MODIFICATION OF BITUMEN USING FLY ASH

A

PROJECT REPORT

Submitted in partial fulfillment of requirements for the award of degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the Supervision

Of

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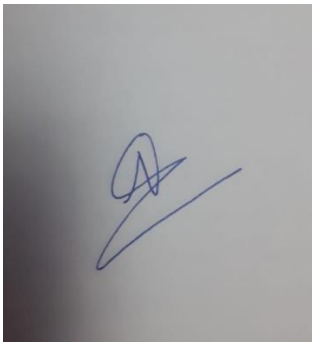
STUDENT DECLARATION

We hereby declare that the work presented in the Project report entitled "**MODIFICATION OF BITUMEN USING FLY ASH**" submitted for the partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering at**Jaypee University of Information Technology, Waknaghat** is an authentic record of our work carried out under the supervision of **Dr. Rajiv Ganguly** and **Dr. Aakash Gupta**.This work has not been submitted elsewhere for the reward of any other degree/diploma. We are fully responsible for the contents of our project report.



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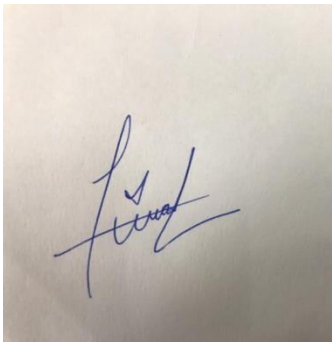

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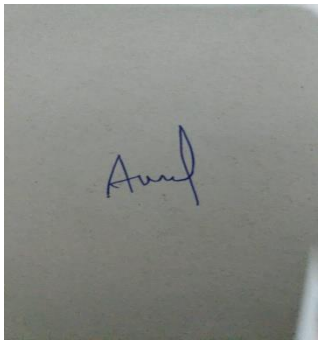

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled "**Modification of Bitumen using Fly Ash**" in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the department of Civil Engineering , **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Ajay Sharma(161625), Himanshu Kapoor(161614), Anmol Singhal(161617)** during a period from August, 2019 to May, 2020 under the supervision of **Dr. Rajiv Ganguly,** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge

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ABSTRACT

Fly ash and waste tire burnt out by vehicles is one of the many mechanical waste deposits in India. Fly ash is the fundamental strong waste released by coal-fired power plant. In India, the yearly emanation of fly ash is more than 0.3 billion tons, and it is one of the principle mechanical waste buildup. The utilization of four-wheeler, bikes and so on is expanding step by step. Subsequently measure of waste tires additionally expanding. Waste tires in India are classified as solid or hazardous waste. It is assessed that 60 percent of waste tires are arranged through obscure courses in the urban just as country regions. This prompts different natural issues which incorporate air contamination related with open burning of tires and aesthetic contamination. Along these lines, it is important to use the wastes successfully with specialized improvement in each field. A decent plan of Modified bituminous mix is relied upon to bring about a mix which is sufficiently strong, solid and resistive to fatigue and changeless disfigurement and simultaneously environ mentally friendly and economical. A mix designer attempts to accomplish these prerequisites through various tests on the mix in with fluctuated extents of material mixes and settles the best one. The research result shows that the Marshall technique for bituminous mix configuration was done for changing rates of Fly ash and to decide the distinctive mix design qualities.

Index Terms— Fly ash, Modified Bitumen, Marshal Stability

CHAPTER 1

INTRODUCTION

1.1 GENERAL

There are various methods for transportation, among this road transportation is one of the essential methods and most usually utilized one for transportation of merchandise and enterprises all through the world. Today road network has gotten one of the basic spines for the development here and there as it gives a decent access to the suburbanites to go to their ideal spot. Road network has been received quite a while in the past by the individuals when different methods of transport were not concocted. From most recent 50 years road transportation has extended for offering types of assistance to the both travelers and merchandise. This is considered as one of the fundamental methods for transportation.

For a solid and stable economy great roadway foundation is fundamental. Alongside the other advancement exercises road infrastructure is developing at a quick rate in India. Today highway transportation has fast, high burden, high traffic density and channelized traffic, so subsequently asphalts are exposed to various sorts of trouble, for example, weakness breaking, rutting, raveling, etc and furthermore the life expectancy of roads laid with customary bituminous blends has diminished because of the expansion in the rush hour gridlock development and over-burdening of vehicles. Which lead to the decrease in the riding quality, in this way bringing about over the top vehicle working expenses and incessant support intercessions because of the untimely disappointment of asphalts. In an ever-developing economy like India giving solid roads has consistently been an issue. The issue for the most part emerges because of differing atmosphere, landscape condition, precipitation powers and soil attributes. Gigantic aggregate of speculation can be spared if the road network is planned with exact and exact procedures. This will likewise bring about better execution of administration interstate. In this way, it turns out to be much progressively imperative to investigate the different choices that can be utilized so as to create and improve the nature of the asphalts and conquer the issue of asphalt disappointments. Modification of bituminous mix is one of the satisfactory techniques that is being broke down and widely concentrated in the course of the last few years.

1.1.1 Evolution of road surface

Prior during the bygone eras the greater part of the roads were unsurfaced and were known as the truck track. They were laid with no compaction of soil. The unsurfaced roads were developed with regular soil taken from the get pits and compaction was finished by the traffic moving over it. No or next to no of consideration was given towards the seepage facility. Such roads had a little life expectancy and were regularly harmed by overwhelming precipitation falls.

Water bound macadam roads (WBM) were an improved variant of the unsurfaced roads, having indistinguishable constituents from the unsurfaced ones, combined (either pre-blend or in-situ) with water and compacted in order to get improved quality. A lot of residue was delivered by WBM streets so to diminish the residue oiled roads were presented and crankcase oil, squander transformer oil, squander vegetable and so forth were utilized.

The following significant advance in the development of road surface was the presentation of seal coat. The base course was fixed with a slight film of bitumen total blend in order to secure it against the dampness and the traffic and consequently expanding its usefulness. The lesser the measure of water entering the base and sub base layers, the higher the life expectancy of the road surface.

With the changing time there was a sharp increment in the rush hour gridlock which thusly prompted better asphalt request. This brought about the age of bituminous concrete or asphaltic solid which is a high thick reviewed premix. These sorts of roads have superior and greater surface course. Bitumen mix overlays can be laid of around 20-40 mm least to as high as 300-500 mm or considerably more.

1.1.2 Recent times

Two kinds of asphalt structure are usually planned either as a flexible pavement or a rigid pavement. Flexible asphalts anyway shapes greater part of asphalts worked in India because of their auxiliary conduct, preferences over rigid asphalts and economy. Flexible asphalts act in an adaptable manner in their auxiliary activity under the applied loads thus have low or immaterial flexural quality. For offering types of assistance to travelers and merchandise larger part of roads built comprises of flexible pavement organize greater part of the roads.

Flexible pavement generally comprises of four layers:

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

There are normally three segments of flexible pavement. bitumen, total and air void. Bitumen is generally utilized as binding material if there should be an occurrence of flexible asphalt. Bitumen is a visco-elastic material that is separated from oil, with the assistance of frictional refining. bitumen is generally dissolvable in carbon sulfide. In its strong state it is its known as black-top and in its fluid state is known as mineral tar. As of late there is high increment of interstate usage because of the fast increment of traffic out and about all through the world which has prompted overwhelming burden suggestions on the pavement by the development of the traffic. Anyway unmodified bitumen and typically rehearsed high class great black-top cement has been neglected to fulfill the expanding request and level of performance anticipated. This inadequacy prompts unnecessary rutting, warm breaking and thus bring about shorter existence of asphalt.

To illuminate such issues, it has driven the consideration of numerous specialists and organizations worried to it to search for different endeavors that can be made for improving the properties of the bitumen to manage the issues identified with pavement upsets. One of the strategies which have as of late got more consideration is change of the bitumen with different materials generally named as admixtures. A few admixtures have been referred to fill in as modifiers of bitumen if altogether blended in with it, bringing about an expansion of binder properties. These admixtures are straightforwardly added to the bitumen as a bitumen modifier or it tends to be included into the total containing the mix.

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

- Polymers
    1. Plastic polymer
    2. Fiber polymer
    3. Elastomers

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

Anyway modified bitumen is ordinarily delivered at progressively costly costs accordingly it can prompt the increase in the economy of the modification forms. Fly ash has effectively been utilized as filler for bitumen blends for quite a while, as it's effectively accessible at exceptionally ease contrasted with different fillers. The buildup acquired from consuming/burning of coal is Fly ash was accounted for to be able to fill in as a bitumen extender

1.2 Objectives of the study

- Evaluating physical properties of virgin bitumen of viscosity grading (VG 30).
- To evaluate the properties of bitumen having different percentages of fly ash as admixture.
- To compare the performance of modified bitumen with fly ash and as an admixture with virgin bitumen through laboratory investigation.
- To find out different Marshall mix characteristics (like stability, flow, air voids) of bituminous mix from both virgin and modified bitumen

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1.3 Need of the study

To meet above objectives the scope of the project are going to be formulated as follows:

- To improve the strength and permeability of pavements by additives.
- To help in the reduction of undulations on road caused by channelized traffic, high load & water.
- Bitumen at a point loses its bond & gets deteriorated.

CHAPTER- 2

LITERATURE REVIEW

2.2 Previous research

Abdula Zain Ul Aabideen Dar and Mohd Zeeshan Khan (2018)in this study fly ash was used as replacement for bitumen and various physical and Marshall properties were tested out for different percentages of fly ash i.e 4%, 6% and 8%. Bitumen content was also varied to find out the optimum bitumen content with the same fly ash content for each. Stability values showed increasing value for increase in fly ash content, increase in Marshall properties such as flow value and air voids also showed increase with fly ash addition. Physical values such as less penetration value, low ductility and decreasing density were found out through the different experimental observations.

Vishal Sharma, Satish Chandra and Rajanchoudhary (2010) in this fly ash was use as filler in the bituminous blend. Fly ash for this study was gathered from different thermal stations in various areas of India. After the assortment fly ash was partitioned into four gatherings relying upon different physical and substance properties and afterward will be utilized as filler material in bitumen blend. Residue of stone which is utilized as most normal filler in India was likewise utilized for examination. Bitumen blends arranged in with differing F/B proportions was inspected for different properties like viscosity, softening point and penetration. Tensile strength ratio , Marshal strength, retained stability, and creep test were performed on these blends utilizing five sorts of fillers in with shifting level of filler (4%), (5.5%),(7%), and (8%), by the bitumen 60/70 grade. All the outcomes acquired where broke down and afterward examination between everything 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 prepared various samples of bituminous mixes having fly ash, cement and lime as filler with different percentage of bitumen and laboratory investigation was performed. The following results were observed:

- Fly ash can be used as a filler in asphalt mix successfully.

- With addition of filler, optimum bitumen content was seen lower in mixture.

Konstantin Sobolev, Ismael flores and Justin David Bohler (2013) studied about determining the feasibility of fillers in asphalt concrete. Two different binders were used. These binders were fully mixed with fillers i.e. fly ash, lime and cement. Following results were observed:

- Rheological properties of asphalt were significantly improved with the addition of fillers
- Fly ash also appeared improving the aging resistance of mastics.

S.D.Katara, C.S.Modhiya, N.G.Raval (2014) studied on the Influence of Modified Bituminous Mix using Fly Ash. This study discloses that the Marshall Stability value has shown increasing tendency and the maximum values have been increased upto 25 % by addition of fly ash, which is the strength parameter of the mix. Increase of density of the mix is also being shown in the cases of FLY ASH when compared with 60/70 grade bitumen.

- It offers more stable and durable mix for the flexible pavements.
- The serviceability and resistance to moisture also improved when it is compared to the conventional method of construction.
- The other parameter values that is. Vv, VMA and VFB in both the circumstances Fly ash were found out to be within required specifications
- In this study not only it utilizes the waste fly ash and tyres in road construction industry but it has also successfully improved the different parameters which will lead to improved and long life of roads.
- This study will also have a positive impact on the environment as it will lessen the volume of surplus waste product to be disposed by burning and land filling.
- Not only it would develop a technology which is eco-friendly but will add value to waste product too.

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

- The mixtures containing 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 favorably to the results for mixtures containing limestone dust.

2.3 SUMMARY

For the most part, the bitumen and aggregates are the fundamental materials where the test are performed. Presently a day, alteration of bitumen or incomplete or full substitution of bitumen was introduced and asphalt properties are upgraded. This exploration is chiefly for using waste materials in street development, the waste material utilized here fly ash. In this research, we utilize fly ash as an incomplete substitution of bitumen. In the wake of contemplating past research papers fractional supplanting of bitumen with fly ash is gainful for our nation. We arranged various samples for tests in the laboratory.

CHAPTER-3

MATERIAL CHARACTERIZATION AND METHODOLOGY

3.1Material –

- Bitumen
- Fly Ash

3.1.1 Bitumen- It is non-crystalline hydro carbon in strong or fluid state having properties of adhesion; it is acquired by artificial or natural refining of crude oil. Instead of water it is soluble in carbon di sulfide. Properties of bitumen not just rely upon its source from which it is extracted but also on preparation methods. In North America it is scratch named as asphaltic concrete or asphalt. Normally happening 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 do 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 80º 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 extracted with the help of fluxing bitumen with appropriate solvents. By adding kerosene viscosity gets reduced in bitumen. It's one of the important application is in tack coat.

3.1.2.4 Bitumen Emulsion:

At a particular temperature bitumen emulsion is a free flowing liquid. Proper quality emulsifier is important to make sure that it 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 are commonly called as modified bitumen. Commonly used modifiers are SBS, EVA, LDPE and HDPE.

3.2 Fly ash

From combustion of pulverized 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 tons 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.

Fig 3.1 Fly Ash Sample

3.2.2 Fly ash chemical composition

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

Chemical Composition	Percentage (%)	
	Class F	Class C
Silica (SiO2)	55	40
Alumina (Al2O3)	26	17
Iron Oxide (Fe2O3)	7	6
Calcium Oxide (CaO)	9	24
Magnesium Oxide	2	5
Sulphur Trioxide (SO3)	1	3

Table 3.1 Fly Ash chemical composition

3.3 Aggregates

3.3.1 Selection of Aggregates

Aggregates which possess sufficient strength, toughness, soundness, hardness and polished stone value are chosen, keeping in view the availability. Crushed aggregates and sharp sand produce high stability of the mix when compared with gravel and rounded sands.

3.3.2 Aggregate Grading Selection

The properties of a bituminous mix including the stability and density are considerably hooked in to the aggregates and their grain size distribution. Most of the engineering organizations have specified the utilization of dense graded mixes and not open graded mixes. As maximum size of aggregates gives higher stability, usually the larger size which will be adopted depends on the compacted thickness of the pavement layer. Maximum aggregate size of 25 to 50 mm is employed within the bituminous mixes for base course and 12.5 to 18.7 mm is employed for surface course.

Sieve size (mm)	Gradation limits (%)	Passing (%)	Retained (%)
12.7	100	100	0
9.52	80-100	90	10
4.76	55-72	63.5	26.5
2.00	36-53	44.5	19.0
0.42	16-28	22	22.5
0.177	8-16	12	10.0
0.074	4-10	7	5
Pan	-	-	7

Table 3.2 Grading of aggregates as per MoRTH specifications

3.3.3 Determination of Specific Gravity of Aggregates

This test is done as per IS 2386 P- III. Specific Gravity is the proportion of strength and quality of the aggregate. Specific Gravity of aggregates is defined as the weight of aggregates by the weight of an equivalent volume of water.

3.4 Tests on Bitumen

3.4.1 Penetration Test

Most Commonly use technique for evaluating the consistency ofbitumen 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
- Stopwatch
- Container

- Thermometer
- Water bath

Fig 3.2 (a) Bitumen sample in mould (b) Penetrometer

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

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.

3.4.2 Ductility test- It is an empirical test which measures the bitumen cohesive strength. Thistest 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.

Fig 3.3 Ductility Test Apparatus

Apparatus-

- Testing Machine
- Brass Mould
- Water bath
- Thermometer

Principle- Bitumen sample ductility is measure by stretching the sample till it breaks at specificspeed 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 poured 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.

3.4.3 Specific Gravity Test

This test is done as per IS 1202 1978. Specific Gravity of the Bitumen is the proportion of the heaviness of a given volume of bitumen to the heaviness of a given volume of water at a standard temperature of 27°C. The specific gravity of the bitumen helps in structuring the bitumen blend. The Specific Gravity of the bitumen relies on its concoction properties. Bitumen having a lot of polluting influences or contaminations will have high specific gravity. For the most part, the Specific Gravity of Bitumen changes from 1.10 to 1.25.Specific gravity of Bitumen $=\frac{(w2-w1)}{(w3-w1)-(w4-w2)}$

Where,

W1= Weight of empty Specific Gravity Bottle,

W2= Weight of Specific Gravity Bottle + Bitumen,

W3= Weight of Specific Gravity Bottle + Water,

W4= Weight of Specific Gravity Bottle + Water + Bitumen.

Fig 3.4Specific Gravity Bottle

3.5 Marshall Stability Test

3.5.1 Concept of Marshall Stability test

The "Marshall Stability "of the bituminous blend example is characterized as a most extreme load conveyed in kg at the standard test temperature of 60°C when load is applied under determined test condition. The "Flow Value" is the all out deformation that the Marshall test example under-goes at the most extreme burden, communicated in mm units.

The Marshall Stability estimation of a compacted sample of bituminous blend demonstrates its resistance from disfigurement under applied gradual load and flow value shows the degree of distortion it experiences because of loading or its 'flexibility'.

The flexibility is estimated as per the "flow value" which is estimated by the adjustment in breadth of the sample toward load application between the beginning of loading and at the time of most extreme load. During the loading, a joined dial check gauge measures the sample's plastic flow (distortion) because of the loading. The related plastic progression of sample at material failure is called flow value.

3.5.2 Preparation of test specimens

Roughly 1200gm of filler and aggregates is warmed to a temperature of 175-190oC. Bitumen is warmed to a temperature of 121-125ºC with the primary preliminary level of bitumen (state 3.5 or 4% by weight of the mineral aggregates). The warmed aggregates and bitumen are completely mixed at a temperature of 154 - 160ºC. The blend is set in a preheated form and compacted by a rammer with 75 blows on either side at temperature of 138oC to 149oC. The heaviness of blended aggregates taken for the arrangement of the example might be reasonably adjusted to acquire a compacted thickness of 63.5+/ - 3 mm. Save the blend in the mould for 24 hours and after that remove the example from the form with the assistance of test extractor. The weight of the specimen is noted in air and in water. The example is kept drenched in a water bath at a temperature of 60°C for about 30 to 45 minutes. The given specimen is prepared to stack in the Marshall Stability test mechanical assembly. Vary the level of bitumen and the molasses in the altered bitumen and repeat again.

Preparation of test specimens for modified bitumen is also done in the same way by modifying bitumen with varying percentages of fly ash. Bitumen is heated up to a temperature of 85ºC -

110ºC for proper mixing of fly ash with bitumen. The modified bitumen is then used in Marshall test & repeated for varying percentages of bitumen & fly ash one by one.

Fig 3.5(a) Marshall stability apparatus

Fig 3.5(b) Sample placed in Marshall test apparatus

3.5.3 Mix Properties

3.5.3.1 Theoretical specific gravity Gt

Theoretical specific gravity Gt is that specific gravity without considering air voids, and is given by:

$$G_t = \frac{W_1 + W_2 + W_3 + W_b}{\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_b}{G_b}}$$

where, W1 is the weight of coarse aggregate within the total mix, W2 is the weight of fine aggregate within the total mix, W3 is the weight of filler within the total mix, Wb is the weight of bitumen within the total mix, G1 is the apparent specific gravity of coarse aggregate, G2 is the apparent specific gravity of fine aggregate, G3 is the apparent specific gravity of filler and Gb is the apparent specific gravity of bitumen.

3.5.3.2 Bulk specific gravity Gm

The bulk specific gravity or the particular specific gravity of the blend Gm is the specific gravity considering air voids and is detected by:

$$G_m = \frac{W_m}{W_m - W_w}$$

where, Wm is the weight of blend in air, Ww is the weight of blend in water, note that Wm-Ww gives the volume of the blend. Many times to get exact bulk specific gravity, the sample is covered with slim film of paraffin wax, when weight is taken in the water. This, anyway requires to think about the weight and volume of wax in the counts.

3.5.3.3 Percentage air voids Vv

Air voids Vv is the percent of air voids by volume in the specimen and is given by:

$$V_v = \frac{(G_t - G_m)100}{G_t}$$

here, Gt is the theoretical specific gravity of the mix and Gm is the bulk or actual specific gravity of the blend by equation.

3.5.3.4 Volume of Bitumen percentage Vb

Vb, the volume of bitumen is the percentage of volume of bitumen to the total volume and is given by:

$$V_b = \frac{\frac{W_b}{G_b}}{\frac{W_1+W_2+W_3+W_b}{G_m}}$$

where, W1 is the weight of coarse aggregate in the all out blend, W2 is the weight of fine aggregate in the all out blend, W3 is the weight of filler in the all out blend, Wb is the weight of bitumen in the all out blend, Gb is the apparent specific gravity of bitumen, and Gm is the bulk specific gravity of blend in the equation.

3.5.3.5 Voids in mineral aggregate VMA

Voids in mineral aggregate VMA is the volume of voids in the aggreagtes, and is the aggregate of air voids and volume of bitumen, and is determined from:

$$VMA = V_v + V_b$$

where, Vv is the percentage of air voids in the mix and Vb is percentage bitumen content in the mix.

3.5.3.6 Voids filled with bitumen VFB

Voids filled up with bitumen VFB is the voids in the mineral aggregate casing work loaded up with the bitumen, and is determined as:

$$VFB = \frac{V_b \times 100}{VMA}$$

where, Vb is percent bitumen content in the mix, and VMA is the percent voids in the mineral aggregate.

3.5.4 Determination of Marshall Stability and flow

Marshall stability of a test sample is the most extreme load required to create failure when the sample is preheated to an endorsed temperature set in an extraordinary test head and the load is applied at a steady strain (5 cm for every minute). While the strength test in progress dial check is utilized to gauge the vertical deformation of the sample. The deformation at the failing point communicated in units of 0.25 mm is known as the flow value of the sample.

Fig 3.6 Removing sample after load test

3.5.5 Apply stability correction

It is conceivable while making the sample the thickness somewhat differs from the standard particular of 63.5mm. Thusly, observed stability values should be revised to those which would have been acquired if the examples had been actually 63.5 mm. This is finished by duplicating each observed value by an appropriated connection factors as given in Table:

Volume of specimen (cm^3)	Thickness of specimen (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	1.00
523 - 535	65.1	0.96
536 - 546	66.7	0.93
547 - 559	68.3	0.89
560 - 573	69.9	0.86

Table 3.3 Correction factors for Marshall stability values

(Khanna S K, Justo C E G)

CHAPTER- 4

RESULTS AND DATA ANALYSIS

4.1 Introduction

In this chapter the different properties of bitumen and bituminous mix in both unmodified and modified bitumen is given and are compared along with a study published under "International Journal of Trend in Scientific Research and Development (IJTSRD) ISSN: 2456-6470".

4.2 Data Analysis

Particularly 3 specimens of modified bitumen and 9 specimens of Bituminous mix were prepared and tested in the lab. The results are analyzed and discussed as under:

4.2.1 Bitumen Tests analysis

Tests	**Modified Bitumen**			**Virgin Bitumen**
	4% Fly ash	**6% Fly ash**	**8% Fly ash**	
Penetration test	46.2mm	39.4mm	32.3mm	64.5mm
Specific Gravity	1.07	1.08	1.09	1.03
Ductility	46.5cm	39.9cm	37.5cm	76cm

Table 4.1 Test Results on bitumen

Based on the results of the experiments shown in table 4.1 it is seen that the ductility values decreased with addition of fly ash as the fly ash caused the bitumen to become stiffer, penetration value decreases with addition of fly ash indicating the more viscous nature of modified bitumen and specific gravity increases with increasing percentage of fly ash.

4.2.2 Marshall Test Results

Bitumen Content (%)	Gm	Vv (%)	VFB (%)	Stability (Kg)	Flow mm
4.5	2.289	5.1	82.66	31.42	7.5
5	2.293	4.6	85.58	49.54	9.1
5.5	2.5	4.0	86.95	42.67	10.9

Table 4.2 Test Results of Marshall apparatus for virgin bitumen

From the table 4.2 it is observed that maximum stability is at 5% bitumen content, air voids at 4.5% bitumen content and specific gravity at 5.5 % bitumen content. These three helps us to find the optimum bitumen content. Also it can be observed that flow value is increasing with increase in bitumen content. The air void percentage also decreases but then increases with increasing bitumen content.

Bitumen Content (%)	Fly ash content (%)	Gm	Vv (%)	VFB (%)	Stability (Kg)	Flow (mm)
4.5	4	2.42	12.5	59.1	59.1	6.5
4.5	6	2.386	13.7	56.103	74.2	7.4
4.5	8	2.357	14.6	55.765	79.7	8
5	4	2.55	8.1	69.4	62.67	4.9
5	6	2.45	8.7	68.88	74.56	6.1
5	8	2.425	9.5	65.67	77.9	6.7
5.5	4	2.39	9.9	67.1	72.7	4.1
5.5	6	2.36	10.4	65.48	76.55	4.8
5.5	8	2.31	12.1	60.91	80.8	6.9

Table 4.3Results of Marshall characteristics of mix using modified bitumen

From the above table 4.3 it very well may be seen that stability is expanding with increment in fly ash content and is most extreme at 5.5 % bitumen content when fly ash content is 8% rather than 5% bitumen in table 4.2. It is also seen that air void percentage is still maximum at

4.5% bitumen content. There is also a decreasing change in value of VFB with increase in fly ash content showing that there is less % of voids filled with bitumen.

Specific gravity of the modified mix is also now maximum at 5 % bitumen content and 4% fly ash content. Showing that the density of the mix decreases on addition of fly ash.

Test	Modified Bitumen			Unmodified Bitumen
	4% Fly ash	6% Fly Ash	8% Fly ash	
Penetration Test	45.2mm	38.5mm	31.6mm	63.5mm
Ductility	48cm	40.5cm	37.8cm	100+
Specific Gravity	1.08	1.09	1.1	1.04

Table 4.4 Properties of modified and unmodified Bitumen (From study)

Based on the results of the experiments shown in table 4.1 it is seen that the ductility values decreased with increment of fly ash as the fly ash caused the bitumen to become stiffer, penetration value drops with fly ash addition indicating the more viscous nature of modified bitumen and specific gravity increments with expanding level of fly ash. These values are taken from the study of Abdula Zain Ul Aabideen Dar and Mohd Zeeshan Khan (2018).

Bitumen Content (%)	Gm	Vv (%)	VFB (%)	Stability (kg)	Flow (mm)
4.5	2.292	4.8	79.66	27.88	6
5	2.297	4.0	82.37	44.2	8.6
5.5	2.89	3.7	83.40	39.44	10.8

Table 4.5 Results of Marshall characteristics of mix (From Study)

From the table 4.5 it is observed that maximum stability is at 5% bitumen content, air voids at 4.5% bitumen content and specific gravity at 5.5 % bitumen content. These three helps us to find the optimum bitumen content.Also, it can be observed that flow value is increasing with increase in bitumen content. The air void percentage also decreases but then increases with increasing bitumen content.These values are taken from the study of Abdula Zain Ul Aabideen Dar and Mohd Zeeshan Khan (2018).

Bitumen Content (%)	Fly Ash Content (%)	Gm	Vv (%)	VFB (%)	Stability (Kg)	Flow (mm)
4.5	4	2.31	11.8	59.74	55.9	6
4.5	6	2.286	12.9	55.972	69.3	6.6
4.5	8	2.267	13.5	55	76.1	7.8
5	4	2.41	7.7	68.95	60.52	4.4
5	6	2.40	8.0	68.25	70.72	5.4
5	8	2.36	9.2	64.48	74.8	6.1
5.5	4	2.35	9.3	65.05	70.72	3.25
5.5	6	2.33	9.7	63.26	75.82	4.2
5.5	8	2.295	11.3	58.91	78.20	6.1

Table 4.6 Marshall Characteristics of a mix using modified bitumen (From Study)

From the table 4.6 it is observed that the maximum stability is achieved at 5.5 % bitumen content at 8% fly ash content. The stability increases on increasing the fly ash content showing increase in strength of the mix. The specific gravity of mix decreases with increase in fly ash content showing the decrease in density. Air voids percentage also increases with increasing fly ash content. Flow values also tend to increase with increase in fly ash content. These values are taken from the study of Abdula Zain Ul Aabideen Dar and Mohd Zeeshan Khan (2018)

4.3 Analysis through Graphs

4.3.1 Binder content (%) vs Marshall stability (kg)

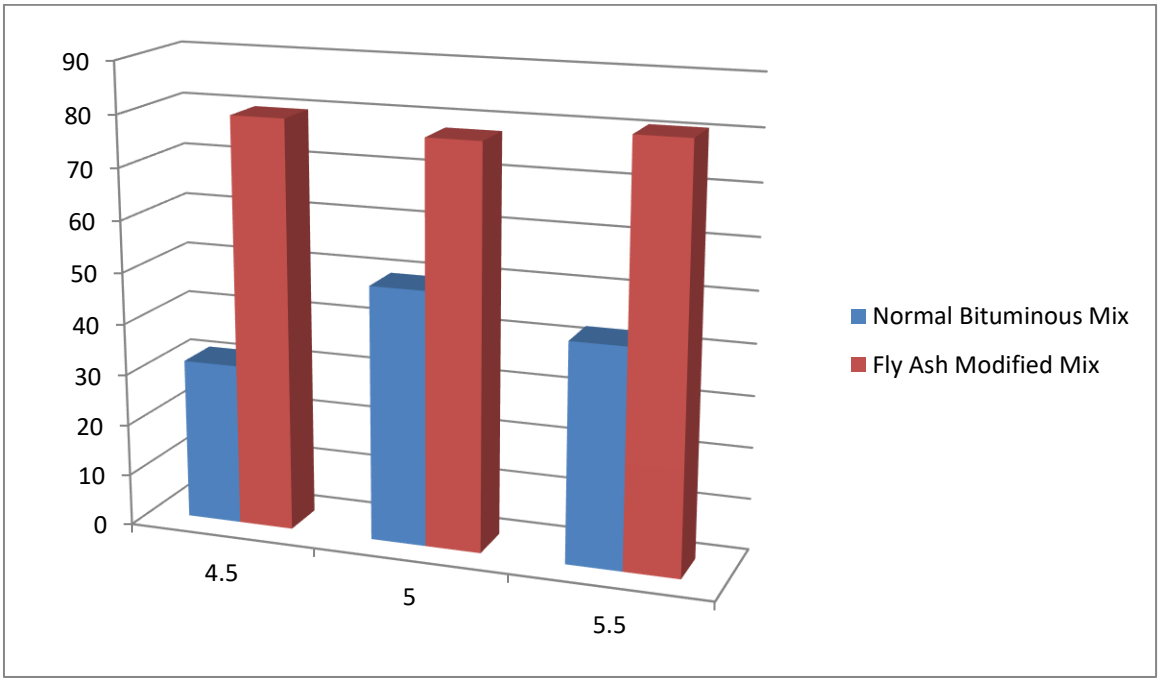

Fig 4.1 Bitumen Content vs Marshall Stability

From fig 4.1 it is seen that the stability of fly ash modified mix is more (most at 8% fly ash content) as compared to that of normal bituminous mix in all percentages of bitumen content. From the figure the maximum stability is 49.54 kg in case of normal bituminous mix and 80.8 kg in case of fly ash modified bituminous mix. This means that addition of Fly ash has increased the maximum stability by 63.10 %. The maximum stability is found at 5% Bitumen content of normal bituminous mix and 5.5 % in case of Fly ash modified mix.

4.3.2 Binder content (%) vs percentage air voids Vv (%)

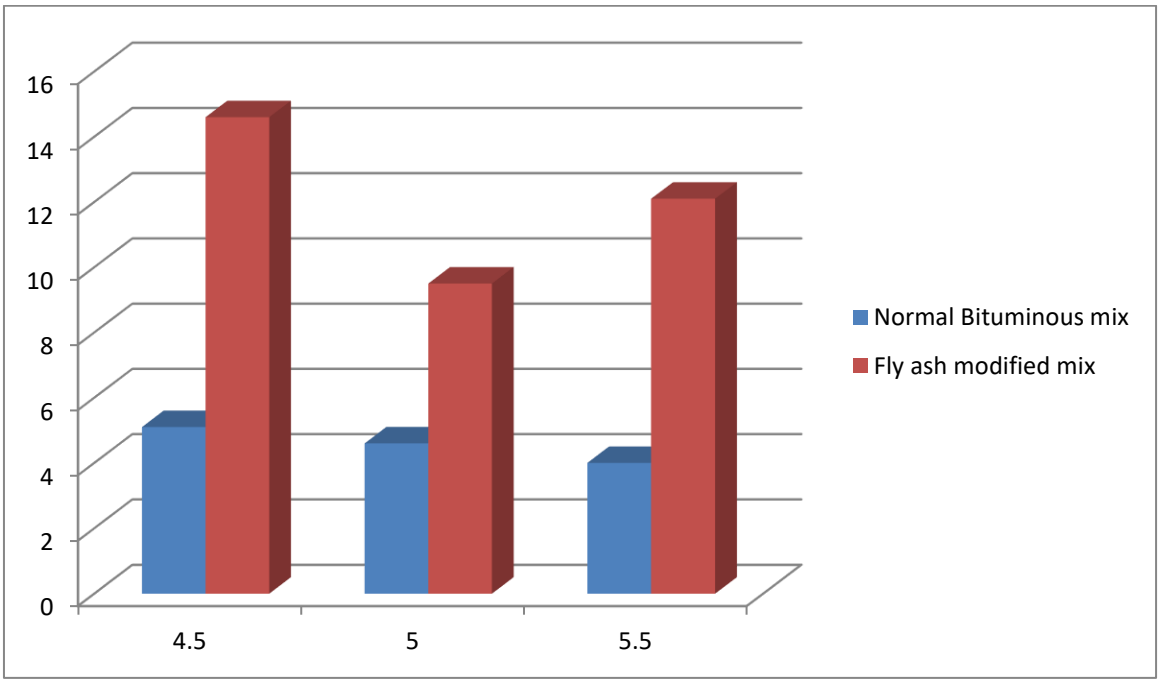

Fig 4.2 Bitumen content (%) vs Vv (%)

From the fig 4.2 we can point out that the percentage of air voids keeps decreasing in both types of mixes on increase of bitumen content up to 5% bitumen content after which there is a minimal increase of air voids in modified mix. It is also seen that addition of fly ash increases the percent of air voids in the bituminous mix with increase in fly ash content in the bitumen. This is due to the reason that the binding is less efficient in fly ash modified bituminous mix.

4.3.3 Binder content (%) vs Marshall Flow value (mm)

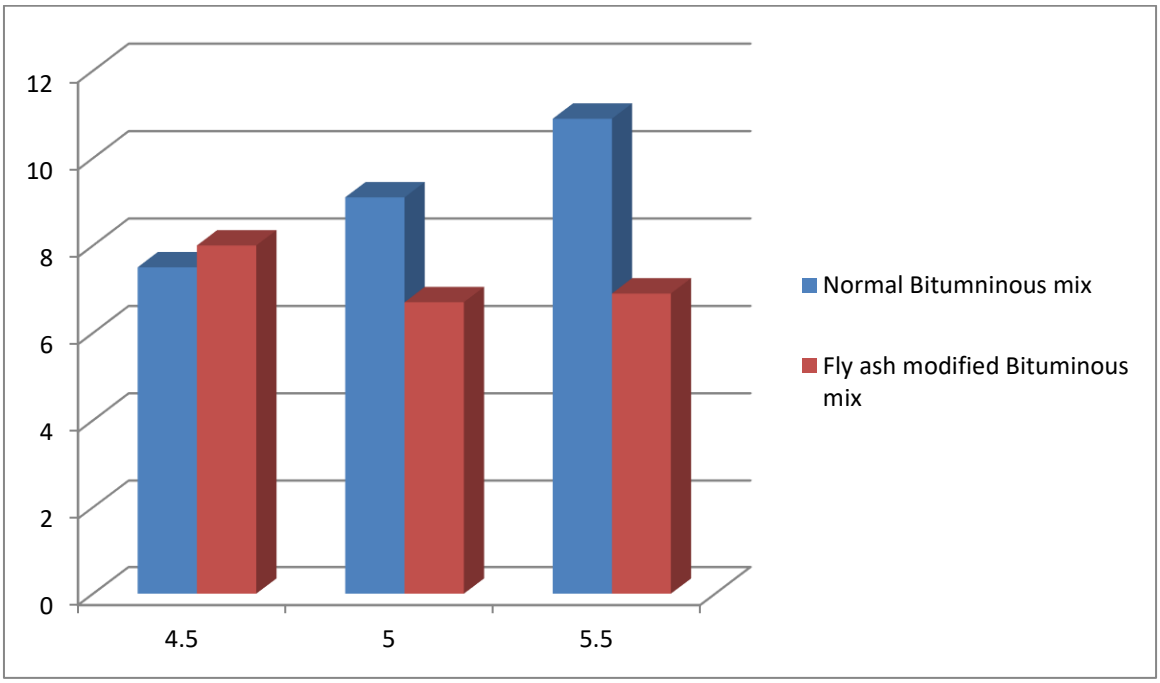

Fig 4.3 Binder content (%) vs Marshall Flow value (%)

From the fig 4.3 it is observed that the flow values steadily increases in case of normal bituminous mix and in case of modified mix it drops down then increases gradually. Flow values of fly ash mixes are less than normal mixes in most cases because fly ash stiffens the bituminous mix. Increase in stiffness avoids scraping of pavement and makes it strong so it is desirable.

4.3.4 Binder content vs Voids filled with Bitumen – VFB (%)

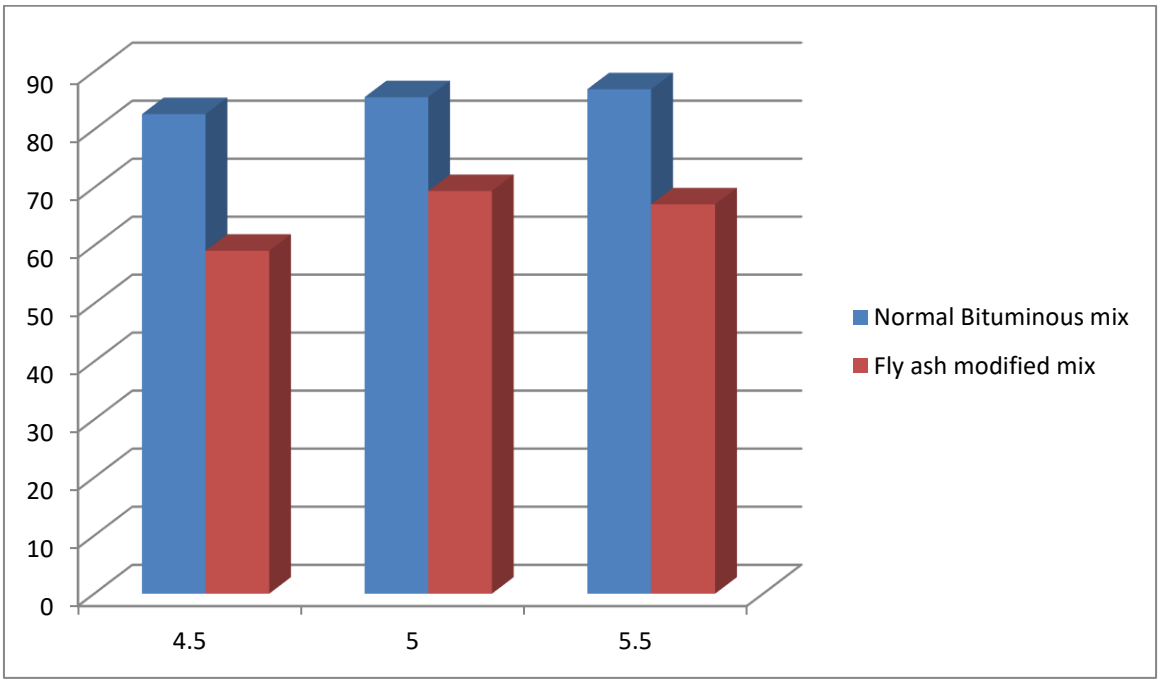

Fig 4.4 Binder content (%) vs VFB (%)

From the above fig 4.4 it is clear that the VFB in case of normal mixes increases as percentage of bitumen increases. In fly ash modified mix it is seen that VFB first increases then decreases. It can also be seen that VFB in normal mixes is more than modified mix. This is due to the reason that more & more fly ash particles fill up the voids first leaving out bitumen. Hence VFB percentage is more in case of normal mixes and less air voids.

4.3.5 Binder Content (%) vs Bulk specific gravity

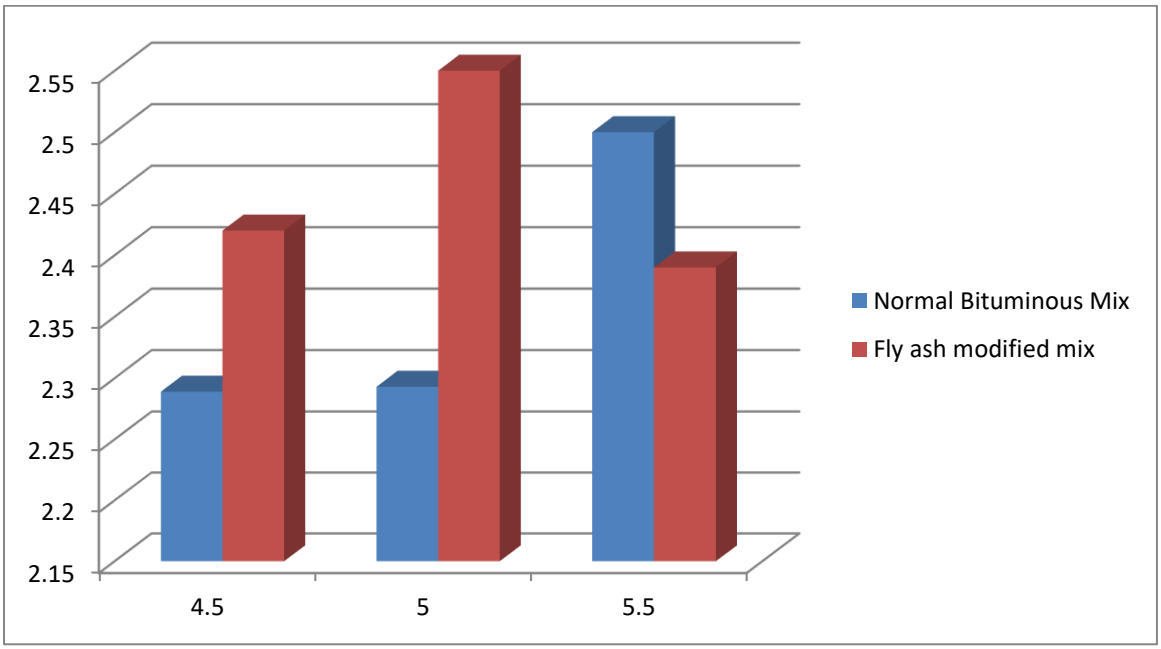

Fig. 4.5 Binder content (%) vs Bulk specific gravity (Gm)

From fig 4.5 it is seen that specific gravity of normal bituminous mix increases on increasing bitumen content. In case of fly ash modified bituminous mix specific gravity increases up to 5% bitumen content & then decreases. The specific gravity is higher in case of Fly ash modified bituminous mix except at 5.5 % bitumen content

Type of Mix	Max Stability (kg)	Max percentage air voids (Vv)	Max specific gravity	Optimum Bitumen Content
Normal Bituminous mix	49.54@ 5% BC	5.1@ 4.5% BC	2.5 @ 5.5% BC	5%
Fly ash modified Bituminous mix	80.8 @ 5.5% BC & 8% Fly ash content	14.6 @ 4.5% BC & 8% fly ash content	2.55 @ 5% BC & 4% fly ash content	5%
Normal Bituminous mix (study)	44.2@ 5% BC	4.8 @ 4.5% BC	2.89 @ 5.5% BC	5.1%
Fly ash modified Bituminous Mix (study)	78.20@ 5.5% BC & 8% fly ash content	13.5 @ 4.5% BC & 8% fly ash content	2.41 @ 5% BC & 4% fly ash content	5%

Table 4.7 Optimum Bitumen Content for various specimens

4.4 Concluding Remarks

From the above results it can be concluded as:

- Fly ash modified bitumen in our present study & in Abdula Zain Ul Aabideen Dar and Mohd Zeeshan Khan (2018) showed variations in the properties and stability due to the reason that fly ash increases stiffness on increasing its content.
- Past comparing the results of our and selected studies we see that Marshall stability achieved was more than the targeted stability.

Hence, through study of the results of the different lab tests on Normal Bituminous Mix and Fly ash modified Mix, we conclude that the stability of Normal Bituminous mix can be increased and improved my modifying bitumen with addition of fly ash in a suitable amount which is a major environmental pollutant.

CHAPTER – 5

CONCLUSIONS

5.1 Conclusions

In light of the aftereffects of the analyses led on virgin and modified bitumen utilizing fly ash in various amounts the accompanying outlines have been drawn:

- The ductility values decreased with addition of fly ash from 76cm to a minimum of 37.5cm at 8% fly ash as the fly ash caused the bitumen to become stiffer and strong.
- The penetration value decreases with addition of fly ash from 64.5mm to a minimum of 34.3mm at 8% fly ash content indicating the more viscous nature of modified bitumen . Along these lines low-grade bitumen can be altered to bargain higher loads.
- The stability values tend to increase with increase in fly ash content in Marshall stability test. An increase by 63.10% was seen from normal Bituminous mixes
- The maximum stability was achieved at a point when percentage of fly ash used was 8% and bitumen content at 5.5 %.
- The flow value through Marshall test also increases with increase in fly ash content. This demonstrates more protection from permanent deformation of bituminous blends in with including of fly ash.
- The specific gravity decreased with addition of fly ash indicating decrease in density of the bituminous mix.
- Increasing content of fly ash affects the properties of binders badly my making it stiffer and hence is not suitable for highway construction.

5.2 Future Scope

- Assessment of Indirect tensile strength of blends arranged from modified binder utilizing fly ash.
- Evaluation of fatigue performance of bituminous blends arranged in with adjusted bitumen by utilizing distinctive level of fly ash.
- Find out the relative rutting qualities of various bituminous blends by utilizing Static Indentation Test at 60ºC.

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