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**PROGRESS REPORT**  
**Slurry/Micro-Surface Mix Design Procedure**  
**October 2006 – March 2007**

**To:** T. Joe Holland, CALTRANS  
**Contract No.:** CALTRANS 65A0151  
**Contractor:** Fugro Consultants, Inc.  
**Contract Period:** June 30, 2003 – Nov. 30, 2007  
**Prepared By:** Jim Moulthrop, Principal Investigator  
**Date Prepared:** April 19, 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, and figures.

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**PHASE I—LITERATURE SEARCH AND WORK PLAN DEVELOPMENT**

**Task 1 Literature Review and Industry Survey—Completed**

The literature review process is complete 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 complete. The results are included in the Phase I Interim Report that was submitted to CALTRANS in March 2004.

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## **PHASE II—MIX DESIGN PROCEDURE DEVELOPMENT**

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

Progress on Tasks 3 and 4 has been summarized in the August 2005 progress report as well as presented at the September 15, 2005 videoconference. Draft test protocols for the Automated Mixing Test (AMT) and the Cohesion Abrasion Test (CAT) tests were included in Appendices A and B of the September 2005 report.

Two aggregates and two asphalt emulsions were used initially in the study. Four slurry systems (mixes) were created using all possible combination of aggregate and emulsion:

Aggregates:

- A1 Table Mountain (ISSA Type III)
- A2 Lopke Gravel Products (ISSA Type III)

Emulsions:

- E1 Koch Ralumac
- E2 Polymer Modified LMCQS-1h, VSS Emultech

Mixes:

- M1 A1+E1
- M2 A1+E2
- M3 A2+E1
- M4 A2+E2

A third aggregate and emulsion were acquired during the third quarter of 2006. The aggregate is a sandstone from Delta Materials in Marble Falls, TX, and the emulsion is from Ergon Asphalt and Emulsions, Inc., from their Waco, TX, plant. The aggregate and emulsion were used to design the “unknown” mix, denoted M5:

- Mix: M5 A3+E3
- Aggregate: A3 Marble Falls
- Binder: E3 Ergon

Testing continued during the last reporting period, CAT testing is now 79% complete. The following tables illustrate the proposed test factorial and the progress made up to date:



**Table 1. Aggregate Tests**

Test	Table Mountain	Lopke Gravel	Marble Falls
Sieve Analysis LA Abrasion Sulfate Soundness Sand Equivalent Durability Index Micro-Deval	All Completed	All Completed	All Completed

**Table 2. Emulsion/Asphalt Residue Tests**

Test	Koch Ralumac	Polymer Modified LMCQS-1h, VSS Emultech	Ergon
Residue Recovery Penetration Ring and Ball Softening Point Dynamic Shear Rheometer	All Completed	All Completed	All Completed

**Table 3. ISSA Mix Tests**

Test	M1	M2	M3	M4	M5
Mixing Test (TB113) Wet Track Abrasion Test (WTAT TB100) Wet Stripping Test (TB114)	All Completed	All Completed	All Completed	All Completed	All Completed

**Table 4. New/Modified Mix Tests, Percent Completed**

Test	M1	M2	M3	M4	M5
Automated Mixing Test (AMT)	100% (6 of 6)	100% (6 of 6)	100% (6 of 6)	100% (6 of 6)	100% (6 of 6)
<b>Cohesion Abrasion Tests (CAT)</b>	<b>100%</b> <b>(60 of 60)</b>	<b>100%</b> <b>(60 of 60)</b>	<b>100%</b> <b>(60 of 60)</b>	<b>100%</b> <b>(60 of 60)</b>	<b>100%</b> <b>(60 of 60)</b>
Automated Cohesion Test (ACT)	0% (0 of 24)	0% (0 of 24)	0% (0 of 24)	0% (0 of 24)	0% (0 of 24)
Asphalt Pavement Analyzer (APA)	0% (0 of 24)	0% (0 of 24)	0% (0 of 24)	0% (0 of 24)	0% (0 of 24)

As illustrated in Table 4, the CAT testing is now complete.

The Automated Cohesion Test device is now operational. The “first article” design has been developed by Temple Systems Lab of Dayton, OH and is presented in Figure 1. Testing on sandpaper has been completed to assure that the device will function properly. Work is underway to run the device on an Ohio microsurfacing mix and compare the results to current ISSA procedures. The device will then be sent to CEL to complete the testing matrix.

MeadWestvaco has graciously agreed to perform some additional testing on the device before we place it in full production testing.



**Figure 1. Automated Cohesion Test (under development).**

Overall, to complete all the remaining tests, the team estimates it will be accomplished by the end of May 2007.

### **Draft Specification**

A first draft of the specification has been developed in August 2005. Traffic, temperature, humidity and the desired set time dictate the threshold values to be met by a particular slurry system. The draft specification was provided in Appendix C of the September 2005 report.

### **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 test factorials proposed for this part of the study were given in the July-September 2006 progress report. Tables 5 through 8 summarize progress made to date on the ruggedness testing; an “X” next to the test number indicates that the test was completed.



**Table 5. Automated Mixing Test (AMT)**

Parameter	Units	Values		Test No.							
		High (H)	Low (L)	1	2	3	4	5	6	7	8
1. Filler	%	+0.5	-0.5	H	L	L	H	L	H	H	L
2. Additive	%	+0.1	-0.1	H	H	L	L	H	L	H	L
3. Water	%	+2	-2	H	H	H	L	L	H	L	L
4. Emulsion	%	+2	-2	L	H	H	H	L	L	H	L
5. Temperature	C	+2	-2	H	L	H	H	H	L	L	L
6. Humidity	%	+10	-10	L	H	L	H	H	H	L	L

**Table 6. Automated Cohesion Test**

Parameter	Units	Values		Test No.			
		High (H)	Low (L)	1	2	3	4
1. Cure Temp	C	+2	-2	L	L	H	H
2. Cure Time	min	+3	-3	L	H	L	H
3. Cure Humidity	%	+10	-10	H	L	L	H

**Table 7. Cohesion-Abrasion Test (CAT) – Short Term (Cured, 1-Hour Soak)**

Parameter	Units	Values		Test No.							
		High (H)	Low (L)	1X	2	3X	4X	5	6X	7	8X
1. Cure Time	min	5	-5	H	L	L	H	L	H	H	L
2. Cure Temp.	C	2	-2	H	H	L	L	H	L	H	L
3. Humidity	%	10	-10	H	H	H	L	L	H	L	L
4. Test Time	s	5	-5	L	H	H	H	L	L	H	L
5. Test Temp.	C	5	-5	H	L	H	H	H	L	L	L
6. Test Duration	s	5	-5	L	H	L	H	H	H	L	L

**Table 8. Cohesion-Abrasion Test (CAT) – Long Term (Cured, 6-Day Soak)**

Parameter	Units	Values		Test No.			
		High (H)	Low (L)	1	2	3	4
1. Soak Time	min	15min	-15min	L	L	H	H
2. Test Duration	s	5	-5	L	H	L	H
3. Water Temp.	C	5	-5	H	L	L	H

Ruggedness testing is performed concurrently with the evaluation testing of Tasks 3 and 4.

**Task 6—Phase II Report**

Work on the Phase II Report began in May 2006. A draft of the Chapter describing the philosophy and development of the new mix design is currently available. The Chapters describing the evaluation and ruggedness testing efforts will be finalized after completing all laboratory testing.

**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 first draft of the Reference Manual has been included in Appendix A of the August 2005 progress report.

The team is working on the Draft Reference Manual as well as two of the PowerPoint modules associated with the training course. The team plans to have a completed Draft of the Reference Manual by the end of April 2007. Also, Draft PowerPoint Presentation Modules will be available by the end of April 2007 for all except one or two of the Reference Manual chapters.

### **Task 9—Pilot Projects/Procedure Validation**

The team developed guidelines for selecting pilot projects to be used by State agencies. 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

The final version of the Guidance Document was included in Appendix A of the October 2004 and April 2005 progress reports. The document was forwarded to the participant State agencies and other agencies interested in participating in the pilot project study. An alternative layout was proposed in the September 2005 report, for pavements on which snow plows are used.



The following State agencies expressed an interest in participating in this task:

- KS
- TX
- MN
- MI
- CA

### **Task 10—Final Report**

No Activity

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### **NEXT REPORTING PERIOD'S WORK PLAN**

The activities planned for next month are listed below.

- ◆ Coordinate with CALTRANS personnel on an as-needed basis.
  - ◆ Begin ACT evaluation testing.
  - ◆ Continue with the ruggedness testing plan.
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### **PROBLEMS / RECOMMENDED SOLUTIONS**

All problems with the acquisition of the test equipment have been overcome. The Automated Cohesion Testing should start within weeks. Significant delays in testing have occurred and are discussed in the report. Overall, project activities have been delayed by at least six months.

The team met in Sacramento on March 22, 2007, to discuss progress and plan for the completion of the project tasks. Gary Hicks and Glynn Holleran are no longer part of the project team. Minutes from the meeting are included in Attachment A.

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### **FINANCIAL STATUS**

The Financial Summary Table shows the estimated expenses incurred during the reporting period and to the present from the inception of the contract. Testing has been removed as a separate Cost Element item because it is a subcontractor task activity.

The Financial Summary Chart illustrates total expenditures by month for the project.

cc: Jim Moulthrop  
Dragos Andrei  
Haiping Zhou

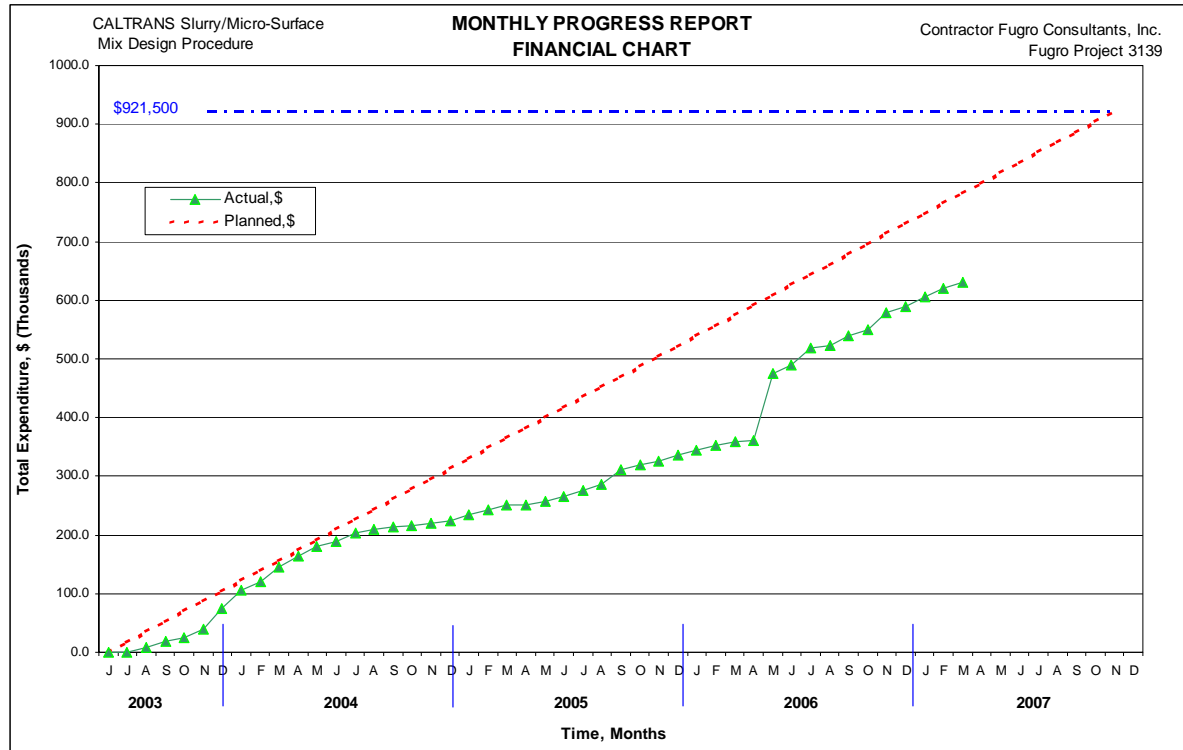
Glynn Holleran  
David Peshkin  
Stephen Seeds

Carol Goldman  
Charles Antle



**Financial Summary Table – Estimated Expenses for Last Period**

Cost Element	Report Period Expenditures, \$	Cumulative Costs, \$
Direct Labor	2,030	68,594
Overhead	3,085	104,263
Consultants/Subcontractors		
MACTEC	0	77,995
APTech	317	152,256
CEL	14,790	156,540
Temple Systems Lab	0	20,000
Travel	1,177	15,166
Communication	0	1,026
Materials/Supplies/Shipping	0	3,329
Fee	629	19,238
Phase II Retention	(2,203)	50,629
<b>Total</b>	<b>19,826</b>	<b>630,367</b>



**Financial Summary Chart – Total Expenditures by Month**



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## ATTACHMENT A

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### Meeting Notes Project Team Meeting: CALTRANS Slurry/Microsurfacing Study Translab Building, Folsom Blvd., Sacramento, CA March 22, 2007

ATTENDEES:           JOE HOLLAND                           CAROL GOLDMAN  
                          TIM MARTIN                             STEVE SEEDS  
                          DRAGOS ANDREI                       JIM MOULTHROP

#### Budget:

- MACTEC and Fugro budgets need to be re-done: Andrei/Moulthrop.
- Project is more than a year late and we need to focus on getting the work done by the end of 2007. This will take some major effort by everyone.

#### CEL Tasks:

- CAT testing done. Data will be reviewed and sent to Dragos/Joe/Jim by 3/28/07.
- ACT testing: 120 specimens need to be tested. Contact needs to be made with MeadWestvaco (Jim), Paragon (Jim), or MACTEC Phoenix (Dragos) to see if they can do the work.
- Mixing test completed.
- Caltrans has an AAT device and Joe will contact lab manager to determine if work can be done there.
- Test protocols draft to be done by 5/1/07.
- Ruggedness testing data needs to be sent to Charles Antle for review and comment.
- A current ISSA design on the project mixes needs to be summarized.

#### Other Testing Items:

- Dragos to prepare Field Testing Draft by 5/1/07.

#### Other Action Items:

- Joe to contact NY, MN, TX, and CA about possible pilot projects.
- Jim will contact Temple Systems to see how much the equipment will cost and determine if another cohesion machine is available.
- Dragos will add to the Progress Report and send to Fugro by 3/30/07.
- Jim will send Dragos and Tim the Phase I Report by 3/27/07.



- Jim will check with equipment manufactures to determine the possibility of an automated sampling device on the machines.
- Jim will get a TTI Micro inspection booklet by 3/26/07.
- Jim will send Steve a copy of the ISSA A-143 procedure by 3/28/07.
- Jim and Steve will review the Pre-Construction Module requirements from the Phase I report to determine what is required.
- Tim and Steve will review the Performance Evaluation Plan and Field Data Collection plan and make necessary revision.
- Tim and Steve will review, revise, and edit the Phase III report outline by 4/15/07.
- Tim will summarize the Phase III plans by 4/3/07.
- Tim and Steve will edit and prepare a project pocket guide checklist using the current FPP pocket guide and the TTI booklet by 4/3/07.

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**Agenda**  
**Project Team Meeting: CALTRANS Slurry/Microsurfacing Study**  
**Translab Building, Folsom Blvd., Sacramento, CA**  
**March 22, 2007**

1000	Call to Order	Moulthrop
	Progress Report on Phase II Testing	Goldman/Andrei
	Mixing Device (need name for this)	
	CAT	
	APT?	
	Ruggedness testing	
	Test protocols (AASHTO and ASTM)	
	Repeatability of measurements	
	Data Analysis	
	Phase II Report	Moulthrop
	Phase III Activities	Seeds/Martin
	Field verification (test sections)	
	Training Course	
	Reference Manual	
	1.5 day course	
	Tailgate training	
	Final Report	Other
1700	Adjournment	

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