Preliminary Findings from VDOT Demo on Dowel Alignment Using Magnetic Imaging Tool Scan-2

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Demonstration Team

- **VDOT**
  - Kenneth Jennings
  - Jeff Martin & Robert Honeywell

- **VTRC**
  - Rick Childs

- **CPTP/CTL**
  - Tom Yu
Device designed specifically for the measurement of dowel bar position and alignment

– Developed by Magnetic Imaging Tools, GmbH
MIT Scan-2

Designed specifically for measuring dowel bar position and alignment using Magnetic tomography technology.
Dowel Alignment

Plan
- Horizontal translation
- Longitudinal translation
- Horizontal skew

Section
- Vertical translation
- Vertical tilt
Advantages

• Works on fresh or hardened concrete
• Real-time, automated data analysis
• Very accurate and reliable
• Efficient (1-2 min per joint)
  – 200 or more joints can be tested in an 8-hr workday
  – Up to 3 lanes can be tested in a single pass
So what if dowels are misaligned?

- The effectiveness of dowel bars may be compromised
  - Loss of load transfer efficiency (LTE)
  - Premature development of faulting
- Pavement damage may result
  - Spalling
  - Cracking
Demonstration Plan

- MIT SCAN-2 from FHWA under CPTP
- Training and Pilot Demo
  - US 460, Appomattox Bypass
  - November, 2005
- Perform scanning in different condition
  - Dowel Placement
  - Traffic Condition / Level
  - Five Demo Projects
### Features of MIT Scan-2

- Very efficient
- Automated data analysis
- Real-time results
- Works on fresh or hardened concrete

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**Highway** : US 90  
**Direction** : E  
**Station No.** : 1 + 00  
**Lane** : Lane 1  
**Joint** : 1  
**Bar type** : 454 x 38mm  
**Bar spacing** : 300 mm  
**Concrete thickness** : 280 mm  

<table>
<thead>
<tr>
<th>Bar No.</th>
<th>x-Loca Depth</th>
<th>Side Shift</th>
<th>Misalignm. Bar Shift</th>
<th>Vert. Space</th>
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<tbody>
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<td>-26</td>
<td>2</td>
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</tbody>
</table>
xs - X-Position  
zs - Depth  
dy - Side shift  
sh - Horiz. Misalignment  
sv - Vert. Misalignment  
* - Norm depth  
+ - Left end of bar  
- - Right end of bar  
Unit: Millimeter
Five Demo Projects

- I-64 in Hampton Roads District
  - EB HOV in City of Chesapeake
  - JPCP Constructed 1997
- US 60 in James City County
  - Very old JRCP
- I-66 in NOVA (Fairfax County)
  - JPCP Constructed 1995
  - WB Lane Between US 50 and VA 28
- I-295 in Richmond (Henrico County)
  - CRCP Constructed 1987
  - Southbound lane south of US 60
- US-460 in Lynchburg (Appomattox Bypass)
  - Eastbound between VA 26 to VA 24
  - JPCP Constructed in 1993-94
Key Factors Affecting Dowel Alignment

- **Basket**
  - Placement prior to paving
  - Number and type of pins used for anchoring

- **Dowel Bar Inserter (DBI)**
  - Equipment type
  - Equipment adjustment
  - PCC mix design
Dowel Placement

- Dowel Basket
  - US 460
  - I-64
- Mechanically Inserted Dowel (DBI)
  - I-66
- JRCP (No Dowel)
  - US 60
- Continuously Reinforced
  - I-295
  - No Transverse Steel
Safety

• All VDOT safety rules must be followed

• Traffic Control
  – Lane closer is preferable
  – Crash cushion in close proximity (25’ to 50’)
  – Rolling traffic control
    • Avoid bend or curve that obstruct long view
  – Traffic on the passing lane also need some control

• No injury reported

“No data is worth someone’s life” - Ken Jennings
Typical Results: US 460
Joint 87 (Travel and Acc. Lane)
Typical Results: US 460
Joint 87 (Travel and Acc. Lane)
Typical Results: I-66
Joint 54 (Travel Lane and shoulder)
Typical Results: I-66
Joint 54 (Travel Lane and shoulder)
Typical Results:
I-64, Joint 67

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Date + Time: 14/12/2005 14:23
File: g:\05_12_14\14121423.hdf

Highway: US 64
Direction: E
Station No.: 0 + 528
Joint: 67
Lane: Lane 4
Bar type: 454 x 38mm
Bar spacing: 300 mm
Concrete thickness: 230 mm

<table>
<thead>
<tr>
<th>Bar No.</th>
<th>x-Loca Depth</th>
<th>Side Shift</th>
<th>Bar Misalign.</th>
<th>Vert. Space</th>
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</table>
Summary Result for I-64

<table>
<thead>
<tr>
<th>Range of misalignment, mm</th>
<th>Percent of bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>d ≤ 10</td>
<td>91.6%</td>
</tr>
<tr>
<td>9 &lt; d ≤ 15</td>
<td>5.6%</td>
</tr>
<tr>
<td>15 &lt; d ≤ 20</td>
<td>13.2%</td>
</tr>
<tr>
<td>20 &lt; d ≤ 25</td>
<td>2.5% 3.9%</td>
</tr>
<tr>
<td>d &gt; 25</td>
<td>0.3% 0.8% 0.1% 1.3%</td>
</tr>
</tbody>
</table>
Joint Score

• Reflects the risk of joint locking – the higher the Joint score, the higher the risk
• Determined as a sum of product of number of bars at each level of misalignment and weighting factors
• Further research is needed to refine Joint Score

<table>
<thead>
<tr>
<th>Range of misalignment, mm</th>
<th>Weight</th>
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<tbody>
<tr>
<td>10 &lt; d ≤ 15</td>
<td>0</td>
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<tr>
<td>15 &lt; d ≤ 20</td>
<td>2</td>
</tr>
<tr>
<td>20 &lt; d ≤ 25</td>
<td>4</td>
</tr>
<tr>
<td>25 &lt; d ≤ 38</td>
<td>5</td>
</tr>
<tr>
<td>38 &lt; d</td>
<td>10</td>
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</tbody>
</table>
• Three replicate measurements
  • Interstate 64 at Hampton Roads District
  • Joints 1 through 9
  • 11 bars in each joint
  • 11 bars x 9 joints x 3 replicates
  • Total 297 measurements – 99 dowel bars @ 3 each

• Difference among replicate measurements
  • Depth – 100% within 2mm
  • Side Shift – 95% within 6mm
  • Horizontal Misalignments – 95% within 7mm
  • Vertical Misalignments – 98% within 2mm

• Statistical Repeatability
  • VDOT data – Analysis is being performed at VTRC
  • FHWA/ CPTP – ±5 mm at 95% confidence level
  • Manufacturer – ±2 mm for repeat measurements at same settings.
Bars must be insulated (epoxy coated), and the basket shipping wire is cut.
Dowels placed in a basket

Basket wire not cut

Basket wire cut

shipping wire
Typical Joint

Problem Joints
Calibration of MIT-Scan
Caltrans Dowel Box
Field Verification
Field Verification
Conclusions

• MIT Scan is user friendly
  – Learning was fast
  – Data analysis is more involved

• Safety concern
  – Existing pavement
  – Traffic control

• Areas of concerns with scanned data
  – Dowel basket shipping wire
  – Dowels deeper than 8 inch
  – Presence of tie bar
Conclusions

• MIT Scan Successfully performs
  – Mechanically inserted dowels
  – Dowels on the basket but shipping wire have to be cut

• MIT Scan would not do…
  – CRCP - Bar spacing and depth
  – JRCP - Interference from reinforcement

• CPTP Equipment Loan Program
  – Very efficient
  – Provided an opportunity to explore the new technology
  – Technical support is excellent
100 Years of Excellence
Thank You