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Laboratory Evaluation of Asphalt Pavements With Different Fillers

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ABSTRACT:

When a vehicle passes on the road, there is always some kind deformation on the pavement. As soon as load is removed, the pavement regains its original position. But with the elastic deformation, there is some plastic deformation. This plastic deformation that occurs due to load stresses result in deterioration of pavement. Due to accumulation of these stresses, various types of failure occur in pavement especially fatigue and rutting. The flexible pavement mainly consist of coarse aggregates, fine aggregates, filler and bitumen. In this investigation, effect of different types of fillers was evaluated. It is observed that with the addition of filler, asphalt mixes showed improved resistance against rutting and frost related damage. The Marshall stability of asphalt mixes incorporated with different fillers increased with cement showing maximum stability followed by fly ash and stone dust. The incorporation of fillers such as fly-ash which can cause land pollution are exploited in the pavement construction sector. This will help in maintaining the nature of the environment as well as help in saving our natural resources. Fillers also improved the density of the mixes. It is recommended for future to test asphalt samples with different proportions of fillers at different temperatures especially for cold region areas.

KEYWORDS: Marshall Stability, fillers, asphalt pavements, rutting, fatigue.

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INTRODUCTION:

Pavement is a durable coating laid in the targeted area to support vehicles or pedestrians. In the past, widespread use of cobblestones and granite was made, but now these surfaces are mostly replaced by asphalt or concrete. Road surfaces are regularly marked to guide vehicular traffic. The asphalt is composed of three major components; aggregates, binder and fillers. The relationship between these different components leads to a family of asphalt mixtures with different properties. Asphalt typically includes a proportion of air, which is often regarded as the fourth component. Minimizing the amount of air through the proper design and a proper compaction is essential to ensure a durable product. Furthermore, very little air, caused by overfilling aggregate structure can lead to rutting. Basically, gaps/voids are measured in the air and do not take into account the interactions between bitumen and filler. Charge interactions in the different types of bitumen can lead to changes in different ways. The filler may cause variations in the viscosity of the liquid phase as a result of the restructuring, changes or other physical effects. Fillers modify the properties, accelerate the performance, and offer greater durability to composites, polymers, rubber, adhesives, coatings and building materials (such as concrete and asphalt). Fillers are used to reduce the cost of materials, increase the stiffness and provide special features to a material (such as color or fireproof). The effects of fillers are therefore crucial. Typical fillers are fine powders having a particle size in the range 0-100μm. Fillers can be naturally occurring like calcium carbonate, manufactured or derived from industrial waste such as fly ash from power plant. Other conventional fillers include silica, kaolin, mica, feldspar and silica materials. Fillers modify the system in two ways. Firstly, the manner in which shape, particle size and the size distribution of the particles of the filler affect the system by filling the liquid with solid particles. Secondly, the way that the interactions between the solid and liquid phase of the mixture meets the material. Second interactions may vary by strong chemical bonds or physical interactions leading reinforced materials strength. Fillers are used to reduce the cost of materials, to modify the processing characteristics and to increase the rigidity. The fillers are used to improve the surface properties and thermal properties (such as conductivity). Asphalt fillers can be defined as "finely divided mineral substance, such as rock dust, slag dust, hydrated lime, hydraulic cement, fly ash or other suitable material" and typically this definition refers to the size fraction smaller than 75μm or 63μm. Fillers in asphalt are used to obtain greater rigidity or stiffness, reduce down permanent deformation, to increase the density and reduce the cost of asphalt mixtures[1]. Excess filler in asphalt mixtures can lead to problems with fatigue cracking or increasing stiffness. Too little can cause "bleeding" of the mixture of bitumen[2, 3]. These additives increase the stiffness of asphalt mix, improve rutting resistance of pavements and also improve the durability of the mix. Their use also Reduces potential for asphalt stripping. Reduced cost as compared to other mineral fillers. The analysis of lime in construction of road was done and it was observed that lime has good potential in the application of highways[4]. Its low specific gravity, smooth draining nature, ease during compaction, insensitiveness towards change in moisture and better frictional properties can be successfully exploited in construction of roads. A study was conducted on the feasibility of fillers in asphalt concrete[5]. Two different binders were used. These binders were fully blended with filler materials i.e. fly ash, lime and cement .The study result demonstrated that Fly ash helps in improving the aging resistance of mastics. With the addition of fillers, compatibility of mixtures was not affected. Researchers in their study developed samples of bituminous aggregate mixtures having fly ash, cement and lime as a filler with varying percentage of bitumen. After preparing various samples, laboratory investigation was done. The following results were observed: Fly ash as a filler can be used in asphalt mixtures successfully[6]. With the addition of filler, optimum bitumen content was observed to be lower in mixtures. For flexible pavements, lower proportion of optimum moisture content is considered better. It leads to fewer voids in sub grade. Thus with the usage of pavement, there will be less settlement. Fly ash also helps in reducing potential for asphalt stripping due to its hydrophobic nature.

EXPERIMENTAL INVESTIGATION:

The various materials used in this study are limestone aggregates, fine crushed stone dust, bitumen (VG-10), river sand and different fillers.

ASPHALT BINDER:

Asphalt used in the study is of penetration grade 80/100 (VG-10). This grade is having low viscosity and is better suited for cold regions. It was purchased from the local distributor "ROYAL BITUMEN DEALERS". Several tests have been conducted in laboratory to evaluate the physical properties of Asphalt Binder

Table 1: Test results conduced on bitumen, VG-10 (80/100 Penetration grade)

Test Property	**Testing Method**	**Average Value obtained**	**Standard Values (IS;73/MORTH)**
Penetration value (25^0C, 100g, 5sec), 0.1mm	IS: 1203	96	80-100
Softening point value (R&B), ^{0}C	IS: 1205	50	≥40
Flash point (Cleveland open cup), ^{0}C	IS: 1448 [P:69]	230	≥220
Ductility of residue from TFOT (25^0C, 50 mm per minute rate), cm	IS: 1208	85	≥75
Specific gravity	IS: 1202	1.02	0.99-1.2

FILLERS

Three different types of fillers were selected in this study. These are lime, cement, and fly ash. Cement was bought from the local distributor of the ACC plant, Phagwara. Lime and fly ash was brought from various local sources. The filler material is screened by No. 200 sieve[7]. Specific Gravity of the cement, lime and fly ash was calculated and noted down.

Table 2: Specific Gravity of various fillers

Fillers	Specific gravity
Lime	2.1
Fly ash	2.5
Cement	3.2

AGGREGATES:

In combination to the binder, and mineral fillers used in Marshall Technique, crushed stone will be used in the preparation of bituminous mixture samples. Aggregate having desirable properties such as strength, hardness, toughness, specific gravity and shape is selected. The determination of physical properties of aggregates is done by performing various tests. The coarse aggregates and fine aggregates are isolated into different screen sizes. Aggregates are sieved, examined and recombined in laboratory to meet the specific gradation·

Table 3: Physical properties of aggregates

Materials	Limestone Aggregates
AGGREGATE IMPACT VALUE %	14
LOS ANGELES ABRASHION VALUE %	15
SPECIFIC GRAVITY	2.78
WATER ABSRPTION %	0.88

MARSHALL MIX DESIGNS:

Marshall Stability test is performed to determine the optimum bitumen content and the test samples shall be prepared by combining varying percentages of bitumen ranging from 4.5% by the weight of aggregates to 6.5% with an increase of 0.5 % for each type of fillers. The Specimen preparation, compaction and testing will take place according to Marshall Mix Design Method[8].

Marshall Stability and Flow Tests are conducted on each sample. The bulk specific gravity, density, and percent air voids will be determined for each sample

GRADATION:

For preparation of bituminous mixes, aggregate gradation is done according to the MORTH specifications. The combined gradation should be within the limits as per MORTH. The various sieves are put along one another according to the size. About 2.5 to 3kg of aggregates is taken and sieved through the various sizes. The percentage passing through each sieve is shown in table 4 below

Table 4: Proportioning and gradation of aggregates

Is sieve (mm)	Size of aggregates (mm) (individual gradation)					Blending (Hit and trial method)					combined Gradation	Desired limits
	20	10	6	sand	filler	20	10	6	sand	filler		
						20%	22%	30%	25%	3%	100%	
26.5	80	100	100	100	100	16	22	30	25	3	96	90-100
19	38	100	100	100	100	7.6	22	30	25	3	87.6	71-95
13.2	12	80	92	100	100	2.4	17.6	27.6	25	3	75.6	56-80
9.5	5	30	82	100	100	1	6.6	24.6	25	3	60.2	40-65
4.75	0.8	10	40	100	100	0.16	2.2	12	25	3	42.36	38-54
2.36	0.2	3	25	80	100	0.04	0.66	7.5	20	3	31.2	28-42
0.3	-	0.7	10	38	100	-	0.154	3	9.5	3	15.654	7-21
0.075	-	0.54	0.3	12	26	-	0.1188	0.09	3	0.78	3.988	2-8

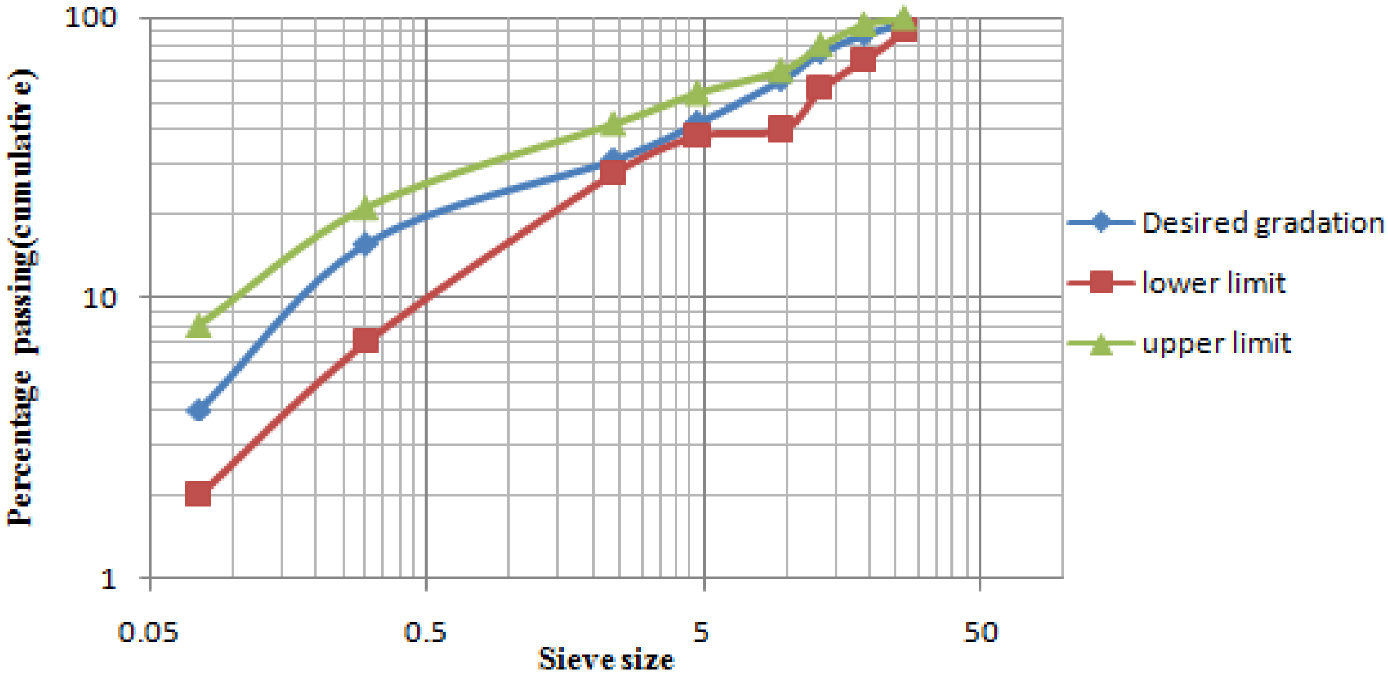

Figure 1: Gradation curves of aggregates

Table 5: Marshall Characteristics of a mix using virgin bitumen

Bitumen Content (%)	Unit wt. (g/cc)	Air voids (%) (Va)	Voids filled with bitumen (VFB)%	Stability (kN)	Flow (mm)
4.5	2.361	5.58	65.38	9.21	2.13
5	2.38	4.46	72.31	9.45	2.25
5.5	2.391	4.12	75.04	10.8	2.52
6	2.364	3.3	78.03	11.3	2.78
6.5	2.352	2.83	82.42	9.82	3.03

Table 6: Marshall Characteristics of a mix with cement as a filler:

Bitumen content (%)	Unit wt. (g/cc)	Air void (%) (Vv)	VFB (%)	Stability (kN)	Flow (mm)
4.5	2.53	5.76	65.3	13.35	2.15
5	2.55	4.23	74	14.8	2.32
5.5	2.539	4	78	13.01	2.61
6	2.52	3.87	79.6	12.03	3.01
6.5	2.49	3.8	83.3	11.32	3.24

Table 7: Marshall Characteristics of mix with fly ash as filler:

Bitumen content (%)	Unit wt. (g/cc)	Air void (%) (Vv)	VFB (%)	Stability (KN)	Flow (mm)
4.5	2.48	4.62	72.02	13.03	3.23
5	2.495	3.21	79.6	14.31	3.36
5.5	2.471	3.06	82.06	12.62	3.58
6	2.468	2.6	85.07	11.59	3.76
6.5	2.461	2.45	87.03	10.32	3.88

Table 8: Marshall Characteristics of mix with stone dust as filler:

Bitumen content (%)	Unit wt. (g/cc)	Air voids (%) (Vv)	VFB (%)	Stability (kg)	Flow (mm)
4.5	2.518	5.33	67.60	13.15	2.61
5	2.527	4.3	73.83	14.35	2.76
5.5	2.524	3.74	78.42	12.81	3.01
6	2.496	3.88	78.01	11.72	3.43
6.5	2.48	3.42	82.64	10.41	3.51

COMPARISON OF VARIOUS PROPERTIES BETWEEN MODIFIED MIXES AND VIRGIN MIXES:

STABILITY:

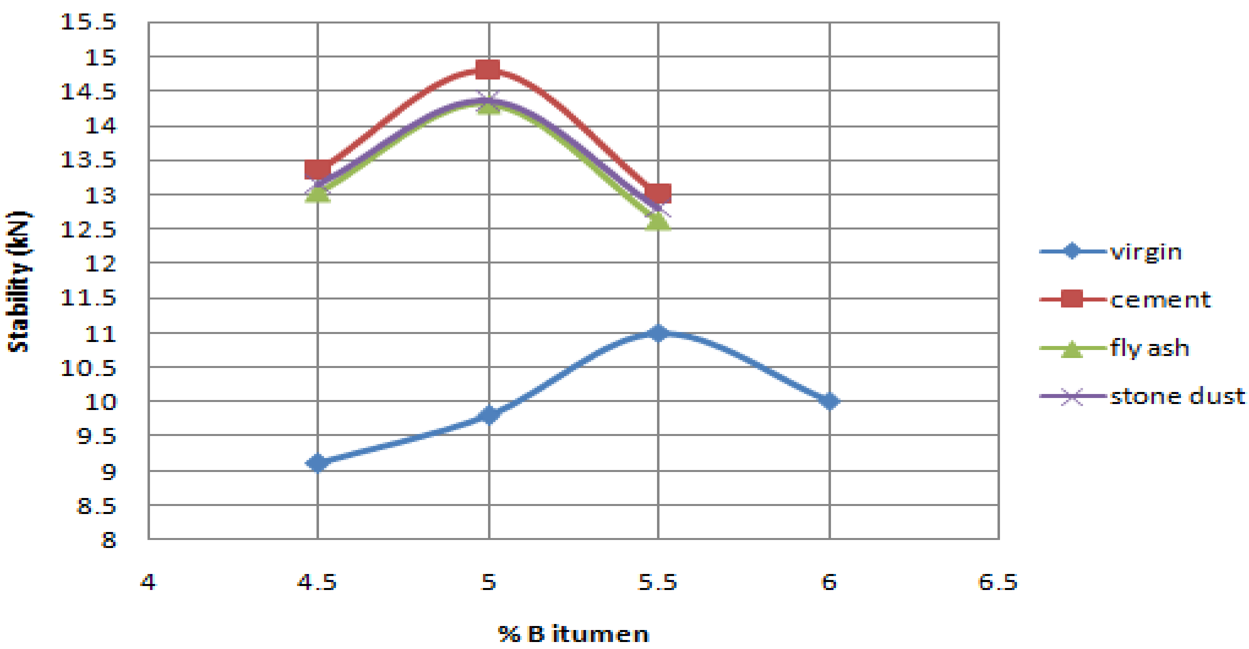

Figure 2: Showing maximum stability with cement incorporated mixes

FLOW VALUE:

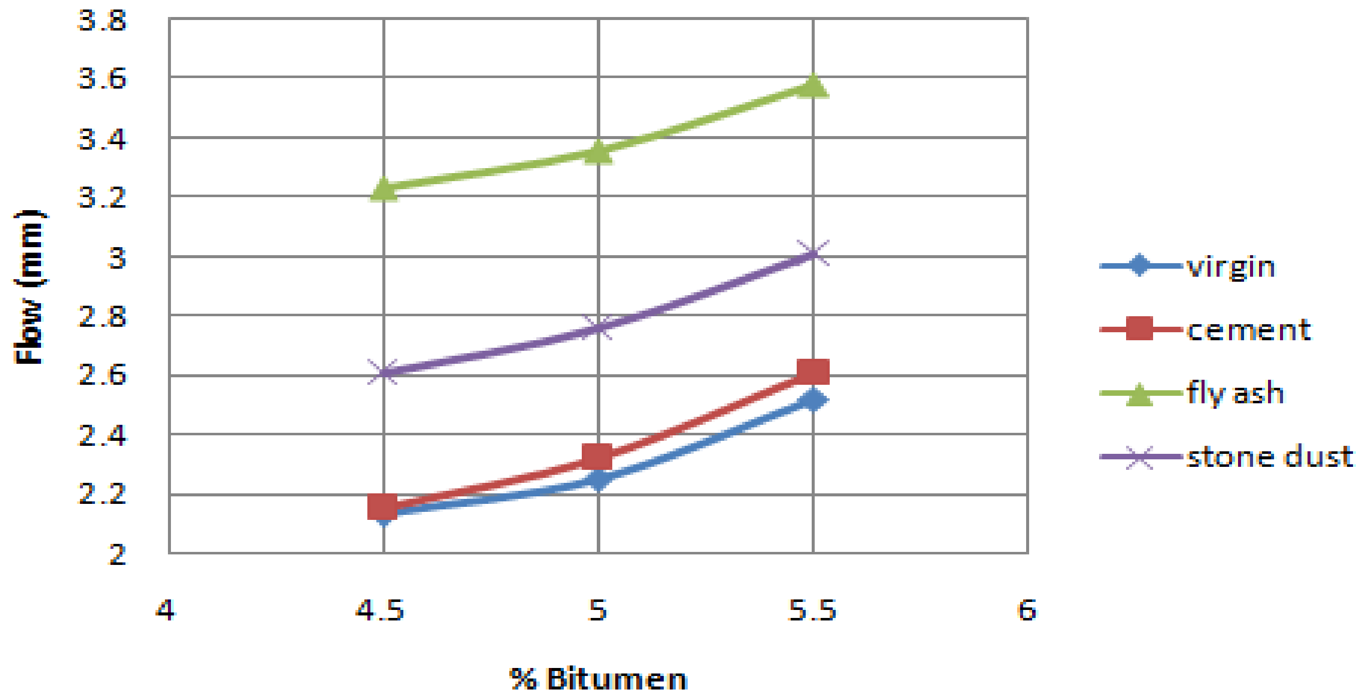

Figure 3: Showing Maximum flow with respect to fly ash

VOIDS FILLED WITH BITUMEN (VFB):

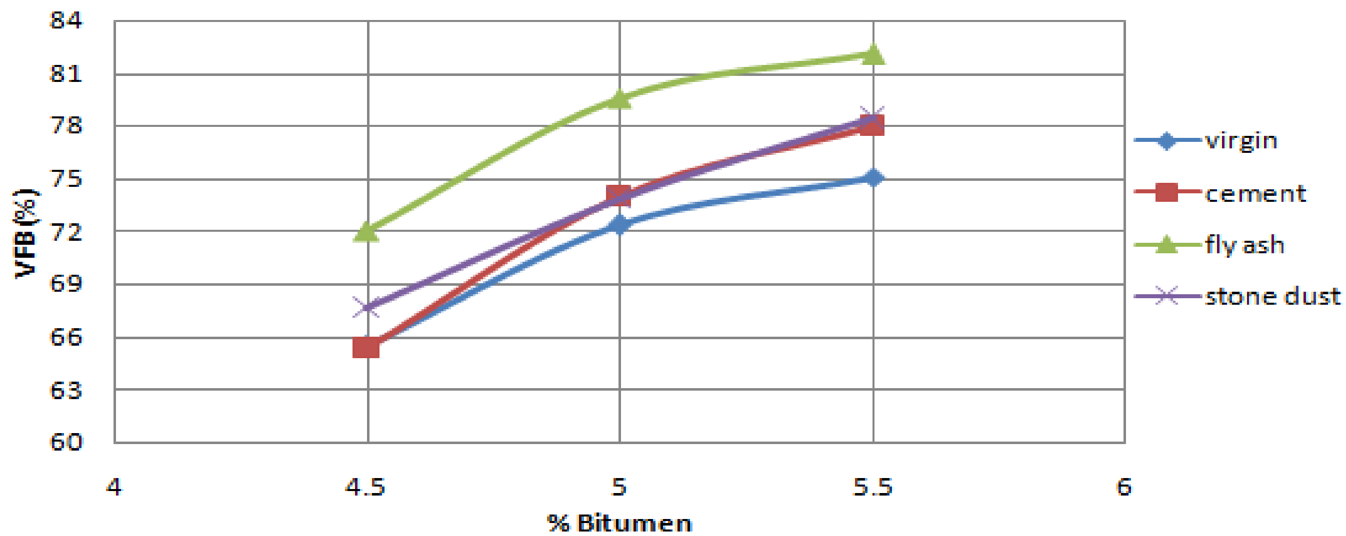

Figure 4: Showing maximum VFB with respect to fly ash

Air Voids:

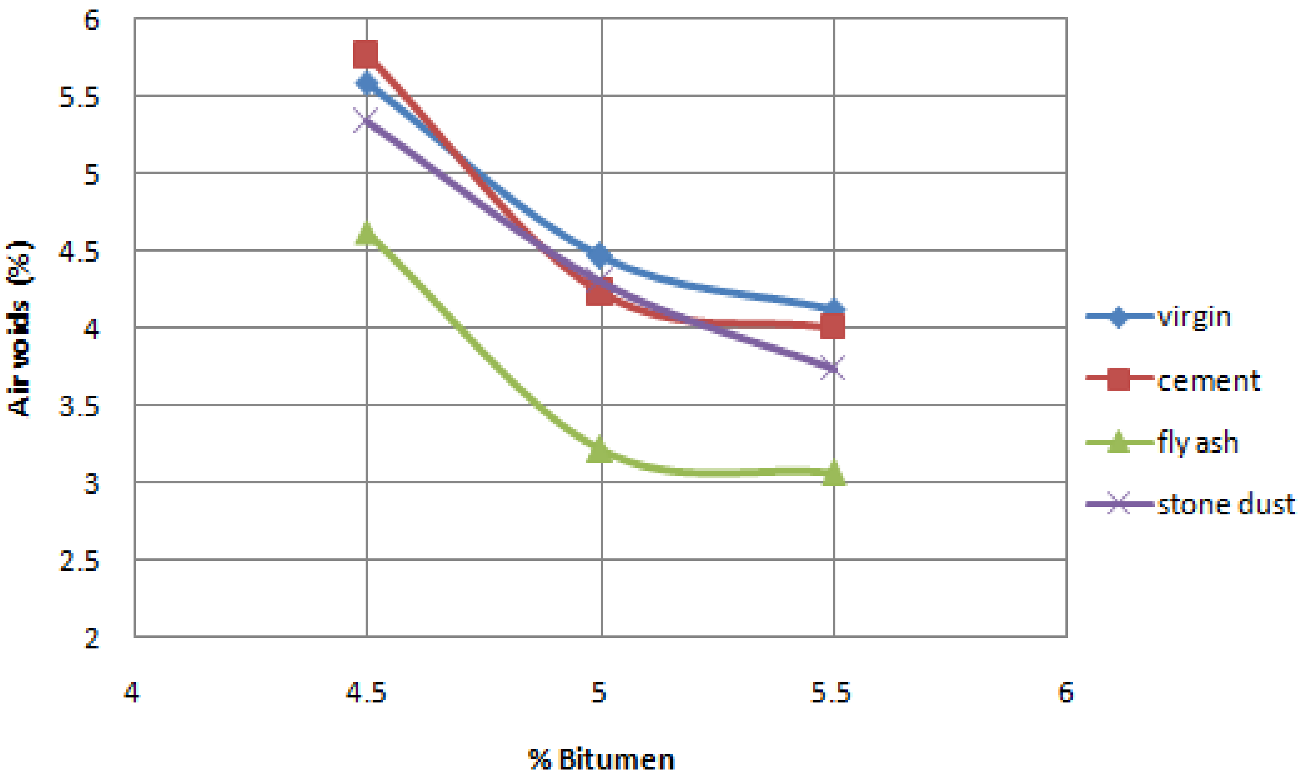

Figure 5: Showing minimum air voids with respect to fly ash

CONCLUSION:

Based on the results of the experimental investigations conducted on normal and modified bitumen using fillers, the following summaries have been drawn:

(1) The incorporation of various fillers in asphalt mixes improved the stability with cement incorporation showing maximum stability and virgin showing least stability.

(2) The use of fillers tend to fill more voids between aggregate grains. Thus mix will continue to gain strength, leading to increased resistance of bituminous mix against rutting

(3) The density of bituminous mixes prepared with fillers increases up to certain limits and then decreases.

(4) The incorporation of fillers improves the mechanical properties of bituminous mixes. Their incorporation will also reduce the harmful effect on the environment.

From the above results, it is observed that fly ash being a waste product can be effectively used as a filler to improve the properties of bituminous mix. Fly ash also being cost effective as compared to cement and lime.

FUTURE SCOPE:

The long term performances of these mixes has to be evaluated before going for all out use. Their use at different temperatures under different conditions has to be evaluated. The fatigue and low temperature cracking is to be evaluated.

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