DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Evaluation of Open-Graded Friction Course (OGFC) Mix Design

This study proposes a volumetric-based OGFC mix design to provide a better way to determine the initial binder content rather than basing it on the bulk specific gravity of the aggregate blend which is the current method.

Pavement

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Project Title:
Evaluation of Open-Graded Friction Course (OGFC) Mix Design

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WHAT IS THE NEED?

The California Department of Transportation (Caltrans) currently uses California Test 368 (CT 368) (August 2003) "Standard Method for Determining Optimum Bitumen Content (OBC) for Open Graded Asphalt Concrete" for Open Graded Friction Course (OGFC) mix design. The OBC determined using this method is expected to provide a mix with an asphalt film thickness that provides good durability and avoids excessive asphalt drainage. Only conventional (unmodified) asphalts were used in CT 368, but in a recent modification, PG 64-10 asphalt cement replaced AR-4000 material. To determine the OBC for both the polymer-modified asphalts and asphalt rubber binders introduced more recently, a factor is now applied to increase the OBC determined for the design mix with the PG 64-10 asphalt cement.

Among several disadvantages associated with the current CT 368 procedure are (1) there is no verification of stone-on-stone contact; (2) there is no determination of volumetric and mechanistic properties of compacted specimens; and (3) there is no performance testing for aging and moisture damage for the state's different climate regions.

Recently the National Center of Asphalt Technology (NCAT) (1) developed an improved design procedure for OGFC mixes. This methodology includes (1) materials selection, (2) trial gradations, (3) selection of an optimum gradation, (4) selection of an optimum binder content, and (5) moisture susceptibility determination using the modified Lottman method in accordance with AASHTO T 283 with one freeze-thaw cycle.

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WHAT WAS OUR GOAL?

- Verify the NCAT procedure – selection of optimum gradation based on volumetric criteria.
- Evaluate the NCAT procedure – selection of optimum asphalt binder content based on results from the draindown and Cantabro (durability) tests that satisfy the established NCAT performance criteria.
- Identify potential problems in the NCAT OGFC mix design procedure.
- Evaluate the possibility of incorporating the NCAT OGFC mix design procedure into the revision of CT 368 or develop an appropriate OGFC mix design procedure based on the findings of this study.
- Provide recommendations for the revision of CT 368.

WHAT DID WE DO?

To accomplish these objectives, representative OGFC mixes were used. These mixes were prepared using three different binders (PG 64-10, PG 64-28 PM, and an asphalt rubber [AR]), three aggregates obtained from representative sources in California, and three representative gradations within the ½ in. OGFC gradation limits of Section 39 of the California Standard Specifications (CSS).

Phase I: Selection of optimum gradation
In this phase, initial trial binder contents were determined using the current test methods, CT 368 and AASHTO T 305. For each combination of the three aggregates, three binders, and three gradations, one loose mix sample for determining the theoretical maximum specific gravity (Gmm) and three Superpave gyratory compacted (SGC) samples with 50 gyrations were prepared. The optimum gradations were determined from volumetric criteria based on determinations of the bulk specific gravities of the compacted asphalt mixes (Gmb), the air-void contents (Va or Vair), and the voids in the coarse aggregate of the compacted mixes (VCAMIX).

Phase II: Selection of optimum binder content
This phase developed the methodology used to select optimum binder contents for the optimum gradations for the three aggregates, specifically the three G1 (coarse) gradations selected in the Phase I.

Phase III: Supplemental tests

Based on the findings from Phases I and II, supplemental tests were conducted in Phase III using two mixes selected from the earlier studies. The purpose of this investigation was to provide a preliminary evaluation of the effects of gyratory compactive effort (number of gyrations), aggregate gradation, and specimen conditioning on the performance testing and specifications for OGFC mix design. This phase of the study also investigated the effect of gradation type on Cantabro loss by using a variety of previously untested additional specimens that had been fabricated for Phase I.

Development of OGFC mix design chart
The development of the weight-volume relationships for a compacted asphalt mixture, with consideration of asphalt absorption by the coarse aggregate and any fibers included in the mix, that are used in this chapter have been developed and are based primarily on those contained
in "Asphalt Paving Mixtures" and "The Asphalt Handbook."

WHAT WAS THE OUTCOME?

This investigation of OGFC mix design used three aggregate types, three binder types, and three trial gradations to prepare specimens using Superpave gyratory compactors for volumetric, draindown, Cantabro, and other performance tests.

1. Superpave Gyratory Compaction. The use of a number between 50 and 100 (on the order of 70) of gyrations with the Superpave

Gyratory Compactor (SGC),is recommended between 50 and 100, on the order of 70, is recommended.

2. Air Void Specification. Open-graded friction course mixes are primarily designed to have a large number of void spaces in the compacted mix without any sacrifices to durability over their design life. The open void structure helps drain water and preserve surface friction, reducing skid and hydroplaning-related accidents, and thus increasing roadway safety during wet weather. From this perspective, it is not necessary to specify the upper limit of the air-void content if a compacted mix can meet the performance specifications for permeability, Cantabro (measure of durability performance), and Hamburg Wheel Tracking Device testing (HWTD, measure of rutting and moisture sensitivity).

3. Selection of Binder Type. The tree-based modeling and correlation analyses completed in this study indicated that binder type is the most significant factor affecting the Cantabro performance of an OGFC mix, and that PG 64-28 PM binder demonstrated superiority over the other two binder types, PG 64-10 and AR. These results are limited to the three binders used in this study but strongly indicate that binder type and/or grade selection is extremely important to balance draindown and durability.

4. Maximum Cantabro Loss Specification. The Cantabro test results obtained in this study indicate that it will be difficult for many mixes meet the specification of 15 percent maximum Cantabro loss recommended by the NCAT approach. It is suggested that the specification of 15 percent maximum Cantabro loss be re-evaluated and coupled with the specification for the value of the dust-to-asphalt ratio (percent passing the No. 200 [0.075 mm] sieve) and/or fines content (percent passing the No. 200 sieve) to ensure that the performance specification calibrated with the in-situ data can satisfy the requirements for OGFC design life.

5. Further Study—Calibration of Mix Design Chart. The OGFC mix design chart should be calibrated based on further laboratory testing ensure that it delivers the desired air-void content while also producing mixes that meet the desired properties for the three performance-related tests: draindown, Cantabro (measure of durability performance), and HWTD testing (measure of rutting and moisture sensitivity). The calibration should be done by performing laboratory testing to determine the effects of the percent passing the No. 200 sieve, the dust-to-asphalt ratio, fibers, binder grade, nominal maximum aggregate size (NMAS), percent absorbed asphalt in the aggregate, and percent passing the break point sieve size on air-void content, and on the performance-related test results. Furthermore, an approach should be developed to include the results of performance-related tests in the design chart to determine the allowable range of binder contents that will meet all design requirements.

WHAT WAS THE BENEFIT?

This study identified specific areas in the NCAT procedure that improves the durability of the Open Graded Friction Course (OGFC) mix designs. In addition, a OGFC mix design chart is proposed to provide a more general design that accommodates the newer binder types (e.g., polymer modified, rubberized, etc.) that are being developed by the oil industries. The improvements to both design processes will lead to longer lasting OGFC pavement treatments that will ultimately provide for safer pavements for the traveling public.

LEARN MORE

http://www.ucprc.ucdavis.edu/PDF/UCPRC-SR-2013-02.pdf

IMAGES

Image1: Three aggregates used in the tests per sieve size.

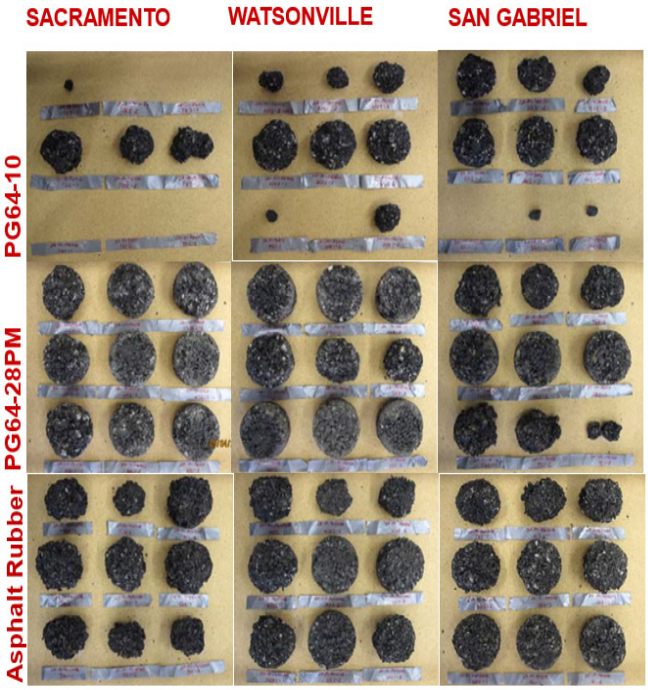

Image2: Photographic summary of Cantabro tests using Phase I SGC specimens