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Performance Issues of Pavement with Cementitiously Stabilized Layers

Junlin WANG
College of Civil Engineering. Chongqing Jiaotong University, Chongqing, 400074, CHINA

Abstract: Our country has built highways for the semi-rigid base asphalt pavement structure, the structure bearing capacity is strong, rut depth is small, good water stability, and has become the main structural type of high grade highway in China. But the practice has proved that there are some inevitable semi-rigid base asphalt pavement of technical problems, in a number of highways open to traffic soon after the pavement early damage phenomenon more serious, such as rutting, and vertical and horizontal cracks, cracks and potholes, local loose aging, seriously affected the normal traffic, but also violates the highway within the use fixed number of year is not for the purpose of the large maintenance. This paper analysis the properties of cementitiously stabilized materials linked to pavement performance, summing up the experiences of domestic and foreign research and related pavement distresses and the fatigue of CSL and related pavement distresses, stiffness of CSL and related pavement performance and erudibility, to do researches for the development of the improvement of the pavement.

Keywords: CSL; Block cracking in HMA; Transverse cracking induced by shrinkage of CSL

1. Introduction

Our country began to use in road construction since the 50's, calcareous soil as pavement base and in subsequent decades of lime stable kind of semi-rigid material has always been grade highway main types at the grass-roots level in China. From the mid 70's, our country began to use the cement stabilized material as base. With the continuous development of national economy in the 80's, due to the awareness of highway traffic on important role in promoting the development of national economy, our country began to development of highway traffic on a large scale. 90 s, highway construction is still in the phase of the peak, every year there are tens of thousands of kilometers of roads have been built, including thousands of kilometers of high grade highway [1]. During this period by the cement stabilized material and lime and fly-ash stabilized material of semi-rigid material accounted for all levels of consumption of the highway pavement base materials more than 95%.

From the road performance inorganic binder, which is mainly composed of cement, lime stabilized soil has its unique advantages, such as compared with flexible base material with high intensity, large bearing capacity, good water stability, strong plate body; Inorganic binder stabilized soil materials accessible, can fully use of local sand materials; Also in use for many years accumulated a lot of design, the construction unit built using inorganic binder stabilized soil base construction experience. Therefore, semi-rigid base materials at present even a long period of time will still dominate in road base materials in our country.

Semi-rigid base materials have prominent advantages at the same time there are also some disadvantages, the semi-rigid material in the process of using the main problems are: when selecting raw materials or not at that time, the mixture ratio design semi-rigid base is easy to appear insufficient crack resistance and erosion resistance, frost resistance is bad still exist and poor surface bonding defects. Therefore, the understanding of the semi rigid base materials remained deeply, in order to reduce the error of actual use. The application practice and research show that by adjusting the ratio of mixture of various materials, can effectively change the strength and modulus of semi-rigid material, including the crack resistance, erosion resistance performance, and allow them to have a more extensive applicability.

2. Block Cracking in HMA

Block cracking often is reported in the HMA surface when the pavement has a stabilized base. Block cracking is caused by shrinkage of the underlying stabilized base and often occurs when the HMA layer is thin, as for local roads (Figure 1). Highways in many parts of the world that use stiff bases and thin HMA layers also have encountered this problem (Yue 2004, Zube 1969). The shrinkage, caused by a loss of moisture and temperature variation, typically initiates shortly after construction and continues thereafter. According to Zube (1969), high unconfined compressive strength (UCS) causes block cracking which is likely due to the high shrinkage of CSL with high cement content and high strength. In short, block cracking can be attributed to the shrinkage of CSL [2].

Figure 1. Block Cracking in HMA with Stabilized Base (Scullion 2002)

3. Transverse Cracking Induced by Shrinkage of CSL

Transverse cracking in the surface layer that results from shrinkage of the stabilized base, as shown in Figure 2, starts from the bottom of the surface layer and propagates through the surface layer. The cracking is due to the bond between the surface layer and stabilized base and granular base, but at a much later stage (Ramsey 1959). The shrinkage cracking of the subbase causes stress concentrations at the locations of the cracks and eventually affects the stress distribution in the surface layer.

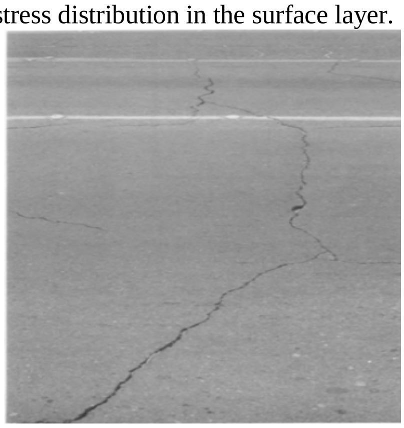

Figure 2. Transverse Cracking due to Shrinkage Cracking of CSL (Freeman and Little 2002)

Atkinson (1990) reports that shrinkage cracking in CSL causes transverse cracking in HMA and is prominent in thin HMA pavement. Chen (2007) reports that lack of mellowing for lime slurry stabilized base layers causes shrinkage cracking and then transverse cracking in the HMA surface[4]. Little et al. (1995) found that a high modulus value causes wide shrinkage cracks and low load transfers across the crack.
George (2002) found that high-strength CSL are prone to shrinkage cracking, based on Long-Term Pavement Performance (LTPP) and other pavements. When the 7-day in-service strength is 300 psi or lower, no shrinkage cracking occurs. Increasing the fines content increases the cracking intensity. Bituminous curing of the CSL before the placement of the surface layers corresponds to 65% relative humidity (RH) for most specifications. In the laboratory, moist curing corresponds to 95% RH. Crack width is significantly affected by drying shrinkage. Crack spacing decreases with an increase in friction between the CSL and underlying layer. For wide shrinkage cracks, load transfer efficiency is between 35% and 55%, and 80% for fine cracks for coarse-grained aggregate. Cracks wider than 0.1 inch (measured on HMA surface) affect the pavement performance significantly. For fine-grained soil, the critical crack width is claimed to be 0.06 inch. Decreasing the strength of the CSL decreases the tensile stress in the CSL. There is an optimum shrinkage strain level: 525 microstrain for fine-grained soil and 310 microstrain for coarse-grained soils, respectively [3].
Therefore, as with block cracking, the shrinkage of CSL causes transverse cracking of asphalt pavement and thus is included in this study.

4. Rutting

Due to the high stiffness of CSL, rutting in the CSL and subgrade can be reduced substantially when compared to unbound materials (Von Quintus et al. 2005). However, the existence of CSL could affect the rutting in asphalt pavements in terms of three factors: high shear stress in the HMA layer, erosion, and failure of the CSL.

4.1. Rutting induced by high shear stress in the HMA layer

The existence of CSL changes the stress/strain distribution and induces high shear strain in the HMA layer. As a result, there is high potential for rutting in the HMA layer (Bonnot 1991). Meng et al. (2004) report that the high stiffness of CSL leads to deep rutting in HMA as well as top-down cracking due to the increased shear stress distribution in the HMA layer. In addition, once the CSL are cracked and water infiltrates into the pavement, rutting develops quickly at the interface of the base and HMA layers.

4.2. Rutting induced by erosion of CSL

Rutting can occur when there is a loose layer between the HMA and CSL, which results from erosion and pumping of fines in the CSL. De Beer (1985) found that when lime is used to treat sand that is used as a base material, raveling, instead of fracturing, occurs, which causes rutting or increased tensile strain at the bottom of the HMA layer for alligator cracking. Metcalf et al. (2001) found debonding between the asphalt and CSL, with free water and a soft layer at the interface. The erosion of CSL causes rutting. CSL that are thick and have low cement content perform best in terms of rutting and cracking. Li et al. (1992) also report that when CSL are dry, minimal rutting occurs. However, after CSL are cracked, the entrance of water causes rutting quickly.

4.3. Rutting due to fatigue failure in CSL

Top compression/crushing results from fatigue that is due to repeated compression at the top of the CSL. For thick CSL, the tensile strain at the bottom is very small so that tensile fatigue is not an issue. According to De Beer (1990), thick CSL fail in compression (crushing) in the top 2 - 3 inches. As a result, rutting occurs in the crushed materials Increasing the UCS reduces the compression strain and thus increases the compression fatigue life. A compressive strain of 1% is stated to be the failure strain for compression fatigue. The compressive strain increases as the load repetitions increase.

Theyse et al. (1996) report that increasing the UCS increases the compression fatigue life With regard to compression fatigue characterization, a 0.08-inch rut is criterion used for crushing initiation and a 0.4-inch rut is used for advanced rutting (Theyse et al. 1995). Jameson et al (1992) also report that for thick CSL (>12 in.), crushing occurs in the top 2 inches of the CSL Crushing does not cause cracking in the surface layer. However, Theyse et al. observed permanent deformation. The lower the cement content, the finer is the crushed CSL.

5. Heave

Expansive soils often are stabilized to mitigate swelling. However, heaving could still occur when sulfate-bearing soil is stabilized with calcium-based stabilizer in the presence of moisture. Chen et al. (2005) report that the formation of ettringite in lime-treated sulfate-bearing soil causes heaving in the pavement surface. Si (2008) reports that the swell of fly ash-stabilized sulfate-bearing soil causes heave in HMA. Lime and fly ash are effective in reducing the swell of sulfate-bearing soils.

6. Conclusion

Practice shows that there are some inevitable semi-rigid base asphalt pavement technical problems, such as due to shrinkage properties of semi-rigid base material of asphalt pavement early cracking of semi-rigid base materials in water action of vehicle load and temperature gradient under the combination of the phenomenon of pumping mud at the grass-roots level, under the condition of heavy traffic phenomenon of early fatigue damage and so on. In this paper, from the characteristics of semi-rigid base, typical structure and the main diseases and prevention measures of semi rigid base asphalt pavement is introduced in detail, and the structure optimization and overloading condition half rigid base asphalt roadbed development were discussed. Through a lot of investigation and study, analyze the properties of cementitiously stabilized materials linked to pavement performance, mainly the shrinkage of CSL and related pavement distresses and the fatigue of CSL and related pavement distresses, stiffness of CSL and related pavement performance and erudibility, to do researches for the development of the improvement of the pavement.

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