

MONTHLY PROGRESS REPORT Slurry/Micro-Surface Mix Design Procedure September 2004

To: T. Joe Holland, CALTRANS
Contract No.: CALTRANS 65A0151
Contractor: Fugro Consultants LP
Contract Period: June 30, 2003 – Nov. 30, 2007
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PROJECT OVERVIEW

The overall goal of this research is to improve the performance of slurry seal and micro-surfacing systems through the development of a rational mix design procedure, guidelines, and specifications.

Phase I of the project has two major components: 1) the first consists of a literature review and a survey of industry/agencies using slurry and micro-surfacing systems, 2) the second deals with the development of a detailed work plan for Phases II and III.

In Phase II, the project team will evaluate existing and potential new test methods, evaluate successful constructability indicators, conduct ruggedness tests on recommended equipment and procedures, and prepare a report that summarizes all the activities undertaken under the task.

In Phase III, the project team will develop guidelines and specifications, a training program, and provide expertise and oversight in the construction of pilot projects intended to validate the recommended design procedures and guidelines. All activities of the study will be documented in a Final Report.

NOTE: New information for the current month is notated by double-lines to the left of text, tables, or figures.

PHASE I—LITERATURE SEARCH AND WORK PLAN DEVELOPMENT

Task 1—Literature Review and Industry Survey

Task 1.1 Literature Review

Completed. The literature review process is completed with all sources of information on the design and use of micro-surfacing and slurry seals reviewed and summarized in Chapter 2 of the Phase I Report.

Planned. Although the literature review process is finalized, any new information will be reviewed as it becomes available.

Task 1.2 Industry, Agency, and Advisory Panel Surveys

Completed. Following discussion between team members and Caltrans, three surveys were designed:

- Agencies: Those using the AASHTO LISTSERVE link (United States and Canada).
- Contractors and Manufacturers: Those in the United States and the international slurry surfacing and micro-surfacing industry.
- Advisory Panel Contractors.

The three proposed survey questionnaires were included in the August 2003 monthly report and the results were summarized in the Phase I Report.

Task 2—Work Plans for Phases II and III

Completed. The Phase II Work Plan was included in Chapter 3 of the Phase I Report. The Phase III Work Plan was included in Chapter 4 of the Phase I Report. The final Phase I Report was submitted to CALTRANS in March 2004.

PHASE II—MIX DESIGN PROCEDURE DEVELOPMENT

Tasks 3 & 4—Evaluation of Potential Test Methods & Successful Constructability Indicators

The team is working towards the acquisition of the new test equipment to be used in Phase II. The equipment includes:

- Visco-Time®: an apparatus that will measure the rotational viscosity of a slurry system with time. The results will be used to evaluate the time available for mixing and spreading the mixture in the field and an estimate of the set time. Two similar devices are available from Europe: Viscosclick and Eurostar. The difference between the two devices is in the method of measuring the rotational torque: Viscosclick measures the torque acting on the mixing shaft while Eurostar measures the torque acting on the motor that rotates the mixing shaft. Viscosclick is potentially more accurate, but also more expensive. A preliminary evaluation and comparison of the two devices will be carried out by the team next month. The study will allow for the selection of the device best suited for the project.

The Consolidated Engineering Laboratory management is reviewing the final contract arrangements for the acquisition of the equipment and the target date for the delivery of the devices is late September 2004.

After a lot of legwork on Glynn Holleran's part we have finally nailed down an arrangement to have IKA Works Inc., a Wilmington, North Carolina supplier, loan us two

different automated mixing devices for two months, EUROSTAR and the VISCOKLICK VK 600. These will be shipped to the CEL Laboratories the week of September 27th. The EUROSTAR measures the torque on the specimen indirectly by sensing the change in the power delivered to the motor of the stirrer. The VISCOKLICK VK 600, which is about an additional \$800, measures the torque directly on the stirrer shaft. Both devices will be evaluated and one will be selected for the project.

- French Wet Track Abrasion Test (FWTAT) Device: An apparatus that is very similar to the Wet Track Abrasion Test (WTAT), but uses a set of wheels instead of the rubber hose normally used for the abrasion head. The apparatus has been modified to use the French Wheel fixture and is going through refinements.

This equipment has been manufactured, is in the laboratory at Consolidated Engineering Laboratories, and is ready to begin testing. Several trials on “dummy” specimens have been done to assure that the equipment is in working order. During the shake down of the apparatus it was discovered that the shaft on the assembly was too long which won't permit the use of a standard WTAT fixture. This shaft is currently being modified by CEL and will be ready for further testing by 1 October.

In addition, it is the intention of the research team to test mixtures in the laboratory as they will be delivered to the field. The current ISSA TB 100 procedure (WTAT) requires the coarser materials to be scalped from the aggregate before mix samples are prepared for the test. We plan to use the entire mixture gradation which will require the fabrication of specimen molds to accommodate the coarser aggregate. We plan to work with a local machine shop in Oakland to fabricate metal and acrylic molds.

- Modified Cohesion Tester: An automated modified cohesion tester (i.e., the torque will be applied by means of an automated device instead of a manual method). The team is in the process of modifying the device to make it automated.

We anticipate the modifications to be complete and the device ready for testing by the end of September 2004.

- Environmental Chamber: Many of the tests of Phase II will be performed under controlled temperature and humidity conditions that require the use of one or several environmental chambers. These are already available in the CEL laboratories where most of the testing will be performed.

The matrix of tests to be performed in Task 3 is being reviewed by the team; a range of conditions will be used in the test program:

- Humidity: high and low
- Temperature: 10, 25 and 30°C (50, 77 and 86°F)
- Cure time: 30, 60, 90 minutes; 12 and 24 hours
- Soak time: 1 hour; 1,3,6 and 9 days

Tentatively, five mixes will be included in the test program of which four are made of aggregates and binders known to perform well in slurry systems and one will be made of materials for which the performance is unknown. The five mixes are:

- Mix 1 Ralumac + Table Mountain Aggregate (supplied by Koch)
- Mix 2 Ralumac + Lopke Gravel Aggregate (Koch formulation for emulsion)
- Mix 3 VSS PMCQS-1h + Table Mountain Aggregate
- Mix 4 Vestal PM CQS -1h + Lopke Gravel Aggregate
- Mix 5 Unknown

Testing of the Table Mountain Aggregate is complete. The Lopke Gravel Aggregate will be received and tested next month.

Tests have been completed for both aggregates. Tests included sieve analysis, sand equivalent, Los Angeles abrasion, and sodium sulfate soundness testing. The results were noted in Attachment A of the July 2004 progress report. The aggregates have been forwarded to Valley Slurry Seal and Koch Materials for the formulation of the emulsions.

The sodium sulfate testing had been re-done because an old solution was used for the initial testing and there is some concern that the results might not be valid. The results are included in Attachment A of the August 2004 (current) progress report.

Tests on both emulsions are underway at CEL to determine the Sabolt viscosity and residue content.

The standard suite of ISSA mix design tests will be performed on both mixtures to establish "benchmarks" before progressing to the new and modified test procedures.

Task 5—Ruggedness Tests of Recommended Equipment and Procedures

In comparison with the testing in Tasks 3 and 4, the tests of Task 5 will be performed at a single set of temperature, humidity, and cure time conditions. "Standard" conditions were chosen by the team: 50 percent humidity, 25°C temperature, etc. Slight variations in these parameters will be allowed to evaluate the ruggedness of the test procedures. The team is currently reviewing the test factorials proposed in the Phase II Work Plan.

Task 6—Phase II Report

No Activity

PHASE III— PILOT PROJECTS AND IMPLEMENTATION

Task 7—Development of Guidelines and Specifications

A list of references that contain guidelines and specifications has been drafted and is noted below:

- ISSA A105 Guidelines for Slurry—Available
- ISSA A143 Guidelines for Micro-Surfacing—Available
- TTI Report 1289-2F Use of Micro-Surfacing in Highway Pavements—Available.
Report contains:
 - Methods and Materials Specifications
 - Quality Control and Assurance Tests (including field cohesion and vane shear tests)
 - Quality Control Guidelines (including materials acceptance tests and mixture design verification)
 - A Checklist
 - Usage Guidelines.
- ISSA Inspector's Manual—Available
- Caltrans Maintenance Technical Advisory Guide Final Draft—Available
- The ISSA Workshop Folder—Available

The guidelines and specifications will be a concise collection, presented in AASHTO format. This is one area of Phase III where the team can work at present. At the end of Phase II, the document will be appended with findings and recommendations relative to the new tests developed in Phase II.

Task 8—Workshop Training Program/Pre-Construction Module

The team agreed that work could commence in several chapters of the Reference Manual to be developed under this task. The Reference Manual will be a comprehensive, textbook-like document with background information, explanations, and pertinent information on the design and use of slurry systems.

A template for the Reference Manual has been produced and work has begun on the development. A draft outline of the Manual is presented here:

- Chapter 1. Introduction
 - Historical Developments
 - Why Slurry Systems
 - The Future of Slurry Systems
 - Objectives of the Manual
 - Organization of Material
- Chapter 2. Slurry Systems Review
 - What is Slurry Seal
 - What is Micro-Surfacing
 - Slurry Systems
- Chapter 3. Project Selection Criteria
- Chapter 4. Mix Design
 - Mix Design Flowchart
 - Binder Requirements
 - Aggregate Requirements

- Blending Requirements
- Test Methods
- Mix Design Examples
- Chapter 5. SyRaMiD Specifications
- Chapter 6. Construction Considerations and Limitations
 - Project Geometry
 - Weather Limitations
- Chapter 7. Construction Operations
 - Equipment and Calibration Requirements
 - Surface Preparation
 - Workmanship Requirements
 - Stockpile Management
 - Mix Design Verification
 - Troubleshooting
- Chapter 8. Quality Control
- References
- Appendices
 - Test Protocols
- Glossary

Task 9—Pilot Projects/Procedure Validation

The team is working on the development of guidelines for selecting pilot projects to be used by State agencies. Currently, the proposed pilot project layout contains six different sections:

- A control section placed using the ISSA current procedure.
- A bare section (do nothing)
- Improved mix design (using the method developed in Phase II), Replicate 1
- Another contractor-based control (ISSA design).
- Another bare section.
- Improved mix design (using the method developed in Phase II), Replicate 2

|| A draft of the guidance document is included in Appendix A of this report.

Task 10—Final Report

No Activity

NEXT MONTH'S WORK PLAN

The activities planned for next month are listed below.

- Coordinate with CALTRANS personnel on an as-needed basis.
- Continue with Phase II and Phase III activities.

PROBLEMS / RECOMMENDED SOLUTIONS

The process of acquiring and adapting the test systems took longer than initially anticipated. It is expected that by the end of the next reporting period all equipment-related problems will be overcome.

Appendix A
Criteria for Project Selection - Draft

CRITERIA FOR PROJECT SELECTION - DRAFT

Introduction

Recognizing the need for more rational design methods for micro-surfacing and slurry seal, the Federal Highway Administration (FHWA) enlisted the California Department of Transportation (CALTRANS) to perform a pooled fund study to which the following States contributed: California, Delaware, Georgia, Illinois, Kansas, Maine, Michigan, Minnesota, Missouri, New Hampshire, New York, North Dakota, Texas and Vermont.

The overall goal of the CALTRANS Project 65a0151 – “Slurry/Micro-Surface Mix Design Procedure” is to improve the performance of slurry seal and micro-surfacing systems through the development of a rational mix design procedure, guidelines, and specifications.

The project started in 2003 and will continue till the end of 2007. The work plan is organized in three phases as described below:

Phase I of the project has two major components: 1) the first consists of a literature review and a survey of industry/agencies using slurry and micro-surfacing systems, 2) the second part of Phase I deals with the development of a detailed work plan for Phases II and III. All work on Phase I has been completed and the findings and results are summarized in the Phase I Report (1)

In Phase II, the project team will evaluate existing and potential new test methods, evaluate successful constructability indicators, conduct ruggedness tests on recommended equipment and procedures, and prepare a report that summarizes all the activities undertaken under the task. Phase II is under development.

In Phase III, the project team will develop guidelines and specifications, a training program, and provide expertise and oversight in the construction of pilot projects intended to validate the recommended design procedures and guidelines.

Scope

This document is developed under the activities of Phase III of the project and contains guidelines to assist state highway agencies with the selection of pilot projects to be included in the factorial of pavement test sections of Phase III.

Site Selection Process

There are a large number of factors that affect the performance of slurry seal and micro-surfacing projects. These include climate, traffic, condition of the existing pavement prior to the application, workmanship and mix design. The 14 states involved in the pooled fund study (California, Delaware, Georgia, Illinois, Kansas, Maine, Michigan, Minnesota, Missouri, New

Hampshire, New York, North Dakota, Texas and Vermont) provide a diverse set of climatic conditions ideally suited for this study.

The site selection is a two-step process:

Step 1. Using this document as guidance, state agencies will identify candidate test sites in their state

Step 2. The project team will select the specific projects to be included in the “national” factorial from the candidate projects proposed by the state agencies

As described in Step 1, the participating state agencies play a key role in many aspects of this research effort. The states are responsible for the following activities:

- Nomination of test sites
- Construction of test sections
- Provision of traffic control for all test site data collection
- Reporting as-built construction data
- Reporting skid resistance if available
- Reporting structural information (deflection data, cross section thickness/material)
- Reporting maintenance activities

The research teams will be more involved in Step 2 and its responsibilities include:

- Development of experimental design
- Coordination among participating agencies
- Final acceptance of nominated test sites
- Development of uniform data collection guidelines and forms
- Coordination of material sampling and testing
- Monitoring pavement performance
- Data analysis and reporting
- Review of material mix designs and construction plans

Site Selection Guidelines for Agencies

State agencies should consider the following variables in identifying suitable locations for the micro-surfacing test sites:

Traffic

The amount of traffic for the pilot projects is divided into two levels:

- High: from 25,000 ADT and above (>10 Million ESALs)
- Moderate: from 10,000 ADT to 25,000 ADT (approximately 4-10 Million ESALs over 20 years w/10% trucks)

The agencies should identify test sections under both categories of traffic.

Climate

Four distinct climatic regions have been identified by the FHWA Long Term Pavement Performance (LTPP) program and are illustrated in Figure 1. These regions are:

- Wet Freeze
- Wet No-Freeze,
- Dry Freeze
- Dry No-Freeze.

For states that are located at the confluence of two climatic regions we suggest that candidate sites are selected in both regions. If a state is located only within one of the 4 LTPP climatic regions, we suggest that the agency selects sites at different locations within the state where the agency is aware that significant differences in climate exist.

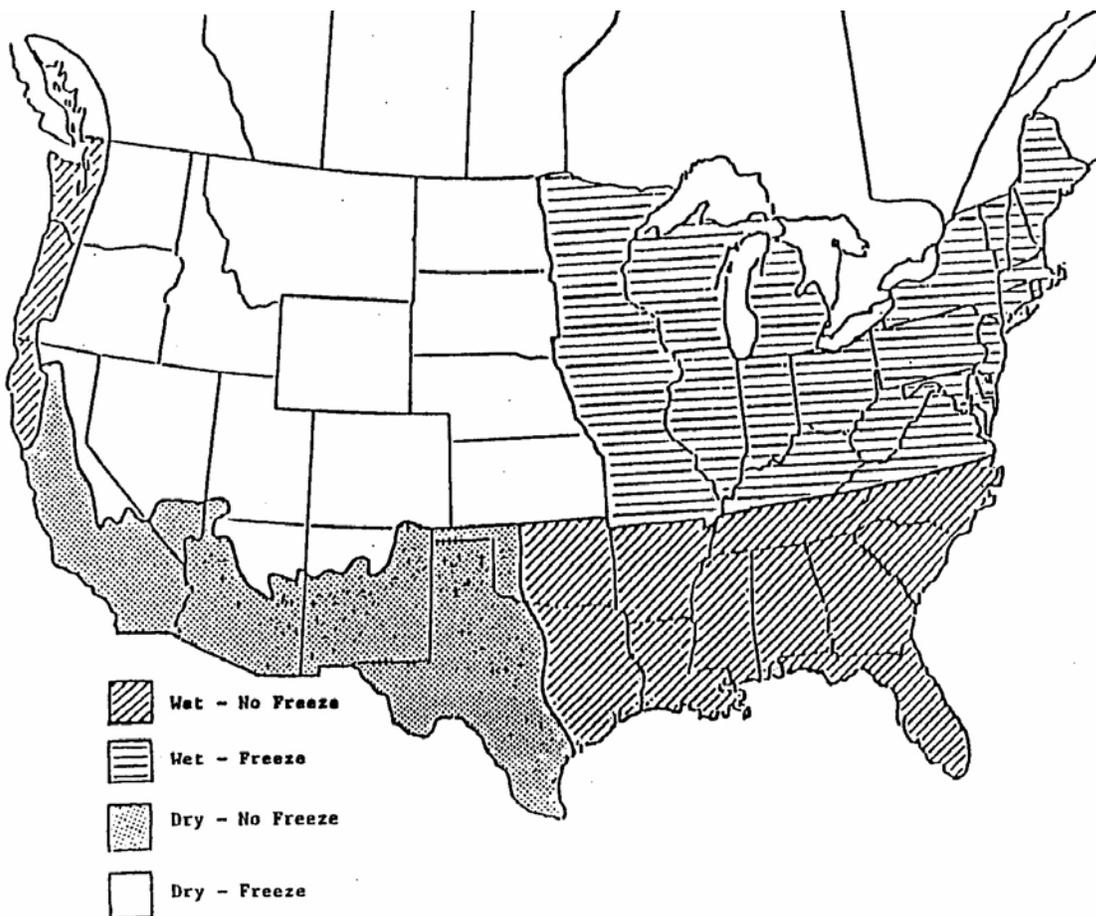


Figure 1. LTPP Climatic Regions

Pavement Surface

Two types of pavements should be included in the factorial of test sections:

- Asphalt pavements
- Portland cement concrete pavements

Table 1 can be used by agencies to summarize the nominated candidate test sites:

Table 1. Desired Characteristics of Nominated Test Sections

Pavement Surface	Climatic Region	Traffic Level	Project Name
Asphalt Concrete	Region 1	Low	Project 1 Project 2
		High	Project 3 Project 4
	Region 2	Low	Project 5 Project 6
		High	Project 7 Project 8
Portland Cement Concrete	Region 1	Low	Project 9 Project 10
		High	Project 11 Project 12
	Region 2	Low	Project 13 Project 14
		High	Project 15 Project 16

Ideally, 16 sites should be nominated in states that have 2 climatic regions. If only 1 climatic region is present, the number of sites reduces to 8. However, agencies will nominate as many projects as possible in any of the categories of surface, climate and traffic given in Table 1. The actual number of sites to be included in the experiment will be dependent on the resources of the state agency.

In addition, an examination of the site conditions prior to selection **must** be conducted to insure uniformity among the test sections. These include:

Adequate length

Insure that the site is long enough to accommodate the number and length of test sections to be included in the site.

Uniform traffic:

Particular attention to entrance and exit ramps should be taken to insure uniform traffic among the test sections.

Pavement Geometry

It is preferred that the geometries of the roadway be determined to mitigate the affects of super-elevation or sharp turns that will influence the interaction of the tire and the pavement between different test sections. It is also recommended that the test sections be located on relatively

straight roadway with uniform vertical grade. Horizontal curves greater than 3° and vertical grades greater than 4% should be avoided.

Pavement condition

- The existing condition of the pavement (surface distress) should also be determined. It is recommended to select pavements with no distress. However, sites with limited distress will be accepted as long as the site has uniform conditions (raveling, bleeding, transverse cracks, etc.). Sites with rutting in excess of one inch on average over the test site or greater than 1.5 inches per location is not permitted. In terms of ride quality, it is recommended that the surface of the pavement be smooth and provide an excellent ride level to reduce the affects this may have on individual sections within a test site. As a target, the existing surface should have a pro-rated profile index of less than 158mm per 1000m (10 inches per mile) as measured by a calibrated profiler.
- While friction is of interest to the research group to assess the level of improvement in regard to this parameter, the level of friction is not a requirement for the site selection. Any available friction information available from the states will be appreciated.
- The affects of stripping are also of concern to the research group. The stripping potential of the proposed test site should be determined prior to the acceptance of the test site. The TSR test is recommended to determine the stripping strength of the adhesive bonds. The test should be run on samples at the beginning and ending of the test sections.
- The structural capacity of the pavement is important in determining the life span of the pavement. It is recommended that only those sites with sufficient remaining life (5 years) be used for this study. This should prevent the need for maintenance and rehabilitation activities prior to completing the study or future studies that may be warranted in the near future. To assess the adequacy of the structure, FWD deflection information should be obtained if the state budget permits. This testing should be conducted every 100 feet along the selected test site. A Surface Curvature Index (SCI) of less than 20 (Sensor 1 – Sensor 2 at 12 inch spacing) at 9,000lb load level indicates a good pavement structure and potentially a good candidate for the experiment. The remaining life of the section cannot be determined solely on this information alone as it is also dependant on the climate and traffic. This information will be used only as a guide for the selection of candidate test sites.

Test Section Layout

The section layout is presented in Figure 2. The pilot project will contain, in this sequence:

- A 500 ft section placed using the ISSA (International Slurry Surfacing Association) mix design procedure
- A 500 ft control section, with no treatment
- A 500 ft section placed using the Slurry Systems Rational Mix Design (SYRAMID) developed in this project
- A second 500 ft ISSA section
- A second 500 ft control section
- A second 500 ft SYRAMID section

- Transition zones, 100 ft long are used before and after each section, as illustrated in Figure 2

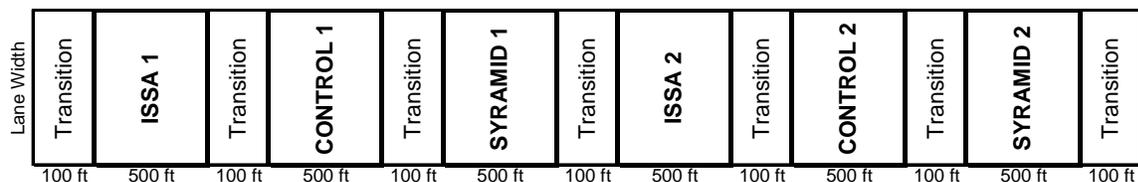


Figure 2. Pilot Project Schematic Layout

The total length of the pilot project is 3,700 ft. The placement of the treatments will be done according to the construction guidelines that will be provided upon completion of the experimental matrix. Only one traffic control operation is required to provide the safety for personnel monitoring the test sections.

Contact Information

In case if you have any questions, please contact:

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References

1. Phase I Report, Slurry / Micro-Surfacing Mix Design Procedure, Contract 65A0151, February 2004
2. Strategic Highway Research Program – Research Plans, NCHRP 20-20, Washington DC, May 1986.
3. SPS-3 Construction Guidelines, FHWA-LTPP Program, March 31, 1990.