Subject: TPF-5(504) MnDOT plans for the construction of controlled filed pavement test sections for the stripping study (Proposed Plan)

Version control

Version	Description	Date	Prepared by
1.0	Preliminary Construction Plan	03/27/2023	Eyoab Zegeye

Objectives

One of the objectives of the TPF-5 (504) pool fund study is to recreate typical full-depth bituminous and bituminous overlayed concrete pavements affected by stripping originating at the interfaces. The study envisions accomplishing the stated objective by identifying, producing and installing materials or mixes that closely simulate the conditions of stripping in actual pavements: failure of bonds between the binder and aggregate particles, loss of fine particles, continuously increasing void contents, loss of bearing capacity and deterioration etc.

Needs

These sections will be employed to:

- Further, explore and refine the capability of 3D-GPR and other NDT testing technologies at detecting stripping conditions in typical pavement sections.
- Identify the factors that impact the effectiveness of NDT technologies in detecting and assessing stripping.
- Extract signature stripping responses or signal reflections that will be used to develop automated stripping detection algorithms.
- Employ to verify and validate the effectiveness of NDT equipment and software applications at detecting stripping and other hidden targets and conditions.

This document describes a preliminary construction plan for the test sectioned planned to be built in MnROAD.

Approach

The MnDOT team responsible for the TPF-5(504) pool fund study conducted a comprehensive review of the previous R06D study to assess its benefits, challenges, and lessons learned. Additionally, they engaged in an extensive and productive discussion with Mike Heinzman, the principal investigator of the R06D study, who graciously shared valuable insights regarding the successes and failures encountered during the construction and testing of field and laboratory samples in the previous study. Furthermore, a concise literature review was conducted to identify the factors contributing to stripping in pavements and how this phenomenon manifests itself.

Based on the insights gained from the above activities, the MnDOT team selected a suitable site within the MnROAD test facility for constructing a new test section. Forensic investigation, including GPR and FWD surveys and analyses, was performed to evaluate the conditions of the existing road to determine whether to build or completely replace it with new layers. Afterward, the MnDOT team developed preliminary drawings and plans, which underwent rigorous review, modification, and discussion in multiple meetings involving experts from various backgrounds, including MROAD construction operations, pavement design, materials, flexible pavement, and rigid pavement expertise. A list of the people consulted in developing and reviewing the construction plan is provided with this document. Following internal deliberation on the feasibility and constructability of the proposed plans, the MnDOT team is now circulating the plan documents to the state members, manufacturers, and supporters of the pool fund study to gather additional feedback, suggestions for adding or removing factors, and a consensus on proceeding with the construction of the test sections.

Plan Details

This document is to be read along with the attached excel spreadsheet containing the drawings of the proposed cells

Location/Site

The location identified for constructing the field-controlled sections for the stripping experiments is in the MnROAD testing facility. MnROAD staff identified and offered an existing service road in the west-northern end of the Low Volume Road (LVR) testing loop adjacent to the I94 Mainline test sections (see picture below)

Figure 1. Existing road service at MnROAD testing facility to be used in this study (in red)

Background

The service road was originally built as a gravel road on top of a clay subgrade. In 1999, a portion of the road, approximately 1500 feet long, was replaced with Hot Mix Asphalt (HMA) mix. Approximately five (5) inches of asphalt concrete (AC) mix was placed on the existing surfacing aggregate. The width of the road section is approximately 14 inches. The section served as a test to establish paving techniques and develop a rolling pattern before placing the AC mixes on the LVR sections. The road is practically not used for any moving or testing traffic.

Forensic investigation

Visual and video-aided examination of the existing pavement revealed that the road is moderately poor and shows signs of deterioration related to aging. The surface is affected by several distresses, including thermal and fatigue cracking, raveling and patchings.

Figure 2. Picture of the road segment's road surface conditions

The GPR survey estimated the top bituminous layer to be approximately 5 inches. The thickness variability within the length of the road is minimal.

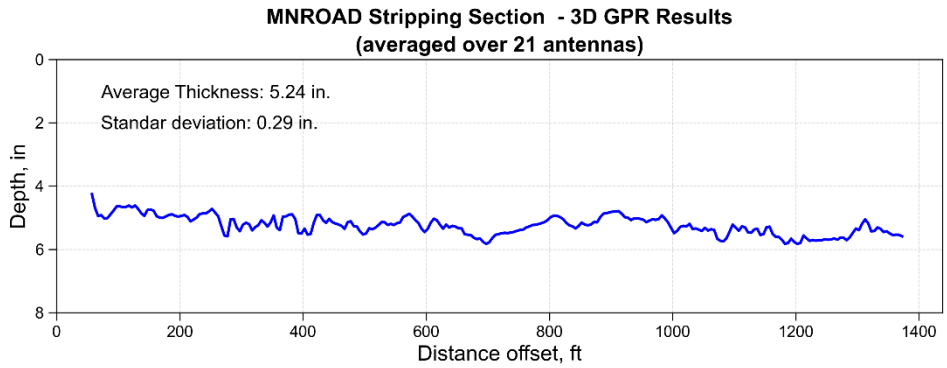

Figure 3. Summary of 3D-GPR thickness measurement (traveling from the east to the west end of the road)

The FWD results indicate, as was to be expected that the section has moderate to poor bearing capacity. Note that the road consists of an aging thin AC layer on top of a few inches of gravel lift. Nevertheless, the existing pavement has a reasonably uniform distribution of strength and structural integrity throughout the length of the bituminous layer. A small exception was observed on the first 50 -100 feet of the road traveling from east to west. This initial section yielded higher deflections at the center plate, suggesting a relatively weaker portion.

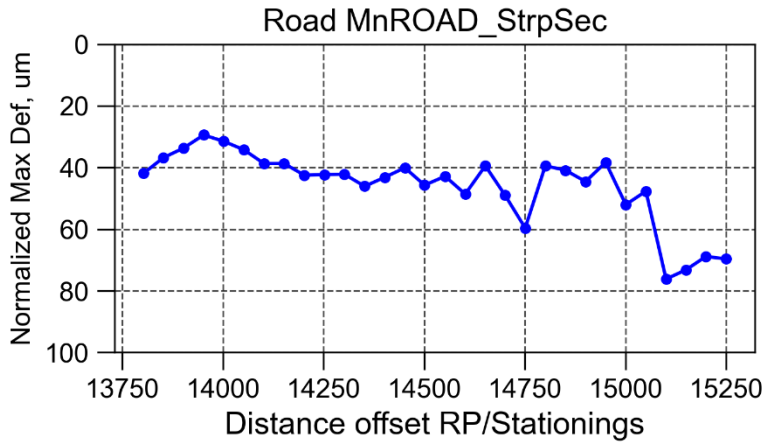

Figure 4. Summary of FWD center plate deflections (adjusted to 21.1 C) (traveling from the west to the east end of the road)

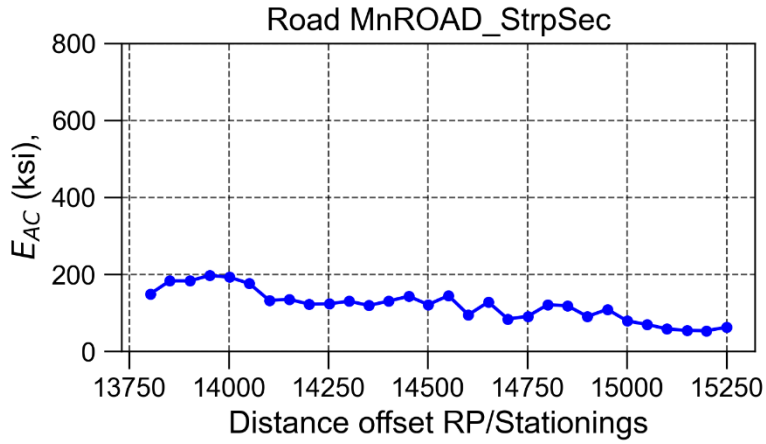

Figure 5. Summary of FWD back-calculated AC moduli (adjusted to 21.1 C) (traveling from the west to the east end of the road)

Proposed structure(s)

Based on the review of the historical and forensic investigation results, MnDOT is proposing to:

- For the AC on the PCC portion: Mill down the old bituminous pavement to 5 in, recompact the base and replace with concrete slabs 12' x 12' (length x width). The PCC slabs will not require metal reinforcement. Two lifts of AC, each at least 3 inches thick, will be placed on top of the concrete slabs. The pavement structure will be confined by 1' gravel shoulders on each end. MnDOT is proposing to mill a portion of the existing road on the southeast end which showed relatively weaker strength. A tack coat will be applied over the entire interface surfaces, except where metal plates and the stripping elements are placed, to simulate perfect bonding. The stripping element will be placed at the interfaces on top of the PCC joints where most stripping conditions are known to occur.
- For the full-depth bituminous section: We propose building on top of the existing bituminous pavement after repairing major surface distresses (patching, filling potholes, crack-sealing etc.). Two lifts of AC, each at least 3 inches thick, will be placed on top of the existing road. A tack coat will be applied over the entire interface surfaces, except where metal plates and the stripping elements are placed, to simulate perfect bonding. The pavement structure will be confined by 1' gravel shoulders on each end. The stripping element will be placed at the interfaces between the three layers. The total width of the segment will include 12' of mainline and 2' of shoulders.

Further details are included in the attached drawing and construction plans.

Mix designs/material specifications

MnDOT will provide recommended mix designs for PCC slabs and Superpave AC layers. The AC layer, responsible for hosting the stripping elements, will be designed to reflect a high-quality dense-graded local asphalt mixture. These stripping elements will artificially replicate key stripping conditions such as loss of fine particles and binder, weak particle bonds, increased air voids, and deterioration.

The stripping elements will be created using aggregate and binder from the same sources as the AC Superpave mixture. This approach isolates and enhances the stripping conditions, avoiding additional variabilities caused by material changes. The stripping elements will feature coarser gradation, significantly lower asphalt binder content than the host mix, and receive reduced compaction effort. MnDOT proposes two different mixes for recreating the stripping elements:

- Level 1: This element mimics the approach used in the R06D study. It utilizes Coarse-fractionated Reclaimed Asphalt Pavement (CFRAP) produced with a similar binder type and aggregate source as the host bituminous layer. This material replicates typical stripping conditions, including loss of fine aggregate, weakened particle bonds, and increased air voids.
- Level 2: This material primarily consists of coarse-graded aggregate from the same source as the host mixture, blended with a minimal (negligible) amount of binder from the same source. The binder or emulsion may be sprayed onto the material rather than mixed in a plan. It aims to represent a more severe stripping condition, where a significant portion of the binder and fine aggregate has been lost.

Factors investigated

Based on a comprehensive literature review and various discussions with various MnDOT and outside subject matter experts, we are proposing the following factors to be included in the field experiments:

- Pavement structure or type of receiving surface (variables = 2):
  - Concrete slab (Whitetopping)
  - Old AC (Full-depth Bituminous)
- Stripping sensitivity or severity (variables = 2): One of the critical questions raised in the R06D study was whether the fractionated RAP used in the studies simulated stripping conditions that occur in a deteriorated bituminous layer. In the present study, we hope to explore whether the choice of materials used to simulate stripping significantly affects the outcome. To address this question, we plan to employ two different materials for reproducing stripping conditions. The element proposed in this study attempt to simulate stripping at the early and late (advanced) stages
- Stripping geometry (variable = 4): The design matrix for the test sections will include the following variables related to the geometry of stripping:

- Depth (variables = 2): Stripping occurring at the bottom and mid-depth of a new HMA layer.
- Size (variables = 2): Two different types of stripping, 3 ft x 3 ft and 4 ft x 10 ft.
- Thickness (variables =1): One and two inches thick stripping elements

- Effect of moisture (variables = 2):
  - Varying the moisture content only in the stripped element using purposely designed pipestone and water tanks
  - Moisture conditions that are dictated by seasonal climate changes (i.e., dry, cold, and wet).

Control section

Control sections and transition cells will establish a reference point for analyzing GPR data collected from pavement structures. Furthermore, metal plates will be strategically positioned on the control sections. The reflections obtained from these plates will be utilized to normalize or assess the strength of reflections from interfaces that are well-bonded and those affected by stripping.

List of subject matter experts consulted

Eyoab Zegeye	MnDOT (Research, NDT)
Dai Shongtao	MnDOT (Research, NDT)
Jeff Brunner	MnDOT (Research, Admin)
Steve Cooper	FHWA
Thomas Calhoon	MnDOT (Research, NDT)
Mike Heinzman	Kontur, PI of the R06D Study
John Garrity	MnDOT (Materials office)
Greg Johnson	MnDOT (Materials office)
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Kyle Hoegh	MnDOT (Research, NDT)
Ben Worel	MnDOT (Research, MnROAD)
Mike Vrtis	MnDOT (Research, MnROAD)
Jacob Calvert	MnDOT (Research, MnROAD)

Emil Bautista	MnDOT (Research, MnROAD)
Tom Burnham	MnDOT (Research, Rigid)
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