Pavement Evaluation of the Concrete Tie-bars and Dowel Baskets on Irvin Cobb Drive, US 60, McCracken County, KY

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### 16. Abstract
A 1500 Mhz. ground coupled, ground penetrating radar antenna was used to identify both the horizontal alignment and the vertical displacement of the concrete tie-bars and the transverse joint dowel bar assemblies on a Portland-Cement Concrete-Pavement (PCCP) on US 60 in McCracken County, KY. Approximately 5 lanes miles of PCCP were evaluated using the 1500 Mhz. ground coupled antenna. Results indicate that only one transverse dowel basket out of an approximate total of 1,760 were within 4.17 inches of the pavement surface. Seven transverse dowel baskets were misaligned four inches or greater from the location of the sawed joint. These areas represent 0.45 percent of the total transverse joints on the project. The ground penetrating radar results also indicated there were no areas along the longitudinal joint where the tie-bars were either too close to the pavement surface or missing.

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Ground Penetrating Radar, Dowel Bars, Portland Cement Concrete Pavement

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in cooperation with

Kentucky Transportation Cabinet
Commonwealth of Kentucky

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December 2013
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ACKNOWLEDGEMENTS

The authors of this report would like to acknowledge the members of the technical advisory group that has been both an instrumental part throughout the discovery process of this project and made contributive efforts in producing this report. The technical advisory group was comprised of members from the following: Kentucky Transportation Cabinet Division of Construction and Kentucky Transportation Cabinet Division of Design.
I. INTRODUCTION

In October/November 2013 the Kentucky Transportation Center (KTC) evaluated the newly constructed 11 inch Portland-Cement-Concrete-Pavement (PCCP) on US 60 in McCracken County, using a Ground Penetrating Radar (GPR) unit. The evaluation was conducted to assist the Kentucky Transportation Cabinet (KYTC) in determining the horizontal alignment and vertical placement of the longitudinal joint tie-bars and the transverse joint dowel baskets per the special construction note (Appendix I). This report summarized the collected field data from the Ground Penetrating Radar analysis conducted on US 60 to determine the potential misalignment/displacement of either the longitudinal tie-bars and/or the transverse dowel baskets.

II. METHODOLOGY

The field evaluation involved pushing a three wheel cart in conjunction with a 1500 MHz ground coupled GPR antenna just outside the wheel paths of each driving lane (Figure 1) and along the longitudinal joints where the tie bars are located. The project length was approximately 1.25 miles. The GPR equipment was calibrated using four field cores located over the tie-bars. The field calibration process for the GPR unit typically ensures a real-time vertical measurement of +/- ½ inch in the field. This procedure is based on the Depth Scale Calibration section of the GSSI Handbook for Radar Inspection of Concrete (GSSI 2001).

Figure 1: GPR antenna and three wheel cart checking the dowel basket depth and alignment
The specific sections of the pavement to be scanned were determined by the following.

- Longitudinal joint--checking for missing and/or displaced tie-bars
- Approximately two feet on either side of the centerline joint--checking for misaligned, high, and/or missing transverse joint dowel baskets
- Approximately one foot inside of the outside edge of the pavement both lanes--checking for misaligned, high, and/or missing transverse joint dowel baskets

III. SUMMARY OF FINDINGS

A. Longitudinal Tie-Bars

When tie-bars were less than 4.17 inches below the surface, less than 2 inches from the bottom, or were missing; they were marked in the field as follows:

- Missing Tie-Bars – marked with green paint
- Tie-Bars within 4.17 inches of the pavement surface – marked with green paint
- Tie-Bars less than 2 inches from the bottom of pavement – marked with green paint

The reason for marking the bars that were less than 4.17 inches below the surface was to identify bars that may have been inadvertently saw-cut when forming the centerline joint. KYTC standard drawing No. RPX-010-04 states the following requirements for the depth of saw cut: “T/3, T= pavement thickness with a 3 inch minimum”. Special Note for Dowel Bar and Tie Bar Placement in JPC Pavement included in the project proposal and in Appendix I Section 3.2 indicate that tie bars shall be placed within T/3 + ½ inch and not less than 2 inches from the bottom of the slab. For this section of pavement to meet this requirement tie-bars must be located at least 4.17 inches from the pavement surface and no more than 9 inches from the pavement surface. Figure 2 displays a sample of the GPR data identifying the approximate depth of the tie-bars.

The GPR data analysis indicated that there were NO occurrences of either missing and/or high tie-bars on US 60 in the areas that were scanned. In addition, there were NO occurrences of tie-bars being placed deeper than required by Kentucky specifications for PCCP pavement.
Longitudinal Tie Bars

Figure 2: GPR data displaying depths of tie-bars (tie-bar locations indicated by green diamonds)

B. Transverse Dowel Bars

In accordance to the special note section 3.1 included in Appendix I, dowel bars that were less than 4.17 inches below the surface, greater than 7.33 inches below the surface, or were misaligned by more than four inches were marked in the field as follows:

- Bars less than 4.17 inches from surface were outlined; depth from surface was given – marked with orange paint
- Bars greater than 7.33 inches from surface were outlined; depth from surface was given – marked with orange paint
- Bars misaligned by 4 inches or more were labeled “S” for Skewed; length of misalignment was given – marked with orange paint

The survey of the vertical placement and/or alignment of the transverse dowel-bars was conducted using GPR scanning at approximately two feet on either side of the centerline joint and approximately one foot inside of the outside edge of pavement. Table 1 below summarizes the areas where high/deep dowel-bars and/or misaligned dowel baskets were observed. Misaligned dowel baskets were identified as areas where the dowel basket assembly was skewed approximately four inches or more away from the transverse joint. Figure 3 displays a sample of collected GPR data identifying dowel-bars that are less than 4.17 inches down from the surface of the pavement.
Table 1: Quantity and locations of displaced and/or misaligned dowel baskets

<table>
<thead>
<tr>
<th>Direction</th>
<th>Station #</th>
<th>Lane</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>EB</td>
<td>509+58</td>
<td>Right</td>
<td>Misaligned</td>
</tr>
<tr>
<td>WB</td>
<td>512+76</td>
<td>Right</td>
<td>Misaligned</td>
</tr>
<tr>
<td>WB</td>
<td>515+24</td>
<td>Left</td>
<td>Misaligned</td>
</tr>
<tr>
<td>EB</td>
<td>530+33</td>
<td>Right</td>
<td>Misaligned</td>
</tr>
<tr>
<td>EB</td>
<td>536+90</td>
<td>Right</td>
<td>High</td>
</tr>
<tr>
<td>EB</td>
<td>540+42</td>
<td>Left</td>
<td>Misaligned</td>
</tr>
<tr>
<td>EB</td>
<td>548+85</td>
<td>Left</td>
<td>Misaligned</td>
</tr>
<tr>
<td>EB</td>
<td>548+85</td>
<td>Right</td>
<td>Misaligned</td>
</tr>
</tbody>
</table>

Figure 3: GPR displaying high dowel bars
IV. CONCLUSIONS

The results of the Center’s evaluation indicate that one transverse dowel basket, out of an approximate total of 1,760, was above the minimum depth of 4.17 inches of the pavement surface. Seven transverse dowel baskets were misaligned four inches or greater from the location of the sawed joint. These areas represent 0.45% of the total joints on the project.

The results also indicated there were no areas along the longitudinal joint where the tie-bars were either too close to the pavement surface or missing. Table 2 below compares the findings of this GPR evaluation along with three other concrete pavement projects evaluated previously in Kentucky.

Table 2: Summary of Findings Compared to Other GPR Concrete Pavement Evaluations

<table>
<thead>
<tr>
<th>Project</th>
<th>% Tie Bars Found Out Of Spec</th>
<th>% Dowel Baskets Found Out Of Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (2011)</td>
<td>0.00%</td>
<td>0.33%</td>
</tr>
<tr>
<td>B (2013)</td>
<td>0.00%</td>
<td>0.45%</td>
</tr>
<tr>
<td>C (2012)</td>
<td>1.20%</td>
<td>1.30%</td>
</tr>
<tr>
<td>D (2010)</td>
<td>3.10%</td>
<td>6.40%</td>
</tr>
</tbody>
</table>

It is the authors’ opinion, that this project was completed with proper construction methods in regards to the placement of the tie bars and dowel baskets. As seen in Table 2, the project compares favorably with the other previously constructed and inspected concrete pavement projects.
REFERENCES

Appendix I: Special Note for Dowel Bar and Tie Bar Placement in JPC Pavement

July 9, 2013

CALL NO. 104
CONTRACT ID NO. 131042
ADDITIONAL # 2

Subject: McCracken County, STP 0601 (175)
        Letting July 12, 2013

        (1) Added - Special Note - Pages 55(a)-55(b) of 108

Proposal revisions are available at http://transportation.ky.gov/Construction-Procurement/

If you have any questions, please contact us at 502-564-3500.

Sincerely,

Ryan Griffith
Acting Director
Division of Construction Procurement

RG: ks
Enclosures
1-2025.00
US 60, McCracken County

SPECIAL NOTE FOR DOWEL BAR AND TIE BAR PLACEMENT IN JPC PAVEMENT

This Special Note will apply where indicated on the plans or in the proposal. Section references herein are to the Department’s 2012 Standard Specifications for Road and Bridge Construction.

1.0 DESCRIPTION. This Special Note applies when new JPC pavement is placed on a project. Allowable tolerances are outlined for both dowel bar and tie bar placement in driving lanes and shoulders. Concrete patches will not be tested under this special note except for the instance where corrective work is required on the placement of new JPC pavement which may require concrete patching. Testing will include longitudinal joints between driving lanes and shoulders if the shoulders are constructed with JPC pavement. Transverse joints in the shoulders will not be tested. No concrete patching will be tested except for repairs required on new JPC pavement. Working with concrete requires at least seven days or more of curing time. The concrete should be dry for at least 24 hrs prior to testing.

This Special Note specifies the allowable tolerances for placement of dowel bars and tie bars in JPC pavement.

2.0 MATERIALS. Conform to Subsection 501 or 502.

3.0 CONSTRUCTION.

3.1 Dowel Bars. Transverse dowel bars, which are generally in baskets, should be located in the center of the slab vertically. They should not be skewed or rotated. Conform to Section 501 of the Standard Specification and Standard Drawing RPS-020-13, place dowel bars to the tolerances shown in the table below.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal offset</td>
<td>±1 inch</td>
</tr>
<tr>
<td>Longitudinal translation</td>
<td>±3 inches</td>
</tr>
<tr>
<td>Horizontal skew</td>
<td>¼ inch, max</td>
</tr>
<tr>
<td>Vertical skew</td>
<td>¼ inch, max</td>
</tr>
<tr>
<td>Vertical depth</td>
<td></td>
</tr>
</tbody>
</table>

The minimum distance below the concrete pavement surface must be:

\[ DB = \frac{T}{3} + 1\frac{1}{8} \text{ inch} \]

Where:

- \(DB\) = vertical distance in inches, measured from the concrete pavement surface to any point along the top of dowel bar, and
- \(T\) = actual concrete pavement thickness at joint location, in inches.

The maximum distance below the surface to any point along the dowel bar should be 2T/3.
I-2025.00
US 60, McCracken County

Dowel bars determined to be out of tolerance are to be marked in the field with marking paint. Corrective work will be required with the following circumstances:
- if 3 or more bars are rotated longitudinally 3 inches or more
- if more than two consecutive joints have any bars that are skewed vertically or horizontally

Any corrective work shall be completed in accordance with the 2012 SN 11J – Special Note for Full Depth Concrete Pavement Repair. Contrary to Special Note 11J, all joint repairs completed due to corrective work shall be sealed with silicone rubber unless approved by the Engineer.

3.2 Tie Bars. Install tie bars at a depth equal to 1/3 of the slab thickness. Tie bars shall be perpendicular to the longitudinal joint and parallel with the concrete pavement surface. Installation shall be to the tolerances outlined below:
- Not less than 1/2 inch below the saw cut depth of the joints
- 2" clearance from pavement surface and bottom of pavement

Corrective action will be required for the following circumstances:
- 2 consecutive tie bars are missing or outside of the tolerance listed above
- 4 or more bars in a slab are missing or outside of the tolerances listed (does not have to be consecutive)

The correction shall be made by cross stitching to place the new tie bars accordingly.

4.0 MEASUREMENT

4.1 Testing Limits. All driving lanes and shoulders requiring load transfer assemblies will be tested with Ground Penetrating Radar (GPR) equipment. All longitudinal joints will be tested. The Kentucky Transportation Center (KTC) will perform all testing.

4.2 Validation. A minimum of one location per lane mile will be cored to verify GPR testing. Two 4 inch cores shall be obtained at each location. One core will be taken on each dowel bar and to expose both ends and allow physical measurements. KTC will conduct coring while the contractor shall patch all core holes.

July 9, 2013