IAPA Annual Conference

I.C. for HMA

03/13/2017
Intelligent Compaction for HMA

- Keys to success
- What is Intelligent Compaction?
- Why use Intelligent Compaction?
- Systems
- Options
- Benefits
- Weaknesses
- Data. Lots and Lots (probably some sublots) of Data.
Keys to Success (Rebecca Embacher, MnDOT)

- No one should be asked to bid on something they don’t understand
- Staged implementation, learn to walk before you run
- Collaboration between Agency and Contractors
- Agency flexibility during the early stages
- Get local Equipment and Technology dealers involved early
- Work with Equipment and Technology Dealers to involve factory SME’s when needed
- Get familiar with VETA
Contractor Collaboration

- Meeting Platforms
  - Asphalt Pavement Quality and Technology Committee (3-4 times / year)
  - Specification Committee (1-2 times / year)
  - Association of General Contractors (2 times / year)
  - Ad-Hoc Committees (as needed)
  - Minnesota Asphalt Paving Association (all meeting platforms)
  - Workshops
  - Training

- Discussions
  - Specification development
  - Implementation Schedules
  - Debriefings
  - New technologies, practices & opportunities
  - Solutions to existing problems
  - Needs / Resources
What does Intelligent Compaction do?

- **Displays and records:**
  - **Pass count** of a roller
    - Can be used on entire roller train
      - Breakdown, intermediate, finish
  - **Temperature** of asphalt surface
    - Operator notified if mat temperature is outside of user-defined range
  - **CMV** (Compaction Meter Value)
    - CMV is an indication of mat stiffness and is recorded using an accelerometer
    - It is not density
Why use IC Technology?

- To solve a problem
  - If there is no problem to solve, we have an answer in search of a question.

- Does anyone have problems with Compaction?
  - Yes: We’ll move on with the presentation.
  - No: Thank You and have a nice day! See you at the bar!
Why use IC Technology?

- To achieve the desired compaction the compactor operator needs to achieve a *specified pass count* target at a *specified speed* (or ipf) within a *specified temperature range*.
  - The problem; No one can effectively keep track of all these things all day every day?
Why use IC Technology?

- Common issues we see today in the field:
  - The operator can easily lose track and the job becomes guesswork
  - Increasing speed to catch up with the paving train
    - Are there enough compactors on site?
  - Machines running “tandem”
    - You got that covered while I was getting water, right?
  - The supervisor cannot monitor pass count performance and cannot verify accurate completion of the compaction job
  - Inconsistent density
    - Under compaction
    - Over compaction
    - Outlying cores
  - Penalties, missed bonuses, premature road failure and legal issues
Why use IC Technology?

- Beneficial for all operators, especially inexperienced operators/night work
- Ensures proper mat compaction
- Ensures compaction efforts during temp windows
- Financial incentives
- Implementing IC Technology gives us actionable data
  - Real Time Data
  - Historical Data
Benefit: Pass Count Mapping

- To achieve the desired compaction the compactor operator needs to achieve a *specified pass count* target at a *specified speed* (or ipf) within a specified temperature range.
  - Operator doesn’t have to guess
  - Display gives operator real time pass count
  - Ensure uniform compaction efforts
  - Ensure complete coverage
Pass Count Mapping

*Avoid over or under-compaction*

- Displays pass count maps, allowing operator to track where pass count target has been met
- Pass count mapping allows you to monitor the number of passes over an area and adjust your effort
Benefit: Temperature Mapping

- To achieve the desired compaction the compactor operator needs to achieve a certain pass count target at a specified speed (or ipf) within a specified temperature range.

- Common issues we see today in the field:
  - Rollers too far behind the paver, mat too cool
  - Rollers in the “Tender Zone”
Temperature Mapping

*Know exactly where to be for ideal compaction timing*

• When installed with two optional IS310 Infrared Sensors, CCS900 maps the surface temperature of the mat

• Displays temperature maps, allowing operator to judge his time window for compaction across the surface
Benefit: CMV Mapping

- Ensure proper vibe state during compaction effort
- Ensure proper machine settings (freq and amp)
- Knowledge of results of compaction effort
- Historical Data
CMV – Compaction Meter Value

*Understand your compaction*

- CMV is an accelerometer based sensor that gives the operator an indication of the stiffness and consolidation of the material below the roller.
- The value may be correlated to the accepted static density test being used on the project.
- Takes into account the level of compaction taking place with respect to the vibratory effort, roller size, weight, speed, vibratory frequency and amplitude of the drum.
Benefit: Historical Data

- Though it is an “After the fact” analysis, historical data can help us improve our work flow and our final product by helping us to plan intelligently.
- Proof that work was performed as per specification.
- Data can be analyzed to determine root cause of some problems.
What is being specified in IC?

- **Common Specifications:**
  - Pass count of vibratory roller
    - Have seen requirements for entire roller train
  - Temperature mapping of asphalt mat
  - Typically, RTK precision is required
  - Coordinate systems vary by project
  - In US, VETA output is expected
  - CMV often specified, although does not usually affect pay
Systems

- Pass Count, Temperature Mapping, ICMV
  - Atlas Copco (Dynapac); Dyn@lyzer
  - Bomag; Asphalt Manager
  - Caterpillar; Cat Compaction Control
  - Hamm/ Wirtgen; HCQ
  - Sakai; Compaction Information System2
  - Volvo; Volvo IC w/Density Direct
  - Topcon; C-63 Intelligent Compaction System
  - Trimble; CCS900 Intelligent Compaction System
Accelerometer

- **Weaknesses**
  - Too many variables. Temperature, thickness, depth of reading, mix design, speed, direction, amplitude, frequency.
  - A reasonable correlation can be made between Density and “stiffness” (CMV) in a very controlled situation. Real world paving and compaction can’t be controlled that tightly.
  - Accelerometer reads ~3-10’ deep. We only care about top layer.
  - Accelerometer will indicate a stiff mat regardless of its density once the mat has cooled.
Accelerometer

- **Benefits**
  - Can help us understand underlying deficiencies (Weak areas)
    - Plan for future rehabilitation
  - Lets us understand vibe state, amplitude, and frequency
  - Can give us a reasonable understanding of density if we control the other variables
GNSS Accuracy

- Differing levels of GNSS Accuracy
  - Differential GNSS using SBAS (WAAS) ~3’ accuracy
    - UTM Coordinate System
    - Not repeatable
  - RTK GNSS .1’ accuracy
    - State Plane, Arbitrary Localization, you pick.
    - Pass to pass repeatability
    - Navigate to problem areas
    - Utilize 3D Design if available
    - Requires a correction stream; Local Base or VRS (CORS)
Temperature Sensors

- Center Mounted Sensor; Always reading a “wet” mat
- Front and Rear Mounted Sensors; Always reading a “dry” mat
Other Options

- **Map Sharing**
  - Operators of multiple machines share mapping information.
  - Several manufacturers offer map sharing

- **Web based data**

- **Veta (Veda)**

- **In field reporting**
What is Machine to Machine Mapping?

- Enables 2 or more machines to share mapping data in real time
- Machines able to work from a common updated map
Cloud Based Data

Automatic Data Transfer to Cloud

- Modem, or Wi-Fi for transferring to cloud storage

40-60% data losses through manual data transfer methods
IC- Benefits

- Uniform efforts make more uniform cores.
- Operator has data required to make decisions and adjustments in real time.
- Supervisor has actionable data at his fingertips.
- Huge amount of Data!
IC- Weaknesses

- No Common Data Platform
  - Veta helps

- Continued disagreement regarding what is “important”

- FHWA definition of Intelligent Compaction is too narrow
  - Emerging technologies
  - Trans Tech PQI380 OTR (Coming Soon)

- Huge amount of data! Planning ahead will make the difference between success and failure.
What is VETA?

- VETA is a software for viewing and analyzing geospatial data
- Developed by The Transtec Group and sponsored by Minnesota Department of Transportation (MnDOT).
- VETA can import data from various intelligent compaction (IC) machines and MOBA PAVE-IR thermal profile data to perform viewing, editing/layering, point tests, and analysis.
- Download at intelligentcompaction.com
Why MnDOT is using Veta?

Non-Proprietary Software
- Low Bid Build
- Ease of Statewide deployment within State Agency

Database
- Construction/As-Built Record
- Correlate to Pavement Performance
- Compaction Curves – Rolling Pattern Development

Specification Refinements

Support Multiple Technologies
- Intelligent Compaction
- Paver Mounted Thermal Profiling
- Ground Penetrating Radar
- Digital Test Rolling
- Spot Tests (Density, FWD, etc.)
- ...other geospatial technologies

Training / Field Support
- Effects of Paver Stops on Ride & compaction efforts
- Effects of Compaction Efforts on Uniformity
- ...and more
Instrumentation of Entire Rolling Train
Data

**Design File (Background, Alignment File)**

- **Layers**
  - Centerline
  - Station Text
  - Station Tick Marks
  - Exceptions
  - Closed Complex Shapes

- **Horizontal Accuracy**
  - ± 2 in (50 mm)

- **3 Working Days of Contract Approval**
  - Format
    - DGN
    - 2D-KMZ (Veta)
  - County coordinate system
  - Total lane miles per material type/lift

**Goal:** Eliminate need of complex shapes by 2018!
Data

Complex Shapes – Trimming Data

Before using complex shape in Veta to remove extraneous data

147+55.36  499.818.208  153.273.824

After using complex shape in Veta to remove extraneous data

147+55.36  498.818.208  153.273.824
Data

Complex Shapes – Trimming Data (cont.)

- Create separate complex shape, per lane, for each side of exception
Lot Establishment (not lots used for density!)

Used for ease in mapping and data analyses in Trimble VisionLink Legacy & Veta

<table>
<thead>
<tr>
<th>Specification</th>
<th>Definition</th>
</tr>
</thead>
</table>
| 2353 (UTBWC) | Measurements for a given:  
  - Day  
  - Material Type  
  - Lift  
  - Centerline Offsets  
  - Direction of Travel (Divided Highway) |
| 2360 (HMA, WMA) |  |
| 2365 (SMA) |  |
| 2215 (SFDR) | Measurements for a given:  
  - Material Type  
  - Lift  
  - Centerline Offsets  
  - Direction of Travel (Divided Highway) |
| 2331 (CIR) |  |
Standardized Naming Convention of Lots

- Creative naming conventions.
- Multiple names for one lot.
- Roller operators selecting different names.

<table>
<thead>
<tr>
<th>Standardized Format*</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROUTE-MATL-L#-XXX-XXX</td>
<td>Undivided Highways (e.g., TH12-HMA-L1-CL-12R)</td>
</tr>
<tr>
<td>ROUTE-MATL-L#-XXX-XXX-DT</td>
<td>Divided Highways (e.g., TH12-HMA-L1-CL-12R-NB)</td>
</tr>
</tbody>
</table>

*Add an additional designation behind route for instances where more than one site calibration is needed within the project limits (e.g., TH12N-HMA-L1-12L-CL, TH12S-HMA-L1-12L-CL)
### Lot Naming Standardization: Route

<table>
<thead>
<tr>
<th>Acronym or Short Form</th>
<th>Full Name or Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR</td>
<td>County Road</td>
</tr>
<tr>
<td>CSAH</td>
<td>County State Aid Highway</td>
</tr>
<tr>
<td>MS</td>
<td>Municipal Street</td>
</tr>
<tr>
<td>MSAS</td>
<td>Municipal State Aid Street</td>
</tr>
<tr>
<td>TH</td>
<td>Trunk Highway</td>
</tr>
</tbody>
</table>

Replace **ROUTE** with route system followed by the route number (e.g., TH12)
### Lot Naming Standardization: Material / Surface Type

**ROUTE-MATL-L# -XXX-XXX**

<table>
<thead>
<tr>
<th>Acronym or Short Form</th>
<th>Specification</th>
<th>Full Name or Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFDR-P</td>
<td>2215</td>
<td>SFDR - Pulverization</td>
</tr>
<tr>
<td>SFDR-I</td>
<td></td>
<td>SFDR – Mixing/Injecting</td>
</tr>
<tr>
<td>CIR</td>
<td>2331</td>
<td>Cold In-Place Recycling</td>
</tr>
<tr>
<td>UTBWC</td>
<td>2353</td>
<td>Ultrathin Bonded Wearing Course</td>
</tr>
<tr>
<td>HMA</td>
<td>2360</td>
<td>Hot Mix Asphalt</td>
</tr>
<tr>
<td>WMA</td>
<td></td>
<td>Warm Mix Asphalt</td>
</tr>
<tr>
<td>SMA</td>
<td>2365</td>
<td>Stone Matrix Asphalt</td>
</tr>
</tbody>
</table>
# Lot Naming Standardization: Lift Number

**ROUTE-MATL-L#-XXX-XXX**

<table>
<thead>
<tr>
<th>Acronym or Short Form</th>
<th>Full Name or Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Lift 1</td>
</tr>
<tr>
<td>L2</td>
<td>Lift 2</td>
</tr>
<tr>
<td>L3</td>
<td>Lift 3</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Ln</td>
<td>Lift n</td>
</tr>
</tbody>
</table>
Lot Naming Standardization: Centerline Offset

ROUTE-MATL-L# -XXX-XXX

STA. 339+51.58 - 362+84.57
(21ST ST.- L&M)

22L-11L
11'
DRIVING LANE

11L-CL
11'
DRIVING LANE

CL-11R
11'
CONTINUOUS LEFT TURN LANE

(3)

11R-22R
11'
DRIVING LANE

(2)

11R-22R
11'
DRIVING LANE

(2)

T.H. 169
(TH169NP)

22R-33R
11'
RT. TURN LANE

VAR.

EXISTING BITUMINOUS PAVEMENT

5.0" TYPE SP 12-5 WEARING COURSE MIX - SPEC. 2360 (1)
3.0" MILL BITUMINOUS SURFACE - SPEC. 2237
PLACE BITUMINOUS PATCHING MIXTURE - SPEC. 2231 (1)
### Lot Naming Standardization: Direction of Travel (Divided Highways)

**ROUTE-MATL-L#-XXX-XXX-DT**

<table>
<thead>
<tr>
<th>Acronym or Short Form</th>
<th>Full Name or Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>North Bound</td>
</tr>
<tr>
<td>SB</td>
<td>South Bound</td>
</tr>
<tr>
<td>EB</td>
<td>East Bound</td>
</tr>
<tr>
<td>WB</td>
<td>West Bound</td>
</tr>
</tbody>
</table>
Example 1 – Divided Highway, 12-ft Asphalt Paving

<table>
<thead>
<tr>
<th>Production Area</th>
<th>Lift</th>
<th>Lot ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>TH12-HMA-L1-12L-CL-WB</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>TH12-HMA-L2-12L-CL-WB</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>TH12-HMA-L1-CL-12R-WB</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>TH12-HMA-L2-CL-12R-WB</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>TH12-HMA-L1-12L-CL-EB</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>TH12-HMA-L2-12L-CL-EB</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>TH12-HMA-L1-CL-12R-EB</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>TH12-HMA-L2-CL-12R-EB</td>
</tr>
</tbody>
</table>
## Data

### Undivided Highway, Auxiliary Lane, 18-ft Asphalt Paving

<table>
<thead>
<tr>
<th>Production Area</th>
<th>Lift</th>
<th>Lot ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>TH12-HMA-L1-18L-CL</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>TH12-HMA-L2-18L-CL</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>TH12-HMA-L1-CL-18R</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>TH12-HMA-L2-CL-18R</td>
</tr>
</tbody>
</table>
Use Machine Design to Store Lot Names w/ IC Measurements

TH12-HMA-L1-CL-12R

Trimble VisionLink Legacy

Veta

Data Filters
- Operation Filters
  - TH12-HMA-L1-CL-12R
  - Design name
  - Time filter (unused)
  - Location Filter

Imported file name
Machine ID

Trimble
Data

Selection of Lot Name using the CB460

Figure Courtesy of Ziegler CAT
Data

Verification of Selected Lot Name on CB460

Figure Courtesy of Ziegler CAT
Data

Engineer Collects Coordinates of Lot Boundaries
Data

Trimble Feature Code Library used for Lot Boundary Coordinates

PROJECT NUMBER: SP2105-56
ROUTE NUMBER: 54
Paving Date: Wednesday, August 17, 2016
Lot Corners: B1
Centerline Offset Typical: 12L-CL
Direction of Travel: NB

ROUTE SYSTEM: TH
Material Type: HMA (2360)
Boundary: Lot
Lift Number: L1
Keyed in CL Offsets (non typical): ?

Auton H:? V:? Options Store

Trimble
Lot Boundary Coordinates used in Veta Location Filter

Data

Rover Coordinates

11492.5 689236
11492.0 689180
11417.6 690498
11414.7 690538
Data

Use Standardized Naming Convention for Filters in Veta

LOT# MMDDYY LOTNAME

Filter Group Names
Data

- **Pass Count**
  - 3
  - 2
  - 1

- **CMV**
  - 65.0
  - 40.0
  - 30.0
  - 10.0
  - 0.0

- **Speed (mph)**
  - 80
  - 70
  - 60
  - 50
  - 40
  - 30
  - 20
  - 10
  - 0.0

- **Temperature (°F)**
  - 300
  - 275
  - 250
  - 225
  - 200
  - 175
  - 150
  - 100
  - 70

**Breakdown Roller**
- 11050218 HMA-L2-13L-CL
- Roller coverage and pattern looks good.
- Vibration turned off too soon prior to roll out onto adjacent lane.
- Fast rolling speeds.
- Cooler rolling temperatures.

---

Project L (cont.)
### Data

#### Breakdown Roller

*11 050216 HMA-L2-12L-CL*

Roller coverage and pattern looks good.

Vibration was on; location in between areas where operator rolls out onto adjacent lane.

Fast rolling speeds.

Cooler rolling temperatures.
- www.intelligentcompaction.com

- Thank You!

- Questions?

- If you want to discuss more, I will probably be at the bar with a glass of Bourbon in my hand this evening.