Preface

An important function of the Transportation Research Board (TRB) is to stimulate research that addresses problems facing the transportation community. In support of this function, TRB technical committees identify problems, and develop and disseminate research problem statements for use by practitioners, researchers, and others. The problem statements listed below were developed by the TRB committee noted above. These problem statements should not be considered comprehensive; they may only represent a portion of overall research problems identified by committee members.

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I. Problem 1: Evaluation of Rubblization Techniques Over Soft Soils

II. Problem Statement:

Various states have adopted Rubblization in their pavement sections however some of these sections have performed poorly when constructed over soft soils. Various states need to modify their construction methods to account for the soft soils within the pavement structure. In Wisconsin, in areas where poor subgrade was a problem, the speed of the machine was increased to minimize the energy delivered into the pavement during rubblization. The reduction in energy per area of rubblized pavement due to the increased speed of the rubblization machine results in larger 15 to 20 mm pieces of concrete. The quality of the crushed stone was pretty consistent. In
places where the pieces were considered too big the machine was slowed down again to meet specifications. Speed was varied based on quality of the concrete and the resulting diameter of the aggregate. After being rubblized, the crushed concrete comprised of particles larger than the requisite 5 cm diameter pieces and the concrete was seated with one or two passes with a vibratory grid roller. Then a rubber roller was used to compact any uneven areas left by the grid roller. The grid roller tends to bridge some areas, and the rubber roller gets in those grooves. Finally, a steel-wheel roller was used to eliminate any unevenness [RAT 00]. The rubblized section is performing well three years after construction.

In Iowa, a 3.0 km (1.9 mi) section of L63 in Mills County was rubblized using a resonant frequency vibration pavement breaker. The main findings were that the presence of edge drains was found to improve the structural rating of the rubblized roadway. The drains provided good drainage to the base and kept it stable [TYM 95]. Similarly, experience in Colorado with rubblization over soft soils has resulted in edge drains being recommended in conjunction with rubblization as a to control subgrade moisture. The Colorado Department of Transportation has found that edge drains worked extremely well in getting excess water out of the pavement system [DON 00]. In Michigan, a study clearly showed that the provision of sufficient drainage and thickness of overlay will lead to durable pavements and that, for certain concrete pavements, rubblization is not a viable option because it may lead to inadequate pavement performance [NIE 00], [GAL 99]. Thus, several state agencies have had success with rubblization over soft soils by providing edge drains, modifying rubblization techniques, and providing sufficient overlay thicknesses.

Some of the modifications to construction include:

1. Edge drains should be installed to provide adequate drainage.
2. Allowing sufficient time for pore water to dissipate and drain through the edge may help in reducing pore pressure. This means that a geotechnical evaluation for excess pore pressures to dissipate in underlying layers should be performed prior to construction.
3. Rubblization may not be suitable over soft soils with high water table and other options of rehabilitation like crack and seat should be considered.

III. Research Objective:

The objective of this research is to recommend rubblization techniques over soft soils.

IV. Proposed Scope of Work

Tasks
Accomplishment of this objective will require at least the following tasks that are grouped into two separate phases.

Phase I – Evaluate Current Rubblization Techniques
(1) In addition to the method used by MnDOT and KDOT and the research performed by URI and KSU, collect and review other relevant domestic and foreign literature, research findings, performance data, current practices, and other information relative to the use, testing, and evaluation of partial-depth CIR. This information may be obtained from published and unpublished reports, contacts with transportation agencies and industry organizations, and other sources. The literature review should note distresses that are observed with this rehabilitation strategy.

(2) Identify the performance parameters of the CIR layer that are important to short and long-term performance and develop new procedures or modifications of current test procedures for measuring those performance-related properties. The simple performance tests from NCHRP 9-19 and the material property inputs required by the 2002 Design Guide should be reviewed and evaluated.

(3) Prepare an updated, detailed work plan for Phase II that includes an experimental plan to evaluate and validate the most promising procedures for measuring CIR properties that relate to pavement performance. A detailed, statistically but practical experimental plan should be developed as a part of this task. The experimental plan should identify those test sections or projects that are to be included in Phase II.

(4) Prepare an interim report that documents the research performed in Phase I and includes the updated work plan for Phase II. Following review of the interim report by the sponsor, the research team will be required to make a presentation to the project panel. Work on Phase II of the project will not begin until the interim report is approved and the Phase II work plan is authorized by the sponsor.

Phase II – Develop Modifications to Rubblization Techniques Over soft soils
(5) Execute the plan approved in Task 5. Based on the results of this work, recommend sets of tests for evaluating CIR used in pavement layers. Also, recommend criteria for interpreting test results and assessing CIR acceptability for use in pavement layers.

(6) Determine the ability to use the procedures developed for determining CIR-layer structural coefficients that are required inputs for the 1993 AASHTO Design Guide and the mixture properties that are required by the 2002 Design Guide. A library of mixture properties should be developed to be used on a national basis with the 2002 Design Guide, especially if that Guide is adopted by AASHTO for future use in designing flexible pavement structures.

(7) Submit a final report that documents the entire research effort. The report shall include an implementation plan for moving the results of this research into practice.

V. Literature Search Summary:


I. **Problem 2:** Design and Construction Guidelines for Composite Concrete Over Asphalt Pavements

II. **Problem Statement:**

Composite pavements consist of two or more pavement layers, having some degree of bond and shear strength at their interface. The pavement layers, which are mainly Portland cement concrete (PCC) and hot mix asphalt (HMA) layers, act as one unit in response to applied traffic loads and environmental effects. In recent years many composite pavements have been constructed in new and rehabilitation projects in the US and abroad, involving combinations of HMA on PCC, PCC on HMA or PCC on PCC layers. Since the topic is very broad, this problem statement will only pertain to composite pavements, which consist of PCC on HMA layers.

In new construction, composite PCC on HMA pavement include full depth concrete pavement on HMA base in new construction. In Rehabilitation projects, Whitetopping and unbonded PCC overlay can also qualify as composite pavements when some degree of bond is established by design or unintentionally between the PCC and HMA layers.

The performance of these composite pavements has been mixed varying from excellent to poor. Level of performance has often been attributed to design, material properties and construction issues including: thickness of concrete and HMA layers, stiffness of the pavement layers, degree of bond at the interface, concrete panel size, environmental effects (curling and warping of the concrete layer), condition of the HMA layer, and drainage.


There is a need for effective design and construction guidelines for composite pavements of concrete over asphalt layers. These guidelines should be based on better understanding of the effect of design, materials properties and construction parameter on the performance of the PCC/HMA composite pavements. An improved methodology for characterizing the bond condition in the field is also essential for proper design and construction the pavement. This effort should also serve as the first step in the development of an effective mechanistic design for long lasting composite pavements.

III. Research Objective:

The main objective of the proposed research is to develop design and construction guidelines for composite PCC-HMA pavements. This objective would be accomplished by evaluating the influence of design, material properties and construction on the performance of composite PCC-HMA pavements.

Specific objectives include:
1. Characterizing initial and long term bond at the interface between the layers,
2. Determining the optimum thickness ratios of the two layers, based on load and environmental conditions,
3. Characterizing the condition of the HMA layer
4. Optimizing Layer stiffness
5. Selecting optimum pavement panel size/joint spacing.
7. Identifying drainage needs based on degree of initial bond and potential degradation of bond with time.
8. Incorporating the results into design and construction guidelines. Also, providing recommendations on where composite pavements are most effective.

IV. Proposed Scope of Work

To accomplish objectives of this research, the following tasks are proposed as a minimum:

Task 1
Conduct a literature search, and survey of states and industry on the use, design, material characteristics of layers, construction practices, and performance of composite pavements, which consist of PCC over HMA layers. Identify in-service pavement sections for detailed field evaluation.

Task 2
Develop an effective test /methodology for characterizing bond strength between the layers.
Task 3
Based on results of Task 1 select test sections from existing pavements. The test sections would include combinations of layer thickness, degree of bond, different conditions of HMS layer, concrete panel sizes, layers’ modulii, and drainage conditions.

Task 4
Perform condition survey and deflection tests on the field sections to determine load response characteristics of the various field sections. Identify critical, design, material and construction features. Also evaluate drainage conditions and any impact of presence or lack of drainage on pavement performance.

Task 5
Construct and instrument a test section, which would include design features critical to the performance of the composite pavement. Measure pavement response to load and curling and warping effects. Perform deflection tests to determine stiffness characteristic of the pavement layers and system.

Task 6
Develop and/ or evaluate existing computer models capable of analyzing and predicting pavement response to load and environmental effects. The computer programs should be capable of evaluating multiple combinations of layer thickness and stiffness, different degree of bond between the layers, different panel size, and various curling warping cases.

Task 7
Develop design and construction guidelines for composite PCC/HMA pavements. These guidelines should also identify circumstances under which composite pavements are most effective.

V. Funding and Time:

Recommended Funding: $400,000

Research Period: 36 months

VIII. Date and Submitted by:

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I. **Problem 3:** Development of a Performance-Related Mix Design Method for Cold in Place Recycling (CIR)

II. **Problem Statement:**

Partial-depth cold in-place recycling (CIR) is a method that has been used with varying degrees of success to rehabilitate flexible pavements. For this rehabilitation strategy, the existing pavement is milled to a depth of three to four inches within the asphalt pavement structure, the millings are transferred to a screening unit where the oversize materials are crushed. All materials are combined and mixed in a mixing unit and blended with an asphalt emulsion. This mixture is then placed in a windrow behind a paving “train,” picked up and placed by a paving machine, and compacted. CIR can be used to remove transverse and reflective cracks, restore oxidized pavements, re-establish crowns, maintain clearances, improve aggregate gradations, and minimize the need for new materials, as well as strengthen the pavement.

CIR has been reported to be a cost-effective treatment for deteriorated pavements, and a recent FHWA policy statement recommends recycled materials be considered for all paving projects. A New Mexico study of 45 CIR projects estimated an average saving of $7,074 in construction costs per lane-km ($11,384 per lane-mile), and $7,524 per lane-km in life cycle costs ($12,109 per lane-mile).

A survey conducted of 38 State Departments of Transportation by the Rocky Mountain User Producer Group found that many agencies routinely use the technique. However, the survey identified that there are problems with performance reliability, specifically pointing to the lack of a uniform, well-defined design procedure. Typical problems with this rehabilitation strategy include raveling, thermal cracking, compaction, low early strength and extended curing time. Other agencies are reluctant to try CIR because of those problems.

Much recent hot-mix asphalt research focuses on lessening risks of early pavement failures through the use of performance-related specifications. Some state agencies, such as Minnesota DOT (MnDOT) and Kansas DOT (KDOT), have adopted new CIR mix design methods that include performance-related tests. These tests help identify some of the problems sometimes associated with CIR. Some of the design equipment and procedures use equipment developed for Superpave. Recent research has been performed by the University of Rhode Island (URI) and University of Kansas, but these research
projects did not produce comprehensive mix design methods.

The Foundation for Pavement Preservation (FPP) and FHWA identified emulsion mixes with RAP as a research need, as documented in the Research Problem Statement Workshop document. This meeting was held in Sacramento, CA on June 21 – 22, 2001.

Research is needed to assess the design methods used by MnDOT and KDOT (identical), to use applicable findings from the URI and University of Kansas research, and to develop a uniform CIR design method that can be used by any agency. The simple performance tests that are being developed and validated under NCHRP 9-19 should be considered.

III. Research Objective:

The objective of this research is to recommend procedures for a performance-related based CIR mix design method that will improve the predictability and performance of CIR.

IV. Proposed Scope of Work

Tasks
Accomplishment of this objective will require at least the following tasks that are grouped into two separate phases.

PHASE I
Evaluate and recommend procedures for a performance-based mix design procedure for CIR

(1) In addition to the method used by MnDOT and KDOT and the research performed by URI and KSU, collect and review other relevant domestic and foreign literature, research findings, performance data, current practices, and other information relative to the use, testing, and evaluation of partial-depth CIR. This information may be obtained from published and unpublished reports, contacts with transportation agencies and industry organizations, and other sources. The literature review should note distresses that are observed with this rehabilitation strategy.

(2) Identify the performance parameters of the CIR layer that are important to short and long-term performance and develop new procedures or modifications of current test procedures for measuring those performance-related properties. The simple performance tests from NCHRP 9-19 and the material property inputs required by the 2002 Design Guide should be reviewed and evaluated.

(3) Identify the performance parameters of pavements that may be affected by the properties of the CIR layer, including consideration of the layer’s structural behavior, constructibility, and
related environmental concerns. Identify—with consideration to practicability, accuracy, and other relevant factors—potential new procedures or modifications of current test procedures for measuring those performance-related properties for which no suitable test method has been identified. Recommend procedures for further evaluation in Phase II.

(4) Prepare an updated, detailed work plan for Phase II that includes an experimental plan to evaluate and validate the most promising procedures for measuring CIR properties that relate to pavement performance. A detailed, statistically but practical experimental plan should be developed as a part of this task. The experimental plan should identify those test sections or projects that are to be included in Phase II.

(5) Prepare an interim report that documents the research performed in Phase I and includes the updated work plan for Phase II. Following review of the interim report by the sponsor, the research team will be required to make a presentation to the project panel. Work on Phase II of the project will not begin until the interim report is approved and the Phase II work plan is authorized by the sponsor.

**PHASE II**

Develop and validate the CIR mix design procedures identified in Phase I

(6) Execute the plan approved in Task 5. Based on the results of this work, recommend sets of tests for evaluating CIR used in pavement layers. Also, recommend criteria for interpreting test results and assessing CIR acceptability for use in pavement layers.

(7) Determine the ability to use the procedures developed for determining CIR-layer structural coefficients that are required inputs for the 1993 AASHTO Design Guide and the mixture properties that are required by the 2002 Design Guide. A library of mixture properties should be developed to be used on a national basis with the 2002 Design Guide, especially if that Guide is adopted by AASHTO for future use in designing flexible pavement structures.

(8) For those tests recommended in Task 6 that are not currently AASHTO or ASTM standards, develop protocols in a format suitable for consideration and adoption by AASHTO.

(9) Submit a final report that documents the entire research effort. The report shall include an implementation plan for moving the results of this research into practice.