MONTHLY PROGRESS REPORT
Slurry/Micro-Surface Mix Design Procedure
October 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—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. The three 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.

All activities of Phase I are completed. The results are included in the Phase I Interim Report that 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: Viscoclick and Eurostar. The difference between these two devices is in the method of measuring the rotational torque: Viscoclick measures the torque acting on the mixing shaft while Eurostar measures the torque acting on the motor that rotates the mixing shaft. Viscoclick is potentially more accurate, but also more expensive. A preliminary evaluation and comparison of the two devices will be carried out as soon as the equipment becomes available.

The equipment will be loaned to the project for three months by IKA, a distributor in North Carolina. They have promised us delivery on several occasions, but for one reason or another they have not met the delivery time. They now indicate that the delivery will be no later than November 12, 2004.

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.

As reported last month, the shaft for the device was not the proper size and it has been modified. This equipment is in the laboratory at Consolidated Engineering Laboratories, and is ready to begin testing.

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.

The project team anticipated that the modifications would be complete and the device ready for testing by the end of October 2004, but because of minor design changes, the equipment delivery is not expected until November 15, 2004.

Specimen Preparation Molds: 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. The entire mixture gradation will be used and will require the fabrication of specimen molds to accommodate the coarser aggregate. A local machine shop in Oakland, CA, will fabricate the metal and acrylic molds.

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: 1hour; 1,3,6 and 9 Days

Tentatively, five mixes are planned for inclusion in the test program. Four will be 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 is expected to be received and tested in December 2004.

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 progress report.

Tests on both emulsions are underway at CEL to determine the Sabolt viscosity and residue content. Information on the emulsion from Koch is noted below in Table 1.

Identification	Residue, %	Penetration, dmm	Softening Point, ° C
MK-1	61.7	47	64.1
MK-2	64.3	52	59.5

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. It is anticipated that all the ISSA “standard” mix design work will be completed by November 30, 2004.

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 (e.g., 50 percent humidity, 25°C temperature). 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 was included in Appendix A of the September 2004 monthly progress report. The final version of the Guidance Document is included in Appendix A of this report. The document will be forwarded to the participant State agencies and other agencies interested in participating in the pilot project study.

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

Despite all efforts, there are still problems with the acquisition of the test equipment. This may cause a delay with the planned testing schedule. The team will make every effort to expedite the work when the equipment is received. However, all other project activities will follow the initial schedule.

APPENDIX A

CRITERIA FOR PILOT PROJECT SELECTION

CALTRANS Project 65A0151
"Slurry/Micro-Surface Mix Design Procedure"

November 2004

CRITERIA FOR PROJECT SELECTION

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 through 2007. The work plan is organized into three phases, as described below:

Phase I: Literature Search and Work Development Plan. Phase I consists of two major components:

1. A literature review and a survey of industry/agencies using slurry and micro-surfacing systems.
2. 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)]

Phase II: Mix Design Procedure Development. 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.

Phase III: Pilot Projects and Implementation. 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.[2] The 14 States involved in the pooled fund study 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 a guide, State agencies will identify candidate test sites in their State. 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 (cross section thickness/material)
- Reporting maintenance activities

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. The research team 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 three variables in identifying suitable locations for the micro-surfacing test sites:

1. Traffic: The amount of traffic for the pilot projects is divided into two levels:
    a. High: from 25,000 ADT and above (>10 Million ESALs)
    b. 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.

2. 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:
    a. Wet Freeze
    b. Wet No-Freeze
    c. Dry Freeze
    d. Dry No-Freeze

    For States that are located at the confluence of two climatic regions, the project team suggests that candidate sites should be selected in both regions. If a State is located within only one of the four LTPP climatic regions, the agency should select sites at different locations within the State where significant differences in climate exist.

3. Pavement Surface. Two types of pavements should be included in the factorial of test sections:
    a. Apshalt Pavements
    b. Portland Cement Concrete Pavements

Table 1 can be used by agencies to summarize the nominated candidate test sites. This table assumes that an agency is located in two LTTP climatic regions. Ideally, 16 sites should be nominated in States that have two climatic regions. If an agency has only one LTPP climatic region, the matrix would be halved.

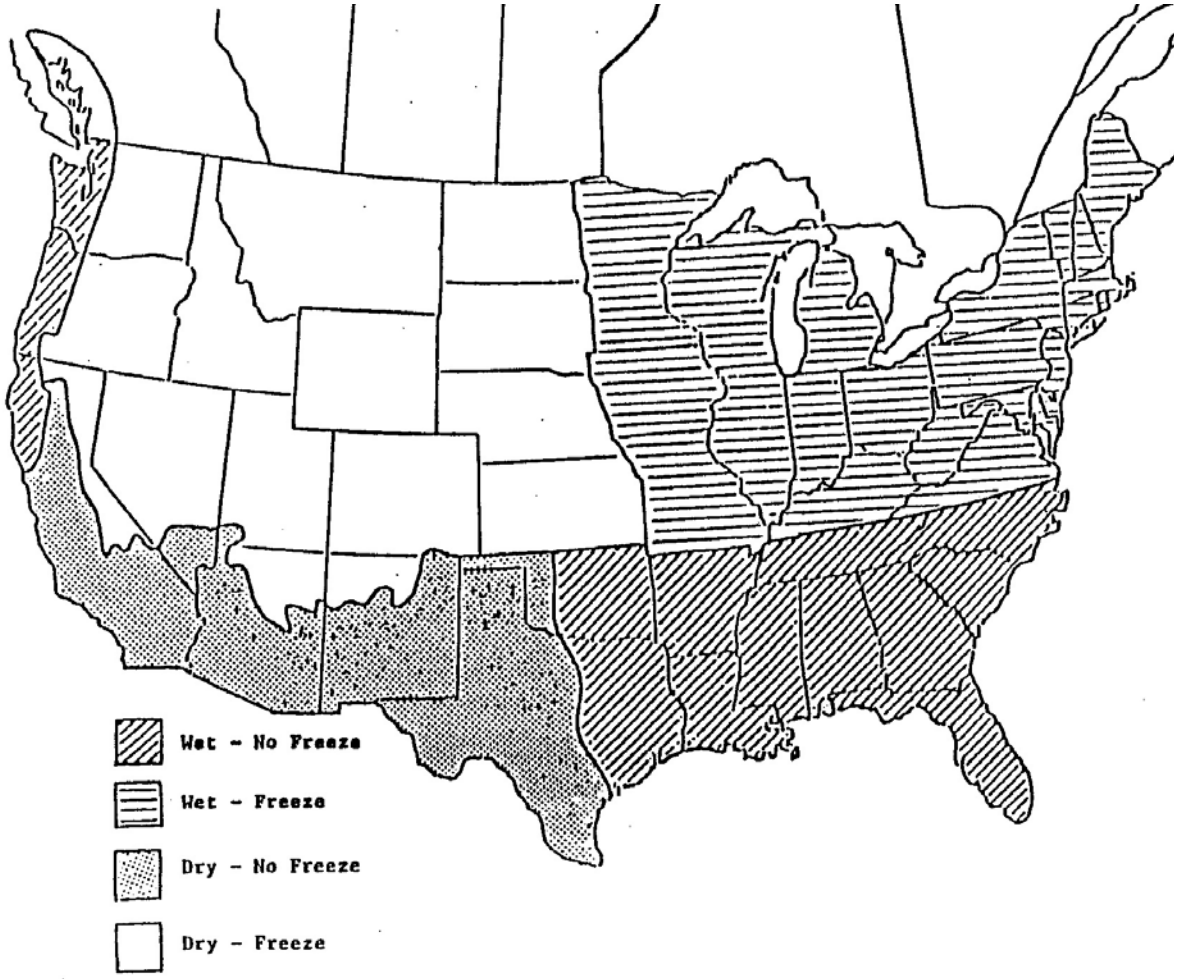

Figure 1. LTPP climatic regions[3]

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

Note: Some agencies have policies that prohibit the placement of bituminous surfaces on Portland cement concrete surfaces. If this is the case in a particular State, the candidate test sites will be limited to flexible pavement sections.

The actual number of sites included in the experiment will be dependent opon the resources of the State agencies. As a minimum, one or two sites are desired for each State agency.

In addition, an examination of the site conditions prior to selection should be conducted to ensure uniformity among the test sections, including:

- Adequate length. Ensure 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 ensure uniform traffic among the test sections.

- Pavement Geometry Considerations: 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 roadways with uniform vertical grade. Horizontal curves greater than 3^o and vertical grades greater than 4 percent should be avoided.

- Pavement Condition Requirements

  - The existing condition of the pavement (surface distress) should also be determined. Pavements with no distress are recommended. However, sites with limited distress will be accepted as long as the site has uniform conditions (e.g., raveling, bleeding, transverse cracks). Sites with rutting in excess of 25 mm (1 in) on average over the test site or greater than 38 mm (1.5 in) per location are not to be selected. 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 prorated profile index of less than 1,550 mm/km (100 in/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 Tensile Strength Ratio (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 current study. To assess the adequacy of the structure, FWD deflection information should be obtained **if the State budget permits**. This testing should be conducted every 30 m (100 ft) along the selected test site. A Surface Curvature Index (SCI) of less than 20 (Sensor 1-Sensor 2 at 305 mm [12 in] spacing) at 4,082 kg (9,000 lb) 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 because 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 152-m (500-ft) section placed using the ISSA (International Slurry Surfacing Association) mix design procedure
- A 152-m (500-ft) control section, with no treatment
- A 152-m (500-ft) section placed using the Slurry Systems Rational Mix Design (SYRAMID) developed in this project
- A second 152-m (500-ft) ISSA section
- A second 152-m (500-ft) control section
- A second 152-m (500-ft) SYRAMID section
- Transition zones of 30 m (100 ft) lengths are used before and after each section, as illustrated in Figure 2.

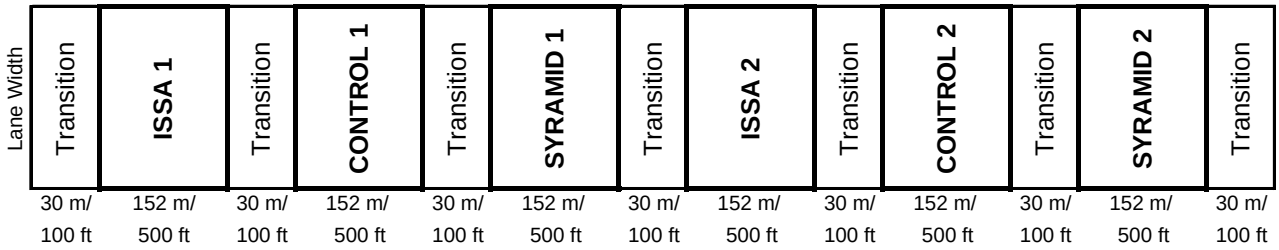

Figure 2. Pilot Project Schematic Layout

The total minimum length of the pilot project is 1,128 m (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 safety for the personnel monitoring the test sections.

Timeline

For planning purposes, it is anticipated that these test sections will be constructed during the latter part of the 2005 construction season at the earliest. It is more likely that they will be constructed during 2006.

Contact Information

If there are 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.