EXHIBIT A
SCOPE OF SERVICES

DISC SHAPED COMPACT TENSION (DCT) SPECIFICATIONS DEVELOPMENT FOR ASPHALT PAVEMENT

BACKGROUND
Low temperature cracking is the most prevalent pavement distress found in asphalt pavements in cold climates. As the temperature drops, the restrained pavement tries to shrink. Tensile stresses build to a critical point at which a crack is formed. Current specifications attempt to address this issue by requiring an asphalt binder with a certain low-temperature grade, i.e. xx-34. While this is a good start, it does not account for other factors such as HMA aggregate types & gradations, presence of recycled materials, and aggregate base and subgrade characteristics. Research has shown that binder tests alone are not sufficient to predict low temperature cracking performance in the field; testing asphalt mixtures at temperatures relevant to the climatic conditions for the pavement locations is necessary to obtain a reliable performance prediction. Furthermore, mixture testing techniques should be based on fracture mechanics rather than stiffness and strength. While still a point of debate, the pavement support conditions (base and subgrade) may also play an important role in extent of cracking and should be considered.

After 10 years of low-temperature cracking research, the Disk-Shaped Compact Tension (DCT) test emerged as the test to measure the fracture resistance of asphalt mixtures. The DCT test measures a mechanical property known as fracture energy. MnDOT is nearing the end of the DCT Low-Temperature Fracture Testing Pilot Project, which implemented a trial specification on 5 asphalt paving projects in 2013. Preliminary results are promising, and the DCT Pilot study has identified the next steps for implementation.

The objectives of the research are to:
- Assess DCT testing variability through round robin testing among selected consultants and MnDOT
- Verify / establish fracture energy criterion for asphalt concrete construction acceptance. This includes reviewing existing literature and data from MnDOT and other agencies.
- Develop DCT testing and fracture energy specifications for asphalt mix acceptance
- If needed, provide support to MnDOT for implementing the DCT testing specification.

OBJECTIVE
Mixes with higher fracture energy have been shown to have better low-temperature cracking performance. By requiring mixes to meet a certain fracture energy level, thermal cracking will be reduced or delayed; meaning the pavement should last longer. MnDOT pavement management data has shown that mixtures using Superpave Performance Graded Binder with Low Temperature Grade (PGLT) of -34°C have better performance than mixtures with PGLT -28°C binders. However, recently constructed projects appear to contradict those findings, i.e., a few newly constructed sections with xx-34 binder have exhibited poor low temperature cracking performance after only two winters. The DCT testing at the University of Minnesota Duluth and MnDOT Research have shown that not all mixtures using PGLT -34 binders would meet the required minimum fracture energy levels used in the 2013 Pilot Study. Thus, it is expected that the DCT performance specification would improve low-temperature cracking performance in Minnesota asphalt pavements.

SCOPE
MnDOT is nearing the end of the DCT Low-Temperature Fracture Testing Pilot Project, which implemented a trial specification on 5 asphalt paving projects in 2013. Preliminary results are promising, and the DCT Pilot study has identified the next steps for implementation. The scope of work for this project includes:
- Develop a database of fracture energy on a broad spectrum of current asphalt mixtures to understand sensitivity, variability, and scope of implementing fracture energy performance specifications
- Develop specifications
- Educate and support districts, consultants, contractors (develop guidelines on how to obtain field cores, what parameters influence test results)
- Project selection and management (determine which upcoming projects are a good fit, monitor ongoing projects, working with construction offices & contractors)
- Resolving current unknowns with DCT testing (effect of warm-mix asphalt (WMA), differences between lab mix designs & plant produced mix)

- Fostering the internal transition from research to production. This project builds upon the DCT Low-Temperature Fracture Pilot Testing Project. The investigator will need to coordinate with the district materials engineers and the TAP to select construction projects. District equipment, which is needed for full implementation, will be funded separately.

ASSISTANCE

The assistance from staff at the MnDOT Office of Materials and Road Research will be essential in this project. Following are key aspects where assistance will be provided:

- **Project selection:** The MnDOT Bituminous Office and the Road Research division will need provide continuous feedback to the researchers in selection of projects.
- **Sample procurement:** The MnDOT Office of Materials and Road Research and district offices will coordinate the sample collection effort.
- **DCT Testing:** Significant amount of DCT testing as part of this study will be conducted at the OM&RR laboratory.
- **Construction and mix data:** The database developed through this study will require access to construction plans, mix design records and previous test results. The MnDOT Office of Materials and Road Research will provide this data to the researchers.

WORK PLAN

Task Descriptions

Task 1: Develop database of fracture energy on current asphalt mixtures

Under this task, the University will:

- Review literature and existing data from MnDOT and other agencies, which includes other agency's practices and specifications.
- Populate the results from the DCT pilot implementation efforts undertaken in 2013 in a database. The database should include the details on the mix design as well as the pavement structure and traffic levels.
- Design the database to include additional results and data that will be collected as part of the current study.

Task 2: Project selection and sample procurement

Under this task, the University will:

- A broad spectrum of asphalt mixtures will be tested in order to better understand the sensitivity, variability, and scope of implementing fracture energy performance specifications. The researchers will work with MnDOT and contractors to select eight (8) projects from which materials will be samples.
    - Obtain a mixture using -28 and -34 binder from eight separate contractors/producers, mainly on traffic level 3 and 4 mixes, is desired, although alternative traffic levels or Stone Matrix Asphalt (SMA) mixes may also be tested.
    - It is recommended that as many projects as possible be either reconstruction, over full-depth reclaims (FDR), or deep mill and overlays (M&O). If these types of projects are not available then the selected mixes should at least be representative of these types of construction. These sections will be added to the list of test sections which were part of the DCT Pilot study that is currently underway. Based on field results over time, these sections could be used to adjust the minimum 400 J/m2 level if needed.
- With the help of MnDOT the researchers will collect the materials from the selected projects.
    - The samples will be production, plant produced mix. Gyratory samples, identical to those used for tensile strength ratio (TSR) testing, compacted at the plant would be ideal, as it would eliminate a variable that may occur from reheating and recompacting mix in the lab. To fulfill this testing goal, a minimum of 4 gyratory samples for each testing party per mix (4 testing parties are anticipated, see Task-3), plus an additional 2 cylinders of mix for MnDOT's Trial Mix lab to obtain AC content and voids will be required.
    - On several projects, it is recommended to obtain gyratory pucks from lab produced mix designs, from plant produced-plant compacted mix, from loose mix collected behind the paver, and from field cores obtained within a few days of paving (i.e. all samples would be on the same mix). A comparison of fracture energies would give an indication on what effect reheating the material may have, and possibly provide some trend (e.g. between 10%-20% reduction) on differences in fracture energies between mix designs and production mixes. One of these projects should be a mix with a WMA additive (For example, Crow Wing County has a job in summer of 2014 with WMA additive).

Task 3: DCT testing and data analysis
Under this task, the University will:

- Test the samples collected in Task 2 to measure the DCT fracture energies in this task. The samples testing entails:
  - Specimen Fabrication: The DCT specimens will be prepared from the gyratory pucks of plant produced-plant compacted mixes. For each mix type a minimum of four (4) gyratory pucks will be processed to manufacture a minimum of four (4) replicate specimens (each DCT specimen will consist of approximately the center 50 mm (2") of the gyratory sample).
  - DCT Testing: Tests on minimum of four (4) replicate test samples will be conducted by following the ASTM D7313 test procedure with MnDOT recommended modifications to the procedure. A maximum of two (2) mixes from each of eight (8) different contractor will be tested for a total of sixteen (16) different mixtures (64 total specimens).
  - Data Analysis: The measurements from DCT tests will be analyzed to determine fracture energy of the mix as well as to estimate the strength of mix.
- Samples will be tested by:
  - University of Minnesota Duluth (UMD)
  - MnDOT Office of Materials and Road Research
  - Two consultants (American Engineering Testing and Braun Intertec). The consultant testing is conducted through separate consultant contracts that are setup between MnDOT and the consultants.
- Since these mixture tests are part of the mix design acceptance, researchers will make all efforts to provide results to MnDOT as quickly as possible. The target time of one week from the day of receipt of gyratory pucks will be attempted. Note: This data analysis includes the results from all 4 testing labs i.e., 254 tests.

Deliverable:

Task 4: Database Update and Development of DCT Performance Specifications
Under this task, the University will:

- Enter the results from testing conducted in Task 3 into the database developed in Task 1. Conduct statistical analysis of the data to document factors such as test repeatability and reproducibility.
- On basis of the database analysis as well as the results of a consultant contract examining the sensitivity of thermal cracking to fracture energy using the IlliTC model the DCT performance based specifications will be developed.
- Provide recommendations to the MnDOT Bituminous Specification Committee.

Task 5: Implementation of the DCT Performance Specification on Selected Projects
Under this task, the University will:

- Work with the MnDOT's Bituminous Unit, District Materials and Construction Offices, and contractors to implement the performance specification on selected projects for the 2015 construction season. This is a continuous and ongoing process. Determining which projects are a good fit, monitoring incoming projects, and observing and documenting ongoing projects are important components of this task. Acceptance testing will be performed at the MnDOT Office of Materials and Road Research's Maplewood lab.
- Conduct an assessment on the feasibility of implementing the DCT performance specifications statewide for the 2016 construction season during this task. Modifications to the DCT specification may be needed and if that is the case, such modifications will also be developed as part of this task.
- Hold a technical advisory panel (TAP) meeting prior to conclusion of Task 4. On basis of the findings and results from Tasks 1 through 4 the TAP will make recommendation regarding continuation of the project and whether Tasks 5 and 6 should undertake or not.

Task 6: Provide Support to MnDOT Districts with Implementation
Under this task, the University will:

- Provide support and training to the districts in order to for MnDOT district labs to implement and run DCT tests. The support and training includes: preparation of test specimens, conducting test, and analysis of results. This will also include guidelines on how to procure field cores.

Task 7: Implementation of DCT Performance Test on Standard Projects
Under this task, the University will:

- Perform implementation of the DCT performance specification on standard types of projects recommended in the Task 3 of this project. This includes working with the bituminous office, districts, construction offices, and contractors to implement the performance specifications. Acceptance testing will be performed at the MnDOT Materials lab.
- Provide support to MnDOT district offices in managing the information on individual projects.

Task 8: 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 9: 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:	A database with mixture properties (PG grade, modified or neat binder, % RAP, etc.), pavement structure and fracture energy values along with a brief report summarizing the results will be delivered.
2:	A matrix with mixture properties (PG grade, modified or neat binder, % RAP, etc.) and fracture energy values will be populated and a brief report summarizing the results will be written; this should include results from the inter-laboratory comparison.
3:	(1) Interim report on Task-2; (2) Laboratory Test Results Electronic Format.
4:	Electronic submission of updated database with results from testing conducted in Task 3 and summary report with draft specification based on DCT performance test that is to be used for projects in 2015.
5:	A detailed report on the selection process of the projects, the results of testing, and changes to mixes that occurred will be produced. Additionally, the report will include recommendations on which types of projects (case-by-case basis, all new/reconstruction, over FDR, deep Mill & Overlay, etc.) the fracture energy specification should be fully implemented. The report will also include an assessment on the feasibility of implementing the DCT performance specifications statewide for the 2016 construction season as well as any required modifications to the specifications. It is also expected that presentation and support will be given at MnDOT MEO Meetings as needed. Updates will also be given at the bi-weekly construction meetings, and other MnDOT-MAPA Technology meetings as needed.
6:	Summary report entailing the support and training efforts as well as copy of training material that will be provided to the districts.
7:	A detailed report on the implementation process will be produced. Report will include results from select projects from 2016 construction.
8:	A Draft Report and Final Report, approved for publication
9:	Final Published Report

PROJECT SCHEDULE

Task Completion Dates

Task:	Draft Deliverable Due Date:	Final Task Approval Date:
1:	December 31, 2014	February 28, 2015
2:	December 31, 2014	February 28, 2015
3:	February 28, 2015	April 30, 2015
4:	April 30, 2015	June 30, 2015
5:	March 31, 2016	June 30, 2016
6:	October 31, 2016	December 31, 2016
7:	October 31, 2016	December 31, 2016
8:	February 28, 2017	April 30, 2017
9:	N/A	June 30, 2017

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