International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 9, September-2018

EFFECT OF USING METAKAOLIN AS FILLER IN BITUMINOUS MIX

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Abstract—***This study investigates the effects of using Metakaolin (MK) in bituminous mixture as a replacement of common filler. In perspective of the same, samples were prepared for various bitumen content differing from 4.0-5.5% at 0.5% increment as well as percentage of filler varying from 2 to 6 % of Metakaolin was used. By using Marshall mix design the optimum binder content were evaluated for all the mixes. The results from the experiment indicates higher stability value with optimum binder content for the mix having 4.456 % of bitumen at 4% of metakaolin as optimum filler in comparison with the standard specifications. In this experimental study the feasibility of using metakaolin as alternative filler instead of conventional filler can be used by satisfying the standard specifications.***

Keywords — Metakaolin, Marshall, Filler, Rutting, Optimum Binder Content.

INTRODUCTION

Hot mix asphalt pavements are being increasingly constructed in India, as the government is allocating huge amount of resources to upgrade the existing road network nation-wide. However, it is reported that common premature pavement distresses such as permanent deformation (rutting) and fatigue cracks are being observed within the few years after opening the roads to traffic. Subsequently, this induces large amount of maintenance and road users cost that would have negative effect on the nation's economy. These days, due environmental and monetary concern researchers have widely examined the utilization of waste materials instead of regular filler.Metakaolin is a pozzolanic material, which is obtained by calcination of kaolinitic clay at a temperature between 500^{o}C and 800^{o} C. kaolin is a fine white clay mineral that has been traditionally used in the manufacture of porcelain.The present examination was conveyed to watch the impact of metakaolin and their substance on Marshall properties of Dense bituminous macadam (DBM). Based on the test results, the practicality of metakaolinas filler in optimum proportion is assessed comparing with control mixture.

I. MATERIALS AND METHODS

MATERIALS

Aggregates

Aggregates having specific gravity of 2.696 and 2.65 for coarse and fine aggregates were respectively used which are brought from I.Pangidi village in west Godavari district of Andhra Pradesh, India. The aggregate gradation of DBM having grading zone -2 of having a nominal maximum aggregate size of 26.5 mm, with a layer thickness of 50-75 mm by IRC:111-2009 specifications was used.

TABLE 1

AGGREGATE GRADATION FOR DBM

IS SIEVE SIZE (MM)	CUMULATIVE PERCENTAGE BY WEIGHT OF TOTAL AGGREGATE PASSING
37.5	100
26.5	90-100
19	71-95
13.2	56-80
4.75	38-54
2.36	28-42
0.3	7-21
0.075	2-8
Bitumen content (min)	4.5%

Bitumen

Viscosity grade (VG) 30 grade paving bitumen supplied by Hindustan Petroleum, Visakh refinery, India(fig.1) was used in this investigation to prepare HMA mixes after confirming the results with IS 73-2013

Fig.1 Bitumen

TABLE 2

TEST RESULTS OF BITUMEN

Property	Test method	Results obtained	Recommended values
Penetration at 25^0C, 100g, @0.1mm	IS:1203-1978	52	50-70
Softening point (Ring & Ball)	IS:1205-1978	52.5 ^{0} C	min 47 ^{0} C
Ductility @27^o C	IS:1208-1978	45	min 40 cm
Specific gravity	IS:1202-1978	1.022	0.95-1.05
Absolute viscosity	IS:1206-1978	2510 poises	min 2410 poises

Filler

In this present study, metakaolin marketed by jeetmulljaichandlall Pvt .Ltd. Chennai, Tamilnadu was used. The physical characteristics and chemical characteristics are given in below table.

TABLE 3

PHYSICAL CHARACTERISTICS OF METAKAOLIN

1.	Moisture content	0.18%
2.	Specific gravity	2.65
3.	Bulk density	710 Kg/m^3
4.	pH	7.0

TABLE 4

CHEMICAL COMPOSITION OF METAKAOLIN

S no	Constituent Elements	Composition in%
1	Silica SiO_2	53.7 %
2	Alumina Al_2O_3	39.2 %
3	Iron oxide Fe_2O_3	3.84 %
4	Titanium oxide TiO_2	5.97%

According to the standard specifications provided by ASTM (C618-2012), the sum of SiO_2 Al_2O_3

Method

Design of Dense Btuminous Macadam (DBM)

The method for DBM was adopted from marshal mix design method for the preparation of specimens. The standard Marshall specimens were prepared by applying 75 blows on each side of the specimen according to MS -2, 7^{th} edition, asphalt institute, asphalt mix design method having five different bitumen percentages ranging from 4 – 5.5 % by total weight of aggregates at an increase of 0.5%, and filler from 2-6% at an increase of 2%.

Marshall stability, flow and Marshall quotient tests

The primary reason for Marshall mix design is to find the optimum binder content withrespect to different blend proportions. For these reasons, it is required to perform Marshall stability and flow test on each sample under a loading rate of 50.5 mm/min at 60◦C based on MS-2, asphalt mix design method. Marshall quotient, which is a kind of pseudo stiffness, can be calculated as the ratio of stability to flow.

II. RESULTS AND DISCUSSION

As discussed earlier, the Marshall method of mix design was used to ascertain the optimum bitumen content of mixes relative to filler ratio in comparision with the standards given in IRC: 111-2009.The Optimum binder content was calculated from the data shown in table5 and selected at 4% air voids. The other Marshall properties like Marshall quotient, flow, stability, voids filled with bitumen (VFB), voids in mineral aggregate(VMA) were given in table 5

TABLE 5

FILLER TYPE	FILLER PERCENTAGE	OBC (%)	VMA%	VFB%	STABILITY (kN)	FLOW (mm)
MK	2	4.693	14.2	73.5	16.05	3.09
	4	4.45	13.55	72.5	16.25	2.4
	6	4.73	14.39	72.8	15.68	4.2

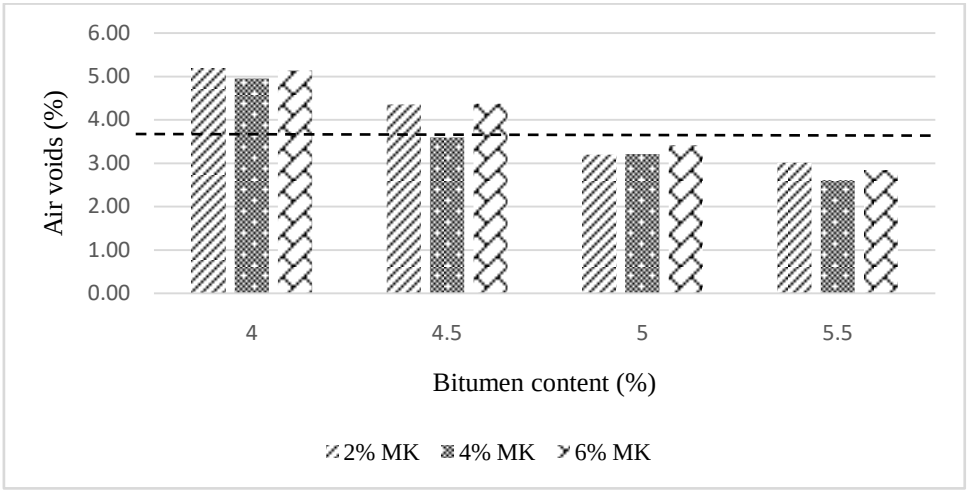

Fig .2. Variation of air void (%) vs bitumen content at different filler content.

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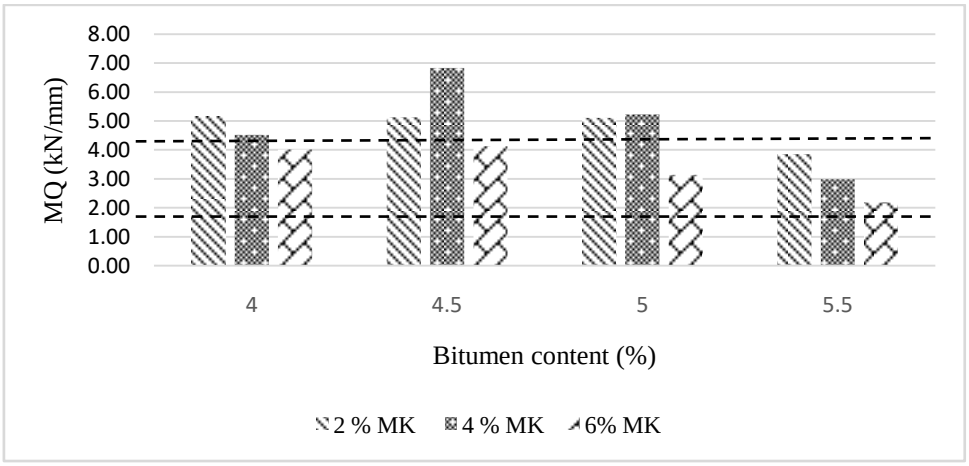

Fig.3.Variation of MQ values vs bitumen content at different filler content

Addition of metakaolin at 2,4and 6 %, the optimum binder content 4.69, 4.45 and 4.73respectively. the optimum binder content values at 2 % MK is 4.69 and decreased at 4 % MK is 4.45 and again raised at 6% MK at 4.73.

III. CONCLUSION

On the basis of results obtained from Marshall test properties, the following conclusions are done. The Marshall stability value is found maximum at 16 .25kN at 4% metakaolin. The max density is found at 2.442 g/cc at 4.46% bitumen content. At 4% of air voids the bitumen content obtained as 4.69%, it is also observed that air voids are decreased, which is required for better strength and service life of the pavement and the Flow and VFB is increased by addition of bitumen. The optimum bitumen content obtained at 4% of air voids are 4.46.

The potential utilization of metakaolin, in bituminous mix was investigated through Marshall mix design.

According to the obtained results the addition of 4% of metakaolin will satisfy all the recommendation's prescribed in IRC:111-2009 .

So, by using metakaolin we can replace the conventional fillers like hydrated lime, fly ash, cement. The results obtained from this clearly shows that metakaolin as a filler not only satisfies the all the standard specifications but also gives lesser deformation with better strength.

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