QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): ____IOWA DOT_____

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *TPF-5 (224)*	**Transportation Pooled Fund Program - Report Period:** Quarter 1 (January 1 – March 31) Quarter 2 (April 1 – June 30) X Quarter 3 (July 1 – September 30) Quarter 4 (October 4 – December 31)

Project Title: Investigation of Deterioration of Joints in Concrete Pavements		
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Lead Agency Project ID: RF 0323	**Other Project ID (i.e., contract #):** Addendum 361	**Project Start Date:** 11/01/09
Original Project End Date: 6/30/12	**Current Project End Date:** 6/30/13	**Number of Extensions:**

Project schedule status:

X On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Total Percentage of Work Completed
$440,000	$257,935.72	75%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$38,107.93		5%

Project Description:

See attached report

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

- A report discussing work completed to date was published
- A paper was prepared at the Seattle Conference
- Samples were prepared and tested in mercury intrusion porosimetry to assess whether there is a critical microstructure similar to D-cracking aggregates

Anticipated work next quarter:

- Work will continue calibrating a model of moisture movement from the edge of joint will be against published data.
- A paper will be prepared discussing water movement in concrete
- Additional field permeameter tests will be conducted
- Field samples previously obtained from various locations will be subjected to a protocol intended to indicate whether the type of aggregate or paste system has an effect on permeability with particular attention paid to the ITZ. Testing will include air permeability before and after cycling freezing and thawing.
- Laboratory mixtures will also be prepared and exposed to vacuum saturation with various salt solutions, to assess the amount, rate and effects of water movement. Salt penetration and secondary deposits will be assessed using electron microscopy. These data along with figures obtained from the literature will also be used to help calibrate a computer model of water movement.
- Data from all of the field and laboratory tests will be assembled and reviewed to develop a summary of damage mechanisms along with recommendations for prevention in new concrete.

Significant Results:

- See attached report

Circumstance affecting project or budget (Describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope, and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Progress Statement for
Investigation of Deterioration of Joints in Concrete Pavements

1. Scope of Pooled Fund TPF 5(224)

The objective of this project is to identify the failure mechanisms behind early deterioration occurring in the joints of concrete pavements in various northern states, and to develop strategies to prevent the deterioration of new pavements in the future. Tied to this understanding will be the ability to provide effective guidance on what to do about repairing and/or slowing the distress in existing pavements.

The proposed research approach will be to:

- Conduct in-depth interviews of stakeholders in locations having the problem
- Develop a database of parameters from sites where distress is observed
- Test samples taken from selected sites
- Investigate techniques to treat locations where the problem is occurring
- Attempt to reproduce and mitigate distress in laboratory samples
- Identify failure mechanisms
- Provide guidance for practitioners about prevention and mitigation methods

2. Work Plan

The following tasks were suggested to address this need:

Tech Briefs

Three tech-briefs were to be prepared that discuss current knowledge and recommendations.

The first to provide an overview of the distress and what is known about it at present has been published. The second was to provide guidelines on sound construction practices. On review it was decided that an existing document from the South Dakota deicing salts project fulfilled this need, and has been referenced in the first tech brief. The third to discuss potential treatments for existing pavements has been postponed due to observations in laboratory testing that indicated issues with simply using an absorption test. A fourth tech brief has been planned on saw-cutting based on the results from an earlier study however this is currently on hold.

Database

A survey was developed that sought information from regions reporting the distress. Information was collected from 19 states and has been compiled in a spreadsheet. The data were analyzed to seek for commonalities and trends, but the information received was incomplete and not particularly useful.

As a supplement to this activity, tours were conducted in IA, IN, WI, MI and WI to inspect, photograph, and gather information for use in selecting potential coring locations. These tours were conducted by team members from ISU and MTU. Other tours are being planned in KS and PA.

Sampling and Analysis

Based on the tours, core samples have been collected from WI, MN, IN and IA and submitted for petrographic analysis. It is planned to collect more samples from MI when the weather permits.

Petrographic reports have been published.

Laboratory Testing

Considerable laboratory testing has been completed and more is ongoing:

- Work at ISU has shown that the risk of distress is dependent on w/cm, air content and curing. Analysis has shown that distress is unlikely to be related to early traffic loading.
- Work at ISU to study the early damage caused by sawing is complete. Some limited damage was incurred under aggressive sawing.
- Work at ISU is continuing to assess the effects of the interfacial zone on a form of damage observed in the field. Samples have been submitted for mercury intrusion porosimetry.
- A field permeameter has been built to measure permeability of the base and has been tested in one location. More trips are being planned.
- MIP has been conducted on lab samples to assess whether w/cm affects the risk of water being trapped in the pore system in the same way as d-cracking aggregates.
- Work at MTU is continuing to assess the mechanisms behind and effects of ettringite formation in air voids
- Previous work at Purdue examined microstructural and chemical changes in concretes from numerous field locations (both damaged and non-damaged). The results of these tests confirmed that many of the microstructural changes observed in the field concretes have been to great extent duplicated in the laboratory.
- Prior work at Purdue examined stresses development and cracking at saw cut locations. The work identified that damage can develop at the base of the saw cuts in an 'upside down' heart shaped lobe and this microcracking may accelerate water ingress.
- Work at Purdue has demonstrated the effects of saturation on increasing the risk of freeze thaw damage regardless of the air content of the system. Work has shown that salts exhibit different wetting and drying processes than water due to alterations in the viscosity, surface tension and equilibrium relative humidity. This work has highlighted issues with sample conditioning for ASTM C-1585 as well as testing field samples.
- Work at Purdue has developed a testing protocol (under a part of TP(5)-179) that uses electrical resistance to provide an indication of the concretes resistance to chloride ingress.
- Work at Purdue has demonstrated benefits of penetrating sealers has been demonstrated on slowing the rate of saturation and reducing the potential for damage. Numerical models have

also been developed to quantify the ingress of fluids. Additional testing is currently underway to obtain remaining data for use in these models.

- Work at Purdue has recently extended the use of sealants to three field sites. One site, US 231, evaluates the use of SME-PS as a repair technology for a pavement showing early distress. The second and third sites (town of Fishers) evaluate the use of SME-PS on new pavement joints. A fourth site is under discussion as a test site in Michigan while a fifth site is being evaluated in Indiana for materials with a known low entrained air content.

Other tasks complementary to this work are being conducted at ISU, MTU, Purdue and UMKC from funding sources. The findings are being pooled to develop a comprehensive understanding of the multiple mechanisms that are involved in this distress.

3. Tech Transfer

Presentations have been made in 9 states discussing the current understanding developed from the research and making recommendations. A presentation is planned at a national conference in California.

A revised 30 page publication was published (using other funds) to provide interim guidance on what the mechanisms are and how to reduce the risk of distress.

A number of papers have been submitted to journals and conferences. These are listed in section 5.

A report summarizing the work to date has been published.

4. Technical Advisory Committee

A Pooled Fund Technical Advisory Committee (TAC) has been established comprising representatives of states contributing funds to the project. The committee last met in a web meeting in March 2012. It is intended to hold another meeting in the fall.

5. Publications

Arribas-Colón, M., Radliński, M., Olek, J., and Whiting, N., (2010) INVESTIGATION OF PREMATURE DISTRESS AROUND JOINTS IN PCC PAVEMENTS - Phases I and II, JTRP 3016

Raoufi, K., Radlinska, A., Nantung, T., and Weiss, W. J., (2008) "Practical Considerations To Determine The Time And Depth Of Saw-Cuts In Concrete Pavements," TRB

Raoufi, K., Weiss, J., and Nantung, T., (2008) "Numerical Assessment of Saw-Cutting: The Influence on Stress Development and Cracking," 6th RILEM International Conference on Cracking in Concrete Pavements, Chicago, Illinois, USA

Raoufi, K., Nantung, T. E., and Weiss, W. J., (2010) "Numerical Analysis Of Saw-Cutting: The Influence Of Environmental Conditions", ACI Special Publication

Raoufi, K., Their, T., Weiss, J., Olek, J. and Nantung, T. (2009), "Saw-Cutting Guidelines for Concrete Pavements: Examining the Requirements for Time and Depth of Saw-Cutting", Final Report, FHWA/IN/JTRP-2007/5, Joint Transportation Research Program.

Li, W., Pour-Ghaz, M., Castro, J., and Weiss, W. J., (accepted) "Water Absorption and the Critical Degree of Saturation as it relates to Freeze-Thaw Damage in Concrete Pavement Joints," ASCE Journal of Civil Engineering Materials

Spragg, R., Castro, J., Li, W., Pour-Ghaz, M., Huang, P., and Weiss, W. J., (2011) "Wetting and Drying of Concrete in the Presence of Deicing Salt Solutions", Cement and Concrete Composites, Volume 33, Issue 5, May, Pages 535-542

Castro, J. Bentz, D., and Weiss, W. J., (2011) "Effect of Sample Conditioning on the Water Absorption of Concrete," Cement & Concrete Composites 33, 805–813

Spragg, R., Castro, J., Nantung, T.,, Paredes, M., and Weiss, J., (2011) "Variability Analysis of the Bulk Resistivity Measured Using Concrete Cylinders" Internal Report

Coates, K., Mohtar, S., Tao, B., and Weiss, W. J., (2009) "Can Soy Methyl Esters Reduce Fluid Transport and Improve the Durability of Concrete?" Transportation Research Board, pp. 22-30

Golias, M., Castro, J., Peled, A., Tao, B., and Weiss, J., (Accepted) "Soy Methyl Ester (SME) as a Topical Concrete Application for Improving the Durability of Concrete Pavement Joints,"

Pour-Ghaz, M., Castro, J. E., Rajabipour, F., and Weiss, W. J., (2009) 'Measurement and Modeling Fluid Transport in Cracked Concrete," International RILEM Conference on Concrete Durability and Service Life Planning 'Concrete Life '09', Haifa, Israel

Pour-Ghaz, M., Rajabipour, F., Couch, J.B, and Weiss, J., (2010) "Numerical and Experimental Assessment of Unsaturated Fluid Transport in Saw-Cut (Notched) Concrete Elements," ACI SP