

Study on Performance of Modified Bituminous Concrete Mix by using Metakaol in

¹D. Bharath Prakash, ¹G.Murali Krishna, ¹G.Niteesh Babu, ²B. G. Rahul, ³B. Sarath Chandra Kumar

¹B.Tech Student, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, A. P., India.

²Assistant Professor, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, A. P., India.

³Associate Professor, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, A. P., India.

Corresponding author: bharathdevarapalli5652@gmail.com, g5muralik@gmail.com, niteeshgurupa@gmail.com, niteeshgurupa@gmail.com

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Abstract:

We are living in a world where transportation plays a major role in leading the country, in which roadways are used as the most significant way to develop the country, for this we need good quality roads to withstand heavy loads and sustain for many years. so we use metakaolin as a partial replacement of stone dust with different percentages like 5%,10% and 15% for a bitumen mix proportion of 4%,4.5%and 5%, therefore we performed a different test and find out that 4.5% bitumen mix with a replacement of 10% stability is greater than other replacement proportions and other bitumen mix percentages. Where metakaolin is formed from burning the clay mineral kaolinite at 600 to 800°C, which is very rich in minerals that are used to form ceramic materials. These ceramic materials are very high in strength that can be used as a partial replacement in cement. So, we use metakaolin to get higher strength and to maintain the roads for a longer period of time.

Keywords: Metakaolin, ductility, softening point, penetration, Marshall mix design, Bitumen.

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I. INTRODUCTION

Metakaolin is a type of calcined clay material as it forms from the calcination of clay mineral kaolinite, which is heated at the temperature in between 600 to 800°C and metakaolin is a pozzolanic material is formed at the year 1962 in Brazil, where the concrete company is incorporated with china clay and still several countries are trying different methods to do usage of metakaolin, where alternative filler methods are used to increase the strength and stability of bituminous concrete mix design[11], different filler materials like crumb rubber powder, sawdust, granite dust, ceramic powder, and different materials are used, where metakaolin gets higher strength in partial replacement of cement in the cementitious concrete

mix, where 28 days strength is obtained at 7 days curing period [12],

Marshall stability mix design is calculated by using a mix design of 1200g [9] in which aggregates are sieved and used as per Is sieve sizes and Bitumen is added by using different percentages like 4%, 4.5%, 5% is used and a replacement of metakaolin of 5%, 10%and 15% percentages are used as a partial replacement for stone dust to attain high strength each mix is done at 3 trails are prepared for better accuracy of results. After the completion of experiment conduction, evaluation of results are done and compared with normal Marshall mix design [9].



FIGURE 1.1



FIGURE 1.2

II. Experimental Works and Materials

1. Bitumen:

Bitumen consisting of viscosity grade (VG-40) is taken and conducted experiments regarding as per IS and the results obtained [13]. The test results are shown in table 1.

TABLE-1: Bitumen Test results

S.no	Tests	Results	Limits as per IS code
1	Penetration (mm)	53	50-75 (IS: 1203-1978)
2	Softening Point (°C)	54	47-57 (IS: 1205-1978)
3	Ductility (cm)	85	Min 7.5 (IS: 1208-1978)
4	Flash point (°C)	270.6	Min 200 (IS: 1209-1978)
5	Fire point (°C)	295	Min 220 (IS: 1209-1978)

2. Aggregates:

As per IS code of practice the aggregates are sieved and different test are conducted and results are calculated and they are within the limits [10]. The test results are shown in table 2.

TABLE-2: Aggregates test results

S.no	Test	Result	Test conducted as per	Requirements as per Morth
1	Aggregate Impact (%)	16.4	IS 2386:Part(I V)	Max 35
2	Los Angeles Abrasion (%)	24.98	IS 2386:Part(I V)	Max 40
3	Flakiness index (%)	12.5	IS 2386:Part(I)	Max 15
4	Elongation index (%)	17.8	IS 2386:Part(I)	Max 20
5	Water Absorption (%)	1.2	IS 2386:Part(I V)	Max 2%
6	Specific Gravity	2.7	IS 2386:Part(II I)	Min 2.5

3. Metakaolin:

It is a byproduct formed from the burning of clay mineral kalonite and it is rich in minerals that are used to create ceramic materials [7].

3.1 Metakaolin Properties:

The basic guidelines and requirements for metakaolin has to be used in pavement construction are. The properties are shown in the table 3.

TABLE-3: Properties of Metakaolin

S.no	Property	Value
1	Specific Gravity	2.5
2	Density (Kg/m ³)	1005
3	colour	White
4	Particle Size	1 to 20 µm

Gradation: Metakaolin used in the bituminous mix design is graded as per IS code of practice as a conventional mix design [6].

4. Stone dust:

Stone dust is taken from stone crusher and the properties of materials are listed below. “The test properties are shown in table 4”.

TABLE-4: Properties of Stone dust

S.no	Property	value
1	Specific gravity	2.54
2	Density(Kg/m ³)	1510
3	colour	Ash White
4	Particle size	150µm

5. Aggregate Gradation:

Aggregate gradation places crucial role in Marshall mix design to attain stability and decrease air voids percentage. Aggregate gradation is done by using MORTH (V Revision) and table 500-19[9] as posted below. The Aggregate gradation limits are shown in the table 5.

TABLE-5: Gradation of Aggregate

S.no	IS seive size, mm	% passing
1	26.5	100
2	19	90-100
3	13.2	56-88
4	4.75	16-36
5	2.36	4-19
6	0.3	2-10
7	0.075	0-5
8	pan	0-3

6. Marshall Stability:

To determine the stability, Air voids, Flow of the bituminous mix design by using Metakaolin and Stone dust as partial replacement different percentages like 5%, 10%, 15% are used as replacement and tests are performed as bitumen 4%, 4.5% and 5% [11].

Required Specifications for Marshall Mix design as per MORTH 500 V revision [9].The Specifications for Marshall Mix are shown in table 6.

TABLE-6: Specifications for Marshall mix

Property	value
Stability, kg	Min 900
Flow, mm	2-4
Air Voids in Total Mix, %	3-6
Voids Filled with Bitumen, %	65-75
Voids in Mineral Aggregates, %	13-15

III. Aim and objectives

The main of the project is to find out the strength and stability increase due to partial replacement of Metakaolin.

- To identify the stability of Metakaolin in three different percentages.
- To analyze the flow value, density, Air voids in the mix of partial replacement of Metakaolin.

IV. Results and discussion

Optimum binder content:

Compared to other percentages and replacements 4.5% Bitumen content and 10% replacement of metakaolin got higher strength and stability.

Marshall Properties with usage of stone dust as a filler are shown in table 7.

TABLE-7: Marshall Properties with usage of stone dust as filler

Bitumen Content (%)	Stability (kg)	Flow (mm)	[VFB] (%)	Density (g/cc)	Volume of Air voids (%)
4	1498.23	3.06	65.03	2.45	4.93
4.5	1641.44	3.6	70.03	2.54	4.47
5	1514.64	3.73	73.71	2.47	4.06

Marshall properties with usage of Metakaolin as a filler are shown in table 8.

TABLE-8: Marshall Properties with usage of Metakaolin as filler

Bitumen Content (%)	Stability (kg)	Flow (mm)	[VFB] (%)	Density (g/cc)	Volume of Air voids (%)
4	1555.47	3.2	66	2.4	5
4.5	1755.26	3.67	68.73	2.45	4.46
5	1530.28	3.92	72.96	2.47	4.02

The following graphs are plotted using the obtained results:

The obtained graph results are shown in the figures 4.1, 4.2, 4.3, 4.4 and 4.5.

FIGURE: 4.1: Bituman Content Vs Flow

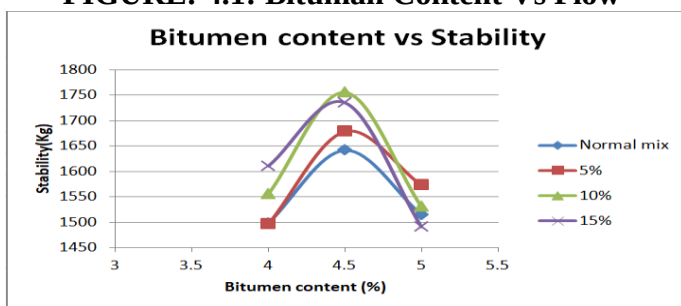


FIGURE: 4.2: Bitumen Content Vs Flow

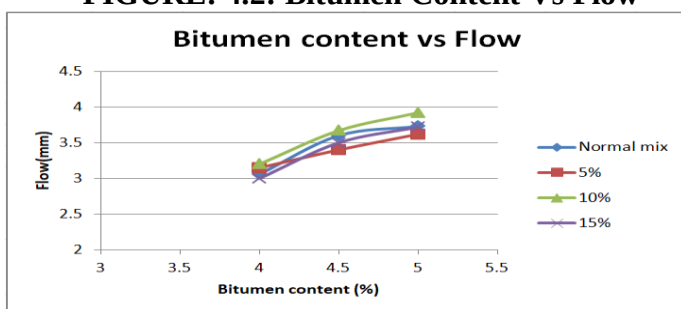


FIGURE: 4.3: Bitumen Content Vs Voids filled with Bitumen

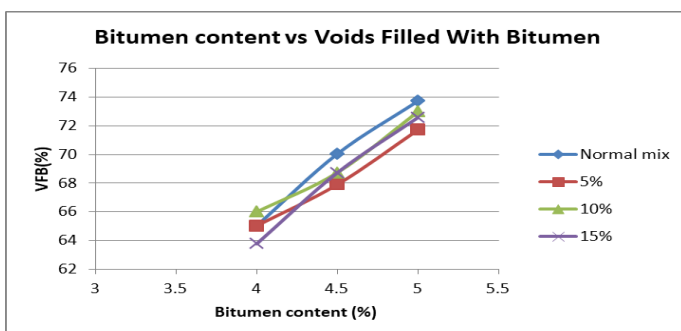


FIGURE: 4.4: Bitumen Content Vs Density

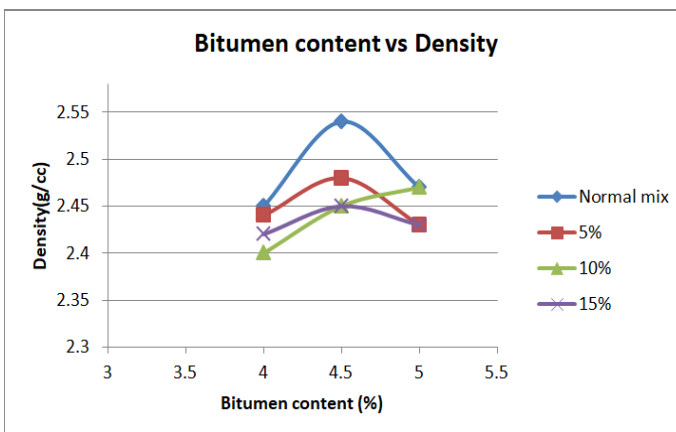
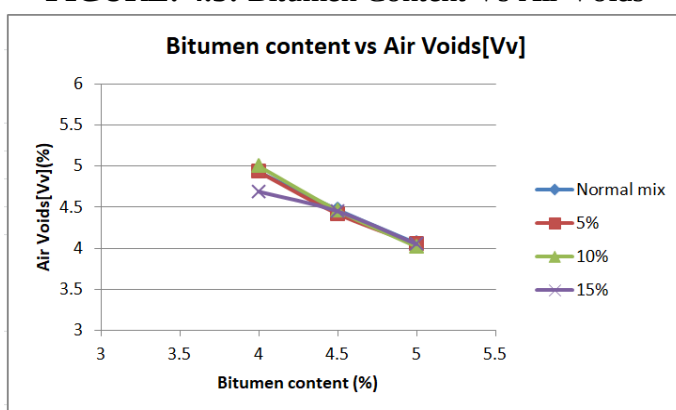


FIGURE: 4.5: Bitumen Content Vs Air Voids



V. Conclusion

The Experimental results suggest that Metakaolin replacement % and bitumen Marshall mix design % for optimum binder content.

- The stability value is 1755.26 (Kg) for 4.5% bitumen mix design and 10% partial replacement.
- The Flow value obtained is 3.67mm which is within the range as per MORTH.
- The VFB (voids filled with bitumen) value is 68.73% which is within the range as per MORTH.
- The Density value is 2.45 g/cc which is within the range as per MORTH.
- The Vv (Air voids percentage) value is 4.46 (%) which is within the range as per MORTH.

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