

**State Planning and Research Program  
Quarterly Report**

**PROJECT TITLE:** TPF-5 (129) Recycled Unbound Pavement Materials

**OBJECTIVES:** To investigate the use of recycled materials in constructing unbound pavement layer. To identify the critical material properties of these recycled materials (strength, stiffness, drainage, volume changes, unsaturated properties, etc.) and develop a testing protocol that can accurately predict pavement performance. To determine what, if any, environmental concerns there may be surrounding the use of these recycled materials.

**PERIOD COVERED:**

January 1, 2010 – March 31, 2010

**PARTICIPATING AGENCIES:**

Minnesota, Texas, Ohio, Wisconsin, Michigan, California

**PROJECT MANAGER:**

Andrew Eller

**LEAD AGENCY:**

Mn/DOT

**PRINCIPAL INVESTIGATOR:**

Dr. Tuncer Edil

University of Wisconsin / RMRC

**SP&R PROJECT NO:**

TPF-5 (129)

**PROJECT IS:**

☐ Planning  
☒ Research &  
Development

**ANNUAL BUDGET:**

\$390,000 Total (5 years of funding)

**PROJECT EXPENDITURES TO DATE:**

Past Quarters

- June 30, 2007 TAP meeting (travel)
- 2007 MnROAD cell construction
- Shipping materials from various states to WI

This Quarter

- TAP meeting in Madison, WI (Feb. 17, 2010)

**WORK COMPLETED:**

See following sheets for University task comments.

**SUMMARY OF ACTIVITIES EXPECTED TO BE PERFORMED NEXT QUARTER:**

1. See attached University task summary.

**STATUS AND COMPLETION DATE:**

1. The project is on schedule and expected to meet the final completion date.

## **Quarterly report: January 1 to March 31, 2010**

### **Task Number IA**

Title: **Literature Review**

Description: The key issue to be addressed in Task I is how to design a full-scale pavement section using properties of RCA or RAP (or blends of RAP or RCA with conventional base course materials) measured in the laboratory. This includes structural capacity, long-term stability and design properties.

Deliverables: Quarterly task reports

Due Date: 11/30/2008

Date Approved

Date Delivered: 3/29/2009

**Progress:** This task is complete with the literature and survey reports are submitted.

Date: 12/31/2009

% Complete: 100%

### **Task Number IB**

Title: **Relationship between Resilient Modulus and Composition of RCA or RAP**

Description: The primary objective of Subtask 1B will be to characterize the resilient modulus of various RCAs, RAPs and blends with natural aggregates. A key goal will be to determine how the mechanical behavior (modulus and plastic strain) of RCA and RAP varies with important compositional variables (e.g., particle shape, binder type, aggregate mineralogy and contamination) and stress condition. Applicability of current modulus-stress relationships for these materials and long-term stability will also be evaluated and recommendations will be made regarding the most appropriate modulus model to use for RCA and for RAP.

Deliverables: Quarterly task reports

Due Date: May 31, 2010

Date Approved

Date Delivered:

Seventeen samples of recycled materials have been received to date. Four of these samples are related to the MnROAD test facility: one recycled asphalt pavement (RAP), one recycled concrete aggregate (RCA), one Minnesota Class-5 aggregate (Class-5), and one blend of 50% Class-5 with 50% RCA (Mix).

**Progress:** An additional seven samples of RAP/RPM and an additional six samples of RCA have been received from a combination of Pooled Fund member states and additional sources located in Colorado, Ohio and New Jersey. WisDOT has promised an additional RCA sample. Particle size distributions, moisture density relationships, and bench-scale resilient modulus testing in accordance with NCHRP 1-28a has been completed for each of the fifteen materials. Additional tests were performed on the seventeen materials to determine the specific gravity, absorption, and impurity content. **Replicate absorption testing is planned to support the original findings.** LA abrasion testing was performed on the four MnROAD materials.

Future work includes LA abrasion testing for three of the larger RCA samples (Texas, Colorado, and Michigan). Sulfate soundness testing is planned for yet-to-be selected RCA and RAP samples.

**Three RAP and three RCA materials have been chosen for further testing involving blends with natural aggregates. Materials were chosen to reflect one typical, one coarse, and one fine gradation each of RAP and RCA.**

Date: 03/31/2010

% Complete: 85%

### **Task Number IC**

Title: **Scaling and Equivalency: Specimen Tests to Field-Scale Conditions**

Description: Differences between pavement moduli measured in the field and laboratory are well established in the literature. Understanding how laboratory tests apply to field conditions is essential when applying laboratory-measured properties to understand field behavior. Similarly, evaluating field-measured moduli in the context of laboratory data requires an understanding of the scaling that exists between field and laboratory-measured moduli. Interpreting the performance of MnROAD test sections constructed with RAP, RCA and blends in conjunction with laboratory test data is an integral part of this project. Additionally, an intent is to use the laboratory data generated in this study

for full-scale conditions. For these reasons, understanding scaling between laboratory and field conditions for RCA, RAP and blends with conventional aggregate are a critical element of this project.

Deliverables: Quarterly task reports

Due Date: 05/30/2010

Date Approved

Date Delivered:

Progress: The  $M_r$  of the four MnROAD samples have been determined through Large-Scale Modeling Experiments (LSME) and small-scale laboratory methods in accordance with NCHRP 1-28a. The  $M_r$  of field-scale pavement sections located at the MnROAD test facility have been determined using data acquired from falling weight deflectometer (FWD) testing. Analysis involving plastic deformation and stiffness of the materials has been completed. **The scaling effects between laboratory and field conditions have been evaluated. The report is under review.**

Date: 03/31/2010

% Complete: 98%

### **Task Number ID**

Title: **Climate Effects**

Description: The effects of climatic variables on mechanical behavior will be evaluated by conducting a series of tests on the three representative RAPs and three representative RCAs identified in Subtask IB. The objective will be to determine systematically how climatic factors and aging affect the resilient modulus and plastic strain (i.e., propensity for rutting). Specific factors to be investigated include freeze-thaw cycling, wet-dry cycling, temperature effects, and moisture effects.

Deliverables: Quarterly task reports

Due Date: 05/31/2011

Date Approved

Date Delivered:

Progress: Nothing to report

Date: 12/31/2009

## **Task Number IIA**

Title: **Compaction Level and Assessment**

Description: A series of tests will be conducted on the three representative samples of RCA and RAP to determine how the resilient modulus and plastic strain of RCA and RAP are affected by compaction level and if the effect of compaction level is influenced by composition of the material. Tests will also be conducted on RCA and RAP blended with conventional base course aggregate at the same percentage used in the MnROAD test sections. Specimens will be prepared with reduced, standard and modified Proctor efforts at optimum water content (reduced Proctor is the same as standard Proctor, except the compaction energy is reduced by using 15 blows per layer instead of 25).

Deliverables: Quarterly task reports

Due Date: 09/30/2010

Date Approved

Date Delivered:

Progress: The four MNROAD materials have been compacted to both standard and modified proctor effort, whereas the remaining thirteen materials have been compacted to modified proctor effort only. All resilient modulus tests have been completed for materials compacted at modified compaction method only.

Date: 03/31/2010

% Complete: 55%

## **Task Number IIB**

Title: **Field Performance and Maintenance**

Description: The PI's understand that FWD testing and pavement distress surveys are to be conducted on the MnROAD test sections by Mn/DOT. Findings from these surveys will be compared to determine if the field performance of the test sections constructed with RCA and RAP differ relative to each other and to control sections existing at MnROAD and with time. This analysis will identify whether distress (e.g., rutting, cracking, drainage problems, etc.) occurs at a different rate in pavements

constructed with RCA and RAP, which would necessitate different levels of maintenance.

Deliverables: Quarterly task reports

Due Date: 05/31/2011

Date Approved

Date Delivered:

Progress: A field test and construction report has been received from MNDOT. PIs expect MnDOT perform additional FWD and pavement distress surveys as part of their monitoring activities and deliver to them for analysis.

The distress surveys and FWD data have not yet been delivered.

Date: 03/31/2010

% Complete: 35%

### Task Number III

Title: **Materials Control**

Description: RAP and RCA are known to contain impurities that may affect their mechanical properties and long-term performance. These impurities often include soft bituminous materials such as crack sealants as well as pavement markings, metallic objects and other potentially deleterious materials. Thus, a testing program will be conducted to assess how impurity type and content affect the resilient modulus and plastic strain of RAP and RCA. This program will be conducted in two parts.

Deliverables: Draft final report

Due Date: 11/30/2010

Date  
Approved

Date  
Delivered:

Progress: The type and amount of impurities were determined on all of the 15

samples received.

Different amounts of deleterious materials (wood, geotextile and RAP) will be blended with the MnROAD RAP and RCA materials and the resilient modulus and plastic strain of these specimens will be recorded.

Date: 03/31/2010

% Complete: 55%

#### **Task Number IV**

Title: **Leaching Characteristics**

Description: The PI's have developed standard protocols for monitoring and evaluating the leaching behavior of pavements constructed with unconventional materials. One aspect of this protocol is the pan lysimeter, which is installed beneath the pavement to monitor leachate discharged from the pavement structure. The PIs understand that pan lysimeters will be installed beneath the MnROAD test sections to collect leachate from the pavement sections constructed with RAP and RCA. The PIs also understand that Mn/DOT will be sampling these lysimeters periodically to determine the volume of water percolating through the test sections and the chemical composition of the percolate. These data will be evaluated by the investigators throughout the project to determine if pavements constructed with RCA and RAP pose any additional risk to the environment compared to pavements constructed with conventional materials.

Deliverables: Quarterly task reports

Due Date: 10/31/2011

Date  
Approved

Date  
Delivered:

Progress: Field lysimeter samples are being collected periodically and analyzed for metals. Column leach tests are initiated for trace metals. A plan is developed for evaluating PAHs from the HMA relative to RAP.

Date: 12/31/2009

% Complete 35%

## **Task Number V**

Title: **Extended Monitoring**

Description: The existing budget is sufficient for a three-year study. Additional interpretation of field data collected in Years 4 and 5 from the MnROAD test sections (e.g., pavement distress, moduli from FWD surveys, etc.) could be included if additional budget is made available at some point. These data would be interpreted in the context of the data collected in Years 1-3. No time or budget for this task is included in this scope of work or cost.

Deliverables: Quarterly task reports

Due Date: 11/30/2011

Date  
Approved

Date  
Delivered:

Progress: Nothing to report

Date: 12/31/2009

## **Task Number VI/VII**

Title: **Final Report and Dissemination**

Description: These tasks will consist of preparation, review and revision of the final report. Two tasks are provided for this activity in accordance with the instructions for this Mn/DOT form. Task VI consists of preparation and submission of the final report. In Task VII, the report is revised to address comments received from the TAC after reviewing the submission from Task VI.

Deliverables: Quarterly task reports

Due Date: 11/30/2011

Date  
Approved

Date



Delivered:

Progress: Nothing to report

Date: 12/31/2009

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**Future plans (note any unexpected changes to the work plan or schedule):**

A project presentation will be made at Minnesota Transportation Conference on  
4/27/2010

**Problems encountered/actions taken (note any unexpected budget issues):**

None