Magnetic Imaging Technology
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H. Thomas Yu

State of the Practice
- The importance of proper dowel alignment is widely recognized, but it could not be verified effectively
- Many agencies specify strict alignment tolerances
  - Tolerance on rotation ranges from 3 mm (1/8 in) to 13 mm (1/2 in) for 457-mm (18-in) dowels
  - Typical tolerance is 10 mm (3/8 in)
- Acceptance is based on limited number of cores

MIT Scan-2
- MIT Scan-2 measures dowel alignment with unparalleled level of efficiency and accuracy
- What to do with all the data generated
- Problems that went unnoticed in the past are being detected – How bad is bad?
- Limitations of existing specifications on dowel placement tolerances:
  - Based on limited laboratory testing and analytical evaluation
  - Not verified with field performance

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

MIT Scan-2
- Device designed specifically for the measurement of dowel bar position and alignment
- Developed by Magnetic Imaging Tools, GmbH
- Based on the principles of pulse induction
Test track at MIT GmbH
Accuracy

- Conditions for best results
  - Depth: 150±40 mm
  - Horizontal & vertical misalignment: ±20 mm
  - Lateral placement error (side shift): ±50 mm
- Reported accuracy
  - Depth: ±4 mm
  - Rotation: ±4 mm
  - Side shift: ±8 mm
  - Repeatability: ±2 mm

Evaluation Results

- MIT specified accuracy was verified
- Overall standard deviation of measurement errors is estimated to be about 3 mm on rotation
  - Accurate to about ±5 mm at 95% confidence level

Dowel Bar Alignment in Typical Concrete Pavements

- Sponsored by American Concrete Pavement Association (ACPA)
- Objective – evaluate and document the dowel bar alignment in typical concrete pavements
  - Evaluated typical-construction projects with no reported construction-related problems
  - Both DBI and basket sections were included
  - MIT Scan-2 was used to measure dowel alignment
**Expanding the Realm of Possibility**

### Project location, ACPA Study

![Map of study locations](image)

- **Basket & DBI**: CA, NV, KY
- **IN2**: KY, MO, IN, GA
- **Retrofit**: NC, SC

### Quantifying Dowel Alignment

![Graph showing percent of bars](image)

- Bars categorized by range of misalignment:
  - $d \leq 10$
  - $10 < d \leq 15$
  - $15 < d \leq 20$
  - $20 < d \leq 25$
  - $d > 25$

### Joint Score

- Developed to assess the risk of joint locking; higher the Joint Score, higher the risk.
- Determined as a sum of product of number of bars at each level of misalignment and weighting factors that reflect the relative adverse effect.
- Further research is needed to refine Joint Score.

<table>
<thead>
<tr>
<th>Range of misalignment, mm</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10 \leq d \leq 15$</td>
<td>0</td>
</tr>
<tr>
<td>$15 \leq d \leq 20$</td>
<td>2</td>
</tr>
<tr>
<td>$20 \leq d \leq 25$</td>
<td>4</td>
</tr>
<tr>
<td>$25 \leq d \leq 38$</td>
<td>5</td>
</tr>
<tr>
<td>$38 &lt; d$</td>
<td>10</td>
</tr>
</tbody>
</table>

### A Joint-by-Joint Look at Dowel Alignment (IN1)

![Graph showing joint score](image)
Expanding the Realm of Possibility

A Joint-by-Joint Look at Dowel Alignment (IN1)

An Overall Project Look at Dowel Alignment (IN1)

High-Risk Level of Misalignment Implied in the Weighting Factors

Findings from the ACPA Study

- Dowel alignment in typical in-service pavements is generally very good
- All projects contained at least a few misaligned bars
- Several projects contained many severely misaligned dowel bars, but none exhibited any distresses
- Poor dowel alignment may cause looseness around dowel bars, which could greatly undermine the effectiveness of dowel bars
- Dowel alignment achieved using baskets and DBI are comparable

Comparison of DBI and Basket

Key Factors Affecting Dowel Alignment

- Basket
  - Placement prior to paving
  - Number and type of pins used for anchoring
- Dowel bar inserter
  - Equipment type
  - Equipment adjustment
  - PCC mix design
Conclusions

- Dowel bar alignment can be determined very accurately and efficiently using MIT Scan.
- There is a critical need to improve specifications on dowel placement tolerance.
  - Must be consistent with field performance and pavement behavior.
  - Consideration should be given to joint-by-joint evaluation.
  - Identify conditions that will cause a joint to lock up.
  - Determine the allowable number of locked joints.
- With care good alignments can be obtained using either baskets or inserters.