Study on performance of new type cold mix epoxy asphalt and mixture for steel deck pavement

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Abstract. In order to improve the performance of steel bridge deck pavement material, improve the construction efficiency and reduce the cost of steel bridge deck pavement, this paper introduces a new type of cold mixed epoxy asphalt, and studies the mechanical properties and curing law of the material through Marshall test. The results show that it has good mechanical properties, and the curing days at room temperature are 2-3 days. Based on the test data, compared with the United States and Japan, this paper analyzes the remarkable characteristics of the cold mix epoxy asphalt, which has the advantages of normal temperature construction, long retention time, good operability, low construction cost, less curing days, early opening of traffic, low material cost and reducing energy consumption. If it is used as the paving material for steel bridge deck, it has a broad application prospect.

1. Introduction

Epoxy asphalt mixture is a common steel deck pavement material. According to the different mixing temperature of epoxy asphalt mixture, epoxy asphalt is divided into hot mix epoxy asphalt (mixing temperature is generally 170℃~190℃), warm mix epoxy asphalt (mixing temperature is generally 110℃~130℃) and cold mix epoxy asphalt (mixing at normal temperature). Whether it is hot mix or warm mix epoxy asphalt, strict requirements are put forward for the construction technology and construction conditions, the curing time is required to be longer⁵, and the construction cost is higher. The research on the application of cold mix epoxy asphalt is relatively less. At present, it is mainly concentrated in the fields of adhesives, laminates, coatings, and rapid repair of steel bridge deck in road and Bridge Engineering⁶. It has not been widely promoted and applied as the pavement material of bridge deck on steel bridge deck. From the perspective of steel bridge deck pavement, this paper introduces a kind of cold mixed epoxy asphalt in view of the construction difficulty and high cost of epoxy asphalt concrete steel bridge deck pavement, and analyzes the differences of its mixture road performance and construction characteristics compared with the United States and Japan.

2. Preparation and characteristics of cold mix epoxy asphalt

Cold mix epoxy asphalt is composed of two components a and B. component A is formed by bisphenol A epoxy resin, additives, asphalt and its active cosolvent at a specific temperature and mixing rate after a certain mixing time. The component is a black homogeneous viscous liquid, as shown in figure 1. Component B is composed of a variety of modified amines. It is a special curing agent used with component A. the component is a brown homogeneous viscous liquid, as shown in figure 2. According
to the mass ratio of 2:1, the mixture of a and B can be obtained by full stirring. It is a light black homogeneous liquid.

Figure 1. Component A

Figure 2. Component B

The results show that the two components of the cold mix epoxy asphalt binder have good compatibility, no segregation and stratification phenomenon, and can ensure the full and uniform solidification; the viscosity of the binder increases to 1 Pa·s at 23℃ for 78min, and can maintain about 4H working time at room temperature, which provides sufficient operation time for the construction of the project site; the adhesion of the cold mix epoxy asphalt binder is low, and the viscosity is low With grade 5, it is always easy to flow at room temperature, suitable for mixing at room temperature, avoiding high-temperature mixing operation, reducing construction difficulty, and having simple and excellent construction performance; the dry time of the cement is 7h, thus ensuring the open traffic hours of the project.

3. Marshall test of cold mix epoxy asphalt mixture

The cold mix epoxy asphalt mixture is tested, and the optimum asphalt aggregate ratio is designed, and the change law of material strength is studied. According to the design of asphalt aggregate ratio, 5 samples are selected for Marshall test to determine the best ratio. According to the best asphalt aggregate ratio, the Marshall strength change law test and other road performance tests are carried out. Under the premise of the best oil stone ratio, the Marshall stability test value after curing is 90.1kN, and the flow value is 39.3, both of which meet the requirements of technical indexes.

Under different temperatures, Marshall specimens were tested for stability at different curing times. The test data are shown in table 1, and the variation diagram is shown in figure 3. The test results show that the curing time of the mixture at room temperature is short, and the curing rate increases with the increase of temperature. After curing for 6h, the stability of Marshall specimen at 35℃ and 20℃ is about 22kN and 10kN, respectively; after curing for 12h, the stability at 35℃ is about 50kN; after curing for 36h, the stability at 20℃ is nearly 50kN; after curing for 24h, the stability at 35℃ is nearly completed, reaching 90kN; when curing for 72h, Marshall Stability the stability at 20℃ is also up to 88kN.

| Curing Time /h | Marshall Stability /kN |
|---------------|------------------------|
|               | 35℃       | 20℃       |
| 0             | 0         | 0         |
| 4             | 17.71     | 7.31      |
| 6             | 22.60     | 9.82      |
| 8             | 27.13     | 10.58     |
| 10            | 36.08     | 11.95     |
| 12            | 49.67     | 13.17     |
| 24            | 90.10     | 35.58     |
| 36            | -         | 48.87     |

Table 1. Marshall stability of mixture with temperature and curing time as variables
4. Analysis of advantages and characteristics

As for the gradation of epoxy asphalt mixture for steel bridge deck pavement, the requirements are given in the technical guide for design and construction of highway steel box girder bridge deck pavement. According to JTG E20-2011 test specification for asphalt and asphalt mixture of Highway Engineering, Gong Chunwei [5] and others studied two aspects of the mixture, including mix proportion design and road performance evaluation, and carried out relevant tests, mainly aiming at the following aspects: high temperature stability, water stability, fatigue performance, low temperature crack resistance, skid resistance, impermeability and oil erosion resistance. According to the national standard GB/T 30598-2014 "general technical conditions for epoxy asphalt composite materials for road and bridge pavement", the basic performance index requirements of materials used for steel deck pavement of Nanjing No.2 Yangtze River Bridge, and the relevant research indexes of chem CO system of the United States and TAF of Japan, the statistics and collation of epoxy asphalt are carried out respectively, and the comparison table is shown in table 2.

| Projects                   | Technical index | Chem Co | TAF  | Cold mix epoxy asphalt |
|----------------------------|-----------------|---------|------|------------------------|
| Mechanical properties      |                 |         |      |                        |
| Marshall stability of cured specimens /kN | ≥40.4       | 81      | 83   | 90                     |
| Stream value /0.1mm        | 20-50           | 48      | 45   | 39                     |
| High temperature performance | Dynamic stability / (times/mm) | ≥8000   | 12524 | 13652 | 66340 |
| Low temperature Performance | Bending tensile strain | ≥2.0×10-3 | 2295 | 2410 | 2328 |
| Water stability            | Freeze-thaw splitting strength ratio TSR/% | ≥70     | 95.27% | 96.08% | 89.3% |
| Construction temperature /°C | -              | 110-121 | 165-190 | 15-70 |
| Reserved time /min         | ≥50             | 90      | 150  | 150  |
| Curing days’/d             | -               | 30-45   | 4-7  | 2-3  |

Figure 3. Variation of Marshall stability of mixture with temperature and curing time as variables
The following is a comparison and analysis between the cold mix epoxy asphalt mixture studied in this paper and the United States and Japan in terms of road performance, construction temperature, retention time, curing days and material cost.

In terms of road performance, it has high Marshall stability and high mechanical performance; it has the best dynamic stability and excellent performance in high temperature rutting resistance; its flexural tensile strain is between Chem CO and TAF, and its low temperature performance meets the specification requirements of no less than 2000 microstrain; its freeze-thaw splitting strength ratio is 89.3%, which is slightly lower than chem Co, TAF, the relevant performance indicators meet the specification requirements of ≥ 70%. In general, its road performance meets the specification requirements, and its high temperature anti rutting performance is remarkable, and other performances are equivalent to those of the United States and Japan.

In terms of construction temperature, its construction temperature can be carried out at 20-70℃, and the normal temperature mixing construction belongs to the category of cold mixed epoxy asphalt; while Chem co material and TAF material need to be mixed at 110-121℃ and 165-190℃ respectively, which can be classified into the category of warm and hot mixed epoxy asphalt. The cold mix epoxy asphalt has excellent room temperature construction characteristics, which can simplify the construction scheme, reduce the construction cost and energy consumption.

In terms of retention time, its retention time is more than 150 min, which is similar to that of TAF and longer than that of chem Co. From mixture mixing, loading, transportation, paving to rolling, the time is wider and the control is more flexible, which will not easily cause waste and save the economic cost.

In terms of curing days, its curing days are 2-3 days, with the shortest open traffic time; Chem Co's curing days are 30-45 days, with the longest open traffic time; TAF's curing days are 4-7 days, with the shortest open traffic time. Therefore, the cold mix epoxy asphalt has low requirements on the finished product protection cost of the project, and can quickly open the traffic.

In terms of material cost, compared with Chem CO and TAF, it has lower cost and price, and the price of imported materials is as high as 60000-80000 yuan/t, while the price of the materials studied is lower than the import price, which has considerable price advantage and great potential application prospect.

5. Conclusion
The following conclusions can be drawn from this paper:

1) In this paper, a kind of cold mix epoxy asphalt is introduced, and the road performance of the mixture is tested. The experimental results show that the road performance is excellent, and it also meets the technical index requirements. Compared with the United States and Japan, it has more advantages in high temperature stability and mechanical properties.

2) It has the following characteristics: normal temperature mixing and paving construction, long capacity time, effectively avoid the construction difficulties of hot mixing and warm mixing epoxy asphalt high temperature operation and strict construction process time requirements, thus reducing the construction cost and energy consumption.

3) The cold mix epoxy asphalt has the characteristics of short curing days, which greatly reduces the open traffic days of epoxy asphalt pavement structure system on steel bridge deck, and also reduces the finished product protection cost after pavement.

4) Compared with the epoxy asphalt in America and Japan, the material cost of the cold mix epoxy asphalt is lower, and the application prospect is broad.

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