EXHIBIT A
SCOPE OF SERVICES

PCC PAVEMENT THICKNESS VARIATION VERSUS OBSERVED PAVEMENT DISTRESS

BACKGROUND

Recent developments in non-destructive testing (NDT) technologies show a great potential for assessing thickness variation in concrete pavements and identification of subsurface damage. These technologies and associated evaluation methods – particularly MIRA ultrasonic tomography and 3D Radar step frequency ground penetrating radar – have immediate implications that can assist MnDOT engineers in QA/QC assessments. However, additional value from thickness variation measurements can be captured if they are completed in a way that provides insight to the causes of pavement failures. This type of evaluation could lead to the development of guidelines for more economical and long lasting pavement solutions. In the proposed study, comprehensive thickness variability assessment on several existing PCC pavements prior to rehabilitation will be conducted and compared to observed surface distress maps. Statistical analysis will be performed to determine correlations between key pavement components and observed distresses. Factors such as overall thickness deficiencies, significant thickness variation, and large variation in base layer properties will be considered. In addition, an evaluation of similar parameters in newly constructed pavements and comparison with existing pavement results will help in identifying the need, if any, for improved QA/QC construction protocols with regard to pavement thickness.

OBJECTIVE

The project will yield benefits in four major areas.

A) A comparison of thickness and distress characteristics will provide information at a frequency and coverage to provide trends and findings previously unavailable that could lead to more economical and long lasting pavement solutions
B) If the correlation of the thickness variation and other parameters with the distress survey map proves to be informative, MnDOT will possess a significant research product for pavement rehabilitation strategies for all rigid pavements in the road network.
C) Although QA/QC is not the overall aim of the project, the research will provide sensitivity and constructability information that would informative for the evolution of MnDOT's QA/QC procedures for rigid pavements.
D) The project will provide an alternative to MnDOTs current destructive practices for thickness verification procedures such as coring.

There are cost savings to each of these benefits. State and local agencies are beneficiaries of this research, and the results, if successful, would be immediately implementable. Examples of the expected benefits of this study include the following: If the thickness deficiencies are correlated with distresses, an improved QA/QC protocol will help prolong pavement life. Detailed thickness variation information will also provide important feedback to MnDOT contractors as to how thickness variation can be reduced. This will help contractors avoid placing excessive concrete thickness and thus reduce cost and carbon footprint of concrete pavements.

SCOPE

Traditionally, PCC thickness is considered to be one of the most important characteristics for concrete pavements. In addition, it is commonly believed that locations of thickness deficiency may reduce pavement life, while excessive thickness increases pavement cost without substantial benefits. However, current PCC thickness information for Minnesota pavements is limited to core measurements taken at approximately 1000 ft spacing. While this type of information is useful as a gross estimate of whether or not the as-constructed pavement meets the designed PCC thickness requirements, thickness deficiencies or other trends due to variation in the construction process are not fully captured.

Until recently, there has not been an efficient way to collect comprehensive and reliable thickness variation information on concrete pavements to test the validity of these assumptions and determine the limitations, if any, of the current frequency of MnDOT thickness testing. Recent research at the University of Minnesota, documented in the doctoral thesis by Dr. Mary Vancura demonstrated the potential of ultrasound tomography in providing this type of information. Figure 1 shows an example section of in service concrete pavement where ultrasonic tomography was implemented to provide additional information between planned core locations. It can be observed that trends such as the dip in thickness shortly after the 10,000 ft. stationing are only caught by the increased coverage from the ultrasound measurements shown in blue between the cores shown in red.

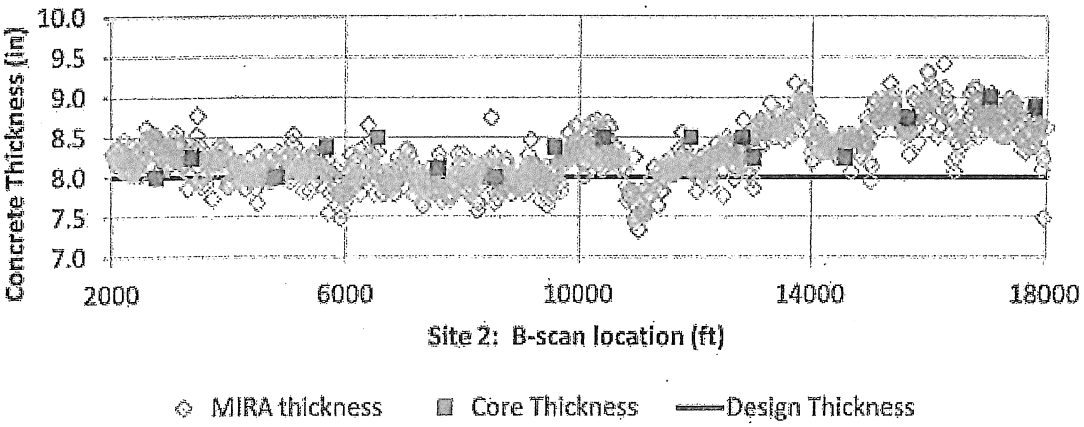

Figure 1. Use of ultrasound tomography to provide additional thickness information between cores.

Additionally a recent collaboration between MnDOT's Office of Materials and the Federal Highway Administration provides the opportunity to utilize 3D GPR technology to allow for expanded information for evaluation of Minnesota pavements. While ultrasound tomography was proven to provide better coverage than traditional destructive measurements, 3D GPR provides the potential provide even greater coverage as well as additional information about major deficiencies in the base layer or subgrade support. Figure 2 shows the advanced pavement evaluation (APE) vehicle that can be utilized to provide additional useful information.

Figure 2. Advanced pavement evaluation (APE) van, retrofit with 3D Radar GPR antennae array.

The proposed study will be designed to provide definitive answers to the cause of pavement failures through application of these technologies and comparison with field distresses. The pavements will either be evaluated prior to rehabilitation or recently constructed, which are closed to traffic. This will allow for collection of high quality and resolution nondestructively measured thickness and distress data. Finally, the project will correlate the distress data with the thickness data using statistical analysis techniques to determine if there is a statistically valid correlation.

ASSISTANCE

The proposed work will require close collaboration with MnDOT in identifying potential test sections, collecting measurements using 3D Radar step frequency GPR, as well as acquisition and verification of existing distress information for the selected pavements.

WORK PLAN

Task Descriptions

Task 1: Select appropriate pavements and develop testing protocol

Potential pavements to include in the project work will be identified through collaboration of the University with MnDOT engineers. The MnDOT pavement management database will be utilized by the University to develop and prioritize a list of applicable pavement sections to test. After this list is compiled, pavement selection should be compared to sections that are already scheduled to be closed to traffic (or not opened to traffic yet). This will ensure that minimal traffic closures are needed for measurements and detailed evaluations. The TAP meeting will be conducted in a timely manner so that the research team can use the information provided by TAP personnel to approve pavement section selection. The TAP members will also be asked to approve a list of hypotheses to test during this project and provide additional hypotheses of interest if applicable. Appropriate test methods and frequencies will be determined based on the characteristics of each selected pavement section. Availability of the advanced pavement evaluation (APE) vehicle equipped with 3D Radar step frequency GPR antennae will be an important factor in the selected pavements and corresponding protocols.

Task 2: Season One data collection, processing, and correlation with distress

The University will collect ultrasound tomography thickness variation data as well as 3D radar information. MnDOT's current distress information will be updated, if necessary, based on visual inspection. The collected data will be processed, tabulated, and catalogued. The University will conduct extensive statistical analysis of the collected data. The analyses will be performed to determine correlations between key pavement components and observed distresses. Factors such as overall thickness deficiencies, significant thickness variation, and large variation in base layer properties will be considered. The strengths and limitations of the pavement selection and testing protocol will be detailed.

Task 3: Season Two data collection, processing, and correlation with distress

The University will use the strengths and limitations of the pavement selection testing protocol to modify the procedures as necessary in collecting ultrasound tomography thickness variation data as well as 3D radar information in season 2. MnDOT's current distress information will be updated, if necessary, based on visual inspection. The collected data will be processed, tabulated, and catalogued. The University will conduct extensive statistical analysis of the collected data. The analyses will be performed to determine correlations between key pavement components and observed distresses. Factors such as overall thickness deficiencies, significant thickness variation, and large variation in base layer properties will be considered.

Task 4: Develop recommendations for improvement of QA/QC protocol

Based on the results of the information obtained in the previous tasks, QA/QC recommendations on type and frequency of nondestructive tests will be provided by the University. These recommendations will be aimed at measurement and control of parameters identified to be correlated with pavement performance (measured distresses).

Task 5: Compile Report, Technical Advisory Panel Review and Revisions

The University will prepare a draft report, following MnDOT's publication guidelines, to document project activities, findings and recommendations. This report will need to be reviewed by the Technical Advisory Panel (TAP), updated by the University's Principal Investigator, and then approved by the Technical Liaison before this task is considered complete. Holding a TAP meeting to discuss the draft report and review comments is strongly encouraged. TAP members may be consulted for clarification or discussion of comments.

Task 6: Final Published Report Completion

During this task, the Approved Report will be processed by MnDOT's Contract Editors. The editors will review the document to ensure the document meets the publication standard. The University's Principal Investigator will then prepare the Final Report and submit it for publication through MnDOT's publishing process.

Task Deliverables

Task:	Deliverable(s):
1:	Memo that identifies pavements to be considered for project work and test protocol
2:	Memo summarizing data collection effort and resulting database
3:	Memo summarizing the results of the analysis
4:	Memo summarizing the developed procedure
5:	A Draft Report and Final Report Approved for Publication
6:	Final Published Report

PROJECT SCHEDULE

Task Completion Dates

Task:	Draft Deliverable Due Date:	Final Task Approval Date:
1:	February 28, 2015	April 30, 2015
2:	February 28, 2015	April 30, 2015
3:	February 28, 2016	April 30, 2016
4:	February 28, 2016	April 30, 2016
5:	May 1, 2016	June 30, 2016
6:	N/A	August 31, 2016

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