution of road surface

Earlier during the old times most of the roads were unsurfaced and were called the cart-track. They were laid without any compaction of soil. The unsurfaced roads were built up with natural soil taken from the borrow pits and compaction was done by the traffic moving over it. No or very little of attention was given towards the drainage facility. Such roads had a very small lifespan and were often damaged by heavy rain falls.

Water bound macadam roads (WBM) were an improved version of the unsurfaced roads, having the same constituents as the unsurfaced roads, mixed together (either pre-mix or in-situ) with water and compacted so as to get improved strength. A large amount of dust was produced by WBM roads so to reduce the dust. Oiled roads were introduced and in these roads crankcase oil, waste transformer oil, waste vegetable etc. were used.

The next major step in the evolution of road surface was the introduction of seal coat. The base course was sealed with a thin film of bitumen aggregate mix so as to protect it against the moisture and the traffic and thereby increasing its serviceability. The lesser the amount of water entering the base and sub base layers, the higher the lifespan of the road surface.

With the changing time there was a sharp increase in the traffic which in turn led to better pavement demand. This resulted in the generation of bituminous concrete or asphaltic concrete which is a high dense graded premix. These types of roads have high performance and higher quality surface course. Bitumen mix overlays can be laid of about 20-40 mm minimum to as high as 300-500mm or even more.

### 2.1.2 Recent times

Two types of pavement structure are commonly designed either as a flexible pavement or a rigid pavement. Flexible pavements however forms majority of pavements built in India due to their structural behaviour, advantages over rigid pavements and economy. Flexible pavements behave in a flexible way in their structural action under the applied loads and so have low or negligible

flexural strength. For providing services to passengers and goods majority of roods constructed consists of flexible pavement network majority of the roads constructed consists are of flexible pavement.

Flexible pavement generally comprises of four layers:

- Soil sub grade
- Sub base course
- Base course
- Surface course

There are usually three component of flexible pavement .bitumen, aggregate and air void. Bitumen is commonly used as binding material in case of flexible pavement. Bitumen is a viscoelastic material that is extracted from petroleum, with the help of frictional distillation .bitumen is usually soluble in carbon disulphide. In its solid state it is its known as asphalt and in its liquid state is known as mineral tar. In recent years there is high increase of highway utilization due to the rapid increase of traffic on the road throughout the world which has lead to heavy load implications on the pavement by the movement of the traffic. However unmodified bitumen and usually practiced high grade classic asphalt concrete has failed to satisfy the increasing demand and level of performance expected. This insufficiency leads to excessive rutting, thermal cracking and hence result in shorter life of pavement.

To irradiate such problems it has led the attention of many researchers and agencies concerned to it to look for various efforts that can be made for improving the properties of the bitumen to deal with the problems related to pavement distresses. One of the methods which have recently received more attention is modification of the bitumen with other materials commonly termed as admixtures. Some admixtures have been known to work as modifiers of bitumen if thoroughly mixed with it, resulting in an increase of binder properties. These admixtures are directly added to the bitumen mixture as a bitumen modifier or it can be added into the aggregate containing the mixture

Most of the admixtures which are being utilized for the bitumen modification are enumerated as:

- Polymers
    1. Plastic polymer
    2. Fibre polymer

3. Elastomers

- Ground Granulated Blast furnace Slag
- Fly ash
- Rubber
    1. Crumb rubber
    2. Natural rubber

However modified bitumen is typically produced at more expensive prices thus it can lead to the increase in the economy of the modification processes. Fly ash has successfully been used as filler for bitumen mixes for a long time, as it's easily available at very low cost compared to other filler's. The residue obtained from burning/combustion of coal is Fly ash. It was reported to have the ability to work as a bitumen extender

## 2.2 Previous research

**John Francis McLaughlin &William Harmer Goetz (1957)** study was carried in which it was investigated that the use of mechanically precipated fly ash as filler for bituminous concrete. They divided their study into three parts, In the first stage a comparison of fly ash and limestone dust fillers in bituminous concrete was made through the use of the Marshall test , The second and third parts involved the use of the ASTM direct compression test. Conclusions made are given below.

- The mixtures containing fly ash had adequate stability as was measured by the Marshall test.
- Stripping resistance of the fly ash mixtures as measured by ASTM D-1075 compared favourably to the results for mixtures containing limestone dust**.**

**Sharma et al. (2010)** in this study fly ash was use as filler in the bituminous mixture. Fly ash for this study was collected from various thermal power stations located in different parts of India. After the collection fly ash was divided into four groups depending on various physical and chemical properties and then will be used as filler material in bitumen mix. Dust of stone which is used as most common filler in India was also used for comparison. Bitumen mixes prepared with diverse F/B ratios was examined for various properties like viscosity, softening point and penetration. Tensile strength ratio, Marshal stability, retained stability, and creep test were performed on these mixes using five types of fillers with varying percentage of filler (4%), (5.5%),

(7%), and (8%), by the bitumen 60/70 grade. All the results obtained where analyzed and then comparison between all was made.

- The study revealed that OBC of mix depends on filler content to a great extent, not only on the fineness of the filler

**M.Jovanovich, A.mujkanovic and A.Seper (2011**) in their study they prepare a various sample of bituminous aggregate mixtures having fly ash, cement and lime as filler with varying percentage of bitumen and laboratory investigation was done. The following results were observed:

- Fly ash as a filler can be used in asphalt mixture successfully.
- With addition of filler, optimum bitumen content was observed lower in mixture

**Konstantin Sobolev, Ismael flores and Justin David Bohler (2013)** study was about determining the feasibility of fillers in asphalt concrete. Two different binders were used. These binders were fully blended with filler materials i.e. fly ash, lime and cement. Following result was observed:

- Rheological properties of asphalt were greatly improved with the adding of fillers
- Fly ash also appears in improving the aging resistance of mastics

**S.D.Katara, C.S.Modhiya, N.G.Raval (2014)** Studied on Influence of Modified Bituminous Mix using Fly Ash, This study using FLY ASH discloses that the Marshal Stability value has shown increasing tendency and the maximum values has been increased by about 25 % by adding of FLY, which is the strength parameter of Bituminous. Increased of density of the mix has also be shown in the cases of FLY ASH when related with 60/70 grade bitumen.

- It will offer more stable and durable mix for the flexible pavements.
- The serviceability and resistance to moisture will also be improved when it is compared to the conventional method of construction.
- The other parameters values that is. Vv, VMA and VFB in both the circumstances FLY ASH have been found out to be within required specifications.

- In this study not only it beneficially utilizes the waste fly ash and tyres in road construction industry but it have also successfully improved the significant parameters which will ultimately lead to improved and long living roads
- This study will also have a positive influence on the environment as it will lessen the volume of surplus waste product to be disposed of by burning and land filling.
- Not only it will develop a technology, which is eco-friendly but also it will add value to waste product.

# MATERIAL CHARACTERIZATION

## Chapter 3

## 3.1Material –

- Bitumen
- Fly ash

**3.1.1 Bitumen-** It is non-crystalline hydro carbon in solid or liquid state possessing properties of adhesion; it is obtained by artificial of natural distillation of crude petroleum. Rather than in water it is soluble in carbon di sulphide. Properties of bitumen not only depend on its source from which it is extracted but also on preparation methods. In North America it is nick named as asphaltic cement or asphalt. Naturally occurring bitumen is called with the name of rock asphalt or natural asphalt.

## 3.1.2 Types of bitumen:

### 3.1.2.1 Based upon Penetration Grade:

Based upon penetration bitumen is graded in following grades:

→ 80/100: this grade of bitumen is suitable for the areas where traffic volume is quite low. Properties of this grade confirm to that of S90 grade of IS 73 – 1992.

→ 60/100: being harder than the above grade it can withstand quite higher traffic loads. Its properties does resemble to that of S65 grade of IS 73- 1992. At present this grade is commonly used in manufacturing of state highways and national highways.

→30/40: among all these grades this grade is harder one and can withstand against very high and heavy traffic loads. Properties of this grade resembles to that of S35 grade of IS 73-1993. Mainly it is used in construction of run ways and in roads where traffic volume is more.

### 3.1.2.2 Industrial grade bitumen:

Blown bitumen is another name given to this grade. Blowing air into hard bitumen at high temperatures is usually beyond 80degree Celsius leads to formation of this grade.

This process involves asphaltene content added which results in various structural changes in bitumen. By addition of asphalt in content properties like softening point and penetration keeps on increasing and decreasing respectively.

#### 3.1.2.3 Cutback

At normal temperature cutback bitumen flows like a liquid and is obtained with the help of fluxing bitumen with appropriate solvents. By addition of kerosene viscosity gets reduced in bitumen. Its one of the most important application is in tack coat.

#### 3.1.2.4 Bitumen Emulsion:

At ample temperature bitumen emulsion is free flowing liquid. Proper quality emulsifier is important to make it sure that has stability over a period of time and most importantly it breaks and sets while its application on road aggregates.

#### 3.1.2.5 Modified bitumen

Various additives or mixes of additives called as modified bitumen can enhance properties of bitumen to a great extent. Bitumen treated using these modifiers is commonly called as modified bitumen. Commonly used modifiers are SBS, EVA, LDPE and HDPE.

## 3.2 Fly ash

From combustion of pulverised coal fly ash is obtained. This is one of the most important bi-product during the whole process; the use of this bi-product is gaining vital importance in preservation of natural resources. In 2001 Above 69 million tons of fly ash was manufactured.

### 3.2.1 Production of Fly ash

With the help of steam generating plants and coal fired electric fly ash is produced usually coal are mixed and propelled by air in the boilers combustion chambers where it burns , heat generation takes place and results in the formation of molten mineral residue. Heat from boiler is extracted by the boiler tube then cooling of flue gas results which leads to hardening of mineral residue thus ash gets formed.

Coarse ash particles as slag falls to the bottommost of the combustion Chamber, whereas lighter fine ash particles which are termed as fly ash does stay suspended in flu gas. Beforehand it is exhaust in the flue gas by particle emission fly ash is remove with the help of control devices which involves electro static precipitator etc.

Presently more than 20 million metric tonnes of fly ash are used yearly in various engineering applications. Usually highway engineering makes use of it, various application involves soil stabilization, flowable fills grouts and structural fills

### 3.2.2 Fly ash chemical composition

These particles are spherical in shape ranging in size from 0.5 micron – 100 micron.

| Chemical composition | Percentage (%) | |
|---|---|---|
| | Class F | Class C |
| Silica ($SiO_2$) | 55 | 40 |
| Alumina ($Al_2O_3$) | 26 | 17 |
| Iron Oxide ($Fe_2O_3$) | 7 | 6 |
| Calcium Oxide (CaO) | 9 | 24 |
| Magnesium Oxide | 2 | 5 |
| Sulphur Trioxide ($SO_3$) | 1 | 3 |

Table 3.1 Fly ash chemical composition

Source: American coal association

# EXPERIMENT AND OBSERVATION

## Chapter 4

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

**Apparatus-**

- Penetrometer
- Thermometer
- Stop watch
- Container
- Water bath

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

**Figure 4.1 – Penetrometer**

**Procedure-**

- The sample is heated till it becomes liquefied while stirring thoroughly to remove unwanted air bubbles
- Pour the sample in a container .The specimen depth should be 10mm or more

- Let it cool in atmospheric temperature and then use the water bath to retain the temperature of the sample
- Now place the sample in such a way that the needle of penetrometer should slightly touch the sample surface
- While starting the stop watch allow the needle to penetrate the sample freely for interval of 5 second.
- Note down the penetration value
- Take at least three reading

**Figure 4.2 – Penetration test Setup**

**Observation-**

Sample 1- Bitumen sample

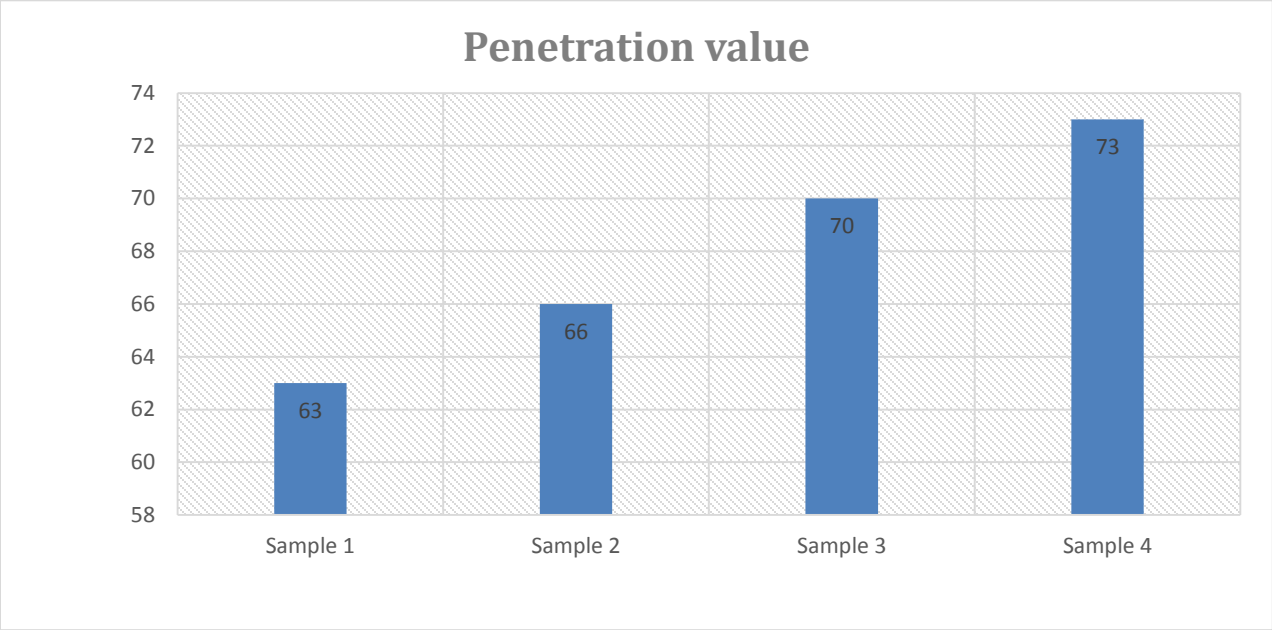
Sample 2- Bitumen + 10% Fly ash sample

Sample 3- Bitumen + 30% Fly ash sample

Sample 4- Bitumen + 50% Fly ash sample

**Table 4.1 – Penetration Value**

| Reading | Pentation value | | | |
|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
| 1 | 63 | 66 | 70 | 76 |
| 2 | 62 | 64 | 73 | 73 |
| 3 | 64 | 68 | 67 | 70 |
| Average | 63 | 66 | 70 | 73 |



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

**Apparatus**-

- Testing machine
- Water bath
- Mold made up of brass
- Thermometer

**Figure 4.3 – Ductility Testing Machine**

**Principle**- Bitumen sample ductility is measure by stretching the sample till it breaks at specific speed and temperature. The distance is before breaking is ductility value and is calculate in centimeter.

**Procedure-**

- The test is to be conducted in the temperature of 27+0.5 Celsius with the pull rate pf 50+2.5 mm/min if not specified.
- Heat sample until it becomes fluid while stirring thoroughly to remove unwanted air bubbles
- Mold is to assemble on the brass plate and should be smeared with mixture of glycerin & dextrin on every part to help avoid sticking of the sample.
- Pour the sample in mold assemble till it is full.
- While pouring the mold, sample should be pour in tinny stream end to end of the mold by moving back and forth.
- Sample should be cool in room temperature for about 30 to 40 minute and then should be place at water bath to maintain the temperature for 30 minutes.
- Excess bitumen should be cut off using hot straight edge knife.
- Now place mold with the sample in the water bath and keep it in specified temperature for 85 to 95 minutes.
- Remove the sample from the plate and also remove the side piece and test the sample straightaway.
- Make sure while conducting the test that the sample should be under water by at least 25 mm in water tank at maintain temperature which is specified
- Ring at each end should be attached to the hook of testing machine and pull horizontally at uniform speed as given till the sample breaks. .
- Measure the distance it travelled till it breaks by pulling apart and is measure in centimeter.
- For each test there should be at least be 3 determination.

**Figure 4.4 – Mold made of brass**

**Observation-**

Sample 1- Bitumen sample

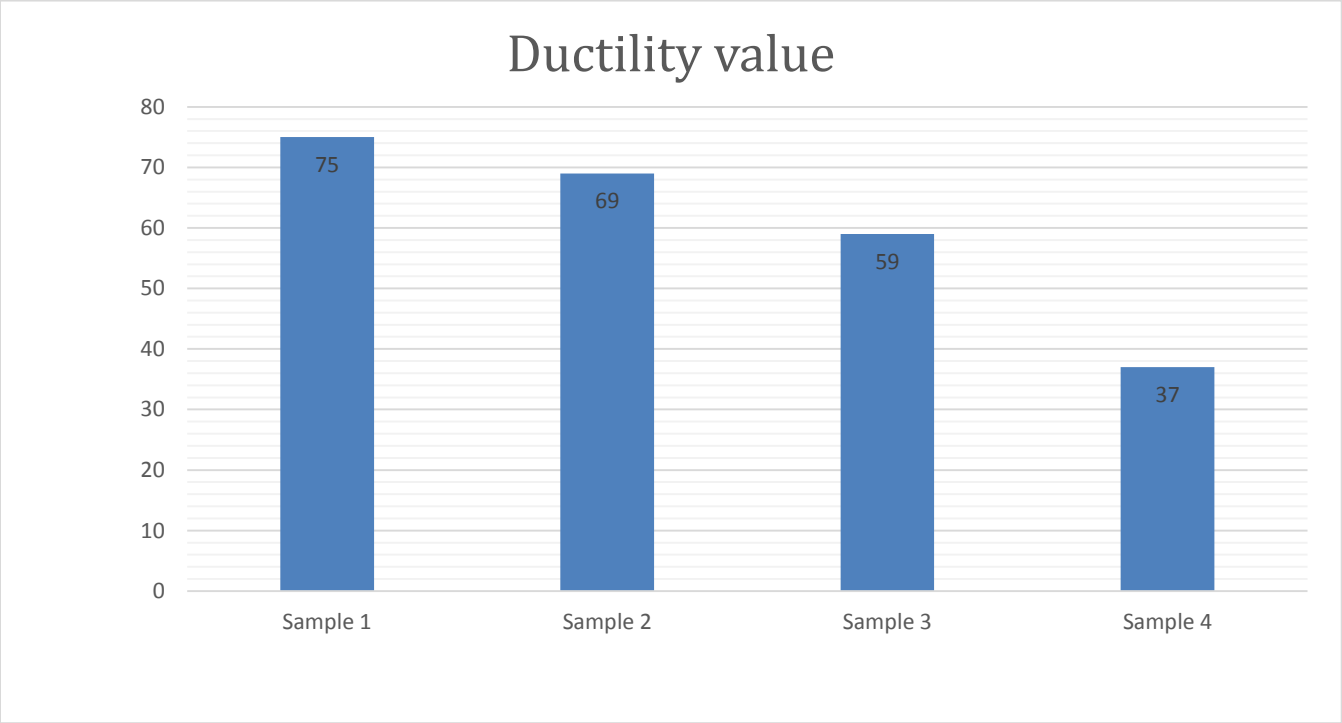
Sample 2- Bitumen + 10% Fly ash sample

Sample 3- Bitumen + 30% Fly ash sample

Sample 4- Bitumen + 50% Fly ash sample

**Table 4.2 –Ductility Value**

| Reading | Ductility value | | | |
|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
| 1 | 74 | 69 | 52 | 37 |
| 2 | 73 | 65 | 64 | 41 |
| 3 | 78 | 73 | 61 | 33 |
| Average | 75 | 69 | 59 | 37 |



**4.3 Softening point test**-Temperature at which substance reach a particular degree of softening is known as softening point.

**Apparatus** -

- Ring and ball standard apparatus
- Water bath
- Thermometer
- Stirrer
- Sharp knife

**Procedure**-

- Material is heated up to (75 to 100) Celsius beyond it softening point.
- It is stir till it is completely liquefied and most of bubble and water are removed.
- The ring is place on metal plate which is coated with mixer of glycerin and dextrin to avoid it from stinking on the plate.
- Pour the sample in the mold till the sufficient level.
- The excess sample is removed after cooling it for 30 minutes in room temperature by using warmed sharp knife
- Gather all the apparatus such as rings, thermometer and ball and assemble it in standard form.
- The water bath should contain of distilled water at room temperature and should filled the bath above 50mm from the upper surface of the ring.
- Freshly boil distilled water should be in the water bath.
- The top surface of bottom plate of support or bottom of bath and bottom of the ring should have a difference of 25mm in between.
- Bath temperature should be maintain at 5 C for 15 minutes than place the balls in the ring at the center.
- Now increase the heat of the bath while stirring the liquid so that temperature is rises at uniform rate of 5+0.5 c per minute until the sample is soften and it allow the ball to pass through the ring.

- Note down the temperature instantaneous shown by the thermometer when the ball touches the bottom of bath

**Figure 4.5 –Test Setup for softening point**

**Observation-**

Sample 1- Bitumen sample

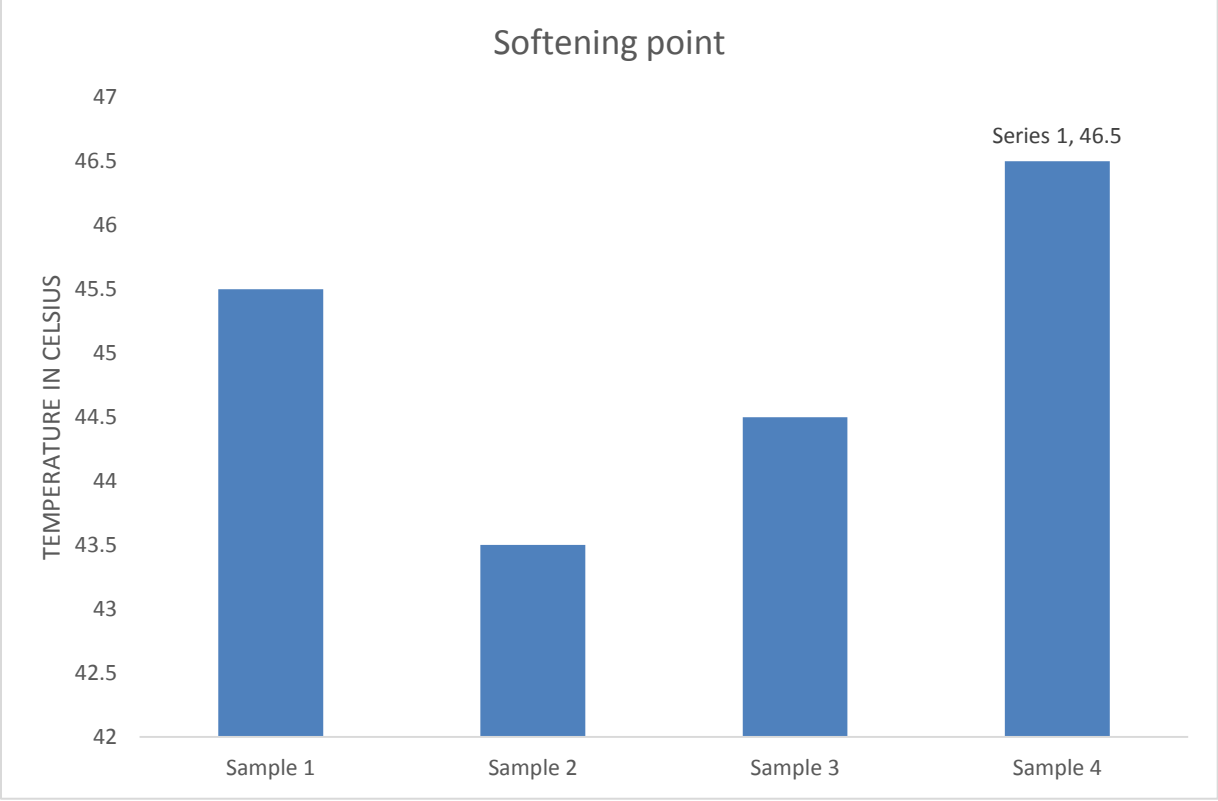
Sample 2- Bitumen + 10% Fly ash sample

Sample 3- Bitumen + 30% Fly ash sample

Sample 4- Bitumen + 50% Fly ash sample

**Table 4.3 – Softening point Value**

| Reading | Softening point (in Celsius) | | | |
|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
| 1 | 45 | 44 | 45 | 46 |
| 2 | 45 | 43 | 44 | 47 |
| Average | 45.5 | 43.5 | 44.5 | 46.5 |



**4.4 Marshall Stability test-** It is performed to analyze the Marshall stability of bituminous mix as per guidelines provided by ASTM D1559. This test involves measuring of resistance to plastic deformation of specimen cylindrical in shape. It is the most common test among all and is used on routine basis for road construction

Apparatus-

- Marshall stability apparatus
- Balance
- Water bath

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

**Marshall Mix Design-** Mixing and compaction temperatures play an important role in the mix design of bituminous mixes therefore BC-1 gradation was selected for present study

**Figure 4.6 – Marshall Stability Apparatus**

**Table 4.4 Bituminous mix gradation**

| IS SIEVE | CUMMULATIVE WEIGHT (Gm) | INDIVIDUAL WEIGHT (Gm) |
|---|---|---|
| 26.5 | 1250 | 0 |
| 19 | 1118.75 | 131.25 |
| 13.2 | 862.5 | 256.25 |
| 9.5 | 775 | 87.5 |
| 4.75 | 562.5 | 212.5 |
| 2.36 | 450 | 112.5 |
| 1.18 | 337.5 | 112.5 |
| 0.6 | 262.5 | 75 |
| 0.3 | 187.5 | 75 |
| 0.15 | 112.5 | 75 |
| 0.075 | 62.5 | 50 |
| <0.075 | | 62.5 |

## Procedure-

- The assessed aggregate & bitumen is heated separately at temperature of 170 c and 163 c respectively.
- Now mixed them nicely and carefully and transfer the material to the mold container arranged.
- With standard hammer (45cm, 4.86kg) apply a blow of 75 on the top side of the sample and inverse the sample and again apply 75 blow. Now leave the mold with sample to cool for few minutes..

- Take out the sample from the mold by slightly pushing it and mark the sample and leave it cure overnight at room temperature.
- Different sample are prepared similarly with varying quantities of bitumen content.
- The mold should be kept in water bath for 30 min at temperature of 60 c before conducting the test.
- Note down the stability value of the sample from the Marshall stability apparatus

**Stability correction**-while making the sample thickness may be little differ from 63.5mm which is the standard specification. Hence, measure values of stability may needed to be adjusted for those which have they gotten if the sample had been accurately 63.5mm. By multiplying each sum stability value by an appropriated correction factors as given below it is done.

**Table 4.5 –Marshall Stability correction factor**

| Volume of sample (cum) | Thickness of sample (mm) | Correction factor |
|---|---|---|
| 457-470 | 57.1 | 1.19 |
| 471-482 | 68.7 | 1.14 |
| 483-495 | 60.3 | 1.09 |
| 496-508 | 61.9 | 1.04 |
| 509-522 | 63.5 | 1 |
| 523-535 | 65.1 | 0.96 |
| 536-546 | 66.7 | 0.93 |
| 547-559 | 68.3 | 0.089 |
| 560-573 | 69.9 | 0.086 |

**Observation-**

Sample 1- Bitumen sample

Sample 2- Bitumen + 10% Fly ash sample

Sample 3- Bitumen + 30% Fly ash sample

Sample 4- Bitumen + 50% Fly ash sample

**Table 4.6- When fly ash is mixed directly with bitumen**

| Sample | Stability (KN) | Flow (mm) |
|---|---|---|
| 1 | 17.84 | 4.572 |
| 2 | 19.39 | 3.943 |
| 3 | 18.96 | 3.654 |
| 4 | 17.54 | 3.354 |

**Table 4.7- when fly ash is used as filler in bituminous mix**

| Sample | Stability (KN) | Flow (mm) |
|---|---|---|
| 1 | 17.84 | 4.572 |
| 2 | 22.94 | 3.847 |
| 3 | 21.96 | 3.451 |
| 4 | 18.14 | 3.155 |

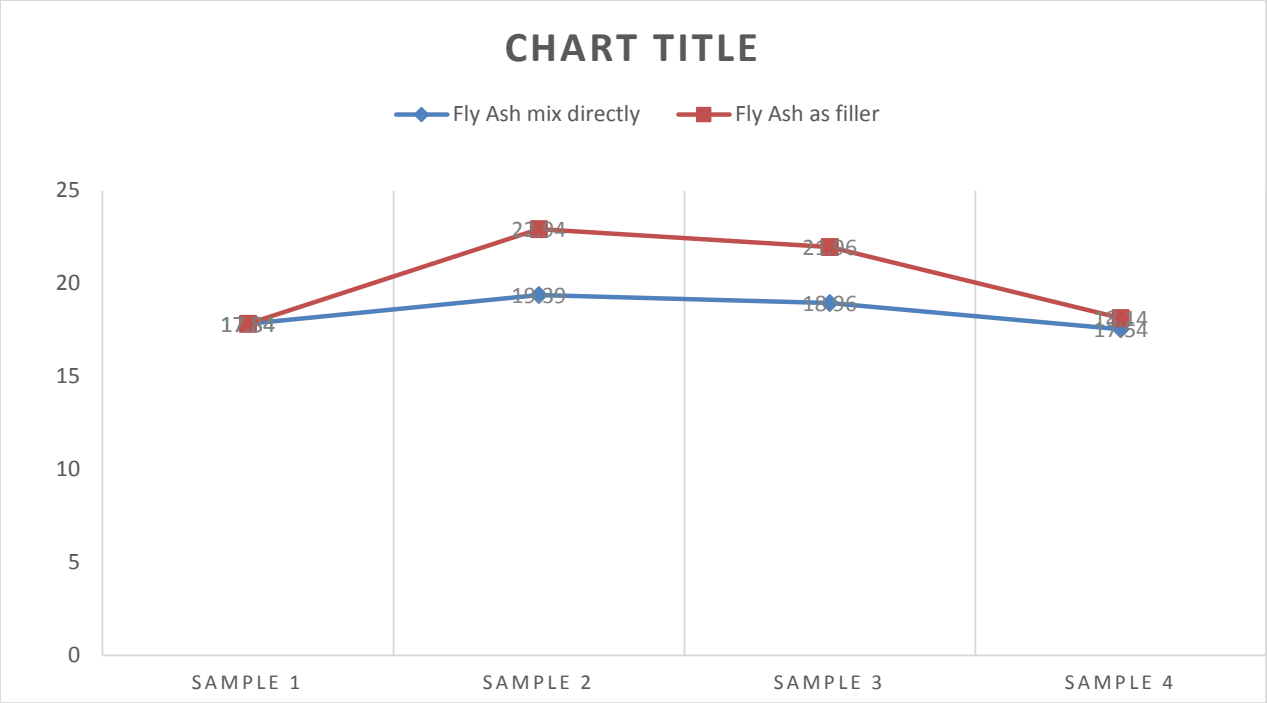


CHART TITLE
Fly Ash mix directly
Fly Ash as filler
25
20
15
10
5
0
SAMPLE 1
SAMPLE 2
SAMPLE 3
SAMPLE 4

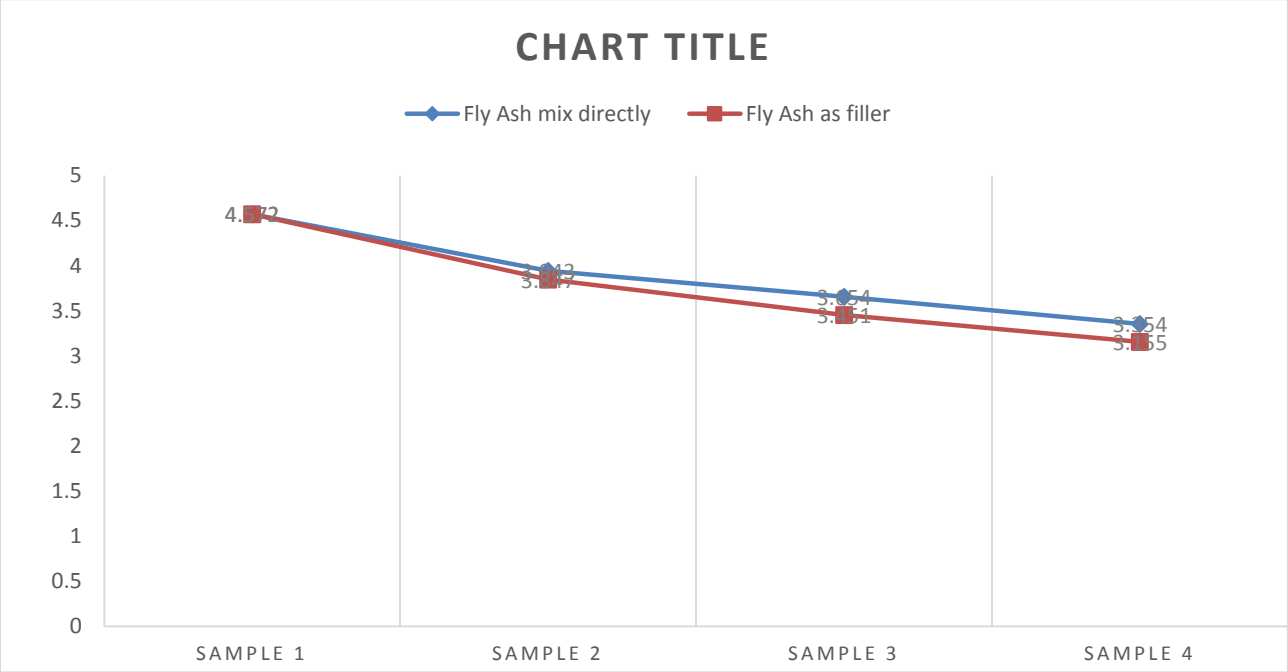


CHART TITLE
Fly Ash mix directly
Fly Ash as filler
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
SAMPLE 1
SAMPLE 2
SAMPLE 3
SAMPLE 4

# CONCLUSION AND FUTURE SCOPE

## Chapter 5

## 5.1 Conclusion-

- Penetration test- As per observation we can observe that while adding of 10% of fly ash to the virgin bitumen doesn't affect the grade of bitumen but when it the percentage of fly ash is increase the penetration value may increase
- Ductility test- As per observation the ductility of bitumen decrease with the increase of fly in the sample. Fly ash cannot be mix consistently with bitumen due to which decrease the elastic property of bitumen
- Softening point test- As per observation with increases or decrease of fly ash have slight effect the softening point of the bitumen
- Marshall Stability- when fly ash is used whether directly or as filler there is increase of stability but decrease of flow value. With respect to the fly ash mix directly to the bitumen the fly ash used as filler has more stability. Hence the bitumen use as filler will be more beneficial

## 5.2 Future scope-

- Using of admixture in the sample may help in positive result
- Honestly there is very less future scope for this experiment

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