FHWA REPORT NO.

THE CONCRETE PAVEMENT TECHNOLOGY PROGRAM (CPTP)

A STATUS REPORT

(TASK 65 ENGINEERING ETG REVIEW COPY)

PREPARED BY

CONSTRUCTION TECHNOLOGY LABORATORIES, INC.
AND
APPLIED PAVEMENT TECHNOLOGY, INC.

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PREFACE

The Concrete Pavement Technology Program (CPTP) is a national program of research, development, and technology transfer that operates within the Federal Highway Administration (FHWA). The focus of the program is on implementing improved methods of designing, constructing, evaluating, and rehabilitating portland cement concrete (PCC) pavements in order to promote cost-effective designs and long-term performance for federal-aid highways.

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CHAPTER 1 - INTRODUCTION

Introduction

The Concrete Pavement Technology Program (CPTP) is a national program of research, development, and technology transfer that operates within the Federal Highway Administration (FHWA). The focus of the program is on implementing improved methods of designing, constructing, evaluating, and rehabilitating portland cement concrete (PCC) pavements in order to promote cost-effective designs and long-term performance for federal-aid highways.

Since the 1890s when the first concrete pavements were constructed, there has been a continuous evolution in concrete pavement technology. In the early years the technology developments emphasized the materials and construction aspects of concrete pavements. This was followed by innovations in procedures to design longer-lasting concrete pavements. Since the 1960s, with the start of the Interstate highway construction, there have been significant developments in various aspects of concrete pavement technology, including repair and rehabilitation.

Concrete pavements are routinely designed to provide low maintenance service lives of 20 to 30 years, and efforts are underway to implement design life requirements of 40 to 60 years. While much progress has been made in the last few decades to improve the performance of concrete pavements and to reduce overall life-cycle costs, many challenges remain and new challenges surface that necessitate a strong commitment to maintaining a vigorous research and development program to support concrete pavement technology. Some of these challenges include:

1. Constrained agency budgets.
2. Increasing traffic volumes and restrictions on construction work zones.
3. Wet-weather safety requirements.
4. Tire/pavement noise considerations.
5. User demands for a smooth and comfortable ride.
6. Shortages of good quality aggregates.
7. Sound understanding of factors that affect concrete pavement behavior.
8. Optimization of concrete pavements to meet design conditions.
9. Development and characterization of durable concrete mixtures.
10. Environmental effects on short-term and long-term concrete pavement behavior and performance.

FHWA has been committed to maintaining and funding a strong research and development (R&D) program to improve concrete pavement performance. During the late 1990s, with funding support from the TEA-21 bill, FHWA began consolidating its overall concrete pavement R&D program under the CPTP umbrella in partnership with the State Departments of

Transportation (DOTs), the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board (TRB), industry, and academia.

As part of the need to assess the current status of the CPTP and to help fulfill the need of a planned approach to future research activities and programs, this report has been prepared to document the FHWA's CPTP initiative and to summarize the status and findings of the projects included in the program. Included in this report are:

1. An executive summary that details the overall framework of the CPTP and the status of the CPTP program as a whole.
2. A summary of the status of the individual CPTP projects, presented as an appendix.
3. Identification of complementary studies being performed by other government agencies (FAA, Corps of Engineers), State DOTs, industry, academia, and international organizations that together may further enhance the goals of the CPTP, maximize the effort of specific CPTP projects, contribute to the enhancement of CPTP products.
4. Preliminary cost/benefit analysis, as appropriate, for potential/promising CPTP products.

First, a brief background on the CPTP initiative is presented, along with a brief overview of some of the project "focus areas."

CPTP Background

CPTP TEA-21 Funding

The Transportation Equity Act for the 21st Century (TEA-21), signed into law in June 1998, authorized highway, highway safety, transit, and other surface transportation programs for a 6-year period. Two important aspects of the Act are its emphasis on rebuilding America's infrastructure and its promotion of advanced research and technology to support an efficient and well-performing pavement infrastructure. As a result of these emphases, TEA-21 included a line item calling for targeted research to improve the performance of concrete pavements for federal-aid highway projects, and the FHWA was called upon to conduct this work in cooperation with industry.

CPTP Vision & Mission

Over the years, many useful products and spin-off products have resulted from FHWA, State DOT, and industry-funded concrete pavement R&D programs. In the past, there was not a very effective framework for implementing and monitoring these innovative products because of the different agencies and organizations involved. In addition, there was little coordinated follow-up of the implemented products. The CPTP is an attempt to change the past practices by providing a more coherent nationally coordinated research program, a program that minimizes duplication and redundancy, while building on the success of each CPTP product.

The CPTP has tremendous potential to provide implementable products that pavement engineers and managers can use in designing and constructing more cost-effective and longer-lasting pavements and in rehabilitating concrete pavements more effectively by adhering to the philosophy of "get in as soon as possible; get out as quickly as possible; and stay out as long as possible." In summary, the CPTP aims to foster and expedite the adoption of new and improved methods and technologies related to the design, construction, repair, and rehabilitation of concrete pavements.

CPTP Specific Goals

The following four goals were established for the CPTP early in its development, reflecting critical needs within the area of concrete pavements:

- Reduce user delays.
- Reduce costs.
- Improve performance.
- Foster innovation.

These goals address the needs of the State department of transportations (DOTs), the concrete pavement industry, and the highway user, while supporting FHWA's strategic goals to improve the mobility, productivity and safety of the Nation's highway system by developing longer lasting, better performing pavements with safer, smoother rides and reduced congestion caused by construction work zones. All individual CPTP projects have been defined and developed with a view to meeting one or more of the above-listed CPTP goals.

Expected CPTP Benefits (For Agencies, Industry, Academia, Users)

Each project in the CPTP is intended to result in one or more products with potential for application in concrete pavement engineering practice. Some examples of CPTP products that are expected to be available for incorporation into the technology transfer, deployment, and delivery activities to be performed under this contract are as follows:

- Software for use in selecting optimized mixture proportions for paving concrete.
- Guidelines and test methods for evaluating compatible combinations of materials for paving concrete.
- Software for use in the design of new and rehabilitated concrete pavements and concrete overlays.
- New and/or refined standard test methods and specifications for paving concrete and for the materials used in paving concrete.
- Guidelines for implementing innovative practices, such as the use of precast pavement panels for repair/rehabilitation and construction of concrete pavements.
- Guidance for developing performance-related specifications.
- Methods for determining life-cycle costs of concrete pavements and for evaluating cost-benefit analyses of various concrete pavement components.

- Guidelines for traffic management associated with rapid repair/rehabilitation and construction activities on high-volume roadways.
- Implementation package to inform and provide guidance to stakeholder groups in government, industry, and academia concerning needed long-term research for concrete pavements.
- New or updated National Highway Institute (NHI) course materials on various aspects of concrete pavement technology.

Limited product deployment and technology transfer activities have been performed and other minor efforts are currently underway. FHWA has taken steps to consolidate the CPTP product deployment and technology transfer effort to ensure that the program results in maximum payoff to the stakeholders and that the key anticipated products/benefits of the CPTP materialize in a timely manner.

Program Administration, Management, and Oversight

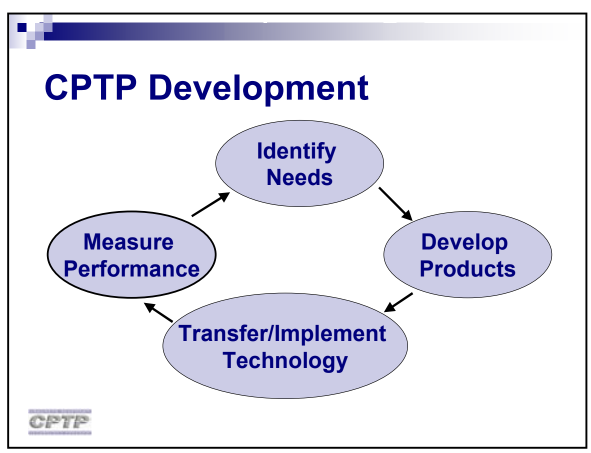
Overview

The TEA-21 bill was signed into law in June 1998 and included a provision earmarking $30 million over a 6-year period for research, development and technology transfer activities related to improved methods of using concrete pavement in the construction, reconstruction, and repair of federal-aid highways. As a follow-up on this provision, FHWA entered into a cooperative agreement with the Innovative Pavement Research Foundation (IPRF) during March 1999 to establish a federal-industry partnership to jointly conduct the CPTP with a total funding of $25 million. Under the terms of this cooperative agreement, FHWA and IPRF were each responsible for managing and conducting $12.5 million of the research.

The research projects selected for inclusion in the CPTP were designated as tasks. The IPRF managed projects were based on a “Blueprint for Research” developed by the America Concrete Pavement Association (ACPA). Projects designated as Tasks 1 to 19 were to be performed under the IPRF oversight and projects designated as Tasks 51 to Tasks 65 were to be performed under FHWA oversight and management. During June 2002, FHWA and IPRF mutually agreed to terminate the CPTP related cooperative agreement. During late 2002 and early 2003, FHWA renegotiated several of the IPRF projects and executed new contracts in accordance with Federal procurement rules.

Expert Task Group Advisory Panels

Most CPTP projects included provisions for establishment of Expert Task Groups (ETGs) to provide technical advice and guidance to the project contractor teams in the conduct of the project. The ETGs typically meet at specific project milestones to review the status of the project and to review specific products developed under each phase of the project. The ETG



membership includes experts in the subject matter from State DOTs, FHWA, industry, and academia.

TRB Oversight Committee (Committee for Research on Improved Concrete Pavement for Federal-Aid Highways)

As part of the FHWA-IPRF cooperative agreement, TRB established Committee EE1007 – *Committee for Research on Improved Concrete Pavement for Federal-Aid Highways*. The committee's membership comprised of senior management personnel from State DOTs, FHWA, AASHTO, TRB and Industry as well as experts from academia. The committee's charge was to review and advise upon the long-range work plan of the joint FHWA-IPRF concrete pavement research program and individual research tasks. The first meeting of the committee was held in June 1999, while the ninth and final meeting of the committee was held in October 2003. Over more than 4 years, the committee played a useful oversight and advisory role in helping maintain focus in the overall CPTP.

CPTP Challenges

The CPTP is an important undertaking of FHWA in partnership with State DOTs, AASHTO, TRB, industry, and academia. The CPTP is only a few years old, but it has developed into a systematic approach to improving concrete pavement technology. The FHWA is committed to carrying this momentum forward to continue to reap the rewards from the CPTP in future years.

The CPTP, like many similar national programs, also needs to overcome many challenges to ensure widespread acceptance of the program, its vision/mission, and successful deployment of the program products. The challenges that need to be addressed include the following:

1. Institutional resistance to innovations, as the highway construction industry is very conservative when it comes to implementing new ideas and new technologies.
2. Perception of high risk/high failure rate in implementing new "untried" products.
3. Many products do not address immediate repair/rehabilitation related needs of the DOTs, such as shorter closure times and longer performance lives.
4. Products for implementation have not been pre-tested. Products need to undergo pre-implementation "ruggedness" testing.
5. Products cannot be buried in very technical reports and documents.
6. In the past, many implementations have not had adequate follow-up monitoring. Therefore, the success or failure of implemented products is not known, except for anecdotal information. As a result, opportunities to further develop/improve implemented products are not usually available.
7. Most DOTs are under-staffed and under-resourced. Therefore, it is required that most new products be well-refined to allow ready acceptance and implementation by DOT staff.
8. Most payoffs in concrete pavement innovations are realized over a long time period. These longer-term benefit projects need to be balanced with shorter-term benefits such as reduced premature failures, reduced construction time, efficient work zone management, and lower overall user costs.

The FHWA CPTP team believes that with the right approach, continued partnering between various involved parties, and continued support of key stakeholders to champion innovative products, the CPTP will remain a dynamic and productive program.

The FHWA is committed to ensuring that there is adequate follow-through of implemented CPTP products whether it is in the field or in the classroom. A formal program has been incorporated within the CPTP to monitor long-term performance and impact of implemented products. With this process, the CPTP can continue to build upon the success of each implementation.

CHAPTER 2 - CPTP FOCUS AREAS

Introduction

The CPTP initiative encompasses a broad range of projects, ranging from materials research to field testing of new technologies, from the development of computer programs to the implementation of technology transfer activities. For purposes of categorization, the CPTP initiative is divided into the following six focus areas relating to various aspects of concrete pavements:

- Focus Area 1: Advanced designs.
- Focus Area 2: Improved materials.
- Focus Area 3: Improved construction processes.
- Focus Area 4: Rapid repair and rehabilitation.
- Focus Area 5: Enhanced user satisfaction.
- Focus Area 6: Trained work force.

Over 30 projects, referred to as tasks, are currently included in these focus areas, and each is closely tied to the overall goals and objectives of the program. The following sections describe each of the six focus areas, and highlight some of the projects that make up each focus area along with significant contributions that have been made to the program. Appendix A lists the CPTP tasks and identifies the associated focus area(s) of each task, with specific project details provided in Appendix B. Appendix C provides information on non-CPTP projects being conducted by others that complement the current CPTP projects.

CPTP Focus Area 1: Advanced Designs

- Performance and Design of Whitetopping Overlays for Heavily-Trafficked Pavements (Task 3).
- Accelerated Loading Tests of Ultra-Thin Whitetopping (Task 5).
- Instrumentation of UTW in Colorado (Task 7C).
- Accelerated Load Testing of Ultra-Thin Whitetopping (Task 55).
- Incremental Costs and Performance Benefits of Various Features of Concrete Pavements (Task 6).
- Field Evaluation of Elliptical Steel Dowel Performance (Task 7G).
- Influence of Sealing Transverse Contraction Joints on the Performance of Concrete Pavement (Task 9).
- Revision of ISLAB 2000 for Subbase/Pavement Interaction (Task 10).
- High Performance Concrete Pavements (Task 53).
- Development of Standard Test for Concrete Coefficient of Thermal Expansion (Task 56A).

CPTP Focus Area 1: Advanced Designs

Projects in this area are looking at ways to improve or advance pavement structural designs. In some cases, this may include projects developing advanced design or analysis methods, while in others it may refer to projects incorporating the use of new or innovative materials or construction procedures. Highlighted projects within this focus area are described below.

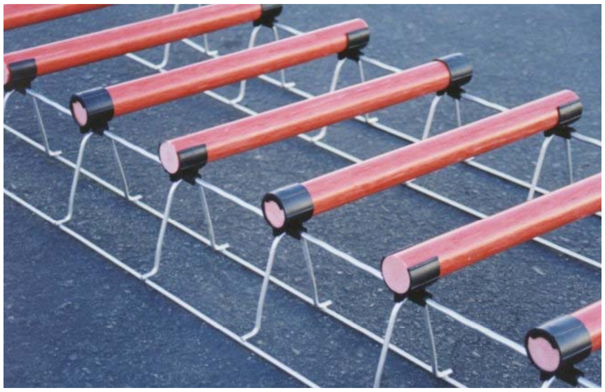
Whitetopping and Ultra-Thin Whitetopping

Under CPTP Tasks 3, 5, 7C, and 55, research is being conducted on the improved design and rehabilitation of whitetopping overlays (concrete overlays of existing hot-mix asphalt [HMA] overlays). This technology is seeing significant growth as an effective rehabilitation measure for distressed HMA pavements, and can consist of conventional whitetopping, thin whitetopping, and ultra-thin whitetopping (UTW). Conventional whitetopping has the longest history of use (dating back to 1918) and is designed essentially as a new pavement on a stabilized base, assuming an unbonded condition between the concrete and the existing HMA pavement. Thin whitetopping is a moderately thin PCC overlay (thicknesses between 102 and 203 mm [4 and 8 in]) that is placed on a milled HMA pavement. The bond between the concrete and HMA pavement is relied upon in the design procedure, and short joint spacing (between 1.8 and 3.7 m [6 and 12 ft]) is used. UTW is similar in concept to thin whitetopping in that the concrete is bonded to a milled HMA, and that bonding is relied upon in the design process. PCC overlay thicknesses are between 50 and 102 mm (2 and 4 in) and square slabs (between 0.6 and 1.8 m [2 and 6 ft] on a side) are employed.

The focus of much of the research in the CPTP has been on the improved design of thin and ultra-thin whitetopping, particularly in the area of bond development and bond contribution to load-carrying capacity. Additional work has been done documenting "best practices" for the repair and rehabilitation of ultra-thin whitetopping overlays.

Joint Design

Several projects within the CPTP are looking at improved and more cost-effective joint designs. For example, in Task 7G and Task 53, the use of different types of dowel bars are being investigated; these include not only the use of elliptical-shaped dowel bars (which are expected to reduce critical dowel-concrete bearing stresses by distributing loading over a wider area) but also the use of alternative dowel bars constructed of a non-corrodible material or containing a non-corrodible cladding for protection against corrosion. Pavement projects incorporating these different types of dowel bars have been constructed and are now being monitored to evaluate their long-term performance and overall cost-effectiveness.



Also being investigated in the area of joint design is the issue of transverse joint sealing (Tasks 9 and 53). This has been the subject of widespread debate within the pavement community, and the CPTP includes several projects directly evaluating the performance of concrete pavement sections with and without sealed transverse joints. Results from these studies are expected to provide improved guidance on when transverse joint sealing may and may not be cost-effective.

Benefit/Cost Tradeoffs of Design Features

The addition of design features (such as dowel bars, drainage, stabilized base, and so on) to a new concrete pavement are expected to have a positive effect on pavement performance, but the addition of such features also increases the overall cost of the pavement structure. Under CPTP Task 6, an evaluation tool is being developed that can be used to assess the relative costs and benefits of incorporating different design features into a concrete pavement design. The tool provides insight into general performance and cost trends associated with those modified pavement designs and, as such, can assist design engineers in developing more cost-effective concrete pavement designs.

Mechanistic Design

Several projects conducted under the CPTP are contributing to the development and implementation of mechanistic pavement design procedures, such as the 2002 Design Guide for New and Rehabilitated Pavements. For example, enhancements to the ISLAB 2000 finite element computer program have been funded, and that program serves as the stress computation "engine" for the 2002 Design Guide rigid pavement design procedure. Moreover, a procedure has been developed (and adopted by AASHTO as a provisional specification) for the determination of the concrete coefficient of thermal expansion, a key materials input in the 2002 Design Guide.

Products and Contributions of CPTP Focus Area 1

- Improved procedures for design of whitetopping overlays *(in development)*.
  - UTW Design guide *(available, pending final review)*.
  - UTW Software *(available, pending final review)*.
  - Colorado's thin whitetopping design procedure calibration *(in development)*.
- Various UTW Performance Reports from FHWA accelerated load testing program *(available now)*.
  - An Analysis of Ride Quality of the Ultra-Thin Whitetopping Overlays at the FHWA Accelerated Loading Facility.
  - Identification of Pavement Failure Mechanisms at FHWA Accelerated Loading Facility Ultra-thin Whitetopping Project.
- Database of UTW performance under accelerated loading *(in development)*.
- Status of High-Performance Concrete Pavements (*available now*).
- Alternative Dowel Bars for Load Transfer in Jointed Concrete Pavements (*available now*).
- Guidelines for determining need for transverse joint sealing *(in development)*.
- ISLAB 2000, enhancement to the finite element analysis tool *(available now)*.
- AASHTO provisional specification on determination of concrete thermal coefficient of expansion (*available now*).

CPTP Focus Area 2: Improved Materials

Projects in this area are looking at ways to improve or advance concrete material selection process and concrete mix design procedure to result in durable concrete paving mixes that can be placed and finished effectively for slipform operations. Highlighted projects within this focus area are described below.

CPTP Focus Area 2: Improved Materials

- Test Standards to Identify Compatible Combinations of Individually Acceptable Concrete Materials (Task 4).
- Concrete Mixture Optimization Using Statistical Mixture Methods (Task 56B).
- Computer-Based Guidelines for Job-Specific Optimization of Paving Concrete (Task 64).
- Freeze-Thaw Durability of Concrete With Marginal Entrained Air Content (Task 56C).
- Development of Alkali-Silica Reactivity Mix-Specified Test Method (Task 56D).
- Variation in Shrinkage Potential of Portland Cement Concrete (Task 56E) – On hold.
- Evaluation of the Workability Test and the Workability of Concrete Paving Mixtures (Task 56F).

<u>Test Standards to Identify Compatible Combinations of Individually Acceptable Concrete Materials</u>

Properly designed and constructed concrete pavements can provide 20 to 25 years of initial service life without significant maintenance. In recent years, however, cases of early-age problems and premature deterioration have resulted from use of incompatible materials. Highway professionals have noted instances of early loss of workability (early stiffening), delayed set (retardation), early-age cracking due to excessive shrinkage, and lack of proper air void system. These problems affect long-term performance and even construction productivity. Important expected outcomes under CPTP Task 4 are the advancements and improvements in testing and characterizing of PCC mixtures to mitigate premature failures in paving concrete. The objectives of this project are to develop practical test protocols and criteria to assess the effects of combinations of materials for concrete pavements on the following three areas:

1. Early stiffening and excessive retardation that can affect workability, placeability, consolidation, and finishing.
2. Potential for early-age cracking, including plastic shrinkage; and possibly the ability to attribute the cause of cracking to chemical, physical, and environmental phenomena.
3. Characteristics of the air-void system, including non-uniformity, insufficient air, coalescence of air voids around aggregate, and excessive large voids, all of which influence strength and / or durability.

The materials under evaluation include portland cement and blended cements; fly ash, slag, silica fume, and other pozzolans; chemical admixtures; and aggregates. The researchers will also consider the effects of production and placement methods, factors influencing aggregate segregation, bleeding and cohesiveness relative to finishability, and the influence of environmental conditions such as temperature. Deficiencies in existing test methods for assessing the suitability of materials for making concrete will be identified.

The test protocols developed will be incorporated into guidelines for evaluating and qualifying combinations of materials to be used in pavements. An implementation plan with recommendations and materials for dissemination of the information developed during this project will also be provided.

Concrete Mixture Optimization

Over the last several years a number of studies have been conducted that dealt with various aspects of the effect of concrete components on the performance of the resulting concrete pavements. The wealth of information now available is too great to be practically assimilated and combined from existing guidelines, reports, tables and predictive models in order for a pavement or materials engineer to derive the optimal mix for a given paving project. Under CPTP Task 64, a coordinated effort is being made to take the results of previous work (including work performed in CPTP Task 56) and integrate them into a computer-based system that will guide the concrete materials engineer in selecting the optimal mix for a particular project. Factors that are being considered include pavement structural design (loading effects), early-age and long-term environmental effects, the construction process, desired service life, available local materials and cost.

Concrete Durability Testing

Under CPTP Task 56, research projects are being conducted to develop additional information and test data to support improvements in characterizing the alkali-silica reactivity (ASR) and freeze-thaw (F-T) durability of paving type concrete mixtures. In a series of laboratory tests, researchers are evaluating the durability of high performance concrete (HPC) with lower amounts of entrained air. These tests will help define more effective air content requirements for HPC. In another study under Task 56, laboratory testing is being conducted to develop a fast, reliable test for assessing ASR potential of concrete mixtures. There is currently no accepted rapid test method to evaluate the ASR susceptibility of concrete mixtures. The commonly used ASTM C1260 test procedure specifically states that it is to be used to assess aggregates and not combinations of aggregates and cementitious materials. The results of this study will result in guidelines for proper use of ASTM C1260 for evaluating combinations of cementitious materials and aggregates.

Products and Contributions of CPTP Focus Area 2

- Guidelines for identifying incompatible combinations of concrete materials *(in development)*.
    - Concrete workability test procedure(s).
    - Field procedure for determining concrete air characteristics using the air void analyzer (AVA).
    - Refined test procedure for determining shrinkage potential of concrete.
- Improved guidelines for optimizing project specific concrete mixtures *(in development)*.
    - Computer-Based Guidelines for Job-Specific Optimization of Paving Concrete
- Improved procedures for evaluating concrete durability *(in development)*.
    - Modified ASTM 1260 procedure for ASR testing

CPTP Focus Area 3: Improved Construction Processes

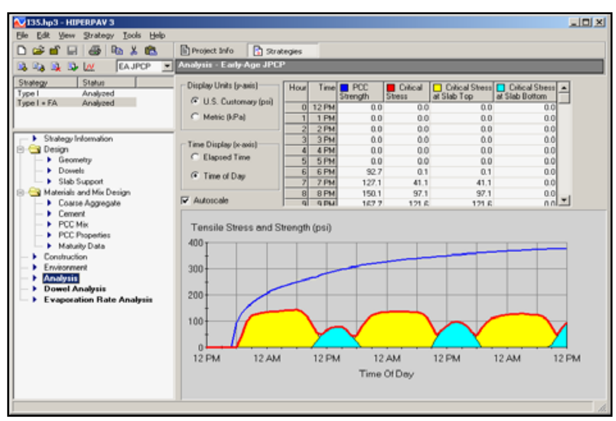
In this focus area, CPTP projects are exploring the use of new or innovative equipment and technologies for improving all aspects of concrete pavement construction. This includes projects on improved construction processes, improved monitoring of in situ conditions, and evaluation and testing of new construction specifications. Highlighted projects within this focus area are described below.

> **CPTP Focus Area 3: Improved Construction Processes**
>
> - Traffic Management Studies for Reconstructing High-Volume Roadways (Task 1–original).
> - Traffic Management Optimization Pilot Studies for Reconstructing Urban Freeways (Task 1–new).
> - Fast Track Construction with Portland Cement Concrete Pavement (PCCP) at Urban Intersections (Task 7B).
> - Implementation of TEMP System (Task 7E).
> - Computer-Based Guidelines for Concrete Pavements (HIPERPAV II) (Task 57).
> - Evaluation of Performance-Related Specifications (PRS) in Tennessee (Tasks 7H).
> - Evaluation of Initial PCC Performance-Related Specification Systems (Task 61).
> - Use of Magnetic Tomography to Evaluate Dowel Bar Placement (Task 7F).
> - Mobile Concrete Laboratory (Task 51).
> - Curing of Portland Cement Concrete Pavements (Task 60).
> - Potential Adverse Effects of High-Smoothness Specifications on Concrete Pavement Performance (Task 62).

Traffic Management During Construction

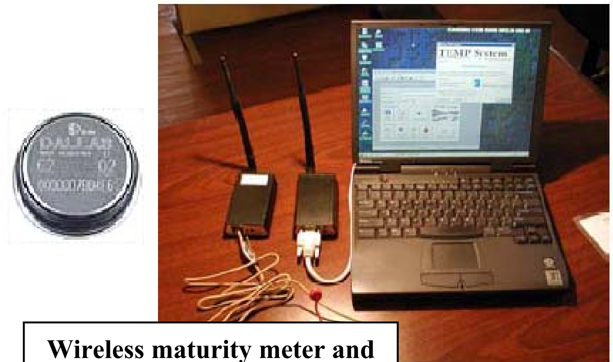
The need for well-planned traffic management and control plans are becoming increasingly important, particularly on high-volume freeways in urban areas, because of the need to minimize traffic disruptions and travel delays associated with lane closures during pavement rehabilitation or reconstruction. The feasibility of rehabilitating an urban freeway and an urban intersection "fast and under traffic" was demonstrated under two CPTP projects (Tasks 1 [original contract] and 7B); a new study (Task 1 [new contract]) is now being conducted to demonstrate traffic-management optimization principles on pilot projects, and includes the development of a decision-making tool that can be used to guide decisions on public involvement approaches.

Paving and Materials Management During Construction



Two CPTP projects are advancing the capabilities of monitoring concrete properties during concrete paving. Under CPTP Task 57, enhancements are being made to the HIPERPAV computer software program, which was originally developed in the late 1990s as a tool to predict concrete strength gain and internal stress conditions as a function of specific mix design parameters and site-specific environmental inputs during the first 72 hours after placement. The enhanced version of the program expands the performance modeling beyond the initial 72 hours after paving and also incorporates the ability to model the early-age behavior of continuously reinforced concrete pavements (CRCP).

Closely tied to the HIPERPAV program is the development of the Total Environmental Management for Paving (TEMP) software under CPTP Task 7E. The TEMP system involves on-site or remote monitoring of pavement temperatures to monitor concrete strength development and can also be used as a means of getting accurate and instantaneous feedback on curing conditions. The TEMP feedback can be used to determine appropriate times for joint sawing or opening the pavement to traffic.



Wireless maturity meter and data acquisition system

Specification Development and Evaluation

Construction specifications are continually evolving in response to new technologies and new developments. Under the CPTP some of these new specifications are being investigated. For example, recent years have seen a growing interest in performance-related specifications (PRS), which are unique in that they allow the selection of quality levels commensurate with desired performance, use in situ measurements of pavement quality characteristics, and have a rational basis for the determination of appropriate incentive/disincentive factors. A model PRS has been developed by FHWA, and under CPTP Tasks 7H and 61 pilot projects are being constructed using the performance-related specification to evaluate its suitability for use in an actual construction project.

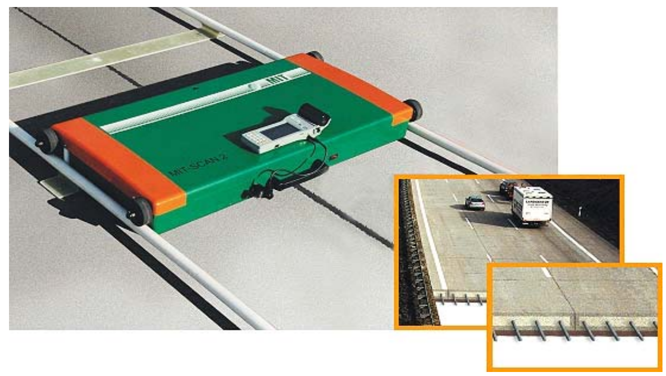
In another CPTP study (Task 62), the potential adverse effects of specifying higher and higher levels of initial smoothness are being studied. The objective is to assess whether any activities carried out during the paving process to achieve some specified level of smoothness could have detrimental effects on concrete properties and pavement performance.

Mobile Concrete Laboratory

Under CPTP Task 51, the mobile concrete laboratory introduces Federal, State and local transportation personnel to the state-of-the-art of concrete technology in materials selection and mixture design, as well as in field and laboratory testing. In addition, the mobile concrete laboratory provides materials testing support to many of the CPTP field trials and demonstration projects.

The mobile concrete laboratory is essentially a state-of-the-art concrete testing facility on wheels. The laboratory is fully equipped with conventional concrete testing equipment (for measurement of air, slump, strength, and elastic modulus) as well as other new and innovative testing technologies, such as maturity meters (for monitoring pavement temperatures to determine appropriate opening times), the vibrating slope apparatus (for measuring concrete workability), the air void analyzer (for rapid measurement of air void contents and air void spacing), and the impact echo device (for measurement of concrete pavement thickness).

Construction Processes



Two CPTP projects are contributing to the overall construction process and control. Under CPTP Task 7F, field trials of a new device for evaluating dowel placement conditions. The magnetic tomography device is a new piece of equipment (German-made) that can be used to evaluate the vertical and horizontal location of dowel bars. In one measurement, the device scans the entire length of a joint and determines the location and alignment of all dowels, providing preliminary results immediately after the measurements. The device is capable of being used on fresh concrete and can measure up to 200 joints in an 8-hour shift. Preliminary analyses indicate an accuracy of ±2 mm.

Under CPTP Task 60, guidelines are being developed for selecting appropriate curing materials and curing procedures given specific concrete mix properties and environmental conditions at the time of paving. This is in recognition of the large number of products available for curing (some of which may not be effective in preventing moisture loss) and the wide range of conditions under which concrete paving is conducted.

Products and Contributions of CPTP Focus Area 3

- Summary of urban reconstruction in California.
  - Urban Concrete Pavement on Interstate 10 (IPRF Special Report 1) *(available now)*.
  - Case Study of Urban Concrete Pavement Reconstruction and Traffic Management for the I-10 (Pomona, CA) Project *(available now)*.
- Weekend intersection reconstruction in Washington State.
  - Accelerated Construction of Urban Intersections with Portland Cement Concrete Pavement (PCCP), Final Report *(available now)*.
  - Video tape on urban intersection construction *(available now)*.
- Guidelines for traffic management (in development).
- Enhanced software programs for monitoring concrete properties during paving (HIPERPAV II and TEMP) *(available Summer 2004)*.
- Field evaluations of performance-related specifications.
  - Appendix II: Performance-Related Specification for Use in Determining Pay Factor Adjustments. Prepared for: R-25175, I-66, Clarksville, IN, March 18, 2002.
  - Appendix II: Performance-Related Specification Design and AQC Values as Determined for Use in Determining Pay Factor Adjustments Prepared for Project R-24432, Marion County, IN.
  - Chini, A.R., L.C. Muszynski, and J.K. Hicks, 2003, *Determination of Acceptance Permeability Characteristics for Performance-Related Specifications for Portland Cement Concrete.* Final Report. University of Florida, Gainesville, FL.
- Summary of the effect of high initial smoothness on concrete properties and performance *(in development)*.
- Field demonstrations of new testing equipment and technologies.
  - Mobile Concrete Laboratory Project Reports – 9902 CA – Use of Fast-Setting Hydraulic Cement Concrete for Interstate Concrete Pavement Rehabilitation, I-10, Pomona, California Revised Field Test Report, date unknown *(available now)*.
  - Mobile Concrete Laboratory Project Reports – 9903 SD – I-94 Pavement Replacement – Richardton, North Dakota, Summer, 1999, Summary Report, date unknown *(available now)*.
  - Mobile Concrete Laboratory Project Reports – 9904 SD – Tensile Bond Strength of a High Performance Concrete Bridge Deck Overlay – I-90, Sturgis, South Dakota, Summer, 1999, date unknown *(available now)*.
  - Mobile Concrete Laboratory Project Reports – 0005 NE – Summary report 0005, US 275, Valley, Nebraska, Fall 2000, date unknown *(available now)*.
  - Mobile Concrete Laboratory Project Reports – 0202 – Woodrow Wilson Bridge Foundation Concrete Thermal Modeling, date unknown *(available now)*.
  - Mobile Concrete Laboratory Project Reports – 0204 – Summary Report, Kernville Viaduct HPC Deck Concrete, Johnstown, PA, Summer 2002, date unknown *(available now)*.
  - Mobile Concrete Laboratory Project Reports – 0205 – US 23, Future I-26 New Interstate Concrete Paving Madison County, North Carolina, Summer, 2002, date unknown *(available now)*.
  - Mobile Concrete Laboratory Project Reports – 0207 AZ – LTPP Impact-Echo Thickness Determinations I-10, Maricopa County, Arizona, Summary Report, December 2002 *(available now)*.
  - Dowel bar alignment testing protocol and test equipment
- Guidelines for concrete curing *(in development)*.

CPTP Focus Area 4: Rapid Repair and Rehabilitation

> **CPTP Focus Area 4: Rapid Repair and Rehabilitation**
>
> - Weekend reconstruction of urban facilities (Tasks 1 and 7C).
> - Precast panels for full-depth repair (Task 7E).
> - Precast panels for rapid rehabilitation (Task 58).
> - Field trials of promising repair and rehabilitation methods (Task 52).
> - Repair of UTW (Task 7B).
> - Improved guidelines & strategies for rehabilitation (Task 54).

Pavement rehabilitation is a major activity for all highway agencies and has several consequences on agency resources and traffic disruptions because of extensive and extended lane closures. The traffic volumes on the primary highway system, especially in urban areas, have seen tremendous increases over the last 20 years, leading in many instances to an earlier-than-expected need to rehabilitate highway pavements. Efforts continue to develop techniques and procedures that will result in cost-effective and longer-lasting concrete pavement rehabilitation to serve the nation's highway system well into the 21st century. In addition, many agencies continue to wrestle with the age-old problem: longer delays now and longer service life versus shorter delays now and shorter service life.

Projects in this area are looking at ways to improve or advance concrete pavement rehabilitation technologies that will allow for faster and more durable repair and rehabilitation/reconstruction of concrete pavements. This effort includes the use of high early strength concrete materials and the use of precast pavement technology. Highlighted projects within this focus area are described below.

Rapid Reconstruction of Urban PCCP Facilities

In Eastern Washington, three major HMA intersections were reconstructed with PCCP in August 2000. The entire reconstruction of each intersection, including demolition of the existing HMA pavement and its replacement with PCCP, took place over a period of 3 days (starting on Thursday evening and opening the intersection to the traffic on Monday morning). Under CPTP Task 7C, the researchers documented this effort along a section of SR 395 in order to provide practitioners additional options for rapid reconstruction of urban facilities. The final report for Task 7C included an analysis of the cost benefit ratio; documentation of the construction process, including innovative construction practices and production rates; and documentation of traffic management strategies. Additionally, video documentation was produced for use in technology transfer. The study documentation and video are being used to educate pavement construction professionals and university students on how urban highway facilities can be reconstructed on a fast track basis, with minimal user disruption, using

innovative construction techniques and traffic management optimization principles. This study was performed in collaboration with the Washington State Department of Transportation.

Under CPTP Task 1, weekend reconstruction of another urban highway facility was also documented. This project involved reconstruction of a 1.8-mile section of I-10 near Pomona, California over one weekend period (55 hours). The documentation prepared under Task 1 provide guidelines for considering factors that improve construction productivity under tight reconstruction schedules and identifies factors that may constrain overall productivity. This study was performed in collaboration with the California Department of Transportation.

<u>Precast Panels for Repair and Rehabilitation</u>

One of the most promising rehabilitation techniques undergoing field trials is the precast concrete pavement technique. This technique, dating back several decades, is being applied to rapid repair of localized failures in concrete pavements (full-depth repairs) and to rehabilitate long lengths of existing poorly performing asphalt and concrete pavements. The precast paving technology has matured and is ready for widespread use. Use of this technology will result in more durable repairs and rehabilitation, help shorten lane closures, and increasing user satisfaction.

Under CPTP Task 7E, the use of precast paving for full-depth repairs of jointed concrete pavements has been demonstrated in Michigan and Colorado. Using this process, full-depth repair patches can be opened to traffic within 6 to 8 hours of lane closure. In the demonstration projects, factory cast 6 by 12 ft panels were used to repair deteriorated joints along sections of the interstate highway system. The repairs involved removal of deteriorated joint concrete, preparation of the base support, placement of a fast-setting bedding material, installation of precast panels, and installation of retrofitted dowel bars at the transverse joints. These projects are under evaluation to determine long-term performance.

Under Task 58, several studies have been funded to determine the feasibility and cost-effectiveness of using precast pavement to rapidly rehabilitate or reconstruct existing concrete or asphalt pavements. In the initial study, the researchers developed a concept for precast concrete pavement and recommended testing the concept through pilot projects. In March 2002, Texas DOT successfully completed the first pilot project on a frontage road near Georgetown, Texas. At this pilot project, the following design and construction features were incorporated:

- Use of longitudinal post-tensioning to tie together a series of precast panels to provide a joint-less slab length of 250 ft. Each precast panel was also pre-tensioned in the transverse direction.
- Use of a thinner precast slab compared to need for a thicker conventional jointed slab.
- Innovative post-tensioning techniques.
- Placement of the precast panels directly over an asphalt concrete base/leveling course.

A successfully developed precast pavement rehabilitation technique will provide many benefits, including the following:

- Expedited construction with almost immediate exposure to traffic.
- Possibility for overnight or weekend construction.
- Greater control over concrete batching and curing.
- Increased durability from post-tensioning.
- Material savings through reduced pavement thickness.
- Reduced demands on construction time lane closures.

Additional precast pavement repair and rehabilitation demonstration projects are planned for the Year 2004.

Repair of UTW

The history of the UTW pavements is still short; however, early evaluations have shown promising performance. Corner cracking and delaminations appear to be the most predominant distress types. With the use of UTW pavements increasing, naturally, the next question is how to repair the system when distresses do occur. The construction of the UTW test sections at the Federal Highway Administration's (FHWA) Turner-Fairbank Highway Research Center (TFHRC) (CPTP Tasks 5 and 55, see Focus Area 1 discussion), subjected to accelerated loading tests, provided an excellent opportunity for evaluating potential UTW pavement repair methods. Under CPTP Task 7B, UTW repair techniques were demonstrated by using some of the distressed slab panels at the FHWA's UTW test section. The repair panels were subjected to accelerated load testing. The study demonstrated that distressed UTW can be quickly and effectively replaced. A final report and a video documenting the repair process are available.

Improved Guidelines and Strategies for Rehabilitation

Under CPTP Task 54, efforts are underway to develop systematic, user-friendly guidelines for the repair and rehabilitation of distressed concrete pavements. As part of this effort, a set of guidelines has been developed for evaluating the condition of existing concrete pavements and for determining the most effective strategy for repair and/or rehabilitation of the pavement, considering future traffic, condition of the existing pavement, cost, and desired service life of the repaired/rehabilitated pavement. A user-friendly software has also been developed to assist pavement engineers identify the most effective rehabilitation alternative for a given set of conditions.

Field Trials of Promising Repair and Rehabilitation Methods

CPTP Task 52 is the continuation of FHWA's SP-205 field demonstration program. The SP-205 is developing field-tested guidance on concrete pavement rehabilitation and repair techniques as well as strategies that emphasizes the *do's* and *don'ts*, and *why* and *when* for concrete pavement restoration (CPR) and preventive maintenance of concrete pavements.

SP-205 is evaluating pavement repair/rehabilitation sites and techniques studied by FHWA in the mid 1980s and testing and evaluating new and innovative CPR techniques and strategies through new test and evaluation projects. The rehabilitation and maintenance strategies considered are full-depth patching, partial-depth patching, sub-sealing, joint resealing, retrofitted load transfer, and grinding and grooving. Periodic evaluation of the field test sites is being carried out under CPTP. About 40 sites are under evaluation. Based on the analysis of the field data, proper timing for repair and preventive maintenance will be defined. A series of updated *Technical Bulletins* will be published for each technique included in this project.

Products and Contributions of CPTP Focus Area 4

- Repair Guidelines on ultra-thin whitetopping repair *(available now).*
  - Repair of Ultra-Thin Whitetopping Roadways and Airfields.
  - Video tape on UTW Repair.
- Summary of urban reconstruction in California.
  - Urban Concrete Pavement on Interstate 10 (IPRF Special Report 1) *(available now).*
  - Case Study of Urban Concrete Pavement Reconstruction and Traffic Management for the I-10 (Pomona, CA) Project *(available now).*
- Weekend intersection reconstruction in Washington State.
  - Accelerated Construction of Urban Intersections with Portland Cement Concrete Pavement (PCCP), Final Report *(available now).*
  - Video tape on urban intersection construction *(available now).*
  - Guidelines for traffic management (in development).
- Precast pavement for full-depth repair
  - Michigan demonstration project *(technical paper available now).*
  - Colorado demonstration project *(constructed 2003, report pending).*
- Precast pavement for AC and PCC pavement rehabilitation
  - Feasibility Study, Final Report *(available now).*
  - Texas pilot project *(report and technical papers available now).*
- Improved guidelines and strategies for PCC pavement rehabilitation
  - Draft documentation (four volumes) *(available now)*
  - Program SAPER *(in development).*
- Improved guidelines for concrete pavement restoration techniques, based on field performance *(in development).*

CPTP Focus Area 5: Enhanced User Satisfaction

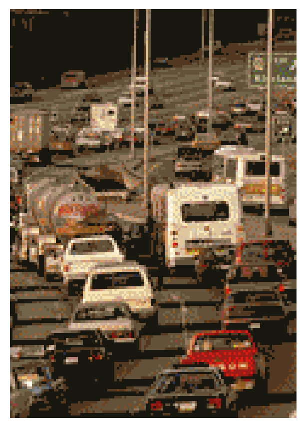
In this focus area, several CPTP projects are aimed at increasing user satisfaction which includes reducing congestion and improving (functional) performance. Congestion can be reduced by improved construction practices and traffic management plans to minimize user delays during urban highway reconstruction and by emphasizing pavement preservation activities to extend the pavement's service life before major rehabilitation or reconstruction is required.

CPTP Focus Area 5: Enhanced User Satisfaction

- Construction traffic management studies to reduce lane closures and congestion (Task 1)
- Smoothness criteria for concrete pavements (Tasks 16 and 53).
- Smoothness characterization (Tasks 62 and 63).
- Traffic noise characteristics (Task 63).
- Surface texturing (Task 53).

Functional performance is determined by how well the pavement serves the user. Until now, riding comfort—a concept developed in 1957—has been the dominant concern. Today the greater need is to optimize riding comfort along with other important functional characteristics of pavements, particularly surface texture (which affects friction and noise). Some of the CPTP studies that are expected to provide contributions in these areas are summarized below.

<u>Congestion Reduction</u>



One of the major user concerns in concrete pavement construction and rehabilitation is congestion reduction. While a number of other CPTP activities will contribute to addressing this concern, implementing innovative construction methods and traffic management methods during urban highway reconstruction to minimize user disruption will improve safety and substantially reduce user costs because these routes will be open to serve traffic. Worker safety will also be improved by reducing workers' exposure to traffic during construction (Task 1).

<u>Smoothness Criteria, Data Collection and Analysis Techniques</u>

Under CPTP Tasks 16, 53, 62, and 63, research is being conducted to improve concrete pavement ride quality for both automobile and commercial vehicles. These activities will support FHWA's national emphasis on improving pavement smoothness. The CPTP research in this focus area is aimed at resolving specific issues unique to portland cement concrete pavements. These issues include:

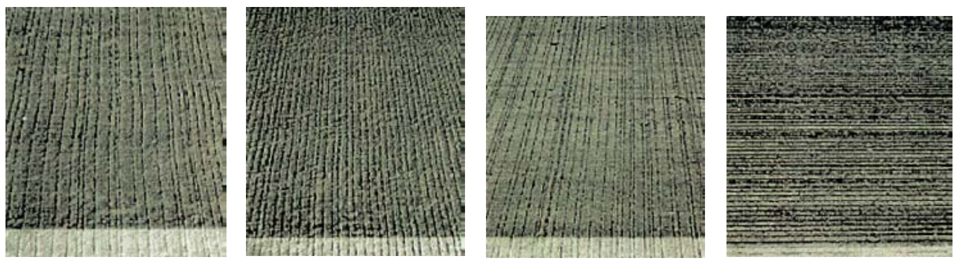
- Developing and specifying improved smoothness criteria which include addressing the effect of texture and joints on ride quality (Task 16).
- Kansas super smooth pavements (Task 53).

- Determining the effects of material properties on pavement smoothness and developing guidelines to assist highway agencies in specifying, and contractors in constructing pavements that are smooth and have good long term performance (Task 62).
- Minimizing slab curvature (and faulting) to improve ride and reduce rate of structural deterioration (Task 63).

The availability and use of recently developed lightweight profilers to measure smoothness soon after concrete placement has required changes in the way smoothness is specified and measured. The protocols developed need to be tested and refined for routine use.

Surface Texturing and Traffic Noise Characteristics

CPTP research is also addressing the surface texture and traffic noise characteristics issues. The Close Proximity (CPX) noise measurement method is being used to determine the relationship between mega texture (50 – 100 mm wave length) and tire pavement noise for PCC pavements (Task 63). This research will help FHWA update the PCC surface texturing guidelines and support the recent Quiet Pavements demonstration effort.



Random Transverse | Uniform Transverse | Random Skewed | Uniform Longitudinal

Products and Contributions of CPTP Focus Area 5

- Guidelines on pavement surface texturing
  - High Performance Concrete Pavement: Pavement Texturing and Tire-Pavement Noise (FHWA-IF-02-020, March 2002) *(available now)*.
- Guidelines for use of inertial profilers for construction quality control and quality assurance *(in development)*.
- Pavement Profile Viewer and Analyzer (ProVAL 2.0) software (*available April 2004*).
- Determination of the effect of materials properties on pavement smoothness *(in development)*.
- Guidelines for specifying and constructing pavements that are smooth and have good long-term performance *(in development)*.

CPTP Focus Area 6: Trained Work Force

CPTP Focus Area 6: Trained Work Force

- Workshops for State DOTs & academia (Task 11).
- Nondestructive testing workshop (Task 59)
- Mobile concrete laboratory – site visits (Task 51).
- Field demonstration projects (Task 65).
- Communications (website, newsletter, product alerts).
- Availability of guides & training material (Task 65).
- Other technology transfer activities (Task 65).

Improvements to the design, construction/reconstruction, maintenance, rehabilitation, and asset management of concrete pavements will be made only when technological advances are put into use. State Departments of Transportation and the concrete paving industry are the primary agents for such advancement as they partner in constructing and maintaining the large majority of highways in the U.S. Therefore, it is essential for key state DOT and industry personnel to become familiar with new concrete pavement technologies as they become available.

CPTP Focus Area 6 is directed at ensuring the appropriate training is made available in a timely manner. Much of the needed training for use and implementation of CPTP products will be provided at no cost to the participants other than travel and per diem.

Training is effective only when it reaches the proper personnel, those empowered to initiate changes in procedures employed by their organizations or those in a position to pass the training on to others. With these personnel in mind, the CPTP training initiatives are directed at state DOT personnel at the technical level or at an administrative level needing overview knowledge of the technologies promoted. Others to be reached by CPTP training include industry personnel and college faculty engaged in teaching construction technology, materials, and pavement design or maintenance courses. The following training, implementation, and communications measures will be employed in this effort.

Workshops

Workshops are an effective teaching approach as they allow students to interact with instructors and, often, to simulate field experiences in a classroom environment. Two 2-day workshops to promote CPTP products to that point in time were conducted in 2000 and 2001 while a 2-day professor's seminar was held in 2001. These workshops were entitled "Concrete Pavement Design - 2000 and Beyond."

Training materials, including the "Handbook of Nondestructive and Innovative Testing Equipment for Concrete", have been developed and two pilot workshops presented on non-destructive and innovative testing procedures. Examples of the procedures or devices included were a maturity test, bond "pull off" test, air void analyzer, impact-echo, and a concrete thickness gauge. Other discussions concerned numerous emerging technologies in the respective areas. The pilot workshops were well received and delivery of additional workshops should begin in early 2004.

Numerous workshops in other areas are anticipated over the next several years. The Alabama DOT has requested two, one each for executive and technical level personnel. Both will deal with the CPTP program in its entirety. Others will deal with surface properties – vehicle interaction and focus on profiles and texturing. Some are expected to deal with the use of the ISLAB 2000 program in the analysis of rigid pavements. Still others will address the design and construction of Ultra Thin Whitetopping (UTW) as well as its use in pavement rehabilitation. Another whole series are anticipated for issues such as "long life" portland cement concrete pavements (PCCP), materials and mix design, joint and dowel design and testing, sealed vs. unsealed joints, and curling and warping of pavement slabs.

CPTP general workshop sessions and poster sessions are planned for the 9th Concrete Pavement Design Conference scheduled for August 2005 in Colorado Springs, Colorado.

Guides and Training Materials (software)

Numerous CPTP and related projects have given rise to guides and training materials. Among the guidelines developed are those on ultra-thin whitetopping (UTW) that have evolved from experience gained through numerous demonstration projects and test sections. Others address fast-track paving and how to deal with the materials, construction, and traffic issues concerned. It is expected that others will be developed from ongoing studies of retrofitted and alternative dowels, HIPERPAV, performance-related specifications (PRS), pavement profiles and texturing, joint sealing, and nondestructive and innovative testing.

Training materials exist or are under development for most of the workshops mentioned above as well as for mechanistic design of PCC pavements, including concrete overlays of CRCP. CPTP staff has on hand slide presentations on most of the CPTP projects mention above and for many of the related projects done by others.

The "2002 Pavement Design Guide" under development by AASHTO will address further mechanistic design issues and provide in one place a full set of design guidelines for jointed pavements.

Software available or under development includes that to address mechanistic design, optimizing selection of concrete pavement design features, performance-related specifications, HIPERPAV design, and much of the nondestructive testing in use.

Finally, the mobile concrete laboratory (MCL) is an excellent training tool for personnel involved in concrete pavement materials testing as it is available to move from agency to agency to provide everything from equipment evaluations to classroom and field demonstration of new and emerging concrete technologies.

Field Demonstration Projects

CPTP products and related materials provide an abundance of opportunity and materials for field demonstration projects, some of the most effective training mechanisms available. Some of those already envisioned are those on monitoring concrete temperature with the TEMP system, precast pavement repairs, and profile and texture measurements. Among others that could evolve from the ongoing and completed studies are those on alternative load transfer, load transfer retrofitting, joint and dowel testing, concrete curing, and traffic management.

Communications (CD, Website, newsletter, product alerts)

A contact list is under development for the CPTP through the use of numerous existing databases as well as through the use of a program “flyer” that was distributed at the 2004 Transportation Research Board (TRB) annual meeting and will be distributed at other venues. The flyer briefly describes the program and solicits mailing and email addresses from persons having an interest in receiving program newsletters and other informational material. Some of the materials envisioned are described below.

A compact disk (CD) or DVD briefly describing the CPTP to executive level personnel will be developed for broad distribution within the concrete pavement community. This instrument will tie into the program website that is being developed under the Task 65 contract. The site will provide a thorough overview of the CPTP as well as links to all participating and related entities.

A draft of the first program newsletter is under development for distribution in early 2004. Articles will deal with ongoing and completed projects directly in the CPTP as well as those from other participants. It is expected that the newsletter will have both state DOT and industry recurring columns in addition to those written by CPTP staff and contractors.

Using the contact list mentioned above, product alerts will be widely distributed, within the community for projects yielding clearly useable results. Each of these documents, consisting of one to three concisely written pages, will give a brief summary of the applicable research, the implementable products identified, sources of materials and information on those products, and implementation guidelines as appropriate. The first alerts have not yet been identified, but will begin to appear in early 2004.

Use of Other Training Technologies

Distance learning, interactive DVDs, and other new technologies are being investigated as potential training tools for the CPTP.

Focus Area 6

The principal products of Focus Area 6 will be the development, integration, and presentation of training for various aspects of the CPTP. The major benefits will be a pavement community better versed in the design, construction, and maintenance of PCC pavements. Specific products include:

- CPTP flyer *(available now)*.
- CPTP website – www.CPTPNow.com (*available now ;site is being enhanced*).
- NDT guidelines and training course *(available Summer 2004)*.
- CPTP Newsletter *(in development)*.
- Field demonstration projects – product specific and focus area specific *(in development)*.
- Product specific and focus area specific workshops *(in development)*.

CHAPTER 3 – SPECIFIC PROGRAM-WIDE CPTP ACTIVITIES

Introduction

A number of key program-wide initiatives have been implemented within the CPTP. These initiatives include Task 15, which is developing a long-range research and development plan for advancing concrete pavement related technologies, and Task 65, which is supporting the technology transfer, marketing and communications activities for the overall CPTP. The following sections present details on these two initiatives.

Long-Range CPTP Research and Development Plan

A significant effort under CPTP is the development of a long-range research and development plan under CPTP Task 15. This important project is laying the foundation for future endeavors to improve concrete pavement technologies that will result in safer, smoother, quieter, and long-lasting concrete pavements. The long-term research plan is the product of extensive input from stakeholder representatives from Federal, State, and local agencies; contractors, suppliers, and consultants; professional associations; and academia, particularly those conducting applied research. At several regional workshops held during 2003, these stakeholders helped define the future research and development needs for paving concrete and concrete pavement technology and identified desirable characteristics of future concrete pavements.

The researchers have identified the following ten major technology tracts for future research:

1. Applied Mechanistic Design Procedures.
2. Performance Driven Mix Design Procedures.
3. Equipment Advancements.
4. Rapid Non-Destructive Quality Control Systems (ICS).
5. Functional Pavement Requirements.
6. Non-Conventional, Non-slip formed Pavements.
7. Advanced Joint Design Program.
8. Performance (In-service) Measurements.
9. Accelerated Concrete Pavement Testing.
10. Environmental Advancements.

The research plan includes details on specific studies to be pursued under each tract. The research plan will be released during early 2004.

CPTP Technology Transfer, Marketing, and Communications Plan

Under CPTP Task 65, an FHWA contractor is providing the engineering and marketing support services that are needed for the timely and cost-effective technology transfer, deployment, and delivery of products resulting from research and development projects in the CPTP.
The engineering support includes the following activities:

- Workshops, seminars, and conferences.
- Field Trials, demonstration projects, and open houses.
- Reports, tech briefs, and brochures.
- User-friendly software.
- Testing standards and guidelines.
- Dedicated web site for CPTP.

The hands-on workshops and field demonstration projects are expected to be important technology transfer activities. It is also expected that several testing standards and guidelines will result from the various CPTP projects – all aimed at improving the practice of design, construction, material selection, testing, repair and rehabilitation.

Maintaining a visible presence in the pavement community is vital to the CPTP, and this will be executed in a variety of ways under Task 65. The development of a comprehensive one-stop website will spearhead the effort, but other activities such as a newsletter, product alerts, and product CDs will also be employed.

CHAPTER 4 - SUMMARY

The CPTP represents an integrated effort to improve concrete pavement performance, fill gaps in current concrete pavement technology, and facilitate the use of new and innovative technology. Through the achievement of the four primary CPTP goals, the end result will be safer, smoother, quieter, and more durable PCC pavements.

CONTACTS FOR CPTP INFORMATION

FHWA Office of Pavement Technology

Sam Tyson
FHWA
Office of Pavement Tech - Infrastructure
400 Seventh Street, SW, HIPT-20, Room 3118
Washington, DC 20590
Phone: (202) 366-1326
Fax: (202) 493-2070
Email: Sam.Tyson@fhwa.dot.gov

FHWA Office of Infrastructure Research and Development

Tom Harman
FHWA – Office of Infrastructure R & D
HRDI-4
6300 Georgetown Pike
McLean, VA 22101-2296
Phone: (202) 493-3072
Fax: (202) 493-3161
Email: tom.harman@fhwa.dot.gov

CPTP Task 65 Contractor (CPTP Technology Transfer, Marketing and Communication Support)

Shiraz Tayabji
Construction Technology Laboratories, Inc.
5565 Sterrett Place, Suite 312
Columbia, MD 21044
Phone: (410) 997-0400
Fax: (410) 997-8480
Cell: (410) 707-4902
Email: stayabji@ctlgroup.com

Kurt Smith
Applied Pavement Technology, Inc.
3001 Research Road, Suite C
Champaign, IL 61822
Phone: (217) 398-3977, ext. 13
Fax: (217) 398-4027
Email: ksmith@pavementsolutions.com

APPENDIX A – CPTP PROJECTS SUMMARY INFORMATION

Project	Project Title	Focus Area(s)	Contract Agency	Contractor
1- (99)	Traffic Management Optimization Pilot Studies for Reconstructing Urban Freeways	4 – R&R	IPRF	University of California
1- (99)	Traffic Management Optimization Pilot Studies for Reconstructing Urban Freeways	4 – R&R	IPRF	Texas Transportation Institute
1- (99)	Traffic Management Optimization Pilot Studies for Reconstructing Urban Freeways	4 – R&R	FHWA	Texas Transportation Institute
2 - (99)	Impact of Texturing and Surface Treatment on Reducing Wet-Weather Accidents	5 – User satisfaction	Not Contracted	NA
3 - (99)	Performance and Design of Whitetopping Overlays for Heavily-Trafficked Pavements	1 - Design, 4 – R&R	IPRF	Transtec, Inc.
3 - (99)	Performance and Design of Whitetopping Overlays for Heavily-Trafficked Pavements	1 - Design, 5 – User satisfaction	FHWA	Transtec, Inc.
4 - (99)	Tests or Standards to Identify Compatible Combinations of Individually Acceptable Concrete Materials	2 – Materials	IPRF	Construction Technology Laboratories, Inc.
4 - (99)	Tests or Standards to Identify Compatible Combinations of Individually Acceptable Concrete Materials	2 – Materials	FHWA	Construction Technology Laboratories, Inc.
5 - (99)	Accelerated Loading Tests of Ultra-Thin Whitetopping (UTW)	1 - Design, 4 – R&R	IPRF	Transtec, Inc.
6 - (99)	Incremental Costs and Performance Benefits of Various Features of Concrete Pavements	1 - Design	IPRF	Applied Pavement Technology, Inc.
6 - (99)	Incremental Costs and Performance Benefits of Various Features of Concrete Pavements	1 - Design	FHWA	Applied Pavement Technology, Inc.
7-B - (99)	Field Trials - UTW Repair Techniques	4 – R&R	IPRF	Construction Technology Laboratories, Inc.
7-C - (99)	Field Trials - Weekend Intersection Reconstruction	4 – R&R	IPRF	University of Washington
7-D - (99)	Field Trials - Instrumentation of UTW in Colorado	4 – R&R	IPRF	Construction Technology Laboratories, Inc.
7-E - (99)	Field Trials - Precast Concrete Slabs for Full Depth Repairs	4 – R&R	FHWA	Michigan State University - Buch
7-F - (99)	Field Trials - Implementation of TEMP System	3 - Construction	FHWA	Transtec, Inc.
7-G - (99)	Field Trials - Magnetic Tomography for Dowel Bar Location	3 - Construction	FHWA	ERES Consultants/ARA

7-H - (99)	Field Trials - Field Evaluation of Elliptical Steel Dowel Performance	1 - Design	FHWA	Iowa State University
7-I - (99)	Field Trials - Evaluation of PRS in Tennessee	3 - Construction	FHWA	ERES Consultants/ARA
8 - (99)	Performance and Design of Separated (Unbonded) Concrete Overlays	4 – R&R	Not Contracted	NA
9 - (00)	Influence of Sealing Transverse Contraction Joints on the Performance of Concrete Pavement	1 - Design	FHWA	ProTech
10 - (00)	Revision of I-Slab 2000 for Subbase/Pavement Interaction	1 - Design	IPRF	ERES Consultants/ARA
11- (00)	Workshops on Concrete Pavement Technology for State DOT Pavement Engineers	6 - Training	IPRF	American Concrete Pavement Association
12-A (01)	Develop a Plan to Investigate the Impacts of Pavement Cracking on Long-Term Performance	1 - Design	IPRF	Construction Technology Laboratories, Inc.
12-B (01)	Develop a Plan to Investigate the Impacts of Pavement Cracking on Long-Term Performance	1 - Design	IPRF	ERES Consultants/ARA
13 - (00)	Determine Actual Life Cycle Costs	1 - Design	IPRF	ERES Consultants/ARA
14 - (00)	AURORA 2000 Pavement System Analysis Tools	1 - Design	IPRF	Transtec, Inc.
14 - (00)	AURORA 2000 Pavement System Analysis Tools	1 - Design	FHWA	Quality Engineering Services, Inc.
15 - (01)	Long-Term Plan for Concrete Pavement Research and Technology	(Future R&D)	IPRF	Iowa State University
15 - (01)	Long-Term Plan for Concrete Pavement Research and Technology	(Future R&D)	FHWA	Iowa State University
16 - (01)	Smoothness Criteria for Concrete Pavements	5 – User satisfaction	FHWA	Soil and Materials Engineers, Inc.
17 - (01)	Subbase Design	1 - Design	Not Contracted	NA
18 - (01)	Roller Compacted Concrete for Asphalt Overlays	1 - Design	Not Contracted	NA
19 - (01)	Communication Services for the Concrete Pavement Technology Program	6 - Training	Not Contracted	NA
51 - (99)	Mobile Concrete Laboratory	3 - Construction	FHWA	Salut, Inc.
52 - (98)	Quality Concrete Rehabilitation and Preservation (SP-205)	4 – R&R	FHWA	Various State Highway Agencies
53 - (98)	High Performance Concrete Pavements (TE-30)	1 – Design 5 – User satisfaction	FHWA	Various State Highway Agencies

54 - (98)	Repair and Rehabilitation of Concrete Pavements	4 – R&R	FHWA	Texas Transportation Institute
55 - (99)	Accelerated Load Testing of Ultra-Thin Whitetopping	4 – R&R	FHWA	FHWA R&D
56 - (99)	PCCP Laboratory Studies		FHWA	FHWA R&D
	56-A -- Development of Standard Test for Concrete Coefficient of Thermal Expansion	1 – Design 2 – Materials	FHWA	FHWA R&D
	56-B -- Concrete Mixture Optimization Using Statistical Mixture Methods	2 – Materials	FHWA	FHWA R&D
	56-C -- Freeze-Thaw Durability of Concrete With Marginal Entrained Air Content	2 – Materials	FHWA	FHWA R&D
	56-D -- Development of Alkali-Silica Reactivity Mix-Specific Test Method	2 – Materials	FHWA	FHWA R&D
	56-E -- Variation of Shrinkage Potential of Portland Cement Concrete	2 – Materials	FHWA	FHWA R&D
	56-F -- Evaluation of the Workability Test and the Workability of Concrete Paving Mixtures	2 – Materials	FHWA	FHWA R&D
57 - (99)	Computer-Based Guidelines for Concrete Pavements (HIPERPAV II)	3 - Construction	FHWA	Transtec, Inc.
58-A - (98)	The Use of Precast Concrete Panels to Expedite Highway Pavement Construction - Phase 1: Feasibility Study	4 – R&R	FHWA	University of Texas
58-B - (98)	The Use of Precast Concrete Panels to Expedite Highway Pavement Construction - Phase 2: Pilot Studies	4 – R&R	FHWA	University of Texas
58-C - (98)	The Use of Precast Concrete Panels to Expedite Highway Pavement Construction - Phase 3: Demonstration Projects	4 – R&R	FHWA	Transtec, Inc.
59 - (00)	Nondestructive and Innovative Testing Workshop	6 - Training	FHWA	Transtec, Inc./SAIC
60 - (99)	Curing of Portland cement Concrete Pavements	3 - Construction	FHWA	U.S. Army Corps of Engineers (WES)
61 - (99)	Evaluation of Initial PCC Performance-Related Specification Systems	5 – User satisfaction	FHWA	Indiana DOT & Florida DOT
62 - (01)	Potential Adverse Effects of High-Smoothness Specifications on Concrete Pavement Performance	3 - Construction	FHWA	Soil and Materials Engineers, Inc.
63 - (02)	Inertial Profile Data for PCC Pavement Performance Evaluation	1 - Design	FHWA	Transtec, Inc.

64 - (02)	Computer-Based Guidelines for Job-Specific Optimization of Paving Concrete	2 – Materials	FHWA	Transtec, Inc.
65 - (03)	Technology Transfer, Deployment and Delivery for the Concrete Pavement Technology Program (CPTP)	6 - Training	FHWA	Construction Technology Laboratories, Inc.

IPRF: Innovative Pavement Research Foundation;
FHWA: Federal Highway Administration

FHWA REPORT NO.

THE CONCRETE PAVEMENT TECHNOLOGY PROGRAM (CPTP)

A STATUS REPORT

APPENDIX B – CPTP PROJECT DETAILS

(TASK 65 ENGINEERING ETG REVIEW COPY)

PREPARED BY

CONSTRUCTION TECHNOLOGY LABORATORIES, INC.
AND
APPLIED PAVEMENT TECHNOLOGY, INC.

FEBRUARY 2004

U.S. Department of Transportation
Federal Highway Administration

CONCRETE PAVEMENT CPTP TECHNOLOGY PROGRAM

APPENDIX B – CPTP PROJECT DETAILS (February 6, 2004)

Key project details on each CPTP project are given in this appendix. These projects are referred to as tasks. Tasks 1 to 19 were designated to be performed under the IPRF program, and some of these tasks were funded and work was performed until the cooperative agreement between IPRF and FHWA was mutually ended. Work on some of the projects was continued under the FHWA management of the CPTP. As such, some of the projects include program details for both the IPRF and the FHWA managed activities, as appropriate.

(THIS IS A WORKING VERSION OF APPENDIX B. IT SHOWS INFORMATION UNDER AVAILABLE REPORTS/ARTICLES/PRESENTATIONS SECTION THAT IS PROVIDED FOR THE ENGINEERING ETG USE ONLY AS SOME OF THE INFORMATION IS NOT AVAILABLE FOR PUBLIC DISTRIBUTION. ALSO, THE FORMAT OF SOME OF THE INFORMATION WILL BE CHANGED FOR THE FINAL PUBLIC VERSION OF THIS DOCUMENT)

Task 1 (99)—Traffic Management Optimization Pilot Studies for Reconstructing Urban Freeways

Project Goals/Objectives: Demonstrate construction processes and traffic management strategies aimed at minimizing traffic and user disruption.

Background: Often the temporary disruption caused by reconstruction of pavements results in costs to the highway user and the local community that dwarf the capital cost of renewal. Concrete pavement contractors suggest that there are variety of innovative construction methods and traffic management methods possible to reconstruct sections of urban freeway with long-life pavement. Unfortunately, there is general skepticism amongst some engineers that long-life pavement reconstruction can be accomplished at minimal user disruption. Success in providing a quality long-life pavement with minimal user disruption would significantly improve safety and substantially reduce user costs because these routes will be open to serve traffic. Worker safety may also be improved by reducing workers' exposure to traffic during construction.

1st Contract

Contracting Dates/IPRF Contract: October 1, 1999 to May 30, 2000

Contract Amount/IPRF Contract: $55,189

Contractor: University of California, Berkeley, California

Principal Investigator: Jeff Roesler

IPRF Contract Manager: Mike Ayers

Status: One project was completed (I-10 in Pomona, California), including a research report by University of California, Berkeley. Electronic copies of the reports are available.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Concrete Pavement Technology Findings – Caltrans Demonstrates Weekend Replacement of Urban Interstate, Innovative Pavement Research Foundation and the Federal Highway Administration, 2001

Concrete Pavement Technology – Weekend Reconstruction – Urban Concrete Pavement on Interstate 10, Innovative Pavement Research Foundation and the Federal Highway Administration – Special Report No. 1, 2001.

Research Reports and Findings – Case Study of Urban Concrete Pavement Reconstruction and Traffic Management for the I-10 (Pomona, CA) Project, University of California, Berkeley, Institute of Transportation Studies, Report available through IPRF, 2001.

Lee, E.B., J. Roesler, J.T. Harvey, and C.W. Ibbs. 2002, Case Study of Urban Concrete Pavement Reconstruction on Interstate 10, *Journal of Construction Engineering and Management*, volume 128 no. 1, American Society of Civil Engineers, Reston, VA.

Other Related Reports/Articles/Presentations/Studies:

Roadway Research Notes – CA4PRS Software – Combining Pavement Engineering, Construction Productivity Analysis, and Traffic Simulation to Expedite Major Freeway Reconstruction Projects, November 2002, California Department of Transportation, Division of Research and Innovation and the University of California Pavement Research Center.

2nd Contract

Contracting Dates:
IPRF Contract: February 22, 2000 to June 2002
FHWA Contract: April 1, 2003 to March 31, 2005

Contract Amount:
IPRF Contract: $545,000 (actual billed amount was less than the contract amount)
FHWA Contract: $421,830

Contractor: Texas Transportation Institute

Principal Investigator: Stuart Anderson

IPRF Contract Manager: Mike Ayers

FHWA Contract Manager: Sam Tyson

Status: Under the IPRF contract, Texas Transportation Institute was developing a protocol of case studies of highways during rehabilitation/reconstruction. Five potential projects were identified (FL, LA, TX, 2 in MI). A project in Mississippi was being investigated for a conceptual study at the time of close-out of the IPRF contract.

The FHWA contract, incorporating a revised and updated statement of work, was awarded to Texas Transportation Institute with an effective start date of April 1, 2003. The Technical Advisory Panel has been organized and held its first meeting on September 1, 2003.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Task 3 (99)—Performance and Design of Whitetopping Overlays for Heavily Trafficked Pavements

Contracting Dates/IPRF Contract: January 21, 2000 to June 2002

Contract Amount/IPRF Contract: $359,900

Contractor: Transtec Group, Inc.

Principal Investigator: Robert Rasmussen

IPRF Contract Manager: Mike Ayers

Project Goals/Objectives: The research effort for Task 3(99) has four major objectives.

1. To document, based in part on available data, the performance of the three classes of whitetopping overlays: ultra-thin (less than 4 inches), thin (4 to 8 inches), and conventional (greater than 8 inches).
2. To develop a design procedure, for each class, that takes critical parameters and site conditions, into account.
3. To develop best practice construction, and quality control guidelines ensure that quality whitetopping pavements are built.
4. To identify potential rehabilitation alternatives, and solutions.

Background: Whitetopping has been used extensively throughout the United States. The design of these overlays has been based on conventional procedures, which assumes the existing asphalt pavement merely serves as a stabilized base course. In many instances, all three classes of whitetopping have exceeded their design expectations. Research is needed to determine an appropriate mechanistic design procedure. In addition to the design procedure, research is needed to identify the existing-pavement conditions that influence whitetopping performance for each class of overlay.

Status: The project was essentially completed under the IPRF management and funding. At the IPRF panel meeting in May 2002, the latest version of the design software and the construction and rehabilitation guidelines were presented and distributed on a CD. The contractor has invoiced IPRF for the full contract amount. IPRF has informed the FHWA that the final products would be completed and delivered to FHWA at a future date. No delivery date has been established as of December 2003.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Rasmussen, R.O., G.K. Chang, J.M. Ruiz, W.J. Wilde, P.K. Nelson, J. Dick, and D.K. Rozycki. 2002, New Software Promises to Put Whitetopping on the Map, *Public Roads,* Volume 66, No. 1, Federal Highway Administration, Washington, DC.

Task 4 (99)—Tests or Standards to Identify Compatible Combinations of Individually Acceptable Concrete Materials

Contracting Dates:
IPRF Contract: August 2000 to June 2002
FHWA Contract: March 2003 (restart) to April 2005

Contract Amount:
IPRF Contract: $550,000 (actual billed amount was less than the contract amount)
FHWA Contract: $390,000 plus $120,000 cost-sharing by the Portland Cement Association

Contractor: Construction Technology Laboratories, Inc.

Principal Investigator:
IPRF Contract: Shiraz Tayabji
FHWA Contract: Peter Taylor

IPRF Contract Manager: Colin Lobo
FHWA Contract Manager: Marcia Simon

Project Goals/Objectives: The objectives and expected results of this research are to develop practical test procedures and criteria to assess the effects of combinations of materials for concrete pavements on:

- Early stiffening and excessive retardation that can affect workability, placeability, consolidation, and finishing
- Potential for early-age cracking, including plastic shrinkage, and possibly the ability to attribute the cause of cracking to chemical, physical, and environmental phenomenon
- Characteristics of the air void system, including non-uniformity, insufficient air, coalescence of air voids around aggregate, and excessive large air voids, all of which influence strength or durability or both

Background: Frequently, field experience has indicated that certain materials combinations may result in undesirable effects on concrete properties such as early stiffening (false set or flash set), inadequate or excessive retardation, excessive cohesiveness, problems with air entrainment, loss of workability, lower than expected strength, and unexpected cracking at early ages.

Reliable tests are needed to predict potential incompatibility of concrete materials that adversely influence the fresh and hardened properties of concrete at early ages. For example, combinations of incompatible materials may lead to early stiffening and unworkable concrete. ASTM C 359 was developed to evaluate early stiffening of portland cement and may not be applicable for evaluating combinations of cementitious materials and the interaction with chemical admixtures. A recent approach that may be more applicable to a combination of materials is the mini-slump cone test. No test exists to predict the potential for plastic cracking or early age hardened concrete cracking due to chemical, physical, or environmental phenomena. There is also no test to evaluate the potential for coalescence of air voids around aggregates, an unstable air void system under placement and consolidation, or a process that identifies an air void system in fresh concrete that will be detrimental to durability, strength, or both.

This research effort should produce tests and procedures to enable material suppliers, concrete producers, and users to identify undesirable material combinations that adversely affect the early-age properties of concrete, evaluate the uniformity of individual materials from the same source, and optimize the combinations for predictable early-age performance. Cracking and durability-related distress in the long term (later ages) is not included in the scope of this project.

Status: Under the IPRF contract, CTL engineers completed Phase 1 of the study, which included reviewing the pertinent literature, obtaining information from the field on problematic paving projects, and refining the laboratory test plan. This project was resumed in March 2003 under the FHWA contract. The contractor convened a technical working panel and submitted a work plan based on the last approved work plan from the original IPRF project. The work plan was reviewed at a panel meeting in June 2003. The contractor revised the work plan based on comments made at that meeting. Work plan approval and commencement of work are expected in September/October, 2003.

Phase 2, currently under way as part of the FHWA contract, includes developing and refining test procedures to identify potentially detrimental combinations of concrete-making materials.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Phase 1 Interim Report and Phase 2 Work Plan

Power Point presentation – Tests or Standards to Identify Compatible Combinations of Individually Acceptable Concrete Materials. By Peter Taylor, CTL, May 2003.

Public Roads – Getting It Together. By Shiraz D. Tayabji, July/August 2002.

Work Plan for FHWA Contract – Tests or Standards to Identify Compatible Combinations of Individually Acceptable Concrete Materials, prepared by CTL, June 2, 2003.

Task 5 (99)—Accelerated Loading Tests of Ultra-Thin Whitetopping (UTW)

Contracting Dates/IPRF Contract: 1999 to June 2002

Contract Amount/IPRF Contract: $200,000 for testing at FHWA's Turner-Fairbank Highway Research Center and analysis of the data

- $35,000 for technology transfer workshop; $48,000 for other technology transfer; $283,000 total allocation for task

Contractor: Transtec Group, Inc.

Principal Investigator: Robert Rasmussen

IPRF Contract Manager: Larry Cole

Project Goals/Objectives: Verify and/or calibrate existing UTW design procedures using testing data from the ultra-thin overlay projects at FHWA's Turner-Fairbank Highway Research Center's Accelerated Loading Facility (ALF).

Background: Ultra-thin whitetopping overlays are relatively new composite pavement designs using 2- to 4-inch thick concrete overlays of asphalt pavements. The original ultra-thin overlay concept, developed in 1990, was for light traffic situations. In practice, some ultra-thin projects have been constructed on heavy-truck ramps, and even high-speed highways. Early performance of these pavements has been excellent, exceeding most expectations. Full-scale load tests were conducted from May 1998 to December 2000 at FHWA's Turner-Fairbank Highway Research Center under a Cooperative Research Agreement between FHWA and the ACPA.

Status: The data from the ALF tests was analyzed as part of Task 3. A technology transfer workshop was conducted in October 1999. The IPRF Contractor made several site visits to the ALF to collect joint opening and bond data. The contractor included these results in the Task 3 interim report. The deliverables from this task are expected to include an Executive Summary, an ALF UTW database, and recommendations and concepts for technology transfer materials

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Rasmussen, R.O., W.J. Wilde, J.M. Ruiz, J. Sherwood, and J. Mack, 2001, An Analysis of Ride Quality of the Ultra-Thin Whitetopping Overlays at the FHWA Accelerated Loading Facility, *Proceedings*, Seventh International Conference on Concrete Pavements, International Society for Concrete Pavements, College Station, TX.

Rasmussen, R.O., B.F. McCullough, J.M. Ruiz, J. Mack, and J.A. Sherwood, 2002, Identification of Pavement Failure Mechanisms at FHWA Accelerated Loading Facility Ultrathin Whitetopping Project, *Transportation Research Record* 1816, Transportation Research Board, Washington, DC.

Task 6 (99)—Incremental Costs and Performance Benefits of Various Features of Concrete Pavements

Contracting Dates:
IPRF Contract: August 2000 to June 2002
FHWA Contract: February 2003 to October 2003

Contract Amount:
IPRF Contract: $165,000 (actual billed amount was less than the contract amount)
FHWA Contract: $74,818

Contractor: Applied Pavement Technology, Inc.

Principal Investigator:
IPRF Contract: John Naughton
FHWA Contract: Kurt Smith

IPRF Contract Manager: Gerald Voigt
FHWA Contract Manager: Peter Kopac

Project Goals/Objectives: To determine the most cost-efficient combination of design features for concrete pavement, considering estimated costs and expected performance improvements of each feature.

Background: There are a variety of design features that can be incorporated into a concrete pavement design. A standard design using certain features is often propagated by a state agency for use system wide. In many cases these standard designs remain constant over many years. Eventually, there may become little institutional knowledge of the purpose and interrelationship of the design features included in the standard section, particularly in terms of the expected cost and performance. To apply the most cost-efficient combination of features and requirements, it is necessary to know how each impacts initial construction cost and pavement performance. While there have been several pavement feature related performance studies in the past, including those in LTPP, cost aspects have been largely ignored. Until the costs and benefits of design and requirement features are examined together, the issue of performance optimization will remain unclear. This project addresses this gap in knowledge.

Status: A draft final report was submitted in October 2003 to reflect comments raised at the meeting of the advisory panel in August 2003. The final report is now undergoing final FHWA editorial review, and the computer software for evaluating the impact of design features is being finalized. All products are expected to be delivered to the FHWA by mid-February 2004.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Research Reports & Findings – Concrete Pavement Research & Technology – An Annotated Bibliography – April 2001 by Applied Pavement Technology, Inc.

Power Point presentation – Incremental Costs and Performance Benefits of Various Features of Concrete Pavements. Presentation given by Kurt Smith, APTech, October 6-7, 2003 in Woods Hole, MA.

Naughton, J. E. and K. D. Smith. The Biggest Bang for Your Buck. *Public Roads*, Volume 66, No. 1.

Hoerner, T.E., K.D. Smith, and J.E. Bruinsma, October 2003, *Incremental Costs and Performance Benefits of Various Features of Concrete Pavement Design Features*, Draft Final Report, Federal Highway Administration, Washington, DC.

Task 7(99)—Field Trials of Concrete Pavement Product and Process Technology

Project Goals/Objectives: Conduct field trials of new products, processes, and technologies in actual construction projects.

Background: In many cases implementing new technology into the highway industry presents the following Catch 22: "A contractor cannot use technology unless it is specified, but a state cannot specify or allow a new technology until it is tried and proven." Task 7 seeks to encourage state agencies to partner with their local contractor and material/equipment supplier constituents to implement new technology for the betterment of the highway user.

Innovation areas for this program include technology that expects to: increase pavement service life, decrease construction time, lower life cycle and initial costs, lower maintenance costs, produce ultra-smooth ride quality, incorporate recycled or waste products while maintaining quality, utilize innovative construction equipment or procedures, and utilize innovative quality initiatives. Specific target areas include: load transfer optimization and materials; alternate concrete mixtures; surface finishing techniques; materials utilization; geometric and thickness alternatives and thin overlay construction.

Through open solicitation, public and private agencies can seek funding to try new or improved concrete pavement technologies in field conditions. Reports, photos, video, and written reports will capture each effort for education and technology transfer.

Task 7(99) B— UTW Repair Techniques

Contracting Dates/IPRF Contract: March 27, 2000 to December 31, 2000

Contract Amount/IPRF Contract: $55,000

Contractor: Construction Technology Laboratories, Inc.

Principal Investigator: Shiraz Tayabji

IPRF Contract Manager: Mike Ayers

Status: UTW Repair project is complete. The final report has been developed and is available in electronic copy. A video has been finalized; copies (VCR and compact disc) are now being produced. A four-page, four-color brochure describing the process for UTW repair is complete and has been widely distributed.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Repair of Ultra-Thin Whitetopping Roadways and Airfields Tech Brief – ACPA

Research Reports & Findings – UTW Pavement Repair Demonstration – CTL – 2001

UTW Pavement Repair Demonstration – Final Report by CTL, December 2000.

Wu, C.L., S. Tayabji, M. Sheehan, and J. Sherwood, 2001, Performance and Repair of UTW Pavements, *Proceedings*, Seventh International Conference on Concrete Pavements, held in Orlando, Florida, September 2001, International Society for Concrete Pavements.

Wu, C.L., S. Tayabji, and J. Sherwood, 2001, Repair of Ultrathin Whitetopping Pavements, *Transportation Research Record* 1778, Transportation Research Board, Washington, DC.

Task 7(99) C— Weekend Intersection Reconstruction

Contracting Dates: June 2000 to June 2003

Contract Amount/IPRF Contract: $54,956

Contractor: University of Washington

Principal Investigator: Dr. Kamran Nemati

IPRF Contract Manager: Mike Ayers

Background: The frequent maintenance required on some asphalt concrete (AC) pavement sections has made reconstruction with Portland Cement Concrete Pavement (PCCP) a more feasible alternative. However many constructability issues need to be addressed in order to realize the full potential of this alternative. In Eastern Washington, three major AC intersections with severe rutting problems are due to be reconstructed with PCCP in August 2000. The entire reconstruction of each intersection, including demolition of the existing AC pavement and its replacement with PCCP, will take place over a period of three days.

Project Goals/Objectives: The goal of this proposed research program is to document this effort in order to provide practitioners additional options for rapid reconstruction of urban facilities.

Status: The reconstruction of an urban intersection on SR 395 in Kennewick was conducted in October 2000. A final report and a video documenting the intersection reconstruction have been prepared. The availability of these products is not known.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Fast Track Construction With Portland Cement Concrete Pavement (PCCP) At Urban Intersections. Proposal to IPRF. June 26, 2000.

Reconstruction Of Urban Intersections Using Portland Cement Concrete Pavement by Jeff S. Uhlmeyer and Linda M. Pierce. Presented at 7th International Conference on Concrete Pavement. September 2001.

In and Out in 72 Hours, (Kennewick, Washington intersection reconstruction) Reprinted from Focus, August 2001, FHWA-IF-03-21, Pavement Preservation Compendium, September 2003.

Nemati, K.M., Uhlmeyer, J.S., Pierce, L.M., and Powell, J.R., Accelerated Construction of Urban Intersections with Portland Cement Concrete Pavement (PCCP), Final Report, Federal Highway Administration, April 2003.

Video tape of intersection reconstruction process.

Task 7(99) C— Instrumentation of UTW in Colorado

Contracting Dates:
IPRF Contract: April 30, 2001 to June 2002
FHWA Contract: September 27, 2002 to December 31, 2003

Contract Amount:
IPRF Contract: $91,519 plus $25,000 cost-sharing by Colorado DOT (actual billed amount was less than the contract amount)
FHWA Contract: $24,386

Contractor: Construction Technology Laboratories, Inc.

Principal Investigator:
IPRF Contract: Chung Wu
FHWA Contract: Shiraz Tayabji

IPRF Contract Manager: Larry Cole
FHWA Contract Manager: Mark Swanlund

Status: Construction time instrumentation was installed during summer of 2001 and load testing was conducted soon after that. A second load testing was conducted during July 2003. Final report is expected in early 2004.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Instrumentation and Field Testing of Thin Whitetopping Pavements in Colorado and Revision of the TWT Design Procedure – Proposal prepared by CTL, December 14, 2000.

Guidelines for the Thickness Design of Bonded Whitetopping Pavement in the State of Colorado, Report No. CDOT-DTD-R-98-10. Prepared by Scott M. Tarr, Matthew J. Sheehan and Paul A. Okamoto, December 1998.

Wu, C. and M. Sheehan, 2002, *Instrumentation and Field Testing of Whitetopping Pavements in Colorado and Revision of the TWT Design Procedure,* Report No. CDOT-DTD-R-2002-3, Construction Technology Laboratories, Inc., Columbia, MD.

Task 7(99) D— Precast Concrete Slabs for Full Depth Repairs

Contracting Dates: March 2003 to March 2006

Contract Amount/ FHWA Contract: $99,321

Contractor: Michigan State University

Principal Investigator: Neeraj Buch

FHWA Contract Manager: Sam Tyson

Project Goals/Objectives: Evaluation of the feasibility of precast slabs for joint repair or slab replacement through several demonstration projects. Overall productivity rates and potential cost and time savings will be documented, and a set of guidelines on the use of the technology will be developed.

Background: One of the limitations associated with conventional concrete repair materials is the time required for the material to cure and gain sufficient strength before being subjected to traffic. In concrete pavement rehabilitation, the use of precast slabs for joint repair or slab replacement is an alternative to conventional cast-in-place repairs. Precast slabs may be an effective means of reducing overall construction time, therefore minimizing user delay and travel costs while also obtaining a long-lasting, durable repair.

Status: The use of precast panels in field installations is currently underway in Michigan and Colorado. In the Michigan project, twenty precast concrete panels were installed on sections of Interstate 675 near Zilwaukee, Michigan, and on Michigan Route 25 near Port Austin.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Buch, N., V. Barnhart, and R. Kowli, 2003, Precast Concrete Slabs as Full-Depth Repairs: Michigan Experience, *Transportation Research Record* 1823, Transportation Research Board, Washington, DC.

Task 7(99) E— Implementation of TEMP System

Contracting Dates: March 2003 to February 2004

Contract Amount/ FHWA Contract: $85,141

Contractor: Transtec Group, Inc.

Principal Investigator: Robert Rasmussen

FHWA Contract Manager: Sam Tyson

Project Goals/Objectives: Demonstrate the Total Environmental Management for Paving (TEMP) software program and temperature management approach on several concrete paving or repair projects.

Background: Maturity methods are being employed by more and more agencies as a means of monitoring the condition of the in-place pavement and determining appropriate times to open the pavement to traffic. The TEMP system enhances current maturity monitoring technology by combining temperature, maturity, and strength predictions into a single measurement system that can be accessed remotely with a handheld or laptop computer.

Status: Field trials have been conducted on two paving projects in Iowa and one repair project on I-64 near Williamsburg, Virginia. A one-day workshop on the TEMP system was conducted on February 2, 2004 at the FHWA's Turner-Fairbank Highway Research Center.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Task 7(99) F— Magnetic Tomography for Dowel Bar Location

Contracting Dates: June 2003 to July 2004

Contract Amount: $125,530

Contractor: ERES Consultants

Principal Investigator: Tom Yu

FHWA Contract Manager: Sam Tyson

Project Goals/Objectives: The objectives of this project are 1) to provide laboratory and field evaluation of the MIT Scan-2 device to assess accuracy and repeatability of measurements of dowel position, 2) to compare the MIT Scan-2 measurements with measurements of other devices such as cover meter and ground penetrating radar (GPR), 3) to demonstrate MIT Scan-2 to contractors and State DOT personnel and collect their comments on usability of this device, and 4) to develop recommendations for use of MIT Scan-2 in QA/QC procedures by contractors and State DOTs and develop comprehensive training material.

Background: The misalignment of dowel bars at transverse joints can significantly detract from pavement performance. Although many agencies specify an allowable tolerance on dowel bar misalignments, rarely are the dowel bar locations checked after paving, largely because there is no economical or rapid way of assessing dowel bar misalignment. Recent research in Germany has developed a Magnetic Imaging Tomography (MIT) device with the specific purpose of rapidly locating steel dowel and tie bars in concrete pavements. In one measurement, the device scans the entire length of a joint and determines the location and alignment of all dowels, providing preliminary results immediately after the measurements. Because of its purported ease of use, accuracy, and measurement capabilities, there is a strong interest in determining the suitability of the device in U.S. concrete pavement construction.

Status: A comprehensive literature search was conducted to identify and evaluate the available devices for determining dowel bar alignment. Laboratory testing on the accuracy of the MIT Scan-2 device is underway. A small field trial of the device was conducted near Reno, NV, with more comprehensive trials planned for 2004. An interim report is expected in early 2004.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

PowerPoint Presentation: Bar Placement Locator—Magnetic Imaging Technology to Locate Dowel Bars Accurately. Given By Tom Yu at the 2003 ACPA Annual Meeting.

Task 7(99) G - Field Evaluation of Elliptical Steel Dowel Performance

Contracting Dates: May 2003 to March 2008

Contract Amount/FHWA Contract: $110,135

Contractor: Iowa State University

Principal Investigator: Jim Cable

FHWA Contract Manager: Sam Tyson

Project Goals/Objectives: The goal of this research is to incorporate elliptically shaped steel and fiber-reinforced polymer (FRP) dowels and basket assemblies in an actual construction project and evaluate their performance over a 5-year period.

Background: Effective load transfer at transverse joints is critical to the performance of jointed concrete pavements. Current trends in load transfer design are toward the use of larger diameter dowel bars as a means of reducing critical dowel-concrete bearing stresses. An intriguing variation in dowel bar design is the use of elliptical-shaped dowel bars, which are expected to reduce critical dowel-concrete bearing stresses by distributing loading over a wider area. However, such designs are new and have not been tested in the field.

Status: Elliptical dowels have been incorporated into construction projects. A construction report on a project incorporating elliptical dowel bars has been prepared.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Cable, J., Edgar, L. and Williams, J., Field Evaluation of Elliptical Steel Dowel Performance, Construction Report, Iowa State University, July 2003.

PowerPoint Presentation: Elliptical Dowel Applications. By Jim Cable. Presented at 2003 TRB Annual Meeting.

Task 7(99) H— Evaluation of PRS in Tennessee

Contracting Dates: July 2003 to March 2004

Contract Amount/FHWA Contract: $127,412

Contractor: ERES Consultants

Principal Investigator: Nasir Gharaibeh

FHWA Contract Manager: Sam Tyson

Project Goals/Objectives: To begin the implementation of performance-related specifications (PRS) by having State highway agencies develop, put into use, and evaluate a PRS system tailored to their needs.

Background: Over the past 25 years, there has been a growing interest in the development of PRS for highway pavement construction. PRS systems are similar to quality assurance specifications; however the measured acceptance quality characteristics (e.g. concrete strength, slab thickness, initial smoothness) are directly related to pavement performance through mathematical relationships. Performance is defined by key distress types and is directly related to the future maintenance and rehabilitation costs and user costs of the highway. This link between acceptance quality characteristics and future life-cycle costs provides the ability to develop rational and fair contractor pay adjustments that depend on the as-constructed quality delivered for the project. Several FHWA research projects on development of PRS have now been completed, and guidance for implementing PRS is now available in the form of: (1) a prototype PRS; (2) a 19-step procedure for developing PRS; and (3) PaveSpec software.

Status: Work in progress. Tennessee has held several PRS planning meetings, and work on identifying a specific project is underway.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Other Related Reports/Articles/Presentations/Studies:

Gharaibeh, N.G., P.A. Kopac, and M.I. Darter, 2001, Effect of Variability and Central Tendency in Performance-Related Specifications for Concrete Pavements, *Proceedings*, Seventh International Conference on Concrete Pavements, International Society for Concrete Pavements, College Station, TX.

Gharaibeh, N.G., J. Stefanski, and M.I. Darter, 2002, Evaluation of Concrete Pavement Construction Scenarios Under Performance- Related Specifications, *Transportation Research Record* 1813, Transportation Research Board, Washington, DC.

Task 9 (00)—Influence of Sealing Transverse Contraction Joints on the Performance of Concrete Pavements

Contracting Dates: March 2003 to March 2006

Contract Amount: $528,748 (FHWA share = $397,948/ ProTech share = $130,800)

Contractor: ProTech Engineering, Inc.

Principal Investigator: Kathleen T. Hall

FHWA Contract Manager: Jim Sherwood

Project Goals/Objectives: The goals of this project are to 1) evaluate the effect on long-term performance of unsealed transverse joints in concrete pavements with different pavement cross-sections and slab dimensions, traffic levels, and climatic conditions, 2) evaluate the effect of different transverse joint sealant materials and configurations on the long-term performance of concrete pavement in various climatic regions, and 3), determine the cost-effectiveness of sealing transverse contraction joints for different pavement designs and materials over a range of climatic zones and traffic levels.

Background: Currently, 96 percent of the state highway agencies require transverse joint sealing, adding about 2 to 7 percent to the initial construction cost of their pavements and even more when considering resealing activities and life-cycle cost analysis. If the use of narrow, unsealed joints on short jointed concrete pavements can provide equally long-term pavement performance as sealed joints, states can save millions of dollars in construction and maintenance costs by eliminating joint sealing on those projects. Reduction in traffic delays during sealant maintenance and increases in worker safety are possible benefits from the elimination of sealants where they are not found cost-effective.

Status: The contract for this project was awarded in March 2003. In the first quarter, a report was produced: *Review of Literature on Concrete Pavement Joint Sealing Practices, Performance, and Cost-Effectiveness* which covered 51 references. The references mostly cover joint sealing in concrete pavements at original construction, although there is some mention of resealing. Work was planned for the quarter recently completed, on subtask 2, to survey opinions and experiences. As the subtask 1 literature review yielded little detail on the cost specifics, and since these costs would be out of date anyway, a particular effort in subtask 2 was planned to obtain joint sealing cost data from contractors and material and equipment suppliers. Work is currently being conducted on a field data collection plan, with a preliminary field testing program being conducted in Phoenix in February 2004 and the bulk of the field work being conducted in early summer 2004.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Other Related Reports/Articles/Presentations/Studies:

LTPP Data Analysis: Relative Performance of Jointed Plain Concrete Pavement with Sealed and Unsealed Joints. Prepared by Kathleen T. Hall and James A. Crovetti, December 2000.

Hall, K.T., C.E. Correa, and A.L. Simpson, 2003, Performance of Rigid Pavement Rehabilitation Treatments in the Long-Term Pavement Performance SPS-6 Experiment, *Transportation Research Record* 1823, Transportation Research Board, Washington, DC.

Hall, K.T., L.D. Evans, J.A. Crovetti, C.E. Correa, and L. Scofield, 2000, Performance of Arizona's SPS-4 Joint Sealing Environment, *Proceedings*, Seventh International Conference on Concrete Pavements, International Society for Concrete Pavements, College Station, TX.

HPCP Summary Report, FHWA-IF-02-026, March 2002, includes two Illinois projects and one Ohio project containing unsealed joints.

Task 10 (00)—Revision of ISLAB 2000 for Subbase/Pavement Interaction

Contracting Dates: June 2000 to September 2001

Contract Amount/IPRF Contract: $40,000

Contractor: ERES Consultants

Principal Investigator: Lev Khazanovich

IPRF Contract Manager: Steven Waalkes

Project Goals/Objectives: Revise the ISLAB 2000 analysis program to account for interaction between the concrete slab and the underlying layer.

Background: One of the main drawbacks of many finite element programs is their ability to adequately model the interface condition between the PCC slab and the underlying layer. The existing finite element programs for pavement analysis assume either zero or full bond (no slippage) for the interface condition. In reality, the amount of layer slippage under a heavy wheel load is somewhere between these two extremes. Having a capability to model and specify the varying levels of slippage between the slab and an underlying layer would greatly improve our ability to fine tune concrete pavement design.

Status: An appropriate mathematical model has been identified, involving a 40 degree-of-freedom stiffness element to address layer interaction. The ISLAB-2000 computer code has been modified to include the layer interface model. The ISLAB-2000 graphical user interface (GUI) has been modified to allow the user to enter new structural model parameters (friction parameters, horizontal joint stiffness, horizontal restraint).

The Users Guide and installation CD were delivered to IPRF on Aug. 14, 2002. The project has been invoiced to the extent of budget by contractor. Work on this project was suspended in June 2002 per direction of IPRF. No further activity or deliverable is expected.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Task 11 (00)—Workshops on Concrete Pavement Technology for State DOT Pavement Engineers

Contracting Dates:

- June 2000 for 2000 Workshop for DOT pavement engineers. 2000 Workshop held on August 10-11
- April 2001 for 2001 Workshop for DOT pavement engineers. 2001 Workshop held June 28-29
- April 2001 for 2001 Professor's Seminar. 2001 Professor's Seminar held June 18-20, 2001

Duration: Annual State DOT Workshops for 4 years. Professor's Seminar in 2001

Contract Amount/IPRF Contract: $60,000 in FY00, $105,000 in FY01

Contractor: American Concrete Pavement Association

Principal Investigators: Larry Cole and Jerry Voigt

IPRF Contract Manager: Daniel Frentress

Project Goals/Objectives: Conduct two-day workshops on current concrete pavement technology for state DOT engineers.

Background: Improvements to the design, construction, rehabilitation, and asset management of concrete pavements will only be made when technological advances are put into use. State Departments of Transportation are the primary agents for such advancement as they are responsible for building and maintaining the large majority of highways in the U.S. Therefore, it is essential for key state DOT engineers to become familiar with new concrete pavement technology. One effective method for transferring technology is through workshops. Workshops are effective when leading authorities present new technology, followed by ample time for participants to share experiences and viewpoints. However, this format is only effective in changing DOT practices when key state DOT staff members are participants. It is important that the right representatives from the state DOTs, as well as pavement experts from the FHWA Regional Resource Centers, participate.

Additionally, college professors of civil engineering can educate students on new technology. University professors, who teach pavement technology, are invited for updates on the latest advances in concrete pavements, including products and findings from the Concrete Pavement Technology Program.

Status: The first state DOT workshop, entitled "Concrete Pavement Design – 2000 and Beyond" was held August 10-11, 2000, in Breckenridge, Colorado. Many positive comments were received from participants regarding the workshop's format, discussion topics, and quality of presentations. The second state DOT workshop was held in San Francisco, CA on June 28-29, 2001. The 2001 Professor's Workshop took place on June 18-20, 2001 in Skokie, IL.

No further activity is anticipated. The ACPA has been conducting Professor Workshops annually since 2002.

<u>Available Reports/Articles/Presentations:</u>

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Conference presentations CDs are available.

Task 12 (00)—Develop a Plan to Investigate the Impacts of Pavement Cracking on Long-Term Performance

Contracting Dates: October 2000 to November 2000

Contract Amount/IPRF Contract: $10,000 Total ($5,000 to two Contractors)

Contractor: Construction Technology Laboratories, Inc. and ERES Consultants

Principal Investigator: Shiraz Tayabji (CTL) and Michael Darter (ERES)

IPRF Contract Manager: Gerald Voigt

Project Goals/Objectives: Conduct a thorough literature search and compile a summary report of the impacts of pavement cracking on long-term concrete pavement. Prepare a research plan to address the impacts of pavement cracking on long-term performance.

Background: Uncontrolled cracking in concrete pavements can be the result of many factors. While such cracking is undesirable, the long-term effects on pavement performance and durability are not clear. Key questions include: What type of cracks affect pavement performance and durability? How does cracking affect performance of pavements built on different bases? How many cracks can be tolerated without significantly affecting ride quality? When is crack repair or slab replacement needed?

Status: The feasibility studies were completed and both concluded that enough information was available to determine the potential for success of a study of the impact of cracking on pavement performance. This task is now complete.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan.

ERES Proposed Research Plan, December 2000

CTL Proposed Research Plan, December 2000

Task 13 (00)—Determine Actual Pavement Life Cycle Costs

Contracting Dates: August 2000 to January 2002

Contract Amount/IPRF Contract: $180,000

Contractor: ERES Consultants

Principal Investigator: Michael Darter

IPRF Contract Manager: Steven Waalkes

Project Goals/Objectives: Conduct comprehensive life cycle cost analyses for three specific highway sections, and prepare and distribute reports disclosing the results.

Background: Many state DOTs have developed life cycle cost analysis models, and frequently conduct such analyses as part of a pavement type selection process. The FHWA has provided some additional guidance on the use and application of life cycle costing, particularly in the area of probabilistic modeling procedures. Unfortunately, very rarely do agencies ever determine actual life cycle cost data from existing projects to assess the reasonableness of their approach or assumptions.

Status: This was a 100% industry funded project. Life cycle cost studies were completed in Tennessee, Utah, and Oklahoma. Individual reports/flyers have been produced for distribution by ACPA.

Available Reports/Articles/Presentations:

A Comparison of Pavement Performance and Costs, Interstate 40, Tennessee. ACPA Special Report SR991P. 2000.

A Comparison of Pavement Performance and Costs, Interstate 15, Utah. ACPA Special Report SR992P. 2000.

A Comparison of Pavement Performance and Costs, Interstate 40, Oklahoma. ACPA Special Report SR993P. 2001.

Other Related Reports/Articles/Presentations/Studies:

A Comparison of Pavement Performance and Costs, Interstate 985 and State Rout 400, Georgia. ACPA Special Report SR994P. 2003.

Gharaibeh, N.G. and M.I. Darter, 2001, Benefits and Costs of Jointed Plain Concrete Pavement Design Features, *Transportation Research Record* 1778, Transportation Research Board, Washington, DC.

Task 14 (00)—AURORA 2000 Pavement System Analysis Tool

Contracting Dates: October 1997 to June 2002

Contract Amount/IPRF Contract: $2,610,000

Contractor: Transtec Group, Inc.

Principal Investigator: Robert Rasmussen

IPRF Contract Manager: Larry Cole

Project Goals/Objectives: Develop a set of system analysis tools for pavements

Background: The work was initiated in 1997 to develop a state-of-the-art, mechanistic pavement design selection and evaluation system. During the course of the work, it has evolved into a system of tools which address planning, design, construction, and economics and packages these tools in a common, user-friendly Windows interface

Status: As the result of a technical review by the project panel, the final deliverables were submitted on September 29, 2000. Software was demonstrated to federal and state DOT and industry representatives at San Francisco Technology Transfer Workshop on June 28-29, 2001. Project is complete.

Contract to perform independent evaluation of Aurora 2000 has been awarded (during Fall 2003) to Quality Engineering Solution. Completion of the independent evaluation is expected in January 2004.

Available Reports/Articles/Presentations:

No reports or other products are available for public release.

Task 15 (01)—Long-Term Plan for Concrete Pavement Research and Technology

Contracting Dates:
IPRF Contract: June 2001 to June 2002
FHWA Contract: February 2003 to mid-2004

Contract Amount:
IPRF Contract: $220,831
FHWA Contract: $413,471 plus industry match of $103,373

Contractor: Iowa State University

Principal Investigator: Ted Ferragut

FHWA Contract Manager: Jim Sherwood

Project Goals/Objectives: Develop a Long-Term Plan and to develop an Action Plan to implement the Long-Term Plan

Background: Task 15 was originally conceived and initiated to address the need for focus and direction in Concrete Pavement Technology Program activities beyond the current work and resources. The Long-Term Plan being developed through this endeavor will chart a path from the current state-of-the-practice to a new generation of concrete pavements. It is intended to guide concrete pavement research, development and technology activities both within and outside of the Concrete Pavement Technology Program, and FHWA's post-TEA-21 Infrastructure Technology Program.

Status: Work on this project resumed (under a new cooperative agreement) in March 2003. The contractor's updated work plan was discussed at a meeting with the project technical panel in early July, and has been revised based on their input. The most significant change recommended by the panel is the addition of a by-invitation "summit" to the planned outreach effort. The project team is striving to complete the plan well in advance of the contract end date, such that the scheduled delivery date for the project deliverables is January 2004. An in-depth discussion of this project is planned for the October 6-7 meeting.

Available Reports/Articles/Presentations:

IPRF RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

4th Outreach Info

- 4th Outreach Workshop Flyer – November 11, 2003
- 4th Outreach Program Welcome
- 4th Outreach Workshop Agenda
- Task 15 Research Plan Development Process

- Task 15 Long Range Concrete Pavement Research Plan – Working “Flag” Copy – Product Summary Table – October 12, 2003
- Concrete Pavement Technology Long Range Plan Handouts – November 11, 2003
- Email regarding 4th Outreach Workshop dated November 6, 2003.

Concrete Pavement Technology Long Term Research and Technology Plan – FHWA, ACPA, and AASHTO – Official “Flag” version 1.1.

Power Point presentation – Long Term Planning and Implementation Concrete Pavement Technology – MCC Outreach Meeting – October 2003.

Power Point presentation – Long Term Planning and Implementation Concrete Pavement Technology – TRB CRICP Meeting – October 2003.

Concrete Pavement Technology Long Term Research and Technology Plan – FHWA, ACPA, and AASHTO – Official “Flag” version 2.0.

Top 10 Major Technology Tracks – Draft “Flag” Copy Addendum

Ferragut, T.R., D. Harrington, and M. Brink, 2002, Road Map to the Future, *Public Roads*, Volume 66, No. 1, Federal Highway Administration, Washington, DC.

Task 16 (01)—Smoothness Criteria for Concrete Pavements

Contracting Dates: Start Date April 2003 – 30 month duration project

Contract Amount/FHWA Contract: $500,000

Contractor: Soil and Materials Engineers, Inc.

Principal Investigator: Starr Kohn

FHWA Contract Manager: Mark Swanlund

Project Goals/Objectives: To determine what profile characteristics are objectionable, how to measure them, what causes them, and how to avoid creating them; specifically to:

1. Determine the limits and value of smoothness specifications for concrete pavement.
2. Determine a method to identify and correct localized roughness features in concrete pavement

Background: Research has shown that concrete pavements built smooth initially stay smooth longer than pavements built rough initially. To provide smoother pavements, many agencies utilize incentive and disincentive provisions in their construction contracts. These provisions provide a financial incentive to contractors who exceed the require pavement smoothness while penalizing contractors who build a pavement rougher than specified. Forty-five of 52 State Highway Agencies (SHAs) utilize specifications for pavement smoothness for construction acceptance for concrete pavement. Of the SHA's using smoothness specifications for concrete pavements most currently use a profilograph or other response-type roughness meter. However, there is growing trend to change the measurement device to inertial profiler and to more advanced roughness indices (International Roughness Index, IRI). AASHTO is currently considering adoption of a Provisional Standard for Pavement Smoothness based upon inertial profilers and IRI.

While there is substantial experience with inertial profilers and IRI for pavement management, the use of inertial profilers and IRI as a construction quality control and quality assurance device is relatively new. There are aspects of using inertial profilers and IRI for quality control and acceptance of concrete pavement that require a more thorough understanding before improved pavement smoothness specifications can be implemented on a widespread basis.

Status: Work in progress. The initial meeting of the Technical Advisory Panel was held in June 2003.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Power Point presentation – Smoothness Criteria for Concrete Pavements. Presentation given by Starr Kohn, SME, October 6-7, 2003 in Woods Hole, MA.

Smoothness Criteria for Concrete Pavements – Soil and Materials Engineers, University of Michigan Transportation Research Center, and APR Consultants.

Smoothness Criteria for Concrete Pavements Literature Review – SME, UMTRI, and APR, June 13, 2003.

Other Related Reports/Articles/Presentations/Studies:

CD-ROM Proceedings, Fourth Annual Pavement/Materials and Testing Workshop, FHWA Office of Pavement Technology and Office of Infrastructure Research and Development, *Pavement Smoothness, Friction, Tire/Pavement Noise, and Texturing*, Arlington, VA, December 9-11, 2003.

TPF-5(063), Improving the quality of Profiler Measurement, LTPP related pooled funds study.

Karamihas, S.M., R.W. Perera, T.D. Gillespie, and S.D. Kohn, 2001, Diurnal Changes in Profile of Eleven Jointed PCC Pavements, *Proceedings*, Seventh International Conference on Concrete Pavements, International Society for Concrete Pavements, College Station, TX.

Perera, R.W. and S.D. Kohn, 2002, *Issues in Pavement Smoothness: A Summary Report,* NCHRP Project 20-51(1), Transportation Research Board, Washington, DC.

Perera, R.W. and S.D. Kohn, 2001, *LTPP Data Analysis: Factors Affecting Pavement Smoothness,* NCHRP Project 20-50(8/13), Transportation Research Board, Washington, DC.

Task 51 (99)—Mobile Concrete Laboratory

Contracting Dates: Start date October 1, 2002 – 3-year contract plus 2 option years

Contract Amount: $1.9 million, including travel costs for 3 years

Contractor: SaLUT, Inc.

Principal Investigators: Jon Mullarky and Leif Wathne

FHWA Contract Manager: Gary Crawford

Project Goals/Objectives: Introduce Federal, State, and local transportation personnel to state-of-the-art concrete technology for materials selection and mixture design, as well as for field and laboratory testing.

Background: Transferring new technology to highway construction agencies and contractors is often a slow process. The Mobile Concrete Laboratory (MCL), initiated by FHWA, attempts to shorten the acceptance time for new technologies and research through further refinement of these technologies. In many cases, the technologies are validated in the field on actual projects, results are documented, and recommendations are made to the participating agency and the researcher. New technologies are also introduced to state highway agencies (SHA's) and industry through demonstrations at the job site, equipment exhibitions at events attended by decision makers, teaching personnel how the new technology can be used, and publishing articles on the results of the MCL activities.

Status: During FY 2003, MCL has provided services to the LTPP program to evaluate the use of the impact-echo technique on existing concrete pavements to measure thickness in lieu of taking destructive cores. MCL has eight ongoing equipment loans to highway agencies evaluating these new technologies. The laboratory was on display at the Concrete Paving Conference in Austin, TX. The MCL staff also arranged and made technical presentations at an Admixture Workshop for New Jersey DOT, a High-Volume Fly Ash Workshop for Colorado DOT, and a Mixture Design Workshop at the Fourth Annual Pennsylvania Concrete Seminar. Technical presentations were made at the Texas Concrete Pavement Workshop; the Self-Consolidating Conference in Chicago, IL; the ACPA First Annual Concrete Pavement Conference in Albany, NY; and the SCAN Conference in Raleigh, NC.

At this time, MCL is committed to FY 2003 projects in Florida and continued work in Pennsylvania. Requests have been received for MCL participation in field projects in California, Indiana, Iowa, Utah and North Carolina.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

FHWA Mobile Concrete Laboratory Flyer, FWA-IF-00-028 – August 2000.

Mobile Concrete Laboratory Project Reports – 9902 CA – Use of Fast-Setting Hydraulic Cement Concrete for Interstate Concrete Pavement Rehabilitation, I-10, Pomona, California Revised Field Test Report, date unknown.

Mobile Concrete Laboratory Project Reports – 9903 SD – I-94 Pavement Replacement – Richardton, North Dakota, Summer, 1999, Summary Report, date unknown.

Mobile Concrete Laboratory Project Reports – 9904 SD – Tensile Bond Strength of a High Performance Concrete Bridge Deck Overlay – I-90, Sturgis, South Dakota, Summer, 1999, date unknown.

Mobile Concrete Laboratory Project Reports – 0005 NE – Summary report 0005, US 275, Valley, Nebraska, Fall 2000, date unknown.

Mobile Concrete Laboratory Project Reports – 0202 – Woodrow Wilson Bridge Foundation Concrete Thermal Modeling, date unknown.

Mobile Concrete Laboratory Project Reports – 0204 – Summary Report, Kernville Viaduct HPC Deck Concrete, Johnstown, PA, Summer 2002, date unknown.

Mobile Concrete Laboratory Project Reports – 0205 – US 23, Future I-26 New Interstate Concrete Paving Madison County, North Carolina, Summer, 2002, date unknown.

Mobile Concrete Laboratory Project Reports – 0207 AZ – LTPP Impact-Echo Thickness Determinations I-10, Maricopa County, Arizona, Summary Report, December 2002.

FHWA Mobile Concrete Laboratory – Transferring Advanced Concrete Technology to Our Partners, date unknown.

Mobile Concrete Library – List of: Peer Review Papers, Journal Articles, and Presentations.

Crawford, G.L., L. Wathne, and J.I. Mullarky, 2002, On the Road Testing Roads, *Public Roads*, Volume 66, No. 1, Federal Highway Administration, Washington, DC.

Task 52 (98)—Quality Concrete Rehabilitation and Preservation (SP-205)

Contracting Dates: Started in 1997 – Ongoing

Contract Amount: $300,000

Contractor: State Departments of Transportation

FHWA Contract Manager: Sam Tyson

Project Goals/Objectives: Special Project 205 will develop guidance on concrete pavement rehabilitation and repair techniques as well as strategies that emphasizes the *do's* and *don'ts*, and *why* and *when* for CPR and preventive maintenance of concrete pavements. The following repair techniques were covered: Full-depth repairs, Partial-depth repairs, Retrofit load transfer, Grooving and grinding, Subsealing, and Joint Resealing.

Background: SP-205 will evaluate the effect of timing on the performance of maintenance and non-overlay rehabilitation strategies. Also the performance of the individual rehabilitation and maintenance strategies for Portland cement concrete pavements will be studied and documented. The last major FHWA effort on concrete pavement rehabilitation was in the mid 1980's. It is time to re-examine the performance of CPR techniques available and to evaluate the influence of new equipment and materials on cost effectiveness of the repairs and maintenance.

Status: Field demonstration project were constructed in MN (Retrofit load transfer), OR (removing ruts due to studded tire wear), WI (partial depth repair), and OK (monolithic bonded overlay and dowel bar retrofit). Only the OR construction report has been received. The field reviews have been completed. The final report needs to be prepared.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; State DOT Work Plans

Hunt, L., 1999, *Millabrading Test Evaluation: Norwood Road – M.P. 287.02 (Southbound Interstate 5), Construction Report,* Report No. FHWA-OR-RD-00-02, Oregon Department of Transportation, Salem, OR.

Burwell, Brent and John Benson, Contractor combines retrofit and overlay to take time and cost off project, (I-40 in Sequoyah County, OK), Roads and Bridges, April 2002.

Correa, Angel, CD-ROM of pictures taken during SP-205 field reviews.

Correa, Angel, Powerpoint presentation, SP-205, Quality CPR, to AASHTO, (MI, MN, SD, and GA field reviews).

SP-205 Work Plan, October 23, 1996 and draft RFP to prepare the final report for SP 205 (never awarded).Note: Draft RFP proposes Implementation Package to include final report and technical briefs(on the six techniques) in paper copy and electronic format, one-hour Powerpoint presentation, and develop workshop presentation materials and conduct a train the trainer workshop.

FHWA has produced updated Technical Bulletin's on Full and Partial Depth Patching based in part on field reviews. Contract underway to QES to update Retrofit Load Transfer guidelines.

NHI Course 131062, PCC Pavement Evaluation and Rehabilitation, FHWA, October 2001. (CD-ROM containing presentations, Instructor's Guide, Reference Manual, and Participant's Workbook available)- Contains information on additional CPR techniques.

NHI 131103,(PM-3), Design and Construction of Quality Preventive Maintenance Treatments, (Course material now being finalized- same techniques being addressed as in SP-205-Available in 2004).

Pavement Preservation Compendium, FHWA-IF-03-21, FHWA, September 2003.

Highway Infrastructure Preservation, TR News Number 228, September-October 2003.

Larson, R.M., D. Petersen, and A. Correa, 1998, *Retrofit Load Transfer: Special Demonstration Project SP – 204,* Report No. FHWA-SA-98-047, Federal Highway Administration, Washington, DC. Note: Join Technical Bulletin with ACPA, Video (Fit to be Tied), and brochure also available.

Task 53 (98)—High Performance Concrete Pavements (TE-30)

Contracting Dates: Start 1995 – Ongoing

Contract Amount: Approximately $500,000 annually

Contractor: Various State Departments of Transportation

FHWA Contract Manager: Mark Swanlund

Project Goals/Objectives: The goals of the TE-30 Project are to construct selected highway projects to explore the applicability of innovative concrete pavement design and construction concepts and monitor the performance of those projects over at least a 5-year period.

Background: Under Test and Evaluation Project 30 (TE-30), High Performance Concrete Pavement (HPCP), the FHWA is exploring the applicability of innovative portland cement concrete (PCC) pavement design and construction concepts in the United States. Suggested innovation areas for the program include increased service life, decreased construction time, reduced life-cycle costs, reduced maintenance costs, ultra-smooth ride quality pavements, use of recycled or waste products, use of innovative construction equipment or procedures, and use of innovative quality initiatives. An example project is Mn/DOT's design for 60-year PCC design which incorporated use of *w/cm* below 0.40, requirement for graded aggregate to minimize paste volume, slag cement requirement to achieve low permeability concrete, and stainless steel clad dowels to prevent corrosion.

Status: A report documenting the status of the projects constructed under the TE-30 program was produced in 2001. A new contract has been released to document new projects that have been added to the program and to update performance data on other projects. State highway agencies involved in the program continue to monitor the performance of their projects, and many have prepared construction and status reports.

A contract was awarded during fall 2003 to update the status of the TE-30 projects.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; State DOT Work Plans

General:

Public Roads – Fine-Tuning Innovative Technologies by Mark Swanlund, July/August 2002.

High Performance Concrete Pavements: Project Summary by Kurt Smith, Publication No. FHWA-IF-02-026, March 2002, Federal Highway Administration.

Status of High-Performance Concrete Pavements Constructed Under FHWA's TE-30 Program. By Kurt Smith and Mark Swanlund. Seventh International Conference on Concrete Pavements, Orlando, FL, September 2001.

State Reports:

Illinois

- Gawedzinski, M, 1997, *Fiber Composite Dowel Bar Experimental Feature Construction Report*, Illinois Department of Transportation, Springfield, IL.
- Gawedzinski, M., 2000, *TE-30 High Performance Rigid Pavements Illinois Project Review*, Illinois Department of Transportation, Springfield, IL.

Iowa

- Cable, J.K., 1998, Evaluation of Mix Time on Concrete Consistency and Consolidation, Proceedings, Crossroads 2000 Conference, Ames, Iowa.
- Cable, J.K. and L.L. McDaniel, 1998a, *Effect of Mix Times on PCC Properties Iowa DOT Project HR-1066*, Iowa Department of Transportation, Ames, IA.
- Cable, J.K. and L.L. McDaniel, 1998b, *Demonstration and Field Evaluation of Alternative Portland Cement Concrete Pavement Reinforcement Materials*, Iowa DOT Project HR-1069, Iowa Department of Transportation, Ames, IA.

Kansas

- Kansas Department of Transportation, 1998, *High Performance Concrete Pavement, K-96 Reno County*, 1998 Annual Report, Kansas Department of Transportation, Topeka, KS.
- Kansas Department of Transportation, 1999, *High Performance Concrete Pavement, K-96 Reno County*, 1999 Annual Report, Kansas Department of Transportation, Topeka, KS.
- Wojakowski, J.B., 1998, *High Performance Concrete Pavement, Report No. FHWA-KS-98/2*, Kansas Department of Transportation, Topeka, KS.

Maryland

- Goulias, D. and C. Schwartz, 1999, *High Performance Portland Cement Concrete Pavement. Project Work Plan*, University of Maryland, Department of Civil and Environmental Engineering, College Park, MD.

Michigan

- Buch, N., R. Lyles, and L. Becker, 2000, *Cost Effectiveness of European Demonstration Project: I-75 Detroit*, Report No. RC-1381, Michigan Department of Transportation, Lansing, MI.
- Federal Highway Administration, 1992, *Report on the 1992 U.S. Tour of European Concrete Highways*, FHWA-SA-93-012, Federal Highway Administration, Washington, DC.
- Federal Highway Administration, 1994, *Michigan Demonstration Project—I-75, Detroit Michigan (European Concrete Pavement)*, FHWA-SA-95-045, Federal Highway Administration, Washington, DC.
- Larson, R.M., S. Vanikar, and S. Forster, 1993, *U.S. Tour of European Concrete Highways (U.S. TECH)*, Follow-Up Tour of Germany and Austria—Summary Report. FHWA-SA-93-080. Federal Highway Administration, Washington, DC.
- Smiley, D.L., 1995, *First Year Performance of the European Concrete Pavement on Northbound I-75—Detroit, Michigan*, Research Report R-1338, Michigan Department of Transportation, Lansing, MI.

- Weinfurter, J.A., D.L. Smiley, and R.D. Till, 1994, *Construction of European Concrete Pavement on Northbound I-75—Detroit, Michigan*, Research Report R-1333, Michigan Department of Transportation, Lansing, MI.

Minnesota

- Minnesota Department of Transportation, 2000, *New JPCP Test Cells at the Mn/ROAD Project*, Minnesota Department of Transportation, Maplewood, MN.
- Rettner, D., 1999, *I-35W High Performance Rigid Pavement Work Plan*, Minnesota Department of Transportation, Maplewood, MN.
- Turgeon, C., 2003, *Minnesota's High Performance Concrete Pavements: Evolution of the Practice*, Preprint Paper, 2003 Annual Meeting of the Transportation Research Board, Washington, DC.
- Rangaraju, P.R., *Development of Some Performance-Based Material Specifications for Minnesota's High Performance Concrete Pavement*, Preprint Paper, 2003 Annual Meeting of the Transportation Research Board, Washington, DC.

Mississippi

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Missouri

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Wisconsin

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Task 54 (99)—Repair and Rehabilitation of Concrete Pavements

Contracting Dates: February 2000 to December 2003

Contract Amount: $612,211

Contractor: Texas A&M Research Foundation

Principal Investigator: Dan Zollinger

FHWA Contract Manager: Jim Sherwood

Project Goals/Objectives: The goal of this project is to develop systematic, user-friendly guidelines for use by state highway agencies in 1) selecting between the better approach between concrete repair and concrete rehabilitation, and 2) selecting specific materials and repair/rehabilitation techniques in order to optimize performance and service life.

Background: The selection of appropriate maintenance and rehabilitation strategies for existing concrete pavements is a complex and involved process. There are a wide range of variables that must be considered in the process, including projected traffic loadings; structural and functional characteristics of the existing pavement; material types, conditions, and properties; environmental factors; and geometric constraints. Many of these factors are closely related to one another and the interactions between them are often extremely complex and difficult to isolate. Consequently, improved guidance is needed on the identification and selection of appropriate repair or rehabilitation treatments, including the selection of appropriate materials and techniques.

Status: A set of four reports has been completed and the computer program for the analysis of rehabilitation strategies (SAPER) is undergoing final modifications. A contract modification was awarded to make the deliverables comply with Section 508, to coordinate full and partial depth pre-cast repairs of a CRCP in the Houston District, and to work on a European Format Project on "pavement strengthening." The European project will analyze accelerated load and field tests. Final project deliverables are anticipated by early 2004.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Zollinger, D.G., K. Smith, and S. Tayabji, 2001, A Framework for Repair and Rehabilitation Treatment Selection for Portland Cement Concrete Pavements, *Proceedings*, Seventh International Conference on Concrete Pavements, International Society for Concrete Pavements, College Station, TX.

Zollinger, D.G., S.D. Tayabji, and K.D. Smith, June 2003, *Repair and Rehabilitation of Concrete Pavements, Volume I: Executive Summary and Key Rehabilitation Considerations,* Draft Final Report, Federal Highway Administration, Washington, DC.

Zollinger, D.G., S.D. Tayabji, K.D. Smith, and J. Liu, June 2003, *Repair and Rehabilitation of Concrete Pavements, Volume II: Guidelines for Pavement Condition Assessment and Evaluation*, Draft Final Report, Federal Highway Administration, Washington, DC.

Zollinger, D.G., S.D. Tayabji, and K.D. Smith, June 2003, *Repair and Rehabilitation of Concrete Pavements, Volume III: Summary of Pavement Rehabilitation Techniques and Strategy Development*, Draft Final Report, Federal Highway Administration, Washington, DC.

Liu, J., D.G. Zollinger, S.D. Tayabji, and K.D. Smith, June 2003, *Repair and Rehabilitation of Concrete Pavements, Volume IV: Strategic Analysis of Pavement Evaluation and Repair (SAPER)*, Draft Final Report, Federal Highway Administration, Washington, DC.

Liu, J., D.G. Zollinger, S. D. Tayabji, and K. D. Smith, January 2004, *SAPER: Tool for Selecting Concrete Pavement Repair and Rehabilitation Treatments*, Preprint Paper, 2004 Meeting of the Transportation Research Board.

Task 55 (99)—Accelerated Load Testing of Ultra-Thin Whitetopping

Contracting Dates: 1998 to 2003

Contract Amount: $325,000

Contractor: FHWA R&D at Turner-Fairbank Highway Research Center

Principal Investigator: Jim Sherwood

FHWA Contract Manager: Jim Sherwood

Project Goals/Objectives: To construct and test UTW sections at the FHWA's Accelerated Loading Facility, in order that data can be collected, to evaluate and develop design procedures. Note: an IPRF Contractor has developed an updated ACPA UTW design method, based on stationary finite element models.

Background: FHWA and the American Concrete Pavement Association began a cooperative agreement in 1998. Response data was collected on eight sections of UTW, at the Accelerated Load Facility (ALF).

Status: Field tests are complete. About $325,000 in contract funds operated the two ALF machines for about 18 months of ALF testing, over the period May 1998 to December 2000. The FHWA Principal Investigator is preparing a final FHWA Report on the Project.

The loading of the eight UTW lanes and data collection is complete, including development of an ALF-UTW database. Assistance continues to be given to the ACPA and their contractors in data analysis. About 100 more 150 mm cores were extracted to conduct the Iowa shear test for bond between the PCC and HMAC materials, and to determine the shear strengths of the existing HMAC layers. In practically every case the bond strength was higher than the shear strength of the HMAC. Sections were removed in the spring of 2002 for construction of the next ALF experiment on modified asphalt concrete pavements.

The two study objectives were to provide a database of accelerated load tests of ultra thin whitetopping, and to evaluate current mechanistic models. An Accelerated Load Facility (ALF)/ Ultra thin Whitetopping (UTW) database version 1 was produced. In addition an extensive analysis has been conducted of the separate pavement response database. The finding was that current stationary load finite element models used for UTW, fail to capture the fundamental behavior. This analysis plus a User's Manual for the ALF/UTW database will comprise the Final Report.

Available Reports/Articles/Presentations:

No reports or other products are available.

Task 56-A (99)—TFHRC PCCP Laboratory Studies: Development of Standard Test for Concrete Coefficient of Thermal Expansion

Contracting Dates: 1999 to 2007

Contract Amount: $76,000 in FY 2004

Contractor: FHWA R&D at Turner-Fairbank Highway Research Center and SaLUT

Principal Investigators: Marcia Simon (FHWA) and Jon Mullarky (SaLUT)

FHWA Contract Manager: Marcia Simon

Project Goals/Objectives: The goals of this project are to:

1. Develop a standard test for measuring the coefficient of thermal expansion of concrete (CTE)
2. Use that test to measure the CTE on a series of cores from pavements in the LTPP program.

Background: CTE is a characteristic determined by the LTPP program to have a potential influence on the performance of pavements. As a result, the concrete laboratories at the Turner-Fairbank Highway Research Center were assigned the task of developing a standard test for this property, since none existed in either AASHTO or ASTM.

Status: A standard CTE test has been developed and finalized. It involves: sawing the cores to a standard length (178 mm/ 7 in.); grinding the ends parallel; soaking the cores to reach SSD condition; mounting the core in a measuring frame using an LVDT; putting the setup in a controlled temperature water bath; and obtaining exact specimen length change and temperature change due to a change in temperature of the bath of 40 C. This test is now AASHTO Provisional Standard TP-60-00, as listed in the 2000 volume. At least partially because of this work, the new 2002 AASHTO design guide will include CTE of the concrete as one of the input variables. Tests continue to be conducted on the LTPP cores, with an estimated 4 years of testing remaining. New water baths were purchased to increase testing throughput.

Available Reports/Articles/Presentations:

Folder – Guidelines for the Use of Lithium to Mitigate or Prevent ASR.

Guidelines for the Use of Lithium to Mitigate or Prevent ASR – FHWA Publication No. FHWA-RD-03-047 – TFHRC, January 2003.

Guidelines for the Use of Lithium to Mitigate or Prevent ASR – FHWA Publication No. FHWA-RD-03-047 – TFHRC, January 2003 (html document).

Simon, M.J., and M.P. Dallaire, 2002, Taking Concrete to the Next Level, *Public Roads*, Volume 66, No. 1, Federal Highway Administration, Washington, DC.

Simon, M.J., W.H. Chesner, T.T. Eighmy, and H. Jongedyk, 2000, National Research Projects on Recycling in Highway Construction, *Better Roads*, Volume 64, No. 1, Federal Highway Administration, Washington, DC.

Task 56-B (99)—TFHRC PCCP Laboratory Studies: Concrete Mixture Optimization Using Statistical Mixture Methods

Contracting Dates: 1999 to 2001

Contract Amount: $0 in FY 2004

Contractor: FHWA R&D at Turner-Fairbank Highway Research Center

Principal Investigator: Marcia Simon

FHWA Contract Manager: Marcia Simon

Project Goals/Objectives:

1. To investigate the feasibility of using statistical experimental design methods in concrete mixture proportioning, and if feasible.
2. To develop an interactive website that will assist interested parties in using these methods.

Background: High-performance concrete (HPC) mixtures typically contain at least six component materials and may be required to meet several performance criteria simultaneously. While the ACI 211 guide for proportioning concrete mixtures and other procedures are good starting points for concrete proportioning, they do not provide information on the optimal proportions for meeting several performance criteria at the same time. As a result, trial and error, considering one factor at a time is the usual process. This approach can be inefficient, costly, and may not result in the best combination of materials. Statistical procedures have been developed for optimizing mixtures in other industries. The feasibility of applying this technique to concrete needs to be explored.

Status: Laboratory work and interactive Web site software development have been completed. The interactive Web site called Concrete Optimization Software Tool and user's guide are accessible online at http://ciks.cbt.gov/cost. The software will also be installed in the FHWA MCL and on the TFHRC Web site. Final project report and a user's guide were submitted for editorial review in January 2003.

Available Reports/Articles/Presentations:

Optimizing High-Performance Concrete Mixtures Using Statistical Response Surface Methods by Marcia J. Simon, Eric S. Lagergren, and Leif G. Wathne, June 1999.

Concrete Mixture Optimization Using Statistical Methods: Final Report. FHWA Publication No. FHWA-RD-03-060, by M.J. Simon, September 2003.

Simon, M.J., E.S. Lagergren, and K.A. Snyder, 1997, Concrete Mixture Optimization Using Statistical Mixture Design Methods, *Proceedings*, High Performance Concrete International Symposium, New Orleans, LA.

Task 56-C (99)—TFHRC PCCP Laboratory Studies: Freeze-Thaw Durability of Concrete with Marginal Entrained Air Content

Contracting Dates: 1999 to 2003

Contract Amount: $0 in FY 2004

Contractor: FHWA R&D at Turner-Fairbank Highway Research Center

Principal Investigator: Marcia Simon

FHWA Contract Manager: Marcia Simon

Project Goals/Objectives:

1. To investigate freeze-thaw durability of concrete with marginal air contents.
2. To investigate improvements in damage assessment of freeze-thaw test specimens.

Background: An adequate entrained air void system in concrete is considered necessary for resistance to distress due to freezing and thawing. Typical air void parameters are 6 percent air, a specific surface greater than 600, and a spacing factor of 0.008 in or less. However, there is evidence that some concretes not meeting these criteria may be freeze-thaw durable, and there is debate as to whether some HPC with sufficiently low water-cementitious ratio require air entrainment. The SHRP project on F/T durability proposed a modified testing procedure using terry cloth covers, and use of the "quality factor" for predicting the performance of concrete F/T specimens. These modifications are being investigated to assess their usefulness in improving freeze-thaw testing.

Status: Phase I is complete. In this phase, concretes with air contents of approximately 3 percent withstood 300 cycles of freeze-thaw testing. The SHRP terry cloth procedure was in most cases as severe as Procedure A, and is less variable than Procedure B. Mass loss was considerably greater in Procedure A (due to scaling). Phase II involves testing of concretes with air content ranging from 2.5 to 4.5 percent and w/c ratios of 0.40 to 0.50 with two different types of AEA. The first part of Phase II is complete and results indicate similar results for freeze-thaw durability. Further data analysis is underway to assess relationship of air void parameters to durability and use of quality factor for assessing damage. Because of continuing problems with steel containers and difficulty obtaining new ones, a study comparing terry cloth and containers at a range of air contents (2.7 to 4.7 percent) was performed to assess the relative severity of testing. If testing results are comparable, further testing will be conducted using terry cloth in lieu of containers. The comparison study was completed in December, 2002. The results indicate comparable durability factors, with terry cloth having slightly higher values, except for the case of non-air entrained concrete, where terry cloth was more severe. Specimens in containers experienced moderate to severe scaling (2-3% mass loss, typically) regardless of air content. The scaling probably had some effect on the durability factor. Surprisingly, nearly all of the air-entrained test beams, even the 2.7 percent air mix, had durability factors above 80% after 300 cycles. This result corroborates the Phase I results. Further investigation of the air void parameters of these mixes is underway, along with analysis of the quality factor from frequency response data. A set of tests using the Air Void Analyzer to determine air void parameters of the fresh concrete is planned for spring, 2003.

Available Reports/Articles/Presentations:

Task 56-D (99)—TFHRC PCCP Laboratory Studies: Development of Alkali-Silica Reactivity Mix-Specific Test Method

Contracting Dates: 1999 to 2003

Contract Amount: $75,000 in FY 2004

Contractor: FHWA R&D at Turner-Fairbank Highway Research Center

Principal Investigator: Marcia Simon

FHWA Contract Manager: Marcia Simon

Project Goals/Objectives: To identify a fast, reliable test for assessing ASR potential of concrete mixtures.

Background: There is currently no rapid test method that is claimed to evaluate the ASR susceptibility of concrete mixtures. ASTM C1260 specifically states that it is to be used to assess aggregates and not combinations of aggregates and cementitious materials (although some researchers have investigated its use for that purpose). The concrete prism test developed in Canada (ASTM C1293) is more realistic, in that it tests concrete rather than mortar, but it can take a year or more to perform. Other methods have been suggested or tried, but are not recommended due to limited data.

Status: Phase I results indicate that the use of different cements can have a significant effect on the expansion measured in C1260, even if the cements meet the criteria set forth in the test method. It is suspected that MgO in the cement could be the cause. A paper documenting this work was presented at the 11th International Conference on Alkali-Aggregate Reactivity in June of 2000. Phase II is underway. Tests are being performed for one year at 38C, for 3 months at 60 C, and for three months at 60 C using modified prisms with longitudinal holes to allow easier moisture ingress (developed at UNH). Variables include w/c (0.4 to 0.5), percent Class F fly ash replacement (0 to 30), and percent recommended lithium dosage (0 to 100). Testing at 38 C began in August 2002. Currently, repeat mixes of 38 C specimens are being performed because of concerns with some early readings. Testing at 60 C has been delayed due to equipment problems with the environmental chamber, which will be resolved by mid-March, 2003. Casting and testing of prisms at 60 C will begin in March 2003.

Available Reports/Articles/Presentations:

Task 56-E (99)—TFHRC PCCP Laboratory Studies: Variation of Shrinkage Potential of Portland Cement Concrete

Contracting Dates: 2002 to 2004

Contract Amount: $48,000 in FY 2004

Contractor: FHWA R&D at Turner-Fairbank Highway Research Center and SaLUT

Principal Investigator: Marcia Simon (FHWA)

FHWA Contract Manager: Marcia Simon

Project Goals/Objectives: To assess the shrinkage behavior of PCC paving mixtures and identify mixtures which minimize shrinkage and the associated cracking tendency.

Background: Uncontrolled cracking in jointed concrete pavements is an area of concern when it comes to providing long service life without the need for premature repair and rehabilitation. One of the primary properties of the concrete influencing the occurrence of cracking is the amount of shrinkage that the concrete undergoes. It is known that the total shrinkage experienced by PCC depends on a number of factors, such as the aggregate volume fraction, cement properties, and curing environment. Further study is needed to investigate the effect of the combination of various concrete components and curing regime on concrete shrinkage.

Status: Equipment has been assembled to conduct restrained and unrestrained shrinkage tests and evaporable/non-evaporable water measurement. Installation of temperature and humidity control for the shrinkage lab was delayed and is expected to be completed by mid-March, 2003. Once the controlled environment room is operational, materials will be obtained and planning/testing will begin.

Available Reports/Articles/Presentations:

Task 56-F (99)—TFHRC PCCP Laboratory Studies: Evaluation of the Workability Test and the Workability of Concrete Paving Mixtures

Contracting Dates: 2002 to 2003

Contract Amount: $10,000 in FY 2004

Contractor: FHWA R&D at Turner-Fairbank Highway Research Center and SaLUT

Principal Investigator: Marcia Simon (FHWA)

FHWA Contract Manager: Marcia Simon

Project Goals/Objectives:

1. To evaluate the operation and repeatability of the newly developed workability test device and procedure.
2. To use that test to measure the workability of a range of concrete paving mixtures, and determine what factors have primary influence on workability.

Background: The slump test measures only part of the concrete properties that influence workability, which is the yield stress. In order to fully define workability the plastic viscosity of the concrete must also be known. Many concrete Rheological devices have been developed, however none are applicable to the relatively stiff slip form paving concrete. The U.S. Army Corps of Engineers (USACE) recently developed a workability-measuring device for FHWA. The vibrating slope apparatus (VSA) quantifies the workability by measuring the time it takes for a measured mass of concrete to move out of the chute under certain vibration energy.

Status: The three new VSAs, with updated electronics and software, were completed in December 2002. Two VSAs were loaned to the University of Texas and Iowa State University for evaluation. The remaining VSA is being evaluated further at TFHRC in this study, which will include assessment of test factors (concrete slump, chute angle, and vibration force), test procedure modifications, and analysis and interpretation methods. Use of FRP instead of steel for the chute (to decrease weight and thus increase effect of vibrator) will also be investigated.

Available Reports/Articles/Presentations:

Task 57 (99)—Computer-Based Guidelines for Concrete Pavements (HIPERPAV II)

Contracting Dates: 2000 to 2004

Contract Amount: The original contract amount was $745,250. A subsequent modification to the contract added Task G (workshops and technical support) and Task H (further improvement of the HIPERPAV-II software), increasing the contract amount to $953,343 and extending the period of performance to January 31, 2004.

Contractor: Transtec Group, Inc.

Principal Investigator: Robert Rasmussen

FHWA Contract Manager: Fred Faradizar

Project Goals/Objectives: The improved and expanded software (HIPERPAV II) program includes modules for prediction of JPCP long-term performance as a function of early-age behavior and early-age behavior of continuously reinforced concrete pavements. Two recent completed FHWA studies have also been incorporated to provide capabilities for optimization of concrete mix designs to meet specific performance criteria, and predict early-age behavior of dowel bars in rigid pavements.

Background: Previously, FHWA developed a computer program, HIPERPAV, to provide guidance to the pavement engineer in the selection of materials and mixture design, pavement design, and construction procedures to avoid early-age cracking in JPCP. The purpose of this project is to investigate and provide guidance on the performance of JPCP beyond the first 72 hours, and to investigate and provide guidance on the early-age behavior of CRCP.

Status: Work in progress. Three workshops were conducted in Pennsylvania, Iowa, and Michigan. The modifications and improvements are being made to the HIPERPAV II software program to reflect feedback received from the Technical Group. The contract completion date is January 31, 2004.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

HIPERPAV II Train the Trainer Workshop material

HIPERPAV – High Performance Concrete Paving Software Brochure by Transtec

Power Point presentation – Sensitivity Analysis for Early-Age Cracking on Jointed Concrete Pavement Estimated with HiperPav by Pavement Research Center, University of California-Berkeley, October 9, 2001.

Public Roads – Paving the Way by J. Mauricio Ruiz, Robert Otto Rasmussen, and Patrician Kim Nelson, July/August 2002.

Texas Workshops Highlight High Performance Concrete Paving Software – article appeared in FOCUS magazine, October 2003.

HIPERPAV: Guidance to Avoid Early-Age Cracking in Concrete Pavement by S.W. Foster, date unknown.

Fast Track Paving: Concrete Temperature Control and Traffic Opening Criteria for Bonded Concrete Overlays – Volume II – HIPERPAV User's Manual, by B. Frank McCullough and Robert Otto Rasmussen, July 15, 1998.

Kim, S.M., P.K. Nelson, M. Ruiz, R.O. Rasmussen, and D. Turner, 2003, Early Age Behavior of Concrete Overlays on Continuously Reinforced Concrete Pavement Overlays, *Proceedings*, Transportation Research Board 82nd Annual Meeting, Transportation Research Board, Washington, DC.

Rasmussen, R.O., J.M. Ruiz, D.K. Rozycki, and B.F. McCullough, 2002, Constructing High-Performance Concrete Pavements with FHWA HIPERPAV Systems Analysis Software, *Transportation Research Record* 1813, Transportation Research Board, Washington, DC.

Ruiz, J.M., A.K. Schindler, R.O. Rasmussen, P.K. Nelson, and G.K. Chang, 2001, Concrete Temperature Modeling and Strength Prediction Using Maturity Concepts in the FHWA HIPERPAV Software, *Proceedings*, Seventh International Conference on Concrete Pavements. International Society for Concrete Pavements, College Station, TX.

Ruiz, J.M., P.J. Kim, A.K. Schindler, and R.O. Rasmussen, 2001, Validation of HIPERPAV for Prediction of Early-Age Jointed Concrete Pavement Behavior, *Transportation Research Record* 1778, Transportation Research Board, Washington, DC.

Task 58-A (98)—The Use of Precast Concrete Panels to Expedite Highway Pavement Construction

Contracting Dates: 1999 to 2000

Contract Amount: $100,000

Contractor: University of Texas in cooperation with the Texas DOT

Principal Investigator: Frank McCullough

FHWA Contract Manager: Mark Swanlund

Project Goals/Objectives: To investigate the feasibility of using precast concrete technology as a means to expedite concrete pavement construction.

Background: Precast concrete construction methods have been developed which are viable alternatives in applications such as buildings and bridges. One of the primary benefits of precast components is the speed of construction. Precast elements can be cast in controlled conditions at a precasting yard, far in advance of when they will be needed, then stockpiled and transported to the jobsite as necessary. Allowing time for concrete to cure before opening to traffic is a time-consuming phase of concrete pavement construction. The use of precast elements would eliminate this step while optimizing curing for the precast slabs.

Status: The feasibility study has been completed; the results are published as Center for Transportation Research Report Number 9-1517-1. The proposed panels are to be cast with continuous shear keys in the edges to aid with alignment when assembled. The panels are pre-tensioned in the transverse direction during fabrication, and post-tensioned in the longitudinal direction during construction. A follow-up project to work with several States to conduct field trials is underway.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Merritt, D.K., N.H. Burns, and B.F. McCullough, 2003, Texas Pilot Project, *Concrete International*, Volume 25, No. 3, American Concrete Institute, Farmington Hills, MI.

Merritt, D.K., B.F. McCullough, and N.H. Burns, 2003, Precast Prestressed Concrete Pavement Pilot Project Near Georgetown, Texas, *Transportation Research Record* 1823, Transportation Research Board, Washington, DC.

Merritt, D.K., B.F. McCullough, N.H. Burns, and A.K. Shindler, 2001, *Feasibility of Precast Prestressed Concrete Panels for Expediting PCC Pavement* Construction, Report No. Project Summary Report; 1517-S, University of Texas, Austin, TX.

Merritt, D., B.F. McCullough, and N.H. Burns, 2001, Feasibility of Using Precast Concrete Panels to Expedite Construction of Portland Cement Concrete Pavements, *Transportation Research Record* 1761, Transportation Research Board, Washington, DC.

Merritt, D.K., F. McCullough, and M.E. Swanlund, 2001, Feasibility of Precast Prestressed Concrete Pavements, *Proceedings*, Seventh International Conference on Concrete Pavements, International Society for Concrete Pavements, College Station, TX.

Task 58-B (98)—The Use of Precast Concrete Panels to Expedite Highway Pavement Construction, Phase 2: Pilot Studies

Contracting Dates: 2000 to 2002

Contract Amount: $100,000

Contractor: University of Texas

Principal Investigator: Frank McCullough

FHWA Contract Manager: Mark Swanlund

Project Goals/Objectives: To investigate the feasibility and demonstrate use of precast concrete technology as a means to expedite concrete pavement construction.

Background: Precast concrete construction methods have been developed which are viable alternatives in applications such as buildings and bridges. One of the primary benefits of precast components is the speed of construction. Precast elements can be cast in controlled conditions at a precasting yard, far in advance of when they will be needed, then stockpiled and transported to the jobsite as necessary. Allowing time for concrete to cure before opening to traffic is a time-consuming phase of concrete pavement construction. The use of precast elements would eliminate this step while optimizing curing for the precast slabs.

Status: Pilot project completed on I-35 frontage road in Georgetown, Texas, November 2001. Pilot project on I-10 in California under construction in October 2002.

UPDATE: Final report expected by mid -2003. Paper prepared for 7th International Conference on Concrete Pavements, Orlando, FL 9/2001. Paper prepared for TRB Annual meeting, 2002, Paper prepared for PCI conference, October 2003. Paper prepared for TRB Annual Meeting, 2003

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Merritt, D.K., B.F. McCullough, and N.H. Burns, 2002, Texas Tests Precast for Speed and Usability, *Public Roads*, Volume 66, No. 1, Federal Highway Administration, Washington, DC.

Task 58-C (98)—The Use of Precast Concrete Panels to Expedite Highway Pavement Construction, Phase 3: Demonstration Projects

Contracting Dates: 2003 to 2004

Contract Amount: $250,000

Contractor: Transtec Group, Inc.

Principal Investigator: David Merritt

FHWA Contract Manager: Mark Swanlund

Project Goals/Objectives: To demonstrate the use of precast, post-tensioned concrete pavements as a means to expedite concrete pavement construction.

Background: Precast concrete construction methods have been developed which are viable alternatives in applications such as buildings and bridges. One of the primary benefits of precast components is the speed of construction. Precast elements can be cast in controlled conditions at a precasting yard, far in advance of when they will be needed, then stockpiled and transported to the jobsite as necessary. Allowing time for concrete to cure before opening to traffic is a time-consuming phase of concrete pavement construction. The use of precast elements would eliminate this step while optimizing curing for the precast slabs.

Status: Projects being developed in California and Missouri.

In addition a contractor is preparing technical summary report on HPCP: Precast Pavement Technology due about April 30, 2004.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Task 59 (00)—Nondestructive and Innovative Testing Workshop

Contracting Dates: September 2000 to March 2003

Contract Amount: $386,000

Contractor: SAIC/Transtec Group, Inc. and FHWA Office of Pavement Technology

FHWA Contract Manager: Gary Crawford

Project Goals/Objectives: The goals of this project are to 1) increase awareness of nondestructive testing technologies to federal, state, and local highway agencies, and 2) promote the use of high-speed testing techniques for performance-related specifications, warranties, QA/QC specifications, and high-performance concrete.

Background: In the last several years, new and innovative testing techniques have evolved that have the potential for greatly improving the accuracy, reliability, and speed of assessing the quality or properties of in-place concrete. These techniques can play a significant role in the next generation of specifications, and it is important that highway agencies become familiar with the new technologies. One way of accomplishing this is through the presentation of hands-on workshops to interested highway agencies nationwide.

Status: Draft training course materials were developed and presented in two pilot workshops: one in Maryland on April 9–11, 2002 and one in Ontario on October 17, 2002. Overall, the pilot workshops were well received and final modifications were made to the course materials, making it a two-day workshop. A new contract for the presentation of the workshop is anticipated to be advertised in early 2004, with a contract award shortly thereafter.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

FHWA High Speed Testing Workshop: Nondestructive Testing and Innovative Technologies. Instructor's Handbook.

FHWA High Speed Testing Workshop: Nondestructive Testing and Innovative Technologies. Participant's Workbook.

Training Course Materials in PowerPoint format.

Guide to Nondestructive Testing of Concrete – FHWA Report No. FHWA-SA-97-105, September 1997.

Task 60 (99)—Curing of Portland Cement Concrete Pavements

Contracting Dates: 1999 to 2003

Contract Amount: $395,000

Contractor: U.S. Army Corps of Engineers, Waterways Experiment Station

Principal Investigator: Toy Poole

FHWA Contract Manager: Marcia Simon

Project Goals/Objectives: To develop guidelines for selecting curing materials and procedures that will ensure adequate curing of pavement concrete, given the variation in concrete mixture proportions and climatic conditions at the time of paving.

Background: Proper curing of concrete has a major influence on the performance of that concrete in service. Because of the relatively large surface area to volume ratio for pavements, this statement is particularly true for concrete pavements. Curing as used in this project includes both moisture control and temperature control of the concrete. Guidance is needed for materials and procedures selection in order to ensure proper curing for pavements in a range of situations.

Status: The first drafts of the deliverables were reviewed, and indicated that a major shift in the researcher's approach was needed. The researchers prepared a second draft of the final report which was much better, but still needed additional streamlining and shift of emphasis. The contractor is now working on the final version of the report to address the latest set of review comments. The final report will include a guide on curing.

Available Reports/Articles/Presentations:

Poole, T. S. 2001. "Methods for Measuring Application Rate of Liquid Membrane-Forming Curing Compounds on Concrete Pavements." *Proceedings*, Seventh International Conference on Concrete Pavements, Orlando, FL.

Other Related Reports/Articles/Presentations/Studies:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

A Review of the Curing Compounds and Application Techniques Used by the Minnesota Department of Transportation for Concrete Pavements by Julie M. Vandenbossche, November 1999.

Investigation into Improved Pavement Curing Materials and Techniques: Part I (Phases I and II) – Final Report – Iowa DOT Project TR-451 by Iowa State University, April 2002

Task 61 (99)—Evaluation of Initial PCC Performance-Related Specification Systems

Contracting Dates: 1999 to 2004

Contract Amount: $225,000

Contractor: Indiana and Florida Departments of Transportation and FHWA

FHWA Contract Manager: Peter Kopac

Project Goals/Objectives: To begin the implementation of performance-related specifications (PRS) by having State highway agencies develop, put into use, and evaluate a PRS system tailored to their needs.

Background: Over the past 25 years, there has been a growing interest in the development of PRS for highway pavement construction. PRS systems are similar to quality assurance specifications; however the measured acceptance quality characteristics (e.g. concrete strength, slab thickness, initial smoothness) are directly related to pavement performance through mathematical relationships. Performance is defined by key distress types and is directly related to the future maintenance and rehabilitation costs and user costs of the highway. This link between acceptance quality characteristics and future life-cycle costs provides the ability to develop rational and fair contractor pay adjustments that depend on the as-constructed quality delivered for the project. Several FHWA research projects on development of PRS have now been completed, and guidance for implementing PRS is now available in the form of: (1) a prototype PRS; (2) a 19-step procedure for developing PRS; and (3) PaveSpec software.

Status: Work in progress. INDOT is currently planning to develop and use PRS on a 3rd project.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; State DOT Work Plans

Appendix II: Performance-Related Specification for Use in Determining Pay Factor Adjustments. Prepared for: R-25175, I-66, Clarksville, IN, March 18, 2002.

Appendix II: Performance-Related Specification Design and AQC Values as Determined for Use in Determining Pay Factor Adjustments Prepared for Project R-24432, Marion County, IN.

Section 501 – Quality Control/Quality Assurance, QC/QA, Portland Cement Concrete Pavement, PCCP Incorporating Performance Related Specification Pay Factors.

Section 501 – Quality Control/Quality Assurance, QC/QA, Portland Cement Concrete Pavement, PCCP Incorporating Performance Related Specification Pay Factors, March 18, 2002.

Peter A. Kopac, Making Roads Better and Better, *Public Roads,* July/August 2002.

Financial Project ID 209600-1-52-01, State Route 9A (I-295 LEG), Duval County – Technical Special Provisions for Performance-Related Specifications for Rigid Pavement by ERES Consultants, July 25, 2001.

Performance-Related Specifications (PRS) A Cooperative Effort to Improve Pavement Quality – Publication No. FHWA-SA-97-098, date unknown.

Chini, A.R., L.C. Muszynski, and J.K. Hicks, 2003, *Determination of Acceptance Permeability Characteristics for Performance-Related Specifications for Portland Cement Concrete.* Final Report. University of Florida, Gainesville, FL.

Other Related Reports/Articles/Presentations/Studies:

Gharaibeh, N.G., P.A. Kopac, and M.I. Darter, 2001, Effect of Variability and Central Tendency in Performance-Related Specifications for Concrete Pavements, *Proceedings*, Seventh International Conference on Concrete Pavements, International Society for Concrete Pavements, College Station, TX.

Gharaibeh, N.G., J. Stefanski, and M.I. Darter, 2002, Evaluation of Concrete Pavement Construction Scenarios Under Performance- Related Specifications, *Transportation Research Record* 1813, Transportation Research Board, Washington, DC.

Task 62 (01)—Potential Adverse Effects of High-Smoothness Specifications on Concrete Pavement Performance

Contracting Dates: July 2001 to July 2004

Contract Amount: $388,000

Contractor: Soil and Materials Engineers, Inc.

Principal Investigator: Starr Kohn

FHWA Contract Manager: Peter Kopac

Project Goals/Objectives: The objectives of this project are to:

1. Assess whether any activities carried out during the paving process in order to achieve some specified level of smoothness could have detrimental effects on concrete properties and pavement performance.
2. Provide guidance on adjustments to materials and procedures to assure construction of pavements that exhibit both exceptional smoothness and performance.

Background: There has been a continuing trend among highway agencies to specify smoother and smoother pavements. The requirements are steadily being raised in response to the user's increased expectations and the paving contractor's increased proficiency. However, while contractors are finding ways to attain the specified smoothness, it is not clear that the result is always an overall improvement in pavement performance.

Like all materials and construction quality characteristics, smoothness should be considered as having an optimal level. Obviously it is undesirable to have a newly constructed pavement that is too rough. Alternately, very smooth pavements, if they fail prematurely, are also undesirable. This project investigates the potential for adverse effects on concrete properties and the performance of concrete pavements from trying to achieve some currently specified levels of smoothness.

Status: Work in progress. The literature review has been completed and the initial meeting of the technical panel was held. The proposed work plan has been approved and the collection and analysis of data is underway. A request for a contract extension is anticipated.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Interim Report, July 2002.

Power Point presentation – Achieving High Levels of Smoothness in PCC Pavements Without Hindering Long Term Performance, Starr Kohn.

Task 63 (02)—Inertial Profile Data for PCC Pavement Performance Evaluation

Contracting Dates: August 2002 to February 2005

Contract Amount: $1,120,000

Contractor: Transtec Group

Principal Investigator: Robert Rasmussen

FHWA Contract Manager: Mark Swanlund

Project Goals/Objectives: The goal of this project is to determine if the magnitude of JPCP slab curvature can be related to pavement performance. This will be accomplished by:

1. Determining the extent of JPCP slab curvature allowable under specific environmental and support conditions to provide long-term performance.
2. Identifying construction methods or design characteristics to achieve recommendations

Background: It has been known for some time that the changes in shape of PCC slabs due to construction conditions (built-in curvature) and environment (temperature curling and moisture warping) in a jointed pavement system have an influence on pavement performance. Exactly how performance is impacted by slab shape and the magnitude of changes to slab shape throughout its life cycle, has not been adequately documented. Many previous attempts to quantify the impact of slab shape on performance or determine the shape of PCC slabs on in-service pavements have been limited by insufficient sample size resulting from use of manual methods for determining slab shape.

Recent advances in inertial profiling technology developed at FHWA's Turner-Fairbank Highway Research Center and advances in computer technology make is possible to measure reliably the shape of very large numbers of PCC pavement slabs over a short period of time and perform analysis of this data. These measurements can be repeated to develop a time-history of pavement slab shape. This technology was recently demonstrated by a high-speed inertial profiler that performed a detailed profile survey of four lanes of a 24 km Interstate pavement four times within a 24-hour period. Results from the testing showed that the magnitude of curvature of the slabs surveyed varied from positive 15 mm to negative 15mm using best-fit curve and simulated straightedge. The daily change in slab curvature was frequently measured at 5-7mm over a 22C pavement temperature range. It is hypothesized that slab shape changes in response to construction conditions, and diurnal temperature gradients may have a significant role in pavement performance.

With the evolution from empirical pavement design to mechanistic pavement design, determination of changes to the shape of slabs in jointed PCC pavement and the distribution of slab curvature on in-service pavements is very critical.

Status: Data collection started in April 2003. The contract was modified in September 2003 to add concurrent Close Proximity (CPX) noise measurement to short interval profile data to determine the relationship between mega texture (50-100 mm wavelength roughness) and tire-pavement noise for PCC pavement.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

Assessment of Profiler Performance for Construction Quality Control: Phase I – Final Draft, by Steven M. Karamihas and Thomas D. Gillespie, December 2002

Other Related Reports/Articles/Presentations/Studies:

Fourth Annual Pavement/Materials and Testing Workshop, Pavement Smoothness, Friction, Tire/Pavement Noise, and Texturing, FHWA Office of Pavement Technology and Office of Infrastructure Research and Development, Arlington, VA, December 9-11, 2003. (multiple papers on the smoothness issue including curl/warp and faulting effect on ride.

PCC Slab Faulting and Joint/Crack Evaluation Analysis, Task Order SEQS-16, Contract DTFH61-00-C-00076, STARODUB, Inc. Revised July 2003.Related research to (Sixbey, et al. 2001) for faulting analysis using high speed profiler and evaluation of whether or not joints are working as designed and constructed.

Task 64 (02)—Computer-Based Guidelines for Job-Specific Optimization of Paving Concrete

Contracting Dates: 2002 to 2005

Contract Amount: $834,000

Contractor: Transtec Group, Inc.

Principal Investigator: Robert Rasmussen

FHWA Contract Manager: Marcia Simon

Project Goals/Objectives: To develop computer-based guidelines for optimizing materials selection and mixture proportioning for job-specific paving concrete.
Background: Over the last several years the FHWA, IPRF, NCHRP and others have conducted a number of studies that dealt with various aspects of the effect of concrete components on the performance of the resulting concrete (using those materials) in concrete pavements. The wealth of information now available is too great to be practically assimilated and combined from existing guidelines, reports, tables and predictive models in order for a pavement or materials engineer to derive the optimal mix for a given paving project. Therefore, a coordinated effort is needed to take the results of previous work and integrate them into a computer-based system that will guide the concrete materials engineer in selecting the optimal mix for a particular project. Factors that need to be considered include pavement structural design (loading effects), early-age and long-term environmental effects, the construction process, desired service life, available local materials and cost.

Status: Contract was awarded on August 30, 2002. A technical panel consisting of several state DOT concrete engineers, contractors, and various trade associations, was formed. The first meeting took place in November 2002. At that meeting, the panel provided direction and feedback to the contractor on their proposed approach. An interim report discussing the technical scope, information gaps, options for software development, a framework for the guidelines, and a detailed work plan for the remainder of the project was submitted in June 2003. A second panel meeting was held in late June 2003. The contractor is modifying the interim report based on comments received during and after that meeting. After the report is completed and approved, detailed development of the guidelines will begin.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

PowerPoint Presentation, TRB Annual Meeting, January 2004.

Other Reports/Articles/Presentations:

Concrete Paving Notes Materials No. 1 – Formation and Characteristics of Portland Cement Concrete for Pavements: The Basis by Dale Harrington, Kejin Wang, Todd Hanson, and Jim Grove, Iowa State University, November 2002.

Optimization of Concrete Pavement Mix Design in Colorado – Phase I Report No. 2002-8, by Robert Otto Rasmussen, J. Mauricio Ruiz, and Dennis J. Turner, June 26, 2002.

Task 65 (03)— Technology Transfer, Deployment and Delivery for the Concrete Pavement Technology Program (CPTP)

Contracting Dates: September 2003 to September 2005 (plus three optional years)

Contract Amount: $5,600,000

Contractor: Construction Technology Laboratories, Inc.

Principal Investigator: Shiraz Tayabji

FHWA Contract Manager: Sam Tyson

Project Goals/Objectives: This contract will provide the engineering and communication services needed for the technology transfer, deployment and delivery of products resulting from the Concrete Pavement Technology Program (CPTP). The scope of the work to be performed under this contract will be defined both by the products that result from the CPTP and by the communication and outreach strategy that is proposed by the contractor and accepted by the FHWA. The technology transfer program is for the benefit of FHWA's customers and partners and it will be planned and executed in a timely and cost-effective manner. Task 65 will support FHWA's efforts to clearly demonstrate the value of the products resulting from the CPTP and to deliver benefits to a variety of end-user groups in the highway community including the States, industry, and academia.

Status: The contract was awarded during September 2001. A CPTP Status Report (this report) has been prepared. In addition, a CPTP information flyer and a website (www.CPTPNOW.com) have been developed. A CPTP newsletter is under development. Meeting of Task 65 Executive ETG and Engineering ETG are planned for early 2004.

Available Reports/Articles/Presentations:

FHWA RFP Objectives, Scope of Work and Proposed Work Plan; Contractor's Work Plan

CPTP Status Report (this report), Federal Highway Administration, February 2004.

CPTP Information Flyer, January 2004

CPTP website: www.CPTPNow.com