Research of SMA - 13 asphalt mixture ratio on the taxiway of HuangHua Airport

Shuaituan Tian [1, 2, *], Yapei Yan [1, 2], Peng Wang [1,2]

[1] China Airport Construction Group Co., Ltd, Beijing, 100101, China
[2] Beijing Super-Creative Technology Co., Ltd, Beijing, 100621, China

Abstract. Because of the large load and large impact force of airport pavement under, it often appears the phenomenon of serious rut. In order to improve this kind of phenomenon, combined with the taxiway of HuangHua Airport area reconstruction project, we analyze the upper layer type of SMA-13 modified asphalt mixture ratio design. we analysis from raw material selection, mixture gradation design and admixture added, and finally choose the excellent performance of asphalt mixture.

Keywords: SMA-13; Oil loss; Mix ratio; Performance test.

1. Introduction

The main raw materials required for asphalt mixture mix ratio test include asphalt, gravel, stone chips, mineral powder, fiber and anti-rut agent. All materials are tested according to relevant specifications. Raw materials are determined by the construction unit and the design unit after investigation, and provide sufficient number of samples for the test. In order to ensure the accuracy of test data, all raw materials are sampled according to the standard sampling method stipulated in the specification to meet the needs of various test projects. Of asphalt mixture pavement involved in a variety of materials, quality must meet the design requirements, at the same time should be in strict accordance with the design requirements of dosage and proportion of added, otherwise will largely reduce the performance of asphalt mixture material, in order to ensure project quality to meet the design intent, specific should meet the following requirements.

2. Material composition

2.1 Coarse aggregate and fine aggregate

The reason why SMA has a good high temperature stability is mainly based on the embedding of a lot of coarse aggregates, so its crushing resistance of coarse aggregates is very high. Coarse aggregate must use tough, rough, angular high quality stone; The needle and flake particle content of coarse aggregate must be strictly limited. The gravel used should not be broken by jaw plate stone crusher, but by hammer or counterattack (rotary) stone crusher. At the same time, because SMA is used for the surface layer of the road surface, aircraft takeoff and landing on the road surface anti-skid performance requirements are very high, coarse aggregate must meet the requirements of anti-skid performance, which requires that it must have a good polishing value.

Through the investigation and comparison of the airport construction party, the technicians of our company selected basalt and limestone coarse aggregate for the target mix ratio design test in the upper layer. Perform raw material test on selected coarse aggregate,

The fine aggregate of asphalt pavement should be machine-made sand, and the fine aggregate should be clean, dry, without impurities, and have appropriate particle gradation. According to the relevant technical requirements, limestone machine-made sand is mainly used in the fine aggregate of asphalt mixture mix ratio test.

2.2 Asphalt

The asphalt binder in asphalt mixture must have high viscosity and good adhesion with aggregate to ensure sufficient high temperature stability and low temperature toughness.

When sampling asphalt test, according to the requirements of the specification, the quantity required by the test will be collected and stored separately, and the samples will be tested according to the specifications. Only the asphalt that meets the requirements of the "Specification for Asphalt Concrete Pavement Design of Civil Airport" (MH5010-2017) can be used.

According to the climate characteristics of Huanghua area and the operation status of Huanghua Airport, it is necessary to enhance the ability of the middle and lower layer of asphalt pavement to resist permanent deformation

* Corresponding author: tianst@cacc.com.cn

(anti-rutting), so SBS modified asphalt is adopted in this mix design.

2.3 Filler

In this overhaul project, mineral powder is used as the filler of asphalt mixture. Its role is very important, and its quality will directly affect the performance of the mixture. Ore powder must be ground from limestone alkaline rock. Mineral powder should be dry, loose particles, no agglomeration, rain or damp agglomeration of mineral powder shall not be used

2.4 Fiber

Fiber stabilizer for SMA mainly includes lignin fiber, mineral fiber, polymer chemical fiber, etc. Its function is to improve the performance of asphalt mixture, adsorption asphalt, reduce leakage. Fiber should be able to withstand the minimum environmental temperature of 250 ℃ without deterioration, and do not cause harm to the environment, do not harm to health.

According to the experience of similar airport projects in the past, polyester fiber is used in the test. Polyester fiber can play the role of oil absorption and reinforcement in asphalt mixture, and can improve the performance of rutting resistance and water damage resistance of the mixture.

2.5 High adhesive

High viscosity asphalt modifier is a new kind of additive specially developed for preparing high viscosity asphalt and high viscosity asphalt mixture. High viscosity asphalt mixture with excellent performance is prepared by directly putting it into mixing pot. The dosage of asphalt mixture is 0.5%. The temperature sensitivity of the prepared asphalt mixture decreases, the high temperature stability, aging resistance and low temperature performance are significantly improved

3. Mix design of SMA-13 asphalt mixture

SMA is a kind of asphalt mixture composed of asphalt, fiber stabilizer, mineral powder and a small amount of fine aggregate. SMA material structure characteristics are: three more and one less, more coarse aggregate, more ore powder, more asphalt, less fine aggregate.

Due to the amount of SMA ore powder, the aggregate specific surface area is large, and more asphalt is needed to cover. At the same time, the skeleton void formed by a large number of coarse aggregate needs more asphalt cement to fill, so the asphalt content of SMA gradation mixture is larger, which forms another characteristic of SMA, the amount of asphalt. Because SMA belongs to discontinuous grading, so from the traditional point of view, THE SMA mixture is easy to segregate, but another characteristic of SMA is rich in oil mud, and the cohesion of mud because of ore powder and larger, so that SMA overcomes the shortcomings of discontinuous grading easy segregation. At the same time, oil-rich cement enhanced the low temperature cracking resistance and aging resistance of SMA. The high content of coarse aggregate in SMA mixture also forms a skeleton structure that can transfer vehicle load efficiently, so SMA has a very high temperature resistance to rutting ability. The high content of coarse aggregate also increases the roughness of the surface of the mixture, so that the SMA surface has a larger structural depth, enhance the anti-skid ability of the road surface and the safety of high-speed driving in rainy and snowy days. In addition, intermittent gradation makes it easy to fill the cement aggregate skeleton, sufficient amount of cement to make the final compacting SMA mixture has a low level of voidage, so that the WATERPROOF performance of SMA is very strong, anti-aging, anti-fatigue advantages outstanding, has a high durability, long service life.

3.1 Selected raw materials

The cementing material is SBS modified asphalt. Coarse aggregate basalt and limestone stone, material specifications of basalt 10 ~ 15mm, 5 ~ 10mm and 3 ~ 5mm; Fine aggregate is limestone, the specification is 0 ~ 3mm; The filling is limestone powder.

The fiber used in this mixing ratio test is polyester fiber, and the dosage is 0.4% of the weight of asphalt mixture, and the anti-rutting agent and high viscosity agent are 0.5% of the weight of asphalt mixture.

3.2 The determination of aggregate gradation ratio

In accordance with the "Civil Airport Asphalt Pavement Construction Technical Specifications" (MH/T 5011-2019), "Highway Asphalt Pavement Construction Technical Specifications" (JTG F40-2004) and "Highway Asphalt Mhoa resin gravel Pavement Technical Guide" (SHC F40-01-2002), the first SMA ore gradation design, To prepare asphalt mixture with coarse, medium and fine grading, it is required that the passing rate of 4.75mm sieve (key sieve) is about ±4% (that is, the passing rate is about 22%, 26% and 30%) in the guideline SM-13 grading range, and the passing rate of 0.075mm is about 10%.

The aggregate gradation ratio of SMA-13 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.

Table 1. SMA-13 ratio of mineral aggregate gradation (%)

Specifications	10 ~ 15mm	5 ~ 10mm	3 ~ 5mm	0 ~ 3mm	filler
Coarse gradation	49	26	7	8	10
Middle gradation	48	28	8	9	10
Fine gradation	47	24	9	10	10

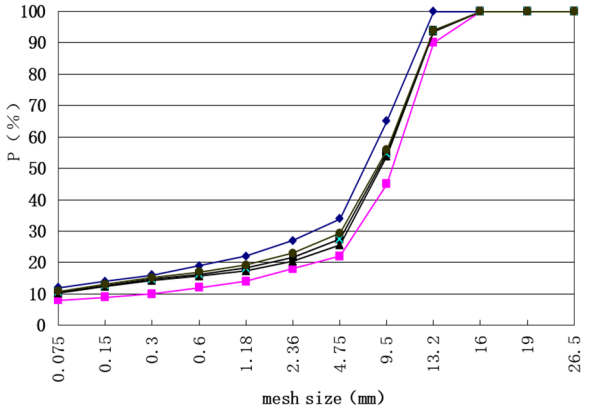

Figure I. SMA-13 grading curve

Content of coarse aggregate P_{CA} and Clearance rate VCA_{DRC} of more than 4.75mm in three mixtures are tested in table3.

Table 2. 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	1.654	25.5	2.899	0.703	42.95
middle	1.646	27.4	2.889	0.685	43.03
fine	1.638	29.4	2.866	0.666	43.24

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.

According to the recommendation of "Technical Specifications for Construction of Asphalt Pavement in Civil Airports" (MH/T 5011-2019), the volume index of selected gradation VCAmix must be less than VCADRC, and THE VMA should be greater than 16.5%. Under the condition that the void ratio meets the requirements of the specification, the high temperature stability (anti-rutting performance) of asphalt mixture can be improved by using coarser aggregate gradation. The coarse gradation can be determined as the design gradation of mineral material by analyzing the above table.

3.3 The determination of the optimum proportion

Marshall design method is adopted to determine the optimum asphalt-stone ratio by rough grading according to the results of ore material grading design.

According to the previous experience of asphalt mixture mixture ratio test in similar engineering, three asphalt-stone ratios were selected for Marshall test, which were 5.7%, 6.0% and 6.3% respectively.

According to the "Civil Airport Asphalt Pavement Construction Technical Specifications" (MH/T 5011-2019), "Highway Asphalt Mma Foot resin gravel Pavement Construction Technical Requirements" (SHC F40-01-2002) and "Highway Asphalt Pavement Construction Technical Specifications" (JTG F40-2004), for SMA asphalt mixture, The density and voidage of the Marshall test should be calculated using the relative density of gross volume measured by the surface dry method, and the maximum theoretical density of mineral materials should be calculated using the gross volume density of aggregate.

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 table4.

Table 3. 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)	2.502	2.507	2.510	–
Theoretical density (g/cm^3)	2.617	2.605	2.594	–
VV （%）	4.4	3.8	3.2	3 ~ 4
VMA （%）	17.2	17.2	17.4	≥16.5
VFA （%）	74	78	81	-
VCA_{mix} （%）	39.17	39.22	39.32	≤VCA_{DRC}
VCA_{DRC} （%）	42.95	42.95	42.95	–
MS （KN）	7.92	7.64	8.13	≥6
FL （0.1mm）	27.6	30.3	34.0	–

Based on the data analysis in the above table, considering that when the design void ratio is 3-4.5%, the corresponding indexes VMA, VCAmix, VFA and Marshall stability meet the requirements, 6.0% is decided as the best oil/stone ratio in combination with the corresponding oil/stone ratio of the design void ratio of 3-4.5% and the actual experience.

It can be seen from the test piece that the coarse aggregate in the asphalt mixture has formed a good skeleton. The asphalt mace has filled the gap of mineral material fully and distributed evenly, and the whole mixture has become a good skeleton dense structure. To sum up, the target mixture ratio of SM-13 asphalt mixture is reasonable and feasible.

3.4 The optimum proportion of validation

When the optimum asphalto-stone ratio is 6.0%, all the Marshall test indexes meet the requirements. Further performance test of SMA is carried out. The method and corresponding performance test are as follows.

1. Schellenberg asphalt leakage test: to check whether the maximum amount of SMA asphalt is appropriate, which is related to the success or failure of SMA structure. Therefore, after the ratio is determined, it is necessary to check whether too much asphalt will cause leakage or too little asphalt will cause dispersion. There are beaker method, enamel plate method, net basket method and so on in the international leakage test. The highway department of Our country has decided to adopt beaker

method as the standard method and formulated the corresponding test regulations. Therefore, the beaker method is used in the mix ratio test to evaluate whether the maximum amount of asphalt is appropriate.

2. Kent fort dispersion test: used to test whether the amount of asphalt is too little or insufficient asphalt adhesion. Asphalt mixture under the action of traffic load, aggregate may fall off from the road surface and disperse, so it must be tested by flying test under certain conditions.

3. Rutting test: SMA is usually used as the surface layer of the road surface, which needs to have good high temperature performance. Whether the asphalt mixture has good high temperature performance can be characterized by the high temperature anti-rut ability of the asphalt mixture. Rutting tests in many projects show that the dynamic stability of modified asphalt can reach 5000 times /mm or more.

4. Water stability test: In China, immersion Marshall test and freeze-thaw splitting test are generally used to test the water stability of asphalt mixture.

5. Water seepage test: an important feature of SMA is that the void rate between the coarse aggregate is fully filled by asphalt ma Foot grease part, the void rate is very small, good SMA structure after rolling molding should be impervious to water or water permeability is very slow, the guidelines require indoor test in the wheel forming plate specimen water seepage coefficient detection.

6. Structural depth test: structural depth represents the sliding resistance of asphalt mixture. In Our country, sand paving method is generally used to test the structural depth on the plate specimen formed by wheel grinding.

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 4. The Road performance verification test results

Test items	Test results
△M（%）	0.09
△S（%）	2.2
DS（time/mm）	10862
MSo（%）	97.8
TSR（%）	90.9
Cw（mL/min）	No seepage
TD（mm）	1.08

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

4. Conclusion

In combination with the taxiway and runway of HuangHua Airport, in order to slove the serious problems of SMA - 13 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 ~ 15mm: 5 ~ 10mm: 3 ~ 5mm: 0 ~ 3mm:fiber=49:26:7:8:10.

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

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