Test of SMA - 16 asphalt mixture ratio on the runway of Da Lian Airport

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Abstract. After years of use, there's oil loss on the asphalt pavement . the bond strength of aggregate decreases . Loose threshing is serious. In order to improve the pavement performance, Extend the service life of pavement , Improve the safety of aircraft operation .we test the SMA-16 modified asphalt mixture on the runway of Da Lian Airport from many factors , including raw materials, admixtures, gradation design, optimum ratio of oil to stone, then we find the best ways to resolve it.

1 Introduction

After years of use, there's oil loss on the asphalt pavement , the bond strength of aggregate decreases . Loose threshing is serious. In order to improve the pavement performance, extend the service life of pavement , improve the safety of aircraft operation, we test the SMA-16 modified asphalt mixture on the runway of Da Lian Airport from many factors , including raw materials, admixtures, gradation design, optimum ratio of oil to stone, then we find the best ways to resolve it .

2 Raw materials

2.1 Asphalt

We use high modulus asphalt and test its performance indicators, we put the results on the below table .

Table1. High modulus asphalt performance test results

Test items		Technical requirements	Test results
Softening point(℃)		＞80	88.3
Penetration(25℃, 100g, 5s) (0.1mm)		≦50	36.3
Ductility(5cm/min，10℃)(cm)		＞40	48.3
Filmy heating operational test163℃/5h	Mass loss (%)	＜1	-0.04
	Penetration ratio (%)	＞70	75.6
	Ductility(10℃) (cm)	＞30	40.8
Equivalent softening point T_{800} (℃)		＞50	61.0
Equivalent brittle point$T_{1.2}$(℃)		＜-13	-18.4
Flash point(COC)(℃)		＞250	277
Elastic recovery(15℃)		＞80	92.3

From the results, it appears that all the performance indicators meet the technical requirements, we can use this asphalt.

2.2 Coarse aggregate and fine aggregate

(1) Coarse aggregate

There are basalt coarse aggregates (10~20mm 、5~10mm)and limestone(3~5mm) aggregates , We tests the aggregate indexes in accordance with the relevant regulations , the test results are shown on the table below.

Table2. The coarse aggregate technical indicators

Aggregate size	Test results	Test items
10~20mm	2.784	Bulk specific gravity
5~10mm	2.840	
3~5mm	2.747	
10~20mm	2.922	Apparent specific gravity
5~10mm	2.980	
3~5mm	2.907	

From the results, it appears the bulk specific gravity and the apparent specific gravity all meet the technical requirements, we can use them in the project.

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Table3. The coarse aggregate particle gradation

mesh /mm	P（%）					
	10～20mm		5～10mm		3～5mm	
	Technical requirements	Test results	Technical requirements	Test results	Technical requirements	Test results
19	95～100	100	—		—	
16	—	95.4				
13.2	—	46.9	100	100	—	
9.5	0～15	2.1	95～100	98.4	—	
4.75	0～5	0	0～10	0.9	85～100	97.8
2.36	—	0	0～5	0.1	0～25	29.3
1.18	—	0	—	0	—	11.1
0.6	—	0	—	0	0～5	5.3
0.3	—	0	—	0	—	2.9
0.15	—	0	—	0	—	2.1
0.075	—	0	—	0	—	0.6

From the results, it appears that the 4.75mm and 2.36mm passing rate of 3~5mm cannot meet the technical requirements. So we suggest that We should screen 3~5mm until the passing rate meet technical requirements.

(2) Fine aggregate

We use 0-3mm fine aggregate, we test their performance indicators, and put them on the below table.

Table4. The basalt fine aggregate particle gradation

mesh （mm）	P（%）	
	Technical requirements	Test results
4.75	100	100
2.36	85～100	92.3
1.18		56.1
0.6	20～50	37.8
0.3		19.2
0.15		12.1
0.075	0～15	2.9

From the results, it appears that 0~3mm can meet the technical requirements.

2.3 Filler

We use the limestone powder filler, we test its performance indicators, we put the results on the table 5.

Table5. The mineral filler technical indicators

Test items		Technical requirements	Test results
Hydrophilic coefficient		≤1	0.6
Particle gradation	＜0.6mm	100	99.4
	＜0.15mm	99.5	96.3
	＜0.075mm	85.2	83.7
Apparent specific gravity （g/cm^3）		≥2.50	2.669
Water content （%）		≤1	0.7

From the results, it appears that all the performance indicators meet the technical requirements, we can use this filler.

2.4 Fiber

We use polyacrylonitrile fiber to test, its main technical indicators are shown in table 6.

Table6. Polyacrylonitrie fiber test results

Test items	Technical requirements	Test results
Diameter （μm）	10~25	12.9
Length （mm）	6±1.5	6.0
Tensile strength （MPa）	≥500	546
Elongation at break （%）	≥15	20

From the chart, we can see all the indicators of polyacrylonitrile fiber meet the specification requirements.

2.5 Anti-rutting agent

We use haichuan Anti-rutting agent, through results, Adding 0.5% anti-rutting agent of the asphalt mixture we can achieve the best test results. We test its performance indicators, and put the results on the below table.

Table7. Anti rutting agent basic indexes test results

Test items	Technical requirements	Test results
Density （g/cm^3）	0.9~1.1	0.96
Melt flow rate （190℃，2.16kg）(g/10min)	≥3	8
Water content （%）	≤2	0.2
Softening point （℃）	140~170℃	141

From the results, it appears that all the performance indicators meet the technical requirement.

3 Mix design of SMA-16 asphalt mixture

3.1 The determination of aggregate gradation ratio

The aggregate gradation ratio of SMA-16 asphalt mixture is formed with five different raw materials .We choose three mix designs. All the mix designs and raw materials are put on the below table.

Table8. SMA-16 ratio of mineral aggregate gradation(%)

Specifications	10~20mm	5~10mm	3~5mm	0~3mm	filler
Coarse gradation	15	24	10	26	5
Middle gradation	15	24	10	26	5
Fine gradation	15	24	10	26	5

Table9. SMA-16 mineral synthesis aggregate gradation

Mesh size(mm)	coarse	middle	fine	upper	lower
26	100.0	100.0	100.0	100	100
19	100.0	100.0	100.0	100	100
16	97.6	97.7	97.7	95	90
13.2	73.5	75.0	75.6	70	60
9.5	50.6	53.6	54.6	50	40
4.75	22.2	26.1	28.1	26	20
2.36	18.7	21.8	23.0	22.5	18
1.18	15.4	17.6	18.3	18	14
0.6	12.9	14.6	15.0	15.5	12
0.3	9.2	10.3	10.5	13	10
0.15	7.6	8.5	8.6	11.5	9
0.075	5.9	6.4	6.5	10	8

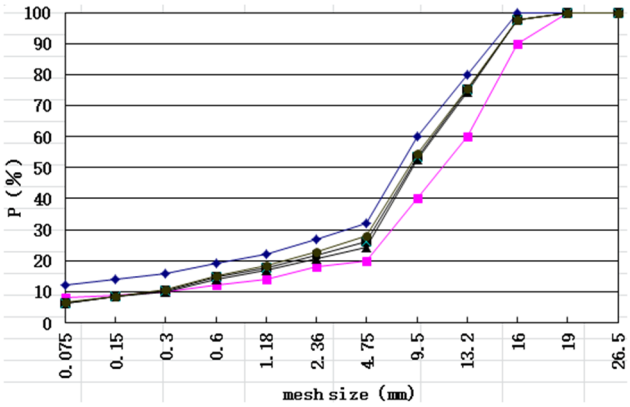

Figure 1. SMA-16 grading curve

Content of coarse aggregate P_{CA} and Clearance rate VCA_{DRC} of more than 4.75mm in three mixtures are tested in table 10.

Table10. The Marshall test results of different asphalt aggregate ratio

items	loose unit weight (g/cm^3)	the passing rate of 4.75 mm (%)	bulk specific gravity of above4.75mm (g/cm^3)	P_{CA}	VCA_{DRC}
coarse	1.720	22.2	2.799	0.734	38.55
middle	1.706	26.1	2.779	0.697	38.61
fine	1.700	28.1	2.773	0.678	38.69

Based on the experience of previous similar airport engineering, we use ratio of 6.0% as a first try oil-stone ratio in Marshall design method, and then mold specimens in accordance with the specification requirements, measure the physical indexes of the specimens. Specific data are shown in table 11.

Table11. Performance of the first grading

Test items	Coarse gradation	Middle gradation	Fine gradation
Bulk specific gravity(g/cm^3)	2.465	2.487	2.503
Theoretical density(g/cm^3)	2.569	2.563	2.567
VV(%)	4.0	3. 0	2.4
VMA(%)	17.04	16.06	15.47
VFA(%)	76.4	81.6	84.7
VCA_{mix}(%)	35.54	37.61	38.87
VCA_{DRC}(%)	38.55	38.61	38.69
MS(KN)	10.75	9.42	9.63
FL(0.1mm)	34.1	36.9	34.2

According to the relevant specifications, the coarse grading is the best grading.

3.2 The determination of the optimum proportion

We select 3 asphalt aggregate ratio of Marshall test and calculate their physical indicators in order to determine the optimum proportion, the test results are shown in the table12.

Table12. The Marshall test results of different asphalt aggregate ratio

Test items	oil-stone ratio(%)			Specification requirements
	5.7	6.0	6.3	
Bulk specific gravity(g/cm^3)	2.458	2.465	2.466	—
Theoretical density(g/cm^3)	2.580	2.569	2.558	—
VV(%)	4.7	4.0	3.6	3～4
VMA(%)	17.1	17.1	17.3	≥16.5

Test items	oil-stone ratio(%)			Specification requirements
	5.7	6.0	6.3	
VFA(%)	72.3	76.3	79.2	-
VCA_{mix}(%)	35.36	35.36	35.52	⩽VCA_{DRC}
VCA_{DRC}(%)	38.55	38.55	38.55	—
MS(KN)	9.46	9.81	10.13	⩾6
FL(0.1mm)	37.2	31.4	28.4	—

According to the requirements of the relevant specification, calculated the optimum proportion of 6.0%.

3.3 The optimum proportion of validation

In the optimum asphalt aggregate ratio of 6.0%, we make Marshall specimen and the dynamic stability of specimen, then test their Physical and mechanical performance. we put the results on the below table.

Table13. The Road performance verification test results

Test items	Test results
△M(%)	0.1
△S(%)	1.81
DS(time/mm)	12000
MSo(%)	89.3
TSR(%)	91.6
Cw(mL/min)	32.1
TD(mm)	1.1

MS is strength index, MSo and TSR are water damage resistance index, DS is high temperature performance index, Cw is water permeability index.

From the results, it appears that all the test results can meet the requirements of related technologies.

Adding anti-rutting agent quality of 0.5% asphalt mixture, dynamic stability of asphalt mixture arrives at 12000 times/mm, MSo arrives at 89.3％, TSR arrives at 91.6%, Cw arrives at 32.1 mL/min. They all meet the design requirements. We can see that the mixture has formed the skeleton dense structure rom the profile of the specimen, it meets with the skeleton dense type AC asphalt mixture design intent.

4 Conclusion

In combination with the runway of Da Lian Airport, in order to slove the serious problems of SMA - 16 asphalt mixture, we achieve these important ways.

First; Starting from the raw material, we should choose the qualified raw materials. including aggregate, filler and asphalt. The important indicators of aggregate are bulk specific gravity, apparent specific gravity, sand equivalent, sturdiness and p%; The important indicators of filler are apparent specific gravity, water content, Particle gradation and hydrophilic coefficient; The important indicators of asphalt are penetration, softening point, ductility, equivalent softening point, equivalent brittle pointT1.2, flash point, density, elastic recovery and filmy heating operational test163℃/5h.

Second: we should choose good aggregate gradation.such as 10～20mm: 5～10mm: 3～5mm: 0～3mm:fiber=15:24:10:26:5.

Third: In order to obviously improve the dynamic stability of mixture, it is reasonable to adding anti-rutting agent.

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