International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 11 | Nov -2016 www.irjet.net p-ISSN: 2395-0072

TO STUDY THE EFFECT OF PARTIAL REPLACEMENT OF LIME BY CEMENT IN MASTIC ASPHALT

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Abstract - *Mastic asphalt has already gained and would further gain world wide acceptance in road construction technique because of its higher durability, higher stability and low maintenance cost. Thick surfacing materials are not only costly and time consuming but also fail at times due to tremendous increase in traffic intensity, on the contrary mastic asphalt prove to be an economical mix in the long run owing to less repairs and more service life. The present investigation is aimed to study the effect of partial replacement of lime by cement at the proportions of 3%, 6%, 9%, 12 % and 15% in the mix. Mastic asphalt samples were prepared with & without coarse aggregates to decide upon the optimum percentage upto which the replacement can be done for both the cases. Design codes such as IS, IRC & MORTH were consulted for the design of mastic asphalt and hardness number test was performed to set the criteria for the acceptability of the replacement percentage. Industrial grade bitumen was used as binder, stone dust was used as fine aggregate, aggregates of size ranging from 2.36 mm to 19 mm were used as coarse aggregates in the course work and the grading & physical requirements of the ingredients were selected as per specifications laid in Indian standard codes. It was observed for the specimens without coarse aggregates the results were neither satisfactory for proportion less than 9% nor more than 12%; while for specimens with coarse aggregates the maximum replacement possible is 12%.*

Key Words: **Mastic Asphalt, Partial Replacement of Filler, Partial Replacement by Cement, Hardness Number Test on Mastic Asphalt, Partial Replacement of lime by cement upto 15%, etc**

1. INTRODUCTION

Mastic asphalt is a very advantageous paving material it provides good riding quality, it can sustain large deformations without cracking, it overcomes the problem of water seepage, it is a self compacting mixture, it provides better skid resistance and rutting resistance as well. Mastic asphalt is laid at critical situations such as roundabouts, intersections, bus stops, toll plazas, bridge decks etc because it has the ability to resist rutting induced by slow or stopped traffic and it being of more flexible nature as compared to other bituminous paving materials can sustain large deflections without cracking. The geography of India and the wide range of climatic conditions have had a decisive and profound influence in the field of road building practices but the placing of mastic asphalt is more or less unaffected by the weather and terrain. Mastic asphalt is a combination of binder, filler, fine aggregates and coarse aggregates mixed in a suitable proportion to yield a void less mass which flows like a liquid at high temperatures and on cooling it becomes solid or semisolid. The Indian standards (IS 1196-1978; Code of Practice for Laying Bitumen Mastic Flooring) and the Indian road congress codes (IRC: 107-2013; Specifications for Bitumen Mastic Wearing Course) are commonly used for design of mastic asphalt. In the present study cement has been used to partially replace the standard filler lime upto 15% with an increment of 3%. Specimens were prepared with and without coarse aggregates and the effect of replacement of lime by cement was noted down at each of the selected percentages. Hardness number test was performed for all the specimens to check the fulfillment of the criteria as per codal requirements.

2. OBJECTIVES OF STUDY

The present research work was undertaken with the following objectives:-

a) To study the effect of partial replacement of lime by cement on mastic asphalt.

3. MATERIAL SELECTION AND THEIR PROPERTIES

Basically mastic asphalt is a blend of bitumen, lime, stone dust and coarse aggregates; beside these cement has also been used in this project work. All the constituent materials for the experimental investigation were selected on the basis of specifications laid in Indian standard codes. The details and properties of the ingredients used in the preparation of mastic asphalt are summarized below:-

3.1. Coarse Aggregates

The coarse aggregates used were crushed rock aggregates ranging from 2.36 mm to 19 mm in size and satisfying all the physical requirements. The grading of coarse aggregates used is given below in table 1.

Table -1: Grading of Coarse Aggregates

IS Sieve (mm)	Percentage Passing	
	Adopted	As per IRC/MORTH
19 mm	100	100
13.2 mm	90	88-96
2.36 mm	1.02	0-5

3.2 Fine Aggregates

Stone dust was used as fine aggregates and was made sure that it conforms to the grading specified by IRC: 107-1992. The grading of fine aggregates is given below in table 2.

Table -2: Grading of Fine Aggregates

S. No	Passing IS Sieve	Retained IS Sieve	Percentage Weight Retained
1	2.36 mm	600 micron	37.0
2	600 micron	212 micron	33.0
3	212 micron	75 micron	15.3
4	75 micron		14.7

3.3 Filler

As per IRC : 107-1992, the filler should be limestone powder passing 75 micron sieve and shall have $CaCO_3$ content not less than 80% but in the present study Portland Pozzolona Cement as well was used as filler material for the preparation of mastic asphalt. The grading of lime and cement is given in the subsequent tables 3 and 4.

Table -3: Grading of Lime

IS Sieve (mm)	Percentage Weight Retained
Passing 2.36 mm but retained on .600 mm	0
Passing 0.600 mm but retained on 0.212 mm	33.0
Passing 0.212 mm but retained on 0.075 mm	13.8
Passing 0.075 mm	53.2

Table -4: Grading of Cement

IS Sieve (mm)	Percentage Weight Retained
Passing 2.36 mm but retained on .600 mm	0
Passing 0.600 mm but retained on 0.212 mm	0
Passing 0.212 mm but retained on 0.075 mm	0
Passing 0.075 mm	100%

3.4 Binder

The binder used was industrial grade bitumen confirming to IS: 702-1961 having suitable consistency and satisfying the set of given physical properties given in MORTH. A few properties of binder used are given in table 5.

Table -5: Properties of Binder

Properties	Observed Values	Limits
Penetration at 25°C	12	10-20
Softening Point,°C	78	60-80
Ductility at 25°C (in cm)	3.3	≥ 3

4. PROPORTIONING OF THE MATERIALS AND PREPARATION OF SAMPLES

Optimum percentages of the various ingredients in the composition of the mix were found and mastic asphalt sample were prepared by conventional cooking process.

4.1 Proportioning of the Materials

Step-1: Grading of Fine Aggregates

Selection of ratio of fine aggregates for the preparation of mastic asphalt was carried out on the basis of sieve analysis. The ratio of 55% and 45% for stone dust and lime respectively satisfied the specifications as given in MORTH and hence was selected for this experimental programme.

Table -6: Grading of Fine Aggregates Inclusive of Filler

S. No	Passing IS Sieve	Retained IS Sieve	Percentage Weight Retained	As per MORT&H
1	2.36 mm	0.600 mm	20.4	0-25
2	0.600 mm	0.212 mm	33.0	10-30
3	0.212 mm	0.075 mm	14.6	10-30
4	0.075 mm		32.0	30-55

Step-2: Finding Out Optimum Binder Content
With the selected ratio of fine aggregates specimens were made at percentages ranging from 14-17 % to find the optimum binder content. In this case the optimum binder percentage is 17% as it satisfies the required hardness number (50-70) criteria.

Table -7: Hardness Number at Different Percentages of Bitumen Content

Bitumen Percentage	Hardness Number		
14%	32	30	35
15%	42	45	42
16%	47	45	52
17%	60	58	61

Step-3: Calculation of Optimum Percentage of Coarse Aggregates
The samples were prepared with the selected percentages of fine aggregates and binder at different percentages of coarse aggregates such as 35%, 40% and 45% of total mix. The optimum percentage of coarse aggregates was selected as 40% of the total mix on the basis of results of hardness number test.

Table -8: Hardness Number at Different Percentages of Coarse Aggregates

Percentage of Aggregates	Hardness Number		
35	22	25	23
40	17	15	16
45	8	12	9

4.2 Preparation of Mastic Asphalt Specimens

Mastic asphalt sample were prepared by conventional cooking process and the following step by step procedure was followed:

1. The required amount of filler material and fine aggregate with specified grading were heated upto 50-60°C in oven separately and then binder of required quantity heated at about 200°C was mixed with filler materials and cooked for 10-15 minutes.
2. For the specimens with coarse aggregates, the required quantity of coarse aggregates are firstly heated in oven up to 60°C and then added to mortar of mastic and cooked for 10-15 minutes. In this way, the mastic asphalt specimens were prepared.
3. After that, the specimens were kept for 2 hours to air dry and after that specimens were put into water bath for the same duration.
4. The mastic samples were prepared in normal open aluminium utensil. 25 mm thick mastic samples of 100 mm diameter were prepared as per the procedure laid down in IRC: 107-1992 and IS: 1195-2002.

5. TESTING OF SPECIMEN AND ANALYSIS OF RESULTS

To achieve the objective of the present study, Wilson Hardness Test was performed. The hardness number of mastic asphalt specimens was determined at 35°C in accordance with the method specified in IS: 1195- 2002. Wilson hardness test is a very quick and simple test in which a load of 31.7 kg is applied to a rod of 6.35 mm diameter to cause an indentation on the specimen. The depth of indentation in hundredth of a cm is recorded after 30 seconds with the help of a dial gauge having an accuracy of 0.01mm and is the required hardness number of the sample. The test is performed in water bath at a constant temperature of 35°C. The hardness number for mastic asphalt specimens shall conform to following range as per the codal requirements:

a) Without CA at 35°C - 50-70 (Hardness Number)

b) With CA at 35°C- 10-20 (Hardness number)

5.1 Testing of Specimen with Replacement of Filler by Cement

Mastic asphalt samples were prepared with the replacement of lime by cement at 3%, 6%, 9%, 12% and 15%. The composition of the mix and the results obtained in the hardness number test are tabulated in table 9.

Table -9: Results of Hardness Number Test with Cement as Filler

S. No.	Composition in %				Hardness Number			
					Observations			
					1st	2nd	3rd	Average
1	Stone Dust= 45	Bitumen= 17	Lime Cement	35 3	90	95	88	91
2			Lime Cement	32 6	71	78	73	74
3			Lime Cement	29 9	66	71	72	69
4			Lime	26	62	58	62	60

			Cement	12				
5			Lime Cement	23 15	50	43	48	47

5.2 Testing of Specimen with Replacement of Filler by Cement (with CA)

Mastic asphalt samples were prepared with the replacement of lime by cement at 3%, 6%, 9%, 12% and 15% along with coarse aggregate. The composition of the mix and the results obtained in hardness number test are tabulated in table 10.

Table -10: Results of Hardness Number Test with Cement (with CA) as Filler

S. No	Composition in %					Hardness Number			
						Observations			
						1st	2nd	3rd	Average
1	Coarse Aggregates= 40	Stone Dust= 27	Bitumen= 10	Lime Cement	20 3	17	14	18	16.33
2				Lime Cement	17 6	15	16	16	15.667
3				Lime Cement	14 9	13	14	14	13.667
4				Lime Cement	11 12	12	13	14	13
5				Lime Cement	8 15	11	9	10	10

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

On the basis of the analysis and interpretations of results obtained from the experimental investigations carried out in the present research work, following conclusions are drawn:

Effect of replacement of Lime by Cement as filler:-

i. For the specimens without coarse aggregates the results were not satisfactory when cement is used as filler in proportion less than 9% as the hardness number does not fall in the range specified in the codes indicating inadequate strength.

ii. More than 12% of replacement is not possible for samples without aggregates as it could be seen that the hardness number falls below 50.

iii. Same trend was observed for specimen with coarse aggregates and the maximum replacement possible is 12% as all the samples met the desired hardness number criteria except for 15%.

iv. The binding effect of cement plays a significant role.

6.2 Recommendations for Further Studies:-

There is substantial scope of carrying out future research work in this area. The possible ideas for further studies are as follows:

i. Experiments can be carried out by using other types of fillers or minerals or aggregates and their effects on characteristics properties.

ii. Possibility of use of industrial grade bitumen with VG-30 or other bitumen sources can be further explored with cement as filler.

iii. A study can be carried out to check the effect of cement on other properties like skid resistance, resistance against rutting etc of mastic asphalt.

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