Performance Issues of Pavement With Cementitiously Stabilized Layers (CSL)

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Abstract

The asphalt pavement damage form, has been made a lot of research at home and abroad. In 2008 our country highway traffic mileage reached 60300 kilometers, a large amount of asphalt pavement has been or will soon enter the maintenance period, overhaul construction also gradually developed, and the high-grade asphalt pavement, in particular, since 2000 the development of heavy vehicle and the vehicle overload severely aggravate the damage of the asphalt surface, such as not timely and effective maintenance, for the safety and comfort of driving will bring a lot of hidden dangers. This article through to the domestic and foreign asphalt pavement early damage repair and failure forms, asphalt layer asphalt pavement overhaul survey of the status, pointed out the current highway construction in China is facing a common form of some local failure: block cracking in HMA; transverse cracking induced by shrinkage of CSL; longitudinal cracking; bottom-up cracking may be due to CSL sur-face raveling or fatigue of the CSL; rutting; heave.

Keywords

Asphalt pavement damage form; Block cracking in HMA; CSL; Rutting; Heave.

1. Introduction

Vigorously for the construction of economic development to promote the construction vigorously in the field of transportation in our country, the highway construction has an important role in the field of transportation. In the construction of highway pavement construction as foundation, road construction is one of the most important step [1]. On water stability of asphalt concrete pavement in structure with high strength, relatively low cost, and stability is very good, the use of time is relatively long were widely used in road construction in our country. With the advantages of this structure is very much, but still found some problem in use process, this kind of cement stabilized base is very prone to shrinkage crack and mapped to the pavement, pavement cracking phenomena will appear, seriously affecting the effects of the use of asphalt concrete pavement. At the same time also brought a vehicle traveling some unsafe factors. Crack is one of the most main damage form of asphalt pavement. Pavement crack not only influence the driving comfort and road capacity and beautiful, and easy to expand the pavement structural damage .So the analysis of water stability of asphalt concrete pavement cracks cause has important meaning, to the highway engineering construction enterprise to provide certain help[2].

The performance of hot mix asphalt (HMA) pavement is significantly affected by cementitious stabilized layers (CSL), especially when CSL are located directly underneath HMA layers. Stabilized subbase and base layers can reduce the rutting of HMA pavement as a result of minimal rutting in the subgrade, subbase, and base (Von Quintus et al. 2005). The bottom-up fatigue cracking of HMA also can be reduced. However, there are performance issues related to CSL, mostly when they are used as the base course.

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 (Fig. 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.

Fig.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 Fig.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 (George 2002). Transverse cracking is also a concern for pavements with a stabilized subbase 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.

Fig.2 Transverse Cracking due to Shrinkage Cracking of CSL (Freeman and Little2002)

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 macrostrain for fine-grained soil and 310 macrostrain for coarse-grained soils, respectively.

4. Longitudinal Cracking

4.1 Longitudinal cracking in wheel path (top-down cracking)

CSL provide strong support for surface layer, which is beneficial in reducing the fatigue of surface layers that can occur as a result of tension at the bottom of the surface layer. Therefore, alligator cracking in HMA can be mitigated when a stabilized base is used, unless the pavement is under-designed or the CSL are fatigued. However, for asphalt pavements that use high-stiffness CSL as the base, the HMA surface layer is prone to top-down fatigue cracking (ARA 2004). This top-down fatigue cracking has been confirmed by other researchers (Meng et al. 2004 and Barstis et al. 2000); and the team's field projects that use stabilized base layers also exhibited this distress. Actually, transverse and longitudinal cracks in the wheel path are the two most major distresses for highway pavements constructed with CSL, as reported by George (2002).

4.2 Longitudinal cracking (outside wheel path): dry-land cracking

Dry-land cracking occurs as a result of shrinkage of expansive soils. The shrinkage cracks reflect through the upper layers and appear in the HMA surface. Luo and Prozzi (2008) report that longitudinal dry-land cracking initiates in untreated expansive soil and appears in the HMA surface. Adding lime reduces the plasticity index (PI) value, suction, compression index value, and the swelling potential of expansive soils. Wise and Hudson (1971) also report that the subgrade beneath the pavement at the centerline has a high moisture content whereas the moisture content underneath the shoulder fluctuates. The shrink and swell caused by moisture change can lead to longitudinal dry-land cracking. Syed and Scullion (2001) indicate that the shrink-swell of subgrade comprised of expansive soil results in dry-land cracking. The shrinkage cracking in the subgrade reflects through the CSL and appears at the HMA surface. This phenomenon also is confirmed by forensic studies by Chen (2007) and Atkinson (1990) in which expansive soil causes dry-land cracking.

5. Bottom-up cracking may be due to CSL surface raveling or fatigue of the CSL, as follows:

5.1 Bottom-up cracking due to CSL surface raveling

Based on accelerated pavement testing, studies (Li et al. 1999, Meng et al. 2004, Thogersen 2005) show that the surface of a stabilized base layer can ravel, creating a layer of loose material between the HMA and base CSL. Raveling of the base increases the strain level at the bottom of the HMA, which can result in alligator cracking. In addition, pumping was observed in these cases. The pumping is caused by the loss of fines in the loose material layer. This phenomenon may be linked to the erodibility of stabilized materials, which often happens when relatively fine raw materials are treated (De Beer 1985).

5.2 Fatigue of stabilized base (bottom-up tension)

The fatigue of a pavement is a form of structural failure. According to studies conducted in South Africa (De Beer 1990), there are two types of fatigue failure for CSL, bottom tension fatigue and top compression (top crushing).

Alligator cracking in thin HMA pavement, also can be accelerated by fatigue cracking of the stabilized base or subbase caused by repeated traffic loads (Pretorius et al. 1972, Li et al. 1999). The fatigue resistance of CSL is reduced when subjected to freeze-thaw and/or wet-dry cycling (Naji and Zaman 2005). Bottom-up cracking in HMA could be due to bottom-up fatigue cracking of the CSL. Under repeated traffic loads, micro cracking is initiated at the bottom of CSL due to tensile stress/strain, and propagates upwards.

6. Rutting

6.1 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.

6.2 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 deboning 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.

Rutting due to fatigue failure in CSL

7. 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

8. Conclusions and Recommends

At present, many high grade highway asphalt pavement in our country have created serious early damage phenomenon, if can fundamentally solve the failure phenomenon, every year will greatly save highway construction investment cost, so studying the cause for early damage of asphalt pavement is of great significance. The damage of the asphalt is common, some of the roads need to constantly renovate a make-over, caused a certain economic losses. This paper systematically analyzes the reasons for damage of asphalt pavement and countermeasures, to reduce the road damage, prolong the service life of pavement.

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