

Performance of Thin Unbonded Concrete Overlays on High Volume Roads

Introduction

Unbonded concrete overlays consist of a new concrete layer, typically 7 - 8" thick, over a 1 - 1.5" thick new bituminous interlayer, all placed over an existing, deteriorated concrete pavement. These conventional overlays have performed very well in Minnesota's extreme climate. Historically, however, their structural design has been somewhat controversial and therefore conservative (thicker), due to the lack of rational design methods devoted strictly to their characteristics.



Given their good performance, and the ever rising cost of construction and materials, interest has developed in exploring whether thinner unbonded concrete overlays could perform to acceptable (and predictable) levels.

In 2008, Mn/DOT initiated a five year study that examines the performance of two thin unbonded concrete overlay projects: Cell 5 of the MnROAD Phase II (SP 8680-157) and a

section of TH 53 near Duluth, Mn (SP 6916-99). These pavement test locations provide a unique opportunity for researchers to include additional environmental and traffic factors in validating performance results. It is anticipated that the results from these studies will improve the understanding of the behavior of this complicated composite system, which will lead to the development of better distress and life prediction models and ultimately contribute to more sustainable pavement designs.

Design

The thin unbonded concrete overlay sections, constructed on the interstate portion of the Minnesota Road Research (MnROAD) facility, consisted of a 4 inch or 5 inch thick concrete layer over a new 1" thick permeable asphalt stabilized stress relief layer (PASSRC), placed over the existing deteriorated 7" thick concrete pavement constructed in 1993. This overlay was constructed with 15 feet long by 13 or 14 feet wide panels, with no dowel bars (relying on the underlying pavement for load transfer) and no joint sealant. Periodically placed wick drains were installed to drain the PASSRC interlayer.

The rehabilitation strategy for TH 53 was a thin unbonded overlay consisting of a 5 inch thick concrete layer over a new 1" thick non-drained bituminous inter-layer, placed over the existing deteriorated 8" thick concrete pavement constructed in 1973. This overlay was constructed with 12 ft long by 12 ft wide panels (with a short test section consisting of 6 ft. long by 6 ft. wide panels), with no dowel bars (relying on the underlying pavement for load transfer) and no joint sealant.

Performance of Conventional Unbonded Concrete Overlays

According to Mn/DOT Pavement Management, conventional unbonded concrete overlays are generally outperforming new full-depth concrete pavements.





Significant differences between the TH 53 and MnROAD test cells include: climatic zone, traffic volume and type, panel size and interlayer type. Also, TH 53 transverse joints were distressed naturally by age, traffic and environmental loadings; whereas a portion of the existing transverse joints in the younger MnROAD cells were artificially distressed prior to the overlay.

Construction

Both overlay projects were constructed in 2008, and due to their lower thicknesses, placed more quickly than a conventional overlay. This created some issues on the TH53 project, as the transverse joint saw crews were often unable to keep ahead of the faster setting thin concrete overlay. This could possibly be the cause of some early random transverse cracking; however, further analysis is needed.

Due to the severe deterioration of many of the transverse joints and panels on the TH53 project supplemental steel reinforcement was installed into the thin overlay in certain areas.

As mentioned above, due to the less deteriorated transverse joints in MnROAD Cell 5, a select number of joints were artificially distressed using a guillotine pavement breaking hammer.

The Mn/DOT Materials and Road Research office installed electronic instrumentation at the time of paving into both the MnROAD and TH53 sections.



Monitoring and Testing

An important part of this study is to develop better distress and life prediction models for thin unbonded concrete overlays. To accomplish this, environmental and load response data from the electronic sensors and condition surveys will be collected and analyzed on a seasonal basis.

Mn/DOT Test Sections:

This study is monitoring four test sections at the MnROAD facility and two test sections on TH 53 north of Duluth.

To establish a baseline for performance monitoring, each test section was subjected to rigorous construction inspection and pre- and post-construction testing. As an example, to characterize the structural condition of the existing PCC panels on TH 53, Falling Weight Deflectometer (FWD) testing was done prior to placement of the HMA bond breaking layer, and again shortly after placement of the thin concrete overlay. Initial results indicate that the 5-inch overlay on TH 53 is currently providing adequate structural capacity; however it remains to be seen as to whether this will change over time, or if the 5-inch overlay sections are enough to carry the traffic at the MnROAD test sections. Additional FWD testing will be conducted as the study progresses to



monitor seasonal variations in structural behavior.



Early Performance

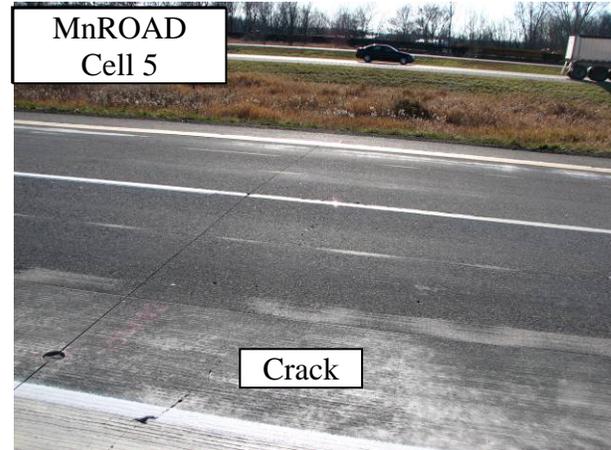
As mentioned previously, inexperience in constructing thin unbonded concrete overlays led to some random transverse cracking on the TH 53 project. A visual distress survey, conducted in April 2009, revealed that approximately 40 cracks had formed in the overlay over the nearly nine mile project length. These cracks had severity ratings of: 7% high, 41% medium, and 51% low.



Falling Weight Deflectometer (FWD) measurements taken on TH 53 during April 2009 indicated that the new concrete overlay had a median joint load transfer efficiency of 86%.

The 4 inch thick overlay test sections at MnROAD began to exhibit noticeable transverse and corner cracking near the joints during the spring of 2009. The specific cause of these cracks is under investigation, but could be linked to the artificially distressed underlying

joints, or excessively curled panels due to long panel lengths in relation to layer thickness.



Conclusions

Thin unbonded concrete overlays were successfully constructed at MnROAD and on TH 53 near Duluth, Minnesota. These projects required nearly one half of the concrete material typically used in conventional unbonded concrete overlay designs.

Monitoring the performance of these sections will provide valuable information for the development of more rational design methods for these sustainable pavement rehabilitation solutions.

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