RESEARCH DIGEST

Digest of Current Concrete Pavement Research

1998

NOTICE:

U.S. Department
of Transportation
Federal Highway
Administration

400 7th Street, S.W.
Washington, DC 20590
Phone: 202-366-6606
Fax: 202-366-7909

Digest of Current Concrete Pavement Research

A sound transportation system is vital to the American economy. Free movement of goods, services and people has contributed greatly to our past economic growth and is essential to our future competitiveness in the world arena.

Pavements form the backbone of our transportation system. However, highway and airport traffic is escalating rapidly, to where pavements must now carry loads far greater than ever before. Coupled with the aging of our infrastructure, many of the over 4 million miles of highway and airfield pavements are now in need of repair, rehabilitation or reconstruction.

Long-life, low-maintenance, and minimal inconvenience to the traveling public are all essential requirements for future pavement construction. To incorporate innovation into transportation research, the traditional focus must shift from products to users. Practical solutions are needed. Ultimately, successful implementation of innovative research depends on the involvement and support of the partners which help shape the transportation system.

The concrete pavement industry today is built on partnerships with the public sector at the federal, state, and local levels. Research vital to expanding and rehabilitating our infrastructure is one focus of such partnering. One of these partnering efforts is the compilation of this digest of current concrete pavement research.

This report summarizes much of the current research in the U.S. relating to concrete paving. It covers projects that were either underway or were completed in 1997. Subject areas include performance evaluation, design, construction, specifications, materials and mix design, rehabilitation, maintenance, recycling, and surface characteristics. Federal, state, university and industry research activities are reported.

The report is intended to:

- Let people know what is being done and help the pavement community stay abreast of developments
- Foster future cooperation
- Foster innovation
- Maximize the benefit of research
- Demonstrate the concrete paving industry's commitment to research

This report reveals that a substantial amount of concrete pavement research is underway. This is indicative of the interest in and commitment to concrete pavements. With the significant changes occurring in transportation, durable concrete pavements will play an increasingly important role in personal mobility, quality of life, and the vitality of the United States in the global marketplace.

Information for this report was compiled through a variety of means including internet and database searches, direct contact, telephone inquiries, and published research reports. An earnest effort was made to include comprehensive abstracts of as many projects as could be identified. In some instances, complete information on a study was not readily available and abbreviated details are included.

It is intended that this report be periodically updated to include new research studies and developments. Written corrections or updates on the projects included in this report, and information regarding other studies should be sent to the American Concrete Pavement Association to the attention of Larry Cole, Vice President—Engineering and Research.

Acknowledgement

Many individuals contributed information for this report. We would like to extend our sincere thanks to all of those people for their assistance, as well as to the researchers whose work has made this report possible.

This document was developed through partnership with the U.S. Department of Transportation's Federal Highway Administration under Cooperative Agreement DTFH61-97-X-00005. "Development and Implementation of Portland Cement Concrete Pavement Management, Design, Maintenance, Construction and Quality Control Procedures." The concrete industry recognizes and appreciates the U.S. DOT's role in improving our nation's transportation system. Particular thanks go to Mr. Theodore L. Neff, who prepared this report.

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Digest of Current Concrete Pavement Research

CHAPTER 1

Pavement Evaluation and Design

Project Title: *LTPP Data Analysis—Analysis of Well and Poorly Performing Pavements*

Investigator(s): ERES Consultants, Inc. & Brent Rauhut Engineering, Inc.

Objectives

The objective of this research is to identify the common design features of pavement sections that lead to good performance of pavements and those that lead to poor performance of pavements. Based on the features identified as being critical to performance, guidelines will be prepared for the design and construction of long-lived PCC and AC pavements.

Description

Background: One of the goals of the LTPP program is to develop improved models for predicting the development of pavement distresses. These models are expected to be broad in their consideration of the key design features such as layer thickness, material properties, and other design features such as drainage, geometric features (e.g., widened lanes), and load transfer at joints. During SHRP, a limited number of studies were conducted, using the limited data available, with various objectives.

Because the development of comprehensive distress models may not occur in the near-term, there is a need to identify critical pavement design and construction features that could be readily implemented by highway agencies. It is expected that implementation of such features can save millions of dollars by extending the performance of new and rehabilitated pavements, and by minimizing or eliminating costly premature failures.

Work Plan

- ***Task 1:*** Establish criteria for pavement sections exhibiting exceptional performance.
- ***Task 2:*** Identify test sections that can be categorized as well performing and poorly performing for each pavement type.
- ***Task 3:*** Perform analysis.
- ***Task 4:*** Prepare a final report that identifies important design features that led to good or poor performance of the selected GPS sites.
- ***Task 5:*** Prepare guidelines for incorporation of those features for design and construction of new and rehabilitated pavements.

STARTED	October 1996
EXPECTED COMPLETION DATE	October 1997
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP Data Analysis—Mechanistic Evaluation of Test Data*

Investigator(s): ERES Consultants, Inc., Champaign, IL

Objectives

The objectives of this research are to analyze the Long Term Pavement Performance (LTPP) program data compiled to date to: 1) develop calibrated mechanistic-empirical design procedures for rigid and flexible pavements; 2) determine, in mechanistic terms, how pavement behavior is affected by seasonal changes; 3) evaluate the factors affecting the cracking of CRC pavements and identify how the cracking pattern and other CRC pavement attributes affect CRC pavement behavior under traffic loading; and 4) perform an analysis of the laboratory-derived resilient modulus test data and identify the mixture and test condition factors affecting modulus values.

Description

Background: The Long Term Pavement Performance (LTPP) program is a 20-year study of pavement performance of test sections subjected to actual traffic loads and environmental conditions. This program is the largest pavement study program ever developed and implemented in North America. The LTPP program presently has more than 2,200 test sections at nearly 1,000 locations.

Work Plan

- ***Task 1:*** Perform a detailed analysis of GPS-1 and GPS-2 test sections to determine the structural responses at these sections given a range of traffic loadings, environmental conditions, and material variability.
- ***Task 2:*** Perform a detailed analysis of GPS-3 and GPS-4 test sections.
- ***Task 3:*** Perform a detailed analysis of GPS-5.
- ***Task 4:*** Perform a detailed analysis of SPS-1 test sections
- ***Task 5:*** Perform a detailed analysis of SPS-2.
- ***Task 6:*** Perform detailed analysis of resilient modulus.

STARTED	1995
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP Data Analysis—Portland Cement Concrete Pavement Design*

Investigator(s): ERES Consultants, Inc., Champaign, IL

Objectives

The objective of this contract is to apply data from the Long Term Pavement Performance (LTPP) program in order to: 1) determine the design features and practices which have a beneficial effect on the performance of rigid pavements, and 2) field verify the NCHRP 1-30 improved support guidelines for concrete pavements.

Description

Scope: This project will examine and analyze LTPP data, with special emphasis on jointed, plain concrete and continuously reinforced concrete pavements. Guidelines for improving design and construction will also be developed.

Background: The Long Term Pavement Performance (LTPP) program is a 20-year study of pavement performance of test sections subjected to actual traffic loads and environmental conditions.

This program is the largest pavement study program ever developed and implemented in North America. The LTPP program presently has more than 2,200 test sections at nearly 1,000 locations.

Work Plan

- ***Task 1:*** Identify the data to be used in all required analyses.
- ***Task 2:*** Apply the LTPP data obtained in previous tasks to field verify the NCHRP 1-30 guidelines for selection of design k values.
- ***Task 3:*** Using LTPP data, evaluate the predictive capability of the NCHRP 1-30 model.
- ***Task 4:*** Prepare interim and final reports.

STARTED	1994
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP Data Analysis—Roughness Evaluation*

Investigator(s): Soils and Materials Engineers

Objectives

The objectives of this contract are to: 1) investigate the development of roughness (expressed in terms of the International Roughness Index, or IRI) in each group of General Pavement Studies sections; 2) evaluate the stability of the IRI over time; 3) relate the changes in a profile statistic over time for each GPS experiment with the variables that affect the development of roughness; 4) investigate the development of roughness for newly constructed flexible and rigid pavements; and 5) investigate the reduction in roughness due to different rehabilitation techniques.

Description

Scope: This project will compile and analyze LTPP data to investigate the development of pavement roughness. Guidelines for improving design and construction will also be developed.

Background: The Long Term Pavement Performance (LTPP) program is a 20-year study of pavement performance of test sections subjected to actual traffic loads and environmental conditions.

This program is the largest pavement study program ever developed and implemented in North America. The LTPP program presently has more than 2,200 test sections at nearly 1,000 locations.

Work Plan

- ***Task 1:*** Identify and obtain data.
- ***Task 2:*** Investigate changes in the IRI.
- ***Task 3:*** Analyze roughness of each GPS site.
- ***Task 4:*** Analyze factors affecting GPS roughness.
- ***Task 5:*** Analyze roughness of SPS sites.
- ***Task 6:*** Determine the effects of pavement rehabilitation techniques on SPS pavement roughness.
- ***Task 7:*** Make recommendations for improved Information Management System (IMS) quality control and assurance.
- ***Task 8:*** Prepare final report.

STARTED	1995
EXPECTED COMPLETION DATE	January 1998
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP Data Analysis—Model Development for Prediction of Distress and Roughness*

Investigator(s): Transtec, Inc., Austin, Texas

Objectives

The objectives of this project are to: 1) develop performance models to predict faulting, cracking, spalling, and International Roughness Index (IRI) using both engineering mechanics and, where needed, empirical regression; 2) incorporate the use of state-of-the-art mechanistic and mechanistic-empirical model forms for calibration to primary concrete pavement distress manifestations (cracking, faulting and spalling); 3) examine the utility of using mechanistic model forms to predict IRI as a function of pavement cracking, spalling and faulting models; and 4) provide guidelines where appropriate for improving these pavement performance models as more LTPP data becomes available in coming years.

Description

Scope: The focus of this project is on an important subset of LTPP relating to the primary traffic and environmentally induced distresses that occur in portland cement concrete (PCC) pavements. These include jointed plain concrete pavements (JPCP), jointed reinforced concrete pavements (JRCP), and continuously reinforced concrete pavements (CRCP). These three pavement types are designated in the LTPP program as General Pavement Studies (GPS) 3, 4, and 5 respectively.

This project will develop performance models that are mechanistically based and which lend themselves to calibration with the LTPP data. Where data is insufficient or correlations not clearly evident or understood, statistical performance models using modern regression techniques will be developed. This project, consequently, will focus on the mechanisms related to specific distress manifestations.

Background: The Long Term Pavement Performance (LTPP) program was initiated in 1987 as part of the Strategic Highway Research Program (SHRP). The objective of the SHRP-LTPP program was to provide the tools for increasing pavement performance and service life in order to better serve the needs of the motoring public, and to provide for the delivery of goods and services without major increases in financial resources. Inherent in meeting this objective was the establishment of the LTPP IMS, which includes a complete inventory of the design, construction, and performance characteristics of numerous pavement sections throughout the country. A subset of this large database (portland cement concrete pavements) is analyzed in this study.

STARTED	
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP General Pavement Study 3—Jointed Plain Concrete*

Investigator(s): Various

Objectives

The objective of this research is to evaluate the long-term performance of jointed, plain (unreinforced) concrete pavements.

Description

Background: The Long Term Pavement Performance (LTPP) program is a 20-year study of pavement performance of test sections subjected to actual traffic loads and environmental conditions. This program is the largest pavement study program ever developed and implemented in North America. The LTPP program presently has more than 2,200 test sections at nearly 1,000 locations.

The LTPP General Pavement Studies were established during the first five years of the LTPP program under the Strategic Highway Research Program. These studies are of existing in-service pavements that were constructed under various local control standards for non-research objectives. The sections selected for inclusion in the GPS studies are representative of the wide range of pavement types and environmental conditions present in North America.

GPS experiments represent the most commonly used pavement structural designs. The LTPP GPS include nine types of existing, original, and rehabilitated in-service pavements. The GPS experiments were designed to include pavements up to 15 years in age.

Work Plan

- ***Task 1:*** Inventory the pavement section information.
- ***Task 2:*** Document routine maintenance activity.
- ***Task 3:*** Compile traffic data.
- ***Task 4:*** Monitor pavement condition over time.
- ***Task 5:*** Measure the pavement's structural capacity using a falling weight deflectometer. FWD measurements are to be taken approximately once every five years on most sections, and 12 to 14 times a year every two years for selected sections.
- ***Task 6:*** Measure the longitudinal profile once every year.
- ***Task 7:*** Monitor surface distress annually.

STARTED	1987
EXPECTED COMPLETION DATE	2007
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP General Pavement Study 4—Jointed Reinforced Concrete*

Investigator(s): Various

Objectives

The objective of this research is to evaluate the long term performance of jointed, reinforced concrete pavements.

Description

Background: The Long Term Pavement Performance (LTPP) program is a 20-year study of pavement performance of test sections subjected to actual traffic loads and environmental conditions. This program is the largest pavement study program ever developed and implemented in North America. The LTPP program presently has more than 2,200 test sections at nearly 1,000 locations.

The LTPP General Pavement Studies were established during the first five years of the LTPP program under the Strategic Highway Research Program. These studies are of existing in-service pavements that were constructed under various local control standards for non-research objectives. The sections selected for inclusion in the GPS studies are representative of the wide range of pavement types and environmental conditions present in North America.

GPS experiments generally represent the most commonly used pavement structural designs. The LTPP GPS include nine types of existing, original, and rehabilitated in-service pavements. The GPS experiments were designed to include pavements up to 15 years in age.

Work Plan

- ***Task 1:*** Inventory the pavement section information.
- ***Task 2:*** Document routine maintenance activity.
- ***Task 3:*** Compile traffic data.
- ***Task 4:*** Monitor pavement condition over time.
- ***Task 5:*** Measure the pavement's structural capacity using a falling weight deflectometer. FWD measurements are to be taken approximately once every five years on most sections, and 12 to 14 times a year every two years for selected sections.
- ***Task 6:*** Measure the longitudinal profile once every year.
- ***Task 7:*** Monitor surface distress annually.

STARTED	1987
EXPECTED COMPLETION DATE	2007
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP General Pavement Study 5—Continuously Reinforced Concrete*

Investigator(s): Various

Objectives

The objective of this research is to evaluate the long term performance of continuously reinforced concrete pavements.

Description

Background: The Long Term Pavement Performance (LTPP) program is a 20-year study of pavement performance of test sections subjected to actual traffic loads and environmental conditions. This program is the largest pavement study program ever developed and implemented in North America. The LTPP program presently has more than 2,200 test sections at nearly 1,000 locations.

The LTPP General Pavement Studies were established during the first five years of the LTPP program under the Strategic Highway Research Program. These studies are of existing in-service pavements that were constructed under various local control standards for non-research objectives. The sections selected for inclusion in the GPS studies are representative of the wide range of pavement types and environmental conditions present in North America.

GPS experiments generally represent the most commonly used pavement structural designs. The LTPP GPS include nine types of existing, original, and rehabilitated in-service pavements. The GPS experiments were designed to include pavements up to 15 years in age.

Work Plan

- ***Task 1:*** Inventory the pavement section information.
- ***Task 2:*** Document routine maintenance activity.
- ***Task 3:*** Compile traffic data.
- ***Task 4:*** Monitor pavement condition over time.
- ***Task 5:*** Measure the pavement's structural capacity using a falling weight deflectometer. FWD measurements are to be taken approximately once every five years on most sections, and 12 to 14 times a year every two years for selected sections.
- ***Task 6:*** Measure the longitudinal profile once every year.
- ***Task 7:*** Monitor surface distress annually.

STARTED	1987
EXPECTED COMPLETION DATE	2007
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP General Pavement Study 9—Unbonded PCC Overlays on PCC Pavements*

Investigator(s): Various

Objectives

The objective of this research is to evaluate the long term performance of unbonded portland cement concrete overlays of existing portland cement concrete pavement surfaces.

Description

Background: The Long Term Pavement Performance (LTPP) program is a 20-year study of pavement performance of test sections subjected to actual traffic loads and environmental conditions. This program is the largest pavement study program ever developed and implemented in North America. The LTPP program presently has more than 2,200 test sections at nearly 1,000 locations.

The LTPP General Pavement Studies were established during the first five years of the LTPP program under the Strategic Highway Research Program. These studies are of existing in-service pavements that were constructed under various local control standards for non-research objectives. The sections selected for inclusion in the GPS studies are representative of the wide range of pavement types and environmental conditions present in North America.

GPS experiments generally represent the most commonly used pavement structural designs. The LTPP GPS include nine types of existing, original, and rehabilitated in-service pavements. The GPS experiments were designed to include pavements up to 15 years in age.

Work Plan

- ***Task 1:*** Inventory the pavement section information.
- ***Task 2:*** Document routine maintenance activity.
- ***Task 3:*** Compile traffic data.
- ***Task 4:*** Monitor pavement condition over time.
- ***Task 5:*** Measure the pavement's structural capacity using a falling weight deflectometer. FWD measurements are to be taken approximately once every five years on most sections, and 12 to 14 times a year every two years for selected sections.
- ***Task 6:*** Measure the longitudinal profile once every year.
- ***Task 7:*** Monitor surface distress annually.

STARTED	1987
EXPECTED COMPLETION DATE	2007
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP Specific Pavement Study 2—Strategic Study of Structural Factors for Rigid Pavements*

Investigator(s): Various

Objectives

The objective of this research is to investigate and evaluate the structural factors that impact performance of portland cement concrete pavements.

Description

Scope: The study currently includes 205 test sections, constructed in the states of Arizona, Arkansas, California, Colorado, Delaware, Iowa, Kansas, Michigan, Nevada, North Carolina, North Dakota, Ohio, Washington, and Wisconsin.

Background: SPS test sections are pavement structures designed and constructed to develop a better understanding of the effects on performance of selected maintenance, rehabilitation, and design factors not adequately covered in the General Pavement Studies. SPS sections are constructed under the LTPP program to allow for control of critical design factors and initiation of performance monitoring from the initial date of construction or opening to traffic. SPS experiments consist of nine studies involving newly constructed or rehabilitated in-service pavements with multiple test sections.

Work Plan

- ***Task 1:*** Inventory the pavement section information.
- ***Task 2:*** Document routine maintenance activity.
- ***Task 3:*** Compile traffic data.
- ***Task 4:*** Monitor pavement condition over time.
- ***Task 5:*** Measure the pavement's structural capacity using a falling weight deflectometer. FWD measurements are to be taken approximately once every five years on most sections, and 12 to 14 times a year every two years for selected sections.
- ***Task 6:*** Measure the longitudinal profile once every year.
- ***Task 7:*** Monitor surface distress annually.

STARTED	1987
EXPECTED COMPLETION DATE	2007
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP Specific Pavement Study 8—Study of Environmental Effects in the Absence of Heavy Loads*

Investigator(s): Various

Objectives

The objective of this research is to monitor and evaluate the effects that environmental changes have on the performance of portland cement concrete pavements in the absence of heavy traffic loads.

Description

Scope: The study currently includes 19 test sections, constructed in the states of Arizona, Arkansas, California, Colorado, Missouri, Ohio, Texas, and Washington.

Background: SPS test sections are pavement structures designed and constructed to develop a better understanding of the effects on performance of selected maintenance, rehabilitation, and design factors not adequately covered in the General Pavement Studies. SPS sections are constructed under the LTPP program to allow for control of critical design factors and initiation of performance monitoring from the initial date of construction or opening to traffic. SPS experiments consist of nine studies involving newly constructed or rehabilitated in-service pavements with multiple test sections.

Work Plan

- ***Task 1:*** Inventory the pavement section information.
- ***Task 2:*** Document routine maintenance activity.
- ***Task 3:*** Compile traffic data.
- ***Task 4:*** Monitor pavement condition over time.
- ***Task 5:*** Measure the pavement's structural capacity using a falling weight deflectometer. FWD measurements are to be taken approximately once every five years on most sections, and 12 to 14 times a year every two years for selected sections.
- ***Task 6:*** Measure the longitudinal profile once every year.
- ***Task 7:*** Monitor surface distress annually.

STARTED	1987
EXPECTED COMPLETION DATE	2007
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *Validation of Performance Models for Portland Cement Concrete Pavement Construction*

Investigator(s): ERES Consultants, Inc., Champaign, IL

Objectives

The objectives of this research are to: 1) validate, and where appropriate, make improvements or adjustments to the distress-prediction models currently used in the prototype PRS for portland cement concrete (PCC) paving; and 2) develop guidelines to assist agencies in making state- specific adjustments to the recommended national distress prediction models or in developing additional models.

Description

Background: Since 1987, the Federal Highway Administration has been supporting the development of Performance-Related Specifications for highway construction as one of its high-priority research areas. Performance-related specifications (PRS) are specifications that require materials and construction acceptance tests, the results of which correlate, to a known degree, with the performance of the completed product. Under FHWA's research prototype PRS have been developed for the construction of jointed plain concrete pavements (JPCP) and jointed reinforced concrete pavements (JRCP). These PRS use performance-prediction (i.e. distress prediction) models believed to be the best national models currently available to predict when, and to what extent, a newly constructed pavement will exhibit various distresses. Distress types predicted include transverse cracking (fatigue), joint faulting, transverse joint deterioration, and longitudinal joint spalling; these are then used to estimate the present serviceability rating.

For PRS to offer the greatest benefits, the incorporated performance-prediction modes must be accurate. Consequently, research is needed to evaluate the models' abilities to predict distresses, and where necessary to make adjustments in the models so as to ensure better predictions.

Work Plan

- ***Task 1:*** Design and develop a comprehensive database.
- ***Task 2:*** Using the database, validate and/or make improvements to the distress-prediction models currently used in the prototype.
- ***Task 3:*** Develop guidelines and make recommendations to assist in establishing when and how to adjust, or develop further distress-prediction models that may better reflect local conditions.

STARTED	November 1997
EXPECTED COMPLETION DATE	May 1999
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	$218,038

For more information about this project, contact Mr. Peter Kopac, Federal Highway Administration, at (703) 285-2432.

Project Title: *Design, Construction, and Rehabilitation of Continuously Reinforced Concrete Pavements*

Investigator(s): PCS/Law Engineering, Beltsville, MD

Objectives

The objective of this research is to conduct field investigations and laboratory testing to evaluate the effect of new design features and different rehabilitation treatments on continuously reinforced concrete (CRC) pavement performance.

Description

Scope: 25 test sections were evaluated in six states: Illinois, Iowa, Oklahoma, Oregon, Pennsylvania and Wisconsin. Field data collection included: visual condition surveys, nondestructive deflection testing, profile measurement, corrosion testing, coring and shallow borings, determination of steel location, and photographic imaging. A primary focus of this study was to identify the critical factors that influence crack spacing in CRC pavements.

Background: Over the years, many highway agencies have conducted research to develop better understanding of the effects of various design and construction features on the performance of CRC pavements. A large number of these studies have focused on pavement thickness, concrete aggregate type, amount of steel reinforcement, and base/subbase type. Studies also have been conducted to address the benefits of epoxy-coated reinforcement and the effectiveness of permeable treated base layers.

Work Plan

- ***Task 1:*** Conduct a literature review and prepare an annotated bibliography.
- ***Task 2:*** Conduct a field investigation and laboratory testing related to in-service pavement sections.
- ***Task 3:*** Evaluate the effectiveness of various maintenance and rehabilitation strategies.
- ***Task 4:*** Prepare a final report.

STARTED	October 8, 1990
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	$248,075

For more information about this project, contact Mr. Jim Sherwood, Federal Highway Administration, at (703) 285-2619.

Project Title: *Early and Long Term Effects of Curling and Warping on Jointed Concrete Pavement*

Investigator(s): Don Janssen, University of Washington

Objectives

The objectives of this research are to: 1) determine the magnitude and location of maximum and critical stresses and deformation developed in jointed rigid pavements as a result of temperature, moisture, shrinkage and creep effects; and 2) develop recommendations for jointed concrete pavement analysis, design and construction to maintain the combined stresses below critical levels (those at which distress or damage to the pavement will occur) in the immediate post-construction period as well as over the long term.

STARTED	January 1995
EXPECTED COMPLETION DATE	July 1997
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	$610,403

For more information about this project, contact Dr. Steve Forster, Federal Highway Administration, at (703) 285-2073.

Project Title: *Mechanistic-Based Airport Pavement Design Concepts/Procedures*

Investigator(s): Barenberg, Thompson and Tutumluer, University of Illinois

Objectives

The objectives of this effort are to: 1) review mechanistic-based design procedures and suggest possible approaches to FAA; 2) review the research activities by other investigators associated with the FAA Center of Excellence; 3) ensure that the investigators are aware of the technology needed to support/develop a mechanistic-based design procedure; and 4) assist the research teams in presenting their findings in the best possible format for incorporation into a mechanistic-based design procedure.

Description

Scope: Concrete Pavements - Neural network models are being used to develop algorithms to predict concrete airport pavement responses (strains, deflections and stresses) for an array of slab thicknesses, subgrade support conditions, loading conditions, and joint load transfer efficiencies. More than 30,000 analyses of slabs, under varying loading conditions, slab thicknesses, load transfer efficiencies, and subgrade support, have been run using the ILLI-SLAB computer program.

Background: FAA is responsible for the development of design procedures for airport pavements. While the overall objective of the FAA is to develop a unified approach for design of all airport pavement types, it is apparent there are differences in the behavior and failure mechanisms for concrete and flexible pavement systems. Thus different technology and efforts are required to bring mechanistic-based designs to fruition for these two types of pavement systems.

Work Plan

- ***Task 1:*** Develop algorithms to assess the effect of joint conditions on a pavement's response to aircraft loading.
- ***Task 2:*** Review the research activities of other researchers at the FAA Center of Excellence.

STARTED	N/A
EXPECTED COMPLETION DATE	N/A
SPONSORING ORGANIZATION(S)	Federal Aviation Administration
FUNDING	Information not available

For more information about this project, contact Dr. Barry Dempsey, Federal Aviation Administration's Center of Excellence for Airport Pavement Research, at (217) 893-0705.

Project Title: *Relationship Between Joint Performance and Geometric and Mechanical Properties of Concrete Joints*

Investigator(s): Hawkins, Barenberg and Lange, University of Illinois

Objectives

The primary objective of this study is to determine the factors that affect the joint behavior and performance in concrete pavements.

Description

Scope: This investigation is focusing on the behavior and performance of joints at both the micro and macro levels. The micro level refers to joint roughness and joint geometry and how they affect shear strength and load transfer efficiency across the joints. Macro level refers to the interaction between load, slab support, and joint configuration and the effect of these parameters on joint performance.

Parameters to be evaluated are: 1) Effect of aggregate size, type and hardness; 2) Effect of crack width; 3) Effect of normal stresses across the joint; 4) Age of concrete when the crack for the joint is formed; 5) Procedures and devices to improve joint performance.

Work Plan

- ***Task 1:*** Determine the levels of stress that are anticipated at joints.
- ***Task 2:*** Develop laboratory procedures and equipment to evaluate those factors affecting joint performance.
- ***Task 3:*** Evaluate the various parameters using the established procedures and equipment.

STARTED	April 1995
EXPECTED COMPLETION DATE	October 1999
SPONSORING ORGANIZATION(S)	Federal Aviation Administration
FUNDING	$185,000 to date $150,000 future (estimated)

For more information about this project, contact Dr. Barry Dempsey, Federal Aviation Administration's Center of Excellence for Airport Pavement Research, at (217) 893-0705.

Project Title: *Correlation of Subgrade k Value to Elastic Modulus and Other Soil Properties for Use in Rigid Airport Pavement Design*

Investigator(s): M. Darter and K. T. Hall, University of Illinois

Objectives

The objective of this research is to develop recommendations for selection of subgrade inputs for rigid pavement designs, based on sound correlations between k values, soil types and properties, and subgrade elastic moduli.

Description

Background: The FAA design procedure for rigid pavements is based on subgrade characterization by a modulus of subgrade reaction (k value). Among the issues which should be examined in selecting appropriate k value inputs for modern rigid airport pavement design are: (1) how well does the k value obtained from the standard test method represent the response of the subgrade under a modern rigid airport pavement to a load applied over a fairly large area by rapidly moving aircraft gear; and (2) how can k value be related to material properties such as Young's (elastic) modulus so that if design is done using an elastic modulus to characterize the subgrade, the responses of a jointed concrete pavement at joints and corners will be realistic?

Work Plan

- ***Task 1:*** Review existing correlations between k value and other subgrade properties and tests.
- ***Task 2:*** Examine additional available data from sources such as the U.S. Air Force, the Corps of Engineers Waterways Experiment Station, and the Long Term Pavement Performance Study of the Strategic Highway Research Program.
- ***Task 3:*** Use computer modeling to examine the effect of subgrade characterization on pavement responses and to verify k value/ E modulus correlations.
- ***Task 4:*** Prepare a final report.

STARTED	
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	Federal Aviation Administration
FUNDING	Information not available

For more information about this project, contact Dr. Barry Dempsey, Federal Aviation Administration's Center of Excellence for Airport Pavement Research, at (217) 893-0705.

Project Title: *Stabilized Base Materials*

Investigator(s): Thompson, Young, and Lange, University of Illinois

Objectives

The objective of this research is to identify and evaluate the most current, emerging, and new technologies that relate to stabilized base material use in airport pavements.

Description

Background: The Federal Aviation Administration is responsible for the development and maintenance of "Standards for Specifying Construction of Airports" and airport pavement design procedures. The current pavement design procedures require stabilized base and subbase for new pavements designed to accommodate aircraft weighing over 100 kips. Stabilized material thicknesses are established by applying "Equivalency Factors" to convert granular subbase or base thicknesses to "stabilized material" thickness.

Frequently used cementitiously stabilized materials are cement-treated materials (aggregates and soils; mix-in-place and plant mix) and pozzolanic-stabilized materials (PSM). Roller-compacted concrete also has potential applications in airport pavement construction.

The FAA movement toward the use of mechanistic-based design (LEDFAA) and the arrival of new and heavier aircraft has accentuated the need to review and evaluate the appropriate role and effective utilization of stabilized materials in airport pavements.

Work Plan

- ***Task 1:*** Update the recent state-of-the-art summary M-E Thickness Design for High Strength Stabilized Base (HSSB) prepared in the NCHRP 1-26 Project.
- ***Task 2:*** Document the use of stabilized bases in airport projects.
- ***Task 3:*** Identify technological inadequacies and deficiencies; suggest appropriate research and development efforts for inclusion in current and future COE projects.
- ***Task 4:*** Develop suggested procedures and methodologies for incorporating/integrating stabilized base data into the FAA specifications and mechanistic-based airport pavement design procedure.
- ***Task 5:*** Prepare a consolidated state-of-the-art summary report on the engineering properties and characteristics of high strength stabilized bases.

STARTED	
EXPECTED COMPLETION DATE	
SPONSORING ORGANIZATION(S)	Federal Aviation Administration
FUNDING	Information not available

For more information about this project, contact Dr. Barry Dempsey, Federal Aviation Administration's Center of Excellence for Airport Pavement Research, at (217) 893-0705.

Project Title: *Structural Behavior and Modeling of Airport Pavement Systems*

Investigator(s): Dodds, Hjelmstad, Parsons and Pecknold, University of Illinois

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this research is to develop three-dimensional finite element models that describe the behavior of interfaces encountered in pavements.

Description:

Scope: This study will involve: (1) modeling the resilient response of granular materials, (2) studying wheel load interaction through three-dimensional finite element analysis, (3) generating efficient three-dimensional finite element meshes and computing nodal loads for arbitrary wheel placement, and (4) application of infinite elements in the numerical analyses of multilayered pavement systems.

Background: The behavior of granular materials used in pavements under repeated loadings has been an important subject for pavement researchers. Constitutive relations such as K-0 and Uzan-Witzcak models have been developed for these materials. These two material models are based on the generally accepted assumption that granular materials behave elastically after they undergo significant permanent deformations at early stages of their service life caused by repeated loading and compaction during construction. To conveniently describe the nonlinear elastic behavior of the materials the concept of "resilient modulus," which is defined as the ratio of the deviator stress to the recoverable axial strain, has been proposed and used.

Work Plan

- ***Task 1:*** Conduct a literature review.
- ***Task 2:*** Conduct 3-D finite element analyses of a pavement section with three different constitutive models to assess the amount of interaction between wheel loads.
- ***Task 3:*** Evaluate the models' accuracy in predicting the actual behavior of granular materials.
- ***Task 4:*** Develop a new, constitutive model for predicting behavior of granular materials.
- ***Task 5:*** Calibrate the model using triaxial resilient data and compare predicted strains to applied stresses.

For more information about this project, contact Dr. Barry Dempsey, Federal Aviation Administration's Center of Excellence for Airport Pavement Research, at (217) 893-0705.

Project Title: *Advanced Airport Pavement Design Methodologies*

Investigator(s): Federal Aviation Administration

Objectives

The objective of this research is to devise new design procedures that can accurately consider pavement responses to landing gear loads and will better predict service lives of designed pavements.

Description

Scope: Full-scale testing data will be obtained form the National Airport Pavement Test Machine. Finite element methods will be used to model layered pavement structures. This effort will consist of the following five projects:

1) Finite Element Modeling of Rigid Pavement Structures
2) Joint Modeling of Rigid Pavements
3) Modeling of Layer Interfaces
4) In-Service Behavior of Stabilized-Base Materials
5) Modeling Requirements of Pavement Materials in Cold Regions

Background: New design procedures are needed to support the introduction of new generation aircraft, including the Boeing 777. These new, very heavy aircraft, weighing 1.3 million pounds or more, have complex gear configurations and high gear loads. The effects of the 777 and other modern heavier aircraft on pavement performance must be considered in the design and rehabilitation of pavements at major airports.

Current airport pavement designs are very much the result of extrapolating and cobbling together of empirical methods of highway engineering origins. These current design and evaluation methodologies are not adequate for determining wheel-interactions and analyzing the pavement responses required to design airport pavements for the new generation of commercial aircraft.

Work Plan

- ***Task 1:*** Use the National Airport Pavement Test machine to conduct accelerated full-scale testing on pavements.
- ***Task 2:*** Using finite element analysis methods, model the layered pavement structures so that specific features of airport pavements can be explicitly analyzed.

STARTED	1996
EXPECTED COMPLETION DATE	2006
SPONSORING ORGANIZATION(S)	Federal Aviation Administration
FUNDING	Information not available

For more information about this project, contact the Federal Aviation Administration at (609) 435-6967.

Project Title: *Runway Pavement Instrumentation at Denver International Airport*

Investigator(s): Federal Aviation Administration

Objectives

The objective of this research is to study the in-situ response and performance of portland cement concrete pavements located at the Denver International Airport (DIA).

Description

Scope: In 1992, the U.S. Army Corps of Engineers Waterways Experiment Station, under contract to FAA, instrumented several pavement slabs in the take-off area of a runway at DIA during construction. A total of 460 sensors were installed in the various layers of the pavement structure. An elaborate data acquisition system was put in place to control the sensors and to perform data collection.

Remote access was established in 1994. Data collection will be continued during the coming years.

Background: A better understanding of in-situ behavior of airport pavements under operational conditions is one of the critical elements in the development of improved design methodologies, new pavement materials, advanced construction techniques, and better maintenance procedures.

Work Plan

- ***Task 1:*** Instrument slabs.
- ***Task 2:*** Collect data on real-time pavement response to actual aircraft traffic, environmental parameters, and weather conditions.
- ***Task 3:*** Conduct periodic pavement inspections and measure deflection using a falling weight deflectometer.

STARTED	1992
EXPECTED COMPLETION DATE	
SPONSORING ORGANIZATION(S)	Federal Aviation Administration
FUNDING	Information not available

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *Evaluation/Characterization of Airport Pavements Using Impact-Echo and Spectral Analysis of Surface Waves*

Investigator(s): Henrique L.M. dos Reis, University of Illinois

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this research is to develop a scanning instrument capable of scanning airport pavements to evaluate layer thicknesses, material properties, segregation in asphalt concrete, damage accumulation and other defects, such as delaminations.

Description

Scope: Ongoing efforts are being directed towards the development of a fully automated feature pavement scan instrument to carry out nondestructive testing and evaluation (NDT&E) measurements of airport pavements.

Background: The impact-echo technique is based upon a simple concept: a mechanical impact is generated on the surface of the test object, and the surface displacement close to the impact point is measured. The stress waves, which propagate into the object, undergo multiple reflections between the test surface and the internal defects of the opposite boundary of the test object. By monitoring the surface displacements caused by the arrival of the multiple reflections (echoes), the depth of the reflecting surface can be determined.

The spectral analysis of surface waves (SASW) technique is based on the principle that the various wavelength components in the impact-generated surface wave penetrate to different depths in the layered pavements. By monitoring the surface motion at two points at known distant apart, information is extracted about the velocity of the various wavelength components which can then be used to infer the material properties of the different layers including the stiffness profiles of the pavement.

Acousto-ultrasonics is an analytical ultrasonic NDE technique, which measures the relative efficiency of energy transmission in the specimen.

For more information about this project, contact Dr. Barry Dempsey, Federal Aviation Administration's Center of Excellence for Airport Pavement Research, at (217) 893-0705.

Project Title: *National Airport Pavement Registry*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this project is to develop a database that registers all newly constructed airport pavements supported by the Federal Aviation Administration under the Airport Improvement Program (AIP) funds.

Description

Scope: An industrial advisory committee will be formed to advise the FAA on information required to be registered in the database.

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *Subgrade Evaluation for Airport Pavement Design*

Investigator(s): Thompson and Tutumluer, University of Illinois

Sponsoring Organization(s): Federal Aviation Administration

Objectives:

The objectives of this research are to: 1) develop improved and/or new procedures for establishing modulus/strength inputs (including subgrade design criteria) for subgrade soils and granular base and subbase materials, for use in mechanistic-based airport pavement design; and 2) establish concepts and procedures for effectively considering "subgrade stability" in airport pavement construction operations.

Description:

Background: Subgrade soil and granular base/subbase evaluation is an important part of airport pavement design. Moduli and strength are of major concern. Soil and granular material layer moduli are important inputs to elastic layer pavement (ELP) programs such as the LEDFAA procedure (JULEA ELP) and stress-dependent finite element programs like ILLI-PAVE. Those programs such as ILLI-PAVE that can accommodate material failure criteria (e.g. Mohr-Coulomb) also require strength inputs. Some subgrade design criteria are based on modulus (like LEDFAA and Corps of Engineers) or strength (like the University of Illinois' Subgrade Stress Ratio approach) parameters.

Work Plan

- ***Task 1:*** Conduct a literature review.
- ***Task 2:*** Develop nonlinear characterization models to predict the cross-anisotropic behavior observed in granular materials.
- ***Task 3:*** Incorporate the granular base model into the GT-PAVE structural analysis program.

For more information about this project, contact Dr. Barry Dempsey, Federal Aviation Administration's Center of Excellence for Airport Pavement Research, at (217) 893-0705.

Project Title: *Constitutive Modeling of Concrete for Airport Pavements*

Investigator(s): S.P. Shah and J.S. Popovics, Northwestern University

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this research is to develop a fatigue damage based biaxial (tension-torsion) constitutive model of concrete in airport pavements

Work Plan

- ***Task 1:*** Conduct tests on hollow cylindrical specimens to establish the validity of the proposed test approach with regard to specimen mounting, the closed-loop loading system, the data measurement and acquisition system, and the applied nondestructive tests.
- ***Task 2:*** Use established method to test full-scale concrete specimens.

For more information about this project, contact Dr. Barry Dempsey, Federal Aviation Administration's Center of Excellence for Airport Pavement Research, at (217) 893-0705.

Project Title: *Nondestructive Evaluation of Airport Pavements*

Investigator(s): J.D. Achenbach and J.S. Popovics, Northwestern University

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objectives of this research are: (1) development of a device(s) which generates repeatable and controllable ultrasound/sound signals in pavement structures; (2) development of a method(s) to efficiently receive signals consistent with and sensitive to the generated ultrasound/sound; (3) development of a technique for the determination of the extent of cracking at contraction joints in rigid airport pavements; (4) development of a technique for characterization of individual layer properties within rigid and flexible airport pavement systems; and (5) development of a technique for nondestructive characterization of layer interfaces within rigid and flexible airport pavement systems.

Description

Scope: The method for nondestructive, one-sided wave velocity determination in concrete is to be refined. The modified approach compensates for two problems commonly encountered with ultrasonic testing of concrete: high coherent noise levels in the signal and material signal dispersion of the propagating waves. The entire procedure of data acquisition, manipulation, and presentation is to be performed by a computer program.

Background: Airport pavements suffer damage as a result of service loads. The new generation of commercial aircraft is expected to intensify this problem because of increased payloads and tighter landing gear configurations. It is important that damage be detected and characterized in a timely and reliable fashion. The use of ultrasonic and sonic nondestructive evaluation (NDE) methods enables inspection deep within the pavement, and offers direct and quick information on the elastic moduli, or other constitutive parameters, and the presence of flaws.

For more information about this project, contact Dr. Barry Dempsey, Federal Aviation Administration's Center of Excellence for Airport Pavement Research, at (217) 893-0705.

Project Title: *SHRP Products for Airport Pavements*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this project is to evaluate the Strategic Highway Research Program (SHRP) products and to assess their applicability to airport pavements.

Description

Background: The federally funded Strategic Highway Research Program (SHRP) has produced a series of specifications, tests, guidelines, and technologies that are directed at highway pavement applications. Although the SHRP products have been derived from highway-oriented research, they may be of value in airport pavement applications as well.

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *Airport Pavement Performance Study*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this project is to study the performance of airport pavements.

Description

Scope: Information on different types of distresses in airport pavements is being collected and then analyzed against design specifications. Critical areas that significantly influence airport pavement performance will be further investigated.

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *Roughness Criteria for Airport Pavements*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this project is to determine and improve profile characteristics of runways and taxiways in order to obtain and maintain roughness levels acceptable for aircraft.

Description

Scope: Specific tasks consist of: tracking runway roughness changes over time, development of a runway profile index (RPI), determining practical roughness criteria, and performing simulations.

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *Airport Pavement Evaluation Techniques*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this project is to investigate the state-of-the-art nondestructive evaluation techniques currently being utilized in the field for evaluating airport pavements, to provide a thorough review of existing techniques, and to identify new technologies to develop better nondestructive testing (NDT) for airport pavement evaluations.

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *Material Models for Cold Regions*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this project is to provide a critical review of existing material models that are either being used or having the potential to be applied to the design of airport pavements. With the review results available, the Federal Aviation Administration will assess the applicability of these material models for incorporating into airport pavement design guidelines.

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *Drainage Layer Study at Kansas City International Airport*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this project is to investigate the performance of a drainage layer in an airport pavement at the Kansas City International Airport (KCI).

Description

Scope: Instruments have been installed in a pavement drainage layer on a runway section at KCI airport. Data will be collected to learn more about drainage layer performance.

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *ACN/PCN Calculations*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objectives of this research are to: 1) conduct critical reviews of current procedures in computing the Aircraft Classification Number (ACN) and Pavement Classification Number (PCN); and 2) based on the review results, establish a technical approach for the development of better computational techniques.

For more information about this project, contact the Federal Aviation Administration at (609) 435-6967.

Project Title: *Synthesis of Information Related to Highway Problems—Pavement Subsurface Drainage Systems (Synthesis No. 239)*

Investigator(s): Barry R. Christopher, Roswell, Georgia

Objectives

In the NCHRP Synthesis program, particular highway problems, or sets of closely related problems, are designated as topics for information synthesis. The objective is to summarize in a document, the state-of-the-art knowledge about the topic, including: what has been learned from experience, what engineering practices are being used, what research has been done, what problems remain unsolved, and what recommendations should be made.

Description

Scope: This synthesis will document the state of the practice in pavement subsurface drainage. It will summarize the current research completed or underway. It will also provide performance information available on drainage systems and their impact on pavement life.

Background: This synthesis will update and supplement Synthesis 96 of the same title. There has been significant activity in subsurface drainage in the areas of design, construction, and maintenance since the previous report was printed in 1982. Most states are routinely using some form of positive subsurface drainage to extend pavement life.

Work Plan

- ***Task 1:*** Locate and assemble documented information.
- ***Task 2:*** Learn what engineering practice has been used for solving or alleviating the problem.
- ***Task 3:*** Identify all ongoing research.
- ***Task 4:*** Learn what problems remain largely unsolved.
- ***Task 5:*** Organize, evaluates and document the useful information that is acquired.
- ***Task 6:*** Evaluate the effectiveness of the synthesis after it has been in the hands of its users for a period of time.
- ***Task 7:*** Prepare the final synthesis document.

STARTED	September 1, 1993
EXPECTED COMPLETION DATE	April 30, 1997
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	Information not available

For more information about this project, contact Mr. Crawford F. Jencks, NCHRP, at (202) 334-2379.

Project Title: *Determination of Pavement Damage from Super-Single and Singled-Out Dual Truck Tires (Project 1-36)*

Investigator(s): Peter E. Sebaaly, University of Nevada, Reno

Objectives

The primary objective of the research is to develop a procedure to estimate pavement damage associated with the use of single-tire configurations compared with that of conventional dual-tire configurations. The research will also seek to identify technical and regulatory approaches for controlling pavement damage from single-tire use.

Description

Background: The use of super-single tires and the practice of removing one tire from a conventional dual tire configuration, known as singled-out dual tires, have increased in recent years, primarily because of their favorable effects on a truck's tare weight and rolling resistance. Single-tire configurations have different widths, pressures, and footprint dimensions than do conventional dual tires.

Although research has shown that pavement deflections caused by single-tire configurations are higher than those caused by conventional dual-tire configurations, it has not provided clear conclusions concerning the extent of pavement damage or the measures needed to limit such damage. Research is needed to address the effects of using single-tire configurations on pavement damage and to identify possible approaches for controlling pavement damage.

Work Plan

- ***Task 1:*** Review relevant literature, research findings, performance data, state regulations, and current practices relative to the use of super-single and singled-out dual tires.
- ***Task 2:*** Determine the prevalence of super-single and singled-out dual tires in single- and multi-axle configurations; estimate future trends.
- ***Task 3:*** Identify and evaluate analytical procedures to compare the distress caused by super-single and singled-out dual tires to that caused by dual tires. Recommend procedures that merit further development and evaluation.
- ***Task 4:*** Further develop and assess the suitability of the procedures.
- ***Task 5:*** Develop a procedure for estimating and comparing the damage caused by single-tire configurations to that caused by conventional dual-tires.
- ***Task 6:*** Identify materials, design, and construction approaches that should be considered to control pavement damage resulting from single-tire use.
- ***Task 7:*** Submit a final report.

STARTED	November 1, 1996
EXPECTED COMPLETION DATE	July 31, 1999
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$400,000

For more information about this project, contact Dr. Amir N. Hanna, NCHRP, at (202) 334-1892.

Project Title: *Guide for Pavement Management (Project 1-35A)*

Investigator(s): Contract Pending

Objectives

The objective of this research is to develop a Guide for Pavement Management that discusses technologies and processes pertaining to selection, collection, reporting, management, and analysis of data used in pavement management.

Description

Scope: Because much of the material needed for Guide development is currently available, the work will focus on compiling, reviewing, and documenting relevant information.

Background: Most highway agencies are now engaged in the development, implementation, and operation of pavement management systems. The Guidelines for Pavement Management Systems, published by AASHTO in July 1990, contains information needed for establishing a framework for a pavement management system. However, this document does not address the day-to-day issues encountered by pavement engineers or the issues associated with new and emerging technologies. Thus, there is a need to develop a comprehensive Guide for Pavement Management that documents the state of the practice and identifies state-of-the-art technologies and processes applicable to pavement management systems. Such a guide will help engineers to effectively manage the investment in pavements and achieve the best possible value for the public dollar.

Work Plan

- ***Task 1:*** Review literature, research, and current practices relative to pavement management to identify the issues involved in the development, implementation, and operation of pavement management systems, and to obtain the information needed to develop the Guide.
- ***Task 2:*** Develop a draft version of each Guide chapter.

STARTED	November 1997
EXPECTED COMPLETION DATE	May 1999
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$200,000

For more information about this project, contact Dr. Amir N. Hanna, NCHRP, at (202) 334-1892.

Project Title: *Performance of Subsurface Pavement Drainage (Project 1-34)*

Investigator(s): Michael Darter, ERES Consultants, Inc., Champaign, Illinois

Objectives

The objective of this research is to develop guidelines to enable designers to consider the effect of subsurface drainage on pavement performance.

Description

Scope: The project will investigate the effectiveness of (1) subsurface drainage of surface-infiltration water, (2) bases (permeable and dense-graded), (3) edge drains, and (4) retrofit subsurface drainage on the performance of pavements.

Background: Little has been done to assess the performance of pavements that incorporate various subsurface drainage systems in new roadway designs or in retrofits of existing pavement structures.

State transportation agencies need to have performance data that quantify the additional pavement life to be gained from the installation of pavement drainage systems.

Design guidelines based on performance data are needed to estimate the additional pavement life gained from a new or retrofit installation of a pavement drainage system.

Work Plan

- ***Task 1:*** Evaluate information on the design and performance of pavements with subsurface pavement-drainage systems.
- ***Task 2:*** Select appropriate pavement- performance criteria for evaluating drainage effectiveness.
- ***Task 3:*** Design a comprehensive database. Identify data items and determine the existence of data or the potential to obtain data. Collect representative data and verify its usefulness through site visits.
- ***Task 4:*** Collect data and any pertinent information necessary to complete the database.
- ***Task 5:*** Determine the relationship between subsurface drainage of surface-infiltration water and improved pavement performance.
- ***Task 6:*** Develop a detailed process to conduct a life cycle cost analysis of subsurface pavement drainage.
- ***Task 7:*** Produce guidelines based on performance data.
- ***Task 8:*** Develop an implementation plan.
- ***Task 9:*** Prepare a final report.

STARTED	May 15, 1995
EXPECTED COMPLETION DATE	March 14, 1998
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$499,985

For more information about this project, contact Mr. Edward T. Harrigan, NCHRP, at (202) 334-3232.

Project Title: *Systems for Design of Highway Pavements (Project 1-32)*

Investigator(s): Michael I. Darter, ERES Consultants, Inc.

Objectives

The objectives of this research are (1) to evaluate the feasibility of developing a comprehensive catalog of recommended design features for both flexible and rigid pavements, and a corresponding prototype expert system; and (2) if feasible, to develop such a catalog and expert system.

Description

Background: A rational pavement design must consider the effects of soil, climate, traffic loading, construction materials, and other design details and features on pavement performance and life-cycle costs. The objective of the design is to identify pavement structures that will provide acceptable performance and economy over the intended design life. However, the AASHTO Pavement Design Guide does not provide specific recommendations for many design features.

A catalog that identifies recommended design features for pavements would help designers. Supplementing such a catalog with a microcomputer-oriented, knowledge-based expert system would further enhance the catalog's use and facilitate its updating.

Work Plan

- ***Task 1:*** Identify the parameters and site conditions necessary to characterize current design features for both flexible and rigid pavements.
- ***Task 2:*** Survey highway agencies and compile a summary of current design features.
- ***Task 3:*** Evaluate the feasibility of producing a catalog of recommended design features.
- ***Task 4:*** Establish recommendations for each cell in the factorial matrix.
- ***Task 5:*** Prepare a Catalog of Recommended Pavement Design Features.
- ***Task 6:*** Develop a prototype microcomputer-oriented, knowledge-based expert system for selecting the recommended design features.
- ***Task 7:*** Recommend a plan for extending the prototype expert system into an operational system through implementation, evaluation, and validation.
- ***Task 8:*** Prepare a final report.

STARTED	February 1, 1994
EXPECTED COMPLETION DATE	May 30, 1997
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$500,000

For more information about this project, contact Dr. Amir N. Hanna, NCHRP, at (202) 334-1892.

Project Title: *Synthesis of Information Related to Highway Problems—User and Mitigation Costs in Highway Projects (Synthesis Topic 27-12)*

Investigator(s): David L. Lewis, Hickling Lewis Brod, Inc., Silver Spring, MD

Objectives

In the NCHRP Synthesis program, particular highway problems, or sets of closely related problems, are designated as topics for information synthesis. The objective is to summarize, in a document, the state-of-the-art knowledge about the topic, including: what has been learned from experience, what engineering practices are being used, what research has been done, what problems remain unsolved, and what recommendations should be made.

Description

Scope: This synthesis will consider design, construction, and maintenance elements of life-cycle costs evaluation. The synthesis will include case examples (urban and rural) of how user costs and the costs of mitigation have been applied to evaluating alternatives. The investigation will include factors such as uncertainty, why the particular approach was selected, the political factors that may have influenced the decision, and how quality control contributed to the process.

Background: User costs and the cost of mitigation measures to avoid them are key components in determining life-cycle cost estimates for pavement design and construction alternatives.

Work Plan

- ***Task 1:*** Locate and assemble documented information.
- ***Task 2:*** Learn what engineering practice has been used for solving or alleviating the problem.
- ***Task 3:*** Identify all ongoing research.
- ***Task 4:*** Learn what problems remain largely unsolved.
- ***Task 5:*** Organize, evaluates and document the useful information that is acquired.
- ***Task 6:*** Evaluate the effectiveness of the synthesis after it has been in the hands of its users for a period of time.
- ***Task 7:*** Prepare the final synthesis document

STARTED	September 28, 1995
EXPECTED COMPLETION DATE	September 30, 1997
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	Information not available

For more information about this project, contact Mr. Crawford F. Jencks, NCHRP, at (202) 334-2379.

Project Title: *Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures (Project 1-37 and 1-37A)*

Investigator(s): Phase I (1-37) — R. Gary Hicks, Nichols Consulting Engineers, Chtd.;
Phase II (1-37A) — contract pending

Objectives

The objectives of this project are to: (1) develop a document and associated software for adoption by AASHTO as the 2002 AASHTO Guide for Design of New and Rehabilitated Pavement Structures; (2) work to facilitate AASHTO approval and user implementation; and (3) develop a plan to support use of the guide.

Description

Scope: This project will initiate the process of developing the 2002 Guide. Information that will be incorporated and the topics that need adjustments will be identified. Appropriate language for use in the Guide will be developed. Improvements that require a major research effort will not be appropriate for the 2002 Guide.

Background: The AASHTO Guide for the Design of Pavement Structures is the most widely used method for design of new and rehabilitated highway pavements. Because mechanistic approaches more realistically characterize in-service pavements and improve the reliability of designs, it is expected that the next generation of design methodologies will rely heavily on mechanistic principles. However, because of the gaps that exist in what is known about how mechanistic response parameters (e.g. stress, strain, deflection) relate to observable pavement performance indicators (serviceability and distress), mechanistic design methods need to be supported by empirical relationships. Many of the issues relating to the mechanistic-empirical approach need to be better defined before practical and realistic design procedures can be developed and put into use.

Work Plan

- ***Task 1:*** Review the current AASHTO Guide for Design of Pavement Structures and recommend changes in format, content, presentation, and other matters.
- ***Task 2:*** Review relevant literature and research, and monitor ongoing research activities. Identify critical issues that must be resolved to develop and implement a mechanistic-empirical approach.
- ***Task 3:*** Develop an action plan to address issues.
- ***Task 4:*** Develop a plan for implementation, training, and related activities.
- ***Task 5:*** Write an initial draft of the proposed 2002 Guide and related software by July 1, 1999.
- ***Task 6:*** Deliver a second draft of the proposed 2002 Guide and associated software by March 1, 2000.
- ***Task 7:*** Deliver a final draft of the proposed 2002 Guide by September 1, 2000.

STARTED **PHASE I (1-37)**	December 20, 1996
PHASE II (1-37A)	1998
EXPECTED COMPLETION DATE	
PHASE I (1-37)	July 31, 1997
PHASE II (1-37A)	December 31, 2001
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$325,489-Phase I

For more information about this project, contact Dr. Amir Hanna, NCHRP, at (202) 334-1892.

Project Title: *Methodology to Improve Pavement-Investment Decisions (Project 1-33)*

Investigator(s): A. T. Papagiannakis, Washington State University, Pullman, Washington

Objectives

The objective of this research is to develop a methodology, which may be integrated into pavement management systems, to improve pavement investment decisions.

Description

Scope: A pavement investment decision should consider, for all classes of vehicles, costs: 1) related to the pavement itself, 2) from delays caused by reconstruction and maintenance, 3) associated with cargo damage, and 4) associated with driver comfort.

Background: Pavement investment strategies must consider both user and agency measures of pavement quality. Conventional user-oriented measures of pavement serviceability are based on automobile occupant reaction to pavement condition. Such measures do not reflect the full range of vehicle classes, and their relationship to user costs is not well defined.

A more useful measure would incorporate both pavement condition and user costs for all vehicle classes. User costs consist of vehicle-operating costs for the full range of vehicle classes, costs of delays due to construction, costs of transporting goods over the full spectrum of pavements, and costs attributable to driver and passenger discomfort.

Transportation agencies normally monitor and evaluate the condition, performance, structural capacity, and maintenance costs of their pavements in assessing pavement needs.

Research is needed to develop an improved methodology that incorporates user costs, condition measures, and agency inputs

Work Plan

- ***Task 1:*** Review, evaluate and summarize current methodologies used for pavement investment decisions and identify sources of related data.
- ***Task 2:*** Develop a conceptual methodology that incorporates a full range of user costs for all classes of vehicles and for a full spectrum of pavements in the United States.
- ***Task 3:*** Identify all necessary data, data sources and gaps in the data. Collect representative data and evaluate the availability and integrity of the data.
- ***Task 4:*** Collect data to complete the database.
- ***Task 5:*** Develop and test the methodology.
- ***Task 6:*** Develop an implementation plan to use in incorporating the results into practice. Provide a manual containing procedures, software, and examples.
- ***Task 7:*** Submit a final report.

STARTED	July 1, 1995
EXPECTED COMPLETION DATE	June 30, 1998
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$499,800

For more information about this project, contact Dr. Amir N. Hanna, NCHRP, at (202) 334-1892.

Project Title: *Long-Life Rigid Pavement Project*

Investigator(s): California Department of Transportation

Objectives

The objectives of this research are to evaluate the performance of specific fast-setting hydraulic cement concrete products for possible use in rehabilitating heavily traveled urban freeways, and to develop design parameters and procedures required for implementation of the fast-setting longer life pavements demanded by current reconstruction needs.

Description

Scope: Accelerated pavement testing is viewed as a stepping stone from laboratory and analytical methods to field performance. A Heavy Vehicle Simulator (HVS) unit will be used to test the fast-setting concrete.

Background: The congestion created when utilizing conventional rehabilitation strategies for rigid pavements in urban areas is unacceptable due to user delays. User delays in urban areas play a major role in the evaluation of life cycle cost alternatives and are politically challenging for highway agencies. User delay costs can be overriding factors in the evaluation of design and rehabilitation options. The benefit cost ratio for reduced user delays is around 5:1. Highway maintenance and construction activities create safety hazards to both field personnel and the traveling public. A long life pavement has been defined as one that can provide 30 or more years of service life with minimal maintenance efforts.

Through improved materials and enhanced rehabilitation strategies, rigid pavements will become more cost effective. The results from this project will improve the understanding of rigid pavement behavior leading to mechanistic methods.

Work Plan

- ***Task 1:*** Evaluate the production capabilities of contractors and suppliers to see if the production of a high volume of material in a short period of time is achievable.
- ***Task 2:*** Evaluate the rehabilitation process to see if it can be performed within a 60-70 hour construction window. Phases 1 and 2 will be in protected construction zones where normal construction is already being performed.
- ***Task 3:*** Evaluate the performance of the materials and rehabilitation strategies. This phase will consist of laboratory testing, mechanistic analysis and accelerated pavement testing.

STARTED	1997
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	California Department of Transportation
FUNDING	Information not available

For more information about this project, contact Dr. Shakir Shatnawi, Caltrans, at (916) 227-7306.

Project Title: *Determine Initial Cause for Current Premature PCC Pavement Deterioration*

Investigator(s): Scott Schlorholtz, Iowa State University

Objectives

The objectives of this research are to: determine the initial cause of premature deterioration of some portland cement concrete pavements constructed mainly since 1983, and determine the contribution to deterioration from alkali-silica reactivity (ASR) and/or from ettringite expansion.

STARTED	May 1, 1997
EXPECTED COMPLETION DATE	April 30, 1998
SPONSORING ORGANIZATION(S)	Iowa Department of Transportation
FUNDING	$141,762

For more information about this project, contact Mr. Vernon Marks, Iowa Department of Transportation, at (515) 239-1447.

Project Title: *Pooled Fund Study of Premature Rigid Pavement Deterioration*

Investigator(s): Hamlin Jennings, Northwestern University

Objectives

The objective of this research is to conduct a statistical analysis of material and construction variables, and identify those that do and do not contribute to portland cement concrete pavement distress.

STARTED	February 1, 1996
EXPECTED COMPLETION DATE	November 30, 1997
SPONSORING ORGANIZATION(S)	Iowa Department of Transportation
FUNDING	$120,000

For more information about this project, contact Mr. Vernon Marks, Iowa Department of Transportation, at (515) 239-1447.

Project Title: *Durability of Highway Concrete Pavements*

Investigator(s): James R. Clifton, National Institute of Standards and Technology

Objectives

The objective of this research is to identify probable processes responsible for premature deterioration of concrete pavements in Iowa.

Description

Scope: Cores were obtained from seven different pavement locations. The cores will be evaluated in the laboratory by NIST.

STARTED	August 1, 1996
EXPECTED COMPLETION DATE	September 30, 1997
SPONSORING ORGANIZATION(S)	Iowa Department of Transportation Portland Cement Association
FUNDING	$100,000

For more information about this project, contact Mr. Vernon Marks, Iowa Department of Transportation, at (515) 239-1447.

Project Title: *Influence of Special Design Variables Upon Rigid Pavement Performance Regarding Paving Width*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objective of this research is to either confirm or modify the current Minnesota Department of Transportation's practices that restrict rigid paving widths to 36 feet without butt joints.

Description

Scope: This project will be done by comparing the performance of a 40-foot widened-edge design pavement without butt joints to a standard 27-foot widened-edge design.

The work associated with this research project will be carried out at three rigid pavement sections in the 5-year design area of the Minnesota Road Research Project. One section will serve as the control for this study and has a standard 27-foot wide pavement with bituminous shoulders. The second is a section with 40-foot wide rigid paving. The cross section will consist of bituminous shoulders, a 14-foot rigid widened lane, a 12-foot rigid lane, and a 14-foot rigid widened lane that will not be opened to traffic. The non-traffic lane allows traffic and environmental loadings to be evaluated separately.

Tied longitudinal joints will be constructed between lanes. Panels will include supplemental reinforcing steel in the center lane.

The third section will be similar to the second, except it will have no supplemental reinforcing steel. Base design, panel lengths, and dowels are the same for all three test sections.

Background: Current MnDOT practice limits the width of rigid paving to 30 feet without supplemental reinforcement, or 36 feet with supplemental reinforcement steel. Pavements of greater width must be constructed with a longitudinal butt joint. This type of construction often results in separation and faulting at the butt joint.

Because of today's increasing traffic loadings and with proper pavement design, it is believed that three lanes tied together with widened edges are constructable and will perform better.

Work Plan

- ***Task 1:*** Instrument each section with strain gages and temperature sensors.
- ***Task 2:*** Periodically perform visual surveys, measure ride quality and measure joint efficiency using a falling weight deflectometer.
- ***Task 3:*** Conduct a forensic evaluation of the pavement to detect subsurface distress.
- ***Task 4:*** Prepare a final report.

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING*	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Influence of Pavement Variability Upon Reliability Based Pavement Performance Models*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objective of this study is to determine the effect of the variation of each pavement design parameter on the reliability of pavement performance.

Description

Scope: At the Minnesota Road Research Project (MRRP) facility, a well planned testing and sampling program is envisioned for each pavement cell. Because of this, the distribution (mean and variance) of pavement variables will be known. Also, pavement loadings and performance will be known precisely.

This presents an ideal opportunity to correlate the variability in pavement design parameters to the variability in pavement performance. Flexible pavements, rigid pavements, and aggregate surfaces will undergo this statistical scrutiny.

For unreinforced jointed rigid pavements the following pavement design variables influence pavement performance in the AASHTO model:

- Effective modulus of subgrade reaction
- Concrete elastic modulus
- Modulus of rupture of concrete
- Drainage coefficient
- Load transfer coefficient
- Thickness of concrete slab

Background: One of the major changes in the 1986 AASHTO Pavement Design Guide was the introduction of a reliability based analysis procedure. The design level of reliability selected by the Engineer is probably the most significant factor influencing the design, and hence performance of any roadway structure. Design reliability is important because it reflects the collective variability of all pavement design parameters influencing performance.

More control over some appropriate pavement variables will yield more predictable pavement performance and perhaps less control over others will not significantly reduce predictability.

STARTED	1997
EXPECTED COMPLETION DATE	
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Influence of Special Design Variables Upon Rigid Pavement Performance Regarding Contraction Joints*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objective of this research is to identify optimum contraction joint design parameters under in-situ Minnesota roadway conditions. Minnesota Department of Transportation design standards will be modified if they do not reflect the optimum parameters confirmed by this research project. A secondary objective of this research is to develop a method for nondestructive testing of deteriorated contraction joints that will sufficiently characterize their condition so appropriate repair actions can be recommended.

Description

Scope: Low volume road cells with 1-inch dowels and no dowels, as well as ten-year mainline cells with 1.25-inch dowels and 1.5-inch dowels will be the focus of this project. Two outside lane contraction joints in each of the 4 cells will be instrumented. Radar will be used to verify the correct placement of dowels during construction. Ride levels and joint efficiency ratings using the falling weight deflectometer will be measured throughout the life of these sections. At the end of the life of these cells, a forensic evaluation will be performed on the instrumented joints to determine their condition.

Contraction joints in the widened pavement area (5-year mainline) will be monitored visually during their life and at the time of the forensic evaluation for additional information.

Background: The two basic designs used to accomplish vertical load transfer rely on either dowel bars or aggregate interlock. Under ideal conditions, contraction joints are designed to transfer all of the vertical loadings (traffic) and none of the longitudinal (temperature) loadings between rigid pavement slabs.

Unfortunately Minnesota roadway conditions are far from ideal. As a result, the performance of contraction joints diminishes with time. Construction conditions, maintenance operations, weather, and real-world traffic all contribute to the deterioration and possible failure of these joints.

The most pressing performance issue is how to establish and maintain good vertical load transfer so pumping and faulting at contraction joints are minimized.

Work Plan

- ***Task 1:*** Instrument the test sections with strain and pressure gages, and temperature sensors.
- ***Task 2:*** Using radar, verify the correct placement of dowels during construction.
- ***Task 3:*** Periodically measure ride smoothness, and measure joint efficiency using the falling weight deflectometer.
- ***Task 4:*** Prepare a final report

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Development of Vehicle Load Damage Factors for Rigid Pavements*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objective of this research is to provide estimates of rigid pavement damage caused by different vehicle loading systems.

Description:

Scope: This project is to be done by driving vehicles over instrumented pavements and monitoring the reactions to the loads. By knowing the response of the pavement to the load, a mechanistic analysis can be performed to ascertain the effect of the load on pavement life.

The test cells which would be suitable for this project have a variety of design details such as the presence of dowels, panel lengths, and cross-section geometry. Additionally, there are two types of subgrade soils present: an AASHTO A-6 loam and an A-7 clay.

Background: Load equivalency factors provide a means for equating the damage done by various vehicle weights and tire configurations to that of a standard weight and configuration. In the AASHTO pavement design procedure, this is the 18,000-lb equivalent single-axle load (ESAL). This is a single axle with dual tires inflated to 70 psi at a weight of 18,000 pounds.

The ESAL concept originated at the AASHO Road Test where single axles and tandem axles with dual tires were used to load the pavements. In the pavement design process, load equivalency factors were determined as a function of structural capacity and terminal serviceability index. While these are widely used in the design of pavements, there are some deficiencies inherent in them. First, the contribution of different suspension systems cannot be included. Second, the tire type used at the AASHO Road Test was a bias ply tire, and the current trend is toward radial tires, which have different pressure distributions.

The inflation pressure used for the ESAL was 70 psi, while most trucks use about 100 psi today. A dual tire configuration of standard size tires was used in the development of the ESAL; whereas now configurations such as super singles and high-cube (small tires, high pressure) tires are appearing. Lastly, the axle configurations now include tridem axles and drop axles.

STARTED	1990
EXPECTED COMPLETION DATE	
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation Various (Pooled Fund Study)
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Verification of Empirical Design Models for New Rigid Pavements*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objective of this research is to provide data for the validation or modification of the AASHTO and MnDOT design approaches for rigid pavements. The result of this effort will be the possible implementation of the updated design procedures at the state and local level in Minnesota.

Description

Scope: The study will be conducted by monitoring the performance of the portland cement concrete sections at the Minnesota Road Research Project (MRRP) and comparing the actual performance to that predicted by the AASHTO and MnDOT methods.

Subbase materials of various levels of quality will be incorporated into both the mainline and low-volume road experiments. Different schemes for subsurface drainage will be tried on the mainline experiment. The low-volume road will have two types of subgrade materials. There will be different traffic levels for the mainline 5- and 10-year experiments and the low-volume road. The mainline sections will be subjected to the mixed traffic of an actual interstate, and the low-volume road will have fixed traffic of known loads. Surface distress and serviceability will be measured periodically as traffic is applied to the sections. The relationships of these performance measurements to traffic levels and material qualities will be determined through regression analysis.

This testing will also indicate what value of load transfer factor is appropriate for Minnesota conditions.

Background: The 1986 AASHTO Guide for the Design of Pavement Structures and the MnDOT Road Design Manual provide methods for the design of portland cement concrete surfaced roads. These procedures are based on the expected loss of serviceability of the road for a given level of traffic on different quality materials. Over time, changes have been made to the Minnesota design method based on performance observations; however, the basic relationships have been maintained. While it is obvious that changes should be made in the approach to pavement design, engineers have lacked the data to ascertain the effects of traffic changes.

Work Plan

- ***Task 1:*** Take samples of concrete to test the modulus of rupture and modulus of elasticity.
- ***Task 2:*** Using resilient modulus testing, characterize, aggregate subbase and subgrade materials in order to determine the effective composite k-value.
- ***Task 3:*** Measure drainage effectiveness to estimate the coefficient of drainage.
- ***Task 4:*** Conduct nondestructive deflection testing on a periodic basis to understand how changes in material properties affect the performance of rigid pavements.

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Development of Mechanistically Based Design Methods for Rigid Pavements-Minnesota Road Research Project*

Investigator(s): Minnesota Department of Transportation

Objectives

The objective of this research is to develop a mechanistic or empirical-mechanistic design procedure in which physical responses of the roadway are used along with some means of accounting for cumulative damage to the structure. The ultimate goal is to incorporate stochastic processes, such as changes in environmental conditions and traffic loading, into mechanistic analyses of pavement response.

Description

Scope: A range of pavements—from thin concrete surface over dense aggregate subbase to thick PCC surface over an open-graded drainage layer—will be constructed with a variety of design details, such as dowel diameters, paving widths, panel lengths, and cross-section geometry. Traffic levels will vary from light truck traffic to heavy interstate traffic, over a 10-year period. Additionally, there will be two types of subgrade present: loam and clay.

Background: Rigid pavements have historically been designed by quasi-mechanistic means. These approaches are theoretically based on work done by Westergaard and others in the 1920's to the 1940's. Over time, mechanics principles have been integrated into empirical equations. More rational approaches to thickness design are needed to accommodate future changes in traffic conditions and material types. Such approaches should be based on a pavement's physical response as opposed to an empirical relationship.

Work Plan

- ***Task 1:*** Visually survey and measure ride quality periodically.
- ***Task 2:*** Test samples taken during construction to characterize the subgrade, aggregate materials, and concrete mixtures.
- ***Task 3:*** Conduct nondestructive testing with a falling weight deflectometer periodically for backcalculation of layer moduli and joint efficiency calculations.
- ***Task 4:*** Perform instrumentation, with the primary emphasis on measuring temperature and moisture contents.

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Influence of Special Design Variables Upon Rigid Pavement Performance Regarding Cement Type and Content*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objective of this research is to evaluate the differences between different types of cement as related to constructibility, performance, and roughness of the finished pavement.

Description

Scope: The test loops will contain 1850 feet of 12-inch thick reinforced concrete pavement. One loop will be long enough for 3 test sections, each over 600 feet long.

Background: MN/DOT uses high-early strength concrete in PCC pavements where the roadway must be opened for traffic as quickly as possible. The Department's normal procedure for making high-early-strength concrete is to increase the cement content of the standard mix by 30%. The added cement increases the cement-void ratio, cohesiveness, plasticity, and strength, and results in the mix attaining sufficient compressive strength with less cure time. The decreased workability caused by the additional cement is partially compensated for by increasing the water content, which should not be increased more than 5%. The workability of high- early-strength concrete decreases rapidly if it is not placed soon after being mixed. Construction delays during placement sometimes result in concrete being placed with a very low slump, which makes it difficult to achieve sufficient consolidation and a smooth finished surface.

Work Plan

- ***Task 1:*** Samples will be taken of the mixes for modulus of rupture and compressive strength tests.
- ***Task 2:*** Other comparisons will be made by means of the profilometer, visual surveys, and cores.

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Influence of Special Design Variables Upon Rigid Pavement Performance Regarding Aggregate Class*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objective of this research is to evaluate the performance of PCC pavement mixtures with different percentages of Class A and Class B aggregate.

Description

Scope: The test loops will contain 1850 feet of 12-inch thick reinforced concrete pavement. One loop will be long enough for 3 test sections, each over 600 feet long. The PCC mix in one test section will contain all Class A aggregate. Another section will use 50% Class A 3/4+ and 50% Class B 3/4-. The other section will have 35% Class A 3/4+ and 65% Class B 3/4-. All three sections will use Type I cement. Traffic data will be included in the analysis.

Background: Aggregates used in concrete mixtures are classified A through E. Class A is quarried granite, trap rock, or quartzite. Class B is all other quarried rock. Class E is a mixture of two or more of the other classes. Symptoms of D-Cracking have recently been observed in some PCC pavement mixtures containing Class A aggregate and in others with Class E, which in this case is a mixture of Class A 3/4+ and Class B 3/4-.

Work Plan

- ***Task 1:*** Conduct visual surveys of the test sections.
- ***Task 2:*** Take cores of the concrete.
- ***Task 3:*** Prepare a final report.

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Influence of Special Design Variables Upon Rigid Pavement Performance Regarding Joint Spacing*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objective of this research is to compare the performance of unreinforced rigid pavement of various slab lengths having different designs and traffic loadings in a cold environment.

Description

Scope: Unreinforced pavement slab lengths of 12, 15, 20, and 24 feet exist at the Minnesota Road Research Project (MRRP). One of the rigid cells has a 12-foot panel length, five have 15-foot lengths, seven have 20-foot lengths, and one has a 24-foot length.

Visual and ride surveys will be done periodically on the rigid cells in this research project. At the end of the life of an instrumented panel it will be excavated to look for additional signs of distress.

Background: Rigid pavement reinforcing steel is expensive and can corrode causing pavement distress. This corrosion is accelerated in a pavement where a lot of deicing salt is used. One alternative is to use an unreinforced rigid pavement design, but then a shorter joint spacing is required which raises costs. Research is needed to determine what design factors dictate the optimum joint spacing of an unreinforced rigid pavement in a cold environment, and how cost and performance are balanced.

If the optimum joint spacing considerations determined by research are different than existing design standards, Minnesota Department of Transportation standards will be modified or expanded.

Work Plan

- ***Task 1:*** Instrument test sections with strain gages and temperature sensors.
- ***Task 2:*** Conduct visual and ride surveys of all test sections.
- ***Task 3:*** Excavate each section at the end of its service life to look for additional signs of distress.

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Influence of New Vehicle Gear Configurations and Tire Systems on Pavement Performance*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objectives of this study are to: (1) determine the effect of various permitted gear-tire-load systems on pavement structures as part of the development of a mechanistic method for pavement design; and (2) test gear-tire-load systems that are not currently permitted in order to determine their effect on pavement structures.

Description

Scope: **(1)** Gear-tire-load systems will be monitored on the mainline cells and specially configured systems will be tested on the low volume road cells. The measurement of the strains and deflections of the well instrumented cells, under a variety of conditions will lead to a basic mechanistic understanding of the effect of heavy traffic loadings on pavement structure. This knowledge will support the Minnesota Department of Transportation's development of mechanistically-based pavement design methods.

(2) Non-permitted gear-tire-load systems will be driven on the low volume road test cells. Some of these cells will be heavily instrumented to capture strains and deflections in the pavement structures under various conditions. These responses will undergo a mechanistic analysis to predict the effect of the systems on pavement life. This will allow realistic costs to be associated with permits.

Background: New heavy vehicle designs are appearing faster than we can fully understand the effects of current vehicle designs on our pavements. Under empirical pavement design methods, traffic loadings are generalized (ESALs and CESALs). However, as the mechanistic approach to pavement design is developed, specific knowledge about the effects of traffic loadings on pavement structures is required. In addition, there has been increasing pressure from the trucking industry to permit new and heavier vehicles on roadways. For these reasons the MRRP facility with its strong emphasis on pavement instrumentation will be used to perform thorough analyses of the effects of new and heavy traffic loadings on concrete, bituminous, and aggregate surfaced roads.

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Influence of Special Design Variables Upon Rigid Pavement Performance Regarding Edge Drains*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objectives of this research are to compare the influence of Minnesota Department of Transportation's two edge drain designs on rigid pavement performance, and to establish guidelines for selecting subsurface drainage alternatives for rigid pavements.

Description

Scope: Heavy instrumentation will allow complex moisture and flow patterns to be described and analyzed. The focus of this project will be the Minnesota Road Research Project (MRRP) mainline, 10-year design road cells (open-graded base with drain, dense-graded base with no drain, and dense-graded base with drain). These 3 cells are the same except for base materials, edge drain design, and panel length.

The 5-year design, mainline cells with dense-graded base with no drain and open-graded base with drain will be a secondary focus. Except for base materials, edge drain design, and panel length these two cells are the same.

Although there are basic design differences between the 5-year and 10-year mainline designs, some comparison may be possible. Two contraction joints in each of the 5 cells will be instrumented. Instrumented tipping buckets will be installed at edge outlets to continuously measure outflow rates.

Background: Water in rigid pavement structures or subgrade materials is associated with a multitude of pavement performance problems. Erosion, pumping, freeze/thaw deterioration, frost heave, reduced subgrade strengths, and concrete deterioration can lead to corner and panel cracks, joint failure, and faulting. MnDOT has installed many new and retrofit edge drains in rigid pavement structures, although not all pavement structures are drained.

MnDOT has two basic edge drain designs: (1) an open-graded permeable base design with a course aggregate in the drain trench and no geotextile wrap on the drainpipe, and (2) a dense-graded traditional base with a fine filter aggregate in the trench and a geotextile wrap on the drainpipe.

Work Plan

- ***Task 1:*** Instrument two contraction joints in each of the five test sections.
- ***Task 2:*** Continuously measure water outflow rates using instrumented tipping buckets.
- ***Task 3:*** Measure ride smoothness, faulting, and measure joint efficiency using a falling weight deflectometer, throughout the life of the sections.
- ***Task 4:*** Conduct forensic analysis of the instrumented joints to determine the condition of the pavement structure and subgrade materials.

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation, at (612) 282-2267.

Project Title: *Influence of Unbound Granular Base/Subbase Properties Upon Rigid Pavement Performance/Distress*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objective of this study is to better understand the influence of granular base/subbase material properties and design on the performance of rigid pavements so granular base/subbase specification and design parameters can be verified or refined.

Description

Scope: At the Minnesota Road Research Project (MRRP) facility, a wide range of unbound granular base/subbase types has been selected for use in both the low-volume and mainline rigid pavement cells. All rigid cell bases and subbases will be monitored to evaluate base/subbase design performance.

Test sections represent various base/subbase designs under different loading conditions, but are somewhat uniform in pavement design. These will be instrumented to track subsurface environmental conditions. One set of six moisture sensors and six temperature sensors will be placed vertically, 6 inches apart in the base/subbase of each of nine test sections. Supplemental data from other MRRP instrumentation of drainage, pumping, and frost action will be used as well.

This data will be considered along with traffic and surface environmental conditions in the analysis of base/subbase performance.

Background: Granular materials are given less attention in rigid pavement design than in flexible design. This is partially due to the stiffer nature of the surfacing material. A "granular material" can range anywhere from a dirty sand gravel to an open-graded drainable material. In addition construction, traffic, and environmental variability will affect the performance of granular materials in terms of strength, modulus, frost behavior, and drainability.

Work Plan

- ***Task 1:*** Test and inspect material properties and placement procedures during cell construction.
- ***Task 2:*** Measure deflection with a falling weight deflectometer, and measure ride smoothness.
- ***Task 3:*** Survey visible pavement distress.
- ***Task 4:*** Conduct an inspection of the base/subbase materials after the life of a cell to inventory loss, segregation, or degradation of material.

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation at (612) 779-5521.

Project Title: *Influence of Subgrade Type Upon Pavement Performance*

Investigator(s): Minnesota Department of Transportation, St. Paul, MN

Objectives

The objectives of this research are to: (1) revise (or confirm) current design methods for low volume roads over subgrades with low structural stability so better pavement performance results without increasing cost; and (2) more fully define and understand the parameters that affect the structural stability and performance characteristics of subgrade soils under high volume roads so design models can be verified, modified, or developed. This study will supplement and enhance other Minnesota Road Research Project (MRRP) studies.

Description

Scope: This project will compare the response and performance of various low volume road designs and subgrade soil variables. Two traffic levels and various environmental loadings will be considered. This approach will focus on all MRRP low volume road cells. Since this project is related to other MRRP projects, it will share instrumentation with these projects. Data related to frost action, drainage, mechanistic performance, and empirical performance will be obtained in this manner. However, extensive additional sampling and testing of the subgrades and subgrade material will be required for this project. A forensic analysis of the subgrade will also provide valuable data.

Background: The two components, foundation and pavement, of any roadway are built in very different ways, but are expected to work in concert. The pavement structure is designed, specified, constructed, and tested, while the subgrade soil is less subject to control. In addition, the subgrade is more difficult to test under in-situ conditions and more likely to be saturated. Finally, the subgrade soil typically has a lower structural stability and is more susceptible to frost action. For these reasons, we are better able to predict the strength and performance of pavement structures than of subgrade soils.

On high volume roads, economics dictate a strong pavement structure that may bridge subgrade problems; but, on low volume roads, the structural stability of the subgrade material becomes more critical. Although subgrade characteristics will be considered as part of other MRRP objectives, the unique problems associated with predicting subgrade structural stability require an in-depth analysis.

Work Plan

- ***Task 1:*** Compare the response and performance of low volume road designs over two low stability subgrade soils.
- ***Task 2:*** Evaluate the impact of the characteristics and variability of low stability soils on the response and performance of rigid and flexible pavements under various environmental loadings.
- ***Task 3:*** Prepare interim and final reports.

STARTED	1990
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Minnesota Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Minnesota Department of Transportation at (612) 282-2267.

Project Title: *Review and Develop a Life-Cycle Cost and Network Analysis*

Investigator(s): Cornell University, Ithaca, New York

Objectives

The objective of this research is to create a step-by-step manual of procedures and data requirements to perform life-cycle cost and network analysis for New York State pavements.

STARTED	April 22, 1994
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	New York State Department of Transportation
FUNDING	$130,325

For more information about this project, contact the New York State Department of Transportation, at (518) 457-5826.

Project Title: *Continued Monitoring of Instrumented Pavement in Ohio*

Investigator(s): S. Sargand, Ohio University

Objectives

The overall objective of this research is to assess the long term performance of flexible and rigid pavement. Specific objectives of this study are to: 1) compare field results from nondestructive testing to data obtained from controlled testing; 2) determine the influence of factors such as temperature, moisture content, and freezing; 3) compare the structural response of pavement systems subjected to static and dynamic loading; 4) determine the level of stress induced in the slab, base, and subbase by traffic loads; and 5) evaluate the impact of drainability of base material on structural performance.

Description

Scope: Test sections will be located on U.S. Routes 23, 33 and 35, and State Route 2 in Ohio.

Work Plan

- ***Task 1:*** Instrument pavement test sections.
- ***Task 2:*** Collect seasonal data and monitor structural performance due to environmental factors.
- ***Task 3:*** Continuously monitor pavement distress.
- ***Task 4:*** Analyze and prepare data for inclusion in the Long Term Pavement Performance (LTPP) program database.

STARTED	September 3, 1996
EXPECTED COMPLETION DATE	September 3, 2001
SPONSORING ORGANIZATION(S)	Ohio Department of Transportation
FUNDING	$906,523

For more information about this project, contact the Ohio Department of Transportation, at (614) 275-1381.

Project Title: *Instrumentation of a Rigid Pavement System*

Investigator(s): Sargand & Hazen, Ohio University

Objectives

The objective of this research is to: 1) develop a field instrumentation program for monitoring short-term and long-term structural performance of rigid pavement; 2) measure the deflection of concrete slabs due to traffic loading, Falling Weight Deflectometer loading, Dynaflect loading, under various climatic conditions; 3) determine the level of stress induced in the slab, base and subbase by traffic loads; 4) determine the influence of temperature and moisture content on the response of rigid pavement systems; and 5) evaluate the impact of drainability of base material on the structural performance of rigid pavements.

Description

Scope: The structural response of rigid pavement systems subjected to loading will be compared.

STARTED	March 9, 1992
EXPECTED COMPLETION DATE	April 9, 1997
SPONSORING ORGANIZATION(S)	Ohio Department of Transportation
FUNDING	$357,898

For more information about this project, contact the Ohio Department of Transportation, at (614) 275-1381.

Project Title: *Coordination of Load Response Instrumentation of SHRP Pavements*

Investigator(s): S. Sargand, Ohio University

Objectives

The objective of this research is to oversee and coordinate the instrumentation and associated data collection of Ohio test sections included in the Strategic Highway Research Program's Long Term Pavement Performance Program (LTPP).

Work Plan

- ***Task 1:*** Install strain gages and linear variable differential transformers in flexible and rigid pavements.
- ***Task 2:*** Monitor sensors to evaluate structural performance.
- ***Task 3:*** Install seasonal instrumentation.
- ***Task 4:*** Coordinate instrumentation procedure and data collection.
- ***Task 5:*** Conduct a preliminary analysis of data.
- ***Task 6:*** Develop a non-contact instrumentation system that will monitor horizontal and vertical movement of joints.
- ***Task 7:*** Prepare a final report.

STARTED	June 13, 1994
EXPECTED COMPLETION DATE	June 13, 1997
SPONSORING ORGANIZATION(S)	Ohio Department of Transportation
FUNDING	$627,502

For more information about this project, contact the Ohio Department of Transportation at (614) 275-1381.

Project Title: *Life-Cycle Cost Analysis for Pavement Type Selection*

Objectives

The objective of this research is to develop a life cycle cost analysis (LCCA) procedure that is applicable to rigid pavements in Texas.

Work Plan

- ***Task 1:*** Survey the current status of pavement LCCA, including methods and computer programs, and identify an acceptable procedure for rigid pavements.
- ***Task 2:*** Determine the cost components that should be used, such as length of analysis period, traffic, user costs, and maintenance and rehabilitation methods.
- ***Task 3:*** Develop a computerized method for performing LCCA for rigid pavements that is suitable for Texas conditions.

STARTED	1997
EXPECTED COMPLETION DATE	
SPONSORING ORGANIZATION(S)	Texas Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Texas Department of Transportation, at (512) 465-7403.

Project Title: *Rigid Pavement Database*

Investigator(s): McCullough and Hudson, University of Texas at Austin

Sponsoring Organization(s): Texas Department of Transportation

Objectives

The objectives of this research are to: 1) establish survey data; 2) develop a factorial to select pavement sections for condition survey; 3) conduct a condition survey on selected pavement sections; 4) establish methods of measurement; 5) investigate the possibilities of developing a database management system; and 6) develop design manuals for asphalt overlay on concrete pavements.

Description

Background: Condition surveys constitute the data feedback system based on periodic observations that are necessary to continue improvement and implementation of pavement management systems. Statewide condition surveys on rigid pavements conducted in Texas since 1974 form the one of the best databases in the United States. However, condition surveys need to be carried out in the future so that design procedures involving prediction models can be verified. Monitoring of special study pavement sections has provided a tremendous amount of useful information that has contributed significantly to the development of rigid pavement rehabilitation design systems, as well as criteria for prioritization and scheduling of overlays on rigid pavements at the network level.

Development of a suitable rigid pavement database will create an important source of valuable information for planning, design, construction, maintenance, and rehabilitation purposes.

For more information about this project, contact the Center for Transportation Research, University of Texas at Austin, at (512) 232-3100.

Project Title: *Cost Effective Concrete Pavement Cross-Sections*

Investigator(s): J. Crovetti, Marquette University

Objectives

The objectives of this study are to: (1) investigate various strategies for transverse joint reinforcement with load transfer devices, including variable spacing, composition, configuration, and/or size of dowel bars within the truck and passing lanes; (2) investigate the feasibility of using varying slab geometry within the truck and passing lanes, including thickened edges, thickened slab ends, and trapezoidal slab cross-sections; and (3) investigate the feasibility of incorporating alternative drainage layer designs within the pavement system.

Description

Background: The present pavement selection policy of WisDOT limits the design alternatives for portland cement concrete (PCC) pavements and inhibits the designer's ability to select cross-sections deviating from uniform slab thicknesses with doweled transverse joints. There is a need to develop low-risk feasible pavement design alternatives that reduce initial PCC pavement costs while maintaining or improving pavement performance.

STARTED	May 14, 1996
EXPECTED COMPLETION DATE	December 31, 1998
SPONSORING ORGANIZATION(S)	Wisconsin Department of Transportation
FUNDING	$72,556

For more information about this project, contact the Wisconsin Department of Transportation at (608) 246-7950.

Project Title: *Investigation of Feasible Pavement Design Alternatives for the Wisconsin Department of Transportation*

Investigator(s): T. Nelson, University of Wisconsin at Madison

Objectives

The objectives of this study are to: 1) justify the lifting of current design selection restrictions, 2) broaden the pavement options open to the designer; and 3) develop an objective process for pavement design in the State of Wisconsin.

STARTED	
EXPECTED COMPLETION DATE	January 31, 1997
SPONSORING ORGANIZATION(S)	Wisconsin Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Wisconsin Department of Transportation at (608) 246-7952.

Project Title: *Joint Sealing/Joint Spacing and PCC Performance as Affected by Joint Spacing and Sealing*

Investigator(s): T. Rutkowski, Wisconsin Department of Transportation; Madison, Wisconsin

Objectives

The objectives of this project are to evaluate: 1) pavement performance as it is affected by contraction joint spacing; 2) pavement performance as it is affected by the use (or non-use) of joint sealants; and 3) the quality of service and useful life of various joint sealants.

STARTED	January 1, 1974
EXPECTED COMPLETION DATE	December 31, 1998
SPONSORING ORGANIZATION(S)	Wisconsin Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Wisconsin Department of Transportation at (608) 246-7952.

Project Title: *Performance Evaluation of Pavement Structures with Doweled Transverse Joints and Constructed Over Open-Graded and/or Dense-Graded Bases*

Investigator(s): T. Rutkowski, Wisconsin Department of Transportation, Madison, Wisconsin

Objectives

The objectives of this study are to evaluate three possible solutions individually, or in combination, which will correct joint faulting problems by: 1) adding positive load transfer; 2) eliminating free water in the pavement structure; and 3) eliminating erodible material in the base.

STARTED	January 1, 1988
EXPECTED COMPLETION DATE	December 31, 1998
SPONSORING ORGANIZATION(S)	Wisconsin Department of Transportation
FUNDING	$46,024

For more information about this project, contact the Wisconsin Department of Transportation at (608) 246-7952.

Project Title: *Effects of Thick Subbases on Pavement Design, Construction, Performance, and Life Cycle Cost*

Investigator(s): T. Nelson, University of Wisconsin at Madison

Objectives

The objective of this project is to gain a better understanding and to develop guidance on the use of thick subbases by defining materials suitable for use, and by identifying proper construction techniques.

STARTED	January 15, 1995
EXPECTED COMPLETION DATE	May 16, 1997
SPONSORING ORGANIZATION(S)	Wisconsin Department of Transportation Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact the Wisconsin Department of Transportation at (608) 246-7952.

Project Title: *Mechanistic Design Review*

Investigator(s): Paul Okamoto, Construction Technology Laboratories, Skokie, Illinois

Objectives

The objective of this study is to develop an improved mechanistic highway pavement thickness design procedure which incorporates data gathered from recent research projects on joint faulting, warping and curling, and slab-subbase interaction effects.

Description

Scope: The project is to evaluate current mechanistic highway design procedures for portland cement concrete pavement and to make recommendations for an improved design methodology. Pertinent research findings will be compared and corelated to field performance data and current design methods.

Results will be used to improve mechanistic design procedures in general and which could then be incorporated into an AASHTO mechanistic thickness design procedure.

Background: This project is needed to optimize and enhance design of portland cement concrete pavements. Many current mechanistic design procedures incorporate non-load-related stresses, including curling and warping. Similarly, many mechanistic approaches assume an unrealistic interface condition whenever a lean concrete or other very stiff subbase is used. These factors impose severe thickness penalties on rigid pavements that can result in an over-designed pavement and can impact pavement type selection. A rational mechanistic design must be developed to reflect the current state-of-the-art design procedures.

Work Plan

- ***Task 1:*** Perform a literature search.
- ***Task 2:*** Evaluate data to develop inputs into the pavement design process.

STARTED	August 31, 1993
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	$53,000

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association, at (847) 966-2272.

Project Title: *Strategic Highway Research Program Long-Term Pavement Data Acquisition*

Investigator(s): Paul Okamoto, Construction Technology Laboratories, Skokie, Illinois

Objectives

The objective of this research is to develop expertise in: 1) extracting and monitoring information from the Long Term Pavement Performance (LTPP) database; and 2) performing studies using database management and statistical software.

Results will be used to make: detailed studies of specific pavement features, performance comparisons of different types of pavement, improvements in concrete pavement design, and recommendations for the most cost-effective concrete pavement design features.

Description

Scope: This project will acquire, analyze and maintain data from the LTPP database.

Background: The SHRP LTPP database contains the most detailed information currently available on the performance of both concrete and asphalt roadways. Data from various types of pavements can be extracted from the database in different forms, depending on individual needs. The development of expertise in utilizing the database can be very beneficial for future highway research, in terms of saving both time and money.

Rapid and inexpensive access to the information will directly benefit the pavement industry, allowing convenient comparisons between pavement design alternatives, current and accurate comparisons of performance, etc.

Work Plan

- ***Task 1:*** Evaluate data management and analysis procedures to identify suitable methodologies for utilizing the LTPP database.
- ***Task 2:*** Setup a relational database, and an analysis for assessing the adequacy of the 1986 AASHTO equation for designing jointed portland cement concrete pavements with doweled joints.
- ***Task 3:*** Future work to be determined based on the results of Task 1 and 2.

STARTED	June 21, 1994
EXPECTED COMPLETION DATE	1998
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	$44,000

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association, at (847) 966-2272.

Project Title: *Warping, Curling, and Subbase Interaction for Concrete Pavements*

Investigator(s): Paul Okamoto, Construction Technology Laboratories, Skokie, Illinois

Objectives

The objectives of this research are to: 1) produce credible data regarding the combined effect of load stresses, and warping and curling restraint stresses, and the effects of edge and corner deformations due to curling and warping; and 2) determine the effects of stabilized and lean concrete bases on pavement thickness determined by mechanistic and/or classical design methods.

Description

Scope: The project will test full-scale slabs. Data will be collected to determine if current mechanistic design methods properly consider: 1) the curling effects on pavement design; and 2) the influence of warping and relaxation on pavement restraint stresses.

Background: In recent years, pavement researchers have focused on stresses, such as curling and warping restraint, that are currently not incorporated in formulations used to determine rigid pavement design thickness. If trends towards incorporating temperature stresses persist, they may have a significant economic impact on pavement selection. Similarly, when lean concrete or other very stiff subbases are used, current formulations assume an unrealistic interface condition. This penalizes concrete pavement thickness, as determined by classical and/or mechanistic pavement design methods.

Work Plan

- ***Task 1:*** Construct two pavement slabs, one placed on a granular base and the second on a lean concrete base.
- ***Task 2:*** Instrument with embedded and external strain gages, deflectometers, temperature sensing devices, and moisture meters to permit continuous monitoring.
- ***Task 3:*** Analyze the effects of curling and warping, including the effects of nonlinear temperature and moisture gradients, as well as the action of stiff subbases.

STARTED	August 28 1992
EXPECTED COMPLETION DATE	
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	$488,000

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association, at (847) 966-2272.

Project Title: *Evaluation of Cement Treated Bases and Subbases Under PCC Pavements*

Investigator(s): Paul Okamoto, Construction Technology Laboratories, Skokie, Illinois

Objectives

The objectives of this study are to perform a critical evaluation of the available information regarding the performance of lean concrete and cement treated pavement bases and subbases under portland cement concrete pavements.

Description

Scope: This project will perform an extensive review of published research on lean concrete and cement treated bases, to determine whether the respective data are valid and sufficient to substantiate findings and conclusions.

Work in progress, and additional databases will be reviewed to verify or contradict published research work. If these studies are unable to provide the required information, field work to acquire to the necessary data will be performed.

Background: Recent information has given the impression that cement stabilized bases are either of dubious benefit or may even be deleterious to pavement performance. Combined with a growing perception that free-draining bases are beneficial, some engineers have concluded that cement stabilized bases are no good. The question is whether sufficient data have been acquired, and whether the data have been adequately and correctly analyzed.

Work Plan

- ***Task 1:*** Review SHRP General Pavement Study data.
- ***Task 2:*** Review literature and data. Analyze SHRP GPS data.
- ***Task 3:*** Write a comprehensive report on the results.

STARTED	September 10, 1992
EXPECTED COMPLETION DATE	
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	$190,000

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association, at (847) 966-2272.

Project Title: *Evaluate Load Transfer and Causes for Longitudinal Cracking in Multilane Highway Pavements*

Investigator(s): Paul Okamoto, Construction Technology Laboratories, Skokie, Illinois

Objectives

The objectives of this study are to provide a better understanding of longitudinal cracking in multilane highway pavements, and to recommend design and construction procedures to minimize that cracking.

Description

Scope: A theoretical analysis will be conducted to assess the reinforcing steel requirement for longitudinal joints. Current construction procedures will be evaluated. Curling and warping stresses will be used to determine the causes for longitudinal cracking. This study will identify possible causes of longitudinal cracking, and will give design and construction methods focusing on elimination of longitudinal cracking.

Background: To handle the traffic of high volume urban conditions, highway widths are increasing to three lanes and wider, some with tied concrete shoulders.

Longitudinal cracking has occurred in some multilane pavements and can become a maintenance problem and a potential hazard to vehicles. Reducing longitudinal multilane pavement cracking will help ensure long life of concrete pavements, and will minimize maintenance and associated life cycle costs.

Work Plan

- ***Task 1:*** Review databases, and current practices.
- ***Task 2:*** Survey practices and specifications.
- ***Task 3:*** Develop a predictive equation.
- ***Task 4:*** Make design and construction recommendations for tie bar size, tie bar spacing, and joint depth.
- ***Task 5:*** Document analysis of cause(s) for longitudinal cracking, and provide design and construction recommendations.

STARTED	1994
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	$225,000

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association, at (847) 966-2272.

CHAPTER 2

Construction Specifications and Procedures

Project Title: *Laboratory/Field Investigation of Performance-Related PCCP Construction Variables*

Investigator(s): ERES Consultants, Incorporated, Champaign, IL

Objectives

The objectives of this research are to: 1) establish relationships between PCC pavement quality characteristics and pavement performance; 2) develop an improved prototype Performance Related Specification (PRS); 3) verify the reasonableness of the prototype; 4) develop a method a state DOT can follow in developing Level 1 (basic entry-level) PRS; and 5) develop and analyze a life cycle cost data base.

Description

Scope: The scope of this project is to review, refine and complete the current prototype performance related specification (PRS). This effort includes an investigation of quality characteristics through the use of a literature review, and laboratory and field studies. The findings are to be incorporated into a revised prototype, which is capable of being used in a field trial to evaluate the specification's effectiveness and reasonableness for process control and acceptance.

Work Plan

- ***Task 1:*** Organize a group of experts.
- ***Task 2:*** Determine typical variables associated with PRS test methods.
- ***Task 3:*** Revise Level 2 prototype PRS and develop method for Level 1 PRS.
- ***Task 4:*** Plan laboratory and field studies for construction variables.
- ***Task 5:*** Conduct studies.
- ***Task 6:*** Revise computer program.
- ***Task 7:*** Conduct field simulations in 4 states.
- ***Task 8:*** Collect and analyze life cycle cost data.
- ***Task 9:*** Prepare final report.

STARTED	March 31, 1994
EXPECTED COMPLETION DATE	November 30, 1997
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	$679,552

For more information about this project, contact Mr. Peter Kopac, Federal Highway Administration at (703) 285-2432.

Project Title: *Measurement and Specification of Construction Quality*

Investigator(s): Brent Rauhut Engineering, Inc.

Objectives

The objectives of this research are to: 1) determine how current quality control test results vary in the constructed project, and how this variability affects pavement performance; and 2) assess the suitability of current methods of quantifying materials and construction quality and quality variability, and develop improved methods that minimize current shortcomings.

Description

Scope: The scope of this project is to perform extensive testing on 3 PCC and 3 asphalt paving projects to obtain a better understanding of quality in the constructed project and to determine the variability of quality characteristics, particularly with respect to location of the test. Both portland cement concrete and asphalt concrete paving will be tested.

For the PCC paving, the quality characteristics will include strength, thickness, smoothness, air content, and density. Test results will be analyzed with the aim of developing improved, more efficient methods of measuring and specifying materials and construction quality.

Work Plan

- ***Task 1:*** Measure the quality characteristics of strength, thickness, smoothness, air content, and density on each of the 3 PCC paving projects. Frequent tests are to be made—with test frequency approaching 100% sampling.
- ***Task 2:*** Analyze the data.
- ***Task 3:*** Develop improved methods.
- ***Task 4:*** Prepare final report.

STARTED	October 1994
EXPECTED COMPLETION DATE	December 1997
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	$440,817

For more information about this project, contact Mr. Peter Kopac, Federal Highway Administration at (703) 285-2432.

Project Title: *Fast Track Paving: Concrete Temperature Control and Traffic Opening Criteria for Bonded Concrete Overlays*

Investigator(s): Transtec, Inc., Austin, Texas

Objectives

The objectives of this research are to: 1) provide guidelines for the control of concrete temperature during curing for portland cement concrete pavement construction; and 2) provide guidelines for the monitoring of bond and bond strength criteria for the opening to traffic of newly constructed bonded concrete overlays.

Description

Scope: The focus of this research project is on modeling early-age behavior of PCCP subjected to stresses from moisture and thermal changes.

Background: It has been theorized that early-age behavior due to temperature and moisture changes can significantly affect the performance of a portland cement concrete pavement over its service life. During the first 72 hours following placement, the strength of portland cement concrete is relatively low in comparison to the strength that it will eventually achieve. During this "early-age" period, critical stresses can develop which may lead to pavement damage, and ultimately, a loss of performance.

Most existing stress and strength models are too simplistic for practical application due to their inherent assumptions. These models generally fail to account for the complex interactions between the numerous mechanisms involved, resulting in a significant loss of accuracy. Therefore, an ideal tool for this type of pavement analysis would allow for flexibility in the large number of inputs that determine these phenomena. In addition the ideal tool should be immediately implementable by prompting for inputs which are readily available to the practitioner.

Work Plan

- ***Task 1:*** Identify design and construction inputs, which are most likely to lead to good behavior during the early-age period, thus extending the life of the pavement structure.
- ***Task 2:*** Develop numerical models to predict early-age behavior in jointed plain concrete pavements.
- ***Task 3:*** Develop a comprehensive software package for use by practicing engineers and qualified technicians.
- ***Task 4:*** Prepare a final report.

STARTED	September 30, 1993
EXPECTED COMPLETION DATE	September 30, 1997
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	$600,082

For more information about this project, contact Dr. Steve Forster, Federal Highway Administration at (703) 285-2073.

Project Title: *Guidelines for Longitudinal Pavement Profile Measurement (Project 10-47)*

Investigator(s): Thomas D. Gillespie, University of Michigan, Ann Arbor, Michigan

Objectives

The objective of this research is to recommend guidelines for longitudinal pavement measurement based on the intended application and factors affecting data accuracy and reliability.

Description

Background: Profile measurement involves at least four interdependent variables: the equipment, the driver/operator, the pavement and its environment, and the roughness index being generated. Current standards appear to address the equipment, but not the other variables. Standards for accuracy and repeatability of profile measurements may need to be reconsidered.

Furthermore, accuracy requirements should be based on the intended use of the measurement. Although high degrees of accuracy may be justified for research purposes, the demands for network-level pavement management may be less stringent. Specifications, sampling intervals and wave frequency content should be consistent with the requirements.

Work Plan

- ***Task 1:*** Review relevant practices, performance data, research, and other information related to longitudinal pavement profile measurement and analysis.
- ***Task 2:*** Identify the key factors that affect the measurement of longitudinal pavement profile, and quantify their effects on the roughness index.
- ***Task 3:*** Evaluate the key factors that affect the measurement of longitudinal pavement profile.
- ***Task 4:*** Analyze data to quantify the effects of the key factors.
- ***Task 5:*** Prepare guidelines that relate longitudinal pavement profile measurement requirements to the intended use.
- ***Task 6:*** Prepare a final report.

STARTED	July 1, 1996
EXPECTED COMPLETION DATE	December 31, 1997
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$300,000

For more information about this project, contact Mr. Lloyd R. Crowther, NCHRP at (202) 334-3427.

Project Title: *Evaluation of the Iowa Vacuum Tester*

Investigator(s): W. Outcalt, Colorado Department of Transportation

Objectives

The objective of this study is to evaluate the Iowa Vacuum Tester for testing of joint seals in concrete pavements.

Description

Scope: The Iowa Vacuum Tester will be used to conduct an evaluation of joint seals on a whitetopping project in Colorado. The evaluation from the Vacuum Tester will be compared to data obtained from evaluations performed by the contractors of the Strategic Highway Research Program's Long Term Pavement Performance Study SPS-4 who are independently evaluating the same test section.

Background: Properly installed and functioning joint seals are very important to the life of concrete pavement. Joint seals have been evaluated in the past mainly by visually checking the condition of the sealant and joint. This procedure is time consuming, inconvenient, and heavily dependent on the experience of the evaluator. The Iowa DOT has developed a system that gives a positive indication if there is a leak in a joint seal.

STARTED	November 1, 1996
EXPECTED COMPLETION DATE	December 1, 1997
SPONSORING ORGANIZATION(S)	Colorado Department of Transportation
FUNDING	$10,000

For more information about this project, contact Mr. W. Outcalt, Colorado Department of Transportation at (303) 757-9978.

Project Title: *A Comprehensive Quality Incentive Program for Portland Cement Concrete Paving*

Investigator(s): James K. Cable, Iowa State University

Objectives

The objective of this research is to develop performance-based specifications for the constructions of portland cement concrete pavements.

Background

The result of this research will be a specification that can be used to determine the level or magnitude of incentives, and their method of measurement that result in a desired level of pavement performance.

Work Plan

- ***Task 1:*** Monitor the pilot monitoring plan developed by ERES Consultants, Inc.
- ***Task 2:*** Develop draft specifications.

STARTED	April 15, 1997
EXPECTED COMPLETION DATE	April 14, 1998
SPONSORING ORGANIZATION(S)	Iowa Department of Transportation
FUNDING	$34,997

For more information about this project, contact Mr. Vernon Marks, Iowa Department of Transportation at (515) 239-1447.

Project Title: *Evaluation Vibrator Performance vs. Concrete Consolidation and Air Matrix*

Investigator(s): Iowa Department of Transportation

Objectives

The objective of this research is to observe the installation and operation of two separate devices for monitoring of individual vibrator speeds; and to evaluate the equipment for ease of use, accuracy, durability, and maintenance requirements.

Description

Scope: The two devices will be tested in the field for various combinations of vibrator parameters.

Background: The Iowa DOT has identified various potential causes of early deterioration of portland cement concrete pavements. One of the possible causes is the lack of uniform consolidation of the concrete slab both vertically and transversely across the slab. Previous research identified notable differences in air content vertically through concrete cores taken directly behind the vibrator and between vibrators.

Work Plan

- ***Task 1:*** Collect field data on the installation and operation of two frequency monitoring devices.
- ***Task 2:*** Use the devices to monitor six vibrators of different diameters and centrifugal forces, at combinations of two different paver track speeds and two frequencies.
- ***Task 3:*** Core the hardened slab and measure air content and distribution using scanning electron microscope and linear traverse methods.
- ***Task 4:*** Prepare a final report.

STARTED	June 15, 1996
EXPECTED COMPLETION DATE	June 1, 1998
SPONSORING ORGANIZATION(S)	Iowa Department of Transportation Federal Highway Administration Portland Cement Association
FUNDING	$116,616

For more information about this project, contact Mr. Vernon Marks, Iowa Department of Transportation at (515) 239-1447.

Project Title: *Curing*

Investigator(s): RPI

Objectives

The objectives of this research are to: (1) predict the temperature and water fraction profiles that exist during the first 72 hours of curing in concrete pavements and bridge decks; and (2) determine under what conditions concrete can be successfully placed.

STARTED	January 20, 1993
EXPECTED COMPLETION DATE	August 31, 1997
SPONSORING ORGANIZATION(S)	New York State Department of Transportation
FUNDING	$35,000

For more information about this project, contact the New York State Department of Transportation at (518) 457-5826.

Project Title: *Feasibility for the Development of Field Test to be Performed During Construction to Ensure Structural Design Criteria for Rigid Pavements*

Investigator(s): Texas Department of Transportation

Sponsoring Organization: Texas Department of Transportation

Objectives

The objective of this project is to identify test procedures that can be conducted in the field and that measure material properties or pavement characteristics that reflect compliance with structural design criteria.

Description

Background: The study will consider the material and pavement characteristics incorporated in the AASHTO Design procedure, noting any limitations as to the availability of information required by the AASHTO procedure to describe material and pavement characteristics. The significance of any material or pavement characteristic, associated with the structural design criteria of a pavement lies in the strength of its correlation to pavement performance. As possible test parameters are identified, emphasis will be placed on repeatability and reproducibility and consideration for test equipment requirements.

For more information about this project, contact the Texas Department of Transportation at (512) 465-7403.

Project Title: *Evaluation of Vibrator Performance vs. Concrete Consolidation and Air Matrix*

Investigator(s): James K. Cable, Iowa State University

Objectives

The objective of this research is to evaluate the quality of consolidation and the air matrix developed by various vibrator variations in type, location, angle, frequency and paver track speed.

Description

Scope: This project will include three parts: a field testing program, analysis of consolidation and air matrix data, and preparation of a final report.

Background: Premature deterioration in slipform paver trails has been observed and has been attributed to the lack of uniform vibration. Studies indicate that excessive vibration increases aggregate segregation and decreases air contents.

Non-uniform vibration may increase concrete susceptibility to premature deterioration due to freezing and thawing, alkali-silica reactivity (ASR), and sulfate attack. Lack of consolidation may increase freeze-thaw susceptibility and decrease tensile strength.

The determination of the air content and air distribution of in-situ pavements have not been quantified by research to date. Measurement of air content in hardened concrete has traditionally been accomplished by the linear traverse method, which is time consuming and expensive.

With the use of scanning electron microscope image analysis, the air system of the hardened concrete will be evaluated on multiple cores. This system holds promise of being very quick, inexpensive, and more accurate.

Work Plan

- ***Task 1:*** Collect field data. Observe overall paving operation.
- ***Task 2:*** Core the pavement test sections.
- ***Task 3:*** Analyze the concrete cores and test for air content and bubble distribution.
- ***Task 4:*** Analyze data and develop guidelines for vibrator variables and their respective impact on the air matrix, and methods for measuring the size and distribution of air bubbles.
- ***Task 5:*** Prepare a final report presenting the results.

STARTED	April 1, 1997
EXPECTED COMPLETION DATE	June 1, 1998
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	$86,616

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association at (847) 966-2272.

Project Title: *Opening of PCC Pavements—Dowels*

Investigator(s): Paul Okamoto, Construction Technology Laboratories, Skokie, Illinois

Objectives

The objective of this study is to develop experimental performance information from portland cement concrete slab tests that will permit early loading of doweled highway pavements by construction and/or public traffic.

Description

Scope: This project will investigate what are the true failure criteria for doweled joints, develop a rational dowel bar fatigue type model allowing small fatigue consumption at early ages, and modify (if necessary) dowel bar design (diameter and spacing) procedures.

Background: Doweled pavement performance is currently evaluated using faulting prediction models which mainly incorporate thickness, dowel diameter, and climatic variables. Deficiencies with these models include inaccurate faulting values for common climatic variable inputs.

An earlier PCA study recommended opening strength criteria to minimize fatigue effects at early ages. Flexural strengths were established for construction equipment as well as public traffic. For public traffic, opening strengths were established as a function of traffic category and volume, slab thicknesses, and subbase support.

Research data developed in this project can be incorporated with other pavement research results into development of mechanistic pavement design procedures. The dowel performance model can also be directly incorporated into traffic opening criteria.

Work Plan

- ***Task 1:*** Review performance models of doweled joints.
- ***Task 2:*** Modify the PCA erosion model to apply to early-age loading and traffic opening criteria.
- ***Task 3:*** Conduct a laboratory investigation to evaluate failure modes.
- ***Task 4:*** Use results of the full-scale testing and laboratory program to modify and calibrate the doweled joint bearing stress model.
- ***Task 5:*** Develop recommendations and criteria for opening doweled PCC pavements to traffic.
- ***Task 6:*** Prepare a final report.

STARTED	September 1995
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	$70,000

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association at (847) 966-2272.

CHAPTER 3

Rehabilitation and Maintenance

Project Title: *Detection, Analysis & Treatment of Materials-Related Distress in PCC Pavement*

Investigator(s): Tom Van Dam, Michigan Tech University

Objectives

The objective of this research is to develop guidelines for: 1) the systematic field evaluation and representative sampling for laboratory study of distressed areas of concrete pavement; 2) the laboratory evaluation of the concrete pavement samples in order to determine the cause(s) of the distress; and 3) the appropriate treatments of the distresses in existing pavements, and prevention of the distresses in new pavements.

Description

Scope: Research existing information to determine the current practice in concrete pavement materials-related distress evaluation and the collection of samples representative of the distress(es). Also, compile current information on equipment and procedures for the laboratory evaluation and analysis of samples from concrete pavement to determine the cause and extent of distress. Collect information on current practices and procedures to treat the materials-related distresses in existing concrete pavements, as well as materials and procedures to prevent these distresses in new concrete pavements.

Once this information has been collected, develop tentative guidelines to carry out pavement evaluation in the field and distress identification and establishment of causative relationships in the laboratory. Apply developed guidelines to several in-service pavements suffering from unidentified distress in order to test the applicability of the guidelines. Following conduct of field and laboratory evaluations according to the guidelines, evaluate the results of the analyses, and improve the guidelines where necessary to attain optimal results. Based on the results of the laboratory and field investigations, update the information on treating existing pavements with material-related distress and preventing these distresses in new pavements. Produce final guidelines for the appropriate treatment of the distresses in existing pavements and prevention of the distresses in new pavements. The goal is to enhance the performance of existing concrete pavements, and ensure that new pavements are made with high performance concrete (HPC).

Work Plan

- ***Task 1:*** Collect current information.
- ***Task 2:*** Evaluate and validate guidelines.
- ***Task 3:*** Prepare guidelines and recommendations for distress treatment in existing pavements and prevention in new pavements.
- ***Task 4:***: Prepare a final report.

STARTED	October 1996
EXPECTED COMPLETION DATE	October 1999
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	$450,000

For more information about this project, contact Dr. Steve Forster, Federal Highway Administration, at (703) 285-2073.

Project Title: *LTPP Data Analysis—Evaluation of the Effects of Rehabilitation on Pavement Performance*

Investigator(s): ERES Consultants, Inc. & Brent Rauhut Engineering, Inc.

Objectives

The objectives of this research are to: 1) identify performance trends for the different treatments and design features included in the SPS-5, SPS-6, SPS-7, GPS-6A, GPS-6B, GPS-7A, and GPS-7B experiments; 2) develop preliminary distress models to predict the performance of the various rehabilitation treatments; and 3) quantify the short-term effects of pavement rehabilitation on the structural and functional characteristics of pavements.

Description

Background: The Long Term Pavement Performance (LTPP) program is a 20-year study of pavement performance of test sections subjected to actual traffic loads and environmental conditions.

The LTPP General Pavement Studies are of existing in-service pavements that were constructed under various local control standards for non-research objectives. GPS-6 includes asphalt overlays of asphalt, and GPS-7 covers asphalt overlays of concrete.

SPS test sections are pavement structures designed and constructed to develop a better understanding of the effects on performance of selected maintenance, rehabilitation, and design factors not adequately covered in the GPS. SPS-5 includes rehabilitation of asphalt pavements; SPS-6 includes rehabilitation of jointed PCC pavement; and SPS-7 includes bonded PCC overlays of concrete pavements.

Work Plan

- ***Task 1:*** Augment database.
- ***Task 2:*** Study performance comparisons and data plots.
- ***Task 3:*** Identify significant variables using statistical analyses.
- ***Task 4:*** Develop distress prediction models.
- ***Task 5:*** Perform sensitivity analyses to quantify the effects of significant variables.
- ***Task 6:*** Assess the adequacy and analytical potential of the LTPP SPS-5, SPS-6, and SPS-7 experiments.
- ***Task 7:*** Prepare final report.

STARTED	December 1996
EXPECTED COMPLETION DATE	May 1998
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP Data Analysis—Pavement Maintenance Effectiveness*

Investigator(s): Nichols Consulting Engineers, Inc., Reno, Nevada

Objectives

The objective of this research contract is to analyze the data from the Strategic Highway Research Program's Long Term Pavement Performance Specific Pavement Studies 3 and 4, on the effectiveness of maintenance treatments for asphalt (SPS-3) and concrete pavements (SPS-4). The purpose of these studies was to define the most effective timing for the application of various treatments, evaluate the effectiveness of treatments in prolonging the life of the pavement, and share information and experience among highway agencies and industry.

Description

Scope: The concrete pavement preventive maintenance treatments to be studied include: joint and crack sealing, and slab undersealing. To accomplish this project, expert task groups will be formed to evaluate the maintenance effectiveness.

Background: Preventive maintenance operations are conducted to prevent the development of damage or to reduce the rate of damage developed. Preventive maintenance operations are intended to preserve, rather than improve, the structural capacity of the pavement.

Several preventive maintenance operations are available for treatment of portland cement concrete pavements. Joint sealing, crack sealing, undersealing, and hot-mix overlays are typical preventive maintenance treatments The selection of the appropriate preventive maintenance treatment is generally made based on experience. The decision is often made without documentation that clearly defines what is the appropriate treatment, when the treatment should be applied during the life of the roadway, and what is the life expectancy of the treatment.

The main variables in the experimental design for the portland cement concrete pavements were climate (wet-no freeze, wet-freeze, dry-no freeze, dry-freeze), subgrade type (fine and coarse grained), base type (aggregate and stabilized), pavement type (plain and reinforced), and treatment type (joint/crack seating, undersealing, and no treatment). A total of 31 SPS-4 sites actually were established in the United States and Canada in 1990 and 1991.

Work Plan

- ***Task 1:*** Determine the condition of the pavement before the preventive maintenance is applied.
- ***Task 2:*** Every two years, visually inspect each section using the SHRP distress identification manual. Photo log with the PASCO, USA device. Measure deflection with a falling weight deflectometer. Collect friction data from individual states.
- ***Task 3:*** Organize expert task groups, comprised of practitioners, industry, and academia, in each of the four LTPP regions to evaluate effectiveness.
- ***Task 4:*** Analyze the data.
- ***Task 5:*** Prepare a final report.

STARTED	1990
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP Specific Pavement Study 4—Preventive Maintenance Effectiveness of Rigid Pavements*

Investigator(s): Various

Objectives

The objective of this research is to evaluate the effectiveness of pavement maintenance treatments for portland cement concrete surfaced pavements, and to: 1) define the most effective timing for the application of various treatments; 2) evaluate the effectiveness of treatments in prolonging the life of the pavement; and 3) share information and experience among highway agencies and industry.

Description

Scope: The main variables in the experimental design for the portland cement concrete pavements were climate (wet-no freeze, wet-freeze, dry-no freeze, dry-freeze), subgrade type (fine and coarse grained), base type (aggregate and stabilized), pavement type (plain and reinforced), and treatment type. A total of 31 SPS-4 sites actually were placed in the United States and Canada in 1990 and 1991.

Background: Pavement maintenance operations can be conveniently grouped into two categories: corrective and preventive. Corrective pavement maintenance operations, including patching, are performed to restore distressed areas to an acceptable condition. Preventive maintenance operations are applied to pavement surfaces to prevent the development of damage or to reduce the rate of damage developed. Preventive maintenance operations are intended to preserve, rather than improve, the structural capacity of the pavement.

The selection of the appropriate maintenance treatment is generally made based on experience. The decision is often made without documentation that clearly defines what is the appropriate treatment, when the treatment should be applied during the life of the roadway, and what is the life expectancy of the treatment.

Work Plan

- ***Task 1:*** Determine the condition of the pavement before the maintenance is applied.
- ***Task 2:*** Every two years, visually inspect each section using the SHRP distress identification manual. Photo log the section with the PASCO, USA device. Measure deflection with a falling weight deflectometer. Collect friction number data from individual states.

STARTED	1987
EXPECTED COMPLETION DATE	2007
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP Specific Pavement Study 6—Rehabilitation of Jointed Portland Cement Concrete Pavements*

Investigator(s): Various

Objectives

The objective of this research is to monitor and evaluate the performance of rehabilitated portland cement concrete pavements included in the Strategic Highway Research Program's Long Term Pavement Performance Study (LTPP).

Description

Scope: The study currently includes 166 test sections, constructed in the states of Alabama, Arizona, Arkansas, California, Iowa, Illinois, Indiana, Michigan, Missouri, Pennsylvania, South Dakota, and Tennessee; and the province of Alberta.

Background: SPS test sections are pavement structures designed and constructed to develop a better understanding of the effects on performance of selected maintenance, rehabilitation, and design factors not adequately covered in the General Pavement Studies. SPS sections are constructed under the LTPP program to allow for control of critical design factors and initiation of performance monitoring form the initial date of construction or accessibility to traffic. SPS experiments consist of nine studies involving newly constructed or rehabilitated in-service pavements with multiple test sections.

Work Plan

- ***Task 1:*** Inventory the pavement section information.
- ***Task 2:*** Document routine maintenance activity.
- ***Task 3:*** Compile traffic data.
- ***Task 4:*** Monitor pavement condition over time.
- ***Task 5:*** Measure the pavement's structural capacity using a falling weight deflectometer. FWD measurements are to be taken approximately once every five years on most sections, and 12 to 14 times a year every two years for selected sections.
- ***Task 6:*** Measure the longitudinal profile once every year.
- ***Task 7:*** Monitor surface distress annually.

STARTED	1987
EXPECTED COMPLETION DATE	2007
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *LTPP Specific Pavement Study 7—Bonded Portland Cement Concrete Overlays of Concrete Pavements*

Investigator(s): Various

Objectives

The objective of this research is to monitor and evaluate the performance of bonded concrete overlays of concrete pavements that are included in the Strategic Highway Research Program's Long Term Pavement Performance Study (LTPP).

Description

Scope: The study currently includes 39 test sections, constructed in the states of Iowa, Louisiana, Minnesota and Missouri.

Background: SPS test sections are pavement structures designed and constructed to develop a better understanding of the effects on performance of selected maintenance, rehabilitation, and design factors not adequately covered in the General Pavement Studies. SPS sections are constructed under the LTPP program to allow for control of critical design factors and initiation of performance monitoring form the initial date of construction or accessibility to traffic. SPS experiments consist of nine studies involving newly constructed or rehabilitated in-service pavements with multiple test sections.

Work Plan

- ***Task 1:*** Inventory the pavement section information.
- ***Task 2:*** Document routine maintenance activity.
- ***Task 3:*** Compile traffic data.
- ***Task 4:*** Monitor pavement condition over time.
- ***Task 5:*** Measure the pavement's structural capacity using a falling weight deflectometer. FWD measurements are to be taken approximately once every five years on most sections, and 12 to 14 times a year every two years for selected sections.
- ***Task 6:*** Measure the longitudinal profile once every year.
- ***Task 7:*** Monitor surface distress annually.

STARTED	1987
EXPECTED COMPLETION DATE	2007
SPONSORING ORGANIZATION(S)	American Association of State Highway & Transportation Officials Federal Highway Administration Various State DOTs
FUNDING	Information not available

For more information about this project, contact Mr. Charles Churilla, Federal Highway Administration, at (703) 285-2355.

Project Title: *Strategies for Rehabilitating Rigid Pavements Subjected to High-Traffic Volumes (Project 10-50)*

Investigator(s): Dennis A. Morian, Nichols Consulting Engineers, Chtd.

Objectives

The objective of this research is to develop guidelines that can be used to select appropriate strategies for the maintenance, rehabilitation, and reconstruction of rigid pavements subjected to high-traffic volumes.

Description

Background: With increasing traffic on roadways, motorists are becoming more intolerant of delays during pavement maintenance, rehabilitation, and reconstruction. To minimize delays, state highway agencies use strategies that involve various traffic management and construction practices that allow work to be completed at night or during periods of low traffic.

Without sufficient information, the effectiveness of alternative strategies cannot be adequately assessed and the selection of the optimum strategy cannot be made.

Research is needed to evaluate the effectiveness of strategies for maintenance, rehabilitation, and reconstruction of rigid pavements subjected to high traffic volumes and to develop guidelines for the selection of suitable strategies for different situations.

Work Plan

- ***Task 1:*** Review literature and conduct surveys to identify strategies for maintenance, rehabilitation, and reconstruction of rigid pavements subjected to high traffic volumes. Compile a summary of the strategies currently in use or under consideration.
- ***Task 2:*** Evaluate the strategies.
- ***Task 3:*** Further evaluate and validate the promising strategies and develop guidelines for the maintenance, rehabilitation, and reconstruction of rigid pavements.
- ***Task 4:*** Evaluate feasible strategies, define a decision-making process, and develop draft guidelines that take into account levels of service, traffic management considerations, life-cycle costs, climatic conditions, promising materials and construction methods, and other relevant factors.
- ***Task 5:*** Validate the draft guidelines.
- ***Task 6:*** Prepare a final report.

STARTED	February 27, 1997
EXPECTED COMPLETION DATE	May 24, 1999
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$299,703

For more information about this project, contact Dr. Amir N. Hanna, NCHRP, at (202) 334-1892.

Project Title: *Evaluation of Unbonded Portland Cement Concrete Overlays (Project 10-41)*

Investigator(s): Emmanuel Owusu-Antwi, ERES Consultants, Inc.

Objectives

The objectives of this research are to (1) evaluate the performance of existing techniques for rehabilitating portland cement concrete pavements with unbonded concrete overlays; (2) assess the expected long-term performance of these techniques; and (3) recommend guidelines for the use of unbonded concrete overlays

Description

Scope: This project is to be accomplished by compiling a summary of current practices, field and analytical investigations, and validation through case studies. A means for estimating the long-term performance of unbonded overlays and guidelines for design and construction are to be developed.

Background: Many concrete pavements are now approaching the end of their design life, and others have reached their terminal serviceability level. The need to develop appropriate techniques for rehabilitating those pavements is becoming increasingly important.

One such technique involves resurfacing the old pavement with a portland cement concrete overlay, which is separated from the existing pavement by an interlayer.

Guidelines that identify recommended design and construction features on unbonded concrete overlays would help highway authorities to select suitable and reliable details for this type of rehabilitation of concrete pavements.

Work Plan

- ***Task 1:*** Identify the site conditions and design parameters necessary to characterize the performance of unbonded concrete overlays.
- ***Task 2:*** Review and survey practices and performance of unbonded concrete overlays. Conduct field visits as appropriate.
- ***Task 3:*** Compile a summary of current practices in an interim report.
- ***Task 4:*** Develop guidelines for the design and construction of unbonded overlays for U.S. conditions.

STARTED	February 1994
EXPECTED COMPLETION DATE	April 30, 1997
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$200,000

For more information about this project, contact Dr. Amir N. Hanna, NCHRP, at (202) 334-1892.

Project Title: *In-Service Repair of Highway Bridges and Pavements by Internal Time-Release of Repair Chemicals*

Investigator(s): Carolyn Dry, Illinois Universities Transportation Research

Objectives

The objective of this research is to evaluate the feasibility of using chemicals that are added to concrete and are released over the life of a concrete pavement in order for the pavement to be self-repairing.

This study is being conducted for the NCHRP-IDEA program which seeks to introduce new technologies, methods, or processes for application to highways and intermodal surface transportation through development and testing of nontraditional and innovative concepts, including application of those from other technology sectors that have not yet been tested in the highway sector.

Description

Scope: This project will evaluate the self-repairing concrete concept in large-scale laboratory tests and in field conditions on bridges and pavements.

Background: The tests will determine the deflection, stiffness, and damping characteristics of specimens containing fibers filled with chemicals or adhesives. Test results will be used to optimize the amount and type of adhesives/chemicals and fibers for increased damping, stiffening capacity, and deflection reduction. The field tests will be performed in collaboration with the Illinois DOT.

Work Plan

- ***Task 1:*** Prepare concrete specimens with hollow fibers filled with various types of adhesives or sealant and test the specimens under dynamic loading.
- ***Task 2:*** Optimize and test the self-repair methodology on full-scale concrete beams representing typical members and bridge girders under traffic conditions.
- ***Task 3:*** Based on the results, provide guidelines for the use of self-repair technology for highway applications.
- ***Task 4:*** Prepare a final report.

STARTED	1996
EXPECTED COMPLETION DATE	November 30, 1997
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$73,000

For more information about this project, contact Mr. Crawford F. Jencks, NCHRP, at (202) 334-2379.

Project Title: *Florida Ultra-Thin Overlay of Aircraft Parking Aprons*

Investigator(s): Florida Department of Transportation

Objectives

The objective of this research was to evaluate the performance of ultra-thin concrete overlays of both asphalt and concrete pavements on parking aprons at the New Smyrna Beach Airport in Florida.

Description

Scope: The project was limited to several test variables. These variables included: concrete thickness, concrete mix design and slump, joint spacing, surface preparation, and reinforcing fiber. Four variations of fiber reinforcing were used. Overlays were placed on existing pavements consisting of both jointed concrete and asphalt.

STARTED	1996
EXPECTED COMPLETION DATE	January 1997
SPONSORING ORGANIZATION(S)	Florida Department of Transportation
FUNDING	Information not available

For more information about this project, contact Dr. Jamshid Armaghani, Florida Department of Transportation, at (352) 337-3200.

Project Title: *Thin Portland Cement Overlay of an Asphalt Pavement*

Investigator(s): John Wojakowski & Andrew Gisi, Kansas Department of Transportation

Objectives

The objective of this study is to evaluate the performance of thin overlays in Kansas to effectively correct the rutting problem over an extended time.

Description

Background: Rutting of asphalt pavements is not uncommon in Kansas. This distress presents problems by the accumulation of water in wheelpaths, affecting the steering stability of vehicles, and removal of snow from the ruts. It may also contribute to the breakage of embedded wire sensors used with traffic signals. Shoving at intersections is also a problem that compromises safe stopping. The placement of a thin overlay of concrete can solve the rutting problems and has shown good potential to take the high traffic loadings.

A very-early-strength concrete mix will be used. Overlay thicknesses of 50 mm (2 inches) and 90 mm (3-1/2 inches) will be used. The overlays will be sawed full-depth into blocks 0.61 meters (2 feet), 1.22 meters (4 feet), or 1.83 meters (6 feet) on a side.

Work Plan

- ***Task 1:*** Select a location on the basis of minimum transverse cracking, depth of rutting, and proximity to an ongoing project and to Topeka.
- ***Task 2:*** Measure deflections on the old pavement with a falling weight deflectometer (FWD) after milling.
- ***Task 3:*** Test the bond of the portland cement concrete to the asphalt pavement.
- ***Task 4:*** Visually monitor the project and periodically measure deflections with the FWD.
- ***Task 5:*** Prepare annual reports and a final report after five years.

STARTED	1997
EXPECTED COMPLETION DATE	2002
SPONSORING ORGANIZATION(S)	Federal Highway Administration Kansas Department of Transportation
FUNDING	$100,000

For more information about this project, contact Mr. John Wojakowski, Kansas Department of Transportation, at (913) 291-3844.

Project Title: *Mississippi Ultra-Thin Whitetopping on Interstate Highway 20*

Investigator(s): A. Crawley, Mississippi Department of Transportation & U.S. Army Corps of Engineers' Waterways Experiment Station

Objectives

The objective of this research is to demonstrate the feasibility and to evaluate the effectiveness of using ultra-thin whitetopping (UTW) as a rehabilitation strategy for severely rutted asphalt pavement on interstate highways.

Description

Scope: Project construction consisted of 4000 feet of eastbound truck lane on Interstate 20, just west of Bolton, Mississippi. The project was divided into two 2000-foot sections. Section 1 contains plain concrete and concrete with 3-lbs/cubic yard of polypropylene fibrillated fibers. Section 2 contains 25-lbs/cubic yard of polyolefin fibers.

The existing pavement consisted of 16 inches of full depth asphalt. Rutting was significant, averaging approximately 0.5 inches to 1 inch and ranging up to 2 inches in some areas.

Background: Ultra-thin whitetopping consists of a two to four inch concrete overlay placed over an old asphalt pavement that has been milled to remove the rutted and shoved areas. The milling process provides a surface that strengthens the bond between the concrete and the asphalt in order to create a monolithic section.

An ultra-thin whitetopping demonstration project was constructed in Mississippi in 1996. As a result of this project, Mississippi Department of Transportation expressed interest in adapting UTW technology to mainline paving.

Work Plan

- ***Task 1:*** Monitor construction.
- ***Task 2:*** Core asphalt to verify existing pavement thickness.
- ***Task 3:*** Measure deflection using a falling weight deflectometer.
- ***Task 4:*** Monitor distress over time.

STARTED	1997
EXPECTED COMPLETION DATE	
SPONSORING ORGANIZATION(S)	Mississippi Department of Transportation Federal Highway Administration Mississippi Concrete Industries Association
FUNDING	Information not available

For more information about this project, contact Mr. Al Crawley, Mississippi Department of Transportation, at (601) 359-7650.

Project Title: *Polyester Styrene Patching for Concrete Structures*

Investigator(s): S. Bemanian, Nevada Department of Transportation

Objectives

The objective of this research is to determine the effectiveness of using polyester styrene patching materials for repairing common distresses in jointed concrete pavements.

STARTED	October 1, 1989
EXPECTED COMPLETION DATE	September 30, 1997
SPONSORING ORGANIZATION(S)	Nevada Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Nevada Department of Transportation, at (702) 687-5520

Project Title: *Silane Treatment on PCC Pavement*

Investigator(s): North Dakota State Highway Department

Objectives:

The objective of this research is to evaluate and compare the effects of silane on slowing "D" cracking on portland cement concrete pavements.

Description:

Background: "D" cracking is a potentially serious, materials-related form of distress in portland cement concrete pavements. D-cracking can occur when porous coarse aggregate is used in concrete. Damage is caused through freeze-thaw action of water that has permeated the coarse aggregate in the concrete pavement.

Silane has been used as a waterproof sealer on bridge decks and other structures as a means of slowing saltwater ingress and the onset of corrosion. Its waterproofing qualities may reduce the permeability of D-cracking susceptible concrete pavement, and as a result may slow the damaging effects of D-cracking in freeze-thaw environments.

STARTED	May 18, 1992
EXPECTED COMPLETION DATE	May 17, 1997
SPONSORING ORGANIZATION(S)	North Dakota State Highway Department
FUNDING	$47,111

For more information about this project, contact the North Dakota State Highway Department, at (701) 221-6910.

Project Title: *Joint Sealing Effectiveness*

Investigator(s): University of Cincinnati

Objectives

The objectives of this research are to: 1) assess the effectiveness of a variety of joint sealing practices used after the initial sawing of joints, and the repercussions in terms of reduced construction time and life cycle costs; 2) identify those materials and procedures that are most cost effective; and 3) determine the effect of joint sealing techniques on pavement performance.

Description

Scope: The test pavement will be a 10.5 km, four-lane divided highway in Ohio. The pavement cross section will consist primarily of a 10-inch reinforced, jointed concrete slab, constructed over a 4-inch bituminous base and a 6-inch aggregate subbase. Five different joint sealants will be evaluated.

Background: The Federal Highway Administration has implemented a program whose aim is to assess the effectiveness of a number of innovative features in improving rigid pavement performance. The ultimate goal is the design and construction of High Performance Rigid Pavements, which are characterized by the following attributes: 1) Incorporating innovative design features and materials. 2) Enhancing the construction processes so that productivity and quality are simultaneously improved. 3) Prolonging service life, thereby lowering life cycle costs.

Previous studies have demonstrated that joint sealing techniques may make a significant contribution to these attributes of High Performance Concrete pavement.

Work Plan

- ***Task 1:*** Monitor joint construction at the test site.
- ***Task 2:*** Evaluate the performance of joint sealant materials and techniques with respect to such features as adhesion, cohesion, as well as the performance of the pavement (i.e. development of distress and roughness).

STARTED	1997
EXPECTED COMPLETION DATE	1999
SPONSORING ORGANIZATION(S)	Ohio Department of Transportation Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact the Ohio Department of Transportation at (614) 275-1381.

Project Title: *Ultra-Thin Whitetopping in South Carolina*

Investigator(s): South Carolina Department of Transportation

Objectives

The objective of this research is to evaluate the effectiveness of ultra-thin concrete overlays as a means of rehabilitating asphalt pavements, which have severe rutting and shoving.

Description

Scope: Four sites around Columbia, South Carolina were selected for the test sections. These pavements had at least 6-inches of asphalt concrete that was severely rutted and shoving. Two sites carry a large amount of truck traffic.

Background: Many intersections experience rutting and washboarding due to starting and stopping by traffic. These intersections can be a continual maintenance problem for highway agencies.

One rehabilitation strategy for these types of intersections is ultra-thin whitetopping. Ultra-thin whitetopping consists of a two to four inch concrete overlay placed over an old asphalt pavement that has been milled to remove the rutted and shoved areas. The milling process provides a surface that strengthens the bond between the concrete and the asphalt in order to create a monolithic section.

Work Plan

- ***Task 1:*** Evaluate the existing pavement, prior to and after milling, using the Falling Weight Deflectometer. Map any cracking.
- ***Task 2:*** Monitor all aspects of construction.
- ***Task 3:*** After construction—but prior to opening to traffic—measure deflections with the FWD.
- ***Task 4:*** After the section has been open to traffic for six weeks, measure roughness, skid, asphalt/PCC bond strength and permeability.
- ***Task 5:*** Visually inspect on annual basis for three years.

STARTED	September 1997
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	South Carolina Department of Transportation Federal Highway Administration
FUNDING	$313,000

For more information about this project, contact the South Carolina Department of Transportation, at (803) 737-6688.

Project Title: *Thin Bonded Concrete Overlay of Asphalt in Tennessee*

Investigator(s): Tennessee Department of Transportation

Objectives

The objective of this research is to evaluate the constructibility and effectiveness of ultra-thin concrete overlays as a means of rehabilitating asphalt pavement intersections.

Description

Scope: The test section was located at the intersection of major and minor arterial roadways in Memphis, Tennessee. Three inches of the existing asphalt pavement were milled and replaced with three inches of concrete. The concrete contained 3 lbs/cubic yard of polypropylene fibers.

Background: Many intersections experience rutting and washboarding due to starting and stopping by traffic. These intersections can be a continual maintenance problem for highway agencies.

One rehabilitation strategy for these types of intersections is ultra-thin whitetopping. Ultra-thin whitetopping consists of a two- to four-inch concrete overlay placed over an old asphalt pavement that has been milled to remove the rutted and shoved areas. The milling process provides a surface that strengthens the bond between the concrete and the asphalt in order to create a monolithic section.

Work Plan

- ***Task 1:*** Measure deflections using the Falling Weight Deflectometer, before and after the overlay is placed.
- ***Task 2:*** Measure concrete properties, including air content, slump, water/cement ratio, thermal coefficient, and 1-day, 2-day, and 28-day strengths.
- ***Task 3:*** Measure pavement roughness.
- ***Task 4:*** Visually inspect the pavement.

STARTED	October 1995
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	Tennessee Department of Transportation Federal Highway Administration
FUNDING	$201,678

For more information about this project, contact the Tennessee Department of Transportation, at (615) 320-8228.

Project Title: *Full-Scale Bonded Concrete Overlay in IH-30 in Ft. Worth*

Investigator(s): B.F. McCullough, D.W. Fowler and J. Weissmann; University of Texas at Austin

Sponsoring Organization(s): Texas Department of Transportation

Objectives

The objective of this research is to evaluate the economic and technical feasibility of using bonded concrete overlays to extend the life of aging sections of the Interstate highway system.

Description

Scope: The study concentrates on bonded concrete overlay applications on IH-30 in Fort Worth, Texas.

Background: The Interstate highway system, begun in 1956, is coming to the end of its intended economic life. These aging roads—having handled more traffic than was estimated when they were designed and constructed—now require significant surface repair. But because construction can disrupt traffic, feasibility studies must be performed before going ahead with repair in urban areas. Project results will establish a methodology for evaluating other roadways appropriate for bonded concrete overlay applications.

For more information about this project, contact the Center for Transportation Research, University of Texas at Austin, at (512) 232-3100.

Project Title: *Analysis, Design, and Construction of a Bonded Concrete Overlay on IH-10 in El Paso, Texas*

Investigator(s): McCullough, Moody, and Fowler; University of Texas at Austin

Sponsoring Organization(s): Texas Department of Transportation

Objectives

The objective of this research is to design and evaluate the performance of a bonded concrete overlay of an existing concrete pavement on Interstate 10 in El Paso, Texas.

Description

Background: Bonded concrete overlays can be a cost effective long-term rehabilitation strategy for an existing portland cement concrete pavement. However, the use of this particular rehabilitation strategy is dependent upon the condition of the existing concrete pavement. If distress manifestations are significant, the cost to repair the existing pavement structure may preclude bonded concrete overlays as an economically feasible rehabilitation strategy.

Work Plan

- ***Task 1:*** Collect relevant material and environmental data.
- ***Task 2:*** Analyze the data to isolate any variables that could induce delaminations in the overlay.
- ***Task 3:*** Design concrete slab thickness, and structural steel reinforcement.
- ***Task 4:*** Provide technical recommendations on all aspects of plan and specification development for construction.
- ***Task 5:*** Collect data during construction.
- ***Task 6:*** Investigate the feasibility of placing bonded concrete overlays on rural stretches of IH 10.

For more information about this project, contact the Center for Transportation Research, University of Texas at Austin, at (512) 232-3100.

Project Title: *Evaluation of a Thin Bonded Portland Cement Overlay*

Investigator(s): Tom Freeman, Virginia Transportation Research Council

Objectives

The objective of this research is to evaluate the performance of a fast-track thin bonded overlay on a 1,500-meter section of highway in Virginia.

Description

Background: Using thin bonded concrete overlays on old concrete pavement is not new; but constructing them with slipform pavers using fast-track construction is a relatively new practice. A primary goal of this type of construction is to provide a durable, well-performing pavement that can be constructed within minimum lane closure times.

The specifications for constructing the overlay were jointly developed by Virginia Department of Transportation, the Federal Highway Administration, and the American Concrete Pavement Association. The major distresses of the original pavement were joint faulting and spalling. Some concrete panels had longitudinal cracking.

To prepare the pavement for the overlay, the damaged concrete was removed and replaced. The joints were cleaned and resealed with hot-poured joint sealing material. Shotblasting machines were used for the final surface preparation. About one half of the surface to be paved was treated just ahead of the paver with a portland cement slurry grout to facilitate bonding.

The overlay was placed with a slipform paver and was opened to traffic 58 hours after the first load of concrete appeared on the job.

Work Plan

- ***Task 1:*** Construct the experimental section.
- ***Task 2:*** Conduct detailed visual pavement condition surveys annually over 6 years to identify, document, and monitor distress.
- ***Task 3:*** Measure the ride quality with an accelerometer-based inertial road profiler.
- ***Task 4:*** Prepare a final report.

STARTED	1990
EXPECTED COMPLETION DATE	January 1997
SPONSORING ORGANIZATION(S)	Virginia Department of Transportation Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact Mr. Tom Freeman, Virginia Transportation Research Council, at (804) 293-1957.

Project Title: *Concrete Inlay Rehabilitation*

Investigator(s): D.L. Bischoff, Wisconsin Department of Transportation

Objectives

The objective of this study is to evaluate the feasibility and effectiveness of using a concrete inlay to rehabilitate a deteriorated continuously reinforced concrete pavement.

Description

Background: Current design analysis shows an existing continuously reinforced concrete pavement, constructed on Interstate 43 in 1978, to be deficient. The type of pavement deterioration occurring is a symptom of structural failure. Accelerating failures, in the form of "punchouts," are present and most pronounced in the right driving lane.

Concrete inlays have been used to rehabilitate pavements where the distress is primarily confined to one or two lanes. Typically, one lane of pavement is removed and reconstructed, while the adjacent lane(s) of pavement are retained.

STARTED	July 15, 1996
EXPECTED COMPLETION DATE	December 31, 2001
SPONSORING ORGANIZATION(S)	Wisconsin Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Wisconsin Department of Transportation, at (608) 246-7950.

Project Title: *Analysis and Design of Whitetopping Pavements—Colorado Projects*

Investigator(s): Scott Tarr, Construction Technology Laboratories, Skokie, Illinois

Objectives

The objective of this study is to perform instrumentation and load testing of three experimental whitetopping projects in Colorado. Data obtained from this study will be used to supplement the PCA-sponsored research project Analysis and Design of Ultrathin Whitetopping.

Description

Scope: This project will include field instrumentation and load testing, data analysis and report preparation.

Background: Experimental whitetopping pavements have been constructed in Kentucky, Georgia, and Tennessee. Research and performance studies have shown that existing thickness design procedures are not adequate. A rational thickness design procedure calibrated with actual field test results is needed.

Long-term effects of traffic or climate are not incorporated into the design guidelines. Effects of surface preparation on the asphalt-concrete interface bond have not been investigated.

Work Plan

- ***Task 1:*** Conduct a thorough document review.
- ***Task 2:*** Instrument and load test the three whitetopping projects. Tests include: 1) static load testing at various locations to measure load-induced strains, 2) Falling Weight Deflectometer tests, 3) pavement surface profile measurements during load testing, 4) temperature variation measurements along the concrete and asphalt slab depths, 5) direct shear tests of interface bond strength, and 6) determination of concrete and asphalt material properties.
- ***Task 3:*** Analyze data acquired from the field and laboratory testing program using the three-dimensional finite element computer model.
- ***Task 4:*** Prepare a final report.

STARTED	1996
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	$43,000

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association, at (847) 966-2272.

Project Title: *Analysis and Design of Ultrathin Whitetopping*

Investigator(s): Scott Tarr, Construction Technology Laboratories, Skokie, Illinois

Objectives

The objective of this research is to develop a rational thickness design procedure, a performance model, and construction guidelines for ultrathin concrete overlays.

Description

Scope: The study will be accomplished by conducting a literature review, field load-testing on experimental whitetopping pavement sections, performance assessment (condition surveys) on several existing whitetopping pavements, and a theoretical analysis of whitetopping pavement behavior using a 3-D finite element model. Performance models and construction guidelines will also be developed. The thickness design procedure developed will be calibrated with existing ultrathin overlay project performance data.

Background: Ultrathin (2-Ω to 3-in.-thick) concrete overlays over existing asphalt have been experimentally constructed at sites in Kentucky, Georgia, and Tennessee. Studies show that existing thickness design and/or construction procedures are not adequate. A rational thickness design procedure that has been calibrated with actual field performance is needed.

Work Plan

- ***Task 1:*** Review design and construction procedures used to date. Identify and collect data on variables affecting performance and analysis criteria including: climate, load magnitude and frequency, geographic region, joint spacings, joint deflection/stress transfer efficiencies, interface bond, characterization of asphalt structural capacity, measured material properties, and construction procedures.
- ***Task 2:*** Identify variables that should be incorporated into the thickness design method.
- ***Task 3:*** Perform 3-D finite element computer analyses to compute stresses as a function of asphalt structural, interface bond, joint spacing, joint load/stress transfer efficiencies, and traffic. Analyze effects of temperature and/or moisture gradients.
- ***Task 4:*** Establish construction and design recommendations.
- ***Task 5:*** Document results, thickness design procedure and performance model development, and construction/design recommendations in a report.

STARTED	June 29, 1994
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	$253,000

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association, at (847) 966-2272.

CHAPTER 4

Materials and Mix Design

Project Title: *Impact of PCC Strength and Associated Properties on Rigid Pavement Performance*

Investigator(s): Will Hansen, Michigan University

Objectives

The objectives of this research are to: 1) determine the properties of portland cement concrete (PCC) of higher strength found in certain in-service pavements which resulted in exceptional long term performance—in particular, freedom from distress near joints and free edges; 2) identify test methods to measure these properties. Also, determine the material characteristics of the concrete constituents, and their proportions, which are responsible for the levels of these properties found in the concrete; and 3) develop revised mix design procedures, including any additional tests, and prototype mix designs which will result in the production of concrete for use in pavements that would possess these properties while still meeting current construction requirements and economic considerations.

Description

Scope: This study will include a literature search that will be used to relate jointed rigid pavement performance to concrete properties, particularly higher-than-normal strength. Data and samples will be collected from up to 12 field sites. The product of this study will include: the identification of those properties and causative material characteristics that especially-durable concrete possesses; mix design procedures to produce such concrete; and techniques to measure the relevant concrete properties.

Work Plan

- ***Task 1:*** Collect current information to relate long term, low-distress performance of jointed rigid pavements to properties of the concrete and characteristics of the materials.
- ***Task 2:*** Perform on-site data collection, core sampling, condition assessments, and distress evaluations on the test sections.
- ***Task 3:*** Conduct a laboratory evaluation of the concrete properties and material characteristics of the cores. Analyze field and laboratory data.
- ***Task 4:*** Develop recommendations for concrete properties, mix design procedures and test methods.
- ***Task 5:*** Prepare a final report.

STARTED	October 1995
EXPECTED COMPLETION DATE	October 1998
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	$455,276

For more information about this project, contact Dr. Steve Forster, Federal Highway Administration, at (703) 285-2073.

Project Title: *Portland Cement Concrete Rheology and Workability*

Investigator(s): U.S. Corps of Engineers Waterways Experiment Station, Vicksburg, MS

Objectives

The objective of this study is to develop a workability test for plastic concrete The test should be simple and practical, with results that correlate well with ease of placement, consolidation, and finishing of concrete (including high-performance concrete) in the field.

Description

Scope: Existing information will be searched, in order to determine the current state-of-the-knowledge of the factors influencing the workability of concrete and any tests or techniques available worldwide for the determination of concrete workability. Once this information has been collected, the candidate approaches will be evaluated for their practicality. The most suitable approach will be developed or modified as necessary to create a test method, which will then be evaluated by application to a series of laboratory concrete mixes, including HPC. Once the test method is finalized from the laboratory work, it will be further evaluated and validated in the field on actual concrete projects.

Background: Workability is defined as the ease of placement, consolidation, and finishing of fresh portland cement concrete. One of the basic tests commonly run on concrete in the plastic state is the slump test. This test is a good means to monitor and control the consistency of the mixture, both at the plant and at the job site, but it is not completely adequate to describe the rheology and workability of the mixture.

According to recent SHRP findings, the workability of concrete is composed of two elements: the yield stress and the plastic viscosity. These experiments indicated that the slump test had a very good correlation with, and hence was a good predictor of yield stress. However, slump had little or no correlation with plastic viscosity. This means that the slump test provides only half the answer as far as the workability of a given concrete is concerned. This is especially true of high-performance concrete (HPC) mixes containing a variety of admixtures and additives. A test which is more indicative of the workability is therefore needed.

Work Plan

- ***Task 1:*** Collect current information.
- ***Task 2:*** Evaluate candidate approaches to measure workability.
- ***Task 3:*** Prepare a final report.

STARTED	1996
EXPECTED COMPLETION DATE	1998
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact Dr. Steve Forster, Federal Highway Administration, at (703) 285-2073.

Project Title: *Permeability of Concrete Under Various Loading and Moisture Conditions*

Investigator(s): Drexel University

Objectives

The objective of this research is to investigate the significance of various types of permeability tests in regard to concrete durability other than that related to corrosion of reinforcing steel, and the correlation of test results with durability.

Description

Scope: The research will be conducted in two closely related aspects. The first aspect includes three types of experimental studies: (1) effect of external loading on permeability of concrete (both tensile loading and compressive loading); (2) effect of environmental conditions on permeability of concrete (in which the emphasis will be made on the effect of moisture conditions on permeability of concrete); and (3) effect of fatigue loading (in which in-situ testing of concrete permeability under fatigue loading will be performed). Prediction models relating permeability of concrete with distresses will also be developed.

Work Plan

- ***Task 1:*** Carry out tensile and compressive loading separately to observe the effect of different crack patterns on permeability.
- ***Task 2:*** Determine the effects of shrinkage, and simultaneous loading and drying.
- ***Task 3:*** Determine the effect of fatigue loading.
- ***Task 4:*** Develop a model that considers the effects of microcracks, aggregate type, and admixtures on concrete permeability.

STARTED	1997
EXPECTED COMPLETION DATE	1999
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact Dr. Steve Forster, Federal Highway Administration, at (703) 285-2073.

Project Title: *Residual ASR Potential in PCC*

Investigator(s): David Gress, University of New Hampshire

Objectives

The objectives of this research are to: 1) determine and validate a test procedure for evaluating the remaining potential for alkali silicate reaction (ASR) and deleterious expansion in existing pavements and structures; 2) develop a process for determining the viability of repair, rehabilitation or recycling options for pavements and structures, which are either ASR affected or potentially susceptible to ASR; and 3) develop a process for concrete mix design for recycling of concrete with ASR as aggregate in new portland cement concrete.

Description

Scope: This study will investigate techniques and procedures to assess the remaining potential for ASR and deleterious expansion in existing concrete. Possible methods will be evaluated for their ability to accurately predict remaining potential for ASR, their practicality, and the time required to run the procedure. As a result of the evaluation one method will be selected for final development and standardization. A process for determining the viability of repair, rehabilitation or recycling options will be developed. For the recycling options, guidelines will be developed for the incorporation of the existing concrete as recycled concrete aggregate (RCA) in the new concrete.

Background: Much of the infrastructure in the United States is nearing the end of its useful life. Some of this infrastructure is concrete which has been severely affected by ASR.

PCC has been successfully used as RCA for many years; however, little is known about the effect of recycling ASR-distressed concrete as RCA. In concept, it seems reasonable that ASR RCA could be treated as any new potentially reactive aggregate to eliminate ASR in new concrete. In reality it is not.

The status of a given concrete undergoing ASR relative to the level of completion of the reaction and associated distress is essentially unknown. The issue of available alkali and unreacted aggregate in the RCA will be addressed by this research.

Work Plan

- ***Task 1:*** Convene an expert task group to review the scope, objectives and research plan.
- ***Task 2:*** Conduct a laboratory study of evaluation techniques for remaining ASR potential.
- ***Task 3:*** Validate procedure using field ASR concrete samples.
- ***Task 4:*** Develop and evaluate an ASR recycled aggregate mix design procedure.
- ***Task 5:*** Prepare a final report.

STARTED	1997
EXPECTED COMPLETION DATE	1998
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact Dr. Steve Forster, Federal Highway Administration, at (703) 285-2073.

Project Title: *High Performance Concrete for Airport Pavements*

Investigator(s): Young, Lange and Struble, University of Illinois

Objectives

The objectives of this research are to determine how high-performance concrete (HPC) performs in airport pavements, to assess the advantages of HPC pavement overlays, and to develop pavement designs using HPC overlays.

Description

Scope: The project focuses on three important technical issues: 1) how to process an HPC overlay; 2) drying shrinkage in the overlay; and 3) curling due to drying shrinkage and thermal expansion/contraction.

Background: Research on high performance concrete overlays is focusing on drying shrinkage, the thermal expansion coefficient, and bond between the overlay and base concrete, in order to predict the tendency to curl, and on the development of concrete mix designs that provide the rheological behavior required for overlays.

Work Plan

- ***Task 1:*** Measure drying shrinkage of HPC paste and mortar, and model concrete shrinkage from paste measurements.
- ***Task 2:*** Measure thermal expansion coefficient, bond strength, and concrete rheology.
- ***Task 3:*** Develop a finite element model that can be used to forecast curling of overlays
- ***Task 4:*** Collect experimental data (drying shrinkage, thermal expansion, strength of bond between overlay and base concrete) for use in this model.
- ***Task 5:*** Prepare a final report.

STARTED	March 31, 1994
EXPECTED COMPLETION DATE	November 30, 1997
SPONSORING ORGANIZATION(S)	Federal Aviation Administration
FUNDING	Information not available

For more information about this project, contact Dr. Barry Dempsey, Federal Aviation Administration's Center of Excellence for Airport Pavement Research, at (217) 893-0705.

Project Title: *Durability Criteria*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objectives of this research are to: 1) investigate the performance of airport pavements; 2) evaluate different construction techniques and material specifications; and 3) develop improved construction and material specifications that will lead to improved durability of airport pavements.

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *Dynamic Material Characterizations*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objectives of this research are to: 1) investigate techniques for characterizing properties of in-situ pavement materials; and 2) study correlation of material properties of samples prepared in the laboratory and obtained in the field.

Description

Scope: This project will be performed in conjunction with the Minnesota Department of Transportation's Road Test project.

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *Fibrous Concrete Pavements at Rockford Airport*

Investigator(s): Federal Aviation Administration

Sponsoring Organization(s): Federal Aviation Administration

Objectives

The objective of this research is to study the performance of different types of pavement sections, including a prestressed fibrous concrete pavement, by monitoring sensors in the pavement and by performing scheduled pavement evaluations.

Description

Scope: An innovative pavement design was utilized at the taxiway extension project at the Greater Rockford Airport in 1993. The project included a 1200-foot long, 7-inch thick section of continuous prestressed, fibrous concrete pavement. Sensors were installed in the concrete so that field data could be collected.

For more information about this project, contact the Federal Aviation Administration, at (609) 435-6967.

Project Title: *Relationship of Portland Cement Characteristics to Concrete Durability (Project 18-05)*

Investigator(s): Della M. Roy, Pennsylvania State University

Objectives

The objectives of this research are to (1) identify combinations of chemical, physical, and mineralogical requirements of portland cement that will lead to improved concrete durability; and (2) recommend potential improvements to specifications.

Description

Scope: This research is concerned with portland cement, and not with other hydraulic cements.

Background: Many concrete structures, built with concrete mixtures incorporating portland cements meeting AASHTO requirements, have exhibited varying degrees of premature deterioration caused by freezing and thawing, sulfate attack, alkali-aggregate reaction, and reinforcing steel corrosion.

Although a great deal of research has been performed to address the various aspects of concrete durability, this research has not provided clear conclusions concerning the portland cement characteristics that will enhance durability. Further research is needed to assess these effects and to ensure durability.

Work Plan

- ***Task 1:*** Review literature, research, and performance data dealing with the effects of cement and clinker characteristics on durability of concrete.
- ***Task 2:*** Identify concrete properties that relate to durability and are likely to be affected by the characteristics of the cement.
- ***Task 3:*** Identify and discuss the chemical, physical, and mineralogical characteristics of the cement and clinker, and reaction kinetics, that are likely to influence concrete properties.
- ***Task 4:*** Determine the effects of combinations of cement characteristics on durability and recommend improvements to cement specifications.
- ***Task 5:*** Develop multi-variate quantitative models that relate combinations of portland cement characteristics to durability.
- ***Task 6:*** Identify combinations of chemical, physical, and mineralogical requirements of portland cement that will lead to an improved concrete durability and recommend potential improvements to specifications.
- ***Task 7:*** Submit a final report.

STARTED	April 7, 1997
EXPECTED COMPLETION DATE	October 1999
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$400,000

For more information about this project, contact Dr. Amir N. Hanna, NCHRP, at (202) 334-1892.

Project Title: *Durability of Early-Opening-to-Traffic Portland Cement Concrete for Pavement Rehabilitation (Project 18-04)*

Investigator(s): Pending

Objectives

The objectives of the research are to (1) evaluate the durability of portland cement concrete commonly used in early-opening-to-traffic pavement rehabilitation; and (2) recommend guidelines for materials, mixtures, and construction practices.

Description

Scope: This research will deal with concrete mixtures that are suited for opening to traffic within approximately 4 to 24 hours after placement and will be limited to full-depth rehabilitation such as full-depth repair and slab replacement.

Background: To minimize delays, highway agencies are interested in using early-opening-to-traffic rehabilitation strategies that allow work to be completed at night or during periods of low traffic. Generally, concrete used in these applications is expected to become strong enough to carry traffic within 4 to 24 hours after placement.

Much of the recent research on early-opening-to-traffic concrete investigated the mechanical properties of the concrete but not its durability aspects. In the absence of this information, the durability and long-term performance of the concrete cannot be assured, and the cost-effectiveness of the rehabilitation strategy cannot be properly assessed.

Research is needed to evaluate the durability of concrete used in early-opening-to-traffic pavement selection of suitable materials, mixtures, and construction practices for different applications.

Work Plan

- ***Task 1:*** Review literature, research, performance data, and current practices.
- ***Task 2:*** Identify the combinations of materials, mixtures, and construction practices normally used in early-opening-to-traffic rehabilitation.
- ***Task 3:*** Evaluate the long-term performance and durability aspects of different age-categories of early-opening-to-traffic portland cement concrete mixtures.
- ***Task 4:*** Evaluate the effects of material combinations and construction variables on freeze-thaw resistance, drying shrinkage, volumetric changes, chemical resistance, fatigue performance, permeability, and other aspects of concrete durability.
- ***Task 5:*** Develop field evaluations and laboratory tests to assess the durability of the combinations of concrete mixtures and construction techniques.
- ***Task 6:*** Determine the effects of combinations of materials, construction techniques, and traffic loading.
- ***Task 7:*** Develop guidelines for the selection of materials, mixtures, and construction practices.
- ***Task 8:*** Submit a final report.

STARTED	November 1997
EXPECTED COMPLETION DATE	February 2000
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$400,000

For more information about this project, contact Dr. Amir N. Hanna, NCHRP, at (202) 334-1892.

Project Title: *Nondestructive Testing to Determine In-Situ Material Properties of Pavement Layers (Project 10-44)*

Investigator(s): Harold L. Von Quintus, Brent Rauhut Engineering, Inc.

Objectives

The objective of the research is to recommend suitable nondestructive test (NDT) methods for determining the in-situ material properties of pavement layers for use in pavement evaluation.

Description

Scope: This research will evaluate existing methods to assess their effectiveness in determining the in-situ material properties of pavement layers and, if this effectiveness is inadequate, identify or develop new methods. The research is concerned with the in-situ material properties in each layer of rehabilitated and unrehabilitated rigid and flexible pavements; however, emphasis will be placed on the in-situ properties of the top pavement layer.

Background: Knowledge of the in-situ material properties of pavement layers is essential for evaluating the effective structural capacity of the pavement and in selecting an appropriate rehabilitation strategy. Destructive and nondestructive tests (NDT) are used for field testing and evaluating pavement layers. Although many agencies use NDT techniques for pavement evaluation, these techniques may not accurately characterize the in-situ material properties, particularly those of the top pavement layer.

Research is needed to evaluate existing NDT methods and to identify or develop suitable methods for determining the in-situ material properties of pavement layers.

Work Plan

- ***Task 1:*** Identify the in-situ material properties necessary to characterize pavement layers.
- ***Task 2:*** Review literature, current practices, ongoing research and development work, and other information relative to NDT test methods for measuring in-situ material properties.
- ***Task 3:*** Evaluate the NDT test methods.
- ***Task 4:*** Propose improvements to NDT methods currently used. Also, propose modifications to current methods or identify new methods to measure those properties for which no suitable test method has been identified.
- ***Task 5:*** Evaluate and validate the promising NDT test methods.
- ***Task 6:*** Recommend NDT test methods for measuring material properties of pavement layers.
- ***Task 7:*** Develop protocols for the recommended methods.
- ***Task 8:*** Prepare a final report.

STARTED	April 3, 1995
EXPECTED COMPLETION DATE	January 2, 1998
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$500,000

For more information about this project, contact Dr. Amir N. Hanna, NCHRP, at (202) 334-1892.

Project Title: *Aggregate Tests Related to Performance of Portland Cement Concrete (Projects 4-20 and 4-20A)*

Investigator(s): Phase I (4-20) — David W. Fowler, Texas A&M Research Foundation
Phase II (4-20A) — Richard C. Meininger

Objectives

The objectives of the research are to (1) identify the aggregate properties that influence the performance of portland cement concrete; and (2) recommend a set of aggregate tests that relate to the performance of concrete used in pavement construction.

Description

Scope: This research will evaluate existing aggregate tests to assess their usefulness in prediction of pavement performance. Where this usefulness to performance prediction is inadequate, new tests will be developed. Although this project is concerned primarily with the evaluation of aggregates used in concrete pavements, it also will have relevance to other concrete highway structures.

Background: The properties of aggregates used in portland cement concrete mixtures are very important to the performance of highway structures. Clearly, proper aggregate selection is necessary for attaining desired performance.

Many current aggregate tests were developed empirically to characterize an aggregate without any relationship to the performance. The highway industry would be better served by other tests that would provide a clearer relationship to performance.

Thus, research is needed to evaluate existing aggregate tests, identify new tests that relate to performance, and develop better procedures for testing and selection of aggregates used in various portland cement concrete applications.

Work Plan

Phase I (Project 4-20)

- ***Task 1:*** Identify and discuss the performance parameters of portland cement concrete that may be affected by the properties of the aggregates.
- ***Task 2:*** Identify the aggregate properties that influence performance and can be used to predict performance.
- ***Task 3:*** Identify and evaluate test procedures currently used for measuring properties of aggregates used in concrete pavements.
- ***Task 4:*** Identify potential techniques for measuring those performance-related properties for which no suitable test method has been identified.
- ***Task 5:*** Submit an interim report.

Phase II (Project 4-20A)

- ***Task 6:*** Evaluate and validate the test methods and techniques identified.
- ***Task 7:*** Recommend a set of tests for evaluating aggregates used in concrete pavements.
- ***Task 8:*** Develop protocols for the recommended tests.
- ***Task 9:*** Submit a final report.

STARTED	**PHASE I (4-20)**	March 15, 1995
	PHASE II (4-20A)	May 27, 1997
EXPECTED COMPLETION DATE		
	PHASE I (4-20)	December 31, 1996
	PHASE II (4-20A)	January 31, 1998
SPONSORING ORGANIZATION(S)		National Cooperative Highway Research Program
FUNDING	**PHASE I (4-20)**	$132,890
	PHASE II (4-20A)	$30,000

For more information about this project, contact Dr. Amir Hanna, NCHRP, at (202) 334-1892.

Project Title: *Alternative Dowel Bar Materials*

Investigator(s): Illinois Department of Transportation

Objectives

The objectives of this project are to: 1) demonstrate the in-service field application of various fiber composite dowels in portland cement concrete pavement; 2) evaluate the installation procedures required; 3) evaluate the performance of these materials in terms of joint deflection, and pavement distress over a five-year period; and 4) evaluate the effect of dowel bar diameter and joint sealing on performance.

Description

Scope: This project will include five experimental sections. Sections 1 and 2 will use fiber composite dowel bars; Section 3 will use bars made of different resins with a standard 1.5-inch diameter; Section 4 and 5 will epoxy-coated dowels with and without joint sealant.

Background: Results from laboratory test indicate that fiber composite bars perform as well as, or better than, steel dowel bars and that aging has little or no effect on the bars. Tests using full-scale concrete pavements supported on simulated subgrades show fiber composite bars outperform steel dowel bars. This has also been confirmed in field trials.

Work Plan

- ***Task 1:*** Monitor installation of dowel bars in test sections.
- ***Task 2:*** Measure initial pavement deflection and load transfer efficiency using the falling weight deflectometer (FWD).
- ***Task 3:*** Measure load transfer efficiency and visually inspect every six months.
- ***Task 4:*** Monitor for at least five years.
- ***Task 5:*** Periodically collect traffic data.
- ***Task 6:*** Prepare a final report.

STARTED	1997
EXPECTED COMPLETION DATE	2002
SPONSORING ORGANIZATION(S)	Illinois Department of Transportation Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact the Illinois Department of Transportation at (217) 782-7200.

Project Title: *Evaluation of Photoacoustic Spectroscopy for Quality Control of Cement*

Investigator(s): G. Norton & S. Bajic, MTEC Photoacoustics, Inc.

Objectives

The objective of this research is to determine the feasibility, strength and limitations of using a photoacoustic spectrometer for chemical analysis of cement.

Description

Background: Major investigations have not yet clearly determined the cause for some premature portland cement concrete pavement deterioration. Some changes in cement chemistry over recent years could be a contributing factor. Improved photoacoustic spectroscopy equipment is now available to determine cement chemistry more quickly and economically. This research will determine if the photoacoustic spectroscopy method can be utilized to provide an improved chemical analysis of cement.

Work Plan

- ***Task 1:*** Study instrumental and sample preparation variables.
- ***Task 2:*** Using the photoacoustic spectrometer, analyze standard mixtures with a variety of sulfate minerals.

STARTED	March 17, 1997
EXPECTED COMPLETION DATE	November 30, 1997
SPONSORING ORGANIZATION(S)	Iowa Department of Transportation
FUNDING	$12,053

For more information about this project, contact Mr. Vernon Marks, Iowa Department of Transportation, at (515) 239-1447.

Project Title: *Evaluation of Concrete Mixing Time vs. Concrete Consistency and Consolidation*

Investigator(s): James Cable, Iowa State University

Objectives

The objective of this study is to collect and evaluate data regarding the relationship of concrete mixing time to air content and distribution, consolidation, and workability for pavement construction.

Description

Scope: This project is to study the relationship between the impact of mix design and mixer type on the consolidation and retention of air distribution between the mixer and the consolidated slab.

Background: The Iowa DOT has identified possible causes for potential early deterioration of portland cement concrete pavements. One of the possible causes is the lack of uniform consolidation of the concrete slab both vertically and transversely across the slab. Previous research identified notable differences in air content vertically through concrete cores taken directly behind the vibrator and between vibrators.

Work Plan

- ***Task 1:*** Measure air content at the batch plant.
- ***Task 2:*** Measure air content of the concrete in-place on grade.
- ***Task 3:*** Core the hardened slabs and analyze air content using a scanning electron microscope.
- ***Task 4:*** Prepare a final report.

STARTED	June 15, 1996
EXPECTED COMPLETION DATE	June 30, 1997
SPONSORING ORGANIZATION(S)	Iowa Department of Transportation Federal Highway Administration Iowa Concrete Paving Association
FUNDING	$159,568

For more information about this project, contact Mr. Vernon Marks, Iowa Department of Transportation, at (515) 239-1447.

Project Title: *Field Evaluation of Alternative Portland Cement Concrete Pavement Reinforcement Materials*

Investigator(s): James Cable, Iowa State University

Objectives

The objectives of this project are to: 1) demonstrate the in-service field application of various fiber composite, epoxy-coated steel and stainless steel dowels in portland cement concrete pavement; 2) evaluate the installation procedures required; and 3) evaluate the performance of joints in terms of deflection, bar orientation, bar deterioration, pavement distress and joint opening over a five-year period.

Description

Background: The Iowa DOT and the Federal Highway Administration are interested in looking at ways to improve and extend the performance of concrete pavements. In the area of jointed pavements, this includes the consideration of alternative joint reinforcement materials. Previous testing in the laboratory has indicated that fiber composite and stainless steel materials may provide the corrosion resistance that is desired and may extend the performance of pavements.

Work Plan

- ***Task 1:*** Install dowel bars in a series of joints on a project.
- ***Task 2:*** Test to determine the location and orientation of the bars using ground penetrating radar and coring.
- ***Task 3:*** Measure deflections at the joints using the falling weight deflectometer.
- ***Task 4:*** Measure joint opening, deflection and distress on a biannual basis for five years.

STARTED	June 16, 1997
EXPECTED COMPLETION DATE	June 30, 2003
SPONSORING ORGANIZATION(S)	Iowa Department of Transportation Federal Highway Administration Iowa Concrete Paving Association
FUNDING	$268,213

For more information about this project, contact Mr. Vernon Marks, Iowa Department of Transportation, at (515) 239-1447.

Project Title: *High Performance Concrete for Pavement*

Investigator(s): John Wojakowski, Kansas Department of Transportation & Steve Tritsch, American Concrete Pavement Association

Objectives:

The objectives of this study are to: (1) evaluate the performance of a two-lift concrete pavement system, which uses lower-cost materials in the concrete of the bottom lift, and normal, or premium, concrete in the top lift; (2) evaluate innovative dowel bars; and (3) evaluate the performance of a premium high initial-strength portland cement concrete pavement.

Description:

Scope: 11 test sections will be constructed. Three sections will be built with two-lift construction. The two-lift construction will utilize durable materials that are less expensive or desirable in the first lift, with a second lift of higher-quality mixes for the wearing surface. One of the two-lift sections will utilize 15% recycled asphalt pavement in the concrete mix of the bottom lift. Fiber composite dowel bars will be used in up to three test sections.

Background: The benefits to be derived include a mix design methodology utilizing recycled or alternative materials in portland cement concrete pavement that provides equivalent or better performance at equivalent or less cost. Additionally, data will be gathered on performance of a new load transfer device which could significantly impact joint design and performance.

Life cycle costs are expected to be lower. Benefits from development of a premium high performance pavement could lead to utilization of similar pavements in high traffic locations where minimization of maintenance is highly desirable.

Work Plan

- ***Task 1:*** Evaluate mix designs using varying proportions of recycled and/or low-cost materials.
- ***Task 2:*** Prepare plans and specifications.
- ***Task 3:*** Place 11 half-kilometer and one-kilometer test sections of pavement incorporating the two lift construction sequence as well as the field testing of innovative load transfer devices and premium pavement mixes.
- ***Task 4:*** Evaluate construction.
- ***Task 5:*** Evaluate performance for a minimum of five years. Performance will be evaluated by Falling Weight Deflectometer measurement of deflections, profilometer roughness readings, surface friction testing and distress mapping.
- ***Task 6:*** Prepare a final report.

STARTED	1997
EXPECTED COMPLETION DATE	2002
SPONSORING ORGANIZATION(S)	Federal Highway Administration Kansas Department of Transportation
FUNDING	$400,500

For more information about this project, contact Mr. John Wojakowski, Kansas Department of Transportation, at (913) 291-3844.

Project Title: *Investigation of Calcium Hydroxide Depletion as a Cause of Concrete Pavement Deterioration*

Investigator(s): R. Muethel, Michigan Department of Transportation

Objectives

The objective of this research is to determine, by chemical and physical testing, the significance of calcium hydroxide depletion as a contributor to the deterioration of concrete mortar in pavements.

Description

Background: The deterioration of concrete pavements at cracks and joints often referred to as D-cracking has been associated with freeze-thaw failure of the coarse aggregate. However, in many cases, concrete pavements containing coarse aggregate that is not recognized as being susceptible to D-cracking failure eventually develop the characteristic crack patterns commonly associated with D-cracking. Such distress may be the result of carbonation, and the leaching of calcium hydroxide from the concrete by the action of carbonic acid and other acids that are often present in the pavement environment.

Work Plan

- ***Task 1:*** Examine laboratory specimens and field cores using the petrographic technique of phenolphthalein staining to identify zones of reduced pH.
- ***Task 2:*** Conduct rapid permeability tests.
- ***Task 3:*** Conduct chemical tests.
- ***Task 4:*** Examine with a scanning electron microscope.

STARTED	
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	Michigan Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Michigan Department of Transportation at (517) 322-1766.

Project Title: High-Early-Strength Concrete

Investigator(s): P. Soroushian, Michigan State University

Objectives

The objectives of this research are to: 1) identify common materials and processes for making high-early-strength concrete, and evaluate their durability characteristics; 2) evaluate the effects of weather conditions and early traffic loading on the long-term performance of high-early-strength concrete; and 3) develop specifications to produce durable high-early-strength concrete and assess the durability characteristics of new high-early-strength concrete materials.

The ultimate goal of the project is to evaluate and achieve long-term durability and to provide criteria for evaluating suitability of new or modified combinations of material.

Description

Background: Early opening to traffic is an important requirement of many rehabilitation projects. Under such conditions, concrete must often be placed at night or between morning and evening peak periods, and become strong enough to carry traffic within several hours. The focus of research to date has been on mechanical properties of high-early-strength concrete, but not on its durability characteristics. Rigorous requirements for mix design and strength development have always been stipulated, often with limited consideration to temperature and crack control, and curing. The long-term durability of this type of concrete has not been established, and there are concerns that some concrete mixtures and construction practices compromise long-term performance.

Work Plan

- ***Task 1:*** Identify and analyze available combinations of materials and processes, normally used in Michigan, for making high-early-strength concrete supplied in a transit mixer.
- ***Task 2:*** Evaluate the differences of selected combinations of materials and processes in regard to structure, strength development and durability.
- ***Task 3:*** Investigate the effects of placement techniques in different Michigan weather conditions.
- ***Task 4:*** Evaluate the effects of early loading on long-term performance.
- ***Task 5:*** Develop specifications for selection of materials and construction practices.
- ***Task 6:*** Prepare a final report.

STARTED	1995
EXPECTED COMPLETION DATE	1997
SPONSORING ORGANIZATION(S)	Michigan Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Michigan Department of Transportation at (517) 322-1766.

Project Title: *Moisture Sensors in a Base and Subbase*

Investigator(s): North Dakota State Highway Department

Objectives

The objective of this research is to compare the moisture level in the base and subgrade beneath a permeable base with the moisture content level in a dense-graded base course and subgrade. A portland cement concrete pavement will be used over both types of base.

STARTED	May 2, 1994
EXPECTED COMPLETION DATE	May 1, 1999
SPONSORING ORGANIZATION(S)	North Dakota State Highway Department
FUNDING	$15,000

For more information about this project, contact the North Dakota State Highway Department, at (701) 221-6910.

Project Title: *Silicone versus Preformed Compression Joint Seals for Concrete Pavement*

Investigator(s): North Dakota State Highway Department

Objectives

The objective of this research is to determine which joint sealer—silicone or preformed compression—has the best performance at the best price.

STARTED	August 1, 1994
EXPECTED COMPLETION DATE	August 1, 1999
SPONSORING ORGANIZATION(S)	North Dakota State Highway Department
FUNDING	$163,682

For more information about this project, contact the North Dakota State Highway Department, at (701) 221-6909.

Project Title: *Evaluation of the Use of Ground Granulated Blast Furnace Slag in Concrete Pavement*

Investigator(s): Ohio Department of Transportation

Objectives

The objectives of this research are to: 1) determine the influence of ground granulated blast furnace slag cement (GGBF) on the setting process of concrete paving mixtures; 2) evaluate the performance of pavement containing GGBF, with respect to environmental factors and dynamic loading; 3) determine the effect of addition of GGBF on the mechanical properties of concrete; and 4) compare the cost of pavement constructed with GGBF to standard pavements.

Description

Scope: Test sections will be constructed as part of a seven-mile reconstruction of a 4-lane highway in Ohio. The pavement will be 10-inches thick, placed over 4-inches of asphalt treated base, with 21-foot joint spacing. One thousand feet will be concrete without GGBF; the remainder will have GGBF.

Work Plan

- ***Task 1:*** Install sensors in the center of the slab and near the joints in each of the test slabs.
- ***Task 2:*** Conduct laboratory tests to determine flexural and compressive strength.
- ***Task 3:*** Take concrete samples at 1, 2, 3, 7, 14, 28, 90, and 365 days.
- ***Task 4:*** Four times a year, measure deflection using a falling weight deflectometer.
- ***Task 5:*** Prepare a final report.

STARTED	1997
EXPECTED COMPLETION DATE	1999
SPONSORING ORGANIZATION(S)	Ohio Department of Transportation Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact the Ohio Department of Transportation, at (614) 275-1381.

Project Title: *Construction and Evaluation of PCC Pavement Using Alternate Dowel Bar Materials and Dowel Bar Spacing*

Investigator(s): Ohio Department of Transportation

Objectives

The objectives of this research are to: 1) compare the cost effectiveness and performance of stainless steel, hollow pipe, concrete-filled dowels with that of epoxy-coated steel bars; 2) investigate the influence of seasonal change on the performance of joints; 3) examine the joint transfer mechanism under traffic loading; and 4) recommend guidelines for use of concrete-filled stainless steel pipe dowels in pavement joints.

Description

Scope: This study will compare the performance of 1-3/4-inch diameter fiberglass, 1-1/2-inch diameter solid stainless steel, 1-1/2-inch diameter epoxy-coated steel, and 1-1/2-inch diameter concrete-filled, stainless steel tube dowel bars.

Background: Proper selection and installation of dowels is critical for satisfactory long-term performance of concrete pavements. This project will contribute to the rational selection of dowel bars based on cost effectiveness, geometry, and material, and will improve the understanding of the effects of environmental and traffic loads on joint performance.

Work Plan

- ***Task 1:*** Install a limited number of strain gages and thermocouples in the test slabs.
- ***Task 2:*** Conduct nondestructive testing to measure deflections and dowel stresses, every three months for two year.
- ***Task 3:*** Analyze data on the basis of traffic, time and response to NDT.
- ***Task 4:*** Conduct a parametric study using 3-D finite element analysis, and compare to field data.

STARTED	1997
EXPECTED COMPLETION DATE	2000
SPONSORING ORGANIZATION(S)	Ohio Department of Transportation Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact the Ohio Department of Transportation, at (614) 275-1381.

Project Title: *Evaluation of Portland Cement Concretes Containing Ground Granulated Blast Furnace Slag*

Investigator(s): Sehn, University of Akron

Objectives

The objectives of this research are to: 1) evaluate the strength, durability, and workability of concrete containing different percentages of ground granulated blast furnace slag (GGBF) as a partial replacement for portland cement; 2) compare GGBF concrete to standard and micro-silica concrete; 3) develop guidelines for the specification and use of GGBF; and 4) evaluate the economics of using GGBF.

STARTED	August 16, 1993
EXPECTED COMPLETION DATE	February 16, 1999
SPONSORING ORGANIZATION(S)	Ohio Department of Transportation Federal Highway Administration
FUNDING	$366,450

For more information about this project, contact the Ohio Department of Transportation, at (614) 275-1381.

Project Title: *Permeability and Stability of Base and Subbase Materials*

Investigator(s): Randolph, University of Toledo

Objectives

The objectives of this research are to: 1) investigate the permeability of various types of soil, granular base, "New Jersey" and "Iowa" permeable bases, asphalt treated permeable bases, and cement-treated permeable bases; 2) investigate the materials to determine the amount of water retained after they are permitted to drain, and consequently, the effective porosities; and 3) specify a permeability device and procedure that will permit determination of in-situ base permeabilities.

Description

Scope: Three sources of materials—natural sands and gravels, crushed limestone, and slag—will be investigated.

STARTED	March 2, 1992
EXPECTED COMPLETION DATE	1998
SPONSORING ORGANIZATION(S)	Ohio Department of Transportation
FUNDING	$149,111

For more information about this project, contact the Ohio Department of Transportation, at (614) 275-1381.

Project Title: *Performance Evaluation of Texas Pavements Made with Different Coarse Aggregates*

Investigator(s): B.F. McCullough, University of Texas at Austin and D. Zollinger, Texas A&M University
Sponsoring Organization(s): Texas Department of Transportation

Objectives

The objective of this research is to evaluate the comparative performance of pavements (both concrete and asphalt) made with crushed limestone and/or siliceous river gravel as coarse aggregates.

Description

Background: Portland cement concrete (PCC) pavements, as well as asphalt concrete (AC) pavements in Texas are mostly made using crushed limestone and/or siliceous river gravel as coarse aggregates. It is well known that there is a large influence of the coarse aggregate on the performance of pavement structures since 60 to 80 percent of the PCC pavement volume is comprised by the aggregate, and something more than 75 percent for AC pavements.

The evaluation of the performance of rigid pavements and flexible pavements made with siliceous river gravel and with crushed limestone as coarse aggregates is necessary in order to determine the extent of performance difference attributable to these two aggregates. By determining the difference in performance with these aggregates, as well as by determining the main factors that affect these aggregates when used to build pavements in Texas, one can then make design adjustments and adaptations for pavements made with different aggregates.

For more information about this project, contact the Texas Transportation Institute, Texas A&M University, at (409) 845-9918 or the Center for Transportation Research, University of Texas at Austin, at (512) 232-3100.

Project Title: *The Effect of Changes in Total Aggregate Gradation on Portland Cement Concrete*

Investigator(s): S. Cramer, University of Wisconsin at Madison

Objectives

The objective of this study is to evaluate the freeze-thaw durability and other concrete properties of optimized mixes.

STARTED	
EXPECTED COMPLETION DATE	May 31, 1997
SPONSORING ORGANIZATION(S)	Wisconsin Department of Transportation
FUNDING	Information not available

For more information about this project, contact Mr. Terry Rutkowski, Wisconsin DOT, at (608) 246-7952

Project Title: *Strategies for Enhancing the Freeze-Thaw Durability of PCC Pavements*

Investigator(s): S. Cramer, University of Wisconsin at Madison

Objectives

The objectives of this study are to: 1) increase the service life of pavements by improving the durability of Wisconsin DOT paving mixes; and 2) reduce durability related distress that is exhibited at joints.

Description

Background: Wisconsin DOT portland cement concrete pavements have typically had service lives of 20 to 30 years. There is potential to increase the service life of these pavements by addressing durability problems caused by freeze-thaw deterioration at cracks and joints.

STARTED	1997
EXPECTED COMPLETION DATE	1998
SPONSORING ORGANIZATION(S)	Wisconsin Department of Transportation Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact Mr. Terry Rutkowski, Wisconsin DOT, at (608) 246-7952

CHAPTER 5

Surface Characteristics

Project Title: *Synthesis of Information Related to Highway Problems—Relationship Between Pavement Surface Texture and Highway Traffic Noise (Synthesis Topic 26-05)*

Investigator(s): Roger L. Wayson, University of Central Florida, Orlando, FL

Objectives

This synthesis will provide information on the relationships between pavement texture and highway traffic noise, considering other surface frictional properties and drainage.

In the NCHRP Synthesis program, particular highway problems, or sets of closely related problems, are designated as topics for information synthesis. The objective is to summarize in a document, the state-of-the-art knowledge about the topic, including: what has been learned from experience, what engineering practices are being used, what research has been done, what problems remain unsolved, and what recommendations should be made.

Description

Scope: The synthesis will consider various surface treatments for new and rehabilitated concrete and asphalt pavements. It will cover noise characteristics both in the areas adjacent to the roadway and in the interior of the vehicle. Changes in the relationships between texture and noise, over time, will be addressed.

Background: There is a growing concern, particularly in Europe, over the noise caused by the interaction of vehicles and a pavement surface. However, relatively little has been published in the United States on the long-term relationship between noise and pavement surface texture.

Work Plan

- ***Task 1:*** Locate and assemble documented information.
- ***Task 2:*** Learn what engineering practice has been used for solving or alleviating the problem.
- ***Task 3:*** Identify all ongoing research.
- ***Task 4:*** Learn what problems remain largely unsolved.
- ***Task 5:*** Organize, evaluates and document the useful information that is acquired.
- ***Task 6:*** Evaluate the effectiveness of the synthesis after it has been in the hands of its users for a period of time.
- ***Task 7:*** Prepare the final synthesis document.

STARTED	September 1, 1994
EXPECTED COMPLETION DATE	January 31, 1998
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	Information not available

For more information about this project, contact Mr. Crawford F. Jencks, NCHRP, at (202) 334-2379.

Project Title: *Improved Surface Drainage of Pavements (Project 1-29)*

Investigator(s): D. Anderson, J. R. Reed, Pennsylvania State University

Objectives:

The objective of this research is to identify effective methods and develop guidelines for improving the surface drainage of pavements.

Description:

Scope: Factors to be studied include the following: (1) geometric factors such as cross slope, longitudinal grade, width of the pavement, and superelevation; (2) pervious pavements and various pavement surface characteristics; and (3) positive interception techniques such as slotted drains.

Background: Water depth is a safety issue on high-speed roadways. One of the primary concerns is the mechanism known as sheet flow, where a layer of water flows across an expanse of pavement. Rapid removal of water to minimize sheet flow on the surface needs to be addressed both for the design of new pavements and for correcting existing conditions.

The most effective means for minimizing sheet flow on pavements need to be studied. Normally, geometric design factors should be considered first; however, in many cases, this is not enough. Pervious pavements, surface treatments such as grooving or texturing, sheet flow interception techniques, and other means need to be identified and studied.

Current methods of calculating the depth of sheet flow across pavements, hydroplaning speed, and parameters that are input to these calculations need evaluation.

Work Plan

- ***Task 1:*** Review the available literature relating to sheet flow on pavements and its rapid removal; identify major issues and problems, such as hydroplaning, skid resistance, and splash and spray.
- ***Task 2:*** Identify and assess the state of the practice on pavement surface drainage.
- ***Task 3:*** Evaluate the applicability and limitations of the calculation methods. Perform sensitivity analyses.
- ***Task 4:*** Conduct field tests on existing pavement sections to evaluate the methods.. Evaluate the results of field and laboratory tests through analytical models.
- ***Task 5:*** Develop guidelines for geometric design; identification of problem sites; the use of pervious pavements, textured pavements, surface grooving, and other surface characteristic treatments; and the use of interception techniques.
- ***Task 6:*** Prepare a final report.

STARTED	January 4, 1993
EXPECTED COMPLETION DATE	April 30, 1997
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$400,000

For more information about this project, contact Mr. Frank R. McCullagh, NCHRP, at (202) 334-3232.

Project Title: *Portland Cement Concrete Pavement Texturing*

Investigator(s): A. Ardani, Colorado Department of Transportation

Objectives

The objectives of this study are to: 1) document the constructibility, costs, and functional practicality of several PCC surface textures; 2) assess the impacts of various textures on the frictional characteristics, noise, and ride quality; and 3) identify the best performing surface texture.

Description

Scope: This study includes the evaluation of nine test sections with various textural characteristics. The impacts of various parameters (sawed vs. tined, longitudinal vs. transverse, and random vs. uniform spacing) are to be assessed. Six different texture-measuring devices will be used. Noise data will be acquired for three different locations.

Background: Surface texture plays an important role in providing safety for the traveling public. The depth, spacing, and orientation of the texture can significantly affect the frictional characteristics, noise and quality of ride.

There are a number of methods used to texture concrete pavements. The effects of these methods are not well defined. In addition, recent research has indicated that surface texture can have a profound effect on traffic-induced noise.

Work Plan

- ***Task 1:*** Measure skid numbers to assess the frictional characteristics.
- ***Task 2:*** Measure texture using: 1) a texture (laser) van, 2) an outflow meter, 3) a texture beam, and 4) a tire gauge.
- ***Task 3:*** Measure noise: 1) 25 feet from the center line, 2) inside the test vehicle, and 3) near the right rear tire.
- ***Task 4:*** Measure the pavement roughness using a profilograph.
- ***Task 5:*** Continue data collection annually, for 4 years.

STARTED	1994
EXPECTED COMPLETION DATE	December 30, 1998
SPONSORING ORGANIZATION(S)	Colorado Department of Transportation
FUNDING	

For more information about this project, contact Mr. A. Ardani, Colorado Department of Transportation, at (303) 757-9978.

Project Title: *Evaluation of Tining Widths to Reduce Noise of Concrete Roadways*

Investigator(s): North Dakota State Highway Department

Objectives

The objective of this research is to evaluate the effectiveness of various tining widths to reduce noise.

Description

Background: The depth, spacing, and orientation of the surface tining can significantly affect the frictional characteristics, noise and quality of ride. Recent research has indicated that surface texture can have a profound effect on traffic-induced noise

Different depths and spacing of tining have been used on concrete pavements. The effects of these differences are not well defined.

STARTED	August 1, 1994
EXPECTED COMPLETION DATE	August 1, 1999
SPONSORING ORGANIZATION(S)	North Dakota State Highway Department
FUNDING	Information not available

For more information about this project, contact the North Dakota State Highway Department, at (701) 221-6910.

Project Title: *Impacts Related to Texture Selection*

Investigator(s): D. Kuemmel, Marquette University; Milwaukee, Wisconsin

Objectives

The objective of this research is to analyze different pavement textures and their effect on exterior noise, salt usage and safety.

Description

Background: Surface texture plays an important role in providing safety for the traveling public. The depth, spacing, and orientation of the texture can significantly affect the frictional characteristics, noise and quality of ride. There are a number of methods used to texture concrete pavements. The effects of these methods are not well defined. In addition, recent research has indicated that surface texture can have a profound effect on traffic-induced noise.

STARTED	June 1, 1994
EXPECTED COMPLETION DATE	February 1, 1997
SPONSORING ORGANIZATION(S)	Wisconsin Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Wisconsin DOT at (608) 246-7953.

Project Title: *Effects of Grinding on PCC Pavements*

Investigator(s): T. Wenzel, Marquette University, Milwaukee, Wisconsin

Objectives

The objective of this research is to evaluate how spot grinding of portland cement concrete pavement for correction of smoothness defects affects pavement performance, safety and driver perception.

Description

Background: As highway agencies employ and tighten rideability specifications to provide the public with smoother-riding pavements, the use of spot grinding is increasing. Surface texture plays an important role in providing safety for the traveling public. The effect that grinding has on concrete durability, friction, drainage and rideability are not well defined and need further study.

STARTED	May 9, 1994
EXPECTED COMPLETION DATE	January 31, 1998
SPONSORING ORGANIZATION(S)	Wisconsin Department of Transportation
FUNDING	Information not available

For more information about this project, contact the Wisconsin DOT at (608) 246-7950.

Project Title: *Longevity of Diamond-Ground Concrete Resurfacing*

Investigator(s): Michael I. Darter, ERES Consultants, Inc.

Objectives

The objective of this research is to determine the effectiveness of diamond grinding as a concrete pavement restoration (CPR) technique.

Description

Scope: This project will include a literature review, selection of pavement test sections, collection of pertinent design, construction, environmental, maintenance and performance data of the selected pavement sections.

Background: Diamond grinding has been successfully used to restore concrete pavement surfaces for many years. Diamond grinding can remove joint faulting, provide a smooth pavement surface, and improve pavement skid resistance, and is generally less expensive than an asphalt overlay.

However, no comprehensive study has been conducted to address certain important issues dealing with diamond grinding, such as the life expectancy of diamond-ground surfaces in terms of acceptable riding quality for concrete pavements of varying types in different climatic conditions and variations of other accompanying CPR activities.

Important issues include: 1) what is the immediate impact of diamond grinding on pavement performance; 2) how long do diamond-ground surfaces provide acceptable riding quality; 3) can diamond grinding be used more than once; 4) when is diamond grinding feasible and effective; and 5) is pavement surface durability negatively impacted by diamond grinding?

Work Plan

- ***Task 1:*** Conduct a literature review.
- ***Task 2:*** Identify possible diamond ground pavement sections that can be used in this study.
- ***Task 3:*** Collect data on performance and CPR activities for all selected sections.
- ***Task 4:*** Conduct extensive field studies consisting of visual distress surveys, measurement of faulting, and ride quality.
- ***Task 5:*** Analyze data to identify performance trends.
- ***Task 6:*** Prepare a final report.

STARTED	July 1997
EXPECTED COMPLETION DATE	July 1998
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	$120,000

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association, at (847) 966-2272.

CHAPTER 6

Pavement Recycling and Waste Management

Project Title: *Physical and Mechanical Properties of Recycling PCC Aggregate*

Investigator(s): Mark Snyder, University of Minnesota

Objectives

The objectives of this research are to: 1) determine the cause(s) of pavement distress found to be related to the use of recycled concrete coarse aggregate in concrete pavements; 2) develop a set of practical and reliable guidelines for mix design using recycled aggregate; and 3) develop pavement designs for which recycled aggregate concrete is appropriate.

Description

Scope: This study will evaluate the field performance of nine concrete pavement projects that incorporate recycled concrete aggregate (RCA) in the construction of the pavement. Multiple sections will be evaluated on many of the nine projects, to evaluate the effects of differences in pavement design and to assess variations in performance.

A laboratory-based research effort will be conducted to provide additional insight into the behavior of concrete mixtures using RCA.

Background: In the past two decades, recycling of highway pavement materials has received widespread interest and acceptance as a viable rehabilitation option.

Many PCC pavements have been constructed with recycled concrete aggregate. Most have performed well, although a few have performed poorly. If crushed concrete products are to be used successfully in concrete pavements, then there is a need to better characterize the properties of RCA and concrete mixtures so that the materials produced are suitable for paving applications. Further research is needed to identify the factors that affect performance.

Work Plan

- ***Task 1:*** Perform an extensive field testing program, consisting of pavement condition surveys, drainage surveys, falling weight deflectometer (FWD) testing, coring, and serviceability assessments
- ***Task 2:*** Take a minimum of eight cores from each section for laboratory evaluation of compressive strength, split tensile strength, dynamic elastic modulus, static elastic modulus, and thermal coefficient of expansion, as well as for volumetric surface testing and petrographic analyses.
- ***Task 3:*** Produce guidelines for the design of recycled concrete mixtures and develop recommendations for the design of concrete pavements using recycled concrete aggregate.
- ***Task 4:*** Prepare a final report.

STARTED	October 1993
EXPECTED COMPLETION DATE	October 1997
SPONSORING ORGANIZATION(S)	Federal Highway Administration
FUNDING	Information not available

For more information about this project, contact Dr. Steve Forster, Federal Highway Administration, at (703) 285-2073.

Project Title: *Appropriate Use of Waste and Recycled Materials in the Transportation Industry (Project 4-21)*

Investigator(s): Warren Chesner, Chesner Engineering

Objectives

The objectives of this research are to: (1) develop a methodology for (a) assessing the suitability and practicability of specific waste and recycled materials (WRMs) in transportation applications, (b) determining appropriate uses, (c) developing design and construction guidelines, and (d) evaluating long-term in-service performance; and (2) apply the methodology to a spectrum of WRMs.

Description

Background: Disposal of wastes, such as ash and sludge, is a growing problem. A related problem is the recycling of other waste materials such as concrete, asphalt pavement, tires, glass, and plastics. The transportation industry is under increasing pressure to use waste and recycled materials.

To make prudent decisions concerning the use of WRMs, information is needed about a particular material being considered and its potential application. A process is needed to screen each WRM; evaluate its potential use, benefits, and costs; develop design procedures, tests, and specifications; and plan for in-service evaluation of the application.

Work Plan

- ***Task 1:*** Develop a comprehensive PC-based database on WRMs.
- ***Task 2:*** Identify WRMs, and materials which include WRMs as components, that are being used in transportation applications
- ***Task 3:*** Propose a methodology for assessing the suitability and practicability of WRMs and determining appropriate applications.
- ***Task 4:*** Develop and test the methodology.
- ***Task 5:*** Develop a methodology for designing, constructing, and monitoring field trials.
- ***Task 6:*** Evaluate the WRMs for their suitability and practicability and determine the appropriate applications.
- ***Task 7:*** Develop design criteria and construction guidelines—including quality control—for the WRMs that have an appropriate application.
- ***Task 8:*** Prepare model designs for the construction evaluation and long-term performance monitoring of field trials of selected WRMs.
- ***Task 9:*** Submit a final report.

STARTED	June 1, 1995
EXPECTED COMPLETION DATE	December 31, 1998
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$499,974

For more information about this project, contact Mr. Edward T. Harrigan, NCHRP, at (202) 334-3232.

Project Title: *The Use of Crushed Portland Cement Concrete as Aggregate for Concrete Pavement*

Investigator(s): Texas Department of Transportation

Sponsoring Organization(s): Texas Department of Transportation

Objectives

The objective of this research is to evaluate concrete material properties and the performance of pavements made with crushed concrete as coarse and fine aggregates.

Description

Scope: Special attention will be given to any significant differences in material properties of concrete made with recycled concrete aggregate, compared to concrete containing virgin aggregate. The implications of material properties on concrete pavement performance will be identified. The research team will observe the paving operations closely to detect abnormalities due to the use of recycled aggregates.

Background: In Houston, the construction of a concrete pavement on Interstate 10 is providing a rare opportunity to evaluate recycled concrete. The contractor is using 100% recycled portland cement concrete for the coarse aggregate.

For more information about this project, contact the Texas Department of Transportation at (512) 465-7403.

Project Title: *Recycled Materials in Concrete, Except Glass*

Investigator(s): R.L. Carrasquillo & D.W. Fowler; University of Texas at Austin

Sponsoring Organization(s): Texas Department of Transportation

Objectives

The objective of this research is to develop specifications for the use of recycled materials as constituents of concrete for Texas Department of Transportation highway construction.

Description

Background: Because of the tremendous volumes of concrete produced annually, environmentally concerned engineers have been investigating the potential for using various recycled waste materials in concrete mixes. In addition to the direct cost savings obtained from recycling materials instead of disposing of them in a landfill, recycling can benefit the public by 1) reducing construction material costs, 2) preserving non-renewable natural resources, 3) using locally generated waste as a construction material, and 4) reducing waste disposal.

For more information about this project, contact the Center for Transportation Research, University of Texas at Austin, at (512) 232-3100.

Project Title: *Recycled Materials in Roadbase, Except Glass*

Investigator(s): W.R. Hudson, Tom White; University of Texas at Austin
Sponsoring Organization(s): Texas Department of Transportation

Objectives

The objective of this study is to assist the Texas Department of Transportation in developing an appropriate performance-based specification for the construction of roadbases using recycled concrete and various related materials.

Description

Scope:

Background: As highways age and concrete pavement repairs are made, the disposal of concrete slabs becomes a problem. Added to this is the surplus of concrete that comes from median barriers and demolished commercial buildings. Recycling such materials in roadbases will reduce their surplus volumes in a cost-effective and environmentally friendly way.

For more information about this project, contact the Center for Transportation Research, University of Texas at Austin, at (512) 232-3100.

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Project Title: *Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures (Project 1-37A)*

Investigator(s): John P. Hallin, ERES Consultants, Inc., Champaign, IL

Objectives

The objective of this project is to develop and deliver the 2002 AASHTO Guide for Design of New and Rehabilitated Pavement Structures, based on mechanistic-empirical principles, accompanied by the necessary computational software, for adoption and distribution by AASHTO.

Description

Background: The AASHTO Guide for the Design of Pavement Structures is the primary document used to design new and rehabilitated highway pavements. Throughout the highway community, the major pavement design emphasis is now on rehabilitation, for which empirical design approaches often are inadequate. Because mechanistic-empirical approaches more realistically characterize in-service pavements and improve the reliability of designs, the next generation of design approaches will be based on mechanistic principles. However, because of gaps that exist in the knowledge base, mechanistic design methods need to be supported by empirical relationships, and many of the issues relating to the mechanistic-empirical approach need to be better defined before practical and realistic design procedures can be developed and put into use.

Work Plan

- ***Task A1:*** Submit comprehensive work plan by April 30, 1998.
- ***Task A2:*** Develop marketing strategies to promote national interest and acceptance.
- ***Task A3:*** Develop software to support initial draft of the Guide.
- ***Task A4:*** Prepare an initial draft and revised version, incorporating reviewers' comments.
- ***Task A5:*** Submit final report that documents the entire research effort.

STARTED	February, 1998
EXPECTED COMPLETION DATE	April, 1999—Phase II, Stage A
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$1,297,709

For more information about this project, contact Dr. Amir Hanna, NCHRP, at (202) 334-1892.

Project Title: *Aggregate Tests Related to Performance of Portland Cement Concrete Pavements (Project 4-20B)*

Investigator(s): Contract Pending

Objectives

The objective of this research is to recommend a complete set of aggregate tests that relate to the performance of portland cement concrete used in pavement construction.

Description

Background: The properties of coarse and fine aggregates used in portland cement concrete mixtures are very important to the performance of the highway pavements in which they are used. For example, D-cracking of pavements and alkali-silica reactivity damage of pavements can be traced directly to improper aggregate selection and use. Clearly, proper aggregate selection is necessary for attaining desired performance.

Many currently used aggregate tests were developed empirically to characterize an aggregate without, necessarily, understanding the direct relationship to the performance of the final product. Although widespread use, familiarity, and a historical database have perpetuated the popularity of some tests, the highway industry may be better served by other tests that provide clearer relationships with performance.

Thus, research is needed to evaluate existing aggregate tests, identify new tests that relate to performance, and develop better procedures for testing and selection of aggregates used in portland cement concrete pavements.

Work Plan

- ***Task 1:*** Collect and review literature and research findings pertaining to aggregate effects on concrete pavement performance.
- ***Task 2:*** Develop a research plan for laboratory investigation to evaluate tests for aggregate properties that relate to pavement performance.
- ***Task 3:*** Prepare interim report of research performed in Tasks 1 and 2 and a detailed work plan for Tasks 4, 5 and 6.
- ***Task 4:*** Execute the research plan approved in Task 3.
- ***Task 5:*** For tests recommended in Task 4, develop protocols suitable for adoption by AASHTO.
- ***Task 6:*** Submit a final report documenting the entire research effort. The report shall include an implementation plan for moving the research results into practice.

STARTED	Oct., 1998—estimated
EXPECTED COMPLETION DATE	January, 2002
SPONSORING ORGANIZATION(S)	National Cooperative Highway Research Program
FUNDING	$350,000

For more information about this project, contact Dr. Amir Hanna, NCHRP, at (202) 334-1892.

Project Title: *Accelerated Pavement Tests of Ultra-Thin Whitetopping (UTW) Concrete Overlays*

Investigator(s): Federal Highway Administration

Objectives

The objectives of this research are to: 1) evaluate UTW performance under controlled wheel loads and temperature, 2) study the effect of design factors on UTW performance, 3) measure pavement responses to develop mechanistic models, and 4) verify and improve models to predict load-carrying capacity.

Description

UTW pavement sections with several combinations of joint spacings, concrete thickness, and overlaid asphalt thickness will be loaded with the Accelerated Loading Facility (ALF) pavement testing machine.

Work Plan

UTW sections will be constructed and instrumented. Testing will be done to determine material strengths, elastic properties, and bond of the layers (concrete, asphalt, and subgrade). The test sections will be repeatedly loaded with the ALF machine which applies real world truck loading at the rate of 35,000 loads per week. During the test, surveys will record cracks, joint faulting and other pavement distresses. Periodic pavement response measurements of pavement strains and deflections will be taken until significant distress appears.

A report will include analysis of the data and its application to procedures for establishing the load-carrying capacity of UTW pavements.

STARTED	May, 1998
EXPECTED COMPLETION DATE	Testing—November, 1999 Final Report—2000
SPONSORING ORGANIZATION(S)	Federal Highway Administration American Concrete Pavement Association Portland Cement Association
FUNDING	Information not available

For more information about this project, contact Mr. Jim Sherwood, Federal Highway Administration, at (703) 285-2619 or Mr. Larry Cole, American Concrete Pavement Association, at (847) 966-2272.

Project Title: *Comparative Performance of In-Service Highway Pavements*

Investigator(s): Toby L. Crow, ERES Consultants, Inc., Champaign, IL

Objectives

The objective of this research is to conduct comprehensive performance and life cycle cost analysis of different pavement types on rural interstate highways.

Description

This project involves studies of pavements on major highways that have been in service for many years. It involves the collection of historical data on performance, service lives, and costs of different pavement types. This will lead to a better understanding of the factors involved in pavement type selection.

Work Plan

- ***Task 1:*** Identify five appropriate interstate corridor sections.
- ***Task 2:*** Gather and record information for each corridor.
- ***Task 3:*** Prepare a data assessment report for each corridor.
- ***Task 4:*** Perform comprehensive performance and life cycle cost analysis.
- ***Task 5:*** Prepare final report for each corridor.

STARTED	April, 1998
EXPECTED COMPLETION DATE	2 Corridors, 1998 3 Corridors, 1999
SPONSORING ORGANIZATION(S)	Portland Cement Association
FUNDING	Information not available

For more information about this project, contact Mr. Larry Cole, American Concrete Pavement Association, at (847) 966-2272.

American Concrete Pavement Association

5420 Old Orchard Road
Skokie, Illinois 60077-1059
Phone: 847-966-2272
Fax: 847-966-9970
Internet web site:
www.pavement.com

U.S. Department of Transportation
Federal Highway Administration

400 7th Street, S.W.
Washington, DC 20590
Phone: 202-366-6606
Fax: 202-366-7909