

AGGREGATES SUSTAINABILITY THROUGH PREPARATION OF BITUMINOUS MIXES AT COMBINED GRADATION

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Abstract

Aggregates have to primarily bear load stresses and resist abrasive action of traffic movement under dry and wet conditions, when used in the surface course of the pavement. The aggregate gradation plays a vital role in securing desirable properties of resulting bituminous mixes. Different types of mixes are used under different conditions. Generally, the mixes are designed adopting midpoint gradation from the respective gradation tables. Often, the desired mix properties are not completely satisfied and needs some reworking of gradation. Sometimes the required quantity of aggregates may not be available in nearby areas so as to design a required type of mix. To overcome this, the desired aggregates may have to be brought from far off places, leading to time and cost escalation. This further aggravates the already prevailing scarcity of aggregates. Alternatively, if aggregates are available and satisfies the gradation requirements of two different type of mixes, attempt may be made to design a mix combining the gradation of two types of mixes. Possibly, the resulting mix could still satisfy the specified requirements. If so, the available aggregates could be used economically, without compromising on the quality of mixes. This would result in aggregate sustainability. With this objective, two types of bituminous mixes namely SDBC and BC were prepared at midpoint gradation of the specified ranges, as per MoRTH gradation tables and subsequently by combining the above two gradations taking average of the two midpoint gradations. The Marshall mix properties were compared and found that the mix requirements are largely satisfied at the combined gradation as well.

Keywords: Aggregate, sustainability, bituminous mixes, midpoint gradation, combined gradation

1. INTRODUCTION

Coarse aggregate is the prime material used in pavement construction. Aggregates have to primarily bear load stresses occurring on the road and runway pavements and have also to resist abrasive action of traffic movement under dry and wet conditions, when used in the surface course of pavement [1]. Aggregates are used in construction of flexible pavement layers, in granular sub-base and base courses and in various types of bituminous pavement layers in binder and surface courses. Thus the properties of the coarse aggregates are of considerable significance to the highway engineers [2,3]. Further, the aggregate shape factors as well as gradation play a vital role in the properties of bituminous mixes. Conventionally, the mixes are designed adopting midpoint gradation from the respective gradation tables [3]. Often, the desired mix properties are not satisfied and needs some re arrangement of gradation. Also some times the aggregates available would not satisfy the desired gradation requirement. In such a case, if mixes are able to be prepared by combining the gradation of two different type of mixes, the properties may still be satisfied. If so, then, this approach of combining the gradation may lead to aggregate sustainability.

2. EXPERIMENTAL WORK

The aggregates were collected from a nearby quarry and its basic properties such as specific gravity, water absorption, impact value, crushing value were determined [4]. The results are presented in Table 1. 60/70 grade bitumen was used, its properties such as penetration number, specific gravity, softening point, flash and fire point and ductility were determined. The properties are presented in Table 2. Two types of bituminous mixes such as Semi Dense Bituminous Concrete (SDBC) grade 1 and Bituminous Concrete (BC) grade 2 were selected. The midpoint gradation for the two mixes from MoRTH gradation presented in Table 3 was determined [5]. Marshall test specimens were prepared as per ASTM D 1559 at trial bitumen contents of 4.5 % to 6.0% and tested. The optimum bitumen content (OBC) was determined. The specimens were again prepared at so obtained OBC and tested. The average of midpoint gradation of each fraction for SDBC and BC was determined to obtain the combined gradation. The Marshall specimens were again prepared at this combined gradation and tested as explained above. Thus three set of results were obtained, for SDBC and BC corresponding to midpoint gradation and then at combined gradation. The results are presented in Table 3.4.

Table -1: Properties of Coarse Aggregates used

Property	Result
Specific Gravity	2.67
Water Absorption	0.728%
Impact Value	23.75%
Crushing Value	25.11%

Table - 2: Basic Properties of 60/70 Grade Bitumen used

Property	Result
Penetration Number	65
Specific Gravity	1.01
Softening Point	460 C
Ductility	740 mm
Flash and Fire Point	3350 C and 3450 C

Table - 3: Specified Gradation for Bituminous Pavements (MoRTH – 2001 section 500-18)

Grading	1	2
Pavement layer	SDBC	BC
Nominal aggregate size	13mm	10mm
Layer Thickness	35-40 mm	25-30 mm
45		
37.5		
26.5		
19	100	100
13.2	90-100	79-100
9.5	70-90	70-88
4.75	35-51	53-71
2.36	24-39	42-58
1.18	15-30	34-48
0.6	--	26-38
0.3	9-19	18-28
0.15	--	12-20
0.075	3-8	4-10
Bitumen content % by mass of total mix	Min. 4.5	5.0-7.0
Bitumen grade (pen)	65	65*

Table - 4: Marshall Test Properties of SDBC and BC at OBC at Midpoint and Combined Gradation

Marshall Test Property	SDBC		BC		Combined Gradation
	Obtained Values	Recommended Values by MoRTH	Obtained Values	Recommended Values by MoRTH	
OBC %	5.0	Min. 4.5%	5.1	5-7%	5.25
Bulk Density (Gb)	2.37	---	2.423	---	2.409
Stability	2619	820 Kg	1600	900 Kg	2271
Flow	4.7	2-4 mm	5	2-4 mm	7.33
Air Voids (Vv)	4.05	3-5 %	3.86	3-6 %	3.78
Volume of Bitumen (Vb)	11.737	---	12.55	---	12.83
Voids in Mineral Aggregates (VMA)	12.31	11-15%	10.35	11-14 %	10.87

Voids Filled with Bitumen (VFB)	67.10	65-78 %	62.7	65-75 %	65.2
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CONCLUSIONS

1. Generally, the obtained Marshall test properties fall within the MoRTH specifications for both SDBC and BC mixes at mid point gradation, with flow values exceeding the limit.
2. In B.C, the VMA and VFB values are marginally close to specifications.
3. The mix properties when prepared by combining the gradation of the two mixes indicate highest stability and flow values and marginally close VMA and VFB values. With a little modification in gradation, it may be possible to ensure all properties satisfy the specifications.
4. Thus, the combined gradation can still result in satisfactory mixes and help in aggregate sustainability.

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BIOGRAPHIE



The author is a teacher by profession for the past 28 years and has published over 22 papers. He is associated with research on pavement materials, especially aggregates and bitumen.