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The effect of aggregate density on pavement performance of SMA-13 asphalt mixture

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ABSTRACT
This paper chooses the top layer SMA-13 asphalt mixture material as the research object. Basalt was selected as pavement material, and modified SBS asphalt was used as a cementing material. Two basalt aggregates with different densities were used to carry out standard Marshall test in the laboratory. Aimed at the volume parameters of the asphalt mixture carry on anaiysis,and obtian the effect of aggregate density on pavement performance of SMA-13 asphalt mixture, which is that the density of aggregate has a significant effect on the void ratio, saturation, and the gap rate of the aggregate, thus affecting the pavement performance of the asphalt mixture.
Keyword:aggregate density, modified SBS asphalt,pavement performance ,SMA-13

I. INTRODUCTION

Effect of performance index of asphalt mixture, the influence of porosity of asphalt mixture is especially important for SMA asphalt mixture, the voidage of general control in 3% ~ 4.5%, for dense graded asphalt mixture, the voidage of general control in 3% ~ 6%. void ratio is too small, in the asphalt pavement continuous high temperature and summer load effect, prone to rutting; void ratio is too large, the outside water easily into the pavement, water damage of asphalt pavement. The important performance indexes of asphalt and asphalt mixture saturation effect, saturation will cause the road goes on, weeping and rutting of pavement; saturation too small, will result in bond forces between particles is too small, easy to cause the mixture of loose and flake disease. Porosity and saturation therefore is to ensure a reasonable performance of road asphalt mixture factor.

II. BASIC THEORY

Aggregate density is the main index to characterize the aggregate properties, the maximum theoretical relative density and the relative density of the bulk density of the asphalt mixture, Calculation formula of void fraction:

$$VV = (1 - \frac{\gamma_f}{\gamma_t}) \times 100$$

$$VMA = (1 - \frac{\gamma_f}{\gamma_{sb}} \times \frac{P_s}{100}) \times 100$$

$$VFA = \frac{VMA - VV}{VMA} \times 100$$

VV —Void ratio of specimen,%;

VMA —Rate of ore material clearance,%;

VFA —Effective asphalt saturation of test pieces,%;

γ_f —Gross volume relative density of specimens;

γ_t —Maximum theoretical relative density of asphalt mixture;

P_s —A variety of mineral aggregate accounts for the percentage of total mass of asphalt mixtures,%;

γ_{sb} —Synthetic hair bulk density of ore;

By the formula indicates mixture void rate mainly by the gross volume relative density and mixture of the theoretical maximum relative density decision will also influence the mixture voids in mineral aggregate and saturation. Therefore sets the density of information on the effects of mixture of each volume parameters.

III. EXPERIMENGTAL STUDY

In the laboratory selects SMA-13 asphalt mixture material as the research object. The basalts in Fuding City of Fujian Province as upper layer paving pavement material,binder using Xiamen Huate SBS (I-D) modified asphalt and mineral powder in Fujian province and Sanming City, adding 0.4% of the lignin fiber in asphalt mixture SMA-13 and select two different aggregate density, shaping Marshall specimen, the comparative analysis of the volume parameters of mixture, determine the aggregate density and SMA-13 pavement performance of asphalt mixture. After Xuan Wuyan cold material screening test in the laboratory, each file set by rate, target proportion sure, according to 《technical specifications for construction of highway asphalt pavement 》JTG F40-2004, obtained the mineral aggregate gradation of asphalt mixture with SMA-13 as shown in Table 3.1

Table 3.1 Aggregate gradation of SMA-13 asphalt mixture

aggregate size (mm)	mix proportion (%)	The sieve passing rate (mm)（%）									
		16.0	13.2	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
9.5～13.2	53	100	88.9	22.1	1.3	1.0	0.9	0.9	0.9	0.9	0.9
4.75～9.5	22	100	100	99.2	13.5	0.5	0.2	0.2	0.2	0.2	0.2
0～4.75	14	100	100	100	96.9	67.0	48.3	34.2	20.6	12.9	6.4
powder	11	100	100	100	100	100	100	100	97.0	89.4	73.3
target grading		100	94.1	58.5	28.2	21.0	18.3	16.3	14.1	12.2	9.5
normative median		100	95.0	62.5	27.0	20.5	19.0	16.0	13.0	12.0	10.0
the difference		0.0	-0.9	-4.0	1.2	0.5	-0.7	0.3	1.1	0.2	-0.5
norm upper limit		100	100	75	34	26	24	20	16	15	12
specification limit		100	90	50	20	15	14	12	10	9	8

The aggregate gradation curve of SMA-13 mixture is shown in Figure 1.

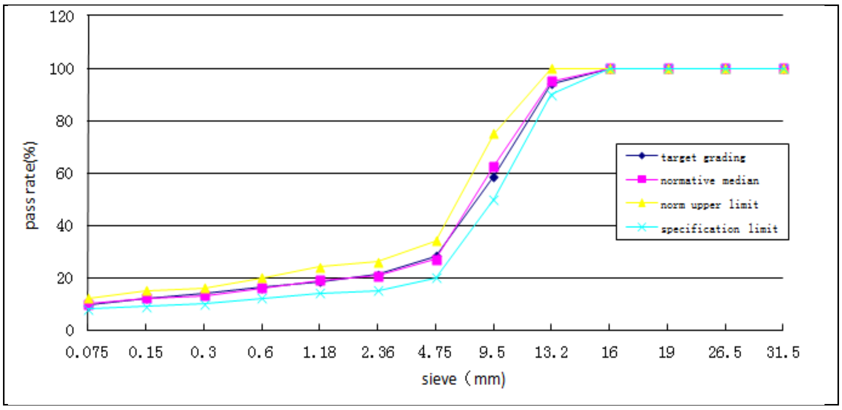

Fig.1. Aggregate gradation of SMA-13 asphalt mixture

The main technical indexes of the SMA-13 asphalt mixture used as the main technical indexes of the modified asphalt are shown in table 3.2.

Table 3.2 index and test results of modified SBS used for SMA-13 asphalt mixture

technical index	company	technical requirement	detection value	test method
penetration（25℃，100g，5s）	0.1mm	40~60	41.2	T 0604
penetration index	—	≥0	0.7	T 0604
softening point (global method)	℃	≥75	87.5	T 0606
ductility（5℃5cm/min）	cm	≥20	25.2	T 0605
density（15℃）	g/cm3	measured value	1.035	T 0603

Through two different density of the surface layer basalt aggregate, with the same kind of gradation and the same batch of modified asphalt to do the contrast experiment, the first set of aggregate density as shown in table 3.3.

Table 3.3 The density of the first set of aggregates

aggregate size（mm）	9.5—13.2	4.75—9.5	0—4.75
apparent relative density	2.882	2.872	2.817
gross volume relative density	2.765	2.758	2.817

In the laboratory with five different asphalt aggregate ratio of 5.1%, 5.4%, 5.7%, 6.0% and 6.3% respectively, forming a group 5 Marshall specimens, each molding 6 Marshall, using double-sided hit real 50, compaction temperature strictly controlled in the 170~175℃, under standard conditions for maintenance of tested the mixture volume parameters as shown in table 3.4 .

Table 3.4 volume parameters of the asphalt mixture measured by the first set of aggregates

aggregate ratio（%）	gross volume relative density	void fraction（%）	ore material clearance rate（%）	asphalt saturation（%）	stability degree（KN）	flow value（0.1mm)
5.1	2.375	8.1	18.2	55.3	9.1	35.1
5.4	2.384	7.5	18.3	58.7	9.2	38.3
5.7	2.389	7.0	18.8	63.6	10.0	37.7
6.0	2.392	6.4	19.3	65.1	10.1	38.7
6.3	2.396	5.9	20.2	67.4	9.0	36.5

From table 3.4 can be seen, with the increase of bulk density, the main volume parameters of asphalt mixture will change different, the void fraction of porosity and saturation changes significantly, but also affect the asphalt mixture with key performance indicators, and its change trend as shown in Figure 2.

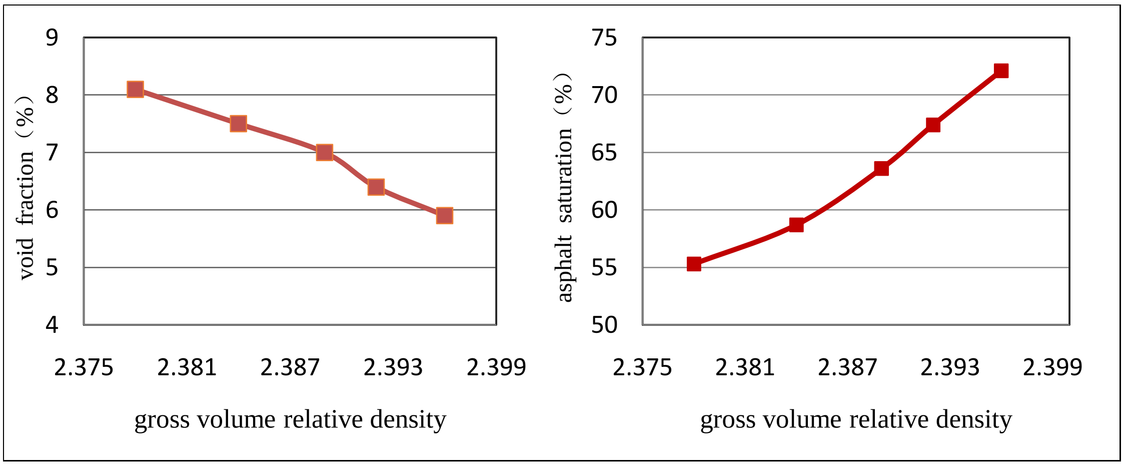

Fig.2. The change of the relative density of the first set of the SMA-13 asphalt mixture and the relationship between the porosity and the saturation

From table 3.4 and figure 2 shows that with increase of bulk density and voids in asphalt mixture rate gradually decreased, degree of saturation increases gradually, in aggregate ratio reached 6.3% when the mixture of porosity and saturation index is still unable to meet the requirements, so in this aggregate as a surface material layer is not to meet the needs of the construction quality of asphalt pavement.

The aggregate density of the second groups of SMA -13asphalt mixture is shown in table 3.5.

Table 3.5 The density of the second set of aggregates

aggregate size（mm）	9.5—13.2	4.75—9.5	0—4.75
apparent relative density	3.016	3.013	2.987
gross volume relative density	2.960	2.934	2.987

The second set of modified asphalt SMA- 13 mixture used in material density in the same mineral aggregate gradation and asphalt aggregate ratio measured by the mixture of volume parameters as shown in table 3.6 .

Table 3.4 volume parameters of the asphalt mixture measured by the second set of aggregates

aggregate ratio（%）	gross volume relative density	void fraction（%）	ore material clearance rate（%）	asphalt saturation（%）	stability degree（KN）	flow value（0.1mm)
5.1	2.557	5.5	17.0	66.7	11.6	32.5
5.4	2.561	5.0	17.1	70.7	13.0	35.1
5.7	2.569	4.6	17.3	75.2	10.5	26.1
6.0	2.578	3.5	17.0	79.7	11.2	35.8
6.3	2.582	2.9	17.1	83.2	11.5	38.0

The relationship between the gross volume relative density of the mixture and the void fraction of the mixture is shown in Figure 3.

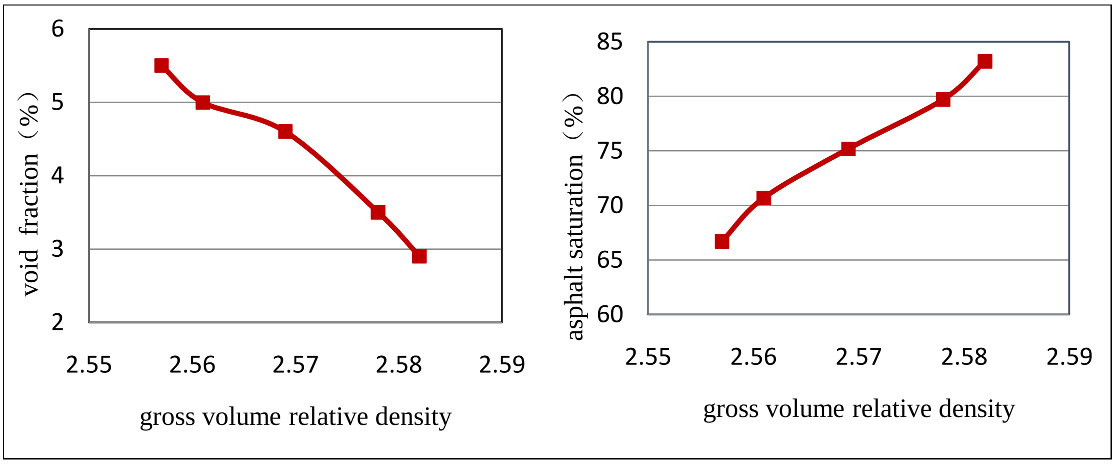

Fig.3. The change of the relative density of the second set of the SMA-13 asphalt mixture and the relationship between the porosity and the saturation

From table 3.6 and Figure 3 can be seen, SMA-13 mixture void rate with the gross volume relative density increases and decreases, saturation with the gross volume relative density increases and increases and by the second group aggregate density obtained mixture volumetric parameter can satisfy the design specification requirements, according to the volume parameter maps for the determination of the optimum asphalt content than a 5.9%, corresponding to the gap rate of 3.8%, mine Ma bit rate of 17.2%, saturation to 78.4%, in line with the requirements of the specification and design, can be used to guide the production.

Ⅳ.CONCLUSION

In view of the SMA-13 asphalt mixture, the aggregate of two different density contrast experiments were carried out under the same conditions, the aggregate density small group in the first time the asphalt aggregate ratio reached 6.3% of the volume parameters of mixture still cannot meet the requirements of specification, and aggregate second group density in whetstone ratio reached 5.8% when the indicators are able to meet the requirements of specification, from two groups of comparative data shows that, with the performance indexes of aggregate density of asphalt mixture will show a good trend, namely the aggregate density and the size of voids of the SMA-13 asphalt mixture rate, saturation of road performance index have obvious effect. Therefore, in the set the material choice, try to choose the larger density, rock texture and dense structure, no hole rock surface and internal ore as the asphalt pavement (especially upper layer) of the material.

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