A Study on the Preparation and Key Properties of Open-Graded Asphalt Stabilized Aggregates Base Mixes

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Abstract. With the increasing development of transportation infrastructure construction, the requirements for the performance of pavement materials are constantly increasing. To meet the drainage and compression requirements of the road surface, open-graded asphalt stabilized crushed stone base mixture has received widespread attention as a new type of road surface material. This article aims to prepare open graded asphalt stabilized crushed stone base application materials and compare their actual performance to evaluate their effectiveness in practical applications. Method and process: Combine ATPB30 and SACPB30 materials, carry out the grading design of the same main skeleton gap filling method, delimit the grading interval in the preparation process by calculating the average density of mineral aggregate, and ensure the authenticity and reliability of the mixture preparation. The best asphalt aggregate ratio is calculated, and the water seepage and compression resistance of the mixture are determined by combining the water seepage experiment and the rutting experiment, so as to complete the analysis of its key performance. Results: For the six randomly selected test nodes, combined with the measured data and information, it is finally concluded that the bending strain ratio of the airport pavement can reach more than 5.5, and each position of the airport pavement test is random, so the results of this calculation are more reliable. Conclusion: Under different backgrounds, through comparative tests from multiple angles and environments, the bending strain ratio of airport pavement finally reached more than 5.5, which indicates that the final performance analysis results obtained by combining the preparation of open graded asphalt stabilized macadam base mixture are more reliable and true, as shown: the smaller the particle size of SACPB30, the better its drainage performance during pavement construction, the corresponding compressive capacity has also been significantly improved, and the practical application effect in deformation control, anti fatigue treatment and crack resistance has been greatly optimized, indicating that the open graded asphalt stabilized crushed stone base mixture is more scientific and reasonable.

Keywords: Open-graded asphalt; Stabilized gravel; Base course mix; Mixture preparation; Performance comparison; Asphalt proportioning

Z. Ahmad et al. (eds.), *Proceedings of the 2024 5th International Conference on Urban Construction and Management Engineering (ICUCME 2024)*, Advances in Engineering Research 242,
https://doi.org/10.2991/978-94-6463-516-4_8

1 Introduction

As an important infrastructure to support the development of national economy, the quality and performance of road engineering have received increasing attention. As an important part of road structure, the research on the preparation technology and key performance of open-graded asphalt stabilized aggregates is of great significance to improve the service life of road and ensure the safety of traffic [1]. As a special pavement material, open-graded asphalt stabilized aggregates base course mix needs to take into full consideration of the selection of raw materials, mix ratio design, preparation process and molding method and other factors in the preparation process [2]. Suitable raw materials and scientific ratio design are the key to prepare high quality open-graded asphalt stabilized gravel base, while the preparation process and molding method directly affect the homogeneity and compactness of the mixture [3]. In order to improve the mix preparation effect and the overall application performance, the analysis and practical research on the preparation and key performance of open-graded asphalt stabilized aggregates base course mixes are proposed. In order to ensure the authenticity and reliability of this analysis, the airport road surface project was selected as the target. Unlike ordinary roads, the stability and durability of airport pavement, as a critical area for aircraft landing and taxiing, are directly related to aviation safety [4] . Therefore, the selection of suitable base material is very critical, and the preparation of open-graded asphalt stabilized aggregates will directly affect the bearing capacity and durability of airport roads. Open-graded asphalt stabilized aggregates have good drainage performance [5] . The airport road surface is constantly exposed to erosion from natural elements, particularly rain and snow. Open-graded asphalt stabilized aggregates serve as an effective solution, efficiently draining away water to keep the road surface dry and prevent water from penetrating into the base layer, thereby mitigating the risk of potential roadway diseases. [6] . In addition, the pavement constructed in this way can withstand the huge load generated by aircraft landing and taking off, and maintain the smoothness and stability of the pavement to ensure the safe landing and taking off of aircraft, resist the erosion of various unfavorable factors, and maintain the integrity and service life of the pavement [7] . In this paper, the preparation technology and key performance of open-graded asphalt stabilized aggregates base mix are systematically studied to provide theoretical basis and technical support for road construction. It is expected to provide more high-quality and high-efficiency pavement materials for road construction and contribute to the sustainable and healthy development of China's transportation industry [8-9] .

2 Experimental Preparation

Before the construction of open-graded asphalt stabilized gravel base layer of airport road surface, it is necessary to carry out the mixture proportioning and preparation according to the actual needs of base layer construction as well as the construction height, depth and area of the road surface, etc., so as to lay the basic conditions and reference basis for the subsequent performance research.

2.1 Experimental Materials

Before the test experiment, it is necessary to preset and determine the raw materials and auxiliary materials used. ATPB30 and SACPB30 open graded asphalt, mineral aggregate (including mineral powder and test ore), cement, hydrated lime, movable mineral powder, etc. are selected this time. Both ATPB30 and SACPB30 open graded asphalt have high viscosity and good adhesion, which can ensure the stability and durability of crushed stone base course. At the same time, their thermal stability and anti-aging performance are also excellent, and they are suitable for high load and high demand occasions such as airport pavement. The selection of mineral materials mainly considers their particle size distribution, hardness, and wear resistance. Cement and hydrated lime as additives can improve the workability and strength of asphalt mixtures. Active mineral powder has a good filling effect, which can refine the gradation of asphalt mixture, improve the compactness and impermeability of the base layer, improve the construction performance of asphalt mixture, and make the base layer more flat and beautiful. In order to ensure the authenticity and reliability of the final test results, it is necessary to conduct the technical property test in advance in combination with the selected asphalt materials to ensure the authenticity of the test. The results are shown in Table 1:

Table 1. Table of results of test treatments of technical properties of asphalt materials

Technical property test	Preset experimental values	Unit annotation value	Planning requirements
Elongation(10°C,5cm/min)	>85	cm	>100
Elongation(15°C,5cm/min)	>90	cm	>100
Needle penetration (30°C,5S,100g)	70	0.1mm	65~95
Softening point (global processing method)	45.6	°C	>42
Wax content (distillation treatment method)	2.13	%	≤2
mass loss	-0.27	%	≤0.13
Needle penetration ratio	60.12	%	≥55

On the basis of table 1, the analysis and study of the results of the processing of tests on the technical properties of asphalt materials was realized. Under different background conditions, the currently selected test asphalt technical properties test to meet the expected standards, can be applied to the experimental test.

2.2 Experimental Setup

According to the actual test requirements, prepare the experimental test device in advance, and carry out the basic experimental layout processing. The dynamic shear rheometer is capable of performing dynamic shear flow treatment on fiber asphalt mortar. The Temperature Sweep device oversees, regulates, and documents the temperature throughout the experimental process. Meanwhile, the Frequency Sweep serves to refine and calibrate the frequency of asphalt treatment. Subsequently, adhering to the prerequisites of the Dynamic Creep test, we will establish the technical parameters of the experimental equipment foundation, as outlined in Table 2:

Table 2. Table of technical parameters for basic implementation

Testing environment	Technical parameter standard value
Minimum torque /μNm	0.5~0.8
Controllable torque deviation /μNm	0.002~0.004
Temperature fluctuation range /°C	-30~160
Minimum frequency/Hz	100~165
Normal stress range/N	0.1~45

According to the specific experimental needs and experimental conditions, other auxiliary equipment and devices may be required, such as rutting testers, high temperature stability testers, extractors, data acquisition systems, humidity control equipment, etc. To ensure the accuracy and reliability of the experiments, and to provide strong support for the preparation and key performance research of open-graded asphalt stabilized aggregates base mixes.

3 Open-Graded Asphalt Stabilized Gravel Base Mix Preparation

Combined with the SAC off grading design method, the grading design for the preparation of the mixture of open graded asphalt stabilized macadam base is carried out, and two kinds of open graded asphalt, ATPB30 and SACPB30, are used for measurement and comparative treatment. See Table 3 for details:

Table 3. Grading Comparison between ATPB30 and SACPB30

Grading	Percentage of sieve mass/ %				
	35.5	20.1	9.5	6.4	4.5
ATPB30	95.2	86.3	47.6	20.6	11.3
SACPB30	94.5	80.7	45.9	10.1	2.6

In combination with Table 3, the comparison and analysis of ATPB30 and SACPB30 grading are realized. It can be observed and analyzed from the data in the table that when the grading is above 9.5mm, the interval is relatively close, and when it is 6.4mm, the gap gradually becomes larger, indicating that the fine aggregate content of ATPB30 is far less than SACPB30. On this basis, the base mixture of crushed stone layer is divided into coarse aggregate, fine aggregate and filler. After screening the materials, measure and calculate the clearance rate at this time to ensure that it is above 15%. At this time, the grading calculation of coarse aggregate and fine aggregate is carried out respectively, the void structure of the skeleton is measured, and the grading design with the main skeleton void filling method is carried out. The details are shown in Formula 1:

$$\left\{ \begin{array}{c} M_a + M_b + M_c = 100 \\ 100 \times (\frac{M_a}{\beta_{ba}} + \frac{M_b}{\beta_a} + \frac{M_c}{\beta_{bc}}) = \frac{M_a \times (\mathrm{VCA}_{DRC})}{\beta} \end{array} \right\} \tag{1}$$

In equation 1: M_a, M_b, M_c indicate the actual amount of coarse aggregate, fine aggregate, and mineral powder, respectively. β_{ba}, β_{ba}, β_{ba} represent bulk density, surface density, and dry mash density, respectively. VCA_{DRC} denotes the dry pounding porosity. Combined with the above measurements, the preset porosity is compared with the porosity of the skeleton structure, and the corresponding difference is determined, and it is judged whether it meets the requirements of the preparation standard. On this basis, the dry compacted porosity was set as the actual measurement, and the average value of the density of the experimental mineral was calculated, as shown in Equation 2:

$$K = \sum_{I=1} \delta I - \sqrt{(1 + xr) \times \frac{\gamma I}{f}} \tag{2}$$

In equation 2: K denotes the average value of the density of the tested material. δ denotes the relative density of asphalt. I indicates the volume of asphalt. I denotes the gap base value, the r indicates the gap position, the f indicates the range of asphalt dosage. γ indicates the usage of a single area. Combined with the current measurement, the open graded asphalt stabilized macadam mixture with the maximum particle size as the standard is measured and calculated through the SAC broken grading design method for grading design, and the grading of ATPB 30 and SACPB30 is compared in the later stage: when the grading is above 9.5mm particle size, the application ratio of the two materials is basically the same, and the interval is close. However, 6.4 mm, the cohesive strength of ATPB30 decreases, the workability is poor, and the void ratio is large; SACPB30 has relatively high cohesive strength, good workability and low porosity.

4 A Study on the Performance of Open-Graded Asphalt Stabilized Crushed Stone Base Mixes for Airport Pavement Construction

Combined with the above open-graded asphalt stabilized gravel base mix preparation process, the next step is to make a comparative analysis of the construction performance of this mix in the airport pavement. The optimum oil/gravel ratio of the asphalt mixture can be calculated by combining the above preparation results, as shown in Equation 3:

$$J = \rho^2 - \frac{\theta}{G} \tag{3}$$

In equation 3: J denotes the optimum oil/gravel ratio of the asphalt mixture. ρ denotes the initial porosity, the θ indicates asphalt leakage loss. G denotes the total amount of asphalt. In conjunction with the current measurements, the calculation of split tensile strength was subsequently carried out as shown in Equation 4:

$$U = \int \partial + \nu - \frac{\psi(1+\zeta)^2}{\rho} \tag{4}$$

In equation 4: U denotes the split tensile strength. ∂ indicates the initial oil-rock ratio, and ν denotes the current void ratio, the ρ indicates the total volume of asphalt. ψ and ζ represent the range of fracturing and the location of repeated fracturing are shown respectively. A comparative analysis of the current changes in the oil/stone ratio is shown in figure 1:

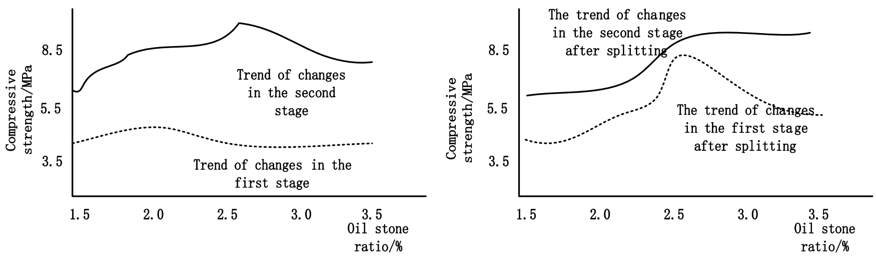

Fig. 1. Graphical representation of the variation of tensile strength versus oil-rock ratio for different cycles

Combined with Figure 1, the analysis of the variation of tensile strength and oil-rock ratio in different cycles was realized, on the basis of which a comparative analysis was carried out on the basis of the data obtained, as shown in Table 4.

Table 4. Comparison table of performance data information

Gradation types	ATPB30	SACPB30
Leakage loss/%	0.35	0.21
Void rate/%	16.5	18.7
Best oil to stone ratio/%	2.9	2.2
Compressive strength/MPa	6.5	8.5
Splitting tensile strength/MPa	0.59	0.95
Analysis of comprehensive comparison results	The overall load capacity and support strength are poor, and the performance changes are	The overall load capacity and support strength are good, with minimal

	significant, making it difficult to better control and handle	performance changes, relatively stable and safe, and relatively better control and handling during the experimental process

Combined with Table 4, the comparative analysis of the performance data is realized. On this basis, the first use of water seepage experiment for the determination of airport road surface performance. The seepage experiment is an important means to evaluate the drainage performance of the pavement. During long-term use, airport pavement needs to have good drainage performance to ensure that it can remain unobstructed in adverse weather conditions such as rainwater. Through water seepage experiments, the permeability coefficient of the mixture can be determined to evaluate its drainage performance.

5 Analysis of Experimental Results

Based on the above measurements and studies, the real-time data and information in the inspection process were collected and integrated, and the key properties of the open-graded asphalt stabilized aggregates base course mixes were analyzed by combining the requirements and objectives of the tests, as shown in Table 5.

Table 5. Data analysis table of test results

Test node	Intensity ratio /%	Residual stability /%	Compressive strength /MPa	Permeability coefficient mL/min	Bending strain ratio
Node 1	60.35	90.24	4.68	85.68	6.37
Node 2	62.14	93.47	5.21	89.34	7.54
Node 3	65.27	96.33	4.09	85.27	8.01
Node 4	62.15	90.24	5.37	90.05	8.64
Node 5	67.54	98.54	5.94	92.13	9.27
Node 6	63.28	95.24	6.27	86.37	6.57

A comprehensive analysis of the test results was conducted using permeability tests and rutting tests, combined with Table 5. A comprehensive evaluation was conducted on the collected data and information for six randomly selected test nodes. The final conclusion drawn from the analysis is that the bending strain ratio of the airport pavement can exceed 5.5. Due to the randomly selected testing locations on the airport road surface, the reliability of the obtained results is relatively high.

6 Discussion

According to the above measurement, the final test conclusion is drawn: under different backgrounds, through the comparative test of multi angles and multi environments, the bending strain ratio of the airport pavement finally reached more than 5.5, which indicates that the final performance analysis results obtained by combining the preparation of open graded asphalt stabilized macadam base mixture are also more reliable and true. As shown: the smaller the particle size of SACPB30, during pavement construction, the drainage performance of itself is better, and the corresponding compressive capacity has also been significantly improved. The practical application effect in deformation control, anti fatigue treatment and crack resistance has been greatly optimized, which indicates that the open graded asphalt stabilized crushed stone base mixture is more scientific and reasonable.

7 Conclusion

In conclusion, the above is an analysis and verification study on the preparation and key performance of open-graded asphalt stabilized aggregates base course mixes. Under the real test background conditions, the open-graded asphalt stabilized aggregates base mixes were successfully prepared by optimizing the design of mix ratio and improving the preparation process, which provided a strong support for the high quality construction of road projects. In addition, during the research process, the key properties of the mixture such as crack resistance, water damage resistance, high temperature stability and low temperature crack resistance were systematically evaluated to summarize the changes in the performance of the external environment and conditions of the role of the influence of the formation of the law, combined with the needs of engineering practice, the actual application of the mixture was tracked and observed to verify its applicability and durability in the actual project. With the aid and support of new materials and new technology, we will continue to deepen the research, improve the preparation technology, enhance the performance of the mixture, and make greater contribution to the prosperity of China's transportation industry.

Acknowledgement

This study was supported by the China Airport Construction Group Co., Ltd., through the Technology Research and Development Project, under Grant JSRDKYN20220311.

References

1. Cui L , Xu J , Ren M ,et al.Modification of FCC slurry oil and deoiled asphalt for making high-grade paving asphalt[J].Chinese Journal of Chemical Engineering, 2022, 44(4):300-309.
2. Alvarez A E , Ovalles E , Reyes-Ortiz O J .Mixture design and performance characterization of asphalt mixtures prepared using paving-heavy crude oils for low-traffic volume roads[J].Construction and Building Materials, 2022(Apr.25):329.
3. Zhang K , Zhao H , Wang S C .Upcycle olive pomace as antioxidant and recycling agent in asphalt paving materials[J].Construction and Building Materials, 2022(May 2):330.
4. Lancaster I M .Paving the Way to Lower-Carbon Asphalt[J].Quarry management, 2022(1):49.

5. Airey G D , Rowe G M , Sias J E ,et al.Black Space Rheological Assessment of Asphalt Material Behavior[J].Journal of Testing and Evaluation: A Multidisciplinary Forum for Applied Sciences and Engineering, 2022(2):50.
6. Wang C , Gong G , Chen Y ,et al.Estimating the Healing Characteristic of Asphalt Binder Using the LASH Test[J].Journal of Materials in Civil Engineering, 2022(2):34.
7. Brito M S , Barroso S H D A , Gondim L M .Analysis of the Use of Euphorbia tirucalli Sap in the Composition of an Asphalt Bio-emulsion[J].Journal of Testing and Evaluation: A Multidisciplinary Forum for Applied Sciences and Engineering, 2023(4):51.
8. Perrin T , Miller L .2023 POWER WASHERS' GUIDEBOOK CLEANING ASPHALT SURFACES[J].Cleaner times: The journal for high prissure water applications, 2023(9):35.
9. G Chen,P Guo,Z Caoo.Study Fatigue Damage Simulation of Asphalt Mixture[J].Computer Simulation, 2022(008):039.