Effect of flakiness & elongation indices on the bituminous mixes

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Abstract— **Flakiness & Elongation index is one of the most prominent criteria that govern behavior and performance of aggregate in the bituminous mixes. The strength and serviceability requirements of bituminous mixture such as Stability, Flow, Voids in Total mix (VTM), Voids Filled with Bitumen and (VFB) highly depend on the physical properties of aggregates. This study conducted by observing the effect of flakiness & elongated index by adding different percentages from 0% to 50% of flaky & elongated aggregates of different sieve with required quantity to the bituminous mixes. The method of Marshall Mix design is adopted for this purpose.**

The change in rotation angle of coarse aggregate was found to correlate well with the internal resistance of a HMA mix. The particle shape determines how aggregate was packed into a dense configuration and also determines the internal resistance of a mix. Cubical particles were desirable for increased aggregate internal friction and improved rutting resistance. Also the Particle index (PI) value correlated well to aggregate geometric characteristics. The more cubical the aggregate, the higher the PI value is obtained.

Index Terms— **Bituminous Concrete (B.C), Flakiness index (F.I), Flow, Hot mix asphalt (HMA), Stability, Voids Filled with Bitumen (VFB), Voids in Total mix (VTM).**

I. INTRODUCTION

Road transport provides greater utility in transport over short and long hauls of lighter weight commodities and of lesser volumes as also for passenger transport for short and medium hauls. Road transport has shown immense potential in highly advanced countries, especially for passenger transport due to flexibility in operation and door to door service. Development in road network is regarded as a social, commercial and economic progress of a country. No region or country can flourish, if it lacks adequate transport facilities and mainly in road network. Road as one of land transportation infrastructure is very important in supporting the economic for both regional and national development.

The quality of material for road construction will also influence the road performance. Bituminous concrete as one of road surface material is mainly influenced by the quality of aggregates. Aggregates are the principal material in pavement, since aggregate occupies 95% by weight in total mixture. Various shapes of aggregates might be occurred during crushing in the crushing plant starting from rounded to flaky and elongated aggregates. Some tests on aggregates have to be done prior its use in asphalt mixture such as gradation, toughness, durability, shape, surface texture, specific gravity, micro texture, etc. The engineering properties of aggregates, including aggregate shape are therefore very important in having satisfied performance of asphalt concrete mixture including the workability index and stiffness modulus. One of the aggregate properties is called as 'flaky' measured as a Flakiness Index (FI) and 'elongated' measured as a Elongation Index (EI) and it is suspected to influence the performance of B.C mixture.

Flakiness index of an aggregate can be defined as a percentage by weight of particles whose least Dimension (Thickness) is less than 0.6 of their mean dimension. Elongation index of an aggregate can be defined as a percentage by weight of particles whose greatest dimension (Length) is greater than one and four fifth times or 1.8 times of their mean dimension. Physical shape of coarse aggregate is a very important property in performance of the bituminous mixes in the highway pavements. Existence of flaky &elongated materials in the bituminous mixes is an undesirable and a dangerous phenomenon because of their tendency to break under wheel load either during compaction in construction stage or in service life of the pavement. The flaky &elongated aggregates will also cause problem in achieving the required degree of compaction.

II. OBJECTIVE OF STUDY

To study the effect of different proportions of flaky & elongated particles (0 %, 10%, 20%, 30%, 40%, and 50%) taking 5.2% as constant bitumen content of CRMB.

- To study the basic properties of CRMB.
- To study the properties of stability, flow by varying the percentages of elongated aggregates using Marshall stability test
- To study the bulk density and volumetric properties (VTM, VFB, VMA) 0f Marshall Specimen's.

III. EXPERIMENTAL INVESTIGATIONS

Basically the materials that are used in this study include aggregate components such as stone dust and flaky & elongated aggregates. Second important item is Base bitumen. The most important tests which are carried out along this thesis are sieve analysis, flakiness & elongation index test and Mix design by using Marshall Mix design method.

Aggregate

Impact Test
Los Angeles abrasion Test
Aggregate crushing value Test

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Stripping Test of aggregate
Flakiness & Elongation index Test of aggregate
Specific gravity of aggregate

Bitumen

Penetration Test
Softening point Test
Ductility Test
Viscosity Test
Specific gravity of bitumen

Mix Design

Specimen preparation
Properties of the Mix
Theoretical specific gravity of the mix G_t
Bulk specific gravity of mix G_{mb}
Air voids percent Vv or VTM
Percent volume of bitumen Vb
Voids in mineral aggregate VMA
Voids filled with bitumen VFB
Marshall Testing

IV. DISCUSSION OF RESULTS

Aggregate test

A number of tests have been discussed for both aggregate and bitumen, in order to insure that their physical property is suitable according to the given criteria. The test results of aggregate and bitumen are given in Annexure1 and Annexure 2.

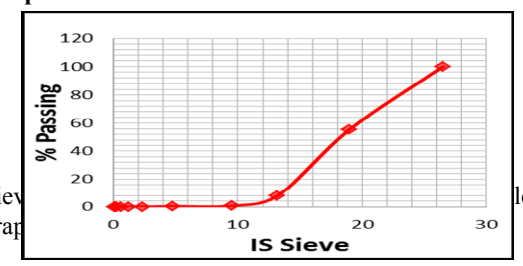
The individual results of sieve analysis are shown with their respective graphs. Sieve analysis result of coarse aggregate as shown in table 1 and graph 1.

20 mm size aggregate weight = 5.457k

Table 1 represents sieve analysis of coarse Aggregates

Is sieve (mm)	Cum Passing %
26.5	100
19	55.58
13.2	8.145
9.5	0.807
4.75	0.44
2.36	0.102
1.18	0.1
0.6	0.1
0.3	0.1
0.15	0.1
0.075	0.1

Graph 1



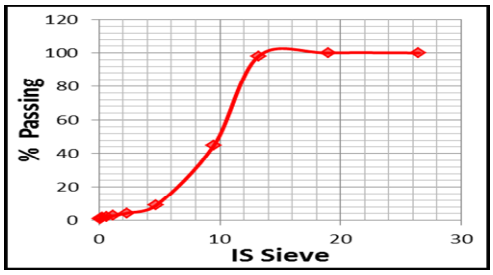
Siev le 2 and grap

12mm size aggregate weight = 4.447kg

Table 2 represents sieve analysis of fine Aggregates

Is sieve (mm)	Cum Passing %
26.5	100
19	100
13.2	98
9.5	44.774
4.75	9
2.36	4.346
1.18	2.8
0.6	2.2
0.3	1.7
0.15	1.3
0.075	0.8

Graph 2



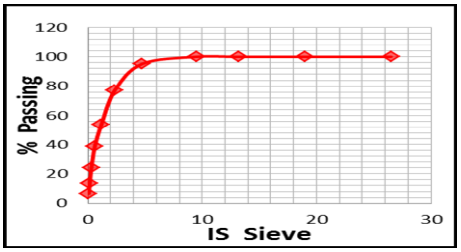
Sieve analysis result of stone dust as shown in table 3 and graph3.

Stone dust weight = 2.504kg

Table 3 represents sieve analysis of fine Aggregates

Is sieve (mm)	Cum Passing %
26.5	100
19	100
13.2	100
9.5	100
4.75	95.248
2.36	77.277
1.18	53.755
0.6	38.58
0.3	23.924
0.15	100
0.075	100

Graph 3



The combined Sieve analysis results of coarse aggregate, fine aggregate and dust are shown in Annexure 3.

B. Bitumen Tests

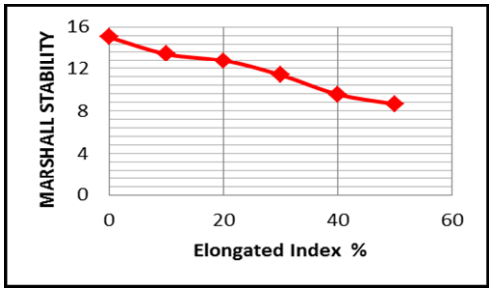
1. Stability

It's the property of strength and performance of the bituminous mixes against wheel loads and traffic intensity.

Table 4 represents stability test results

Flaky & Elongated %	MARSHALL STABILITY (KN)
0	15.03
10	13.44
20	12.78
30	11.38
40	9.55
50	8.63

Graph 4



It was observed that it has been observed that with increasing flakiness & elongation index, stability decreased by 42.58%. The maximum stability is 15.03 KN and sharply decreased to 8.63 KN at 50% flakiness & elongation index.

2. Flow

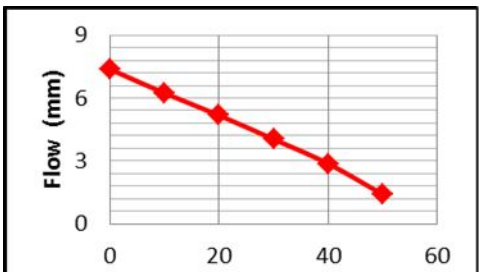
Flow is the deformation of the bituminous mixes under a certain applied load. In this study we observe that the value of flow decreases with increasing elongation index.

Table 5 represents flow index results

Flaky & Elongated %	Flow (mm)
0	7.37
10	6.23
20	5.17
30	4.03
40	2.87
50	1.4

It was observed that the value of flow decreases with increasing elongation index by 81%. The maximum value of flow is 7.37 mm at non-flaky mix and its 1.40 mm at 50% elongation index. The acceptable flow limit is between 2-4 mm.

Graph 5

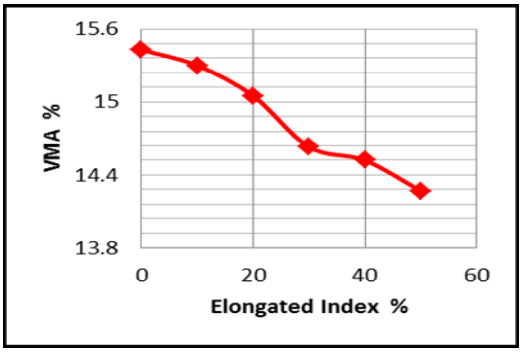


3. Void in mineral aggregate (VMA)

Table 6 represents the VMA Results

Elongated Index	VMA %
0	15.43
10	15.3
20	15.05
30	14.63
40	14.52
50	14.27

Graph 6



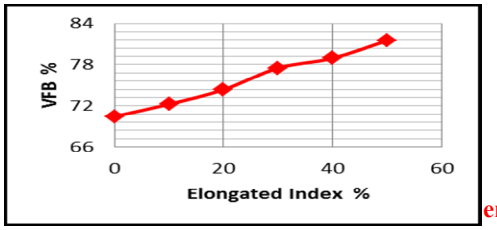
From the results it was observed that the value of VMA is decreasing with increasing of flakiness & elongation index by 7.51%.VMA value is 15.43 % at 0% flakiness & elongation index and 14.27 % at 50 % flakiness & elongation index. The VMA limit is between 12-14% for nominal maximum size of aggregate 19 mm.

4 Void filled with bitumen (VFB)

Table 7 represents VFB results

Flaky & Elongated %	VFB%
0	70.45
10	72.24
20	74.35
30	77.52
40	78.94
50	81.51

Graph 7



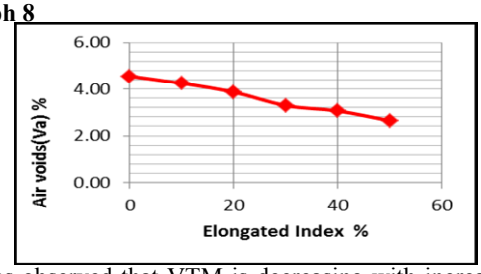
From the results it was observed that the value of VFB is increased by 13.57% from 70.45 % at 0% flaky & elongation index to 81.51% at 50% flakiness & elongation index. The standard limit for VFB is between 65-75%.

5. Void in total mix (VTM)

Table 8 represents VTM results

Flaky & Elongated %	VTM%
0	4.56
10	4.25
20	3.86
30	3.29
40	3.06
50	2.64

Graph 8



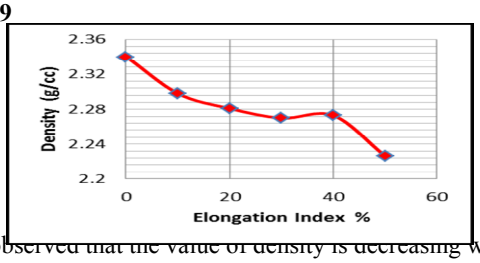
It was observed that VTM is decreasing with increasing of elongation index by 34.19 %. The value of VTM is decreased from 4.56% at 0% flakiness & elongation index to 2.64 % at 50% flakiness &elongation index, while its limit is between 3-6 %.

6. Density

Table 9 represents density results

% of Elongated particles	Density (g/cc) G_{mb}=W1/V
0	2.34
10	2.298
20	2.281
30	2.27
40	2.273
50	2.226

Graph 9



It was observed that the value of density is decreasing with increasing of flakiness & elongation index by 4.871%. At 0% the value of density is 2.34 g/cc, but at 50 % flakiness & elongation index is 2.226%.

CONCLUSION

1. With increasing flakiness & elongation index, stability decreases.
2. Increase of flaky & elongation index decreases the stability due to negative performance of flaky & elongated aggregates in the mix.
3. The value of flow decreases with increasing elongation index.
4. Flow is decreasing with increase in flakiness & elongation index in the mix, because due to lack of degree of interlocking.
5. Void filled with bitumen (VFB) is a property that is highly related to VTM. The more void percentage in the mix, decreases the strength and the more voids are filled by bitumen. So they are inversely proportional.
6. The value of VMA is decreasing with increasing of flakiness & elongation index.
7. VTM is decreasing with increasing of elongation index.
8. The value of density is decreasing with increasing of flakiness & elongation index.

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