INTELLIGENT COMPACTION

More Science Than Art

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Why use IC?

- Good pavement requires a uniform foundation to build on
- Current compaction methods do not meet the needs

Fatigue life increases 70% on average with uniform support
What is it?

- A vibratory roller with a stiffness measurement system that records the material’s stiffness in real time
- A GPS system that tracks the roller’s position and pass counts in real time
- An in-cab display panel showing a color-coded map of stiffness, roller’s position, and pass counts in real time
What is it? - IC Rollers and Measurements

Caterpillar: CMV, MDP

Dynapac: CMV

Bomag: $E_{\text{VIB}}$ (MN/m²)

Sakai: CCV

Case/Ammann: $k_b$ (MN/m)

Hamm: HMV
What is it? - TxDOT IC Retrofit Kit

- Accelerometer
- Receiver
- IC Retrofit Kit
- Display Panel
- Accelerometer
- IC Retrofit Kit
What information does IC provide?

- Stiffness
- Pass Counts
IC provides stiffness and pass counts in two separate data files:

- **All Passes Data**: IC data (stiffness and pass counts) for all passes for a given area
- **Final Coverage Data**: IC data (stiffness and pass counts) only for the last pass for a given area
How to use the IC information?

- **ICMV (IC Measurement Values)**
  - A whole set of IC data collected in a given area
  - ICMV is assumed in normal distribution

- **ICTV (IC Target Value)**
  - The average of ICMV
  - Color codes are based on ICTV
How to use the IC information?

In-situ point tests such as NDG and DCP are performed based on the color-coded maps.
TxDOT IC Projects

Amarillo (1)
LP335

Waco (2)
SH95
FM2311

El Paso (1)
FM1281

Brownwood (3)
FM2214;
SH6;
SH206

Fort Worth (12)
FM156; DFW Connector; US287; FM1938;
FM730; SH267; IH35W; and IH30; FM2264;
FM1189; FM19838 (extension); US281

Paris (2)
SH24
US75

Atlanta (1)
FM450

Beaumont (1)
US90

Austin (1)
FM1460

Houston (1)
SH35
TXDOT Fort Worth District IC Projects

- **FM156 (FHWA Demonstration Project)**
  - FHWA/Pooled-fund study IC demonstration
- **FM1938 (Highway for Life Project)**
  - TxDOT retrofit kit implementation
- **DFW Connector Design-Build Project**
- **US 287 in Mansfield**
- **FM 731 at Lake Weatherford**
- **US 67 Bypass north of Cleburne**
- **IH 35W in North Fort Worth**
- **SH 267 Bypass around Dublin**
- FM 156 (North Fort Worth at Alliance Airport)
- FHWA/TPF IC Study
- Cohesive subgrade, Lime treated subgrade, and Aggregate Base (Flex Base)

**Intelligent Compaction**

- *padfoot drum IC roller*
- *smooth drum IC roller*

- Dynapac Single Smooth drum IC roller
Intelligent Compaction

*K_s* shows compaction progress and a soft area

Case/Ammann
Single-drum padfoot IC roller
Detect Underground Structures

Box Culvert

Point 1:
- CBR (%)
- Depth (mm)
- \( E_{LWD-Z2} = 61.1 \text{ MPa} \)
- \( E_{V1} = 42.1 \text{ MPa} \)
- \( E_{V2} = 121.1 \text{ MPa} \)
- \( E_{FWD-D3} = 57 \text{ MPa} \)
- \( E_{D-SPA} = 44 \text{ MPa} \)

Point 12:
- CBR (%)
- Depth (mm)
- \( E_{LWD-Z2} = 47.5 \text{ MPa} \)
- \( E_{V1} = 42.1 \text{ MPa} \)
- \( E_{V2} = 121.1 \text{ MPa} \)
- \( E_{FWD-D3} = 57 \text{ MPa} \)
- \( E_{D-SPA} = 44 \text{ MPa} \)

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- \( E_{FWD-D3} = 57 \text{ MPa} \)
- \( E_{D-SPA} = 44 \text{ MPa} \)

Point 5:
- CBR (%)
- Depth (mm)
- \( E_{LWD-Z2} = 58.4 \text{ MPa} \)
- \( E_{V1} = 96.9 \text{ MPa} \)
- \( E_{V2} = 381.1 \text{ MPa} \)
- \( E_{FWD-D3} = 145 \text{ MPa} \)
- \( E_{D-SPA} = 88 \text{ MPa} \)

Point 12:
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- \( E_{V2} = 381.1 \text{ MPa} \)
- \( E_{FWD-D3} = 145 \text{ MPa} \)
- \( E_{D-SPA} = 88 \text{ MPa} \)

\( w = 29.5\% \)
\( \gamma_d = 13.8 \text{ kN/m}^3 \)
\( E_{LWD-Z2} = 11.6 \text{ MPa} \)
Differentiate Different Materials

CMV Map $a = 1.2 \text{ mm}, f = 30 \text{ Hz}, v = 3.5 \text{ km/h}$

CMV Map $a = 1.9 \text{ mm}, f = 30 \text{ Hz}, v = 3.5 \text{ km/h}$

Flex Base

Lime Treated Subgrade

Flex Base

Dynapac
Single
Smooth drum
IC roller

Lime Stabilized Subgrade

Flex Base
Intelligent Compaction

- Project Length: 2.205 Miles
  Estimated Cost: $16.5M
  Estimated Duration: 367 Working Days

- Provides a more complete picture of the area being worked
- Less labor required
- Less time required due to testing
Intelligent Compaction

DFW Connector Design-Build Project

- $1.1 billion CDA Design-Build project
- Groundbreaking Feb. 17, 2010
- Expected completion 2014; complete 2013
- Approximately half the construction time needed for traditional contracts
Dallas/Fort Worth Connector

Courtesy Dr. David White Iowa State University

Compaq Report

Data Model: DWF Connector
Display: CCV
Site: Texas DFW Connector
Date: Friday, July 23, 2010

Compaction Analysis

- > 150.0
- 125.0
- 100.0
- 75.0
- 50.0
- 25.0
- 0.0
- Occupied

Filter Settings
Filter: <Not Specified>
Time Start: 12/12/1001 - 07:00:00 am
Time End: 12/12/1001 - 12:00:00 pm

July 2010

Courtesy Mark Morrow NorthGate Constructors
**Intelligent Compaction**

**DFW Connector Project**

Compaction Target Value (CTV) = 42

<table>
<thead>
<tr>
<th>% Target</th>
<th>CCV</th>
<th>IC Data</th>
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<tbody>
<tr>
<td>&gt;130%</td>
<td>55</td>
<td>26%</td>
</tr>
<tr>
<td>90-130%</td>
<td>38-55</td>
<td>68%</td>
</tr>
<tr>
<td>80-90%</td>
<td>34-38</td>
<td>4%</td>
</tr>
<tr>
<td>70-80%</td>
<td>29-34</td>
<td>1%</td>
</tr>
<tr>
<td>&lt;70%</td>
<td>&lt;20</td>
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Current TxDOT QA Criteria:

>90% of IC Data should be equal to or greater than the CTV
- US 287 (Mansfield TX)
- New frontage roads and bridges
- Lime treated subgrade
- Testing of 4 separate locations with DCP, DSPA, IC, and NDG
- FM 730 (over Lake Weatherford headwaters)
- New bridge on roadway realignment
- Wet to inundated natural ground, 5’ rockfill embankment, low PI soil embankment, lime treated subgrade, and flex base
- US 67 (widen to 4 lane divided section)
- SH 267 (construction of a new 4 lane divided bypass)
- IH 35W (Reconstruction of a freeway section)
- Natural field crushed rock, lime treated subgrade, and flex base
IC benefits

- Provides uniformity information
  - Covers 100% of the compacted area
  - Tracks roller’s position and pass counts
- Identifies areas of poor compaction
- Selects areas to test for QC/QA
- Eliminates guesswork and reduces risk of rework
- Optimizes efficiency, maximizes productivity and minimizes costs
- Improves safety in construction zones
IC Challenges

- Executive leadership and champions
- Extensive training for both DOT’s staff and contractors
- GPS system setup
- Data management including data collection, conversion, and analysis
Questions?

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