STUDY ON PAVEMENT PERFORMANCE OF HMA MIX'S AGGREGATE GRADATIONS NEAR RESTRICTED ZONE

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ABSTRACT

According to pavement performance tests this paper analyzes six HMA mixes which gradations are BRZ, CRZ, TRZ, HRZ, ARZ and AC-16 by Chinese Specification respectively. The restricted zone may not be necessary to follow every performance when all other relevant requirements of Superpave design are requested. HMA mix's pavement performance is optimal when the gradation is through the restricted zone.

Keywords: Restricted zone, Pavement Performance, HMA mix

1. GENERAL DESCRIPTION

The control points and restricted zone are the most distinguished characteristics of Superpave mixture. The aggregate gradations must avoid the restricted zone among the control points. When the volume of traffic is larger under specific standards, the gradation passes below the restricted zone. Superpave permits this but does not recommend the gradation above the restricted zone. Some findings in laboratory and field show that the restricted zone seems unnecessary. Many gradations passing through the restricted zone still perform well.

This paper analyzes the pavement performance tests of six gradations, such as the above restricted zone(ARZ), the below restricted zone(BRZ), the through restricted zone(TRZ); humped restricted zone (HRZ); and crossover the restricted zone (CRZ); and AC-16 according to Chinese Specification, which provides theory basis for the engineering applying of Superpave.

Table 1. 16. 0mm N Max. S gradation.

Sieve, mm	Percent Passing（%）					
	BRZ	CRZ	TRZ	HRZ	ARZ	AC-16
19	100	100	100	100	100	100
16	99.2	99.2	99.2	99.2	99.2	95
13.2	92.2	92.2	92.2	92.2	92.2	84
9.5	69.7	69.7	69.7	69.7	69.7	71
4.75	44.0	44.0	44.0	44.0	44.0	50
2.36	27.9	29.9	31.9	33.9	35.9	37
1.18	22.3	24	25.7	26.8	29.3	26.5
0.6	16.3	17.1	18.1	19.8	21.7	18.5
0.3	12.3	12	13	13.4	14.7	12.5
0.15	9	9.3	9.7	10.2	10.9	9.5
0.075	7.1	7.1	7.1	7.1	7.1	6.5
CA	0.85	0.85	0.85	0.85	0.85	0.72
FAc	0.51	0.55	0.58	0.61	0.67	0.53
Faf	0.55	0.5	0.51	0.5	0.50	0.47

2. TEST PLAN

In order to verify the reasonability of the Superpave's restricted zone, we designed Superpave-16 mixtures for test. Keeping constant of coarse aggregates content and changing fine aggregates content, authors studied the effect of restricted zones to mixture’s pavement performance. We designed five gradations near restricted zone and one AC-16 gradation using the Bailey method to evaluate each gradation at mean time. The test plan is shown as Table 1.

3. MATERIALS’ PROPERTIES

Asphalt binder is KLM undertakes Y AH-90$^{\#}$. Asphalt’s properties are shown as Table 2 and Table 3.

Table 2. Asphalt normal properties.

Penetration，100g,5s,(0.1mm)		**94.3**
Penetration Index PI		**-0.354**
Ductility（10℃，5cm/min）,cm		**81.9**
Softening Point（℃）		**47.3**
Flashing Point（℃）		**-**
Specific Gravity（25℃/25℃）		**0.980**
Solubility，%		**99.8**
RTFOT(163℃，85min）	Loss on Heating，%	**-**
	Ductility（15℃，5cm/min），cm	**79.2**
	Penetration Ratio（25℃），%	**73**

Table 3. Asphalt Superpave test results.

				Temperature, ℃	Result	Specification
Unaged Binder	Viscosity		Pa.s	135	-	<3
	Flashing Point		℃	/	-	>230
	DSR, G*/sin δ		Kpa	70	1.13	>1.0
RTFO Aged Residue	DSR,G*/sin δ		Kpa	70	1.88	>2.2
				64	4.36	
PAV Aged Residue	DSR, G**sin δ		Kpa	22	1056	<5000
	BBR	Creep Stiffness	MPa	-18	171	<300
				-24	439.5	
		m	/	-18	0.365	>0.3
				-24	0.275	
PG					64-28	

Gabbro and limestone powder are used. The properties of aggregates are shown as Table 4. Furthermore, authors used 0.3% AST-Ⅲ Anti-stripping agent to prove the adhesion of asphalt and aggregates.

Table 4. Aggregate properties test results.

		Result
Los Angeles Abrasion，%		17.7
Crushed Stone Value，%		14.5
Lashed Stone Value，%		9.5
Flat and Elongated，%		17.23
Adhesion	Unaged Asphalt	2
	Anti-stripping agent（aged）	4

4. DETERMINATION OF OPTIMAL ASPHALT CONTENT

According to Marshall design method to determine OAC, the test results are shown as Table 5 and Figure 1. Mixture's cutaway view is show as Figure 2.

Table 5. Optimal Asphalt Aggregate Ratio(OAAR) and Dust Proportion(DP).

	BRZ	CRZ	TRZ	HRZ	ARZ	AC-16
OAAR %	4.702	4.714	4.733	4.750	4.794	4.924
DP	1.581	1.577	1.571	1.566	1.552	1.513

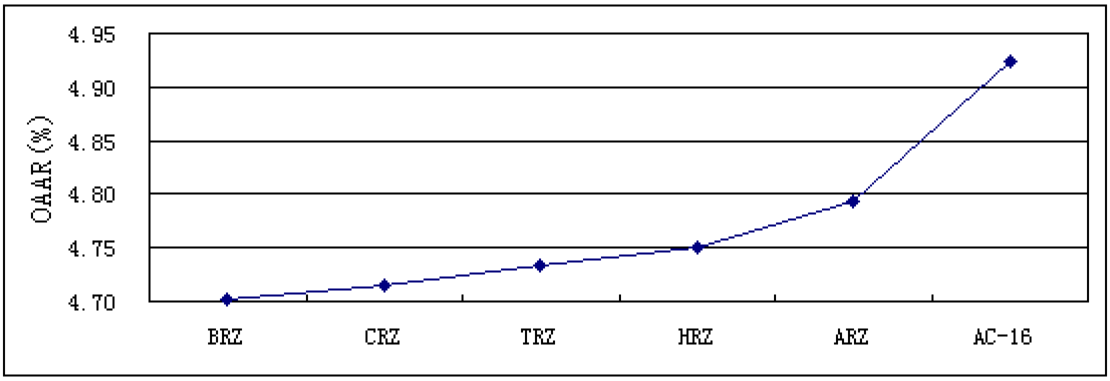

Figure 1. Optimal Asphalt Aggregate Ratio(OAAR).

Test results and conclusions:

- With the increase of fine aggregates， mixture's OAC gets larger. AC-16 mixture's OAC is the largest.
- With the increase of fine aggregates， mixture's DP decreases gradually.
- With the increase of fine aggregates，the skeleton structure of mixtures is propped out gradually. The skeleton structure of AC-16 mixture is the worst.

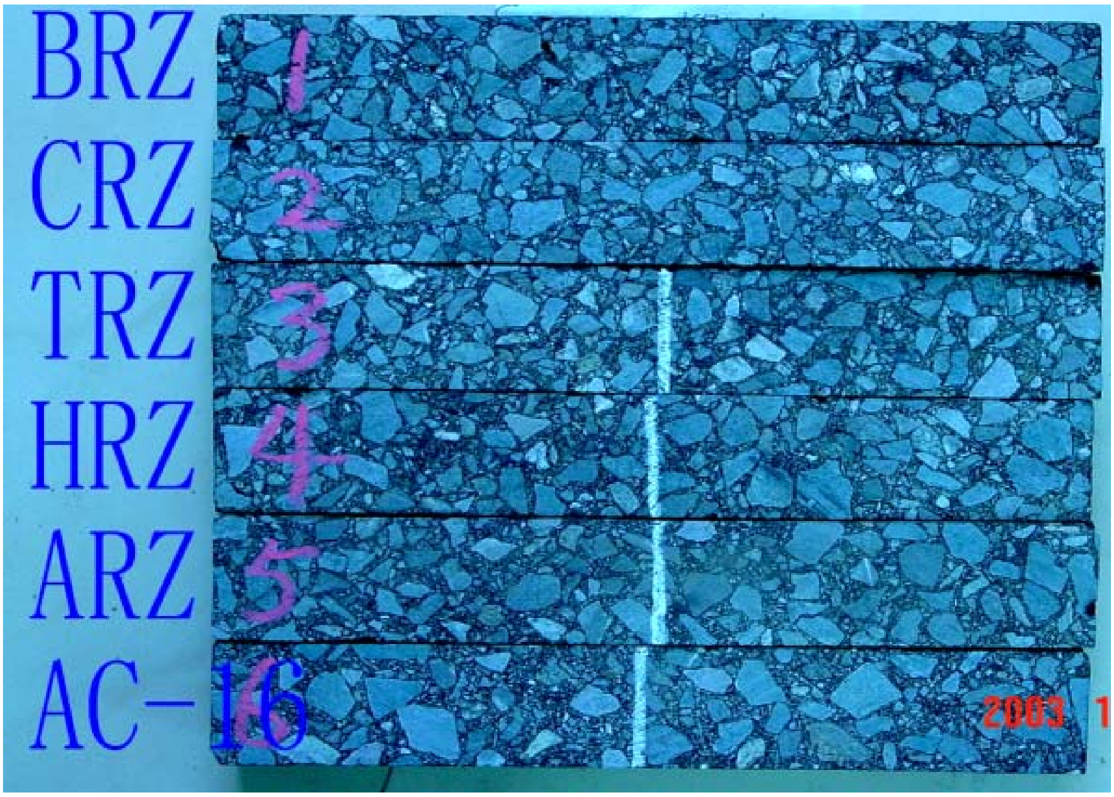

Figure 2. HMA mixture cutaway view.

5. STUDY ON PAVEMENT PERFORMANCE OF HMA MIX'S AGGREGATE GRADATIONS NEAR RESTRICTED ZONE

5.1 Study on Mixture's High Temperature Performance

Under high temperature wheel tracking test results of HMA mixture with 60ºC and 0. 7MPa are shown as Table 6 and Figure 3.

Table 6. HMA mixture wheel tracking test.

	BRZ	CRZ	TRZ	HRZ	ARZ	AC-16
Dynamic Stability （times/mm）	2189.31	3539.29	2712.67	2045.895	1708.295	1858.741
45min Rutting Depth （mm）	2.224	2.927	2.558	3.689	4.332	3.614
60min Rutting Depth （mm）	2.529	3.112	2.799	4.009	4.715	3.966

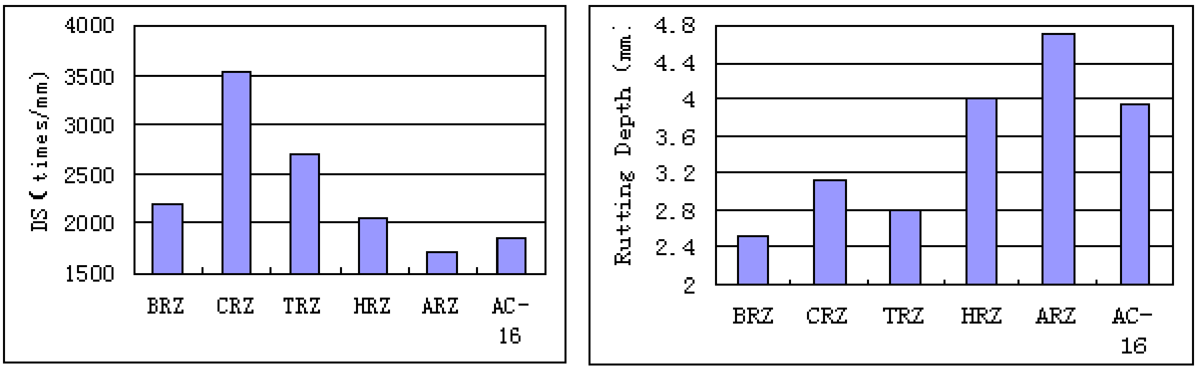

Figure 3. HMA mixture high temperature performance.

5.1.1 Test results and conclusions

- The dynamic stability grows increasingly at first and then decreases gradually along with the increasing of the fine aggregates content. When the FAC is 0.55(CRZ), the mixture's high temperature performance is the best. Its DS can achieve 3539 times/mm. The high temperature performance of ARZ and AC-16 gradations are not ideal and their DSs are nearly 2000 times/mm.
- The rutting depths of BRZ, CRZ, and TRZ are shallow. The rutting depths of ARZ, HRZ and AC-16 are deep. This indicates that the increasing of fine aggregate content is very harmful to the high temperature performance.

5.2 Study on Mixture's Low Temperature Performance

The bending test results of HMA mixture under low temperature are shown as Table 7 and Figure 4.

Table 7. HMA mixture's low temperature bending test.

Temperature	-10ºC	Loading Rate 50mm/min		Dimension 40×40×250mm
	Strength (Mpa)	Maxim Strain (10^{-6})	Stiffness Modulus(Mpa)	Strain Energy (n*m)
BRZ	10.89	1924.82	5665.34	0.44
CRZ	10.85	1716.09	6434.87	0.39
TRZ	12.13	2352.63	5160.32	0.54
HRZ	12.56	1863.47	6757.53	0.47
ARZ	11.22	1703.55	6650.66	0.40
AC-16	12.96	2068.12	6313.59	0.56

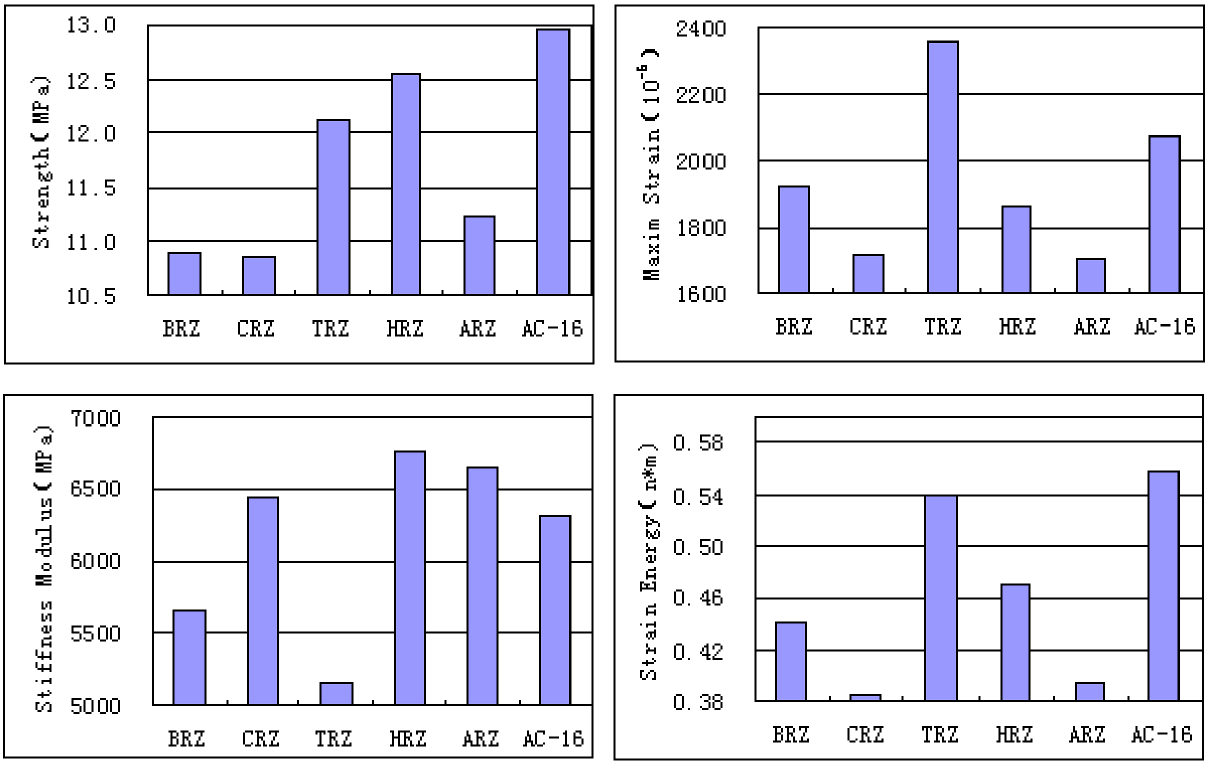

Figure 4. HMA mixture low temperature performance.

5.2.1 Test results and conclusions

- With the increasing of fine aggregate content, the mixture's bending strength grows increasingly at first and then decreases. The bending strength of TRZ and HRZ gradations are bigger, however of the AC-16 gradation is the biggest .
- With the increasing of fine aggregate content, the maxim strain grows firstly and then reduces. The CRZ and ARZ gradations' maxim strain are quite small, and the TRZ gradation's maxim strain can achieve 2352.6 $\mu\varepsilon$. The AC-16 gradation's maxim strain takes the second place .
- By contrary to the trend of maxim strain, the TRZ gradation's stiffness modulus is of the smallest value, and the CRZ, HRZ and ARZ gradations' stiffness modulus are bigger then them.
- The TRZ and AC-16 gradations' strain energy are almost equal with the biggest value. The CRZ and ARZ gradations' strain energy are smaller.
- According to the above low temperature performance index, TRZ and AC-16 gradations' low temperature performance are better. And the other gradations' low temperature performances are not very ideal .

5.3 Study on Mixture's Water Stability

Mixture's water stability test results are shown as Table 8 and Figure 5.

Table 8. HMA mixture water stability test.

	BRZ	CRZ	TRZ	HRZ	ARZ	AC-16
30min Marshall Stability（KN）	8.51	9.91	8.18	9.4	9.95	10.71
48h Marshall Stability（KN）	6.95	8.32	7.30	8.40	9.03	9.68
Retained Stability（%）	81.7	84.0	89.2	87.2	90.8	90.4

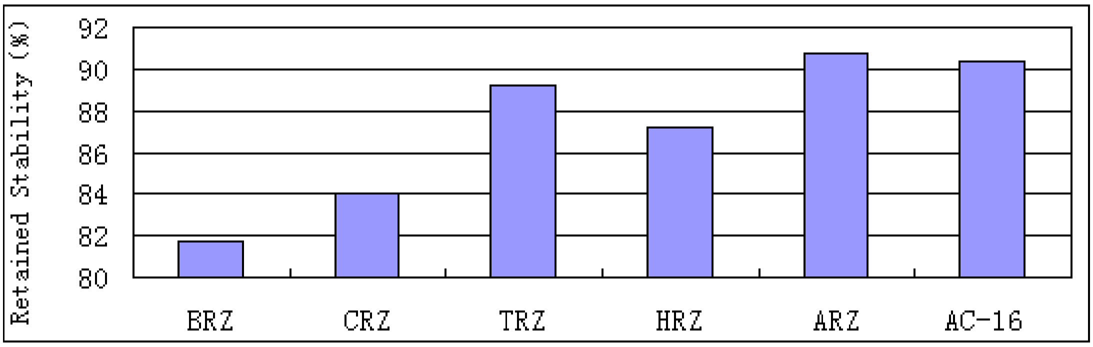

Figure 5. HMA mixture's water stability performance.

5.3.1 Test results and conclusions

With more and more fine aggregates, mixture's retained stability gets bigger. Mixture's water stability gets stronger gradually. ARZ which FAC is 0.67 and AC-16 gradations' water stability are better. With more and more fine aggregates, mixture's OAC may increase. Then the depth of asphalt film wrapping coarse aggregate gets bigger value, so mixture's water stability gets better in these cases. When FAC is larger than 0.58, mixture's retained stability is more than 85%. The mixture's water stability are in good condition.

6. CONCLUSIONS

- With more and more fine aggregates，mixture's OAC gets larger value and DP becomes decreasing.
- With more and more fine aggregates, the skeleton structure of mixtures is propped out gradually. The skeleton structure of AC-16 mixture is the worst.
- When FAC is 0.55(CRZ), the mixture's high temperature performance is the best, and its DS can achieve 3539 times/mm. ARZ and AC-16 gradations' high temperature performance are not ideal and their DS are nearly 2000 times/mm.
- The TRZ and AC-16 gradations' low temperature performance are better while the other gradations' low temperature performance are not very ideal.
- With more and more fine aggregates, mixture's water stability gets stronger gradually. When FAC larger than 0.58, mixture's retained stability is more than 85% and mixture's water stability are better conditions.
- Synthesizing all pavement performances, the BRZ gradation's performances are not very ideal; the CRZ gradation's high temperature performance is the best, however, its low temperature performance and water stability are worse; the TRZ gradation's performances are optimal. The ARZ and AC-16 gradations' high temperature performance are worse, but their low temperature performance and water stability are better under the Chinese specifications.

7. REFERENCES

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BIOGRAPHY

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