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81. Field Performance of Asphalt Pavements with New Technologies in Northern Nevada

82. Influence of mixture characteristics on the oxidative aging of asphalt binders
Detection of moisture in asphaltic concrete by microwave measurements

Author: Al-Qadi, Imadeddin L

Abstract: An experimental technique based upon dielectric properties was developed to measure the volumetric moisture content in asphaltic concrete. The dielectric properties were calculated from the measured reflection coefficients and phase angles. The measurements were obtained over a band of frequencies in the microwave range, 12.4 to 18.0 GHz.

The test program included different aggregate types, aggregate gradations, asphalt types, asphalt contents, void ratios, specimen thicknesses, and surface smoothness. Microwave reflection measurements were obtained for the hot-mix asphalt specimens and their components in a sweep mode over the above frequency band. These measurements were analyzed and the magnitude of the dielectric constant and the loss factor were calculated. The dielectric properties for these mixes were obtained at the dry state and at two levels of moisture contents. Although there were some differences in the dielectric properties of the different mixes, the presence of the water in the mixes overshadows these differences.

Statistically, the dielectric properties were correlated to the mix characteristics. Regression models were developed to predict the volumetric moisture content. However, the suggested model was found to be a function of the dielectric properties of water, dry asphaltic concrete mixture, and wet asphaltic concrete mixture. Therefore, in order to obtain the dry dielectric properties, several cores are needed. An alternative model is a function of air void content, which is very difficult to measure in the field.

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Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences, Concrete, moisture detection

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Place of publication: Ann Arbor

Country of publication: United States

Advisor: Anderson, David A, Sebaaly, Peter E

University/institution: The Pennsylvania State University

University location: United States -- Pennsylvania

Degree: Ph.D.

Source type: Dissertations & Theses
Evaluation of rutting characteristics and layer coefficients of NOVOPHALT mixtures

Author: Qi, Xicheng

Abstract: In this study the effects of NOVOPHALT modifiers on the rutting characteristics of asphalt concrete mixtures and the AASHTO structural layer coefficients of NOVOPHALT mixtures were evaluated. A laboratory test program was conducted to characterize the asphalt concrete mixtures with modified and unmodified binders, which included repeated load creep at three test conditions, static load creep at one temperature, and resilient modulus at three temperatures. Two sources of aggregates and four types of binders were investigated. The test results were used with VESYS 3A-M structural subsystem to predict the effects of the modifiers on pavement rutting performance. AASHTO structural layer coefficients were estimated for the modified mixtures based on rutting criterion.

The results of the study indicate that the rutting resistance of NOVOPHALT modified mixtures were significantly superior to the control mixtures containing AC-20 binder and even better than the mixtures containing AC-40 binder. Therefore, NOVOPHALT mixtures have higher AASHTO structural layer coefficients than the conventional mixtures.

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Subject: Civil engineering; Materials science; Polymers;

Classification: 0543: Civil engineering; 0794: Materials science; 0495: Polymers

Identifier / keyword: Applied sciences, Pure sciences

Pages: 157 p.

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School code: 0139

Source: MAI 31/01, p. 378, Spring 1993

Place of publication: Ann Arbor

Country of publication: United States
The influence of aggregate gradation on permanent deformation of asphalt concrete

Author: Krutz, Neil Carmichael

Abstract: In recent years, technological advances seen in truck tires have led to increases in the loads that pavements are required to carry. The increases in both axle load and tire pressure have resulted in a great increase in the contact pressure at the tire-pavement interface. This has led to many premature pavement failures due to severe rutting.

It is hypothesized that by designing asphalt concrete mixtures to include more coarse aggregate, a mixture more resistant to rutting will be produced. In order to test this hypothesis, a research program was designed to look at the permanent deformation characteristics of mixtures using a variety of gradations.

Conclusions from the program indicated that the gradation plays a very large role in permanent deformation response of the mixture. The data also showed that response is controlled by the binder type as well as any environmental conditioning that the mixture has undergone.

Links: Check for full text via 360 Link

Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences

Pages: 206 p.

Number of pages: 206

Publication year: 1992

Degree date: 1992

School code: 0139
Evaluation of material properties as related to long-term pavement performance

Author: Venugopal, Thimmarayappa

Abstract: The design of asphalt concrete mixture has developed from an uncertain art to a reasonably well defined science during the last several decades. It is primarily a matter of selecting and proportioning materials to obtain asphalt concrete with the desired properties in the finished product. Investigations were conducted to measure the properties of a highly successful flexible pavement section designed and constructed by the Nevada Department of Transportation (NDOT) on I-15 in the southern part of the state. Properties of the asphalt cement, aggregates and the asphalt mixture were evaluated for this pavement section, which led to this highly successful in-service pavement. The temperature susceptibility characteristics of the mixture were excellent. Moisture susceptibility was excellent. The pavement was highly resistant to rutting. Though the aggregates were out of the specifications of some of the FHWA and SHRP recommendations they performed well.

It was concluded that the aggregate source was excellent, gradation was compatible with the source of aggregate, excellent temperature susceptibility and moisture resistance was obtained through proper mix design and construction, excellent quality control/assurance program and construction practice.

Links: Check for full text via 360 Link

Subject: Civil engineering;

Classification: 0543: Civil engineering
The classification of Nevada's 1993 asphalt binders using SHRP's performance-based grading system

Author: Blakely, Stephen Dale

Abstract: Ten different asphalt binders tested in the laboratory and were classified following the Strategic Highway Research Program's performance-based binder specification system (Draft 7). The rheological properties of the binders were evaluated using the Dynamic Shear Rheometer (DSR) device, the Bending Beam Rheometer (BBR), and the Brookfield Viscometer. All the rheological data pertaining to the binders are presented along with a performance-based grading according to SHRP. Several of the binders tested are classified under the AC grading system as polymerized AC-20 (AC-20P). The rheological properties of these similarly graded binders indicate that some of the asphalt's would be graded differently under the SHRP grading system. The report examines these differences and points out the discrepancies within the SHRP grading system. Environmental data as generated by the SHRP Superpave system was utilized to check the recommended
Comparison of laboratory performance of polymer modified AC-20 mixtures with conventional AC-30 mixtures

Author: Farooq, Imran

Abstract: In recent years, pavements constructed with conventional base asphalts have shown increased signs of failure, due to higher traffic volumes, higher tire pressures, and severe climatic conditions. One of the alternative available in minimizing this problem is the addition of polymer to the base asphalt. Recent studies have compared properties of mixtures like AC-20 or AC-40 to polymer modified AC-20 and AC-40 mixtures.
respectively to show the benefits of adding polymer to base asphalts. These studies have conclusively shown that polymerized mixtures out perform their conventional counterparts. However no studies have been undertaken to compare the polymer modified mixtures to a asphalt concrete mixture containing a higher viscosity asphalt cement.

The study presented here took this different approach where the properties of the polymer modified mixture (AC-20P) were compared to the properties of a mixture using a higher viscosity asphalt cement (AC-30). In order to test this hypothesis, a research program was designed to compare the performance of polymerized AC-20 mixture with a conventional AC-30 mixture.

Conclusions from the program indicated that the overall performance of Polymer modified AC-20 mixtures was far superior than that of the conventional AC-30 mixtures.

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Advisor: Sebaaly, Peter E
University/institution: University of Nevada, Reno
University location: United States -- Nevada
Degree: M.S.
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Dissertation/thesis number: 1358130
ProQuest document ID: 304127848
Document URL: http://search.proquest.com/docview/304127848?accountid=452
Copyright: Copyright UMI - Dissertations Publishing 1994
Database: Dissertations & Theses @ University of Nevada Reno, ProQuest Dissertations & Theses Global
Evaluation of aggregate gradations and asphalt binders

Author: Gangavaram, Rajshekar Reddy

Abstract: Aggregate gradation is perhaps the most important element of an asphalt concrete mixture, as it affects almost all of the physical properties of the mixture. In this research program four aggregate sources (i.e., Rural Granite Rye Patch pit, Frehner Sloan pit, Apex pit, Las Vegas Paving pit), three grades of asphalt cement (AC-20P, AC-20 and AC-30) and five distinctly different gradations were included. The objective of this research program is to evaluate the impact of various gradations on the performance of asphalt concrete mixtures and to identify the better performing mixtures for each aggregate source.

A total of 36 mix designs were completed (32 at UNR and four at NDOT) with various combinations of aggregate sources, aggregate gradations and binders. A laboratory testing based on the SHRP's newly developed performance based grading system and the evaluate the temperature susceptibility, moisture susceptibility, tensile strength, permanent deformation, and low temperature performance of the mixtures. Based on the combination of all the factors that were evaluated in this study, it can be concluded that the G1 gradation (used in the NDOT projects) is the best gradation for the Rural, Frehner Sloan and Las Vegas Paving pits while the G5 gradation is the best gradation for the Apex pit. This study emphasizes that each combination of aggregate and binder sources will require its own unique gradation.

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Subject: Civil engineering; Materials science;

Classification: 0543: Civil engineering; 0794: Materials science

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Country of publication: United States

Advisor: Sebaaly, Peter E

University/institution: University of Nevada, Reno

University location: United States -- Nevada

Degree: M.S.

Source type: Dissertations & Theses

Language: English

Document type: Dissertation/Thesis

Dissertation/thesis number: 1376653
Development of life-cycle cost analysis procedures for Nevada’s flexible pavements

Author: Hand, Adam John

Abstract: The Nevada Department of Transportation (NDOT) has established the preservation of the existing highway system as its number one priority. In an attempt to achieve this goal a pavement management system (PMS) was implemented in 1980 which provides for condition analysis. In 1993 pavement performance models were developed to enhance the system. The models provided a basis for the development of life-cycle cost analysis (LCCA) procedures, which will in turn provide a foundation for the development of a network optimization system, the ultimate PMS goal.

The research presented produces LCCA procedures for NDOT. It specifically investigates if and what other state highway agencies are using for LCCA through a survey, conducts in depth analysis of the relationship between performance and economic aspects of flexible pavements, establishes performance periods and all costs for rehabilitation and maintenance treatments employed by NDOT, and provides a solid foundation for the development of a NOS.

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Pages: 176 p.

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School code: 0139
Source: MAI 33/06, p. 1921, Dec 1995
Place of publication: Ann Arbor
Country of publication: United States
Advisor: Sebaaly, Peter
University/institution: University of Nevada, Reno
University location: United States -- Nevada
Degree: M.S.
Development of testing systems for Nevada's crumb rubber modified asphalt binders and mixtures

Author: Troy, Kenneth Erik

Abstract: In recent years, the push to recycle many waste materials has resulted in the use of several waste products in hot-mixed asphalt concrete (HMA). The use of crumb rubber from recycled tires has become increasingly popular in HMA production because of its potential to enhance the properties of such mixtures. Several adaptations to current design methods and testing programs have been made in order to establish criteria for the use of crumb rubber modified (CRM) mixtures.

This report discusses the results of research conducted to evaluate the effectiveness of current SHRP binder classification techniques on CRM binders, as well as establish a mixture design process for gap-graded CRM mixtures used in the state of Nevada. Furthermore, mixture property evaluation of two NDOT gap-graded CRM mixtures will be discussed as part of an ongoing field to lab comparison.

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Subject: Civil engineering;

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Degree date: 1995

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Place of publication: Ann Arbor

Country of publication: United States

Advisor: Sebaaly, Peter
Aging characteristics of asphalt binders and asphalt-aggregate mixtures

Author: Bush, David Aaron

Abstract: For many years, researchers have tried to develop methods to simulate the aging process asphalt undergoes in the field. A large percentage of this research has concentrated on empirical tests using non-polymer modified binders.

The study presented in this report investigated the effectiveness of the Strategic Highway Research Project (SHRP) recommendations for binder and mixture aging methods, using materials from five projects constructed in the state of Nevada. A research program was designed to compare laboratory binder and mixture properties to field binder and mixture properties using current rheological, strength evaluation, and performance testing. Conclusions from the program indicated that the rolling thin film oven test (RTFOT) simulates the aging that the binder experiences in the field, mixture oven aging methods are too severe, and relationships between resilient modulus and temperature can be a good indicator to the field rutting resistance of the mixture.

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Source: MAI 33/06, p. 1919, Dec 1995
Evaluation of hot asphalt concrete mixes containing recycled materials as an alternative for pavement rehabilitation

Author: Castro-Fernandez, Pedro Luis

Abstract: Due to the high cost of raw materials in asphalt concrete, a lot of attention has been paid to recycling as a means of saving in raw materials (aggregates, asphalt cement, and hauling of materials). Even though it's been found that recycled pavements can provide the same quality as pavements built from all new materials, the fact of using recycled materials makes all the design and construction process more complicated. There is a series of new factors involved, such as selection of Recycled Asphalt Pavement (RAP) content, selection of new binders and recycling agents, and method to lime treat the aggregates. NDOT has been considering recycling as a rehabilitation alternative for two projects, one project is located in Elko county, and the other in Churchill county; both of these pavements have some rutting and stripping problems. This research project involves the selection of the percentage of RAP to use in the recycled mixtures, the lime treatment method to be applied, the new aggregate gradation, and the optimum properties of the new binders. The goal is to find an alternative of rehabilitation that takes advantage of recycled materials, and that fulfills both NDOT and Superpave specifications, including a high reliability level for the binder properties under the climatic conditions of the project sites.

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Subject: Civil engineering; Materials science;

Classification: 0543: Civil engineering; 0794: Materials science

Identifier / keyword: Applied sciences
Evaluation of an asphalt overlay for rubblized and cracked/seated Portland cement concrete

Author: Ambroz, Joanna Kay

Abstract: Many Portland Cement Concrete (PCC) pavements in the United States are reaching the end of their design life. The Nevada Department of Transportation (NDOT) used the crack and seat and rubblization techniques with a hot mixed asphalt (HMA) overlay to rehabilitate these pavements. This project is located on I-80 in Nevada near Elko, Nevada, and was constructed in 1994. This report defines the asphalt binder and mixture properties of the HMA overlay placed over the cracked and seated and rubblized PCC pavement. Properties determined were stability and resistance to moisture, permanent deformation, and low temperature cracking. A variety of aging techniques were used to condition the HMA to simulate the construction and environmental effects on the mixture. This initial research will be used to evaluate the long-term performance and cost effectiveness of a flexible overlay over cracked and seated and rubblized rigid pavements within Nevada.
Evaluation and development of durability tests for coal tar emulsions

Author: Dietz, Jason Morris

Abstract: In many pavement applications, asphalt concrete is exposed to damage from fuel spills or drippage. Fuel-resistant sealers are often required to protect the asphalt concrete pavement from possible damage. Coal tar emulsion with added aggregate is commonly used to protect the pavement from such damages. These mixtures or sealers often contain additives or modifiers to improve their performance. Five different coal tar emulsions were tested in the laboratory and were evaluated on three levels of mix design. The Scrub Test and Wet Track Abrasion Test (WTAT) for measuring the durability were used for comparison of other different coal tar sealers. The development of durability methods to become a standard will be discussed.
Cost-effective rehabilitation of Portland cement concrete pavement in Nevada

Author: Bemanian, Sohila

Abstract: The purpose of this study, was to evaluate the feasibility of several rehabilitation strategies for Portland Cement Concrete (PCC) pavement. Recommendations were made for future crack and seat, rubblization, and reconstruction projects based on a review of specifications from several other states, the data gathered during the Interstate 80 project, the experience gained during the construction phase of the project, and review of several overlay design procedures.
The results of the study, based on 2 years of field performance, indicate crack and seat, rubblization, and reconstruction techniques are all viable options. The economic analysis indicates crack and seat has the lowest initial cost. However, based on projected future performance, both crack and seat and rubblization have approximately the same life-cycle cost over a 35 year analysis period. Pavement performance monitoring should continue in order to evaluate long term performance and cost-effectiveness of each strategy.

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University/institution: University of Nevada, Reno

University location: United States -- Nevada

Degree: M.S.

Source type: Dissertations & Theses

Language: English

Document type: Dissertation/Thesis

Dissertation/thesis number: 1384464

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Database: Dissertations & Theses @ University of Nevada Reno, ProQuest Dissertations & Theses Global
Abstract: The Nevada Department of Transportation (NDOT), as well as many other State Highway Agencies, have paved thousands of miles of Hot Mix Asphalt (HMA) pavements. One of the major distresses that state agencies try to avoid, by proper design, is thermal cracking due to extreme low temperatures. A significant portion of HMA pavements in the United States are subjected to severe temperature drops. Environmental effects on asphalt pavements can be detrimental to the life of a pavement section. Conclusions from this study indicate that the BBR is a more conservative test than the TSRST. Therefore, the TSRST is not necessary. It was also determined that aging procedures on HMAC mixtures, as well as asphalt binders, has proven to decrease the performance of pavements when subjected to low temperatures. Another significant result is that the performance of lab mixed lab compacted specimens accurately represents field mixture performance.

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Identifier / keyword: Applied sciences
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ISBN: 9780591579192, 0591579197
Advisor: Sebaaly, Peter
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Document type: Dissertation/Thesis
Dissertation/thesis number: 1386814
ProQuest document ID: 304357641
Document URL: http://search.proquest.com/docview/304357641?accountid=452
Copyright: Copyright UMI - Dissertations Publishing 1997
Database: Dissertations & Theses @ University of Nevada Reno, ProQuest Dissertations & Theses Global
Use of asphalt binder and mixture tests for predicting the performance of Nevada's flexible pavements

Author: Suthahar, Nadarajah

Abstract: Pavement performance can be predicted to a degree of certainty using various lab and/or field tests and appropriate analysis. The Superpave binder grading system and new mixture tests are expected to predict the pavement performance in a better manner than earlier tests. However, the Superpave process has not been verified on Nevada's pavements. In this study, the actual pavement performance of seventeen rehabilitation or reconstruction projects constructed in Nevada during the last three to four years were compared with the predicted pavement performance based on the Superpave binder grading system and new mixture tests. Comparisons were performed to analyze the capability of Superpave binder tests and mixture tests in predicting the pavement performance. The high and low temperatures from weather stations close to the projects were also compared with the Superpave weather data recommendations. The results of this study can be used to verify Superpave specifications and/or to alter the specifications specifically for Nevada's conditions.

Links: Check for full text via 360 Link

Subject: Civil engineering;
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Identifier / keyword: Applied sciences
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Place of publication: Ann Arbor
Country of publication: United States
ISBN: 9780591408744, 0591408740
Advisor: Sebaaly, Peter
University/institution: University of Nevada, Reno
University location: United States -- Nevada
Degree: M.S.
Source type: Dissertations & Theses
Language: English
Document type: Dissertation/Thesis
Pay adjustment factors for Superpave performance graded asphalt binders

Author: Charmot, Stephane

Abstract: The Superpave binder specification is performance based. Pay factors can therefore be developed and applied to out of specification binders not meeting the criteria established to prevent rutting, fatigue, and low temperature cracking. Pay factors have been developed to compensate for the loss of performance using life cycle cost analysis. For rutting and fatigue, performance loss due to out of specification binders is based on laboratory test results (respectively the shear tester and the flexural beam device). For low temperature cracking performance loss is estimated from field section evaluations. The sensitivity analysis showed that the life cycles models used for the pay factors calculation were very stable.

Links: Check for full text via 360 Link

Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences

Pages: 283 p.

Number of pages: 283

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Degree date: 1997

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Country of publication: United States

ISBN: 9780591579239, 0591579235

Advisor: Sebaaly, Peter E

University/institution: University of Nevada, Reno

University location: United States -- Nevada

Degree: M.S.

Source type: Dissertations & Theses
Effect of aggregate gradation on performance characteristics of hot mix asphalt

Author: Ridolfi, Dan Victor

Abstract: Designing an asphalt concrete mixture that can carry design traffic loads and resist the effects of environment is a difficult task. The engineer must first select an asphalt cement and a compatible aggregate type and gradation. Based on this combination, an optimum asphalt content is selected to produce a hot mix asphalt (HMA) that can resist the combined action of traffic and environment.

Gradation, asphalt content, and asphalt binder grade affect other performance characteristics of HMA mixtures, such as skid resistance, mixture constructability, and asphalt aging characteristics. This study focuses on aggregate gradation and its effect on the performance of HMA mixtures. An attempt is made to identify the best performing HMA mixtures, and a gradation that performs well with varying aggregate sources and asphalt binder types. The load carrying performance of HMA mixtures is rated on the basis of their resilient modulus, tensile strength, resistance to permanent deformation, and their resistance to simple shear loading. Resistance to environmental conditions is rated on the basis of temperature susceptibility, moisture susceptibility, low temperature cracking. (Abstract shortened by UMI.)

Links: Check for full text via 360 Link

Subject: Civil engineering;
Classification: 0543: Civil engineering
Identifier / keyword: Applied sciences
Pages: 226 p.
Number of pages: 226
Publication year: 1998
Degree date: 1998
School code: 0139
Source: MAI 37/01, p. 315, Feb 1999
Place of publication: Ann Arbor
Country of publication: United States
Mechanical properties of HMA mixtures used in WesTrack Project

Author: Dewan, Md. Shameem Ahmed

Abstract: To further develop the performance related specification technology and provide early field verification for the Superpave asphalt mixture design procedure, a federally funded asphalt pavement research project, named WesTrack Project, is currently underway near Reno, Nevada. WesTrack is a 2.9 km accelerated field test track consisting of 26 sections and loaded by automated truck load facility.

The present study is carried out as a part of the WesTrack material characterization. Mechanical properties, such as, resilient modulus, tensile strength and moisture sensitivity of the HMA mixtures used in the originally constructed 26 sections and rehabilitated 8 sections of the track were investigated. Core samples were collected from the pavement sections at different times after construction and initiation of traffic and tested in the laboratory. Test data were used to evaluate the variation of mechanical properties with mixture variables, such as, asphalt binder content, air voids content and aggregate gradation, as well as with temperature and pavement life. Correlations in between mechanical properties were investigated. At last, efforts have been taken to establish regression models relating mechanical properties and mixture variables.

It was found that mixture variables have significant influence on mechanical properties. Fine and fine plus mixtures seem to behave better than coarse mixtures with respect to mechanical properties. Tensile strength can be better predicted than resilient modulus from the mixture variables. The rates of change of mechanical properties with pavement life for different HMA mixtures are different.

Links: Check for full text via 360 Link

Subject: Civil engineering;

Classification: 0543: Civil engineering
Abstract: For years researchers and practitioners alike in the pavements and materials industry have attempted to establish relationships between laboratory measured material and mixture properties and actual pavement performance. The ultimate goal of any highway agency is to have performance related specifications, which require such relationships. This sounds simple enough, but in reality such a task is not so simple due to the extremely complex behavior of hot mix asphalt. Due to the fact that it takes many years to evaluate new materials and methodologies, the use of accelerated loading facilities such as WesTrack for evaluation purposes becomes very advantageous.

The research presented here produces multiple permanent deformation performance relationships for the
WesTrack project, some of which may be extended to other environments. An attempt to develop similar fatigue performance relationships was unsuccessful due partially to the lack of fatigue distress at WesTrack to date. Additionally, mix design and some quality control data summaries are presented for the project along with an investigation into a potential cause of the premature rutting of coarse Superpave mixes. The investigation resulted in the development of precision statements for the ASTM D5821-95 coarse aggregate angularity test method and a better understanding of the sensitivity of coarse Superpave mixtures.

**Links:** Check for full text via 360 Link

**Subject:** Civil engineering; Materials science;

**Classification:** 0543: Civil engineering; 0794: Materials science

**Identifier / keyword:** Applied sciences, Pavement, WesTrack, Hot-mix, Asphalt

**Pages:** 805 p.

**Number of pages:** 805

**Publication year:** 1998

**Degree date:** 1998

**School code:** 0139

**Source:** DAI-B 59/09, p. 4977, Mar 1999

**Place of publication:** Ann Arbor

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**Advisor:** Sebaaly, Peter E

**University/institution:** University of Nevada, Reno

**University location:** United States -- Nevada

**Degree:** Ph.D.

**Source type:** Dissertations & Theses

**Language:** English

**Document type:** Dissertation/Thesis

**Dissertation/thesis number:** 9907763

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**Database:** Dissertations & Theses @ University of Nevada Reno, ProQuest Dissertations & Theses Global

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**Low-temperature and aging characteristics of Nevada's asphalt binders and mixtures**

**Author:** Lake, Christopher Andrew
Abstract: The deterioration of flexible pavements due to low temperature cracking is a significant and costly problem in the State of Nevada. In 1993, the Nevada Department of Transportation initiated several research efforts aimed at exploring Nevada's problem with this distress. Through two related projects, the University of Nevada was contracted to evaluate several newly developed low temperature performance tests under Nevada's conditions. The focus of the investigation was to determine the applicability of the tests for characterizing the low temperature response of Nevada's asphalt binders and HMA mixtures. This thesis summarizes Nevada's experience with the SHRP low temperature tests and specifications; highlighting the effectiveness of the Superpave PG binder grading system and Thermal Stress Restrained Specimen Test. The contribution of asphalt aging to Nevada's cracking problem is also included in the paper following efforts to validate the Superpave short and long term aging protocol for use in Nevada.

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Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences

Pages: 188 p.

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Publication year: 1999

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Place of publication: Ann Arbor

Country of publication: United States

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Advisor: Sebaaly, Peter

University/institution: University of Nevada, Reno

University location: United States -- Nevada

Degree: M.S.

Source type: Dissertations & Theses

Language: English

Document type: Dissertation/Thesis

Dissertation/thesis number: 1396073

ProQuest document ID: 304512608

Document URL: http://search.proquest.com/docview/304512608?accountid=452

Copyright: Copyright UMI - Dissertations Publishing 1999

Database: Dissertations & Theses @ University of Nevada Reno, ProQuest Dissertations & Theses Global
Analyses and procedures for pavement management systems

Author: Venukanthan, Kanapathipillai Suresh

Abstract: A computerized method has been developed to conduct network optimization analysis for Nevada Department of Transportation. The analysis uses performance models along with life cycle cost analysis to identify the most effective treatment to be applied for a specific pavement section. Performance models were developed for the most common maintenance treatments: sand and chip seals, and rehabilitation treatments: overlay, roadbed modification, and mill and overlay. The models were developed using actual pavement management data collected on field sections for the past fifteen years. The life cycle cost analysis uses the present worth approach along with actual cost figures for initial and annual construction activities.

The individual treatments are used to create alternatives that can provide the acceptable performance level for a given pavement section over the entire analysis period of 20 years. The performance of pavement sections is modeled in terms of the present serviceability index (PSI). The most effective alternative is selected based on the highest benefit cost ratio which is defined as the ratio of area under the PSI curve over the total cost of the alternative. Once the most effective alternative is selected for each pavement section, a summary of the annual expenditures is provided for the group of pavement sections that have been selected for analysis. The group of projects can be the entire network or a group of pavement sections that have been selected by the engineer.

Links: Check for full text via 360 Link

Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences

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ISBN: 9780599437913, 059943791X

Advisor: Sebaaly, Peter

University/institution: University of Nevada, Reno

University location: United States -- Nevada

Degree: M.S.

Source type: Dissertations & Theses
Evaluation of permanent deformation characteristics of hot mix asphalt mixtures using Superpave technology

Author: McNamara, William Marty

Abstract: Permanent Deformation is currently one of the most prevalent modes of failure of asphalt concrete pavements the United States and Canada. Changes in binder chemistry, tire pressures, and traffic loads has resulted in premature failure of many pavement sections. This increased failure rate has forced many government agencies to reevaluate current pavement design and analysis techniques. This revaluation has resulted in the development of the Superpave design system and associated Superpave Shear Tester laboratory performance test that is used to evaluate a hot mix asphalt mixtures resistance to permanent deformation.

This paper presents results of two studies performed by the University of Nevada Pavement/Materials Program which evaluates the rutting potential of a variety of hot mix asphalt mixtures using the Superpave Shear Tester. The major objective of both studies was to gain valuable knowledge about permanent deformation characteristics of various hot mix asphalt mixtures currently used within the state of Nevada.

Links: Check for full text via 360 Link

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Number of pages: 307
Publication year: 1999
Degree date: 1999
School code: 0139
Source: MAI 38/01, p. 246, Feb 2000
Place of publication: Ann Arbor
Country of publication: United States
Comparative analysis of mean absolute deviation and percent within limits approaches for use in quality assurance specifications

Author: Chiravuri, Rajani Manjula

Abstract: The focus of the thesis was to determine the suitability of Mean Absolute Deviation (MAD) procedure to Hot Mix Asphalt (HMA) specifications. To study the suitability, the MAD specification was compared with existing AASHTO based specifications used in many states. Large sets of field data are necessary to compare the pay factors from both specifications. Data from the past projects are not random and pilot project data were not sufficient to draw meaningful comparisons. Using the national data on variability of mixtures properties from past projects, data were simulated to represent the field conditions. These data sets were created using Monte Carlo simulation technique using Quattropo Software package. The data were analyzed and pay factors were calculated using both above said specifications. Comparison of Pay factors from this research determines the affect of specifications on pay adjustment over a wide range of material and procedural variations. AASHTO specification on the other hand did not truly reflect the variability and for extreme mean values, pay factors increased as standard deviation increased. Hence AASHTO response for extreme mean values raises some concerns, as this can become an advantage to contractor with poor quality of work. It was found that the MAD specification reflected the increase in variability in pay factors and faired well over a broad range of mixtures properties. The MAD method is easy to understand and use in field and can also detect process manipulations intentionally made to reach target values. Hence the MAD procedure is suitable and is reliable to use for HMA specifications.

Links: Check for full text via 360 Link

Subject: Civil engineering;
Impact of moisture conditioning on rut resistance in asphalt pavements

Author: Lim, Wee Sen

Abstract: The Superpave system, developed by the Strategic Highway Research Program (SHRP), aims to address the most common distresses in asphalt pavements in the United States. These include, rutting, fatigue, and thermal cracking. The Superpave Shear Tester (SST) was incorporated as part of the Superpave system to quantify mixture properties for pavement performance modeling purposes. The SST is a closed loop feedback, servo hydraulic system that has been widely adopted in the pavement research industry to accurately reproduce stress conditions of hot mix asphalt mixtures subjected to normal traffic loading.

This proposed thesis will investigate the performance of asphalt pavements from three different projects...
2880, 2751 and 2827). Each project includes two sections of different gradations designed by the Nevada Department of Transportation (NDOT), namely Hveem and Superpave mix designs. Projects 2751 and 2827 were only tested with one binder, while project 2880 was assigned the use of two different binders (AC-20P and PG 64-22) resulting in four different test sections.

HMA samples will be compacted to a range between 2% to 4% air voids in which half of the samples will be subjected moisture conditioning as stated in ASSHTO T 283-89. The ultimate goal is to perform statistical comparisons between the dry HMA samples and their moisture conditioned counterparts.

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Identifier / keyword: Applied sciences
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Advisor: Sebaaly, Peter
University/institution: University of Nevada, Reno
University location: United States -- Nevada
Degree: M.S.
Source type: Dissertations & Theses
Language: English
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Dissertation/thesis number: 1401225
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Document URL: http://search.proquest.com/docview/230896367?accountid=452
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Database: Dissertations & Theses @ University of Nevada Reno, ProQuest Dissertations & Theses Global

Evaluation of anti-stripping additives in asphalt mixtures
Abstract: Stripping is the result of the weakening or eventual loss of the adhesive bond in the presence of moisture between the aggregate surface and the asphalt binder in a hot mix asphalt (HMA) pavement. Based on the hypothesis that Anti-stripping agents minimize or eliminate stripping of asphalt cements from aggregate in HMA mixtures, this research work attempts to evaluate the use of anti-stripping additives from two different projects. The Arizona department of transportation project evaluates the effect of adding Portland cement using moisture sensitivity testing on lab prepared samples as well as core samples. These samples represent test sections designed by the Arizona Department of Transportation as part of the Long Term Pavement Performance (LTPP) Specific Pavement Studies (SPS). The test sections are located on US 93 north of Kingman, Arizona. The other project evaluates the effect of using lime and anti-strip liquid on three different highway sections in South Dakota. The sections were designed by the South Dakota department of transportation and are located on I-29, Hwy14 diagonal, and Hwy14 By Pass. (Abstract shortened by UMI.)
Evaluation of cold in-place recycling as alternative for pavement rehabilitation

Author: Tabet, Walid Elias

Abstract: The objective of this research project were to evaluate the performance of cold in place recycling (CIR) materials in rehabilitating low volume roads in Nevada. CIR was selected due to its potential for cost savings and longer performing pavements. The objective of the research were met through the conduct of two major tasks: (1) Develop and implement a mix design procedure. (2) Implement a Field evaluation plan. The mix design procedure would be used to determine the optimum combination of mix components including; lime, binder, and moisture. The field evaluation plan would evaluate the performance of CIR mixtures and provide data to refine the mix design process.

The AASHTO Design Guide is recommended for the thickness design of cold in-place recycled asphalt mixes. Since there is essentially little or no difference in the composition and structural properties of recycled cold mix and cold in-place recycled paving materials, the range of structural layer coefficients recommended for recycled cold mixes (0.25 to 0.35) are also applicable for cold in-place recycled mixes. CIR mixes are not recommended for use as a wearing surface. (Abstract shortened by UMI.)

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Subject: Civil engineering;
Classification: 0543: Civil engineering
Identifier / keyword: Applied sciences
Pages: 124 p.
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Place of publication: Ann Arbor
Country of publication: United States
ISBN: 9780599923041, 0599923040
Advisor: Sebaaly, Peter
University/institution: University of Nevada, Reno
University location: United States -- Nevada
Degree: M.S.
Source type: Dissertations & Theses
Evaluation of asphalt concrete anti-stripping techniques

Author: Stansbury, Kaci Courtni

Abstract: In order to eliminate the moisture sensitivity of asphalt concrete mixtures, the bond between the asphalt binder and the aggregates must be made stronger so that when freeze/thaw cycles occur, the expansion of the water in the pavement does not break the asphalt binder off of the aggregates. The use of anti-stripping additives during construction helps to eliminate this problem and prevent the premature failure of asphalt concrete mixtures.

This research evaluated the effectiveness of four different anti-stripping additives when used in conjunction with two different types of South Dakota aggregate, quartzite and limestone. Core sample from test sections containing lime applied to wet aggregates, lime applied to dry aggregate, UP 5000, a liquid anti-strip additive, and a control section for both types of aggregates were tested for tensile strength, resilient modulus, rutting, and low temperature cracking.

Links: Check for full text via 360 Link

Subject: Civil engineering; Materials science;
Classification: 0543: Civil engineering; 0794: Materials science
Identifier / keyword: Applied sciences
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School code: 0139
Source: MAI 40/02, p. 480, Apr 2002
Place of publication: Ann Arbor
Country of publication: United States
ISBN: 9780493365961, 0493365966
Advisor: Sebaaly, Peter E
Evaluation of Nevada's Superpave and Hveem field mixtures

Author: Hanna, Dany Samir

Abstract: This research compares the performance of Superpave HMA mixtures to NDOT Hveem mixtures of asphalt pavements from four different sections. Two sections were designed with the Superpave volumetric mix design and two were designed using the Hveem design method. Two different binders were used (AC-20P and PG64-22), each binder was used with a Superpave designed mix and a Hveem designed mix resulting in four different sections (SP AC-20P, SP PG64-22, Hveem PG 64-22, and Hveem AC-20P).

The first study compares the permanent deformation resistance of the Superpave mix design sections to the permanent deformation resistance of the Hveem sections. The second study compares the amount of moisture damage between these sections by finding the ratio of the resilient modulus and shear resistance value when wet over the resilient modulus and shear resistance value when dry.

Links: Check for full text via 360 Link

Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences

Pages: 196 p.

Number of pages: 196

Publication year: 2001

Degree date: 2001

School code: 0139

Source: MAI 40/02, p. 478, Apr 2002
Five test methods to evaluate moisture sensitivity and the performance of lime in hot mix asphalt pavement

Author: McCann, Martin Bruce

Abstract: Five test procedures were used to evaluate five mechanical properties and one material property before and after multiple cycles of moisture conditioning for 15 hot mix asphalt (HMA) mixtures. Hydrated lime as an aggregate treatment was used in 12 of the mixes in an effort to enhance mixture properties. An analysis of variance through statistical methods was used to compare the HMA mixes and rank the best method for introducing lime to the HMA mixtures.

The 15 HMA mixtures were comprised from two aggregate sources and three grades of asphalt binder. Lime treating consisted of dry lime added to damp aggregates or the application of a lime slurry. In addition, lime treated mixes were subjected to either zero or 48 hours of marination.

Multiple cycles of freeze-thaw conditioning were implemented as an accelerated moisture damage technique. Moisture sensitivity of the mixtures was evaluated by statistically comparing mixture properties before and after moisture conditioning.

A diametral loading resilient modulus test was used to evaluate the stiffness of the mixtures. A modified version of AASHTO T-283, indirect diametral loading split tensile test, was used to appraise each mixture’s tensile strength property. The repeated shear at constant height derived from the Superpave Simple Shear Test (SST) apparatus assessed each mixture’s shear strain property. The Thermal Stress Restrained Specimen Test (TSRST) evaluated both a material and mechanical property. These measured properties were the coldest temperature which caused the specimen to yield in tension. A repeated axial load, triaxial test was used to evaluate the mixture’s accumulation of axial strain.
The analysis shows that mechanical and material properties for unconditioned, lime treated mixtures and untreated mixtures are relatively the same. After moisture conditioning, the mechanical properties of untreated mixes are severely reduced in comparison to the lime treated mixtures. The evaluation for a superior performing mix to resist moisture sensitivity among the four methods of lime application was statistically inconclusive. In ranking the four methods of lime treatment by their ability to retain mechanical or material properties while being subjected to moisture conditioning, dry lime added to moist aggregates, marinated for 48 hours was shown to have superior performance.

Links: Check for full text via 360 Link

Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences, Moisture sensitivity, Lime, Hot mix asphalt, Pavement, Asphalt

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Advisor: Sebaaly, Peter E

University/institution: University of Nevada, Reno

University location: United States -- Nevada

Degree: Ph.D.

Source type: Dissertations & Theses

Language: English

Document type: Dissertation/Thesis

Dissertation/thesis number: 3042765

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Database: Dissertations & Theses @ University of Nevada Reno, ProQuest Dissertations & Theses Global

Impact of agriculture and construction vehicles on pavements
Abstract: The work presented in this thesis concentrated on the impact of farm vehicles on pavements. There were six pavement sections selected to perform the testing. These pavement sections were instrumented in order to measure base pressure, sub grade pressure, and surface deflection. There were five types of farm vehicles used with eight combinations of loading in the field-testing program. Field-testing was conducted in two seasons to represent the moisture and temperature variations in the pavement sections. Field data were plotted out using Microsoft Excel. Based on these plots, pavement response ratios were calculated. The standard 18,000lb single axle truck was used as the reference testing vehicle. It was found out that Scraper had the highest damage ratios in all the pavement sections. The loaded Terragators8103 and 8144, and over legally loaded Grain Cart also caused more damage to the pavement sections. Tracked Tractor had a little damaging effect on the pavement sections.
Effectiveness of lime on reducing moisture damage to in-service pavements

Author: Hitti, Edgard George

Abstract: This paper presents the results of a study performed at the University of Nevada, Reno which evaluated the use of lime in in-service pavements. Cores sampled from lime-treated and untreated projects in the southern and northwestern parts of Nevada were tested dry for their resilient modulus and tensile strength properties and again wet after being conditioned according to T-283, for as many as 18 freeze-thaw cycles. The overall conclusion of this study indicated that untreated hot mix asphalt (HMA) mixtures are significantly more moisture susceptible to multiple freeze-thaw cycles than mixtures that are treated with lime. The conclusions of this study coincide with results obtained during the collection of pavement management system (PMS) data, which also indicated that lime-treated mixtures perform better than untreated mixtures under similar environmental and traffic conditions.

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Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences

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School code: 0139

Source: MAI 40/05, p. 1270, Oct 2002

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Country of publication: United States

ISBN: 9780493558677, 0493558675

Advisor: Sebaaly, Peter

University/institution: University of Nevada, Reno

University location: United States -- Nevada

Degree: M.S.

Source type: Dissertations & Theses

Language: English

Document type: Dissertation/Thesis
Long-term performance of unmodified and polymer-modified HMA mixtures

Author: Sen, Santanoo A

Abstract: Laboratory procedures do not relate moisture-induced damage to the acceleration of pavement distresses, due to their inability to simulate field conditions. Polymer modified asphalt binders used in Hot Mix Asphalt (HMA) mixtures have become popular to enhance the long-term performance of HMA pavements. The testing program utilized five polymer modified sections and a control section on I-15 in southern Nevada. The overall objective of this research was to evaluate the performance of polymer modified and unmodified HMA mixtures under various stages of conditioning, in terms of resilient modulus and tensile strength properties. Results indicated that polymer modified HMA mixtures performed much better than unmodified HMA mixtures and also showed better resistance against moisture-induced damage. Hence it is recommended to use polymer modified HMA mixtures, especially in extreme weather conditions.

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Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences

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Publication year: 2001

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Country of publication: United States

ISBN: 9780493558868, 0493558861

Advisor: Sebaaly, Peter E

University/institution: University of Nevada, Reno

University location: United States -- Nevada
Evaluation of asphalt concrete anti-stripping techniques

Author: Tohme, Philip Ighnatios

Abstract: In the late 1970's, several pavements throughout the United States began to experience distress associated with the moisture sensitivity of asphalt concrete materials. The primary goal of an anti-stripping additive is to eliminate the moisture sensitivity of the hot mix asphalt (HMA) mixture by improving the bond between the aggregate and the asphalt binder.

The South Dakota Department of Transportation (SDDOT) has been using lime as an anti-stripping additive in HMA for a number of years. Contractors have complained about personnel exposure and problems handling hydrated lime. They have requested the substitution of hydrated lime with liquid or other anti-stripping agents to reduce moisture susceptibility.

This research evaluated the effectiveness of four different anti-stripping additives when used in conjunction with two different types of South Dakota aggregates, quartzite and limestone. The conclusion will be used as guidance for future use of anti-stripping additives in SDDOT.

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Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences

Pages: 257 p.

Number of pages: 257

Publication year: 2002

Degree date: 2002

School code: 0139

Source: MAI 41/03, p. 828, Jun 2003

Place of publication: Ann Arbor
Evaluation of Nevada Superpave

Author: Mehanna, Fadi Elias

Abstract: The objective of this research is to assess the applicability of Superpave mix design process to Nevada's conditions and to compare the performance of Superpave HMA mixtures with the NDOT standard Hveem HMA mixtures where three projects were constructed. Two of the projects included one Hveem and one Superpave section and are contract 2751 constructed in 1996 on SR 278 in Eureka County, Nevada, and contract 2827 constructed in 1997 on US 93 in White Pine County, Nevada. The third project consists of four sections constructed in 1998 on Interstate 80 east of Reno, Nevada, where two sections were designed with the Superpave volumetric mix design method and two sections were designed using the Hveem Design method. Two different binders were used in the three projects (AC20P and PG64-22). Each binder was used with a Superpave designed mix and a Hveem design mix which result in the four sections labeled as SPAC-20P, SPPG64-22, NVPG64-22, and NVAC-20P.
Investigation of cracking failures on a Southern Nevada flexible pavement section

Author: Ozmen, Ozlem

Abstract: The overall objective of this research program was to investigate the mechanical properties of an HMA pavement experiencing premature cracking distress. The flexible pavement investigated in this research is located on SR-163 between MP 17.80 and 3.00 in Southern Nevada. AASHTO T283 "Resistance of Compacted Bituminous to Moisture Induced Damage" is used to determine the moisture susceptibility of the HMA mixtures used on the failed sections. The BMA mixture strength was measured by Resilient Modulus (Mr) and tensile strength (TS). The research is anticipated to accomplish: (1) critically review the literature on basic and applied research conducted on HMA moisture sensitivity; (2) conduct comprehensive testing program to predict the mechanical properties of the HMA mixtures; (3) prepare and conduct a detailed, statistically sound experimental plan to compare the mechanical properties of HMA mixtures.

Links: Check for full text via 360 Link

Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences
Evaluation of field performance of new pavement technologies in Nevada

Author: Bazi, Gabriel M

Abstract: For many years, state highway agencies (SHA) have been trying to find which rehabilitation technology is best suited for their roadways. This research deals with the evaluation of the long term performance of new flexible pavement technologies in Nevada. The main objective of this research after collecting the information data and the performance of all projects under the different categories is to implement the research results and identify which rehabilitation technology is best suited for Nevada's materials, traffic and environment. This was achieved by assessing the field performance of each project under the various categories and if a technique showed a consistently successful long term performance, then it could be used for future projects.

Links: Check for full text via 360 Link
Fatigue resistance of Nevada's hot mix asphalt mixtures

Author: Hajj, Elie Youssef

Abstract: This research evaluated the laboratory fatigue performance of HMA mixtures designed using the Superpave volumetric mix design and the Nevada Department of Transportation (NDOT) Hveem mix design methods. The influence of the long-term oven aging on the fatigue performance is also evaluated. The various mixtures used in this study were sampled from behind the paver during the construction of contract 2751, 2827 and 2880. As a result of this research Superpave mixtures performed better than Hveem mixtures in contract 2751 and 2880 while the opposite is observed in contract 2827. Additionally a reduction in fatigue life was observed for the unmodified asphalt mixes in general as a result of aging whereas the polymer modified asphalt mixes didn't show any reduction in fatigue resistance. Additionally, two generalized performance models are
presented in this thesis, and it was found a significant increase in model accuracy by adding the volumetric

term.

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Research implementation database

Author: Yatheepan, Vivekananthan

Abstract: A database is developed using Oracle database management systems and user interface is
developed using Visual Basic for Nevada Department of Transportation. This is the first step of implementation
and application of the research conducted during last 15 years by NDOT. This software is capable of showing
the project details stored in the database, updating the existing project information and adding new project data
or missing data in the future. The user does not need to be an expert in programming. The software is very user friendly. Information is organized in the order of general information including traffic data, sectional information including performance related data and construction materials information. Visual tools such as message box and graphs are used effectively wherever needed. To enhance the graphical capacity an additional Graphics Server is used with Visual Basic to develop the user interface.

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Development of a software to document pavement technologies in Nevada

Author: Thivakaran, Mahendran

ProQuest document link
Abstract: A database was developed using Oracle database management systems and user interface was developed using Visual Basic for Nevada Department of Transportation (NDOT). This is the first step of implementation and application of the research conducted during the past 15 years by NDOT. This software is capable of showing the project details stored in the database, updating the existing project information and adding new project data. The user does not need to be an expert in programming. The software is very user friendly. Information is organized in the order of general information including traffic data, sectional information including performance related data, construction materials information and special test results. Visual tools such as message boxes and graphs are used effectively wherever needed. To enhance the graphical capacity an additional Graphics Server is used with Visual Basic to develop the user interface.

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Advisor: Sebaaly, Peter E

University/institution: University of Nevada, Reno

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Database: Dissertations & Theses @ University of Nevada Reno, ProQuest Dissertations & Theses Global
Development of a joint density specification

Author: Barrantes-Alpizar, Juan Carlos

Abstract: Hot mixed asphalt (HMA) pavements are normally constructed with multiple passes of the paver, resulting in a longitudinal joint between these passes. The density of the HMA mix at the longitudinal joint is usually lower than the density of the HMA mix throughout the regular mat away from the joint. This low in-place density area usually becomes an easy target for moisture-related damages such as stripping and raveling. A literature review on research efforts and current specifications, and a field-testing program were developed to establish the needed knowledge base for the development and implementation of a longitudinal joint specification for the Nevada Department of Transportation (NDOT).

The field-testing program evaluated the effectiveness of the five joint geometries (natural slope, edge restraining device, cut edge with asphalt tack coat, cut edge without asphalt tack coat, and tapered joint at 3:1) and two compaction techniques (rolling from the hot side with 6 inches overlap over the cold side and rolling from the hot side 6 inches away from the joint) in increasing the joint density and providing improved performance. Different density trends were observed on both sides of the joint. The tapered joint and the cut edge show a good potential of improving the joint density. Further experimentation is required to verify this conclusion.

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University/institution: University of Nevada, Reno

University location: United States -- Nevada

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Language: English

Document type: Dissertation/Thesis
Hot mix asphalt mixtures for Nevada's intersections

Author: Hajj, Elie Y

Abstract: The state of Nevada is experiencing permanent deformation problems with hot mix asphalt pavements at or near intersections. The Nevada Department of Transportation (NDOT) is currently using a Type 2C dense graded mixture in most of its construction. The NDOT Type 2C mixture showed excellent rutting resistance under normal highway traffic, while its resistance to rutting and shoving at intersections in the hot environment of Las Vegas is questionable.

The overall objective of this research was to identify a hot mix asphalt (HMA) mixture with good resistance to rutting and shoving at intersections. To this end, two laboratory evaluations were conducted: I. Postmortem evaluation of in-service intersections and II. Laboratory evaluation of different aggregate gradations.

Based on past performance and data generated from this research, five different aggregate gradations were selected for laboratory evaluation. Aggregates were sampled from the Sloan quarry located south of Las Vegas, Nevada, along Interstate 15. All five gradations were mixed with a polymer-modified PG76-22NV asphalt binder which is the current specified asphalt grade for southern Nevada. A Hveem mix design was conducted for each of the five mixtures.

This part of the research re-evaluated the APA and RSCH as potential candidates for a mix design test for intersection mixtures. In addition, the triaxial compression strength test and the repeated load triaxial test (RLT) were also evaluated. All tests ranked the permanent deformation resistance of the five mixtures in the same order.

Additionally, dynamic mechanistic analyses were performed as an attempt to determine the pavement responses under a heavy loaded truck at and away from the intersection.

The findings of the mechanistic analyses were used to predict permanent deformation potential in the HMA layer. To this end, permanent deformation models for NDOT Type 2C mixture were developed in the laboratory using the repeated load triaxial (RLT) and the repeated shear at constant height (RSCH) testing.

The actual specifications used by NDOT for the various permanent deformation tests were reviewed and adjusted for the HMA mixtures that are going to be used at intersections and stopping areas. (Abstract shortened by UMI.)

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Classification: 0543: Civil engineering

Identifier / keyword: Applied sciences, Pavement deformation, Hot mix asphalt, Nevada
Abstract: The rutting and fatigue cracking are the two primary distress mechanisms that can be present in asphalt concrete under the combined action of traffic loads and environmental conditions. Rutting failure is caused by densefication or plastic flow in Hot Mix Asphalt (HMA) layer. This study was divided into two tasks, task 1: evaluation of the impact of rich-bottom design on the performance of HMA pavements, task 2: evaluation of the impact of lime treatment on the raveling resistance of HMA pavements. The rich-bottom mix has binder content 0.5% higher than the optimum binder content. This rich mix exhibited an improved resistance to fatigue cracking of the HMA pavement. The mean time it does not adversely affect the resistance to rutting. Under the task 2, the hydrated lime was added to the aggregate under different conditions. The resistance to moisture damage was evaluated in terms of the resilient modulus ($M'_R$) properties as a function of freeze-thaw cycles. The lime treatment of HMA mixtures significantly improved the resistance to moisture damage and there was no significant affects of marination time on $M'_R$ properties. (Abstract shortened 12 May 2015 Page 49 of 108 ProQuest)
Evaluation of the rutting resistance of Nevada's Superpave mixtures

Author: Wacker, Brian J

Abstract: Since the completion of the Strategic Highway Research Program (SHRP), the Nevada Department of Transportation (NDOT) has conducted several research efforts on the Superpave mix design method. Previous research with the recommended Superpave gradation has produced hot mixed asphalt (HMA) inferior to NDOT's Hveem mix design. NDOT is now conducting research with a new Superpave gradation which passes
Laboratory testing was used to determine the rut resistance, moisture sensitivity, and overall strength of each mixture. Rut resistance was assessed using the Asphalt Pavement Analyzer (APA), Superpave Shear Tester (SST), and the Repeated Load Triaxial Test (RLT). Moisture sensitivity was assessed using AASHTO T-283 based on the Resilient Modulus (Mr) and the Indirect Tensile Strength (TS). Long-term moisture sensitivity was also assessed using eighteen cycles of AASHTO T-283 based on the Mr. The strength of each mix was assessed by developing the dynamic modulus master curve.
The long term performance of hot mixed asphalt (HMA) pavements is significantly impacted by the properties of the HMA mixture. Regardless of how well the mix design and structural design have been prepared, the properties of the materials delivered to the job site, such as gradation, binder content, and the in-place compaction will ultimately control the behavior of the pavement under the combined action of traffic and environment. The job mix formula allows for certain tolerances in the HMA construction, this research studied the effect of construction variability on performance if the delivered product goes outside the tolerances range. The construction variability was studied for a northern (Lockwood) and a southern (Sloan) Nevada aggregate sources mixed with an unmodified AC-20 and AC-30, respectively. Forty two mixes were prepared for each source and tested for general strength using the resilient modulus, for rutting using the Asphalt Pavement Analyzer, for fatigue using the flexural beam fatigue and for thermal cracking using the Thermal Stress Restrained Specimen Test.

Construction variability has a significant impact on pavement performance regardless of the aggregate source and binder type. However, some laboratory prepared mixtures may provide better performance than the optimum mixture but such mixtures may be impractical in the field. If the contractor violates the specification limits, then there is 81% chance that the pavement section will have lower performance than the optimum mix, therefore strict quality control is recommended to keep the mixes within the specification limits.
Optimization of laboratory performance of hot mixed asphalt concrete with Costa Rican raw materials

Author: Castro-Fernandez, Pedro Luis

Abstract: The performance of asphalt wearing courses in Costa Rica has been questionable for a long time, plastic deformation and moisture damage take place shortly after construction, followed by fatigue cracking in a few years of in-service performance. Apart from having highly variable raw materials, materials and construction specifications haven't been updated in a long time, and now the budget to implement effective pavement management is out of hand. This dissertation focuses on new types of mixes, such as gap graded and coarse dense graded, and asphalt binders, such as stiffer and polymer modified, as alternatives to current specifications, so that mixture performance can be optimized on user's demand.

Raw materials have been prepared and tested, and an appropriate mix design has been performed for every combination of aggregate and asphalt binder (total of 54 treatments). Mixes with optimum binder contents have been tested by plastic deformation, moisture damage and fatigue cracking, so that valuable information has been gathered and statistically analyzed. In addition, laboratory fatigue cracking transfer functions have been develop for Costa Rican materials.

Three aggregate sources have been extensively evaluated, as representative of the hot mixed asphalt production in the country, as well as four asphalt binders (two neat and two polymer modified ones). It has been found that performance is optimized by SBS modified binders together with coarse dense gradations, although optimum selection of gradation and binder has been found very aggregate source dependent. The benefit of SBS modification has been identified, since aggregate source, gradation and binder content become much less significant when SBS modified binders are used, and performance of mixes with SBS modified binders, specially with coarse dense gradations, has outranked the performance of mixes with neat binders. SMA mixes with neat binders have been found to perform better than current Ministry of Public Works' gradations with neat AC30 (only binder currently available at the country), although not as good as coarse dense graded mixes with SBS modified binders. A series of guidelines has been presented, were volumetric requirements are specified together with performance test requirements, for either top wearing courses or bottom fatigue resistance courses.

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Pages: 327 p.
Laboratory evaluation of hot mix asphalt mixtures for Nevada's intersections - phase II

Author: Tannoury, George A.

Abstract: The state of Nevada is experiencing permanent deformation problems with hot mix asphalt pavements at or near intersections. The Nevada Department of Transportation (NDOT) is currently using a Type 2C dense graded HMA mixture in most of its construction. The NDOT Type 2C mixture showed excellent rutting resistance under normal highway traffic loading, while its resistance to rutting and shoving at intersections in the hot environment of Las Vegas is questionable.

The overall objective of this research study is to develop special requirements that can be used to specify an asphalt mixture that can highly resist permanent deformation at intersections in hot climate such as Las Vegas in Nevada State along with a good resistance to fatigue cracking.

The objective of the phase II of the research is to evaluate the fatigue resistance of the three rut resistant mixtures identified in the phase I of the study. Additionally, the rutting resistance of the mixtures is re-evaluated according to the new mechanistic empirical pavement design guide (MEPDG).

A total of three HMA mixtures were evaluated in this research. All the mixtures were designed with a polymer...
modified PG76-22NV binder. The southern Nevada aggregate source (Sloan) was used in this study. The laboratory evaluation assessed the resistance of the mixtures to permanent deformation and fatigue cracking using the asphalt pavement analyzer test, the repeated load triaxial test and the flexural beam fatigue test. However, the mechanistic analysis of the various mixtures shows a consistency with the laboratory test results. The ranking of the mixtures from best to worst for permanent deformation was as follows; NRM mixture, followed by CT mixture, followed by NDOT T2C mixture. However, for the CT mixture showed the best resistance to fatigue cracking followed by the NRM mixture, followed by the NDOT T2C.
Effect of geotextile fabrics on reflective cracking of hot mix asphalt overlays in Washoe County, Nevada

Author: Morian, Nathaniel E.

ProQuest document link

Abstract: This investigation was conducted in an effort to examine the effectiveness of geotextile fabrics used in conjunction with hot mix asphalt overlays over existing hot mix asphalt pavement sections in the jurisdiction of the Engineering Department of Washoe County, Nevada. More specifically, the analysis was focused on the effects of the fabric placement on cracking visible at the surface of the new overlay sections, most notably reflective cracking transferred from the existing pavement prior to the overlay. Only the surface of the pavements were explored using the visual condition survey methods utilized by the Micro PAVER software and pavement management system on multiple overlay projects constructed from 1983 to 2003. The distress measurements of the analysis sections were conducted just prior to the overlay placement and approximately one, three, and five years following the overlay application. The overlay thicknesses varied from 1.5 to 2.5 inches with and without fabric placements.

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Database: Dissertations & Theses @ University of Nevada Reno, ProQuest Dissertations & Theses Global
Unbound materials resilient modulus testing for Truckee Meadows area

Author: Thurairajah, Aravinthan

Abstract: The recent development of Mechanistic-Empirical Pavement Design Guide (MEPDG) requires the resilient modulus ($M_R$) characterization of subgrade materials. Currently Nevada Department of Transportation (NDOT) uses an empirical chart that provides a correlation between resilient modulus and R-value to estimate $M_R$. The Regional Transportation Commission (RTC) of Washoe County also uses a similar procedure. As NDOT attempts to implement the new MEPDG guidelines to design pavements, procedures to evaluate $M_R$ of unbound material, which is expressed as a function of stresses, need to be established. This requires the laboratory testing of unbound materials for the resilient modulus under varying stress conditions.

This research evaluated the testing facility of unbound material at the Western Regional Superpave Center (WRSC) at the University of Nevada, Reno (UNR). Unbound materials were sampled at four different locations from a local project in Reno, Nevada. The subgrade samples were characterized in the laboratory in terms of resilient modulus. The soil classification tests and compaction tests were conducted as the initial steps towards the characterization of subgrade materials. The Resilient modulus tests for the unbound materials were conducted in the repeated load triaxial test according to AASHTO T307-99 (2003) testing procedure. The test results were analyzed using statistical techniques to develop an optimum constitutive model and it was found that the model recommended in MEPDG showed the best fit and regression coefficient.

Additionally, mechanistic analyses results were used to evaluate the resilient modulus values of each type of subgrade. These values were later compared with values from different simplified approaches. Also the load induced stress distributions in the pavement layers with different resilient modulus values have also been compared.

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ISBN: 9780549167037
Advisor: Siddharthan, Raj V., Hajj, Elie Y.
Committee member: Sebaaly, Peter E., Fernandez, George G. C.
Evaluation of Nevada's hot mix asphalt mixtures using tire rubber modified binders

Author: Sebaaly, Haissam K.

Abstract: The Nevada Department of Transportation (NDOT) currently uses two binder grades the PG64-28NV and the PG76-22NV in the northern and the southern parts of the state, respectively. This research effort evaluated the laboratory performance of the hot mix asphalt (HMA) mixtures made with polymer modified binders the PG64-28NV and the PG76-22NV and the performance of the HMA mixtures made with rubber modified and the PG64-28TR and the PG76-22TR. The four mixtures were evaluated in terms of rutting resistance, fatigue cracking resistance, thermal cracking resistance, dynamic modulus, and moisture sensitivity. Two aggregate gradations were used for the northern (Lockwood) and the southern (Sloan) parts of Nevada. The PG64-28NV and the PG64-28TR binders were mixed with Lockwood aggregates, and the PG76-22NV and the PG76-22TR were mixed with Sloan aggregates.

Laboratory experiments were conducted at the Western Regional Superpave Center (WRSC) at the University of Nevada Reno (UNR). The flexural beam fatigue test was conducted to evaluate the resistance of the various mixtures to fatigue cracking. The repeated load triaxial and the asphalt pavement analyzer tests were used to evaluate the resistance of the various mixtures to rutting. The resilient modulus test was conducted to evaluate the resistance of the various mixtures to moisture sensitivity. The thermal stress restrained specimen test was conducted to evaluate the fracture temperatures of the PG64-28NV mix and the PG64-28TR mix. Additionally, the dynamic modulus test was used to evaluate the stiffness of the various mixtures at various temperatures and time of loading.

Additionally, mechanistic analyses have performed to determine the pavement responses for each mixture. Four pavement structures, representing the four mixtures of asphalt with the same base and subgrade were analyzed under an axle load of 18 kips. This load is the maximum allowable axle load by NDOT. The responses in the HMA layer were calculated using the ELSYM5 software and the results were plugged into the laboratory developed performance models to evaluate the number of load repetitions to failure. The time and temperature dependent behavior of the HMA layer under a slow and high moving truck at low and high speeds (2 and 45
mph) is incorporated using the dynamic modulus of each mixture at the corresponding speed and temperature. The base course and subgrade layers were treated as linear elastic materials.

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Laboratory characterization of Nevada’s HMA mixtures for mechanistic empirical design

Author: Bou Jaoude, Ziad P

ProQuest document link

Abstract: The release of the Mechanistic-Empirical Design Guide for New and Rehabilitated Pavement Structures (M-E design guide) generated a new standard for designing and analyzing pavement structures. It is expected to replace the commonly used empirical design methodologies. The M-E design guide provides a performance-based design to the transportation community. It has the capability of analyzing in situ pavement and predicting the remaining life with performance prediction. With that capability, it is a design guide that will reach more users in academia and industry. However, time and resources are needed to accomplish a rational
and accurate design and analysis using the M-E design guide.

In an effort to accelerate the adoption of the new M-E pavement design guide in Nevada, the Nevada Department of Transportation (NDOT) is conducting each year research studies on fifteen pavement projects constructed in three different districts in Nevada. These districts are selected based on different traffic and environmental conditions. This research evaluated the laboratory rutting and fatigue performance and the dynamic modulus of four HMA mixtures in their dry and conditioned state, after one freeze-thaw cycle, designed using the Hveem mix design method. The various mixtures used in this study were sampled from behind the paver during construction of contracts 3239, 3248, 3257 and 3214. All four projects were Hveem designed mixtures with polymer modified asphalt binder. Mixtures from contracts 3239 and 3248 were manufactured with PG64-28NV asphalt and Type 2 and Type 2C dense graded mixtures, respectively. Projects 3257 and 3214 mixtures included PG76-22NV, Type 2 and Type 2C dense graded mixtures, respectively.

Laboratory experiments were conducted at the Western Regional Superpave Center (WRSC) at the University of Nevada Reno (UNR). The flexural beam fatigue test and the repeated load triaxial test were used to evaluate the resistance of the various asphalt mixtures to fatigue and rutting, respectively. To this end, laboratory performance models were developed for the dry and wet conditions of the mixtures. The dynamic modulus test was used to evaluate the dynamic modulus master curve at various temperatures and time of loading. The performance model in conjunction with the dynamic modulus master curve of the HMA mixtures serve as important inputs in the M-E design methodology for flexible pavement.

Additionally, mechanistic analysis was performed as an attempt to determine the pavement responses for each project. Four pavement structures, representing the constructed sections in the field were analyzed under an axle load of 18 kips. This load is the maximum axle load allowed by NDOT. The responses of the asphalt pavement were calculated using the ELSYM 5 software and the results were plugged in the performance models to evaluate the number of load repetitions against the criteria set for fatigue and rutting. The time and temperature dependent behavior of the HMA layer as the truck moves at 45 mph is incorporated by using the dynamic modulus of the HMA mixture at the corresponding speed and temperature. The base course and subgrade layers were treated as linear elastic materials.

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Reflective cracking of flexible pavements: Literature review, analysis models, and testing methods

Author: Loria-Salazar, Luis Guillermo

Abstract: Hot mixed asphalt (HMA) overlay is one of the commonly used methods for rehabilitating deteriorated pavements. The Nevada Department of Transportation (NDOT) uses HMA overlays as a rehabilitation technique for the majority of the state’s flexible pavements. One major type of distress influencing the life of an overlay is reflective cracking. In the past, NDOT has experimented with a number of techniques to reduce the impact of reflective cracking on HMA overlays like cold in-place recycling, reinforced fabrics, stress relief courses, mill and overlay, Portland Cement Concrete (PCC) rubblization, and PCC crack and seat.

In 2006, the Nevada DOT initiated a three-phase research project to identify the promising techniques to mitigate reflective cracking in HMA overlays: (a) Phase I: Review of literature and the performance of the various techniques in Nevada, (b) Phase II: Identify analysis models and laboratory tests, and (c) Phase III: field verification of the selected techniques.

A literature review was conducted for the current and previous efforts outside Nevada on the reflective cracking mitigation techniques in HMA overlays. The standard specifications on the reflective cracking mitigation techniques from all fifty state DOTs were reviewed and summarized. Thirty two states out of fifty have specified a reflective cracking control system in their current standard specifications.

Based on the review of the currently available analytical models to predict the resistance of HMA overlays to reflective cracking, three design methods were identified and summarized: (1) Virginia Tech Simplified Overlay Design Model; (2) Rubber Pavements Association Overlay Design Model; (3) The New AASHTO model for Reflective Cracking.

An overlay design was conducted for three different HMA overlay mixes according to the three identified overlay design methods. In a summary, the Virginia Tech method showed a thinner overlay thickness for the stiffer mix whereas, the Rubber Pavements Association method, which considers both stiffness and fatigue characteristics of the mix, the overlay thickness was dependent on the interaction between the two material properties. On the other hand, a unique and thick overlay thickness was found with the new AASHTO method as it does not
consider the material properties of the overlay mix as part of the design. Additionally, a literature review was performed for the available laboratory tests to evaluate the resistance of HMA mixtures to reflective cracking. None of the reviewed laboratory test methods has undergone field validation except the Texas Transportation Institute (TTI) Overlay Tester which showed consistency between the mixtures' test results and their corresponding field performance. The TTI Overlay Tester results on the cores taken from different highway projects showed that asphalt mixtures performed very well in the field when the reflective cracking life (from the overlay tester) is larger than 300. Finally, based on the analysis of the various findings it was recommended to: (1) Further evaluate the stress relief course as a reflective cracking mitigation technique under Nevada's conditions. (2) Use the TTI Upgraded Overlay Tester to evaluate mixtures in the Laboratory for reflective cracking resistance. (3) Use the Rubber Pavements Association Overlay Design Model to design the require overlay thickness.

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Use of reclaimed asphalt pavements (RAP) in airfield HMA pavements

Author: Pratheepan, Kandiah

Abstract: This thesis documents the results and findings of the research titled "Use of Reclaimed Asphalt Pavements (RAP) in Airfields HMA Pavements". The thesis includes a review of current technology in RAP pavements and its application in highway and airfield pavements. Additionally, it includes the current highway specifications on the use of RAP and a mechanistically based method to transfer the RAP technology that has been successfully used on highway pavements into the design and specification systems for RAP on airport pavements. Review of in-service airfield pavements was conducted as part of this study. Furthermore, the thesis includes an evaluation of the impact of RAP on the performance life of HMA airfield pavements under three actual airport traffic mixes of a large hub, small hub, and general aviation. The Life cycle cost analysis used the characteristics and mechanical properties of HMA mixtures in the LEDFAA1.3 airfield pavement design software to compare the estimated performance life of HMA pavements with and without RAP materials. Finally, sections 401-3.3 and 403-3.3 of FAA’s P-401 and P-403 specifications, respectively, on RAP were reviewed and recommendations were made based on the findings of the research effort conducted in this project.

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Advisor: Hajj, Elie Y.

Committee member: Sebaaly, Peter E., Siddarthan, Raj, Fernandez, George

University/institution: University of Nevada, Reno

Department: Civil Engineering

University location: United States -- Nevada
Environmental conditions and binder aging characteristics in the intermountain region of the United States

Author: Cortez, Edward M.

Abstract: Thermal cracking is a major form of distress in much of the northern United States. Moreover, field performance data indicate that HMA mixtures in the intermountain region of the U.S. experience severe thermal cracking distresses that are not well covered by current technology.

The objective of this research is to develop a binder/mix evaluation and testing system that can effectively simulate the long term properties of HMA mixtures in the intermountain region and to assess the impact of such properties on the resistance of HMA mixtures to thermal cracking.

Particularly, the binder aging kinetics when there is free access to atmospheric oxygen was evaluated. One millimeter film of various asphalt binder types were subjected to long-term oven aging at various temperatures and time periods in ovens with full access to atmospheric oxygen. Mass change was monitored throughout the test. Various properties of the aged binders will be or are already measured: carbonyl growth to determine binder reaction rates and activation energies, rheologic properties, strength properties, and thermal expansion coefficient. Ultimately, the various properties measured will prove valuable during the development of a mixture aging model for the intermountain region.

Additionally, environment and pavement temperature data from fourteen Long Term Pavement Performance sections and four WesTrack sections were available and analyzed. All sections are located within the intermountain region. This region represents a unique environment that impacts HMA mixtures in a manner that is different than the other regions of the United States. It was imperative that these unique features were closely investigated. A database containing pavement temperature rates as well as other relevant properties pertaining to thermal cracking is now available. Recommendations have been presented to better simulate environmental conditions present in the intermountain region.

The two evaluations will ultimately be used in a mixture aging model. The impact of aggregate and mixture properties on the aging of the binder in the mix will be evaluated in another phase and will also be incorporated into the same mixture aging model.

Links: Check for full text via 360 Link
Impact of lime on the mechanical properties of HMA mixtures in Nevada

Author: Sequeira, Wendy

Abstract: The purpose of this research was to evaluate the impact of hydrated lime on the mechanical properties of typical HMA mixtures in Nevada. This research differed from previous studies in several respects. First, because lime is used in HMA primarily for anti-stripping benefits, previous studies rarely quantified lime’s other performance benefits. Second, because testing is typically performed on only the HMA mix being
considered for a project, and only as necessary to satisfy specifications, typical studies do not capture the full range of failure modes and environmental stresses. Furthermore, once specifications are met, test results are rarely translated into pavement performance characteristics. This research, by contrast, evaluated two typical HMA mixtures from the northern part of Nevada and two HMA mixtures from the southern part of Nevada used by NDOT with the most widely accepted laboratory tests. The Hveem mix design method was used in all mixtures. The tests were conducted at 0 and 6 freeze thaw cycles. The moisture damage was evaluated through the dynamic modulus test at various temperatures and frequencies. The asphalt pavement analyzer test and the repeated load triaxial test were used to evaluate the permanent deformation of the mixtures. The flexural beam test was used to assess the fatigue resistance and the thermal stress restrained specimen test was conducted to evaluate thermal cracking resistance. Additionally, mechanistic analysis was performed as an attempt to determine the pavement responses for each mix.

In overall, the laboratory results and the mechanistic analysis showed that lime improved the mechanistic properties of Nevada's mixtures and its relative performance when is compared with the un-treated mixtures.

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Committee member: Sebaaly, Peter, Hajj, Elie, Fernandez, George

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Impact of anti-strip additives on long-term aging properties of asphalt mixtures

Author: Sivakulam, Sivakkolunthar

Abstract: The objective of this study was to evaluate the impact of lime and liquid anti-strip additives on the long-term aging properties of asphalt binders and mixtures sampled from five different U.S. locations. The HMA mixtures were evaluated in terms of their resistance to fatigue cracking and thermal cracking. The asphalt binders were evaluated for intermediate and low temperature rheological properties at different aging stages. Aggregate and asphalt binders were collected from five different sources: Alabama, California, Illinois, South Carolina, and Texas. Each source was evaluated with three different mixtures; untreated, liquid-treated, and lime-treated. Lime was obtained from the National Lime Association (NLA) and the liquid anti-strips were obtained from relevant states. Mix design were conducted according to Superpave mix design method with a minimum dry tensile strength (TS) at 70°F of 70 psi and a tensile strength ratio (TSR) of 80%. All fifteen mixtures were evaluated for fatigue resistance using the flexural beam fatigue test in a strain control mode of testing and for thermal cracking using the Thermal Stress Restrained Specimen Test (TSRST). Additionally, three different asphalt binders were prepared and evaluated for each source; untreated, blended with liquid anti-strips, and blended with lime. All asphalt binders were long-term aged for 100, 400, and 800 hr at 140°F with 2.1 kPa confining pressure. The asphalt mixtures' Rheological properties were determined and compared after aging.

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ISBN: 9781109542356
Advisor: Hajj, Elie Y.
Committee member: Sebaaly, Peter E., Siddharthan, Raj V., Fernandez, George C.
Characteristics of dynamic triaxial testing of asphalt mixtures

Author: Ulloa Calderon, Alvaro

Abstract: Due to the increasing traffic loads and tire pressures, a serious detrimental impact has occurred on flexible pavements in the form of excessive permanent deformation once the critical combination of loading and environmental conditions are reached. This distress, also known as rutting, leads to an increase in road roughness and ultimately jeopardizes the road users' safety.

The flow number (FN) simple performance test for asphalt mixtures was one of the final three tests selected for further evaluation from the twenty-four test/material properties initially examined under the NCHRP 9-19 project. Currently, no standard triaxial testing conditions in terms of the magnitude of the deviator and confining stresses have been specified. In addition, a repeated haversine axial compressive load pulse of 0.1 second and a rest period of 0.9 second are commonly used as part of the triaxial testing conditions. The overall objective of this research was to define the loading conditions that created by a moving truck load in the hot mixed asphalt (HMA) layer. The loading conditions were defined in terms of the triaxial stress levels and the corresponding loading time.

Dynamic mechanistic analysis with circular stress distribution was used to closely simulate field loading conditions. Extensive mechanistic analyses of three different asphalt pavement structures subjected to moving traffic loads at various speeds and under braking and non-braking conditions were conducted using the 3D-Move model. Prediction equations for estimating the anticipated deviator and confining stresses along with the equivalent deviator stress pulse duration as a function of pavement temperature, vehicle speed, and asphalt mixture's stiffness have been developed.

The tandem axle was proven to generate the most critical combination of deviator and confining stresses for...
braking and non-braking conditions at 2 inches below the pavement surface. Thus, this study is focused on
developing the stress state and pulse characteristics required to determine the critical conditions on HMA
mixtures under the loading of the tandem axle.
An increase of 40% was observed in the deviator stress when braking conditions are incorporated. A
preliminary validation of the recommended magnitudes for the deviator and confining stresses on a field mixture
from WesTrack showed consistent results between the flow number test results and field performance.
Based on laboratory experiments, the critical conditions of different field mixtures from the WesTrack project
and also lab produced samples at different air-voids levels were determined. The results indicate that the
tertiary stage will occur under the FN test when a combination of a critical temperature and a given loading
conditions for specific air voids content occurs.

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Classification: 0543: Civil engineering; 0794: Materials science
Identifier / keyword: Applied sciences, Asphalt mixtures, Deviator and confining stresses, Dynamic triaxial test,
Flow number, Loading pulse duration, Rutting

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The effects of reclaimed asphalt pavement (RAP) on the laboratory performances of hot mix asphalts

Author: Shrestha, Raghubar

Abstract: The use of reclaimed asphalt pavement (RAP) in flexible pavement surface layer has been a major sensitive issue in the construction industry. Due to limited space available in landfills, the amount of high quality virgin aggregate declines, and the high price of oil, the use of RAP in new asphalt concrete mixtures has become very attractive. This research has been conducted to study the laboratory performances of HMA mixture containing RAP, in which thermal, fatigue, rutting, moisture sensitivity, and resilient modulus characteristic were evaluated. A Marshall mix design 19 mm mixture containing 0% RAP with binder grade of PG64-22 and PG64-28NV were used as the control mixtures for evaluating properties of mixtures containing 15% and 30% RAP for three different sources of RAP which include one fresh plant waste RAP material. The effects of RAP on the laboratory performances of RAP added HMA mixture depends on type of RAP, amount of RAP, target binder grade to be produced, mixture performances. RAP binders grading, blending, and selection of new virgin binder required to blend with RAP in order to achieved target binder were performed. The final mixtures binder grades were evaluated to verify the blending chart. RAP binders were reasonably graded using standard PG binder grading system, although the NCHRP 9-12 recommends use of the modifies method for RAP binder grading. This search showed that NCHRP method of binder grading is more suitable for old aged RAPs, but not for newly produced RAP such as plant waste RAP which is less than one year old. Blending of RAP binders with virgin binders to produce target binders were successfully accomplished using blending chart method, however the results of the final target binders were found to be conservative. The conservative results might be due to grading system of 6 degree increment at higher and lower performance temperature. Mix design process of RAP added mixtures, although similar to standard mix design, are more complex and involves many calculation steps. The actual effect of RAP binder in final mix should be calculated carefully. To prevent dry mixture short term curing of the HMA mixture before compaction is strongly recommended in the Marshall Mix Design process.

Regardless of sources of RAP, age, proportion (up to 30 percent in this study), RAP added mixtures can reasonably perform as better as virgin mixtures. The study of laboratory performances of RAP added mixtures have shown significant better performances in the thermal cracking and the rutting resistances. However, fatigue performance showed mixed type of results. This author is very optimistic that the fatigue performance of RAP added mixtures can be improved significantly by curing a mixture during mix design process, which ultimately increases the binder contents in the mixture and prevent from being too dry mixture.

Limited research conducted during this project showed that better understanding of fatigue and rutting performances of the HMA containing RAP mixtures can be obtained if mechanistic approaches of pavement analyses are conducted. Better benefit from use of RAP can be achieved from mechanistic analysis, which generally can not be achieved from comparison of laboratory performances only. Based on this study, it has been revealed that cost ratio (with RAP/without RAP) using RAP in HMA mixtures could range from 0.97 to 0.73 when 15-30% RAP is used. Besides the economic benefits, they also provide tremendous environmental conservation and prevention, which are immeasurable in terms of dollar value.

Links: Check for full text via 360 Link

Subject: Civil engineering;
Impact of anti-strip additives on performance of asphalt pavements

Author: Thileepan, Sathanathan

Abstract: Typically, lime and liquid are used as additives to combat moisture damage, and therefore, their impact is only evaluated with respect to their influence on the moisture sensitivity of the HMA mixture. This study extended the evaluation to cover the impact of lime and liquid additives on the structural performance of the HMA mixtures and their impact on the long-term performance of typical HMA pavements. The resistance of the mixtures to fatigue cracking was assessed in a separate study. The developed relationship between the bending strain in the HMA mix and number of load repetitions to failure under beam
fatigue testing conditions at the un-conditioned and moisture-conditioned stages were used in the mechanistic analysis of various pavement structures.

The measured performance properties of the mixtures were used in the AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG) to conduct 20 years structural designs for actual projects selected from the five sources of mixtures. For each project, a total of three structural designs were established by changing the type of mix used in the HMA layer e.g. un-treated, liquid-treated, and lime-treated.

Based on the extensive data generated from this research and the analyses of these data, the following findings are warranted. (1) The use of both liquid and lime additives improved the moisture sensitivity of the HMA mixtures as measured by the tensile strength ratio (TSR) following AASHTO T283 method. However, as the mixtures were subjected to further moisture damage induced through multiple freeze-thaw (F-T) cycling, the untreated and liquid-treated mixtures had significantly reduced their stiffness properties (i.e. E'). On the other hand, the lime-treated mixtures maintained higher stiffness properties for the entire 15 F-T cycles for all five sources.

(2) Lime either maintained or improved the rutting resistance of the HMA mixtures from all five sources. The impact of liquid on the rutting resistance of the HMA mixtures was source dependent; for the non-moisture sensitive mixtures from AL and IL, the liquid additives reduced their resistance to rutting as compare to the un-treated mixtures. (3) The cost analysis data revealed the following: (1) The use of lime additives in HMA mixtures resulted in significant savings, in some cases more than 45%. (2) The use of liquid anti-strip additives in HMA mixtures may result in additional cost, in some cases as high as 50%. (3) The data generated on the four mixtures from Alabama, California, Illinois, and S. Carolina show that lime is highly compatible with the use of neat asphalt binders and will always results in savings on the order of 13-34%. (4) The data generated on the mixtures from Texas show that the lime is highly compatible with the use of polymer-modified binders and will result in savings on the order of 40-45% which is significantly higher than the savings that could be realized with the use of the liquid anti-strip. (5) This data show that the use of lime additives will always improve the performance of the HMA pavement to a magnitude that always far outweighs its cost. On the other hand, the use of liquid anti-strip additives will not always improve the pavement performance to the magnitude that it will offset its cost. (6) The cost analysis data showed that the use of lime in HMA mixtures that do not require improvement in their mix design TSR will still result in significant savings such as the case of the mixtures from Alabama and Illinois. On the other hand, the use of liquid in HMA mixtures that do not require improvement in their mix design TSR will result in significant cost increases such as the case of the mixtures from Alabama and Illinois. (7) The cost analysis data showed that the use of lime in HMA mixtures that require improvement in their mix design TSR will still result in significantly higher savings such as the case of the mixtures from California, S. Carolina, and Texas. On the other hand, the use of liquid in HMA mixtures that require improvement in their TSR will result in mediocre cost savings such as the case of the mixtures from California, S. Carolina, and Texas. Adding the savings realized by the use of lime-treated mixtures from the MEPDG structural designs to the savings realized from the lower thermal cracks per mile resulted in very significant overall cost savings to the highway industry and time savings for the road users. (Abstract shortened by UMI.)

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Impact of Contact Stress Distribution and Pattern on Asphalt Pavement Performance using 3D-Move Analysis Software

Author: Thushanthan, Palasuntharam

Abstract: This research evaluated the impact of the contact stress distribution and pattern on asphalt pavement responses and pavement performance. The impact on pavement performance was evaluated using mixtures’ specific fatigue and rutting performance models. The finite-layer analytical model 3D-Move software was used to evaluate the pavement responses. Four contact stress distributions were analyzed: non-uniform, uniform circular, uniform elliptical and uniform square. A total of four pavement structures were evaluated using two different asphalt mixes and different asphalt and base layer thicknesses. Pavement responses in the various pavement structures were determined under a dual tandem axle at the braking (Longitudinal shear stress present at tire pavement contact) and non-braking (No shear stress present at tire pavement contact) conditions. The results obtained from this study showed a significant difference in pavement responses and performance for the uniform and non-uniform contact stress distributions. Overall, the uniform circular contact stress distribution, which is widely used in pavement design and analysis, overestimated the critical pavement responses such as the vertical strain in the asphalt sublayers and the tensile strain at the bottom of the asphalt.
layer. The non-uniform contact stress distribution resulted in lower rut depth in terms of rutting analysis and it produced lower longitudinal and transverse tensile strains at the bottom of the HMA layer when compared to the uniform circle and uniform square contact stress distribution. When compared to the other three contact stress distributions, the elliptical tire print produced lower values for the longitudinal tensile strain at the bottom of the asphalt layer for all evaluated cases, but higher transverse tensile strains at the bottom of the asphalt layer. The accuracy in estimating the new non-uniform contact stress distribution at a given load level from measured contact stress distributions using the linear interpolation/extrapolation was evaluated. The pavement responses were computed from both predicted new contact stress distribution and the measured contact stress distribution. The results obtained indicate that linear interpolation and extrapolation can be used to predict the new contact stress distribution without significant accuracy loss and this technique will yield more accurate contact stress distribution when the difference between the measured loads used to interpolate/extrapolate and the given load is small.

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Subject: Civil engineering;

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Committee member: Sebaaly, Peter E., Siddharthan, Raj V., Fernandez, George

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Department: Civil and Environmental Engineering

University location: United States -- Nevada

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Properties of warm mix asphalt from two field projects: Reno, Nevada and Manitoba, Canada

Author: Kasozi, Andrew Muliika

Abstract: This study was geared towards evaluating the properties of warm mix asphalt (WMA) mixes that were obtained from two field projects; Reno, NV and Manitoba, Canada, in the laboratory, relative to conventional hot mix asphalt (HMA) mixes. The former field project utilized the Ultrafoam® WMA technology to produce the WMA mixes while the latter used the Advera® zeolite technology. The evaluated mixtures also included different percentages of recycled asphalt pavement (RAP). Generally the study addressed the impact of curing time on volumetric properties of foamed WMA; impact of sample reheating on the mechanical properties of WMA; and evaluation of the resistance of WMA mixtures to moisture damage, permanent deformation and thermal cracking. From the study, it was recommended that production testing for volumetric properties should be conducted within four hours of manufacturing the WMA at the plant immediately after discharge. The mixes should be cured in a sealed container at the expected lay-down/compaction temperature. Overall, the resistance of WMA mix to moisture damage was found to be WMA technology-specific and also dependant on whether or not antistripping additives were incorporated in the mix, all other factors being constant. The resistance to permanent deformation of WMA was generally found to be satisfactory whereas the WMA outperformed the HMA in terms of thermal cracking resistance.

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Committee member: Hajj, Elie Y., Fernandez, George
University/institution: University of Nevada, Reno
Department: Civil and Environmental Engineering
University location: United States -- Nevada
Designing Cold Mix Asphalt (CMA) and Cold-In-Place Recycling (CIR) Using SUPERPAVE Gyratory Compactor

Author: Piratheepan, Murugaiyah

Abstract: The purpose of this research was to develop a performance related mix design procedure for both cold mix asphalt (CMA) and cold-in-place Recycling (CIR) using the Superpave Gyratory compactor (SGC) and evaluate the performances of the mixes using the proposed mix design method.

Two types of aggregate gradations (coarse and fines) according to Superpave specifications and two types of emulsions (CSS-1 and engineered emulsion) were used for the mix design of CMA. The mix designs were conducted following two different methods: a modified Proctor method and a mix design method using the Superpave gyratory compactor. The modified Proctor method was useful in identifying the total fluid content required to achieve maximum dry density of the CMA, but it did not help to obtain the required amounts of water and emulsion separately. The mix design method using the Superpave gyratory compactor was successful in identifying both optimum emulsion content and water content of CMA mixes.

The designed CMA mixes using the Superpave gyratory compactor were evaluated for their moisture susceptibility and raveling performance. The mixes did not perform well in both tests. As a mitigation measure for moisture susceptibility problem, hydrated lime was added to the CMA mixes and the mix designs were conducted again. The identified mix design method for designing CMA mixes was not successful in achieving the target air void of 10.0±1.0% suggesting that the mix design needs to be studied further.

For the mix design of CIR, two types of RAP gradations were evaluated; a graded RAP according to Pacific Coast Conference on Asphalt Specifications (PCCAS), and a non-graded RAP passing 1 inch sieve and two types of emulsions (CMS-2s and engineered emulsion) were used. The mix designs for CIR were conducted following two different methods: a modified Proctor method and a mix design method using the Superpave gyratory compactor. The modified Proctor test method resulted in higher water content to achieve the maximum dry density of the CIR mixes, but it is not practical in the field. Therefore, the modified Proctor method was not evaluated further. The mix design method using the Superpave gyratory compactor was successful in identifying both optimum emulsion content and water content of CIR mixes.

The designed CIR mixes using the Superpave gyratory compactor were evaluated for their moisture susceptibility and raveling performance. The mixes did not perform well in both tests. As a mitigation measure
for moisture susceptibility problem, hydrated lime was added to the CIR mixes and the mix designs were conducted again. The CIR mixes with lime were evaluated for their performances and they showed significant improvement. The CIR mixes were evaluated further for their rutting resistance using the repeated load triaxial (RLT) test and they performed well. The dynamic modulus of the CIR mixes were measured and the master curves were developed using a modified equation given in AASHTO PP61 and they were found to be equivalent to that of hot mix asphalt.

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Evaluation of New and Existing Test Methods to Assess Recycled Asphalt Pavement Properties for Mix Design

Author: Loria-Salazar, Luis Guillermo

Abstract: The use of reclaimed asphalt pavement (RAP) in flexible pavement surface layer has been a major sensitive issue in the construction industry. Due to limited space available in landfills, the decline in the amount of high quality virgin aggregate, and the high price of oil, the use of RAP in new asphalt concrete mixtures has become very attractive. In general, the RAP-percentage used by the various highway agencies is limited to less than 25%. Even many highway agencies have realized the benefits of using RAP, the incorporation of high percentage of RAP (more than 25%) in HMA mixtures, especially in the asphalt surface layer, has been relatively low compared to the possible supply of RAP. Preliminary concerns with HMA mixtures with high RAP content have been the assurance of adequate resistance fatigue and thermal cracking and moisture sensitivity. Therefore, there is a need for the development of design methods and analysis of the properties of HMA mixtures with high RAP contents.

This dissertation focused on two main objectives: (1) To develop systems to evaluate the properties of the aggregates in the RAP materials, and (2) To develop a system to evaluate the properties of RAP binders. The properties of the virgin aggregates (i.e. gradation and specific gravities) were compared to those of aggregates extracted from laboratory-produced (simulated) recycled asphalt pavement (RAP) from four different aggregate sources. Additionally, the extracted asphalt binder contents were compared to their corresponding true binder contents. The study also looked on how the extraction methods influenced the likelihood of a mix designer overestimating or underestimating a given mix design property. The test results were further examined to determine the impact of the RAP aggregate properties on the voids in mineral aggregate (VMA) for mixtures incorporating different percentages of RAP. As a result, recommendations were made to select the most appropriate method for estimating the RAP aggregate specific gravity based on an acceptable level of error in the VMA calculation of mixtures containing varying levels of RAP.

The determination of the RAP-binder properties is one of the most important steps in designing RAP-containing mixtures. Five methodologies were used to determine the RAP-binder properties: (1) Blending charts according to AASHTO T 323; (2) Direct measurements from extracted and recovered asphalt binders using the dynamic shear rheometer. Two methods were used: (a) Master-master curve (MMC) using the CAM (Christensen-Anderson-Mastereanu) model. (b) Master-master curve using the CAS (Christensen-Anderson-Sharrock) model. (3) Mortar method developed by the University of Wisconsin-Madison researchers (4) Backcalculation of the RAP-binder properties using the Hirsch model, and (5) Backcalculation of the RAP-binder properties using the Huet-sayegh model.

Finally, two methodologies were proposed to design RAP-containing mixtures: A system to evaluate the properties of RAP-aggregates and a system to determine the properties of RAP-binders.

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Subject: Civil engineering; Materials science;

Classification: 0543: Civil engineering; 0794: Materials science

Identifier / keyword: Applied sciences, Surface layer, Pavement, Recycled asphalt, Asphalt mixtures, Concrete mixtures

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Review of Percent Within Limits for Dense Graded HMA

Author: Schlierkamp, Roger

Abstract: Nevada Department of Transportation (NDOT) has asked the University of Nevada, Reno to research and develop a Percent With Limits program. They find it difficult to enforce demerits when pavement sections are measured to be out of tolerance. For example, if a pavement section is found to have poor compaction or unacceptable asphalt binder content, they are supposed to suspend the construction. However, they may allow construction to proceed if those same sections pass other parameters. This ambiguity has caused confusion among the contractors and it may have allowed inadequate pavement sections be left in place without penalty. In addition, NDOT currently evaluates pavement sections based on single test points or an average of the test points. There is no consideration for the variability or consistency of the measured parameters, as long as they are within the upper and lower specification limits.

A literature review covering 11 states was performed in order to present to NDOT how other states utilize PWL. They include Arizona, California, Colorado, Idaho, Kansas, Michigan, New Mexico, New York State, Utah, Vermont, and Washington State. These states employ the PWL methodology and details of their methods were
evaluated. This report provides information such as lot and sublot sizes, parameters used for testing, frequency of testing, upper and lower specification limits, pay factor calculations, and how the pay adjustment was conducted.

Pavement performance relies heavily on how well it was constructed. By utilizing a PWL system, contractors are provided an incentive to produce higher quality roads by building them closer to the target values and with less variability. PWL allows the agency to estimate the quality of the constructed pavement and issue bonuses or penalties based on the justified results of the PWL analysis.

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Classification: 0543: Civil engineering

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Database: Dissertations & Theses @ University of Nevada Reno,ProQuest Dissertations & Theses Global
Mechanistic Properties of Field and Laboratory-Produced Warm Mix Asphalt Mixtures from Manitoba, Canada

Author: Porras-Alvarado, Juan Diego

Abstract: Warm Mix Asphalt is a generic term that refers to a specific group of technologies used to produce asphalt paving mixtures at lower temperatures than traditional Hot Mix Asphalt. There are many WMA technologies being used, foaming, organic, and chemical based technologies, and it is believed that others will soon enter the market. The concept and use of warm mix asphalt is becoming more popular in the asphalt industry. The promise of reduced energy consumption, reduced emissions, and a more workable product is very appealing to an industry pressured by environmentalists. However, the use of WMA may come with some potential issues as well. Lower production temperatures may result in softer asphalt due to the reduced oxidative aging. While poorly dried aggregates may create issue with moisture damage. The evaluation of field projects is necessary to determine the real benefits that this technology can offer. The present research analyzed the mechanistic performance of field and laboratory-produced mixtures from the Manitoba PTH-14 project in Canada.

The project was constructed in summer of 2010 and consisted of a side by side HMA control section and three WMA sections in which the Advera, Evotherm 3G and Sasobit technologies were used. This study evaluated the resistance of field and laboratory-produced WMA mixtures in terms of their resistance to moisture damage, resistance to permanent deformation, resistance to reflective cracking and to fatigue cracking. Moisture damage was evaluated using Indirect Tensile Strength and $|E^*|$ property under multiple freeze-thaw cycles. The resistance to permanent deformation was analyzed conducting repeated loaded triaxial testing. Furthermore, the fatigue cracking and reflective cracking were studied using the flexural beam fatigue and the TTI Overlay Tester, respectively.

For the field-produced mixtures all met the minimum unconditioned ITS criterion of 65 psi at 77°F and the minimum indirect tensile strength ratio of 80% after 1 F-T cycle. While comparable TSR and $|E^*|$ ratios were observed for the mixtures after 1 F-T cycle, the WMA-Sasobit exhibited lower resistance to moisture damage when assessed after 3 F-T cycles. Except for the WMA-Sasobit, the WMA mixtures showed similar or higher resistance to reflective cracking when measured using the TTI overlay tester when compared to the HMA-control mixture. All WMA mixtures exhibited similar resistance to permanent deformation in the FN test at the LTPPBind 50% reliability temperature (118°F) when compared to the HMA control section. However, none of the mixtures (including the HMA) met the proposed flow number criterion for warm-mix asphalt. When tested in the FN at the effective pavement temperature (92°F), a different ranking for the mixtures resistance to rutting was detected.

For the field-produced mixtures all met the minimum unconditioned ITS criterion of 65 psi at 77°F; however, the minimum indirect tensile strength ratio of 80% after 1 F-T cycle was not met by the WMA mixtures. Highly stiffness reductions were detected for the WMA mixtures after been subjected to F-T cycling, for both TSR and $|E^*|$ ratio results. Except for the WMA-Sasobit, the WMA mixtures showed similar resistance to reflective cracking when measured using the TTI overlay tester when compared to the HMA-control section. HMA and WMA-Sasobit presented a higher resistance to permanent deformation when compared to WMA-Advera and WMA-Evotherm.

The comparison between the results from the field and laboratory-produced mixtures exhibited differences in performance. The field-produced mixtures presented higher stiffness values when compared to the laboratory-produced mixtures. For this reason a conditioning difference between laboratory protocols and plant production procedures is suggested. Additionally, from the performance data a different conditioning protocol should be further study for each type of additive. The results exhibited adhesion problems between the asphalt binder and
the aggregates that resulted in moisture damage for the laboratory-produced mixtures. A revision for the additives incorporation in laboratory protocols should be further assessed to determine the best way possible to simulate plant procedures. The continuous field monitoring for performance of the various sections will help in assessing any proposed criterion as well as the effectiveness of WMA mixtures in cold weather areas such as Manitoba. Additionally, this data will provide important information of real long term performance that can be compared to the laboratory performance testing of field-produced mixtures.

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Subject: Civil engineering;

Classification: 0543: Civil engineering

Identifier/keyword: Applied sciences, Dynamic modulus, Overlay tester, Reflective cracking, Rutting, Warm mix asphalt

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Committee member: Seebaly, Peter, Siddharthan, Rajarantnam, Quint, Thomas

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Evaluation of Warm Mix Additives for Use in Modified Asphalt Mixtures: Phase I

Author: Wong, Corina B.

Abstract: The intention of this research effort is to evaluate the use of warm mix additives with typical polymer-modified and terminal blend tire rubber asphalt mixtures from Nevada and California. The research effort is broken into three phases that are intended to evaluate the impacts of warm mix additives with typical polymer-modified and terminal blend tire rubber asphalt mixtures from Nevada and California: moisture damage, performance characteristics, and mechanistic analysis.

In Phase I of this research effort, mixture resistance to moisture damage was evaluated using the indirect tensile test and the dynamic modulus at multiple freeze-thaw cycles. Laboratory testing was conducted to address the following: (1) the impact of warm mix additive and reduced production temperatures on the moisture damage resistance of asphalt mixtures, (2) the impact of residual aggregate moisture on the moisture damage resistance of WMA mixtures, (3) the impact of warm mix additives on the moisture damage resistance of anti-strip treated WMA mixtures, and (3) the impact of long-term aging on strength gain and the moisture damage resistance of WMA mixtures.

A total of one aggregate source, four warm mix asphalt technologies (Advera, Sasobit, Revix and Foaming) and three asphalt binder types (neat, polymer-modified and terminal blend tire rubber modified asphalt binders) typically used in both Nevada and California are being evaluated in this study. This thesis will only summarize the test results and findings of the Phase I of the study for two warm-mix additives: Advera and Sasobit. The evaluation of the other two technologies (i.e. Revix and Foaming) as well as the Phase II testing are still in progress and have not been completed.

Links: Check for full text via 360 Link

Subject: Civil engineering; Transportation planning;

Classification: 0543: Civil engineering; 0709: Transportation planning

Identifier / keyword: Social sciences, Applied sciences, Modified asphalt mixtures, Moisture damage, Warm mix additives

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Advisor: Sebaaly, Peter E.

Committee member: Hajj, Elie Y., Fernandez, George C. J.

University/institution: University of Nevada, Reno
Development of Pavement Performance Evaluation Subroutines for 3D-Move Analysis Software

Author: Noel Vijayaruban, Vijayathasan

Abstract: Predicting the pavement performance of existing and new asphalt concrete (AC) pavements is an important and significant task of pavement engineers. It is important to quantifying the factors (material properties, environmental factors and traffic loading) that lead to the pavement deterioration. Generally these distress influencing factors are correlated by mechanistic or mechanistic-empirical relationships in the design. Pavement deterioration process is complex and involves not only structural fatigue but also involves many functional distresses of pavement.

3D-Move analysis software is capable of predicting pavement responses (stresses, strains, and deflections). It is a continuum based finite layer approach that uses the Fourier transform technique; therefore it can handle complex surface loadings such as multiple loads and non-uniform tire pavement contact stresses. The graphical user interface for 3D-Move analysis software was developed using Microsoft Visual Basic.Net 2008. Performance evaluation subroutines also were coded with same programming language in order to maintain the compatibility of overall 3D-Move analysis software. 3D-Move analysis software version 2.0 has two widely used pavement prediction models: MEPDG performance model and VESYS performance model. MEPDG performance model consists of AC top down cracking, AC bottom up cracking, AC rutting, Base rutting, Sub base rutting and Subgrade rutting failure modes and VESYS performance model owes Fatigue cracking, Layer rutting, System rutting and Roughness model. Traffic information is necessary in order to quantify the damage accumulated over the design life of pavement structure. Traffic information window is available with four numbers of seasons. This extended pavement analysis option for performance analysis enables to quantify each failure mode by individual layer's summary output or all layers' summary output. The integrity of the 3D-Move analysis software strengthens by performance model option.

Links: Check for full text via 360 Link

Subject: Civil engineering; Computer science;
Development of Windows-Based Version of the 3D-Move Analysis Software for Pavement Response Analysis

Author: Nitharsan, Rasanayagam

Abstract: In this study, the computer model 3D-Move, which is a continuum finite-layer based approach used that has been available for pavement responses to constant moving surface loads, was developed as a windows-based application (3D-Move Analysis). Old version of 3D-Move (DOS based version) had many drawbacks such as: time consuming in creating a data file and lack of contact stress distribution databases and user-friendly selection of materials characterization. The modified version (3D-Move Analysis) is free of many of the drawbacks found in the old 3D-Move.
This modified version was developed using Microsoft Visual Basic.NET 2008 and it has many features and more user friendly than old version of 3D-Move. Windows controls were used to input the required parameters in this modified version. The 3D-Move Analysis can handle SI and US units. It is capable of analyzing static and dynamic cases. The current version includes performance prediction models such as MEPDG and VESYS to quantify the pavement damage.

As many as six options have been included to specify the tire contact stress distribution in the 3D-Move Analysis. In the Uniform contact stress distribution option, the loading data is created for specified loaded area shape (circle, ellipse or rectangle) with or without braking/rolling. Non-uniform contact stress distribution is another loading option and it uses VRSPTA and Kistler databases which contain varieties of loading data for six types of tires. Semi-Trailer Truck Including Vehicle Dynamics is also an option and it calculates the load distribution on various axles of the 18-wheel tractor-semitrailer during normal highway traffic and braking.

Special Non-Highway Vehicles option includes end dump truck and forklift. Characterization of viscoelastic materials was enhanced by incorporating the master curves development method such as MEPDG model, AMPT model, Non-symmetrical Sigmoidal model (Richard's curve), Huet-Sayegh model and Witczak model. These options use laboratory dynamic modulus data and binder properties to compute the viscoelastic properties of materials as a function of frequency.

In this version, a well-integrated user friendly graphical display that distinguishes between many different types of response points, including the pavement structure has been incorporated. Furthermore, this version is capable of creating the output in text, tabular (Excel) and graphical format.

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**Classification:** 0543: Civil engineering; 0984: Computer science

**Identifier / keyword:** Applied sciences, Pavement response analysis software

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**Advisor:** Siddharthan, Raj V., Hajj, Elie Y.

**Committee member:** Sebaaly, Peter E., Watters, Robert J.

**University/institution:** University of Nevada, Reno

**Department:** Civil and Environmental Engineering

**University location:** United States -- Nevada

**Degree:** M.S.

**Source type:** Dissertations & Theses

**Language:** English
Develop a Laboratory Mixing Procedure for Hot Mix Asphalt Containing RAP Materials

Author: Barton, Matthew

Abstract: The use of reclaimed asphalt pavement (RAP) has become more prevalent with the rising costs of virgin materials and the recent push to develop more environmentally friendly and sustainable roadways. The use of RAP decreases the costs of constructing new pavements by limiting the amount of virgin materials required. For this reason there is a significant amount of research being conducted to examine the effects of using high amounts of RAP in the new HMA mixtures.

The primary objective of this study is to develop a mixing procedure for the laboratory that best simulates the plant-produced samples after their mixing and production process. Three distinct methods for incorporating the RAP material into the mixing process will be examined and compared to the plant produced samples provided by Granite Construction. The general descriptions of the three methods are as follows: Method A: The virgin aggregate, the virgin asphalt binder and the RAP material will all be heated to the appropriate mixing temperature as dictated by the virgin asphalt binder grade. Method B: The virgin aggregate will be superheated in accordance with NAPA’s recommendations from Information Series 123. The virgin asphalt binder will be heated to the appropriate temperature dictated by the performance grade. The RAP material will be dried and added at the ambient temperature. Method C: The virgin aggregate is superheated in accordance with NAPA’s recommendations from Information Series 123. The virgin asphalt binder will be heated to the appropriate temperature dictated by the performance grade. The RAP material will be moisturized to the appropriate moisture content and added at the ambient temperature.

To be able to determine which method of incorporating the RAP material into the laboratory mixing process will produce the mixture that most closely simulates the plant-produced mixture several characteristics will be analyzed. This thesis will examine the mixing temperatures over the duration of the mixing process for each method. This will provide insight into how effectively the virgin aggregate is transferring heat to the RAP material.

Additionally a short term oven aging analysis will help determine the appropriate aging time in the laboratory the replicate the aging experience by the plant-produced mixtures. To assess the different aging levels, the asphalt binder will be extracted from the plant-produced and laboratory-produced mixtures and graded according to the Superpave performance grading system. Lastly, compacted samples will be created for each mixing method as well as for the plant-produced laboratory-compacted mixtures to conduct an analysis of the volumetric properties and dynamic modulus.

Links: Check for full text via 360 Link
Laboratory Evaluation of Warm Mix Asphalt Mixtures in South Dakota, USA

Author: Ahmed, Taha Ahmed Hussien

Abstract: The implementation of warm-mix asphalt (WMA) is becoming more widespread with a growing number of contractors utilizing various WMA technologies. WMA processes were developed to reduce the mixing and compaction temperatures of hot mix asphalt without sacrificing the quality of the resulting pavement. Early research suggests WMA may be more susceptible to moisture damage and rutting than traditional HMA mixtures. The objective of this research was to evaluate various types of WMA paving technologies relative to
HMA mixtures to determine their suitability for use in South Dakota in various applications. This objective was met by conducting an extensive laboratory experiment to assess the performance of WMA mixtures produced using South Dakota's aggregate sources. The conclusions of this study are as follow: 

- Reduced mixing and compaction temperatures were achieved. 
- Lower production temperature and short-term conditioning had significant effects on the performance tests’ results. 
- Statistical differences were found when comparing indirect tensile strength (ITS) values for laboratory-produced mixtures. None of the WMA additives performed as well as the HMA. However, WMA mixtures exhibited satisfactory moisture damage resistance when comparing their result to HMA mixtures produced at the WMA temperatures and short-term conditioning. 
- Flow number and APA results showed that WMA mixtures exhibited accepted level of rutting resistance comparing to HMA mixtures produced at the WMA temperatures and short-term conditioning. 
- Dynamic modulus results showed that, on average, WMA mixtures had significantly lower dynamic modulus values than HMA mixtures, but similar values to HMA mixtures produced at the WMA temperature and short-term conditioning.

Links: Check for full text via 360 Link
Comparative Evaluation of Field and Laboratory-Produced Foamed Asphalt Mixture from Reno, Nevada

Author: Chia, Christine

Abstract: This study evaluated the properties and performance of field-produced HMA and foamed WMA mixtures from the Bravo Ave project in Reno, Nevada in comparison to respective laboratory-produced mixtures utilizing the same materials and mix design. Each mixture contained 15% RAP and was produced with a polymer-modified PG64-28NV asphalt binder. The rheological properties were evaluated for virgin, RAP and extracted/recovered asphalt binders from field and plant-produced mixtures. The mixtures were evaluated for their resistance to moisture damage by means of measuring the dynamic modulus $|E^*|$ and the indirect tensile strength as a function of multiple freeze-thaw cycling. The resistance of the mixtures to permanent deformation was evaluated through the use of the repeated load triaxial (RLT) to measure the flow number (FN). The low-temperature cracking resistance of the mixtures was evaluated using the thermal stress restrained specimen test (TSRST).

From this study it was determined that the HMA had better resistance to moisture damage and permanent deformation than the foamed WMA mixtures. Between the HMA and foamed WMA mixtures, similar asphalt properties and resistance to thermal cracking were seen. The laboratory-produced mixtures did not exhibit similar behaviors as those seen with the field-produced mixtures. Also, reheating of the mixtures from an ambient temperature after mixing seems to only improve the resistance of the mixtures to moisture damage. The non-reheated mixtures had equal or better resistance to permanent deformation and thermal cracking than their reheated counterparts.

Links: Check for full text via 360 Link

Subject: Civil engineering; Petroleum engineering;

Classification: 0543: Civil engineering; 0765: Petroleum engineering

Identifier / keyword: Applied sciences, FMLC asphalt mixtures, Foamed WMA, LMLC asphalt mixtures, Mechanical properties, RAP, Rheological properties

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Advisor: Sebaaly, Peter, Hajj, Elie
Characterization of Field-Produced HMA Mixtures from Nevada for Mechanistic-Empirical Pavement Design

Author: Feaster, Teresa Christine

Abstract: The Nevada Department of Transportation (NDOT), with the help of the Western Regional Superpave Center (WRSC) began steps toward implementing the Mechanistic-Empirical Pavement Design Guide (MEPDG). NDOT is transitioning from AASHTO 1993 design methods to the newer state of the practice method. The MEPDG incorporates the mechanistic-empirical (M-E) pavement models to predict pavement damage as a function of specific traffic, materials and environmental inputs. The use of M-E based methods makes it possible to optimize the design and to more fully ensure that specific distress types will be limited to values less than the failure criteria within the design life of the pavement structure.

To begin implementation 26 field produced mixtures have been sampled from behind the paver, since 2005, throughout the state of Nevada. Each mixture has a Contract designation and will be evaluated using laboratory performance testing for the binders viscosity, dynamic modulus, rutting regression coefficients using the Repeated Load Triaxial (RLT), and fatigue regression coefficients using the Flexural Beam Fatigue tester. Currently the MEPDG prediction models are nationally calibrated and require local or regional calibration to predict pavement performance more accurately. This implementation study is the first steps toward local calibration for Nevada.

Each of the laboratory evaluations will be grouped using a 95% confidence interval to see if the Contracts can all be grouped together or separate groups for binder grade, District divisions within NDOT, Type 2 or 2C mixtures, or by aggregate and/or binder source. Viscosity groups found include binder grade, a District and two binder sources. Dynamic modulus values could be grouped together by District division and six different binder and aggregate sources each. Rutting coefficients were grouped by District, two binder sources, and an aggregate source. Fatigue coefficients can be grouped together for all the Contracts tested and by binder grade.
Each of the Contracts for a group will be averaged for the corresponding input and provided to NDOT as inputs into the MEPDG to begin local calibration.

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**Classification:** 0543: Civil engineering

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**Advisor:** Hajj, Elie Y.

**Committee member:** Sebaaly, Peter E., Siddarthan, Rajarantnam v., Carr, James

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**Department:** Civil and Environmental Engineering

**University location:** United States -- Nevada

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**Development of a Mechanistic-Based Approach to Evaluate Critical Conditions of Hot Mix Asphalt Mixtures**

**Author:** Ulloa Calderon, Alvaro Esteban
Abstract: The performance of an asphalt pavement is significantly impacted by the properties of the asphalt mixture, pavement structure, and the imposed environmental and traffic loading conditions. In particular, hot mix asphalt (HMA) mixtures are believed to have a critical combination of temperature and traffic loading rate which will result in excessive permanent deformation. Designing the appropriate mixture type and properties are significantly important tasks that pavement engineers make on a routine basis. For many years this key decision has been made relying upon empirical procedures that lack fundamental characterization that might not be representative to the specific project condition. In light of this limitation, there is a need to develop an advanced, yet realistically simplified approach to assess, based on closely simulated field conditions, the rutting susceptibility of HMA mixtures under a given set of traffic loads and environmental conditions that are applicable to the project.

In the first phase of this study, dynamic mechanistic analysis with circular stress distribution was used to simulate field loading conditions. Extensive mechanistic analyses of three different asphalt pavement structures subjected to moving traffic loads at various speeds and under braking and non-braking conditions were conducted using the 3D-Move model. Predictive equations for estimating the anticipated deviator and confining stresses along with the equivalent deviator stress pulse duration as a function of pavement temperature, vehicle speed, and asphalt mixture's stiffness have been developed.

This study presents a new mechanistic-based approach that consists of evaluating asphalt mixtures using the repeated load triaxial (RLT) test at field representative testing conditions to determine the critical temperature of the HMA beyond which the mixture becomes unstable. An HMA was considered appropriate for a specific project location if the determined critical temperature was greater than the effective asphalt pavement temperature for rutting determined using the Mechanistic-Empirical Pavement Design Guide (MEPDG) software.

Predictive equations that account for the actual project characteristics such as climate conditions, material characteristics, operational speed, and traffic loading were developed in this study to estimate the effective asphalt pavement temperature. Nine HMA mixtures, each associated with a specific project that has performed well in rutting, were characterized and analyzed for rutting behavior. The critical temperature for each HMA was obtained using RLT results and actual field performance. Flow number criteria as a function of traffic level were also developed for the HMA mixtures.

The proposed approach was validated using three additional mixtures from Nevada, two mixtures from the WesTrack accelerated test facility, three mixtures from the Minnesota Road Interstate test facility (MnROAD) and two additional mixtures from the MnRoad low volume closed loop test facility. Very good agreement between laboratory results and field performance from the 10 different HMA mixtures was achieved supporting the appropriateness of the proposed approach.

Impact of the HMA mixture characteristics and its component interactions on the critical conditions was also studied. This study investigates the influence of aggregate characteristics using Aggregate Imaging Measurement Systems, the asphalt binder non-recoverable creep compliance using the Multiple Stress Creep Recovery test, and asphalt mixture air void content on the rutting performance of HMA mixtures. A comprehensive statistical model to predict the HMA critical temperature has been presented. The statistical model is able to effectively account for the influence of aggregate, binder and HMA mixture properties on rutting potential of asphalt mixtures.

Links: Check for full text via 360 Link

Subject: Civil engineering;

Classification: 0543: Civil engineering
Impact of the variation in dynamic vehicle load on flexible pavement responses

Author: Ahsanuzzaman, Md

Abstract: The purpose of this research was to evaluate the dynamic variation in asphalt pavement critical responses due to dynamic tire load variations. An attempt was also made to develop generalized regression equations to predict the dynamic response variation in flexible pavement under various dynamic load conditions. The study used an extensive database of computed pavement response histories for five different types of sites (smooth, rough, medium rough, very rough and severely rough), two different asphalt pavement structures (thin and thick) at two temperatures (70 °F and 104 °F), subjected to a tandem axle dual tire at three speeds 25, 37 and 50 mph (40, 60 and 80 km/h). All pavement responses were determined using the 3D-Move Analysis.
program (Version 1.2) developed by University of Nevada, Reno. A new term called Dynamic Response Coefficient (DRC) was introduced in this study to address the variation in critical pavement responses due to dynamic loads as traditionally measured by the Dynamic Load Coefficient (DLC). While DLC represents the additional varying component of the tire load, DRC represents the additional varying component of the response value (standard deviation divided by mean response). In this study, DRC was compared with DLC for five different sites based on the roughness condition of the sites. Previous studies showed that DLC varies with vehicle speed and suspension types, and assumes a constant value for the whole pavement structure (lateral and vertical directions). On the other hand, in this study, DRC was found to be significantly varied with the asphalt pavement and function of pavement structure, road roughness conditions, temperatures, vehicle speeds, suspension types, and locations of the point of interest in the pavement. A major contribution of the study is that the variation of pavement responses due to dynamic load in a flexible pavement system can be predicted with generalized regression equations. Fitting parameters (R²) in the range of 0.60 to 0.87 were observed the DRC predictive equations. In addition, verification of those generalized equations was evaluated using different sets of asphalt pavement structures and pavement materials. The differences between calculated and predicted values were found to be within ±20% for the maximum tensile strain and ±30% for the maximum compressive strain in the asphalt layer.

Links: Check for full text via 360 Link

Subject: Statistics; Civil engineering; Materials science;
Classification: 0463: Statistics; 0543: Civil engineering; 0794: Materials science

Identifier / keyword: Pure sciences, Applied sciences, Dynamic load coefficient, Dynamic response coefficient, Flexible pavement response evaluation due to dynamic tire loads by 3d move program, Impact of dynamic loads in flexible pavement responses, Pavement responses due to dynamic tire loads, Tire pavement interactions due to dynamic load

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Committee member: Siddharthan, Raj, Panorska, Anna
University/institution: University of Nevada, Reno
Department: Civil and Environmental Engineering
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Language: English
Long term performance evaluation of cold inplace recycling (CIR) technique in Nevada

Author: Sanjeevan, Selvaratnam

Abstract: Cold in-place recycling (CIR) is one of the commonly used rehabilitation technique for asphalt pavements in Nevada. Nevada Department of Transportation (NDOT) has long been using CMS-2S emulsion for CIR projects and recently has introduced Reflex emulsion and PASS emulsion for CIR. A difference in the performance of the CIR with changing emulsion technology has been observed which warranted the need for this study to assess the long-term performance of CIR pavements throughout Nevada.

The long term performance of 67 CIR projects was evaluated in this study. The evaluated CIR projects were divided based on the rehabilitation type and then sub-divided based on the emulsion technology. Performances of the various projects were analyzed by individual distresses such as longitudinal cracking, fatigue cracking, transverse cracking, block cracking, roughness and rutting using NDOT's pavement management system data. In addition, overall condition of the pavement was evaluated using PCI values. A statistical approach called principal component analysis also used to evaluate the effectiveness of CIR in Nevada.

The study revealed that CIR followed by a HMA overlay and a surface treatment performed much better on high volume roads than CIR with surface treatment on low volume roads. Transverse and longitudinal cracking were the two major types of distresses in CIR pavements. About 50% of the pavements constructed with HMA overlay and surface treatment and 95% of the pavements constructed with only surface treatment experienced transverse cracking during their service life. About 30% of the pavements constructed with HMA overlay and surface treatment and 70% of the pavements constructed with only surface treatment experienced longitudinal cracking.

The CIR technology with HMA overlay and surface treatment significantly improved the rutting resistance and roughness of the pavement. The climatic condition, CIR layer thickness, and surface treatment types were not found to affect the performance of CIR roads. The CMS-2S projects without HMA overlay and 1.5 to 2.5 inches HMA overlay were predicted to reach a PCI value of 60 for rehabilitation 15 years after construction. The CMS-2S projects constructed with 3 to 4 inches of HMA overlay performed excellent up to 9 years and expected to last more than 20 years before rehabilitation. The CIR with CMS-2S and PASS emulsions constructed with surface treatment were predicted to reach a PCI level of 60 after 15 and 19 years, respectively. However, Reflex emulsion was predicted to be due for rehabilitation only after 6 years from construction.

Links: Check for full text via 360 Link

Subject: Engineering; Civil engineering;
Evaluation of Warm Mix Asphalt Technologies and Recycled Asphalt Pavements in Truckee Meadows, Nevada

Author: Diaz Montecino, Cristian

Abstract: This study evaluated the properties and laboratory-performance of Hot Mix Asphalt (HMA) and Warm Mix Asphalt (WMA) mixtures with different levels of Recycled Asphalt Pavements (RAP) content: none for control mixtures, around 15% by dry weight of aggregates, and more than 30% by dry weight of aggregates. The rheological properties were evaluated for virgin and recovered RAP asphalt binders. The target amount of RAP in the mixtures was determined by using Blending Charts and Mortar Experiments. The mixtures are
design through the guidelines established in Marshall Mix Design Method considering additional modifications for RAP and WMA from Superpave Mix Design. The mixtures are evaluated for their resistance to moisture damage by means of measuring the Dynamic Modulus \( |E'| \) after three freeze/thaw cycles and the indirect tensile strength after one and three freeze/thaw cycles. The resistance of the mixtures to permanent deformation was also evaluated by using the Asphalt Mixture Performance Tester (AMPT) to measure the flow number (FN). For this study, it was determined that the resistance to moisture damage decreases as the number of freeze/thaw cycles increases for most of the evaluated mixtures. Mixtures exhibited an increase in dynamic modulus as the RAP percentage increased. A decrease in the resistance to moisture damage was detected with the increase in RAP content for most of the mixtures. HMA mixtures exhibited a better performance in rutting than the WMA mixtures. An increase in rutting resistance was observed with the increase in RAP percentage for HMA mixtures whereas an inconsistent trend was observed for WMA mixtures. Further study is needed to validate the use of the high percentage of RAP in Washoe County.

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Evaluation of Warm Mix Asphalt Additives for Use in Modified Asphalt Mixtures

Author: Chamoun, Zahi

Abstract: The objective of this research effort is to evaluate the use of warm-mix additives with polymer modified and terminal blend tire rubber asphalt mixtures from Nevada and California. The research completed over two stages: first stage evaluated two different WMA technologies; Sasobit and Advera, and second stage evaluated one additional WMA technology; Evotherm.

The experimental program covered the evaluation of resistance of the mixtures to moisture damage, the performance characteristics of the mixtures, and mechanistic analysis of mixtures in simulated pavements. In the both stages, the mixture resistance to moisture damage was evaluated using the indirect tensile test and the dynamic modulus at multiple freeze-thaw cycles, and the resistance of the various asphalt mixtures to permanent deformation using the Asphalt Mixture Performance Tester (AMPT). Resistance of the untreated mixes to fatigue cracking using the flexural beam fatigue was only completed for the first stage.

One source of aggregates was sampled in, two different batches, three warm mix asphalt technologies (Advera, Sasobit and Evotherm) and three asphalt binder types (neat, polymer-modified, and terminal blend tire rubber modified asphalt binders) typically used in Nevada and California were evaluated in this study.

This thesis presents the resistance of the first stage mixtures to permanent deformation and fatigue cracking using two warm-mix additives; Advera and Sasobit, and the resistance to moisture damage and permanent deformation of the second stage mixtures with only one warm-mix additive; Evotherm.

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Advisor: Sebaaly, Peter E.

Committee member: Hajj, Elie Y., Taylor, Dany L., Siddharthan, Raj

University/institution: University of Nevada, Reno
Abstract: Nevada Department of Transportation (NDOT) is currently experimenting with warm mix asphalt (WMA) technologies and recycled asphalt pavement (RAP). The purpose of this experiment is to evaluate the effects of various WMA technologies and various levels of RAP on Nevada mixtures using current Superpave WMA and RAP design techniques. This part of the project evaluated aggregates from Lone Mountain, Rinker, North Tenaya, and Sloan. Advera, Evotherm 3G, and Sonnewarmix, were the WMA technologies evaluated, while plant foaming mixtures will be evaluated at a later time. It was decided that two levels of RAP would be evaluated; one level found through the use of a traditional blending chart and one through a new method known as the mortar experiment. It was also decided that samples mixed at 0.2 percent below optimum binder content (OBC) would be compared to OBC samples. The mortar experiment determined levels of RAP binder replacement for Lone Mountain and Rinker aggregates much lower than the blending chart. The levels were 17 percent and 39 percent, respectively. A mix was successfully designed and tested with 15 percent RAP binder replacement with favorable results; a mix with 35 percent RAP binder replacement will be designed and tested in the near future. It is suggested that further research should be conducted on the mortar method to explore minimization of variables during the experiment. Samples at 0.2 percent binder below the OBC performed comparable to samples at OBC. It is suggested that further analysis of coating and compactability should be performed on the evaluated mixtures as per Superpave WMA standards. As expected, mixes with WMA performed well in resistance to moisture damage and reflective cracking, but did not perform as well in resistance to rutting tests. Mixtures with RAP behaved the opposite; good resistance to rutting but not as good resistance to moisture damage and reflective cracking.
Comprehensive Methodologies for Analysis of Thermal Cracking in Asphalt Concrete Pavements

Author: Alavi, Seyed Mohammad Zia

Abstract: The overall objective of this study was to develop a comprehensive model for thermal cracking analysis in asphalt pavements. The model essentially aims to be utilized as a robust tool for selecting thermal cracking resistant mixture(s) based on the predicted performance at the location of interest. In this comprehensive model, several enhancements have been introduced to remedy the recognized limitations in the available thermal cracking models. The proposed model mainly accounts for the changes of asphalt mixture...
stiffness, strength, and contraction properties with the oxidative aging of asphalt binder over time. Overall, the developed model includes four main components, which are briefly described below:

**Temperature profile prediction:** hourly temperatures at different depths of pavement structure are predicted over time using an enhanced heat transfer model with improved boundary conditions. The numerical calculation with the Finite Control Volume Method (FCVM) in a fully implicit scheme facilitates the consideration of any discontinuity in thermal diffusivity properties of pavement layers as well as significantly optimizes the time of calculation. The required inputs for the model are: (I) hourly climatic and meteorological data (i.e., air temperature, wind speed, and solar radiation) at the pavement location, (II) thickness and thermal diffusivity properties of pavement layers, and (III) monthly variable pavement surface radiation properties (i.e., albedo, emissivity, and absorption coefficient). The Predictions of the model were validated for two Long Term Pavement Performance (LTPP) test sections (i.e., Kingman, Arizona, and Great Falls, Montana).

**Oxidative aging (carbonyl) prediction:** the evolution of carbonyl (CA) with time for the asphalt binder at a specific depth in the pavement, will be predicted using an oxidative aging diffusion-based model, which were developed at the Texas A&M University. The model requires (I) asphalt binder oxidative aging kinetics, (II) asphalt binder hardening parameters, and (III) estimated hourly pavement temperatures, to predict CA over time in the asphalt pavement surface layer. The numerical solution of the model is completed using a fully implicit FCVM. The predicted CA values are used to estimate the evolution of asphalt mixture critical properties (i.e., modulus, contraction, and strength) with time due to aging. Using the model predictions, asphalt mixture laboratory aging temperatures and durations can be suggested to simulate field aging of asphalt materials as occurs over over years of service.

**Thermal Stress Prediction:** the thermal stresses in the asphalt layer are predicted using the 1-D linear viscoelastic constitutive relationship modified to account for the aging of the asphalt material in terms of continuous changes in the relaxation modulus and the coefficient of thermal contraction (CTC) over time. Moreover, the temperature dependency of the asphalt mixture CTC is also taken into consideration. The relaxation modulus is obtained from the continuous relaxation spectrum, which is directly calculated from the dynamic modulus data expressed in complex domain \((E^*)\). Thus, the continuous relaxation spectrum can be defined by few shape function parameters (i.e., complex modulus function coefficients). The spectrum shape parameters for the relaxation modulus can be predicted from the CA level using consistent exponential correlations that were developed for the various evaluated mixtures. The temperature-dependent CTC function is determined from the thermal strain versus temperature measurements under a constant cooling rate. These measurements can be obtained from contraction of an unrestrained specimen during testing by uniaxial thermal stress and strain test (UTSST). UTSST has been developed during this study after enhancing the traditional thermal stress restrained specimen test (TSRST) set up, at the University of Nevada, Reno. The UTSST allows concurrent measurements of thermal stress and thermal strain, respectively, from the restrained and unrestrained asphalt mixture specimens. Mixture specific correlations between the CTC function parameters and the CA level can be used in the model to predict thermal strains and consequently thermal stresses over time.

**Thermal Cracking Events Prediction:** the prediction of the possible cracking events is based on the newly defined crack initiation stress (CIS) limit as obtained from the UTSST results as a function of aging. By definition, a cracking event is when the predicted hourly thermal stress in the asphalt layer reaches the corresponding CIS value at a given aging level. The predicted thermal stress may be compared with different percentages of CIS in order to account for the thermal fatigue cracking. Thermal fatigue cracking is developed by accumulation of damages caused by thermal stresses over cooling/warming cycles, when thermal stresses do not reach the cracking stress limit of the asphalt mixture in one critical cooling event.

Finally, Thermal Cracking Analysis Package (TCAP), coded in MATLAB, provides a graphical user interface (GUI) that can be used to complete thermal cracking analysis, based on the proposed model. TCAP aims to be
used by pavement engineers as a design tool for selecting thermal cracking resistant mixtures based on the predicted performance at the location of interest. Moreover, the output of the software can offer recommendations for appropriate times to apply preventive maintenances on existing pavements. TCAP was used to preliminary analyze thermal cracking resistance of selective asphalt mixtures. The results rationally showed higher potential of thermal cracking events for the mixtures with higher air void contents and the asphalt mixture with the unmodified asphalt binder.

Validation of the model output with the observed field performance of asphalt mixtures in thermal cracking is recommended. Additionally, TCAP compoents can be improved in future.

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Evaluation of Pavement Rating System for Flexible Pavements in Nevada

Author: Suwal, Roshan

ProQuest document link

Abstract: Evaluation of pavement condition is the principle source of information for the effective management of the road network for local and state transportation agencies. However, transportation agencies in the United States are using different pavement rating systems to evaluate their pavement condition. The data collection system, measurement units, and calculation techniques have been modified and updated by several states to incorporate new technological development with time. Several transportation agencies are willing to update their old pavement rating systems while others elected to gradually switch to more accurate rating systems. This study focuses on the potential enhancements on the Pavement Rating Index (PRI) used by Nevada Department of Transportation (NDOT) to make it more consistent with nationally applied systems such as the Pavement Condition Index (PCI) developed by U.S. Army Construction Engineering Research Laboratory. Pavement condition data that were utilized to calculate PRI over the last 15 years were converted into PCI compatible format using a suitable conversion technique. Estimated PCI values were plotted against the corresponding PRI value showed moderate correlation with $R^2$ value of 0.56. The current PRI system was then enhanced to eliminate some of its deficiencies. The statistical relationship between the enhanced PRI and PCI showed improved correlation with $R^2$ value of 0.75. The study concluded that a successful correlation between the PRI system and the PCI system can be achieved in Nevada while maintaining the use of the historical pavement condition data. This study also suggests using a recommended PRIr system which adds the impact of roughness and friction onto the enhanced PRI system. Finally, this study compares the road maintenance strategies suggested by the current PRI system and the PRIr system with the time based schedule and the actual activities applied on the pavement section. This comparison concluded that, while both the PRI and PRIr systems show good correlations with the time based schedule and actual activities for assigning preventive and corrective maintenance strategies, the PRIr system showed improved correlations with the time based schedule and actual activities for assigning the overlay strategy. The PRIr system is recommended for implementation by NDOT due to its consistency with national systems (i.e., PCI) and its superior correlations with time based schedule and actual activities for overlays which leads to significant savings of rehabilitation funds.

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Field Performance of Asphalt Pavements with New Technologies in Northern Nevada

Author: Faeth, Benjamin Michael

Abstract: The Regional Transportation Commission (RTC) of the Washoe Valley Area has been tasked to determine if three advanced asphalt pavement technologies and one modified aggregate gradation are suitable for implementation within Reno, Stead, and Sparks Nevada. This was accomplished through research and test roads and Intersections to determine if Recycled Asphalt Pavement (RAP), Warm Mix Asphalt (WMA), Polymer-Modified Asphalt Binder, and the Type 2-R aggregate gradation were succeeding in their design plans. Over the course of several years the streets being used by RTC to test the technologies are succeeding within their design lifespans, and the Intersections being used to test the Type 2-R aggregate gradation are showing significant resistance to rutting. Due to the roads and Intersections not being more than 10 years old, these conclusions are subject to change over time.

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Influence of mixture characteristics on the oxidative aging of asphalt binders

Author: Morian, Nathan E.

Abstract: The objective of this research effort focused on the evaluation of asphalt mixtures with respect to thermal cracking. Preliminary investigations soon indicated that a fundamental evaluation of thermal cracking was highly dependent upon the more complicated understanding of asphalt binder oxidation. The oxidation of asphalt binders within an asphalt mixture were understood to potentially be influenced by the mixture characteristics (i.e. air void levels, binder content, etc.) and aggregate properties (i.e. aggregate absorption, gradation, etc.). Therefore, this study was conducted in order to investigate and quantify the effects different aggregate sources and mixture properties may have on the oxidation and thermal cracking performance of asphalt mixtures.

The investigation specifically focused on quantifying the oxidation of the asphalt binder alone and as part of the asphalt mixture when subjected to isothermal oven aging. The oxidation parameters of pan-aged asphalt binders were quantified, according to the standard of practice in the industry. These parameters were then compared to extracted and recovered mixture-aged asphalt binders to examine the influence of the main
aggregate and mixture factors on the binder oxidation. The study observed differences between the pan-aged and mixture-aged asphalt binders in terms of oxidation kinetics, rheological measures, and the combined effect represented as the hardening susceptibility.

Further evaluation of the binder oxidation based upon the dynamic modulus measures indicated marked influences of the mixture characteristics, the individual component materials, and the interactions between the investigated factors.

Differentiation of the experimental factors was further identified by the newly developed low-temperature evaluation method, Uniaxial Thermal Stress and Strain Test (UTSST). The UTSST provides a fundamental approach to characterize the thermo-viscoelastic properties of asphalt mixtures permitting the pragmatic evaluation of changes in the stiffness and overall behavior of mixtures as a function of oxidative aging. Five distinct stages in the UTSST modulus were identified as thermo-viscoelastic properties, which are identified as a function of temperature: viscous softening, viscous-glassy transition, glassy hardening, crack initiation, and fracture stages.

Through consideration of the thermo-viscoelastic properties, marked differences in the binder oxidation were noted between the experimental factors. Typically, decreases in the viscous response of the mixtures as well as increases in both the stiffness and brittle behavior were observed with aging. The evaluation method provides definitive measures to monitor multiple aspects of the performance of asphalt mixtures subjected to thermal loading.

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