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Comparative Study of BC mix for NMAS 19.00mm, 13.20mm and 9.50mm using VG-30 Bitumen

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Abstract: Bituminous mix comprises of binder, filler and aggregates, which plays an important role in the performance of the pavement system. Bituminous mixes used in India for different courses have different terminologies, proportions and properties of material, and gradation of aggregates. Aggregate is a major part of bituminous mix and its properties, size and type have considerable effect on performance of mix. Research in the past has demonstrated the effect of aggregate gradation on performance of mix like rutting and Marshall Design parameters. In this paper efforts made to evaluate the effect of nominal maximum aggregate size (NMAS) on properties of bituminous concrete (BC) mix with VG-30 grade bitumen. The primary focus of paper is on introducing a new NMAS i.e. 9.50 mm in MORTH Specifications. Such Fine mix is already in use in western countries and has resulted in satisfactory performance. Such grading can be used for low to medium traffic roads and for urban streets. By using 9.50 mm as NMAS the pavements becomes less permeable to water when compared to other gradation. Thus three BC mixes having NMAS 19 mm, 13.2 mm, and 9.5 mm used with VG 30 grade of bituminous binder for preparing BC mix. Marshall Mix design method used to determine stability, flow and void parameters of these mixes.

Keywords: traffic, PCU, dynamic, speed, data, density, points.

I. Introduction

Transportation plays an important role in development of any country. Indian road network of 33 lakh kilometers, second largest in world and country, consist of around 6.5 lakh kilometers of Highways and Major District roads and 26.5 lakh kilometers of Rural and other district roads. And, about 65% of freight and 80% passenger traffic is carried by the roads in India. (As per NHAI). Most of the Indian Highways are made of flexible pavement, which shows the importance of research work to be carried out for Bituminous Concrete (BC) mix.

Currently, India uses BC mix grading of 19.00 mm and 13.20 mm NMAS for binder and wearing course in construction of bituminous roads. In other countries, such as USA finer 9.50 mm NMAS mix is also used for wearing course.

In India, due to increasing demand in highway construction, scientist and researchers are constantly trying to improve the performance of bituminous pavements. Many researchers have recommended the usage of 9.5 mm NMAS mix for medium to light traffic conditions in India. But, USA uses such mix on National Highway. This shows that there is a good scope to introduce this in India In general, the best

gradation is nothing but the gradation which produce maximum density. However, there must be sufficient air void spaces to permit enough binder content to be incorporated to ensure durability, while still leaving some air space in the mixture to avoid bleeding & rutting. Also, it should provide structural strength and provide surface friction especially (In case of wearing course only).

This research work is aimed at comparative evaluation of three B.C. Mixes with different NMAS in terms of Marshall Properties and permeability characteristics..

II. Objectives of the Study

- To evaluate the Marshall Mix Design properties of bituminous concrete (BC) mix with 9.5 mm nominal maximum aggregate sizes (NMAS) in comparison to those of 13.2 and 19 mm NMAS mixes.
- To determine the effect of NMAS on Marshall Test parameters and Optimum Binder Content.

III. Literature Survey

A good literature review helps to fully understand the need for such work and it is what that allows us to know we are on-track, why, what we are doing is worthwhile, and that we do have a contribution to make. In other words, the literature review is integral to the whole thesis; it is not just a routine step taken to fulfill formal requirements.

It demonstrates that you know the field. This means more than reporting what you've read and understood. Instead, you need to read it critically and to write in such a way that shows you have a feel for the area; you know what the most important issues are and their relevance to your work, you know the controversies, you know what's neglected, you have the anticipation of where it's being taken. All this would allow you to map the field and position your research within the context.

It justifies the reason for your research. This is closely connected with demonstrating that you know the field. It is the knowledge of your field which allows you to identify the gap which your research could fill. However, it is not enough to find a gap. You have also to be able to convince your reader that what you are doing is important and needs to be done.

It allows you to establish your theoretical framework and methodological focus. Even if you are proposing a new theory or a new method, you are doing so in relation to what has been done.

Kandhal and Veeraragavan (2016) reviewed practices for improving ride quality and periodical renewal of bituminous pavements in India for different grading and different mixes. They suggested the use of open graded mixes leads to poor performance in India and shouldn't be use for Improving Riding Quality Programme (IRQP) and Periodic Renewal (PR) whereas BC Grading 1 (19mm) should be used as binder course; BC Grading 2 (13.2mm) and Proposed BC Grading 3 (9.5mm) Should be used for wearing courses. Proposed BC Gradin 3 (9.5mm) should be Preferred over BC Grading 2 (13.2mm) for thin asphalt lifts and city streets**.**

Lodhi and Yadav (2016) studied the effect of aggregate gradation on Marshall Properties of SDBC mix design and to study this aspect they prepared five mixes having different gradation. The gradation used correspond to Lower Grade (L.G), Lower Medium Grade (L.M.G), Medium Grade (M.G), Higher Medium Grade(H.M.G), Higher Grade(H.G.) of the gradation range specified by MoRTH of work on bituminous concrete mixes. The Optimum Binder Content (O.B.C.) is minimum in lower middle grade (L.M.G.) which is more economical and Stability is also maximum in Lower Middle Grade (L.M.G.). and found that in the design of S.D.B.C. mix most of the Marshall properties are superior at Lower Middle gradation of MoRTH specifications.

P. Sarikaand A K Sandra (2015) done the comparative study of various properties of bituminous concrete mixes prepared by MoRTH and superpave gradation as the superpave gradation is more flexible than MoRTH gradation and accepted worldwide whereas MoRTH guidelines are followed in India. They found that Superpave aggregate gradation superior to the MoRTH aggregate gradation in Marshall Properties and can be considered more economical than the MoRTH gradation due less binder content consumption and more stability.

Prajna.S. et al (2014) worked on assessment of Marshall test properties of bituminous concrete mixes using fly ash modified bitumen using grade-1 of MoRTH. Investigations have revealed that modifiers can be used to improve rheological properties of bitumen and bituminous mixes to make it more suitable for road construction.The Marshall Stability value is found maximum of 31.38Kn for 8% fly ash at 5.5% bitumen content which is more than plain bitumen. The bulk density is also found maximum having 2.45 g/cc for 6% addition of fly ash at 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 5.03% and 8% respectively. Modification of Bituminous concrete mix has resulted in maximum stability with less bitumen content, which solves the world oil crisis.

Anik Budiati Bhayangkara (2013) worked on influence of 19 mm as NMAS to marshal properties of asphalt concrete and found that the 19 mm as NMAS is feasible for asphalt concrete mixture because it has stability value 1557, 90 kg, density 2,4 kg/cc, VFWA 90,90%, VIM 3,4%, VMA 15% and flow 3,5%. It is concluded that 19 mm as NMAS can be used for asphalt concrete mixture.

V.

Joshi and Patel (2102) used 19 NMAS to find out the optimum bitumen content by Marshall mix design for DBM. It aims to highlight variability involved in the asphalt mix design process and develop a procedure to find out optimum bitumen content by Marshall mix design method which attain maximum stability. It focuses on the Marshall mix design for DBM at various bitumen proportion. Adequate mix stability to prevent unacceptable distortion and displacement when traffic load is applied.

Prasad et al (2012) did study on Marshall stability properties of BC mix used in road construction by adding waste plastic bottles with two NMAS 13.2mm and 19mm. they found that the optimum plastic content for 60/70 and 80/100 grade bitumen was 8% and for both 60/70 and 80/100 grade bitumen with plastic content 8%, the maximum stability was achieved in 80/100 grade bitumen. There was an increase in stability up to 15% and 10% after adding waste plastic to the mix in 60/70 and 80/100 grade bitumen respectively. There is a decrease in stability value in water sensitivity test results. Unoaked specimens show high stability value but soaked specimens showed a decreasing stability value.

Amir et al (2012) studied that effect of aggregate gradation on rutting of pavements. they found that the Marshall parameters could be good indicator of rutting. Their results show that reducing the air voids percentage and voids in mineral aggregate up to the certain amount, resilient modulus of the mixture will be increased and therefore deformation and non-recoverable strain will reduce. However, for selected gradations in this study, air voids percentage and VMA could not give a good estimation of rutting.

Kandhal and Veeraragavan (2008) reviewed bituminous paving mixes used in India. As MoRTH provides many options for a specific bituminous course (Binder, Wearing, Base) with different grading creates confusion in mix selection and are mainly responsible for the poor performance of flexible pavements in India. Therefore, they amid to have only five dense mixes with different NMAS and made suggestions that 37.5 mm NMAS DBM Base Course Grading 1, 25 mm NMAS DBM Base Course Grading 2, 19mm NMAS BC Binder Course, 12.5 mm NMAS BC Wearing Course Grading 1 (for heavy traffic). 9.5 mm NMAS BC Wearing Course Grading 2 (for light to medium traffic, urban, areas, and thin application).

Wisconsin Highway Research Program The objective of this study was to apply the findings relating NMAS and mixture performance to support revisions to specifications and development of application guidelines for different NMAS mixes.

The research project supports the transition to material selection based on performance properties and provides pavement designers with the knowledge and flexibility to broaden the application of non-typical NMAS sizes. Based upon the research findings, the researchers recommend that WisDOT specifications allow both 9.5-mm and 12.5-mm NMAS HMA in surface courses, 12.5-mm and 19-mm NMAS HMA in intermediate courses and base courses, and 9.5-mm NMAS HMA in levelling courses.

IV. Methodology and Experimental Design

Before starting with the actual research work it is necessary to check that the materials which we are using are of required quality or not. For that, the different properties of materials has been tested and checked that the materials are of required standards or not as per the requirement of Bituminous

Concrete mix. The materials primarily used are VG 30 grade bitumen, aggregates and crushed sand.

TABLE:1 TEST ON AGGREGATE

Test	Rounded off value
Bulk specific gravity 20mm 10mm Crushed Sand	 2.86 2.82 2.74
Water absorption 20mm 10mm Crushed Sand	 0.78% 0.89% 1.17%
Flakiness and elongation index (Combined Index)	18.48%
Aggregate impact value	12.57 %
Aggregate crushing value	16.49%
Los Angles abrasion value	17.50%

Table:2 Test On Bitumen

Sr. No.	Test Parameters	Results
1	Penetration at 250C, 100 gm, 5 secs, 0.1mm.	64
2	Absolute Viscosity at 60^0C, poises.	3165
3	Flash point cleave land open up, ^{0}C.	233^0C
4	Softening Point (R&B), ^{0}C.	53^0C
5	Ductility at 25^0C, after RTFOT	77
6	Specific Gravity at 27 ^{0}C.	1.10

Marshal Mix Design for Bituminous Concrete Mix

The Marshall Stability and flow test provides the performance prediction measure for the Marshall Mix design method. The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute. Load is applied to the specimen till failure, and the maximum load is designated as stability. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) as a result of the loading. The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded. The important steps involved in marshal mix design are summarized next.

Combined Gradation of the Mix

- The individual particle size distribution is to be found out first by using dry sieve analysis for Combined Gradation.

- After finding out individual gradation the proportioning of combined gradation is to be found out by analytical trial and error method to fit the mix within the specified limits of reference. The use of Microsoft Excel will make this calculation easier.

- Check combined gradation by performing confirmatory sieve analysis.

Individual Gradation of Aggregate

- The individual gradations of aggregates and filler materials are as follows:-

Table 3: Individual Gradation Of 20mm Aggregate (5000 Gms)

Sieve Size (mm)	Mass Retained (gm)	% Retained (%)	Cumulative % retained (%)	% Passing (% finer)
26.5	0	0	0	**100**
19	800	16	16	**84**
13.2	4150	83	99	**1**
9.5	50	1	100	**0**
4.75	0	0	100	**0**
2.36	0	0	100	**0**
1.18	0	0	100	**0**
0.6	0	0	100	**0**
0.3	0	0	100	**0**
0.15	0	0	100	**0**
0.075	0	0	100	**0**
Pan	0	0	100	**0**
TOTAL	5000	100		

Table 4: Individual Gradation Of 10mm Aggregate (5000 Gms)

Sieve Size (mm)	Mass Retained (gm)	% Retained (%)	Cumulative % retained (%)	% Passing (% finer)
26.5	0	0	0	**100**
19	0	0	0	**100**
13.2	250	5	5	**95**
9.5	1300	26	31	**69**
4.75	3450	69	100	**0**
2.36	0	0	100	**0**
1.18	0	0	100	**0**
0.6	0	0	100	**0**
0.3	0	0	100	**0**
0.15	0	0	100	**0**
0.075	0	0	100	**0**
Pan	0	0	100	**0**
TOTAL	5000	100		

Table 5: Individual Gradation of Crushed Sand (2500gms)

Sieve Size (mm)	Mass Retained (gm)	% Retained (%)	Cumulative % retained (%)	% Passing (% finer)
26.5	0	0	0	**100**
19	0	0	0	**100**
13.2	0	0	0	**100**
9.5	0	0	0	**100**
4.75	315	11.54	11.54	**88.46**
2.36	543	19.9	31.44	**68.56**
1.18	584	21.4	52.84	**47.16**
0.6	356	13.05	65.89	**34.11**
0.3	206.5	7.57	73.46	**26.54**
0.15	292	10.7	84.16	**15.84**
0.075	272	9.97	94.13	**5.87**
Pan	160	5.86	100	**0**
TOTAL	2728.5	100		

VI. Results

Observations & Calculations of Different Bitumen Contents:

Marshall Mix Design was conducted on different NMAS using VG 30 Bitumen and following results were obtained

Table:6 Results and Graphical representation for 19.00 mm NMAS

Sr. No	Binder Content %	Air voids %	Stability (kg)	Flow (mm)
1	4	5.98	1227	2.13
2	4.5	4.65	1331	2.8
3	5	3.5	1466	3.19
4	5.5	3.11	1119	3.77
5	6	2.76	1023	4.01

Table: 7 Results and Graphical representation for 13.20 mm NMAS

Sr. No	Binder Content %	Air voids %	Stability (kg)	Flow (mm)
1	4.5	5.98	1020	2.71
2	5	4.65	1113	2.95
3	5.5	3.5	1220	3.2
4	6	3.11	1300	3.89
5	6.5	2.76	1265	4.24

Table:9 Results and Graphical representation for 9.5 mm NMAS

Sr. No	Binder Content %	Air voids %	Stability (kg)	Flow (mm)
1	4.5	5.9	1100	3.11
2	5	4.15	1156	3.5
3	5.5	3.18	1241	3.78
4	6	2.11	1167	4.44
5	6.5	1.8	1067	4.87

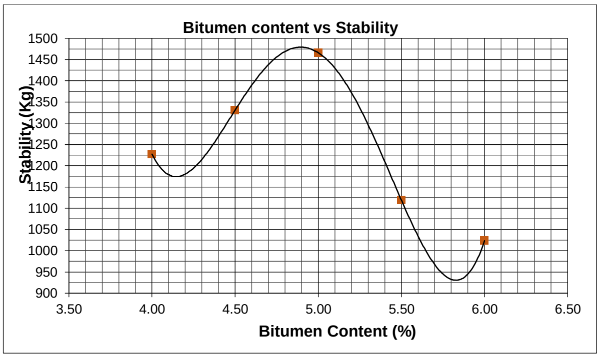

Figure:1 Stability VS Bitumen Content for 19.00 NMAS

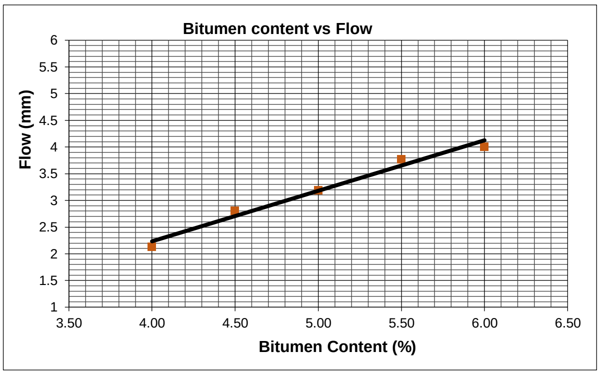

Figure:2 Flow VS Bitumen Content for 19.00 NMAS

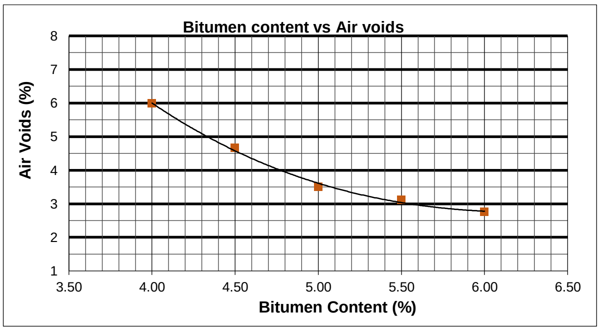

Figure:3 Stability VS Bitumen Content for 19.00 NMAS

The above graph shows the relation between the bitumen content and stability, bitumen content and flow value, bitumen content and Air voids, for 19.00 NMAS and VG-30 Bitumen only.

VII. Conclusion

1. Marshall Readings of all the gradations can be observed from the results obtained above. All the gradations satisfy the minimum requirements pretty satisfactorily. It must be noted that if 9.50 mm NMAS is used, it not only provides greater Marshall Values but ensures that the thickness of the pavement is kept to minimum.
2. The optimum binder content for NMAS 9.5mm, 13.20 mm and 19.00 mm are 6.01%, 5.45 % and 4.7 % respectively.
3. The requirement of bitumen is higher in case of 9.50 mm NMAS but that increment is too marginal i.e. only 0.1% more is needed to obtain the OBC. But when life span of the BC layers of 9.50 mm NMAS is concerned it gives more durability if executed properly.

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