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 the 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.

New Overlay
| Bituminous | Deteriorated PCC |

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.

Mn/DOT initiated a five year study that includes cell 5 of the MnROAD Phase II, 2008 reconstruction project (SP 8680-157) and a section of TH 53 near Duluth, Mn (SP 6916-99).

Performance of Conventional Unbonded Concrete Overlays

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

These two pavement test locations provide a unique opportunity for researchers to include additional environmental and traffic factors and validate 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 unbonded overlay constructed at Minnesota Road Research Project (MnROAD) consisted of a new concrete layer, 4 or 5” thick, over a new 1” thick permeable asphalt stabilized stress relief layer (PASSRC), placed over the existing deteriorated 7” thick concrete pavement constructed in 1993. The new concrete overlay was constructed with 15 ft long by 13 or 14 ft wide panels, with no dowel bars (relying on the underlying pavement for load transfer) and no joint sealant.

The rehabilitation strategy for TH 53 was an unbonded overlay consisting of a new concrete layer, 5” thick, over a new 1” thick non-drainable bituminous inter-layer, placed over the existing deteriorated 8” thick concrete pavement constructed in 1973. The new concrete overlay was constructed with 12 ft long by 12 ft wide panels (and 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.
Major differences between TH 53 and the MnROAD test cells include: different climatic zones, different traffic loadings, different panel sizes and different interlayer types. In addition TH 53 was distressed by age, traffic and environmental loadings, where the younger MnROAD cells were artificially distressed with a guillotine pavement breaking hammer.

**Construction**

Both projects were constructed in 2008 and the thin concrete overlays were placed more quickly than a conventional overlay. This created some issues, as the saw crews were unable to keep up with the faster paced paver and consequently the timing of joint sawing suffered (This was not an issue at MnROAD due to the short 500’ length test section). In addition, TH 53 had weaker areas within the project that were strengthened with supplemental steel reinforcement.

The Materials and Road Research office installed electronic instrumentation at the time of paving which enabled the embedment of sensors within the pavement structure. These sensors, designed to measure dynamic load and environmental effects will provide valuable information on the behavior of these complex pavement systems.

**Monitoring and Testing**

An important part of this study is to develop better distress and life prediction models of thin unbonded concrete overlays. To accomplish this, a number of electronic sensors were installed in MnROAD test cell 5 and TH 53 to measure environmental and load responses. Due to the remote location of the TH 53 site, it had significantly less electronic sensors than MnROAD cell 5.

**Mn/DOT Test Sections:**

This study is monitoring one test section at the MnROAD facility and another on TH 53 north of Duluth.

Both test sections were subjected to the rigorous inspection and a testing regime afforded to all MnROAD test cells including, but not limited to, the following:

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. Additional FWD testing will be conducted as the study progresses to monitor seasonally variations and any other changes in behavior.
Dynamic load testing was performed each season by activating the pavement sensors and recording the responses induced by a truck of known axle weight.

To characterize early age warp and curl, a large concern given the dimensions of the panels in MnROAD test cell 5, laser profile testing was conducted.

**Early Performance**

On TH 53, Falling Weight Deflectometer (FWD) measurements, taken during April 2009, indicated that the new concrete overlay had a median joint load transfer efficiency of 86%. A visual distress survey, conducted in April 2009, revealed that approximately 40 cracks have formed in the overlay over the nearly nine mile project length. These cracks had severity ratings of: 7% high, 41% medium, and 51% low.

At MnROAD, FWD measurements were inconclusive due to temperature differences at the time of measurement. A field visit in November 2009, revealed several low severity cracks. In addition, there was joint damage along the entire length of the shoulder on the driving lane. Further investigation of these distresses will be forthcoming.

**Conclusions**

Thin unbonded concrete overlays were successfully constructed at MnROAD and on TH 53 near Duluth. These projects dramatically reduced overlay thickness by nearly ½ compared to conventional designs. The embedded sensors designed to collect environmental and load response information, as well as close monitoring and evaluations of the pavement sections is providing researchers with valuable information.

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