Quarterly report: June 30 to September 30, 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:

Progress: 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).

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 specific gravity tests were performed on the representative materials. LA abrasion testing was performed on the four MnROAD materials.

Future work includes LA abrasion testing for three of the larger RCA samples (Texas, California, and Michigan). Canada Freeze and Thaw test 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. 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.

Date: 03/31/2010

% Complete: 95%

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 was submitted.

Date: 03/31/2010

% 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: Different Freeze-Thaw Tests were investigated. Future work is to run Canadian Freeze-Thaw testing for MnRoad materials to have a general idea

about the behavior of materials. These results will be compared with Sodium Sulfate Soundness test results.

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 were tested after 1 and 5 freeze and thaw cycles to evaluate how the resilient modulus of the samples of RAP is affected by freezing thawing.10 and 20 freeze-thaw cycles will be applied to these representative RAPs. After completing all freeze-thaw cycles for representative RAPs, reduction factor for freeze-thaw cycling will be recommended based on the findings from these tests. Future works include 1, 5, 10 and 20 freeze-thaw cycles for representative RCAs and Class 5. The tests are underway.

Resilient modulus test was performed on MnRoad RCA after 1 wet-dry cycle. Future work includes also 1, 5, 10 and 30 wet-dry cycles for representative RAPs, RCAs and Class 5 to evaluate the effects of wet-dry cycling. However, there is concern about the meaning and relevance of this test and the concept is being debated. Alternative approaches are being considered.

Date: 12/31/2009

Completed: 45%

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:

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.

Particle size distribution of MnRoad materials after compaction were tested by using modified proctor effort. Future work is to run this test for selected 6RCA and RAP materials.

Progress: All resilient modulus tests have been completed for materials compacted at modified compaction method only. Resilient modulus tests were conducted on one of the representative RAPs compacted with reduced (85% of modified proctor effort) and standard proctor efforts (90% of modified proctor effort) at optimum water content.
Resilient modulus test is planning to be performed all representative RAPs and RCAs compacted with reduced and standard proctor efforts.

Date: 03/31/2010

% Complete: 85%

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:

	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.
Progress:	FWD data collected by MnDOT up to April 2010 has been analyzed. Maximum deflections under FWD loading have been determined for RAP, RCA, Blended RCA/Class 5 and Class 5. Resilient modulus values have been determined for the following layers at each cell location: hot mix asphalt (HMA), base course (RAP, RCA, Blended RCA/Class 5, and Class 5), subbase and subgrade.
	The field data were analyzed and a report was submitted.
Date:	03/31/2010
% Complete:	100%

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:	
	The type and amount of impurities were determined on all of the 15 samples received.
Progress:	The type and amount of impurities were determined on all of the 17 samples received. MnRoad RCA materials were sieved according to the their original PSD, and materials were cleaned properly before

starting resilient modulus test. Wood chips, having uniform physical properties, were gathered.The behavior of wood chips after mixing the water and the aggregates were investigated. 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 Mart's company were gathered. Wood chips were taken from Mart's company to be used in the future. 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.

Date: 03/31/2010

% Complete: 80%

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.

Laboratory column leach tests are underway. Heavy metal leaching and pH characteristics for RCA have been obtained. Difference between lab pH (1-12) and near neutral field pH (~7) for field samples is an important question under investigation.

Date: 12/31/2009

% Complete 55%

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

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

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

None