



Creep performance evaluation of Cold Mix Asphalt patching mixes

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Abstract

Cold Mix Asphalt (CMA) is commonly used in lieu of typical Hot Mix Asphalt (HMA) for localized pavement patching due to the quantities, intermittent locations and times when repairs need to be executed. The objective of this investigation was to evaluate the resistance of CMA to accumulate permanent deformation under cyclic loading, and to present an alternative to assess stability potential from a portable device. Considering CMA is at its weakest state right after placement, and that its resistance to creep improves with curing, the study focused on evaluating the rutting performance of uncured CMA materials at different compaction levels in the laboratory by means of parameters b and FN from a Modified Cyclic Creep Test (MCCT) and by their resistance to penetration with a Light Cone Penetrometer (LCP), defined by the LCP penetration rate (LPR). Based on the experimental results, acceptable laboratory stability can be expected when values below $0.5 \mu\text{ε}/\text{load}$ and over 1000 load cycles are observed for b and FN , respectively. Considering the potential use of the LCP as a field-friendly quality control tool, models to estimate parameters b and FN from the MCCT as a function of LPR and other CMA characteristics were developed using Multiple Linear Regression Analysis (MLRA). The results suggest that when LPR values are limited to $0.50 \text{ mm}/\text{blow}$, CMA materials can be expected to show acceptable stability levels.

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1. Introduction

The constant need to repair localized pavement failures, and the nature of the repairs normally required in terms of material quantities and timing at which the repairs need to be executed, make necessary the use of materials that can be stored and used when needed. Although the behavior of Hot Mix Asphalt (HMA) is somewhat well understood and there is extensive knowledge about its performance, the inability to produce and store HMA in small quantities to be used as required make them unsuitable for pothole and other localized repairs. To fill this need, Cold Mix Asphalt (CMA) is normally used, as its characteristics

allow users to have immediate availability in stock, and use it when and where needed.

Considering that the solvents that allow CMA's mixing and compaction processes can take some time to evaporate, their ability to resist permanent deformation immediately after placement (i.e., fresh or “uncured”) is a major concern. The establishment of protocols to assess CMA's performance in the uncured state is necessary to reduce concerns with their generalized implementation and use.

Once the CMA has been manufactured and is made available, compaction is the single most important factor affecting performance that is completely under the control of the contractor. Having the means to easily assess how compaction affects the ability of a given CMA to resist the accumulation of permanent deformation would be extremely useful, as minimum compaction levels could be established, and quality assessment of available CMA could be executed during procurement processes.

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A methodology to establish rationally the ability of CMA to resist the accumulation of permanent deformation when subjected to cyclic loads, and a procedure with potential field use to quickly assess rutting performance in CMA is presented in the next sections of this document.

2. Literature review

The frequent need of localized small pavement repairs during the year, presents CMA as the perfect candidate for this type of work. Initial studies in the late 70's evaluated the use of cold mixes in pavement patching operations [1]. Prowell and Franklin evaluated a wide variety of cold mixes in the mid 90's for the Virginia DOT patching operations, and developed a performance rating system involving visual inspection of the patches for the presence of bleeding, dishing, debonding, raveling, and pushing/shoving, as well as measurements of workability and patch survival rate [2]. They concluded that mix instability is one of the major limitations preventing the use of cold mixes as successful patching materials.

Although there are different tests to characterize CMA, most characterization methods for these materials focus on mix workability rather than performance, mostly because these materials are often used as a temporary repair. However, research has been done to develop CMA that can be used as a permanent solution [3], although the ability to match the performance of its hot mixed counterpart (i.e., Hot mix Asphalt) has been elusive.

Other characterization tests performed on cold mix materials include particle size gradation, residual asphalt content, and other aggregate tests such as surface area determination, specific gravity and absorption, soundness, and mechanical abrasion. Aggregate gradation, residual asphalt content, and workability are the most commonly used characterization tests for cold mixes.

Recommendations regarding aggregate gradation and shape are reported in the literature. Overall, finer and single sized gradations with low amount of fines (material passing the 0.075 mm sieve) are favored for increased workability [4], but recommendations to allow some coarser aggregate to promote greater stability have been made by Prowell and Franklin [2]. Low aggregate angularity has been connected with poor stability in the mixes.

Excessive initial instability right after construction is one of the main performance-related concerns related to cold mix use. Due to its properties, the workability needed during installation affects negatively the initial resistance against plastic deformation required in the repairs. Patch stability, understood as the ability of a CMA material to resist permanent deformation and shoving, is normally evaluated by primitive procedures (such as penetration with a screw driver, and turning the driving wheel of a passenger car), but the use of structured methods to relate initial stability with more elaborated permanent deformation performance parameters is not generalized. Some efforts to characterize workability and stability in cold asphalt

mixtures have been recently reported in the literature [5,6], but cold mix stability characterization is far from becoming a standard procedure.

A recent NCHRP synthesis of practice published by the Transportation Research Board reports the use of tests to evaluate percent coating of aggregate, stripping potential and draindown susceptibility in cold asphalt patching mixes, and also indicate the use of workability tests using a workability box and a modified pocket penetrometer. The document also highlights the need for technical developments in patching practices, including the need to have rational ways to compare different patching materials as one of the areas of most interest in the United States [7].

Although some researchers have used load tests for CMA evaluation, most researchers have focused on measuring workability characteristics. Estakhri and Button report the use of unconfined compression tests and suggest limiting criteria from this test for assessing workability [8]. However, some research efforts have studied rutting performance in CMA products. Rosales-Herrera et al. evaluated locally produced and proprietary CMA patching materials using slump tests for workability assessment and stability assessment in the laboratory using Hamburg Wheel Tracking tests and a local Texas Stability Tests [6].

Most efforts to understand permanent deformation behavior on bituminous mixes has been focused on Hot Mix Asphalt (HMA), and the majority of tests have been developed around this application. Different methods to characterize permanent deformation behavior in asphalt mixtures include incremental static, dynamic, and creep tests, and several models including binder and mix properties have been developed, although these days most tests use some form of dynamic load applied to confined or unconfined specimens. Although the triaxial test setup can simulate more effectively the stress states that may be expected in the field, its implementation requirements have made unconfined tests very popular.

The response of asphalt bound materials under uniaxial repeated loading can be separated into three stages: a primary stage, where high rates of deformation are present primarily for re-accommodation of the structure of the mix; a secondary stage, in which the rate of deformation per load cycle remains approximately constant; and a tertiary stage, where the rate of deformation increases dramatically with each load repetition until complete failure is reached. Lower strain rates during the secondary stage of deformation suggest a more stable mix after initial densification has been achieved, and the structure of the mixture has finished its relocation due to initial traffic compaction. The number of load cycles at which a mixture enters the tertiary deformation stage (also known as the Flow Number, or *FN*) has become also an accepted rutting performance parameter [9]; higher *FN* values suggest mixes with lower rutting susceptibility.

Arguably the most commonly used permanent deformation characterization model is the Power Model, expressed generally in the form:

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