Improve Material Inputs into Mechanistic Design Properties for Reclaimed HMA & Recycled Concrete Aggregate (RCA) Roadways

Revised Interim REPORT for Tasks 1: Initial Memorandum on Expected Research Benefits and Potential Implementation Steps

Prepared by:

Bora Cetin and Ida Gheibi
Department of Civil and Environmental Engineering
Michigan State University

Tuncer B. Edil
Geoengineering Consultant, LLC

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Minnesota Department of Transportation
Office of Research & Innovation
395 John Ireland Boulevard, MS 330
St. Paul, Minnesota 55155-1899

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CHAPTER 1: INTRODUCTION

1.1. RESEARCH PROJECT ABSTRACT AND OBJECTIVES

In the Mechanistic-Empirical Pavement Design approach (ARA, 2014), pavement performance is evaluated based on mechanistically-determined critical stresses, strains, temperatures, and moisture levels. These are used as inputs to empirical prediction models for predicting pavement distresses such as rutting, fatigue cracking, thermal cracking, and roughness for flexible pavements and cracking, faulting, and roughness for rigid pavements. Accurate characterization of the traffic, climate, and material input parameters is therefore important to ensure that the theoretical computation of pavement stresses, strains, temperatures, and moisture levels are accurate at the critical locations within the system. Local calibration is desirable to improve the accuracy of the empirical distress model predictions for a particular state or region. Depending on the desired level of accuracy of input parameter, three levels of input are provided from Level 1 (highest level of accuracy) to level 3 (lowest level of accuracy). Depending on the criticality of the project and the available resources, the designer has the flexibility to choose any one of the input levels for the design as well as using the combination of different levels. Material parameters associated with EICM are those parameters that are required and used by the EICM models to predict the temperature and moisture conditions within a pavement system. These inputs include Atterberg limits, gradation, and saturated hydraulic conductivity. The “other” category of material properties constitutes those associated with special properties required for the design solution. An example of this category is the coefficient of lateral pressure.

The material parameters required for pavement foundation materials including unbound granular materials, subgrade, and bedrock may be classified in one of three major groups: (1) pavement response model material inputs, (2) Enhanced Integrated Climatic Model (EICM) material inputs, and (3) other material inputs. Pavement response model materials input required are resilient modulus (Mr) and Poisson’s ratio (μ) used for quantifying the stress dependent stiffness of unbound materials under moving wheel loads.

While there is a rich database nationwide about Mr and California Bearing Ratio (CBR)/Unconfined Compressive Strength (UCS) of subgrade and conventional unbound granular aggregates, there is no stiffness/strength/gradation/hydraulic conductivity database for reclaimed hot mix asphalt (HMA) materials-reclaimed asphalt pavement (RAP) material and recycled concrete aggregate (RCA) used as a base/subbase layer in pavement systems. The main goal of this project is to collect these data from the National Road Research Alliance (NRRA) member states and the literature. In addition, the list of field and laboratory tests that had been conducted to use in mechanistic pavement design along with the construction specification will be summarized. Moreover, it will be determined whether any data exist that evaluate the impact of any specific characteristics and/or mix design of RAP on the stiffness and strength of pavement systems in short- and long-term. The research team will also conduct some preliminary sensitivity analyses with AASHTOWare Software by using the collected data to determine the most sensitive parameter that may impact the pavement performance predictions in use of RAP and RCA as a base/subbase material.

1.2. ORGANIZATION OF THE MEMO

This memorandum consists of three chapters. The next two chapters include benefits of this research and the implementation process.

CHAPTER 2: EXPECTED RESEARCH BENEFITS

2.1. HOW DOES THIS RESEARCH BENEFIT TAXPAYERS OF THE NRRA MEMBER STATES?

The proposed study will help to establish a database for RAP And RCA materials` characteristics including resilient modulus (Mr), CBR/UCS, gradations along with construction specifications. Thus, this would lead to more consistent material input and specifications between NRRA agencies. Once a database of material characteristics is established, the cost involved in acquiring and testing field samples for new design is reduced/refined. The outcome of this research in the form of a pavement design specification could be immediately implemented by the department of transportations (DOTs) of states participating in NRRA.

2.2. INITIAL PROJECTION OF EXPECTED BENEFITS

The following benefits are initially expected to be accomplished by end of this project:

- **Construction Savings:** The final report will provide available material characteristics input for pavement design and performance analysis. Accurate information is very important for reliable pavement design. It is expected that the use of actual materials characteristics as input in pavement design and analyses will enable the ability to determine the design thickness of each pavement layer properly, thus avoiding under/overestimated required surface layer and base layer thicknesses. Thus, it will enable construction and maintenance saving.

- **Operation and Maintenance Savings:** Summary of the material input and sensitivity analyses results will enable proper pavement design with proper service life. As a result of this, lower maintenance frequency and cost are expected.

- **Improved Life-Cycle Cost:** This study includes the collection of information of the reclaimed HMA and RCA materials used in pavement foundation design. Proper use of data related to these materials in pavement design will ultimately improve the lifecycle cost of pavement systems.

2.3. EXPECTED TECHNICAL OUTCOME

The following items below will be provided at the end of this study:

- A database that includes the following material input data for pavement design from NRRA state members
    - Index Properties
        - Gradation characteristics

        - Atterberg limits
        - Absorption
        - Binder content
        - Density
        - Void Ratio
    - Strength/Stiffness Properties
        - California Bearing Ratio
        - Resilient Modulus (M_r)
        - Unconfined Compressive Strength
    - Final Report

CHAPTER 3: POTENTIAL IMPLEMENTATION STEPS

3.1. SUMMARY OF RESEARCH METHODOLOGY (SCOPE)

The overall research methodology is proposed by a highly-qualified team with expertise in pavement systems and geotechnical engineering and pavement engineering at Michigan State University (MSU) and Geoengineering Consultant, LLC. The methodology primarily involves collecting and summarizing Mr, CBR/UCS, and gradation data for RAPs and RCAs tested by NRRA state DOT members. Construction specifications, literature, and design methods for building and design pavement foundation layers with RAP and RCA from NRRA member state DOTs will also be investigated. In addition, preliminary sensitivity analyses with the pavement AASHTOWare Pavement ME Design software will be conducted via use of RAP and RCA data collected. Based on the results of this study it will be determined whether more detailed laboratory and field tests will be necessary to enhance the database.

The proposed team has been working on MnDOT data and NRRA states for years and very familiar with the process. This project contains four tasks: (1) initial memorandum on expected research benefits and potential implementation steps, (2) collection of data from NRRA member states and literature, (3) sensitivity analyses, and (4) final report.

3.2. IMPLEMENTATION

Implementation of each task is shown below:

- Under Task 2, a detailed literature review will be conducted to investigate the overall average stiffness/strength and index properties of RAP and RCA materials used in pavement foundation layers in NRRA states. In addition, it is important to report the impact of freeze-thaw cycles and wet/dry cycles on the stiffness and strength of these materials. Moreover, it is also important to report Mr values for RAP materials when they are subjected to different range of temperatures at both cold and hot weather conditions.

  The degree of saturation (moisture content) is considered an influential parameter on the stiffness and strength of pavement materials. Therefore, the Mr data of RAPs and RCAs prepared at different moisture contents will also be collected and reported. Additionally, void ratio, density, and angularity of these materials could be influential and this data will also be collected if available.

- Under Task 3, the project team will perform sensitivity analysis to determine which changes in RAP and RCA materials characteristics most affect the prediction of the pavement performance via use of AASHTOWare Pavement ME Design software in NRRA member states.

- Task 4 will provide all collected data and recommendations about their use for pavement design and analyses.

REFERENCES

ARA (Applied Research Associates). (2014). “AASHTOWare pavement ME design: Release notes build 2.0.19.” Champaign, IL.