



Modification Of Bituminous Concrete Mixes Using Lime Sludge

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Abstract: The design of a satisfactory bituminous mix is a complex task due to the wide variation in properties of its constituents such as bitumen, coarse and fine aggregate, filler, etc. The design also depends on the shape and gradation of the aggregates. Flexible pavement with bituminous surfacing is commonly used in Indian highways. Distress symptoms, such as cracking, rutting, etc., are increasingly caused earlier by high traffic intensity, over loading of vehicles and significant variations in daily and seasonal temperature of the pavement. Investigations have revealed that modifiers can be used to improve properties of bitumen and bituminous mixes to make it more suitable for road construction. Also there are many other materials that may be tried as modifiers in bitumen. This paper reports an investigation carried out on Bituminous Concrete mixes corresponding to grade-1, prepared using midpoint gradation for aggregate combined index of 30% using Lime Sludge as modifier. The conventional Marshall Stability test was conducted on the specimens as per ASTM D 1559. The present investigation comprises of determining the Marshall test properties of Bituminous Concrete Mixes Using 60/70 penetration grade bitumen modified with Lime Sludge as Modifier. The study helps to ascertain the suitability of Lime Sludge as modifier which could minimize the consumption of plain bitumen.

Index Terms - Bituminous Concrete mixes, combined index, Marshall Stability test, Lime Sludge, Mid-point gradation, 60/70 penetration grade bitumen.

I. INTRODUCTION

Conventional bituminous materials have generally performed satisfactorily in most highway pavement and airfield runway applications. However in recent years, severe climates, increased traffic levels, larger and heavier trucks with new axle designs and high tyre pressures, have seemed to add to severe demands of load and environment on the highway system. This has resulted in the need to enhance the properties of existing asphalt material. Polymer modification offers one solution to overcome the deficiencies of bitumen and thereby improve the performance of asphalt mixtures. Polymer modification

offers solution to improve permanent deformation, fatigue life, thermal cracking resistance, wear resistant and ageing of existing asphalt materials.

In India, it is estimated that over 46 lakh kilometers of roads exists. The road transport carries close to 90% of passenger traffic and 70% of freight transport. Investigations in India and countries abroad have revealed that properties of bitumen and bituminous mixes can be improved to meet requirements of pavement with the incorporation of certain additives or blend of additives. These additives are called bitumen modifiers and the bitumen premixed with these modifiers is known as modified bitumen. Modified bitumen is expected to give higher life of surfacing (up to 100%) depending upon degree of modification and type of additives and modification process used.

II. OBJECT OF THE PRESENT STUDY

The objectives of the present study are

- To determine the Marshall Test properties of Bituminous concrete mixes using 60/70 penetration grade bitumen modified using Lime sludge.
- To study the effect of lime sludge as modifier in various proportions in bituminous mixes.

III. MATERIALS USED

3.1 Aggregates

The required quantity of aggregates consisting of assorted sizes was collected from a nearby quarry. The quarry is situated just 2 km away from south-west of Bidadi and its longitude and latitude is $12^{\circ} 47' 24''$ N and $77^{\circ} 21' 49''$ E respectively. The aggregates have been crushed from the rock which is medium grained, mesocratic (grayish black) showing granitic structure. The essential minerals are Quartz, Feldspar and Biotite Mica and minor mineral is Hornblende. It also contains accessory minerals like magnetite. It is an oversaturated acid plutonic igneous rock. It has low specific gravity and very hard. Based on the above observation, the rock is identified as granite.

3.2 Bitumen

The Bitumen of 60/70 penetration grade which was supplied by Mangalore Refinery and Petrochemicals Limited (MRPL) was used.

3.3 Modifier

Lime sludge is produced as a waste product from the papermaking and many other processes. This lime sludge can be converted to be reused or can be used to reclaim other materials from the waste. In the above study, lime sludge is used as the modifier collected from Hindustan paper mill, Kottayam, Kerala.

IV. METHODOLOGY

4.1 Determination of Aggregate Shape Factors

Flakiness and Elongation index was determined as per the procedure laid down by IS: 2386 part-I. The aggregates were sieved into fractions such as 26.5-19, 19-13.2 and 13.2-9.5mm using a gyratory coarse aggregate mechanical sieve shaker. The weight of aggregate in each fraction was found. Using the thickness gauge, each aggregate in the first fraction was passed along its thickness through the respective opening.

The flaky aggregate passing through the respective openings were separated and weighed. Using the length gauge, each aggregate retained on thickness gauge was passed along its length through the respective opening. The elongated aggregate retained in the respective openings were separated. Similarly the elongated aggregates in the other fractions were separated.

4.2 Preparation of Marshall Dry Mix

Table4. 1: Composition of Bituminous Concrete Pavement Layers (MoRTH-2001)

Grading	1	2
Nominal aggregate size	19mm	13mm
Layer thickness	50-65mm	30-45mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	
45	-	-
37.5	-	-
26.5	100	-
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 (pen.)	65	65

4.2.1 Calculation of Weight of Aggregates of Different Fractions

Table 4.2: Percentage of Aggregates Retained on each Sieve

IS Sieve (mm)	Percentage passing	Mid-point of percentage passing	Percentage retained
26.5	100	-	-
19	79-100	89.5	10.5
13.2	59-79	69	20.5
9.5	52-72	62	7
4.75	35-55	45	17
2.36	28-44	36	9
1.18	20-34	27	9
0.6	15-27	21	6
0.3	10-20	15	6
0.15	5-13	9	6
0.075	2-8	5	4

Table 4.3: Quantity of Aggregates for Dry Mix Preparation

IS Sieve (mm)	Weight of FA (g)	Weight of EA (g)	Weight of NF-NE (g)	Total weight aggregates (g)
26.5-19	18.90	18.90	88.20	126.00
19-13.2	36.90	36.90	172.20	246.00
13.2-9.5	12.60	12.60	58.80	84.00
9.5-4.75	-	-	-	204.00
4.75-2.36	-	-	-	108.00
2.36-1.18	-	-	-	108.00
1.18-0.6	-	-	-	72.00
0.6-0.3	-	-	-	72.00
0.3-0.15	-	-	-	72.00
0.15-0.075	-	-	-	48.00
0.075-pan	-	-	-	60.00
Weight of Marshall Mix, g				1200.00

The dry mix was prepared based on mid-point gradation for combined index of 30%, using aggregates of different sizes from 26.5, 19, 13.2, 9.5, 4.75, 2.36, 1.18, 0.6, 0.3, 0.15, 0.075 mm and Marshall powder (passing on IS 0.075 mm and retained on Pan) confirming to grade-1 as per MoRTH-2001 shown in table 3.4. Required quantity of aggregates consisting Flaky Aggregates (FA), Elongated Aggregates (EA) and Non Flaky- Non Elongated Aggregates (NF-NE) was mixed to prepare dry mix weighing 1200g each, shown in table 3.3. Shape test is not applicable for aggregates size less 6.5mm.

4.3 Preparation of Marshall Test Specimens

Approximately 1200g of the aggregate consisting of different aggregate fractions, as worked out earlier, was pre-heated to 175-190°C. The bitumen (plain/modified) was heated to 121-138°C and the first trial bitumen content was added to a preheated steel bowl. The mix was thoroughly mixed at mixing temperature about 154°C. The mix was compacted in a preheated Marshall mould by applying 75 blows on each face of the specimen.

Specimens were prepared at bitumen content 4.5%, 5%, 5.5%, 6% and 6.5% weight of dry mix modified using Lime sludge at 2%, 4%, 6%, 8% and 10% weight of bitumen respectively.

V. RESULTS AND DISCUSSION

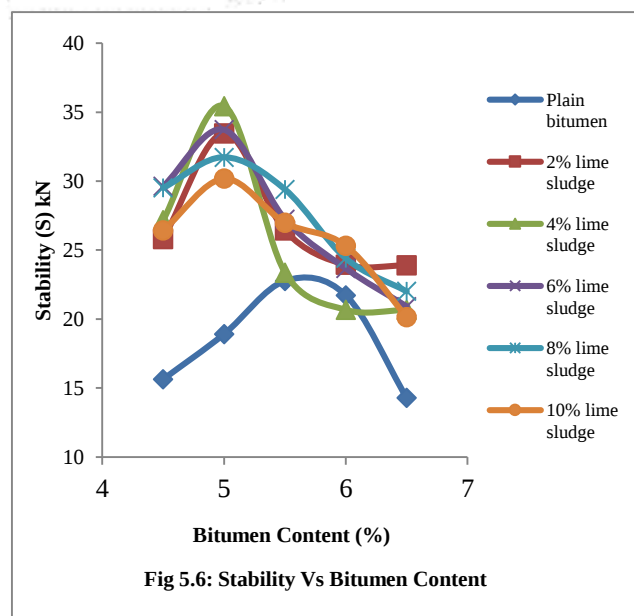
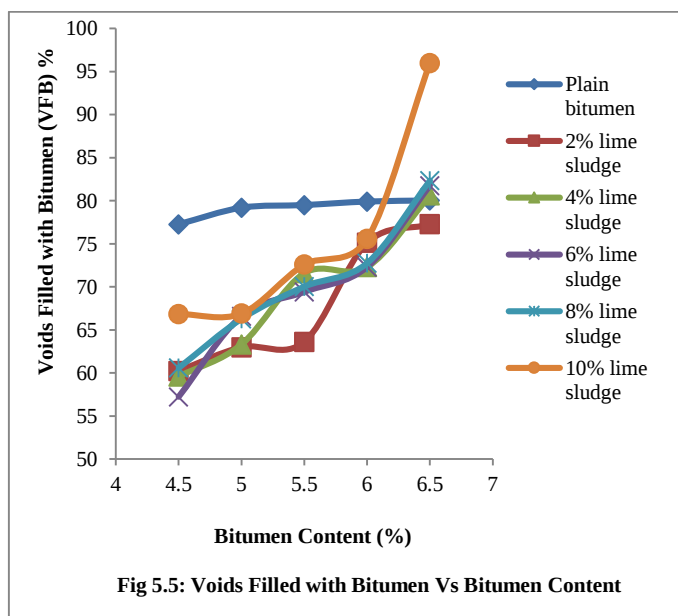
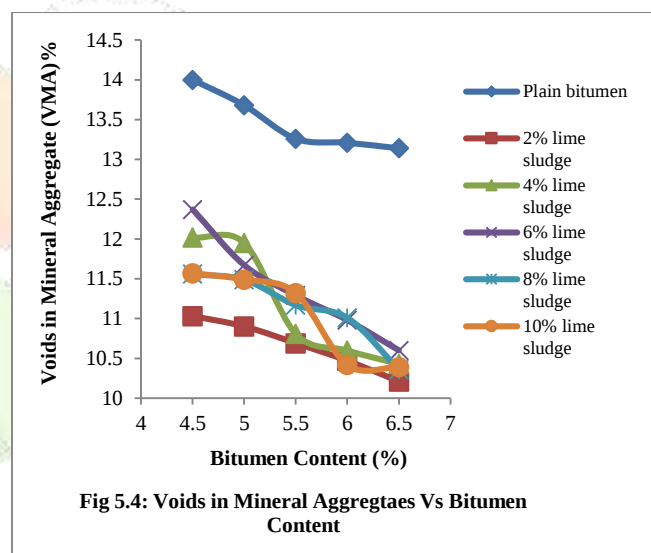
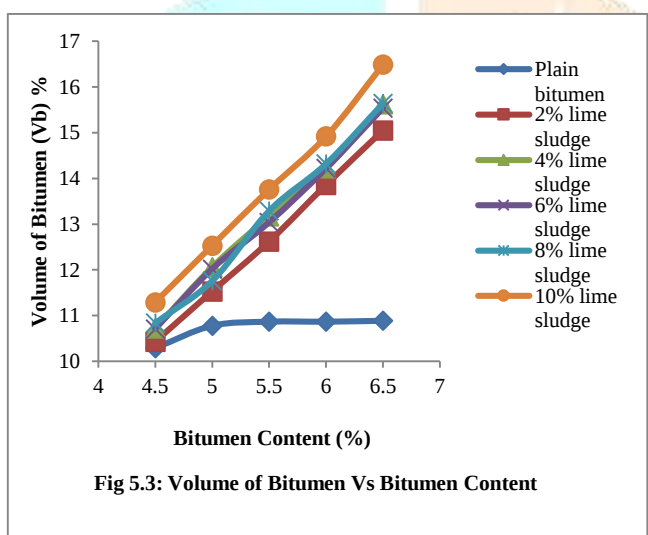
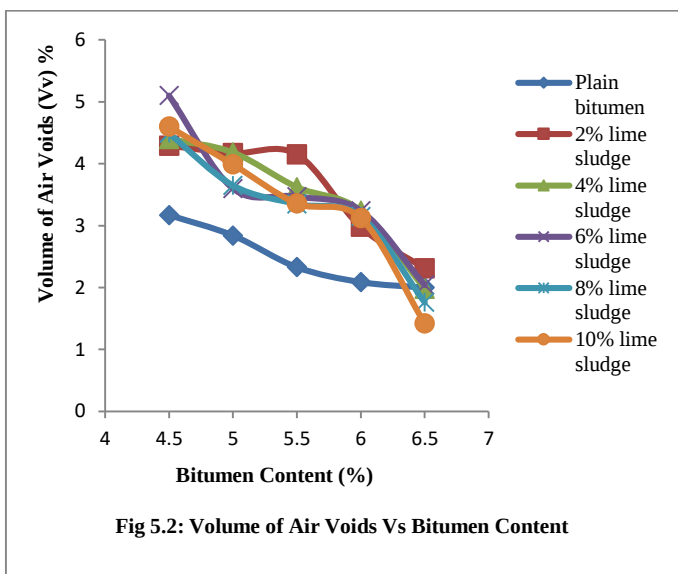
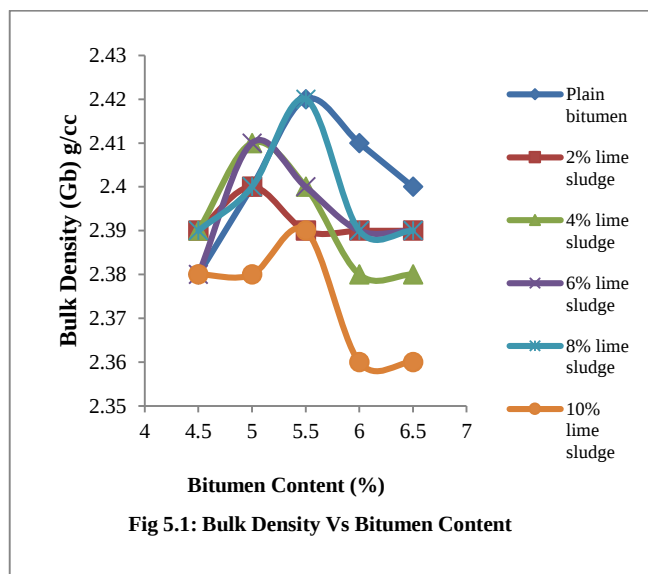
5.2 Results

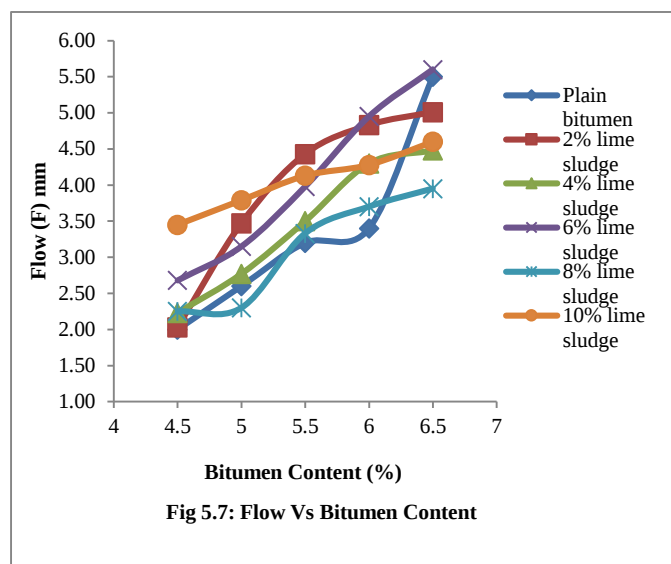
The Marshall Stability test was conducted on the prepared specimens as per ASTM D 1559 to determine the stability and flow values. The Marshall Test properties such as bulk density, Volume of air voids, volume of bitumen, voids in Mineral aggregates, etc were determined, shown in Table 5.1

Table 5.1: Marshall Test Properties of Modified Bituminous Concrete Mixes Using Lime Sludge

Lime sludge Content %	Bulk Density (Gb) g/cc	Volume of Air Voids (Vv) %	Volume of Bitumen (Vb) %	Voids in Mineral Aggregates (VMA) %	Voids Filled with Bitumen (VFB) %	Marshall Stability (S) kN	Flow (F) mm
Bitumen Content 4.5%							
0	2.38	3.17	10.29	14.00	77.27	15.64	2.00
2	2.39	4.29	10.43	11.03	60.24	25.81	2.03
4	2.39	4.40	10.72	12.02	59.60	27.17	2.23
6	2.38	5.10	10.71	12.37	57.23	29.63	2.68
8	2.39	4.49	10.84	11.56	60.60	29.51	2.25
10	2.38	4.60	11.29	11.57	66.85	26.43	3.45
Bitumen Content 5.0%							
0	2.40	2.84	10.78	13.68	79.19	19.91	2.60
2	2.40	4.17	11.53	10.90	62.98	33.46	3.47
4	2.41	4.18	12.06	11.95	63.34	35.44	2.77
6	2.41	3.60	12.02	11.67	66.60	33.73	3.15
8	2.40	3.65	11.76	11.49	66.30	31.73	2.30
10	2.38	3.99	12.53	11.49	66.91	30.18	3.79
Bitumen Content 5.5%							
0	2.42	2.33	10.87	13.26	79.50	22.76	3.20
2	2.39	4.15	12.62	10.69	63.62	26.42	4.43
4	2.40	3.62	13.17	10.81	71.60	23.37	3.50
6	2.40	3.47	13.04	11.29	69.41	27.25	3.98
8	2.42	3.35	13.29	11.17	70.04	29.40	3.33
10	2.39	3.36	13.76	11.32	72.60	26.99	4.13
Bitumen Content 6.0%							
0	2.41	2.09	10.87	13.21	79.91	21.71	3.40
2	2.39	2.98	13.86	10.47	75.13	23.94	4.83
4	2.38	3.24	14.22	10.60	72.31	20.67	4.30
6	2.39	3.24	14.22	10.98	72.31	23.67	4.95
8	2.39	3.15	14.32	11.01	72.77	24.40	3.70
10	2.36	3.12	14.92	10.42	75.58	25.31	4.28
Bitumen Content 6.5%							
0	2.40	2.00	10.89	13.14	80.03	14.28	5.50
2	2.39	2.31	15.05	10.21	77.28	23.90	5.01
4	2.38	1.98	15.62	10.43	80.63	20.66	4.48
6	2.39	2.04	15.54	10.60	81.77	20.91	5.60
8	2.39	1.76	15.64	10.36	82.35	22.01	3.95
10	2.36	1.42	16.49	10.39	96.00	20.14	4.60

Graphs are plotted taking Marshall test properties along Y-axis and bitumen content along X-axis for various Lime sludge content which is as shown in the figure 5.1- 5.7





5.2 Discussion

In this section, the properties such as bulk density, volume of air voids, volume of bitumen, VMA, VFB, Marshall Stability value and flow value were analyzed for lime sludge modified bituminous mix in varying proportion 2%, 4%, 6%, 8% and 10% for 4.5%, 5%, 5.5%, 6% and 6.5% bitumen content, are presented in table 5.1 and shown in figs 5.1 to 5.7. All these properties are indicators of the performance of bituminous concrete mix in the field. In the sight of the usefulness of the addition of modifiers, the following discussions are presented.

From the above results it is observed when the percentage of lime sludge (modifier) increases the Marshall stability values and bulk density values are increased and decreases, where stability is found maximum at 35.44 kN for 4% lime sludge at 5% bitumen content and density of 2.42 g/cc for plain and 8% lime sludge at 5.5% bitumen content respectively.

It is also observed that the volume of air voids, VMA, VMA decreases where as Volume of bitumen, VFB decreases.

VI. CONCLUSIONS

On the basis of observation and analysis of Marshall Test properties using lime sludge, the following conclusions are drawn.

- The Marshall Stability value is found maximum of 35.44 kN for 4% lime sludge at 5.5% bitumen content which is more than plain bitumen.
- The bulk density is also found maximum having 2.42 g/cc for plain and 8% addition of lime sludge at 5.5% bitumen content.
- It is also observed that air voids decrease, which is required for better strength and service life of the pavement and the VFB is increased by addition of bitumen.
- As per MoRTH, Optimum Binder and modifier content is found to be 5.33% and 4% respectively.
- Modification of Bituminous concrete mix has resulted in maximum stability with less bitumen content, which solves the world oil crisis.

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