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EFFECT OF FILLERS ON BITUMINOUS PAVING MIXES

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Abstract
Good bituminous design is necessary to meet stability and durability design standards. Asphalt mixtures contain fillers, asphalt binders, and densely graded coarse and fine aggregates. The purpose of this study is to determine how fillers affect the behavior of asphalt mixture. Fillers are important for filling voids and can change the chemical and physical properties of the product. It is important that the filler flows through a 0.075 mm sieve. Stone dust, lime and cement are traditionally used as fillers.
This research aims to evaluate the effect of low quality and cheap materials such as fly ash in bituminous pavement mixture. As a result of this study, it was determined that asphalt mixtures containing non-traditional materials support the need for use, although they provide Marshall properties and require a slightly higher asphalt content. The use of fillers in this research will help to solve the environmental waste problem to some extent

Keywords :
Bituminous paving mixture, fly ash, aggregate, filler, Marshall test.

1. Introduction
1.1 General
Highway construction in developing countries has increased in the last decade. Due to increasing axle loads and fast traffic, highway paving materials need to be improved. There are generally two types of highway pavements: flexible pavements and rigid pavements. Asphalt or asphalt surface is used for laying simple pavements. These can be in the form of HMA coatings, which are commonly used on highways such as state highways, or surface treatment coatings, such as asphalt pavement, which are commonly used on highways. This type of pavement is called “flexible” because the entire pavement structure “bends” or “deflects” in response to truck loads. Simple siding usually consists of multiple layers of material that are flexible enough to be bent or bent as needed. In comparison, PCC coating is a hard coating. These coatings are "tougher" than flexible coatings due to the higher elastic modulus of PCC. Flexible coatings can be used anywhere because they are inexpensive. Precision engineering of new coatings leads to significant savings and reliability in coating services. Pavements are divided into three main categories:

- Flexible pavements (asphalt surface).
- Rigid pavements(concrete surface)
- Coating made of composite material.

Useful pavements are designed using the following technologies:
Concrete Asphalt Mat (CRAM), deep asphalt pavement and flexible pavement.
1.2. Objectives

The main purpose in the production of bituminous paving mixture is to find the right combination of sand, stone and other materials such as fly ash to create a mixture with these materials.
- Plenty of asphalt to ensure road stability.
- Strong enough to resist shear deformation caused by traffic at higher temperatures.
- Compacted bituminous contains sufficient air space to allow vehicles to be further compressed.
- Enough functionality for easy deployment without need for validation.
- A simple enough way to prevent premature breakouts from turning into curves.
- It is flexible enough at high temperatures to prevent cracking due to shrinkage.

1.3 Scope
It was decided to use the project in phases, mainly in the form of Marshall testing, to obtain the required engineering properties of the asphalt pavement mixture.
- IRC Class 2 Aggregate Classification consists of fly ash/brick dust, granulated blast furnace slag (600 microns to 75 microns) and stone aggregate with a size range of 19 mm to 600 microns.
- 80/100 bitumen was used instead of the 60/70 ratio of the traditional paving mix. Asphalt content in fill varied by brand until Marshall Properties discovered the change.
- Viscosity measurements of 80/100 bitumen at different temperatures were used to determine the asphalt mix and temperature.
- Marshall compares the combination's performance to the IRC's minimum requirements.

2. Literature Review
2.1 Evolution of mix design concept
In order to manage the quick removal of fine particles in the form of dust from Water Bound Macadam, which was brought on by the rapid growth of automobiles, bituminous paving was first applied on rural roads in the 1900s [4]. Heavy oils were initially used as a dust reliever. The necessary amount of heavy oil in the mixture was estimated using an eye estimation procedure known as the pat test. Using this method, the mixture was patted into the shape of a pancake and pressed up against a piece of brown paper. The appropriateness of the quantity was determined based on the amount of stain it made on the paper [4]. The Hubbard field method, which was initially developed on sand-bitumen mixture, was the first formal mix design method. The Hubbard field method could not be used with mixes containing large aggregates. This was one of this procedure's drawbacks. The California Department of Highways' Fransis Hveem, a project engineer, created the Hveem stabilometer in 1927. Hveem chose to measure a variety of mix parameters to determine the ideal amount of bitumen because he had no prior experience determining the perfect mix based solely on color. Hveem estimated the amount of bitumen needed using the surface area calculation concept, which was already in use at the time for cement concrete mix design [4].
In 1946 and 1954, respectively, the Hveem test was supplemented with the moisture susceptibility and sand equivalent tests [4]. Shortly before World War II, Bruce Marshall created the Marshall testing machine. The US Army Corps of Engineers adopted it in the 1930s, and in the 1940s and 1950s, it underwent modifications.
F. Pérez Jiménez et al , [7] ,focuses on the effect of filler nature and content on the behavior of bituminous mastics. The aim of this study is to analyze the effect of filler nature and content on the behavior of bituminous mastics.
[8], has studied the performance characteristics of bituminous concrete with industrial wastes as filler. Physical properties of these materials meet the requirements laid for fillers in Indian specifications. This study explores the possible use of these three industrial wastes along with fly ash and brick dust as filler

in bituminous construction. Different test procedures are used to examine the void content and clay content in fillers. Bituminous concrete (BC) mixes were designed as per Marshall Method.
[9] has studied the effect of fillers on bituminous paving mixes. An attempt has been made in this investigation to assess the influence of non-conventional & cheap fillers such as brick dust & fly ash in bitumen paving mixes. It has been observed as a result of this project that bituminous mixes with these non-conventional fillers result in satisfactory Marshall Properties though requiring a bit higher bitumen content, thus substantiating the need for its use. The fillers used in this investigation are likely to partly solve the solid waste disposal of the environment.
[10] has focused on the study of mineral filler effect on asphalt mixtures properties. In addition to affecting the mechanical properties of asphalts, mineral fillers are also important with respect to stripping or moisture damage. The paper presents mechanical properties of asphalt concrete with paving grade bitumen 80/100.
Filler is a component of asphalt concrete mixture. materials such as cement and lime are expensive, thus we would be considering waste materials that can be used as a filler [11], fillers play a significant role on the characteristics and performance of asphalt concrete mixture.
The gradation aggregates used in this project are as per IRC grading 2 as given in the following table :

Table 1: IRC Grading for bituminous concrete mixes

Grading	**1**	**2**
Nominal aggregate size	19mm	13 mm
Layer thickness	50-65mm	30-45 mm
I.S sieve	Cumulative percent by weight of total aggregate passing	
19	79-100	100
13.2	59-79	79-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	34-48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content by mass of total mix	5.0-6.0	5.0 - 7.0
Bitumen Grade	65	65

3. EXPERIMENTAL INVESTIGATION
3.1 Materials used

The main objective of this study is to examine the effectiveness, results and products of various materials, including waste materials, as other materials for asphalt pavements by comparing them with the asphalt pavement model as a control.
Experimentation forms the basis of this research to achieve the research objectives. Civil Engineering Laboratory tools and equipment will be used to perform all necessary tests. The following types are:

- Coarse Aggregates
- Fine Aggregates
- Bitumen
- Fillers - Fly ash

Coarse aggregate

Aggregates collected throughout the project were passed through a 13 mm sieve and then a 2.36 mm sieve.

Figure 1: Coarse aggregate

Fine aggregate

Aggregate collected through a 0.075 mm sieve and passed through a 2.36 mm sieve was used throughout the project.

Figure 2: Fine aggregate

Bitumen

Bitumen is a hydrocarbon product formed or produced by the pyrolysis process. It can be in gas, liquid or semi-solid form and is soluble in carbon tetrachloride and carbon disulfide. Asphalt material is widely used in highway construction due to its low water quality and stickiness. Paving grade asphalt refers to various grades of asphalt used in road construction and airport pavements.

Figure 3: Bitumen

Mineral fillers

Mineral fillers used in mixtures to improve product adhesion are generally considered fillers. Crushed aggregate and fine sand increase the stability of the mixture compared to gravel and rounded sand. Fillers

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used in asphalt mixtures include brick dust, lime, fly ash, mineral fillers and cement. Additionally, most IS sieves of 0.075 mm or 75 µm size were used as fillers. The filler used in this project is fly ash.

Fly ash

Fly ash is a byproduct of the combustion process in power plants and is used in the paving industry to stabilize roads, subbases and base layers. 4% fly ash is good.

Figure 4: Fly ash

3.2 Methods

3.2.1 Test on Bitumen

- Penetration Test

Table 2: Results of penetration test of Bitumen 80/100

Sample	*Reading-1*	*Reading -2*	*Reading-3*	*Average*	*Final Average*
1	105	84	80	89.67	85.33
2	90	84	69	81.6	

- The softening point test

Table 3: Results of Softening Point test

Specimen no(80/100)	*Softening point(0C)*	*Average*
1	49	47
2	47	

- Specific gravity - Specific gravity Grade 80/100 = 1.03
- Viscosity test
- Ductility test - Ductility = 75cm

3.2.2 Test on Aggregate

- Elongation index
- Flakiness index
- Specific gravity

Table 4: Aggregate test results

Parameters	*Value*
Specific gravity	2.63
Impact Strength (%)	20.21
Abrasion Strength (%)	19.52

Water Absorption (%)	3.07
Crushing strength (%)	19.15

3.3 Procedure to Marshall Test

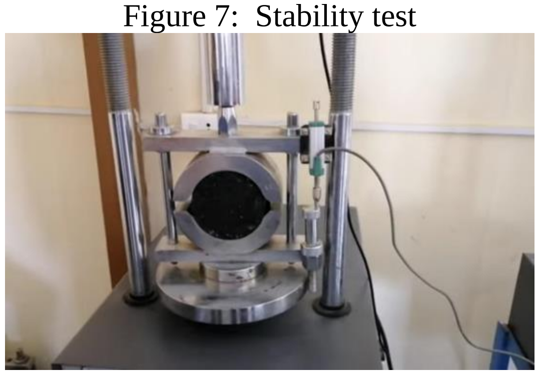
Figure 5: Marshall apparatus

The device heats weight up to 1200 grams to 154 to 160 degrees Celsius. Asphalt is heated at 175-190 degrees Celsius. Asphalt and aggregate are mixed together to create a uniform gray color. The Marshall mold measures 100mm x 64mm and is compressed by 75 machines on each side.

Figure 6: Water bath

The mold is removed and left in the laboratory at room temperature for a day.
In a constant bath at 60 degrees for half an hour. Apply a load of 50 mm per minute in the vertical direction. Marshall stability value is the maximum value at which the model fails.

Figure 7: Stability test



We call the corresponding vertical strain flow rate.
1200 grams of ingredients were used in total to prepare a Marshall specimen. The weight-proportions of the ingredients were determined for different bitumen percentages.

Table 5: Calculation of quantity of aggregates (having fly ash as filler)

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Sieves (in mm)	***Material***	***5% Bitumen***	***5.5% Bitumen***	***6% Bitumen***	***6.5% Bitumen***
19	Stone chips	125	125	124	124
13.2		114	113	113	113
9.5		194	193	192	191
4.75		137	136	135	134
2.36	Slag	102.5	102	101.5	101
1.18		102.5	102	101.5	101
0.6		102.5	102	101.5	101
0.3	Fly ash	80	79.5	79	78.5
0.15		102.5	102	101.5	101
0.075		80	79.5	79	78.5
Total Aggregate		1140	1134	1128	1122
Bitumen		60	66	72	78
Passing 0.075					

4. Results and Discussion

4.1 Marshall Test Results

The results of the Marshall test of individual specimens and average Marshall properties of specimens prepared with brick dust as filler for varying bitumen contents have been presented in tables 6.

Table 6: Test results of Marshall Specimens (specimens with fly ash)

Bitumen (80/100) %	***Sample No.***	***Weight in air***	***Weight in water***	***Flow value (mm)***	***Stability Value(kg)***	***Gt***	***Unit wt (g/cc)***	***% air voids***	***VMA***
	1	1176	608.2	1.7	2080	2.25	2.07	8.69	18.74
	2	1182	618.1	1.9	2000		2.1	7.14	17.33
	3	1066	548.2	1.9	2220		2.06	9.2	19.2
5	4	1172	611.5	2.2	1305		2.09	7.65	17.79
	1	1182	623.3	2.4	2140	2.23	2.1	6.2	17.41
	2	1170	614.5	2.1	1910		2.09	6.69	17.85
	3	1174	616.5	2.7	2570		2.09	6.69	17.85
5.5	4	1142	599.1	2.4	2380		2.08	7.21	18.31
	1	1198	628.6	2.7	2000	2.19	2.1	4.28	16.51
6	2	1164	612.5	3.1	2800		2.11	3.79	16.08

	3	1174	616.1	2.5	2500		2.1	4.28	16.51
	4	1182	619.5	2.9	2550		2.1	4.28	16.51
	1	1098	570.4	3.3	2190	2.17	2.08	4.32	17.44
	2	1084	570.1	3.4	1970		2.1	3.33	16.58
6.5	3	1082	564.1	3.8	2400		2.05	5.85	18.78

Table 7: Average Marshall Properties of samples with fly ash as filler

Marshall properties	***Bitumen %***			
	5	5.5	6	6.5
Stability (kN)	18.64	22.07	23.53	21.39
Unit wt (g/cc)	2.08	2.09	2.1	2.07
Flow value (mm)	1.95	2.4	2.8	3.5
% air void	8.17	6.69	4.18	4.5
VMA (%)	18.27	17.88	16.41	17.6

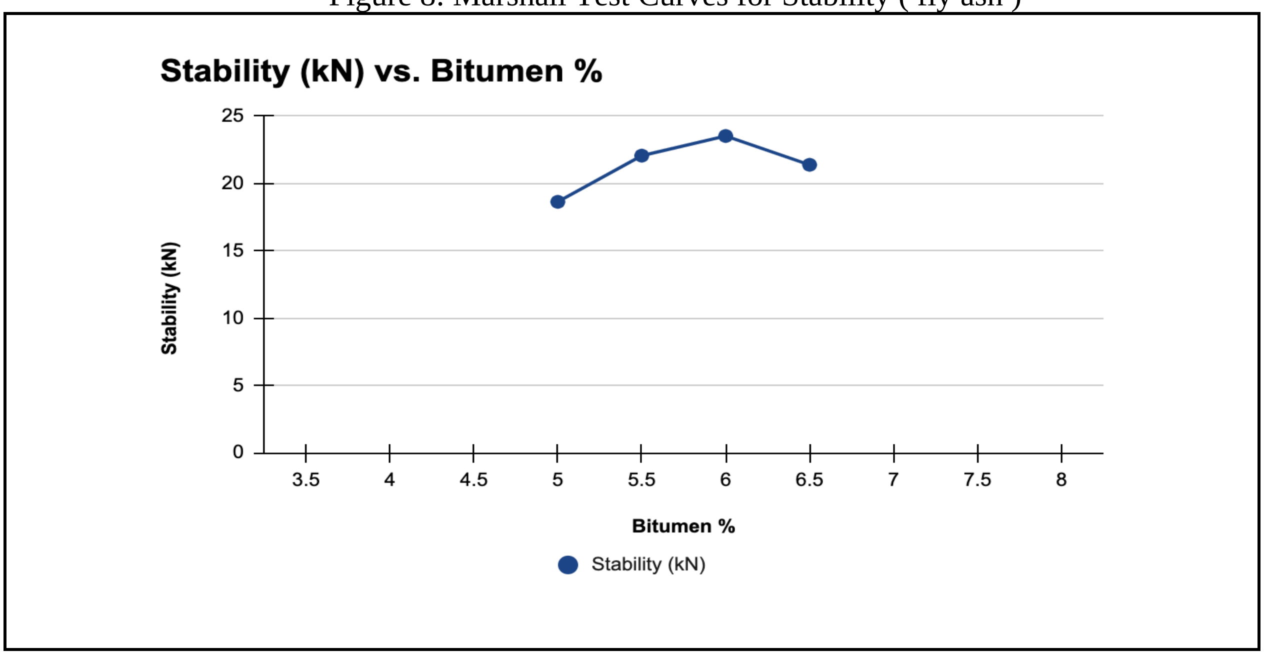
4.2 Discussion of Result

4.2.1 Marshall Mix Design properties using fly ash as filler

Marshall Stability

Fig. 8 shows the variation of Marshall Stability with bitumen content where it is seen that as usual the stability value increases with bitumen content initially and then decreases. Maximum stability value of 23.2 kN is observed at 6% bitumen content in case of fly ash as a filler.

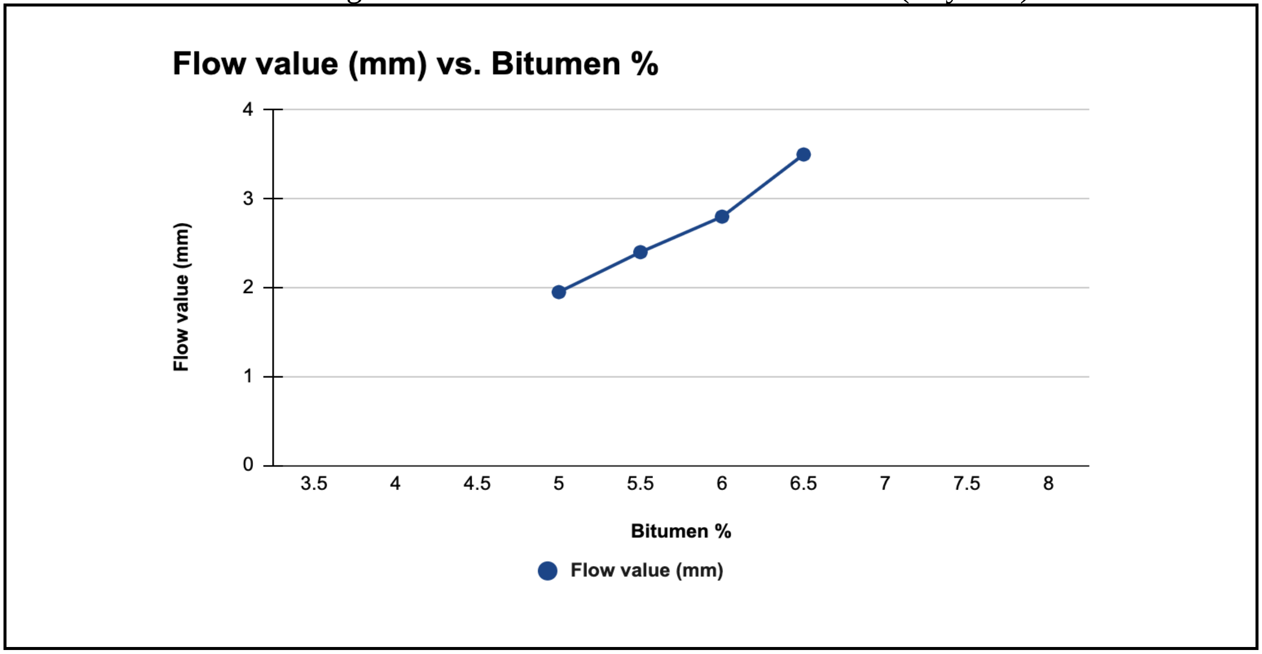
Figure 8: Marshall Test Curves for Stability (fly ash)



Value of Marshall Flow (mm)

The variation of the Marshall flow value with percentage of bitumen content is depicted. It is evident that an increase in bitumen content typically results in an increasing trend.

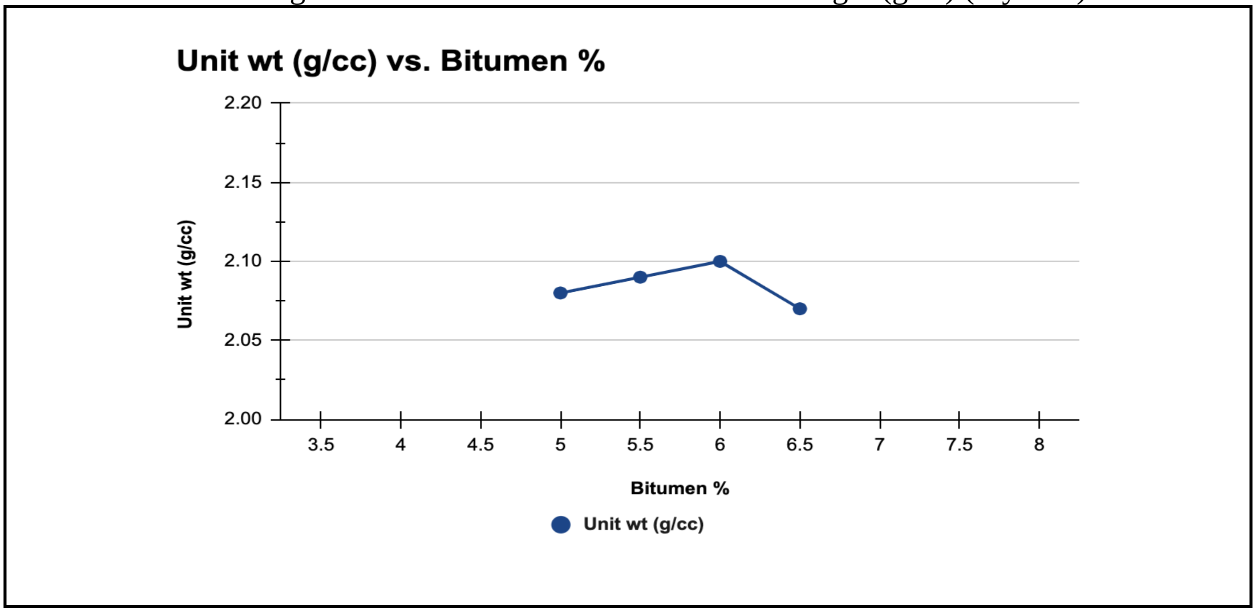
Figure 9: Marshall test curves for flow value (fly ash)



Weight curves for Marshall Units (g/cc)

The bitumen content variation for Marshall specimens containing fly ash as filler is represented graphically by unit weights, with the maximum unit weight obtained in fly ash specimens being 2.10 g/cc at 6% bitumen content.

Figure 10: Marshall test curves for Unit Weight (g/cc) (fly ash)



Fly ash in the Marshall air voids (%) curve

Figure illustrates how the percentage of bitumen content affects the variation in air voids. At 6% bitumen content, the minimum percentage of air voids is 4.13 percent.

Figure 11: Marshall test curves for Air void (%)(fly ash)

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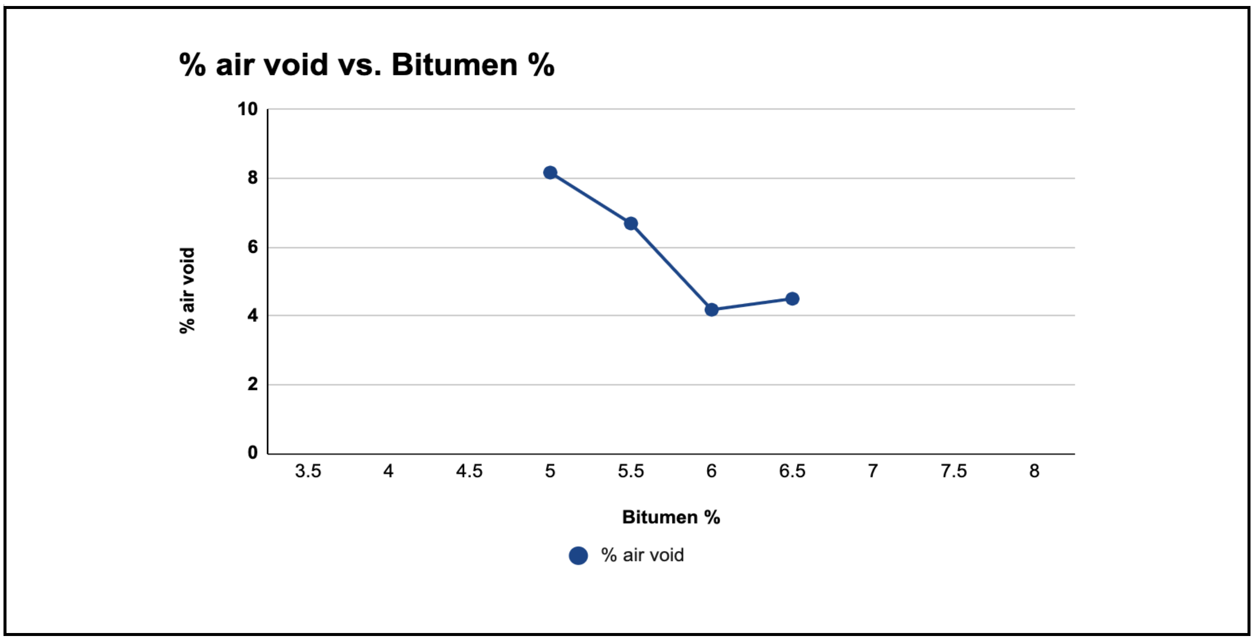
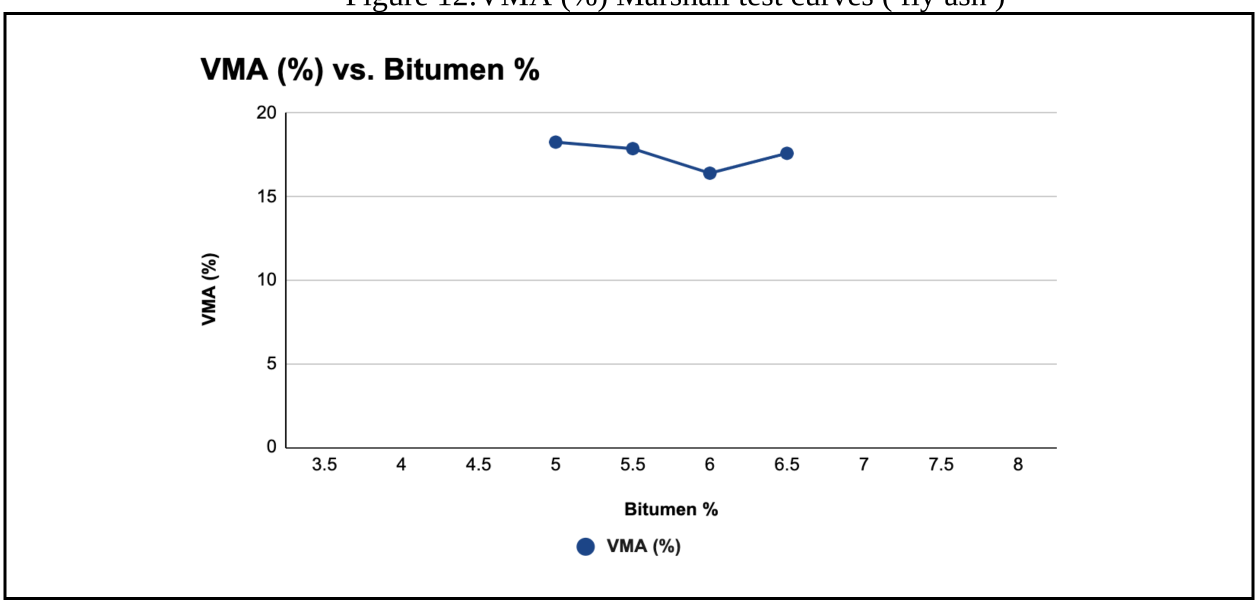


Fly ash on Marshall's VMA (%) curve

In fig. 12 we find that non conventional fillers such as fly ash and brick dust are found to have given a higher stability value at slightly higher bitumen content in comparison with conventional fillers cement and lime this might be due to higher bitumen content.

Figure 12:VMA (%) Marshall test curves (fly ash)



5. Conclusion

- Bituminous mixtures containing fillers such as fly ash have been shown to have almost the same Marshall properties as conventional materials such as cement and lime.
- Bituminous mixture with fly ash as filler shows the best stability when the asphalt content is 6%, and an increase up to 6%, then I will gradually reduce it. Unit weight/density also showed consistency and flow rates were satisfactory at 6% bitumen content.
- It was observed that this mixture should contain more air than the mixture.

- More asphalt content is required to meet design standards and achieve good quality.
- The above discussion clearly shows that with further testing, waste materials such as fly ash can be used to make asphalt concrete mix for paving.
- Additional design changes can be made to use fly ash as asphalt pavement filler, which will solve some construction waste and economic problems.
- Although fly ash can be used instead of cement and stone powder, the waste problem can be effectively solved and the production area for industrial waste can be reduced.< br>After comparing the cost of non-standard equipment with the cost of the model used, the performance of non-standard equipment can be determined, which will reduce the cost of construction.
- It became clear as a result of further tests that waste materials such as fly ash can be used to prepare asphalt mixtures for paving purposes.

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