

## Quarterly report: Jan 1 to March 31, 2011

### 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:

Progress: 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 seventeen materials. Additional tests were performed on the seventeen materials to determine the specific gravity, absorption, and impurity content. 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. Replicate specific gravity tests were performed on the chosen representative RAPs and RCAs materials.

Toughness of the each material investigated by using two different test methods. LA abrasion testing was performed on the four MnRoad (MnRoad RCA, RAP, Class 5 and Blend) materials. Micro-deval tests were conducted on representative materials and Class 5 and Blend.

These representative materials will be blended with Class 5 (natural aggregates). Blends will be prepared with each of three RCAs and RAPs using 30%, 60% and 80% Class 5 granular base (by weight) prepared at optimum compaction and tested for resilient modulus to determine characteristics of RCA and RAP that have the greatest impact on the summary modulus.

The grain size distribution was determined with wet sieving the whole sample. All of the empirical correlations by regressions were redone according to wet sieve test results. Now this additional work is completed, the report is being re-written.

Date: 12/31/2010

% Complete: 75%

### **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: This task is complete with the report submitted.  
Date: 12/31/2010  
% Complete: 100%

### **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: Temperature data gathered by using thermocouples for RCA, RAP and Class 5 by using thermocouples to understand at which temperatures these materials start to freeze and thaw. For the representative RAPs, RCAs, Class 5 and Blend materials were tested after 5, 10 and 20 freeze- thaw cycles to evaluate how the resilient modulus of the recycled materials is affected by freezing thawing. After completing all the replicate freeze-thaw cycles for representative RCAs, reduction factor for freeze-thaw cycling will be recommended based on the findings from resilient modulus test. Seismic modulus test was also conducted during freeze thaw cycles to be able to investigate properly the freezing and thawing effect on recycled materials. Seismic modulus test used as a nondestructive durability test to strengthen the results

gathered from resilient modulus test.

Canadian Freeze and Thaw test was conducted on the representative RCAs and RAPs and Class 5 materials. This test used to research the behavior of recycled materials during freeze-thaw cycles under unconfined conditions. The future work includes running replicate Canadian Freeze and Thaw test on the representative RAPs and RCAs.

Future work includes also conducting resilient modulus test on the recycled materials compacted to 95% of modified proctor density at two different optimum water content: 2% above the optimum water content and 2% below the optimum water content. The aim is to investigate the moisture effects on the stiffness of unbound base materials.

The convenience of the free-free resonant column test to examine the wet-dry effects on recycled materials will be investigated.

Date: 12/31/2010

Completed: %25

## **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. Resilient modulus tests were conducted on the entire representative RAPs and RCAs and Class5 compacted with reduced (85% of modified proctor effort) and standard proctor efforts (90% of modified proctor effort) at optimum water content. The future work includes running the resilient modulus test on Blend samples compacted with reduced (85% of modified proctor effort) and standard proctor efforts (90% of modified proctor effort) at optimum water content. After that this additional work will be completed, the report will be written for this task.

Date: 12/31/2010

% Complete: 65%

### **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 results of these surveys have yet to be delivered.

Date: 12/31/2010

% Complete: 65%

### **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 seventeen 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.  
Wood chips (small size, clean, dry and low-dust) produced by Marth's company were gathered. Optimum water content of MnRoad RCA blended with different amount of wood chips was found. Resilient modulus tests are planning to be performed on MnRoad RCA blended with different percentage of wood chips materials.  
The allowable brick materials for unbound base formed from recycled materials were also investigated.

Date: 12/31/2010

% Complete: 75%

#### **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. Continuation of this activity as long as possible is crucial for definitive conclusions. Column leach tests were initiated for trace metals from RCA. pH control of leaching is important. Currently, concentrations versus pH tests are being conducted. The effects of particle crushing typically required for these tests on leaching behavior and solid-liquid ratio are being investigated before proceeding with the tests. A plan is being developed for evaluating PAHs release from the asphalt in RAP. The tests are taking a long time for equilibrium.

Date: 12/31/2010

% Complete 45%

#### **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: 12/31/2010

#### **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

DateDelivered

Progress: Nothing to report

Date: 12/31/2010

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

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

None other than  
need for more  
time because of  
the nature of  
certain tests.  
Additional  
materials are  
needed from  
MNROAD.