

# Study on Application of Cold-Mixed Asphalt Mixture in Flexible Pavement Structure

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**Abstract.** Cold-mixed cold-laid asphalt mixture pavement structures designed are used to calculate and analyze the mechanical response based on elastic-plastic theory and finite element software; some conclusions with reference value are obtained. According to the results of calculation and analysis, a durable and economical road reconstruction scheme is recommended.

## 1. Introduction

In recent years, many asphalt pavements in China have reached their useful life, and they are about to enter the stage of large-scale reconstruction and restoration to restore their performance. At present, there are more than a dozen high-grade highways in Liaoning Province where asphalt pavements are undergoing repairs or overhauls. The upper, middle and lower layers of asphalt pavements will be milled. How to fully recycle and utilize a large amount of waste asphalt mixture resources lays in front of the road research workers.

## 2. Engineering background

### 2.1 Location

The Jiangzhang road is located in Xinmin City, Shenyang. It is a tertiary road. The starting point of the route is at Jiangjiagangzi, the station is K0+000, and the terminal is at Shenyu road. The station is K8+301.29. The route has a total length of 8.301 km. It is 551.29m from the end of the distance route. The design speed is 40km/h and the whole line is designed in two way two lane.

### 2.2 Original road condition

The original road was built in 1997. The width of the roadbed is 9 meters and the width of the road surface is 7 meters. The structure is 6cm Penetrating asphalt pavement +25cm slag lime soil, due to longer road construction time, more heavy load vehicles cause damage to the road surface seriously, large areas of frost boiling and pits have been generated, which have seriously affected the normal use of the road.

### 2.3 Reconstruction of road conditions

The diseases of the current road section is mainly are mainly pot holes, and 29cm is excavated under the pit and groove section, and 23cm of cement stabilized macadam + 6cm cold recycled asphalt concrete surface layer is replaced. The original pavement structure is as follows:

1cm slurry seal

6cm cold recycled asphalt concrete surface layer



Penetrating oil  
23cm cement stabilized macadam base (cement 4.5%)  
10cm stone slag leveling layer

### 3. Recommended pavement structure

In view of the problems such as low utilization rate of asphalt mixture in current milling, cracks prone to semi-rigid base asphalt pavement, fatigue resistance of cold mixing asphalt mixture and current design method and application of asphalt mixture, on the basis of the previous work of task group, 16 sets of pavement structures designed by orthogonal experiment are used to calculate and analyze the mechanical response based on elastic-plastic theory and finite element software, some conclusions with reference value are obtained. According to the results of calculation and analysis, a durable and economical road reconstruction scheme is recommended for Jiang Zhang road.

The main conclusions are as follows:

(1) When the thickness of each structural layer is constant, the deflection value decreases as the modulus value of each layer of the structure increases.

(2) The subgrade modulus has the greatest impact on the pavement surface deflection. The increase of the subgrade modulus can effectively reduce the overall deflection of the pavement structure, but the rate of decrease of the deflection gradually decreases with the increase of the subgrade resilient modulus.

(3) Under load, although the increase of the base modulus is beneficial to reduce the surface rebound deflection value, the improvement of the subgrade strength is the key to ensure that the subgrade pavement structure has sufficient strength. From calculation and analysis, we can see that the recommended modulus of the embankment is 80 MPa. In the actual project, we should pay attention to the improvement of the ground conditions to obtain a greater improvement in the performance of the pavement. In consideration of the economic rationality of the subgrade treatment, the subgrade modulus should be 80~100MPa.

(4) Under the premise that the resilience modulus of the subgrade meets the requirements, the combination of the pavement structure is conducive to reducing the thickness of the surface layer and saving the pavement material; the modulus of the base layer is reduced to the soft, the deflection of the road surface is increased. The effect of reducing the deflection of the road surface by proper increasing the thickness of the flexible base layer is not obvious.

(5) The thickness of the cold-mixed cold-laid asphalt mixture base layer is more sensitive to changes in its modulus, and the increase in the compressive resilience modulus helps to reduce the thickness.

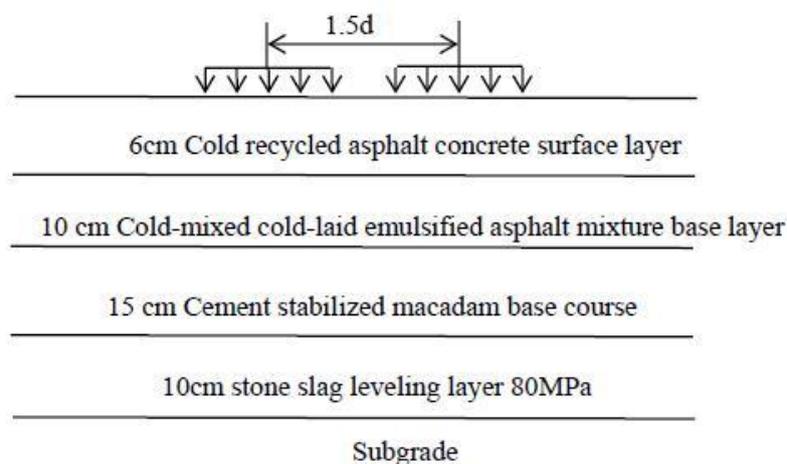
(6) Within the range of orthogonal tests, the influencing factors of the road surface wheel gap deflection value are ranked according to their importance: compressive resilient modulus of subgrade > thickness of cold-mixed emulsified asphalt mixture > compressive resilient modulus of cold-mixed cold-laid emulsified asphalt mixture > Compressive resilient modulus of cement stabilized macadam base material; Influencing factors of maximum shear stress and maximum tensile stress at the bottom of cold recycled asphalt concrete are ranked according to their importance: cold-mixed emulsified asphalt mixture thickness > compressive resilient modulus of subgrade > compressive resilient modulus of cold-mixed emulsified asphalt mixture > compressive resilient modulus of cement stabilized macadam base layer material; The Influencing factors of the maximum shear stress for cold-mixed cold-laid emulsified asphalt mixture flexible base are ranked according to their importance: thickness of cold-mixed cold-laid emulsified asphalt mixture > Compressive resilient modulus of cold-mixed cold-laid emulsified asphalt mixture > Compressive resilient modulus of subgrade > compressive resilient modulus of cement stabilized macadam base layer material; the influencing factors of the maximum tensile stress at the bottom of cold-mixed cold-laid emulsified asphalt mixture base layer are ranked according to their importance: thickness of cold-mixed cold-laid emulsified asphalt mixture base layer > compressive resilience modulus of subgrade > compressive resilience modulus of cement-stabilized macadam base material; the Influencing factors of maximum tensile stress at the bottom of cement-Stabilized macadam base layer are ranked according to their importance: Compressive resilient modulus of subgrade > thickness of cold-mixed cold-laid emulsified asphalt mixture base

layer.

(7) In the scope of orthogonal test, the rebound deflection value at the center of the road surface wheel gap of the simulated pavement structure, the maximum shear stress and the maximum tensile stress at the bottom of the cold recycled asphalt concrete surface layer are reduced with the increase of the thickness and modulus of the pavement structure material and the increase of the modulus of subgrade. The maximum shear stress of the cold-mixed cold-laid emulsified asphalt mixture base layer decreases with the increase of the thickness of the asphalt mixture layer and the modulus of the subgrade, and increases with the increase of the compressive resilience modulus of the cold-mixed cold-laid emulsified asphalt mixture layer. The maximum tensile stress at the bottom of the cold-mixed cold-laid emulsified asphalt mixture base layer in the simulated pavement structure decreases with the increase of the thickness of each structural layer and the subgrade modulus. The maximum tensile stress at the bottom of the cement-stabilized macadam base layer pavement structure decreases with the increase of the thickness of each structural layer and the subgrade modulus. The effect of compressive resilience modulus change on the maximum tensile stress at the bottom of cement stabilized macadam base layer is more significant than that of cold-mixed emulsified asphalt mixture base layer thickness.

(8) Within the range of orthogonal tests, when the load is applied, the effect of increasing the thickness of cement stabilized macadam base layer on the maximum shear stress and the maximum tensile stress at the bottom of cold recycled asphalt concrete surface layer and the tensile stress at the bottom of the cement stabilized macadam base layer is larger, it is beneficial to greatly reduce the maximum shear stress and the maximum tensile stress at the bottom of cold-recycled asphalt concrete, and the maximum tensile stress at the bottom of the cement stabilized macadam base layer. However, due to the maximum tensile stress at the bottom of the layer of cold recycled asphalt concrete is far below its allowable tensile stress, therefore, the maximum tensile stress at the bottom of the layer of cold recycled asphalt concrete cannot be used as a control indicator for the thickness of the cement stabilized macadam base layer.

(9) Within the scope of orthogonal test, when the load is applied, the increase of the thickness of the cement stabilized macadam base layer has no significant effect on the maximum shear stress and the maximum tensile stress at the bottom of the flexible base layer of the emulsified asphalt mixture. The thickness of the cement stabilized macadam base layer increases under heavy load, and the maximum shear stress of the flexible base layer of the emulsified asphalt mixture tend to increase. Therefore, it is necessary to control the thickness of the cement stabilized macadam base layer not too thick. The shear stress experienced by the surface layer varies sensitively with the axle load and increases with the increase of axle load.



**Figure 1.** The recommended pavement structure

(10) The actual design deflection value of Jiang Zhang is 53.0 (0.01mm). Under the action of standard load (tire ground pressure is 0.7MPa) and heavy load (tire ground pressure is 0.84MPa), the pavement structure satisfying the requirement of designing deflection value is Nos.4, 11 and 14, and the No. 5 scheme needs to be improved; On the basis of meeting the design deflexion value of the road surface, The pavement structures with the smaller maximum shear stress of the cold recycled asphalt concrete surface layer and the emulsified asphalt mixture layer and maximum tensile stress at the bottom of its layer and the maximum tensile stress at the bottom of the cement stabilized macadam base layer are sorted Nos.14, 11, 5, and 4 scheme by ascending order.

Under the condition that the thickness of the cold recycled asphalt concrete surface layer is 6cm, and thickness of the stone slag leveling layer is 10cm, the modulus value is the same as the original pavement design modulus, an economically reasonable road structure reconstruction scheme is proposed for Jiangzhang road. As shown in Figure 2. Considering the actual conditions of the elevation control of the current reconstruction project of Jiang Zhang road and the engineering economy, it is recommended that the thickness of the AC-25 emulsified asphalt mixture base layer is 10 cm.

#### 4. Comparison of recommended pavement structure and original pavement structure

The elastoplasticity theory and finite element software were used to calculate the deflection at the center of the road surface wheel gap and mechanical response of the two types of pavement structures. The calculation results are shown in Table 1.

**Table 1.** Comparison of surface deflection and stress response of the recommended pavement structure and original pavement structure

Calculation layer	Tire ground pressure 0.7MPa		Tire ground pressure 0.84MPa	
	Test road	Original pavement structure	Test road	Original pavement structure
Deflection at the center of road surface wheel gap (0.01mm) (0.01mm)	42.038	50.65	50.399	61.86
The maximum tensile stress at the bottom of cold recycled asphalt concrete (MPa)	0.084	0.302	0.19	0.364
Maximum tensile stress at the bottom of cold- mixed cold-laid emulsified asphalt mixture base laye (MPa)	0.19	-	0.23	-
Maximum tensile stress at the bottom of cement stabilized macadam (MPa)	0.18	0.306	0.21	0.369
Maximum shear stress on the pavement (MPa)	0.11	0.204	0.13	0.252

It can be seen from Table 1 that the semi-rigid pavement base is softened, the thickness of cement stabilized macadam is reduced to 15 cm, and the cold-mixed cold-laid emulsified asphalt flexible base layer is 10 cm, which can significantly reduce the maximum tensile stress at the bottom of the cold recycled asphalt concrete surface and the maximum shear strength of it. and the deflection value at the center of the road surface is also reduced, and the suitable thickness of the construction layer for the cement stabilized macadam base is 15cm. When the thickness of the cement stabilized macadam is 23cm, it is not easy to compact.

#### 5. Economic, social and environmental benefits analysis

The aggregates used in the construction of the cold-mixed emulsified asphalt mixture base course include the old asphalt surface material (RAP) that is being milled, accounting for 65% of the total weight of the mixture, 25% of the newly added aggregate, and 10% of the stone

chips. The ratio of oil to stone is 3.8% for emulsified asphalt and 1.5% for cement. RAP is the national highway G102 line surface milling material. The cold emulsified emulsified asphalt mixture makes full use of the old road materials and solves the environmental impact of waste. The environmental damage caused by quarrying is reduced. It is an environmental protection project. It has prolonged the service life, reduced the repair rate of the pavement, reduced the time of interrupting the traffic delay, and greatly reduced the possibility of traffic accidents. Therefore, from the long-term perspective, it is economical and environmentally friendly and cannot be measured in terms of currency. It has good economic, social and environmental benefits.

## **6. Conclusion**

The analysis and comparison of the recommended pavement structure and the original pavement structure in the overall strength, the force performance and the economy, the results show that the recommended pavement structure has good overall strength and stress performance, has good construction operation, can extend the service life of the pavement, and reduce the repair rate of the pavement. It has good economic, social and environmental benefits.

## **7. References**

- [1] Occupation Standard of the People's Republic of China, JTG E20-2011 "Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering" [S]
- [2] Highway Science Research Institute, Ministry of Communications JTG F40 - 2004 "Technical Specifications for Construction of Highway Asphalt Pavements" [S]
- [3] Occupation Standard of the People's Republic of China, JTG E42-2005 "Test Methods of Aggregate for Highway Engineering" [S]
- [4] Report on Application of Cold-mixed Asphalt Mixture in Flexible Pavement Structure [R], 2017