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Laboratory study and performance evaluation of a new type of prime coat material used on cement treated base

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HIGHLIGHTS

- Comparison and selection for the optimum proportioning of prime coat material were conducted.
- The optimum composition of the new prime coat material were chosen.
- The failure surface of the new prime coat was analyzed after the interlayer pull-out test and shear test.

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ABSTRACT

Through many pavement structure inspections, it is found that the interlayer bonding is not adequate. To solve this problem, this study attempt to develop a new type of high-performance prime coat material. Through viscosity tests, exudation-pressure test, high-temperature test and uniaxial penetration test, the penetrability and solidification effects of new prime coat material on the upper surface of the cement treated base(CTB) are evaluated. Based on the results, the optimum proportioning is determined. The improvements on interlayer bonding and pavement performance of the new prime coat material are also evaluated by accelerated loading test, interlayer pull-out test and shear test. The existing test results show that using a mixture of water soluble epoxy resin and emulsified asphalt mixture as the prime coat material of CTB can bring remarkable penetrability, surface consolidation and interlayer bonding effect. Compared with the existing normal emulsified asphalt prime coat material, the interlayer bonding performance of this new prime coat material is significantly improved and the effect of dumper's wheel load is relatively minor. Thus, the mixture of water soluble epoxy resin and emulsified asphalt can be used as a next-generation upgraded prime coat material of CTB.

1. Introduction

In China, asphalt pavement with semi-rigid base is widely used in highways. Statistics show that more than 90% of the total mileage of the highways in China use asphalt pavement with a cement treated base (CTB), and the other grade of roads almost 100% use it [6,9]. The existing design and calculation of the CTB asphalt pavement are based on the assumption that the interlayer contact is continuous. Although for many years the road industry has endeavored to build a reliable continuous contact condition between asphalt pavement and CTB [1], these efforts have not achieved the desired results because of the inherent natures of the CTB material and prime coat material, as well as the Influences of CTB used as construction platform and environment. The results of drilling core samples show that the proportion of delamination is quite high, which to some extent reduces the service life of the pavement.

In China, prime coat material is one of the most important materials in the construction of semi-rigid base asphalt pavement. It provides transitional and cohesive function between semi-rigid base and asphalt pavement surface. Besides, it can also solidify the upper surface of base. With the use of prime coat, the durability of semi-rigid base asphalt pavement can significantly improve because the damages between surface and base will reduce. Throughout the development history of prime coat in highway, there are two kinds of materials: solvent-diluting type and emulsifier type. Solvent-diluting material mainly includes coal pitch, kerosene cutback asphalt or other material diluted with solvent. The emulsifier type includes anionic emulsified asphalt and cationic emulsified asphalt. With the development of technology, emulsified asphalt diluted with kerosene solvent has emerged, which is the combination of these two types of prime coat materials [7].

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The AASHTO has suggested the principle of using this kind of penetrated oil. It requires adding medium-curing liquid asphalt or emulsified asphalt in this penetrated oil which is able to penetrate a sufficient depth into base. When Europe and US are using emulsified asphalt as penetrated oil, they will select emulsified asphalt with different de-emulsification speed, different viscosity and different asphalt content according to different type of base [5]. According to the *Standard specifications for Road and Bridge Construction* published by Louisiana in 2000, the prime coat was stipulated to use cutback asphalt MC-30/MC-70 or AEP modified emulsified asphalt because of the bad penetrating ability of normal emulsified asphalt. Cui [2] studied the usage of SBR modified emulsified asphalt prime coat in Jing-Zhang highway, which obtained great effects. Wang [3] illustrated the key issues in semi-rigid base penetrated oil. Zhang [4] used a series of experiments (penetration depth, interlayer shearing strength, drainage property and indirect tensile strength) to compare kerosene cutback asphalt and emulsified asphalt penetrated oil with different dilution ratio. Thus he concluded that cutback asphalt will be the relatively ideal material for semi-rigid base penetrated oil and the kerosene ratio should be less than 30%.

Barely research has used epoxy emulsified asphalt as the prime coat material. According to engineering construction experience [12–14], the stone dosage and diameter of the stone play critical roles in the interlayer bonding performance. However, experiments and analyses regarding these parameters have not been conducted. In addition, analyses regarding the interlayer bonding failure surface are also insufficient.

2. Objective and scope of this study

(1) Through a series of tests and comparisons, the best proportioning of the prime coat material was selected.
(2) The pavement performance of the new prime coat material would be evaluated by the accelerated loading test, interlayer pull-out and shearing tests. Next, the best epoxy emulsified asphalt dosage, best stone dosage and best stone diameter of the new prime coat material would be determined by analyzing the new prime coat failure surface after the interlayer pull-out test and shearing test.
(3) Based on the existing research about using water soluble epoxy resin or emulsified asphalt as prime coat of CTB, this test further studied the feasibility of combining these two kinds of materials as the new prime coat of CTB through laboratory research, which is able to maintain the interlayer continuous condition between asphalt pavement and CTB so that the performance and service life of pavement can be improved.

The flow chart of the study shown in Fig. 1.

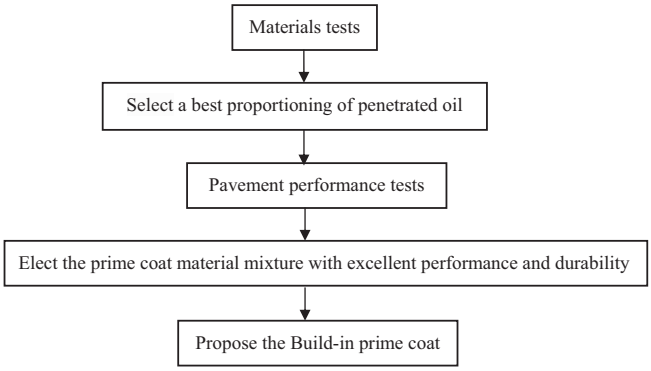

Fig. 1. Flow chart of the study.

3. Materials

The experimental results of the emulsified asphalt and water soluble epoxy resin in the test are respectively shown in Tables 1 and 2, all of which conform to the technical requirements of *Highway Engineering Asphalt and Asphalt Mixture Test Procedures JTG E20-2011*.

The chemical cross-linking reaction occurs after the full amalgamation of the two above materials, and new thermosetting materials are consisted of epoxy resin molecules as the continuous phase and asphaltene molecules as the dispersion phase. After consideration, this study selected the following nine mix proportions (mass percent) of emulsified asphalt to epoxy resin according to the existing research results about the seal coat of water soluble epoxy resin pavement. In terms of the economic efficiency, applicability and durability, the best one would be chosen among the 9 mix proportions.

4. Laboratory tests

4.1. Viscosity test

According to the proportioning shown in Table 3, the emulsified asphalt would be blended with type A and type B of water soluble epoxy resins and continuously stirred with a glass rod for 60 s until homogeneously mixed. Next, the standard viscosity test (Asphalt Standard Viscometer $C_{25,3}$) would be performed on 9 mixtures with different proportioning. Three groups of parallel tests are performed for every type of mixture. To better represent the mixture viscosity, the average efflux time of every mixture would be used as the analytic data and named as *t*. The test results are shown in Fig. 4.

4.2. Exudation-pressure test

According to the requirements of the standard exudation-pressure test in *Highway Engineering Asphalt and Asphalt Mixture Test Procedures JTG E20-2011,* this study would compare the solidified impermeability of different prime coat material. Prime coat material with good solidified impermeability can protect the CTB from the damage caused by water penetrated from surface. In this test, the mixture would be evenly spread on the Open-Graded Friction Course (air void content is 22%) and the spreading volume is 1.2 kg/m^2. After the mixture is completely solidified, exudation-pressure test would be conducted and three groups of parallel tests are performed for every type of mixture. For every type of mixture, the mean value of the seepage volume under water pressure over 3 min will be used for analysis. Detailed data are shown in Table 4.

4.3. Uniaxial penetration test

To find the strength change of the CTB surface before and after the solidification of prime coat material, this study would mold several cylinder specimens of cement stabilized macadam, of which height and diameter are both 15 cm, by the static pressure method. The gradation of cement stabilized macadam adopts the specification value and the cement dosage is 4.5%. The 27 cylinder specimens are divided into 9 groups for 9 types of mixture with different proportioning. After 7 days of standard curing, the specimens will be painted evenly (1.2 kg/m^2) with 10 g of mixture. The mechanical penetration tests will be conducted on these cylinder specimens after the complete solidification of prime coat material. The uniaxial penetration test uses MTS universal material testing