Construction and Building Materials 119 (2016) 80–88

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Technical note

The feasibility of continuous construction of the base and asphalt layers of asphalt pavement to solve the problem of reflective cracks

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HIGHLIGHTS

- A new construction method called CCBA is proposed.
- An anti-cracking agent is developed for CCBA.
- Field test showed that CCBA can lead to fewer reflective cracks in asphalt pavement.

ARTICLE INFO

Article history:
Received 4 September 2015
Received in revised form 31 March 2016
Accepted 2 April 2016
Available online 13 May 2016

Keywords:
Continuous construction of the base and asphalt layers (CCBA)
Test road
Reflective crack
Asphalt pavement
Anti-cracking agent

ABSTRACT

The problem of reflective cracks in asphalt pavements with semi-rigid bases has not yet been effectively solved. This paper proposes a new construction method called continuous construction of the base and asphalt layers (CCBA). In this method, an anti-cracking agent is added to the cement-stabilized base material, and the asphalt pavement is applied when the base has been compacted but not initially set. Laboratory tests of the anti-cracking agent were performed, and test roads in the field were evaluated. The test roads showed that compared with the conventional construction technique (CCT), CCBA results in fewer cracks, can protect the base from cracking, and strengthens the bond between the base and the asphalt pavement.

1. Introduction

Asphalt pavements with semi-rigid bases have the advantages of high strength, good flatness and sound anti-fatigue performance and have become the major type of pavement used for high-grade highways in China. However, they are prone to reflective cracking under traffic loads and the influence of the external environment [1]. It is widely recognized that the tensile and shearing stresses at the bottom of the asphalt layer that form under vehicle wheel loads or environmental loads increases greatly when there are cracks in the base because of the stress concentration at the crack tips. Thus, if there are cracks in the semi-rigid base and the asphalt pavement is not sufficiently thick, further cracks will soon form. These cracks, which propagate in a flexible overlay over the existing cracks, are called reflective cracks because they essentially reflect what is happening beneath them. Reflective cracks can occur in both Portland cement and asphalt pavements as well as over other base materials, such as stabilized bases. These cracks roughen the pavement and allow moisture to penetrate, causing the pavement to deteriorate over the long term. A number of different design strategies have been employed in an effort to slow the development of reflective cracking, including increased overlay thickness [2], joint sawing and sealing [3], pavement fracturing (for Portland cement concrete pavements) [4], stress relief layers [5], reinforcement layers [6,7], and composite geotextile interlayers [8–13]. The University of Illinois investigated the performance of pavements constructed using interlayer stress-absorbing composite (ISAC)-based Portland cement concrete; these investigations revealed that ISAC-based pavements demonstrate unparalleled superiority over single-interlayer pavements, even in the worst environments [14]. Microcracking is also a promising approach. The microcracking concept can be defined as the application of several passes with vibratory rollers over a cement-treated base following a short curing stage, typically of 1–3 days, to create a fine network of cracks. Microcracking has proven quite effective at reducing shrinkage cracking problems in pavement bases; a procedure consisting of three roller passes after 2–3 days of curing

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http://dx.doi.org/10.1016/j.conbuildmat.2016.04.012
0950-0618/

resulted in the best performance [15]. However, the effectiveness of these approaches in overcoming reflective cracking is highly project dependent. For example, increasing the overlay thickness is applicable only for overlays thinner than 9 in [16] and may not significantly decrease thermal stresses, although it may decrease traffic-induced stresses [17]. Furthermore, some applications have shown little or even no success in retarding reflective cracking by interlayer systems. This may be attributable to a lack of understanding of the mechanism through which an interlayer system reduces reflective cracking and/or inappropriate interlayer system installation [18,19].

Obviously, the origin of a reflective crack is a base crack, and the most effective measure to avoid reflective cracking should be to eliminate base cracks. However, preventing the base from cracking is difficult, especially for cement-stabilized bases due to their inherent characteristics of dry shrinkage and temperature shrinkage, accompanied by the negative effects of the conventional construction technique (CCT) for asphalt pavement. CCT has some disadvantages. First, the water spray maintenance procedure may induce base cracks as a result of changes in the base volume caused by constant variation in water content. At this early stage, the strength of the cement-stabilized base is too low to resist the resulting cycles of expansion and shrinkage. Second, during the curing period, the base is exposed to the external environment and is easily influenced by environmental factors such as air temperature, solar radiation, and wind, which can cause thermal expansion and shrinkage and cause base cracks, especially with large temperature differences between day and night. Third, the base is highly likely to become contaminated during the long curing period, which may impair the bond between the base and the asphalt layer. Finally, the long-term hindrance to transportation during the lengthy construction period that is required is sometimes intolerable, especially for emergency urban road repairs. To overcome these construction disadvantages, a creative construction technique called continuous construction of the base and asphalt layers (CCBA) is proposed in this paper. Furthermore, its feasibility for solving the reflective cracking problem in asphalt pavement is investigated.

In this paper, Section 1 reviews the topic of reflective cracking. In Section 2, a creative construction technique called continuous construction of the base and asphalt layers is proposed. The additive required for CCBA, namely, the anti-cracking agent, is then briefly introduced in Section 3. In Section 4, the test roads constructed in the field using this proposed technique are presented and discussed. Finally, the conclusions are presented.

2. The presentation of CCBA

To avoid the disadvantages of the CCT, an innovative construction method called continuous construction of the base and asphalt layers is proposed.

The CCBA process is graphically presented in Fig. 1. The construction process before base construction is the same as that for the CCT. The difference arises after the sub-base is completed. In CCBA, the subsequent step is to pave the base material, which has been mixed with a special additive, and to then continuously pave the asphalt layer immediately after the base is compacted. Both sprinkler-based maintenance for curing the cement-stabilized base and the application of priming oil before paving the asphalt layer are eliminated. In contrast, the CCT procedure includes the following steps: paving and compacting the base; curing the base (usually for several days); applying priming oil, and paving and compacting the asphalt layer; and opening the road to traffic.

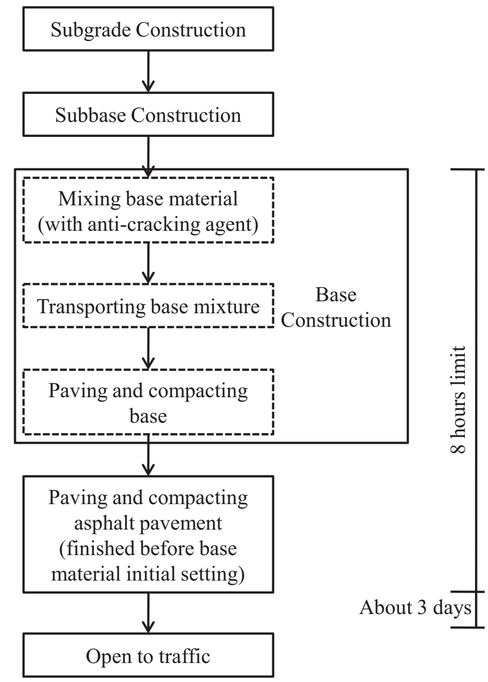

Fig. 1. CCBA procedure.

Compared with the CCT, the most important changes in CCBA lie in the steps in which the asphalt layer is paved and the road is opened to traffic. The construction of both the base and the asphalt layer (at least the sub-asphalt layer) must be completed before the initial setting of the base material, as shown in Fig. 1. Because compacting the cement-stabilized base after its initial setting may destroy the integrity of the base and cause irreversible damage, construction must be completed before this initial setting. Another change in CCBA is when the road can be opened to traffic. An asphalt pavement constructed using the CCT is typically opened to traffic immediately after the asphalt layer is compacted and cooled. However, this is not suitable for CCBA. A road constructed using the CCBA technique cannot be opened to traffic before the cement-stabilized base has gained sufficient strength to endure traffic loads, which usually requires several days. In the field road test presented in Section 4, the base strength was greater than 2.5 MPa three days after paving, indicating that the test road could be opened to traffic after three days.

CCBA is recommended to be conducted using at least one base paver, one base roller, one asphalt mixture paver, and one asphalt mixture roller, as well as several vehicles for transferring materials.

The construction site arrangement is depicted in Fig. 2. The construction equipment is arranged in the following sequence: base pavers, base rollers, asphalt mixture pavers, and asphalt mixture rollers. During construction, the asphalt mixture paving and compaction equipment is followed by the base material spreading and compaction equipment at approximately 50 m behind. The vehicle used to transfer the asphalt mixture transfers the mixture to the asphalt concrete (AC) paver laterally rather than driving directly on the road being paved because the base roller and paver would otherwise be in its way, as shown in Fig. 3. If the paver is allowed to transfer the material laterally, then the transferring vehicle should not drive on the newly paved base road. Otherwise, the transferring vehicle must drive across the paths of the base paver and roller and transfer the AC to the paver directly.

The CCBA compaction scheme is essentially consistent with that of the CCT. Generally, the compaction scheme is determined based on the compaction results from field test roads. The ideal objective