Design of SMA - 13 asphalt mixture ratio on Z3and Z18 of the capital airport

Shuaituan Tian [1, 2, a], Song Ye [1, 2], Fandong Kong [3]

[1]China Airport Construction Group Corporation of CACC, Beijing, 100101, China
[2]Beijing Super-Creative Technology Co., LTD, Beijing, 100621, China
[3]Beijing Capital International Airport Co., Ltd.

E-mail: 420069269@qq.com

Abstract. According to the demand of T2 terminal airlines to operate A380 models, to meet the smooth running of the A380 airliner at the west end of the Capital Airport, So Z3 and Z18 taxiway area of the transformation is imperative. According to the design, the upper layer of this project adopts SMA - 13 modified asphalt mastic macadam mixture. We design the SMA-13 modified asphalt mixture on Z3 and Z18 of the capital airport from any respects, including coarse and fine aggregate, filler, asphalt, fiber and anti-rutting agent, and we hope we can find the best SMA-13 modified asphalt mixture.

1. Introduction

According to the demand of T2 terminal airlines to operate A380 models, to meet the smooth running of the A380 airliner at the west end of the Capital Airport, So Z3 and Z18 taxiway area of the transformation is imperative. According to the design, we need design the SMA-13 modified asphalt mixture.

2. Raw materials

2.1. Asphalt

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

Table 1 Cnooc modified asphalt performance test results

Test items		Technical requirements	Test results
Softening point(℃)		≥80	93.1
Penetration(25℃,100g,5s)(0.1mm)		≤50	43.4
Ductility(5cm/min,10℃)(cm)		＞40	57.4
Filmy heating operational test163℃ /5h	Mass loss(%)	＜1	-0.04
	Penetration ratio(%)	≥60	75.6
	Ductility(10℃)(cm)	≥30	40.8
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 (10~15mm, 5~10mm)and limestone(3~5mm) aggregates , We teste the aggregate indexes in accordance with the relevant regulations , the test results are shown on the table below.

Table 2 The Coarse aggregate technical indicators

Aggregate size	Test results	Test items
10~15mm	2.813	Bulk specific gravity
5~10mm	2.770	
3~5mm	2.715	
10~15mm	2.935	Apparent specific gravity
5~10mm	2.918	
3~5mm	2.805	

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.

Table 3 The Coarse aggregate Particle gradation

mesh (mm)	P(%)					
	10～15mm		5～10mm		3～5mm	
	Technical requirements	Test results	Technical requirements	Test results	Technical requirements	Test results
16	—	100	—		—	
13.2	95～100	80.4	100	100	—	
9.5	0～15	35.5	95～100	94.6	100	100
4.75	0～5	0.8	0～10	12.0	85～100	99.7
2.36	—	0	0～5	0.8	0～25	30.5
1.18	—	0	—	0.6	—	4.2
0.6	—	0	—		0～5	2.2
0.3	—	0	—	1.6	—	2.0
0.15	—	0	—	1.4	—	2.0
0.075	—	0	—	0	—	2.0

From the results, it appears that the 13.2mm and 9.5mm passing rate of 10～15mm, the 9.5mm and 4.75mm passing rate of 5～10mm and the4.75mm and 2.36mm passing rate of 3～5mm can not meet the technical requirements. So we suggest that We should screen 10～15mm ,5～10mm and 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

Table 4 The Basalt FINE aggregate Particle gradation

mesh (mm)	P(%)	
	Technical requirements	Test results
4.75	100	100
2.36	85～100	87.6
1.18		60.4
0.6	20～50	42.4
0.3		30.2
0.15		25.7
0.075	0～15	21.2

From the results, it appears that the 0.6mm and 0.15mm passing rate of 0～3mm can not meet the technical requirements. So we suggest that We should screen 0～3mm until the passing rate meet technical requirements.

2.3. Filler

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

Table 5 The Mineral filler technical indicators

Test items		Technical requirements	Test results
Hydrophilic coefficient		≤1	0.7
Particle gradation	＜0.6mm	100	99.6
	＜0.15mm	90～100	96.5
	＜0.075mm	75～100	83.9
Apparent specific gravity(g/cm^3)		≥2.50	2.774
Water content(%)		≤1	0.14

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 table6.

Table 6 polyacrylonitrie fiber test results

Test items	Technical requirements	Test results
Diameter(μm)	10~25	12.7
Length(mm)	6±1.5	6.0
Tensile strength(MPa)	≥500	522
Elongation at break(%)	≥15	17.5

From the chart, we can see all the indicators of polyacrylonitrile fiber meet the specification requirements, and it can be used in the design and engineering.

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, we put the results on the below table.

Table 7 Anti rutting agent basic indexes test results

Test items	Technical requirements	Test results
Density (g/cm^3)	0.9~1.1	0.92
Melt flow rate(190℃,2.16kg)(g/10min)	≥3	7
Water content(%)	≤2	0.5
Softening point(℃)	110~150℃	140

From the results, it appears that all the performance indicators meet the technical requirements, we can use haichuan Anti-rutting agent.

3. Mix design of SMA-13 asphalt mixture

3.1. The determination of aggregate gradation ratio

The aggregate gradation ratio of SMA-13 asphalt mixture is formed with t five differen raw materials .we choose three mix designs .All the mix designs and raw materials are put on the below table.

Table 8 SMA-13 ratio of mineral aggregate gradation(%)

Specifications	10～15mm	5～10mm	3～5mm	0～3mm	filler
Coarse gradation	52	26	4	7	11
Middle gradation	51	25	6	7	11
Fine gradation	50	24	7	8	11

Table 9 SMA-13 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	100.0	100.0	100.0	100	100
13.2	89.9	90.1	90.3	100	90
9.5	65.1	65.8	66.5	65	45
4.75	25.6	27.5	29.3	34	22
2.36	18.6	19.2	20.3	27	18
1.18	15.6	15.6	16.3	22	14
0.6	14.0	14.1	14.5	19	12
0.3	13.1	13.1	13.5	16	10
0.15	12.5	12.6	12.8	14	9
0.075	10.7	10.7	11.0	12	8

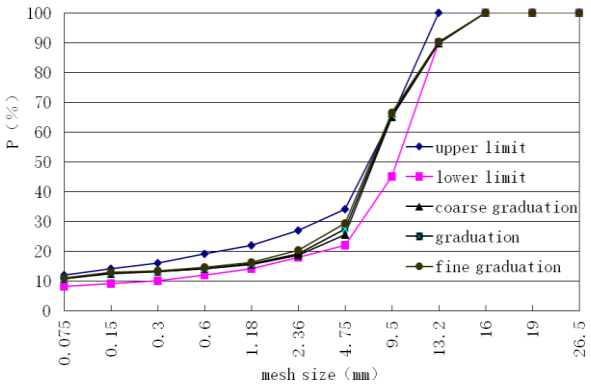

Figure I. SMA-13 grading curve

Content of coarse aggregate P_{CA} and Clearance rate VCA_{DRC} of more than 4.75mm in three mixtures are tested in table10.

Table 10 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	1.622	25.6	2.818	0.702	42.44
middle	1.630	27.5	2.810	0.684	41.99
fine	1.636	29.3	2.804	0.667	41.66

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.

Table 11 Performance of the first grading

Test items	Coarse gradation	Middle gradation	Fine gradation
Bulk specific gravity(g/cm^3)	2.446	2.452	2.470
Theoretical density(g/cm^3)	2.583	2.582	2.581
VV(%)	5.31	5.03	4.31
VMA(%)	17.5	17.4	16.8
VFA(%)	69.7	71.0	74.2
VCA_{mix}(%)	39.08	40.32	41.25
VCA_{DRC}(%)	42.44	41.99	41.66
MS(KN)	9.38	9.12	9.93
FL(0.1mm)	32.5	24.0	28.8

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

3.2. The determination of the optimum proportion

We select 3asphalt 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.

Table 12 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)	2.467	2.474	2.481	—
Theoretical density(g/cm^3)	2.593	2.581	2.570	—
VV(%)	4.85	4.14	3.47	3～5
VMA(%)	16.6	16.6	16.6	≥16.5
VFA(%)	70.9	75.1	79.1	-
VCA_{mix}(%)	41.15	41.14	41.15	≤VCA_{DRC}
VCA_{DRC}(%)	41.66	41.66	41.66	—
MS(KN)	9.67	9.04	11.05	≥6
FL(0.1mm)	25.9	25.6	28.5	—

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.

Table 13 The Road performance verification test results

Test items	Test results
△M(%)	0.05
△S(%)	1.9
DS(time/mm)	10002
MSo(%)	92.3
TSR(%)	86.1
Cw(mL/min)	21
TD(mm)	0.84

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

4. Conclusion

If we want to design the best SMA-13 modified asphalt mixture, we should achieve these important ways.

First; Starting from the raw material, we should choose the qualified raw materials.

Second: we should choose good aggregate gradation.

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

References

[1] The ministry of communications highway engineering science institute. JTJ E20-2011.Standard test methods of bitumen and bituminous mixtures for highway engineering [S].
[2] Xiaoming, Huang. Asphalt and asphalt mixture [M].
[3] The ministry of communications highway engineering science institute. JTG F40-2004. Technical specification for construction of highway asphalt pavement [S].
[4] The civil aviation administration of China. JTG F40-2004. Specification for asphalt concrete pavement construction of civil airports [S].
[5] The ministry of communications highway engineering science institute. JTG E42-2005. Test methods of aggregate for Highway Engineering [S].