ICDM-Veta Workshop

Intelligent Construction Data Management

Flexible Pavements of Ohio
Columbus, OH
16 April 2018
ICDM-Veta Workshop
Intelligent Construction Data Management

TABLE OF CONTENTS

WORKSHOP AGENDA
CONTACT INFORMATION
WORKSHOP SLIDES
   Session 1 – IC/PMTP Basics
   Session 2-1 – IC/PMTP Field Data Collection & Management (I)
   Session 2-2 – IC/PMTP Field Data Collection & Management (II)
   Session 3 – IC Data Analysis & Interpretation
   Session 4 – IC/PMTP Trouble Shooting

VETA SOFTWARE
HANDS-ON SAMPLES
Workshop Agenda

OBJECTIVES

- To understand the basics of the Intelligent Compaction (IC) and Paver-Mounted Thermal Profiles (PMTP) technologies and Veta software.
- To understand DOT IC/PMTP specifications and how to meet the requirements
- To understand the IC/PMTP data collection, data characteristics, and trouble shooting.
- To practice hands-on Veta analysis to understand how to meet DOT's expectation.

WORKSHOP AGENDA

AM

08:30 am  Veta software setup and checks
09:00 am  Session 1 - IC/PMTP Basics
09:45 am  Session 2-1 - IC/PMTP Field Data Collection & Management (I)
10:30 am  Break
10:45 am  Session 2-2 - IC/PMTP Field Data Collection & Management (II)
12:00 pm  Break

PM

01:00 pm  Session 3 - IC/PMTP Data Analysis & Interpretation
02:15 pm  Break
02:30 pm  Session 4 - IC/PMTP Trouble Shooting
03:30 pm  Session 5 - Review and Discussion
04:00 pm  Adjourn
Contact Information

If you would like more information or have questions or comments regarding any of the topics presented at this workshop please contact the following. Thank you for your participation in this workshop.

**ICDM TRAINER**

Dr. George K. Chang, P.E.

Director of Research
The Transtec Group
Address: 6111 Balcones Drive, Austin, Texas USA
Phone: +1 (512) 451-6233
Email: GKchang@TheTranstecGroup.com

Dr. George Chang is recognized as the expert on pavement smoothness and intelligent compaction/construction technologies. His research, teaching, specification development and software tools (such as ProVAL and Veta) have helped made significant technology advancements in the above fields. Dr Chang has been the principal investigator for numerous projects that enhancing pavement materials/structures, pavement surface characteristics, etc. Recognized for his energetic, lively teaching style, Dr. Chang delivers smoothness and intelligent compaction/construction related workshops around world.

Dr. Chang has been the chairman for the International Intelligent Construction Technologies Group (IICTG), Road Profile Users’ Group (RPUG), TRB AFD90 Pavement Surface Properties and Vehicle Interaction committee, etc. Dr. Chang received many awards including a Kummer Lecture Award, Meyer-Horne Award, and ASTM Billiard-Stubstad Award from the ASTM; and NOVA award from Construction Innovation Forum, Founders’ Award from RPUG. His research work has been featured in over 50 professional publications and 100+ reports.

Intelligent Compaction website: [www.IntelligentCompaction.com](http://www.IntelligentCompaction.com)

Transtec Group website: [www.TheTranstecGroup.com](http://www.TheTranstecGroup.com)
Workshop Slides
Section 1 – IC Basics

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Intelligent Construction Data Management

By
Dr. George K. Chang, PE

Session 1A
IC Basics

OEM IC Systems
Section 1 – IC Basics

**Example IC Retrofit System**

- GPS Antenna
- IR Temperature Sensor
- MD-3 and Satellite Radio
- Accelerometer

Courtesy of Topcon/RDO

**Soils IC vs. Asphalt IC**

**Intelligent Compaction Measurement Values (ICMV)**

- Control System
- Accelerometer
- Compaction & reaction force
- Correlation with materials modulus & density
Section 1 – IC Basics

Various ICMVs

Foot Print and Influence Depth
Section 1 – IC Basics

Asphalt Density vs ICMV (Stiffness)

Standard IC Software - Veta

Data Export
- USB, email, etc.

Vendor's cloud

Manual
- USB, etc.

Spot test data

Automatic

Manual

IC/PMTP data
Section 1 – IC Basics

Direct Download from Cloud to Veta

IC/PMTP data

Veta IC Analysis

IC Data Analysis
Section 1 – IC Basics

Veta Analysis – Coverage of Target Passes

Veta Analysis – Coverage of Target ICMV

Benefits of Using IC and PMTP
Section 1 – IC Basics

Premature Failure
Check for soft spots and repair before any paving is allowed.

Identify Underlying Joints
- PCC Joints
- CMV
- HMA Overlay Lift 1
- 15 ft or 4.6 m Joint spacing

Improved Rolling Pattern
Before
After the Blind Test
After
Section 1 – IC Basics

**Improved Roller Coverage**

- First Time Use of IC
  - Lift 1 without IC: 66%
  - Lift 2 with IC: 80%
- 30% Increase in Compaction Efforts

**Adjust Rolling Operations**

- Add One Roller and Slow Down Paver to Improve Asphalt Density

**Identify Causes of Failed Density**

- Failed:
  - Turn off Vib
  - Too Early
- Passed:
  - Consistent Vib Thru Out

Courtesy of MNDOT
Section 1 – IR Basics

Thermal Steaks

Causes of Segregation

Segregation and Thermal Streaks from Tractor

- Center line (A)
- Edge of conveyor tunnel to end of mainframe (B & C)
Section 1 – IR Basics

Comparison of Core Samples

Thermal Maps and Surface Distresses

1.5 Years Later

Thermal Maps and Surface Distresses

18
Section 1 – IR Basics

Thermal Camera vs IR/PMTP

An Example IR/PMTP (MOBA PAVE-IR)

Example IR/PMTP Software (MOBA PPM)
Section 1 – IR Basics

An Example IR/PMTP (Vogele RoadScan)

Example IR/PMTP Onboard Display (Vogele RoadScan)

AASHTO PP80 Range Value

Range = Temp98.5 Percentile – Temp1 Percentile
Section 1 – IR Basics

### AASHTO PP80 Temperature Segregation

<table>
<thead>
<tr>
<th>150-ft Sublots</th>
<th>Range</th>
<th>Segregation</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>$\Delta F \leq 25^\circ F$</td>
<td>NO SEG</td>
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<tr>
<td></td>
<td>$25^\circ F &lt; \Delta F \leq 50^\circ F$</td>
<td>MODERATE</td>
</tr>
<tr>
<td></td>
<td>$\Delta F &gt; 50^\circ F$</td>
<td>SEVERE</td>
</tr>
</tbody>
</table>

### Temperature Segregation – MTV Usage

- **End Dump MTV**
- **All Else Are Equal**
- **MTV**

### Temperature Segregation – Types of Paving

- **End Dump**
- **Pickup Machine**
- **Material Transfer Device**
Section 1 – IR Basics

Identify Inconsistent Windrows
Material and Thermal Segregation

Monitor Material Changes

Mirror of Paver Stops with ALR
IR & Paver Stops
IRI ALR
Session 2A
IC Data Collection & Management

Steel Drum IC Roller

- GPS Antenna
- Infrared Temperature Sensor
- Accelerometer
- NCO.3 and Satel Radio
- GA-60

Veta5
ICDM-Veta Workshop
Intelligent Construction Data Management

By
Dr. George K. Chang, PE

The Transtec Group
The World's Pavement Engineering Specialists
Section 2 – IC Data Collection

Network RTK VRS

GPS Site Localization

GPS Validation
GPS Verification Steps (1/2)

1. Move the IC roller around until the GNSS header computation is initialized.
2. Move the IC roller and park at a selected location.
3. Record the GPS measurements from the IC roller ensuring the distance offsets are applied so that the GPS coordinate is at the center or at left/right edges of the front drum.
4. Mark two locations on the ground adjacent to the right and left edges of the front drum contact patch. Move the IC roller from the marked locations.

GPS Verification Steps (2/2)

4. Use a hand-held rover to measure at the marked locations.
5. Average the rover GPS measurements if the roller GPS measurement is at the center of the front drum.
6. The difference should be within ± 6 in. in both the northing and easting directions.

AASHTO PP81: Diff < 6 in.

Temperature Validation

AASHTO PP81: Diff < 5°F
Section 2 – IC Data Collection

Example Onboard Display

- Cycle as-built type (ICMV, Temp, Passes)
- Configurable test overlay
- Customizable as-built mapping colors, showing updates of all rollers live
- IOMV indicator
- Configurable bar
- Toggle as-built mapping
- Automatic forward/reverse detection with override
- Other roller

Example IC Data Recording

- Enabling As-built Surface
- 153.1 °C
- 117.0 °C

Spot Tests and GPS Data
Section 2 – IC Data Collection

**Spot Tests and GPS Data**

<table>
<thead>
<tr>
<th>Spot</th>
<th>Northing</th>
<th>Easting</th>
<th>Test Type</th>
<th>Value</th>
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**Correct Data Header**

**Daily Production Boundary**

**Example of Daily production boundary**

Clockwise or Counter Clockwise
Hands-on Exercise with Veta
Session 2B
IR/PMTP
Data Collection & Management

Daily PMTP Setup

- Mount IR and GPS receiver on the paver
- Start the paver
- Calibrate IR DMI (if needed)
- Start a new IR file for data collection
- Record data
- Upload IR data to cloud or download to USB

Section 2 – IR Data Collection
Section 2 – IR Data Collection

Vogele RoadScan PMTP

Vogele RoadScan Hardware Kit

Vogele RoadScan System
AASHTO PP80 Temperature Calibration

- Before each project, compare the thermal output from the surface temperature reading(s) to a NIST traceable temperature sensor when measuring a material of a known temperature.

- **Tolerance 3.6°F or 2.0%**
AASHTO PP80 GNSS Calibration

• Before each project, the GNSS output shall be compared to a survey grade rover coordinate over a static point. The comparison is considered acceptable if the X and Y distance between the GNSS system and survey rover are within the required limits (<4 ft).

PMTP DMI Calibration

MOBA PAVE-IR Measurements

1 ft X 1 ft grids
Adjacent Pavements /shoulder
Section 2 – IR Data Collection

Vogele RoadScan Measurements

Fixed infrared camera: 10 m (32.8 ft) wide Scan
Scan grid: 40 time 25 cm x 25 cm grids
Image resolution: 120 x 16 pixels
Temperature range: 32 to 482°F
Inaccuracy: ±±2%

16 individual readings Per 25cm x 25cm Grid
• Provide 1 average value

IC/PMTP data
Spot test data

Data Export
Vendor’s cloud server
Manual USB

Manual USB, email, etc.
Section 2 – IR Data Collection

Direct Download from Cloud to Veta

IC/PMTP data

Hands-on Exercise with Veta
Session 3 – IC Data Analysis

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Intelligent Construction Data Management

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Session 3A
IC Data Analysis & Interpretation

IC Raw and Gridded Data

Raw Data

Gridded Data
Session 3 – IC Data Analysis

### All-Passes Data

<table>
<thead>
<tr>
<th>Data Layer 3</th>
<th>Data Layer 2</th>
<th>Data Layer 1</th>
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</thead>
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<td>Pass 1 Pass 1</td>
<td>Pass 2 Pass 2</td>
<td>Pass 1 Pass 1</td>
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<tr>
<td>Pass 3 Pass 3</td>
<td>Pass 2 Pass 2</td>
<td>Pass 3 Pass 3</td>
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</table>

### Final Coverage Data

Bird Eye View

---

### Vendors IC Data Formats

<table>
<thead>
<tr>
<th>Features</th>
<th>KOMAG</th>
<th>Caterpillar/Trimble</th>
<th>Dynapac</th>
<th>HANIF/Whiggin</th>
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<td>*.cva</td>
<td>*.csv</td>
<td>*.txt</td>
<td>*.vexp</td>
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<td>Text</td>
<td>Text</td>
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<tr>
<td>Raw Ungridded</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geographic GPS data (Long./Lat.)</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Grid data (Northing/Easting)</td>
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<tr>
<td>Coordinate zone in header</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mesh size (horizontal)</td>
<td>0.3m X 0.3m</td>
<td>1.0m X 0.15m</td>
<td>0.4m X 0.4m</td>
<td>0.6m X 0.5m</td>
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---

### Vendors IC Data Formats (cont’d)

<table>
<thead>
<tr>
<th>Features</th>
<th>Sakai/Topcon**</th>
<th>Volvo</th>
<th>MOBA***</th>
<th>Leica***</th>
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<td>*.csv</td>
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<td>Text</td>
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<tr>
<td>Raw Ungridded</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Grid data (Northing/Easting)</td>
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<td>Coordinate zone in header</td>
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<td>0.3m X 0.3m</td>
<td>0.25m X 0.25m</td>
<td>?</td>
</tr>
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</table>

** Direct Download from the Cloud to Veta 5.0+
*** Veta 5.1+
Draft AASHTO ICT Data Standard

Referenced in PP80 & PP81

Standard ICDM Software - Veta

Required in PP81

IC Data Import to Veta

• Specific vendor’s data
• Multiple days’ data
• Multiple rollers’ data from the same vendor
• Mix different vendors’ data (not yet)
• Mix IC data with other types of data – IR, GPR, smoothness (not yet)
IC Data Import to Veta – Local vs. Cloud

- From local files
- Direct import from the Cloud (not yet)

IC Data Import to Veta – Gridded vs. Raw

- Gridded All-passes data (Veta 4.0+)
- Raw ungridded data (BOMAG and TOPCON Cloud)

Data Import Wizard

List of Machines

Machine

- (New)
- (Moved)
- (Added)
- (Deleted)
- Cancel
- Verify
- Select
- Finish
- Close
Session 3 – IC Data Analysis

Manage Imported Data Files

View IC Data Maps

Filtering Data
Filter Group

- Data Filter
- Operation Filter
- Overwrite Filter

Veta Operation Filter

Daily Production Boundary

Sorted Northing Easting
Topo1 4385.077.823 572.07.617
Topo3 4385.077.823 572.07.617
Topo5 4385.063.52 572.05.613
Topo7 4385.059.82 572.05.813
Topo9 4385.056.82 572.05.613
Topo11 4385.053.82 572.05.382
Topo13 4385.050.82 572.05.082
Topo15 4385.047.82 572.04.782
Topo17 4385.044.82 572.04.482
Topo19 4385.041.82 572.04.182
Topo21 4385.038.82 572.03.882
Topo23 4385.035.82 572.03.582
Topo25 4385.032.82 572.03.282
Topo27 4385.029.82 572.02.982
Topo29 4385.026.82 572.02.682

Clockwise or Counter Clockwise
Veta Location Filter
Sorted Daily Production Boundary

IC Data Filtering
Before

Filter Group Generator
Auto-Generated Filter Groups Per Naming Convention in AASHTO PP81 And MnDOT specs
Create Sublots

Spot Tests and GPS data

<table>
<thead>
<tr>
<th>ID</th>
<th>Northing</th>
<th>Easting</th>
<th>Test Type</th>
<th>Value</th>
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<tr>
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Import Spot Test Data
Session 3 – IC Data Analysis

Veta Analysis Results

Coverage Result

Overall Statistical Analysis
Session 3 – IC Data Analysis

Overall Correlation Results

Overall Compaction Curve

Target ICMV for QC
Target ICMV from Trial Section Data

Passing
R > 0.7
Or
R² > 0.5

Coverage of Target ICMV

Sublot Results
Session 3 – IR Data Analysis

**Standard ICDM Software - Veta**

Required in PP80

**Import IR/PMTP Data to Veta**

**Data Filter and Location Filter**
AASHTO PP80 Exclusion of Paver Stops

Exclude 2’ prior to & 8’ after the paver stop area

And Exclude all data < 180 °F

AASHTO PP80 Range Value

\[ \text{Range} = \text{Temp}_{98.5 \text{ Percentile}} - \text{Temp}_{1 \text{ Percentile}} \]
Session 3 – IR Data Analysis

AASHTO PP80 Temperature Segregation

<table>
<thead>
<tr>
<th>150-ft Sublots</th>
<th>Range</th>
<th>Segregation</th>
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<tr>
<td></td>
<td>ΔF ≤ 25.0°F</td>
<td>NO SEG</td>
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<tr>
<td></td>
<td>25.1°F &lt; ΔF ≤ 50.0°F</td>
<td>MODERATE</td>
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<tr>
<td></td>
<td>ΔF &gt; 50.1°F</td>
<td>SEVERE</td>
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</tbody>
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Criteria for Severity of Temperature Segregation

Veta AASHTO Thermal Segregation Report
Temperature Segregation Index (TSI)

\[ TSI = c \times TSI_{StDev} + (100 - c) \times TSI_{STV} \]

\[ TSI \leq 100 \]

where

\[ TSI_{StDev} = 0.77 \times \frac{StDev}{StDev_{SevereStart}} \]

\[ TSI_{STV} = 0.77 \times \frac{TSV_{SevereStart}}{TSV} \]

\[ c = \% \text{ contribution of } TSI_{StDev} \text{ to } TSI, \]

typical value = 50

---

Veta Temperature Segregation Index (TSI) Inputs

<table>
<thead>
<tr>
<th>Severity at three specification</th>
<th>St. Dev. contribution (%)</th>
<th>TSI Index contribution (%)</th>
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<td>63</td>
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<tr>
<td>Moderate</td>
<td>29</td>
<td>43</td>
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<tr>
<td>Low</td>
<td>1%</td>
<td>3%</td>
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Sample Size ~ 71,000

Courtesy of MnDOT
Session 3 – IR Data Analysis

Veta TSI Analysis Outputs

Hands-on Exercise with Veta
GPS Offset – IC Data and Alignment

106.5 ft offset
GPS Offset – IC data and Spot Tests

IC roller GPS Receiver and Radio

- Inspection of radio and cable
- Radio status indicator light (Solid/Flashing)
- Onboard diagnostics
- Communicate with Radio via machine display
- Restart radio: power down, remove cable and reapply cable
- Antennas-switch in known good antennas
- Communicate with Radio via PC

Courtesy of Trimble
**GPS Issues**

- Calibration of site or of machine
- Control points or bad network
- Base station moved
- All rovers and machines offset at equal amount
- Design or data model

**Failed GPS Verification**

<table>
<thead>
<tr>
<th>UTM 32N (World)</th>
<th>RTK</th>
<th>Raw data</th>
<th>Converted to US survey ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northing (m)</td>
<td>Easting (m)</td>
<td>Northing (US ft)</td>
<td>Easting (US ft)</td>
</tr>
<tr>
<td>B1 4255846.700000</td>
<td>599662.700000</td>
<td>13962723.715</td>
<td>1967393.375</td>
</tr>
<tr>
<td>B2 4255844.300000</td>
<td>599663.800000</td>
<td>13962715.841</td>
<td>1967396.984</td>
</tr>
<tr>
<td>(Survey) 4255829</td>
<td>599663.1</td>
<td>13962724.610</td>
<td>1967395.700</td>
</tr>
</tbody>
</table>

**Diff (Bomag - SiteTech)**

<table>
<thead>
<tr>
<th>Northing (survey ft)</th>
<th>Easting (survey ft)</th>
<th>Northing (Survey ft)</th>
<th>Easting (Survey ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.81</td>
<td>3.22</td>
<td>Failed</td>
<td>Failed</td>
</tr>
<tr>
<td>-0.45</td>
<td>6.61</td>
<td>Passed</td>
<td>Failed</td>
</tr>
<tr>
<td>-1.68</td>
<td>3.96</td>
<td>Failed</td>
<td>Failed</td>
</tr>
</tbody>
</table>

**Failed GPS Verification**

- Inconsistent datum (WGS84, NAD83, HARN)
- Incorrect channel of GPS correctional signals
- Outdated firmware
- Incorrect offset values from the receiver to the center or both edges of front roller drum
- Incorrect datum and/or unit conversion
- Software bugs
GPS Coordinate Unit Conversion

- US Survey Feet
  - Meters * 3937/1200 = U.S. Survey Feet
  - 1 meter = 3.280833333333 US Survey Feet
  - 1 US Survey Feet = 0.3048006096 meters
- International Feet
  - 1 int’l Feet = 0.3048 meters
- Meters
  - Diff (int’l feet & US Survey Feet) = 2 PPM (parts per million)

Missing Data

- Incorrect setup for data collection
- IC system not turned on
- No GPS signals or inaccurate signals
- Loose connections of sensors
- Out of ranges for sensors
- Failed telematics for wireless transmission

Loose Connections of IC Components
Session 4 – IC Trouble Shooting

**Missing ICMV**

**Bad GPS Signals**

**Low GPS Accuracy**
Incorrect Export Setting from IC Systems

Design Filter for Data Export
• Create design filters for each roller and all-roller combined corresponding to each lift for each day of operation.
• Organize data files properly.
• Ensure the machine names are spelled out correctly in order to create proper filter for each machine or all machines combined.
• Create design filter for each lift of paving.

Incorrect Accelerometer Installation
Incorrect Accelerometer Setup

Checkerboard Pattern

Incorrect Roller Settings

Unsorted daily boundary data for filtering
sorted in clockwise or counter clockwise
Session 4 – IC Trouble Shooting

Incorrect Boundary Points

Missing Data due to Bad GPS Reception

Other Issues

• Miss-handling of Data Files
• Incorrect File Naming Convention
• File Transmission Errors
Hands-on Exercise with Veta
Session 4 – IR Trouble Shooting

ICDM-Veta Workshop
Intelligent Construction Data Management

By
Dr. George K. Chang, PE

Session 4B
IR-PMTP
Trouble Shooting

Cold Edges
Session 4 – IR Trouble Shooting

Hot Streaking

Correct Cold Edges and Streaking with Filter

Cold Edge Filter
Session 4 – IR Trouble Shooting

Excluded Cold Edges

Cold Edge & Streaking Filter

Before

After

Lack of DMI Calibration

10% DMI Error

1,280 ft
Correction with Proper DMI Calibration

Missing Data

Missing 8,400 ft

Paved at Adjacent Street
### Out of Range Color Palette

![Image of Out of Range Color Palette](image1)

### End Dump Delivery

<table>
<thead>
<tr>
<th>Thermal Segregation Category</th>
<th>Percent of Sublots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0</td>
</tr>
<tr>
<td>Moderate</td>
<td>0</td>
</tr>
<tr>
<td>Severe</td>
<td>100</td>
</tr>
</tbody>
</table>

![Image of End Dump Delivery](image2)

### Pickup Machine

<table>
<thead>
<tr>
<th>Thermal Segregation Category</th>
<th>Percent of Sublots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0</td>
</tr>
<tr>
<td>Moderate</td>
<td>88</td>
</tr>
<tr>
<td>Severe</td>
<td>15</td>
</tr>
</tbody>
</table>

![Image of Pickup Machine](image3)
Temperature Segregation – Types of Paving

Detect High Temperatures
Temperature Changes at Plant

Identify Inconsistent Windrows
Material and Thermal Segregation
Session 4 – IR Trouble Shooting

**Running Paver Dry**
- Pave Hopper Empty
- Pave Hopper Half Full

**Monitor Material Changes**
- HMA with Saturated Aggregates

**Evaluation of Paver Stops**
- Overall graph of paver stops verses paving distance for 12L-CL
Keep Milled Surface Clean

Use of Remixer

Trace Causes of Segregation
Remixing Opportunities

1. Remix Stone that rolled to the truck bed Side Walls
2. Remix Segregation from End & Start of Dumping
3. Remix Cold Cutoff or surface & side wall of truck bed & Insert
4. Remix Segregated stones from Pile in insert during filling
5. Remix Segregation Created During Tractor to Screed Delivery

Remix at Last Point of Handling

Paver Stops

Screed Hold/ Lock/ Freeze
Veta Software

All workshop participants will be required to bring their laptop computers for the hands-on exercises with the Veta software.

**VETA SOFTWARE**
The Veta software 5.0.49 can be downloaded from the following weblink (~ 50MB)

http://www.intelligentcompaction.com/downloads/software/Veta-5.0.49.msi

**VETA SAMPLES**
The Veta example files can be downloaded from the following weblink (~ 100 MB)

http://www.intelligentcompaction.com/downloads/software/Veta-Samples-5.0.zip

**COMPUTER SYSTEM REQUIREMENTS**
The system requirements are: **64-bit versions of Windows 7** SP1 or later with Microsoft .NET 4.6.2+ installed.

**SOFTWARE INSTALLATION**
Participants need to pre-install the Veta software on their laptop computers prior to the workshop.

You must have sufficient privileges to install applications on your computer. If you receive an error message during the installation, ask your administrator to install the software for you. Email any installation questions to ICSupport@TheTranstecGroup.com.

**REFERENCES**
For Veta 4.x users, the following **Veta 5.0 Features document** will be useful:

Hands-on Sample Files

It is recommended to unzip the downloaded Veta sample files to your desktop:

There are several subfolders under the Veta sample files:

- Bomag-CA-HMA
- CAT-TX-Soils
- HAMM-ID-HMA
- MOBA-MN-HMA
- Sakai-IN-HMA
- Sakai-KS-Soils
- TOPCON-MOBA-MO-HMA
- Trimble-CA-CIR
- Trimble-MOBA-MN-HMA
- Trimble-MOBA-MO-HMA

Step-by-Step instructions for the samples in PDFs are also within each sample folder.
BOMAG_CA_HMA

Learning Objectives:

- Import asphalt IC data from a BOMAG system
- Customize color legend to facilitate observation and recognize the importance of color palette
- Create filters group to extract desired data
- Create sublots for detailed analysis

Test Bed #2 (9/5-6/2013)

Description:
This is a long-life asphalt overlay project in Vacaville, CA.
Test bed #2 is located on I-80 in eastbound direction from Station 325+00 to 425+00 for 10,000 ft.
Three IC rollers (Caterpillar, Hamm, and BOMAG) and one conventional roller (BOMAG) were used.
The Caterpillar and Hamm IC rollers were used at the breakdown position in echelon. The BOMAG IC roller was used at the intermediate position, while the conventional Bomag roller was used as the finishing roller. Three roller passes were designated for each roller operation.
Site | I-80, Vacaville, CA
---|---
Project | FHWA IC and HMA In-Place Density Study
Test Bed | TB02 (Night No. 2 paving)
Date | 9/5-6/2013 (night paving)
Manufacturer | BOMAG
Machine | BOMAG 278AD-4 Double-Drum IC Roller
Material Type | Asphalt Base Course
Data Files | CA_BOMAG_Night2A.csva (all-passes IC data) NB-boundary.xlsx

### Instructions

1. Import IC data file with the following settings.

   - Coordinate system: UTM (auto-detected)
   - Location unit: Meters (auto-detected)
   - UTM zone: 10N (auto-detected)
   - State Plane Zone: None
   - Minnesota County Zone: None
   - Oregon CRS Zone: None
   - Location Unit: Meter

Save the Veta project file as CA_BOMAG_Night2A.vetaproj

2. View the IC maps (EVIB, Frequency, Amplitude, Roller Speed, and Temperature).

   - Select the Evib map. Change the color pallet by right-clicking the color legend and select Customize. In the legend dialogue, change the Lower Bounds and Color to the following settings. Use Add/Remove if necessary. Note that software will re-order the pallet based on the Lower Bound values.

   ![Lower Bound (ksi) vs. Color Table](image)

   - Lower Bound (ksi): 60, 50, 40, 30, 20, 10, 0
   - Color: Black, Purple, Blue, Green, Yellow, Orange, Red
- Select "Final Coverage" under the Files on the left panel of the Viewer screen. Select each map and zoom in/out to see local details and overall trends.

- Unselect "Final Coverage" under the Files on the left panel of the Viewer screen, then click each pass to view the data.

Switch to the pass count map and zoom in to maximum. Note that this set of data consists of compaction and mobilization.

Toggle on/off each pass map to observe the main roller passes and overlaps. Observe the rolling patterns. Use the Viewer/Ruler control to measure the length of the rolling zone. Note the data “scattered” around the overpass of Dixon Avenue. Discuss what happens.

Toggle between the pass count and Evib maps to identify common areas for vibratory passes and the different areas for static passes (since only vibratory passes will produce Evib values).

3. Create a filter group

- At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “Paved Area”.

- Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “Paved Area”

  Check this operation filter so that it is linked to the filter group.
  Imported file name: select the only file.
  Time filter: unused.
  Location Filter: (see below)

Click the “Source” button at lower left panel, and select “Custom”
  Switch to Excel or open the paving boundary Excel file directly from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings.
Switch back to Veta. Right click the blank table and select “Paste Location” from the menu.

Click the “Apply filter group” speed button. Inspect the filtered IC map by selecting Final Coverage with viewing tools. Observe the differences between raw data and filtered data.

4. Create a sublot
   Click the tool bar Sublots button.
   Make sure that the created filter group is active.
   Select the Final Coverage IC map
   Click tool bar Add button and name the sublots “Paved area”

   Click chart tool bar Zoom to/Zoom to first location. Right click the western end of the map and select “Set start location.

   Click chart tool bar Zoom to/Zoom to last location. Right click the eastern end of the map and select “Set stop location.

   In the lower left panel, Use the default longitudinal length to be “500” ft. Click the tool bar “Create Lots” button and inspect the created sublots.

6. Analyze the filtered data and examine the results.
   A: Analysis without any filter group and sublots
      Select “None” for the filter group.
      Select “None” for the Sublots.
      Click Analyze and observe the results for the unfiltered data.
      Conduct the following analysis and compare the results.

   B: Analysis with a filter group and sublots
      Make sure the created filter group is selected.

- Analysis Setup:
  Radius : 3.28 ft

EVIB: Cumulative Specification
  Minimum: > 25
  Maximum: none
  Acceptance (%): 70
Pass Count: Cumulative Specification
Minimum: $\geq 2$
Maximum: none
Acceptance (%): 70

Temperature: Cumulative Specification
Minimum: $> 200F$
Maximum: none
Acceptance (%): 70

- Perform analysis and observe the results by selecting menu on the left from top down.

-Coverage
Inspect the coverage pie chart and results table.

- Overall Results/EVIB
Select coverage: Final Coverage. Observe statistical results, histogram, and accumulated distribution under the Distribution tab.

Select coverage: Pass 01.
Observe the correlation analysis results.
Repeat the above for Pass 02, and 03.

Select coverage: All Passes.
Observe statistical results, histogram, and accumulated distribution under the Distribution tab. Examine the correlation analysis results for all passes combined.
Examine the compaction curve and observe the trend.

Repeat the Overall analysis for Frequency, Pass Count, and Temperature.

- Sublot Details
Select each row to examine pass/fail parameters, and compaction curve for each sublot. There are lots of detailed reports.

- Sublot Results/EVIB
Observe the sublot summary table, the mean value bar chart, and the acceptance chart based on the specification target, if defined.
7. Report

- Click the “Report” button and select “PDF” to generate the report. By default, the file name is the data file name tagged with subplot name and a date/time stamp. Select options to customize your report.

- The PDF report is a secured file with randomly generated password protection ideal for agency and contractor’s permanent records.
**CAT-TX-Soils**

**Learning Objectives:**
- Import soils IC data from a Caterpillar system
- Use filter to clean up data
- Perform statistical analysis and compare results
- Compare the construction data and proof rolling data

---

**Test Bed 3A and 3B (11/19/2014)**

Test Bed 3A is compaction of clayey soils using a Caterpillar CS74B single smooth drum roller with a padfoot shell kit at US-67, Cleburne, TX.

Nuclear density tests were conducted after each roller pass at selected locations.

After the compaction (roller “walked-out”), a proofing run was performed at a constant speed, vibration frequency/amplitude, and in forward direction. The proofing run was labeled as Test Bed 3B.

The finished surface was mapped with three different IC rollers with smooth drums (CAT, Hamm, and Sakai) one day later.
<table>
<thead>
<tr>
<th>Site</th>
<th>US-67, Cleburne, TX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>FHWA-TXDOT IC Retrofit Evaluation Study</td>
</tr>
<tr>
<td>Test Bed</td>
<td>TB03A</td>
</tr>
<tr>
<td>Date</td>
<td>11/19/2014</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Caterpillar</td>
</tr>
<tr>
<td>Machine</td>
<td>Caterpillar CS74B single smooth drum with a padfoot shell kit</td>
</tr>
<tr>
<td>Material Type</td>
<td>Soils</td>
</tr>
<tr>
<td>Data Files</td>
<td>CAT-TX-soils-Const (all-passes construction data)</td>
</tr>
<tr>
<td></td>
<td>CAT-TX-soils-Proof (all-passes proof data)</td>
</tr>
</tbody>
</table>

### Instructions

1. Import the IC “construction data” file using the following settings.

   - Coordinate system : GPS (auto-detected)
   - UTM zone : 14N (auto-detected)
   - State Plane Zone : None
   - Minnesota County Zone: None
   - Oregon CRS Zone : None

   Save as CAT-TX-soils.vetaproj

2. View the IC maps (CMV, pass count, frequency, amplitude and roller speed).

   - Select "Final Coverage" under the Files on the left panel of the Viewer screen.

   - Select each pass under the Files on the left panel of the Viewer screen.

3. Analyze the unfiltered data and examine the results.

   - Setup:
     - Filter Group : (empty group)
     - Radius : 3.28 ft (not used)

   - Perform analysis and observe the results by selecting menu on the left from top down.
- Overall Results
  Observe statistical results for each parameter w.r.t.
  Final Coverage and All Passes: histogram and accumulated
distribution under the Distribution tab.

  Under CMV/Coverage: All Passes, examine the
  compaction curve (mean CMVs vs. pass count) and
  observe the trend.

4. Filter and clean data.

- Use Filters to create a section for the compacted area.
  Start a filter group:
    Filter group name template: None
    Folder : (Miscellaneous)
    Filter group name : Compacted area

  Add an Operation Filter and name it “Compacted area”

  Check/select this Operation filter and go through the
  following settings:
    Imported file name: (select the only option)
    Machine ID : (automatically selected)
    Design lot name : (select the only option)
    Time filter (unused)
    Location Filter: (see below)

  Click “Source” and Select “Custom”.
  Right-click with mouse and select four points at the corner
  of the compacted areas in counter-clockwise fashion (or
  clockwise, as long as it is consistent) “add location” to
  create an area that envelope the compacted area. Click the
  created points on the map to adjust locations.
  So that the selection would exclude the static data during
  mobilization and turning-around areas.

  Click “Apply filter group” on the menu bar to update the
  map.

  Observe the filtered map.

5. Analyze the filtered data and examine the results.

- Setup:
Filter Group: Compacted Area
Radius: 3.28 ft (not used)

- Perform analysis and observe the results by selecting menu on the left from top down.

- Overall Results
  Observe statistical results for each parameter w.r.t. Final Coverage and All Passes: histogram and accumulated distribution under the Distribution tab.

Discuss the differences between the results from unfiltered data and filtered data.

  Under CMV/Coverage: All Passes, examine the compaction curve (mean CMVs vs. pass count) and observe the trend.

- Close the project.

5. Repeat the above analysis with the “proof data”. Observe the CMV results and the differences between the final coverage of the construction runs vs. the proofing runs. Discuss whether the proofing runs can be eliminated if the above two data sets are similar.
**Hamm-ID-HMA**

**Learning Objectives:**
- Import of all-passes asphalt IC data from a Hamm system
- Compare IC data from pre-mapping, and compaction of each lift
### Site
US 95, Garwood to Sagle, ID

### Project
FHWA IC Idaho HMA demo

### Test Bed
TB00, TB01, TB02, and TB03

### Date
5/5-8/2014

### Manufacturer
Hamm (Wirtgen)

### Machine
HD+120 double-drum roller

### Material Type
HMA

### Data Files
- Day 0 pre-mapping IC_2070026F(1)_1_amd.vexp (pre-mapping on subbase)
- Day1 Asphalt Base IC_2070026F(1)_1_amd.vexp (asphalt lift no. 1)

### Instructions
1. Import the pre-mapping data file using the following settings.
   - Coordinate system: GPS (auto-detected)
   - UTM zone: 12N (auto-detected)
   - State Plane Zone: None
   - Minnesota County Zone: None
   - Oregon CRS Zone: None
   Save as Day 0 pre-mapping.vetaproj

2. View the IC maps (HMV, Frequency, Amplitude, Roller Speed, and Temperature).

3. Create Filter Groups
   - Create a filter group for Day 0 premapping data:
     - Filter group name template: None
     - Folder: (Miscellaneous)
     - Filter group name: Day 0
   Add an Operation Filter and name it “Day 0”
   Check/select this Operation filter and go through the following settings:
   - Imported file name: (select the Day 0 data)
   - Machine ID: (automatically selected)
   - Design name: (select the only option)
   - Time filter (unused)
   - Location Filter (unused)
Click “Apply filter group” on the menu bar to update the map.

4. Analyze the data and examine the results.

- Setup:
  Filter Group : (empty group)
  Radius : 3.28 ft (not used)

- Perform analysis and observe the results by selecting menu on the left from top down.

- Overall Results
  Observe statistical results for each parameter w.r.t. Final Coverage (ignore All Passes due to only one pass for pre-mapping): histogram and accumulated distribution under the Distribution tab.

5. Import the Day 1 Asphalt lift 1 data for comparison.

Click “Add File” and select “data”. Select the Day 1 Asphalt Base Data.

6. Create Filter Groups

- Create a filter group for Day 1 compaction data:
  Filter group name template: None
  Folder : (Miscellaneous)
  Filter group name : Day 1

Add an Operation Filter and name it “Day 1”

Check/select this Operation filter and go through the following settings:
  Imported file name: (select the Day 1 data)
  Machine ID : (automatically selected)
  Design name : (select the only option)
  Time filter (unused)
  Location Filter (unused)

Click “Apply filter group” on the menu bar to update the map.

7. Analyze the data and examine the results.
- Setup:
  Filter Group : Day 1
  Radius       : 3.28 ft (not used)

- Perform analysis and observe the results by selecting menu on the left from top down.

- Overall Results
  Observe statistical results for each parameter w.r.t. Final Coverage and All Passes: histogram and accumulated distribution under the Distribution tab.

  Under HMV/Coverage: All Passes, examine the compaction curve (mean HMVs vs. pass count) and observe the trend.

Compare the results between premapping and lift one compaction data.
MOBA-MN-HMA

Learning Objectives:
- Import and analyze paver-mounted thermal profile data from MOBA Pave-IR system
- Create filter groups and sublots
- Observe temperature map patterns
- Produce thermal segregation reports and compare results

MN5, US59, and US51 Projects

MOBA PAVE-IR Bar and Scanner
<table>
<thead>
<tr>
<th>Site</th>
<th>Multiple Sites, MN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Multiple projects</td>
</tr>
<tr>
<td>Test Bed</td>
<td>Multiple</td>
</tr>
<tr>
<td>Date</td>
<td>Multiple dates</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>MOBA</td>
</tr>
<tr>
<td>Machine</td>
<td>PAVE-IR thermal profile system</td>
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<tr>
<td>Material Type</td>
<td>HMA</td>
</tr>
<tr>
<td>Data Files</td>
<td>US51-NB-2015_10_02.paveproj</td>
</tr>
<tr>
<td></td>
<td>US59-NB-2015_08_26.paveproj</td>
</tr>
<tr>
<td></td>
<td>MN5-WB_2015_09_21.paveproj</td>
</tr>
</tbody>
</table>

### Instructions

1. Import the US51 thermal profile data file

   - Coordinate system: GPS (auto-detected)
   - UTM zone: 15N (auto-detected)
   - State Plane Zone: N/A
   - Minnesota County Zone: N/A
   - Oregon CRS Zone: N/A

   Save as US59-NB.vetproj

2. View the thermal profile maps.
   - Select "Temperature" and/or "Speed" under Data.

   - Observe Paver Speed and Temperature maps and their patterns. Notice the "cold edges".

3. Create a filter group
   - In the Filters screen, click the “Create” speed button and select “Create filter group”. Name this filter group as “Cold edge filter”.

   - Right click the Data Filter and select “Create Data Filter” in the option menu. Name the Operation filter as instructed. Select Temperature and set Min. temperature to be > 180°F

   - Right click the Operation filter and select “Create Data Filter” in the option menu. Name the Operation filter as instructed.

   Imported file name: (select the US 51 data)
   Sensor Location : (leave all selected)
   Machine ID : (automatically selected)
Time filter (unused)
Cold Edge & Ride Bracket Filter (check and select “Remove cold edges and ride brackets”)
Location Filter (unused)

Click Apply filter group.

Switch the filter groups between (cold edge filter) and (empty group) to compare the temperature maps.

4. Create Sublots
   - Click on Sublots and the "Add" speed button and name as instructed. Sublots will be automated created. Observe the sublots.

5. Analyze the data and examine the results.

   - Analysis Setup:
     Minimum stop duration (min.): 1.
     Remove paver stop areas from analysis: checked
     …Include Semivariogram: unchecked
     Select Analyze sublots

   Analysis Setup/Temperature
   Check “Differential Specification”
     Moderate start: 25 °F
     Severe start: 50 °F

   - Click Analyze button to perform analysis. Observe the results by selecting menu on the left from top down.

   Coverage:
   The actual area is the sensors-covered areas excluding the paver stop areas (2-ft before and 8-ft after each stop).

   Thermal Profile:
   View the thermal profile, Stop Duration, and paver speed vs. distance plots.
   Zoom in to paver stop areas and compare the results.

   Paver Stops:
   View the paver stops map and identify the long paver stop locations. Zoom in any paver stop areas to observe the temperature patterns.
### Overall Results/Speed:
Examine the statistical analysis results, histogram, and accumulated distribution of paver speed.

### Overall Results/Temperature:
Examine the statistical analysis results, histogram, and accumulated distribution of temperature under the “Distribution” tab.

### Sublot Results
Examine the statistical distribution for selected sublots and compare with the temperature maps.
Select the Temperature tab. Click Distribution, Mean, or Differential to examine the results.

Under Distribution: Select any row output of temperature and examine the statistical distribution results for the selected sublot. Compare those results with the heightened temperature map.

Under Mean, compare the mean temperatures for all sublots.

Under Differential, examine of temperature segregation summary table and identify the sublots with severe and moderate temperature segregation under the Category. Examine the corresponding temperature map within a selected sublot with moderate or severe segregation.

### Report

6. Repeat the analysis for the US59 NB data file.
   - NB paving
   - moderate to severe temperature segregation

7. Repeat the analysis for the MN5 WB data file.
   - WB paving
   - temperature segregation changes at midway
**Sakai-IN-HMA**

**Learning Objectives:**
- Import asphalt IC data from a Sakai system
- Create a filter group and sublots
- Use spot test data and perform correlation analysis
- Generation of reports

**Description**

This test bed consists of paving the HMA surface layer on the HMA intermediate layer US 52 EB fast lane. A Bomag double-drum IC roller was used as the break down roller and a Sakai IC roller was used as the intermediate roller for TB04-1, then they are shifted to each other for TB04-2, and then shifted back again for TB04-3. The NNG densities were measured after each roller pass of both Bamag and Sakai at 5 stations with 3 spots at each station (outer edge, lane center, and inner joint).

**Machine nominal setting:**
- Vibration frequency of 4000 vpm, low amplitude, and speed of 3 mph.
### Instructions

1. Import both IC data files using the following settings:
   - Coordinate system: UTM (auto-detected)
   - UTM zone: 16N (auto-detected)
   - State Plane Zone: None
   - Minnesota County Zone: None
   - Oregon CRS Zone: None
   - Location unit: Meters

   Save it as IN_Sakai.vetproj

2. View the IC maps.
   - select "final coverage" on the right panel of the Viewer screen to view passes, frequency, temperature, CCV.
   - select "individual passes" on the right panel of the Viewer screen, then select to view any pass data.

2. Create a boundary filter group
   - At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “Paved Area”.
   - Right click the Operation Filter and select “Create Operation Filter” in the option menu. Name the Operation filter as “Paved Area”

   Check this operation filter so that it is linked to the filter group.
   - Imported file name: (select the only option)
Design lot name: (select the only option)
Time filter (unused)
Location Filter: (see below)

Click “Source” and Select “Custom”.

Switch to Excel or open the paving boundary Excel file directly from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings.

Switch back to Veta. Right click the blank table and select “Paste Location” from the menu.

Click the “Apply filter group” speed button. Inspect the filtered IC map by selecting Final Coverage with viewing tools. Observe the differences between raw data and filtered data.

4. Create Sublots

Click the tool bar Sublots button.
Make sure that the created filter group is active.
Select the Final Coverage IC map

Click chart tool bar Zoom to/Zoom to first location.
Right click the western end of the map and select “Add sublot from here” and use the default name.

Click chart tool bar Zoom to/Zoom to last location.
Right click the eastern end of the map and select “Set stop location and create sublot”.

Inspect the created sublots.

5. Spot Tests
- Open the spot test file. Highlight the yellow-coded cells (including the column headers) under Pass 01 and copy to the clipboard.

- Switch back to Veta/Spot Tests, select “Pass 01” and click the “Paste” button to paste the data to the table. Examine the data table and the plot. Observe the black dots (spot test locations) drawn on the IC map. Hover over some dots to display their information.

- Repeat for Pass No. 2 and 3.
6. Analyze the data and examine the results. Make sure the created filter group is selected.

- Analysis Setup:
  Radius : 3.28 ft
  Select “Analyze sublots”

  CCV: Cumulative Specification
  Minimum: > 12
  Maximum: none
  Acceptance (%): 70

  Pass Count: Cumulative Specification
  Minimum: ≥ 3
  Maximum: none
  Acceptance (%): 70

  Temperature: Cumulative Specification
  Minimum: > 150F
  Maximum: none
  Acceptance (%): 70

- Perform analysis and observe the results by selecting menu on the left from top down.

-Coverage
Inspect the coverage pie chart and results table.

- Overall Results/CCV
  Select coverage: Final Coverage. Observe statistical results, histogram, and accumulated distribution under the Distribution tab.

  Select coverage: All Passes.
  Observe the correlation analysis results.

  Select coverage: All Passes.
  Observe statistical results, histogram, and accumulated distribution under the Distribution tab. Examine the correlation analysis results for all passes combined.
  Examine the compaction curve and observe the trend.

  Repeat the Overall analysis for Frequency, Pass Count, and Temperature.
- Sublot Summary/ICMV
  Observe the sublot summary table, the mean value bar chart, and the acceptance chart based on the specification target, if defined.

- Repeat the Sublot Summary for Frequency, Pass Count, and Temperature.

- Sublot Details
  Select each row to examine pass/fail parameters, and compaction curve for each sublot. There are lots of detailed reports.

7. Report

- Click the “Report” button and select “PDF” to generate the report. Include sublot results. By default, the file name is the data file name tagged with sublot name and a date/time stamp.

- The PDF report is a secured file with randomly generated password protection ideal for agency and contractor’s permanent records.
Learning Objectives:

- Import of all-passes soils test strip IC data from Sakai system
- Define the sections for three test lanes
- Compare compaction curves to determine roller settings

Description: The test bed was constructed by scanning the compacted TB2 to a depth of about 250 mm (10 inches). The area was then compacted in three roller lanes using Sakai SV610 padfoot roller for 13 roller passes. Lanes 1, 2, and 3 were compacted using nominal high, low, and high amplitude settings, respectively. In-situ point measurements were obtained on lanes 2 and 3. The objectives of this test bed were to obtain correlations between padfoot roller MVs and in-situ soil properties.

Machine Nominal settings:
Lane 1 (high amp) \(- f = 26 \text{ Hz}, \omega = 2.19 \text{ mm}, v = 6 \text{ km/h} \)
Lane 2 (low amp) \(- f = 33 \text{ Hz}, \omega = 0.93 \text{ mm}, v = 6 \text{ km/h} \)
Lane 1 (high amp) \(- f = 26 \text{ Hz}, \omega = 2.19 \text{ mm}, v = 6 \text{ km/h} \)

<table>
<thead>
<tr>
<th>Summary of point measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>2, 3</td>
</tr>
<tr>
<td>2, 3</td>
</tr>
<tr>
<td>2, 3</td>
</tr>
</tbody>
</table>

Subgrade compaction and testing in three lanes

Dynatest 450 mm plate diameter FWD

Sakai SV610 padfoot roller used for compaction
Site | US 69, Pleasanton, KS
---|---
Project | FHWA/TPF IC Kansas Soils demo
Test Bed | TB04
Date | 8/19/2008
Manufacturer | Sakai
Machine | SV610T single-drum padfoot IC roller
Material Type | clayey soils (test strip)
Data Files | Sakai-KS-TB04.pln (IC data)
| KS-TB04-CompactionCurves.xlsx (compaction curve data)

<table>
<thead>
<tr>
<th>Instructions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>It's a test strip that contains of 3 test lanes (from west to east) using different machine settings. Machine settings for Lane2 are different from those for Lane1 and Lane3.</td>
<td></td>
</tr>
<tr>
<td>1. Import the data file using the following settings.</td>
<td></td>
</tr>
<tr>
<td>- Coordinate system: UTM (auto-detected)</td>
<td></td>
</tr>
<tr>
<td>- Location unit : Meters (auto-detected)</td>
<td></td>
</tr>
<tr>
<td>- UTM zone : 15N (auto-detected)</td>
<td></td>
</tr>
<tr>
<td>- State Plane Zone : None</td>
<td></td>
</tr>
<tr>
<td>- Minnesota County Zone: None</td>
<td></td>
</tr>
<tr>
<td>- Oregon CRS Zone: None</td>
<td></td>
</tr>
<tr>
<td>- Location Unit : meter</td>
<td></td>
</tr>
<tr>
<td>Save as Sakai-KS vetaproj</td>
<td></td>
</tr>
<tr>
<td>2. View the IC maps (CCV, Frequency, and pass count).</td>
<td></td>
</tr>
<tr>
<td>- Select &quot;Final Coverage&quot; under the Files on the left panel of the Viewer screen.</td>
<td></td>
</tr>
<tr>
<td>3. Filters</td>
<td></td>
</tr>
<tr>
<td>- On the Filters screen, click “Create” and select “Create a Filter Group”. Name it “Lane1”.</td>
<td></td>
</tr>
<tr>
<td>- Right click the left panel and select “Create Operation Filter”. Name it “Lane1”.</td>
<td></td>
</tr>
<tr>
<td>Imported file name: (select the only option)</td>
<td></td>
</tr>
<tr>
<td>Design lot name : (select the only option)</td>
<td></td>
</tr>
<tr>
<td>Machine ID : (automatically selected)</td>
<td></td>
</tr>
<tr>
<td>Time filter (unused)</td>
<td></td>
</tr>
<tr>
<td>Location Filter: (follow the subsequent instructions)</td>
<td></td>
</tr>
<tr>
<td>Click “Source” and Select “Custom”.</td>
<td></td>
</tr>
</tbody>
</table>
On the IC map, right click to add points to define the four corners of the left most lane (in counter clockwise manner) as Lane 1. Click the created locations to adjust the position. Then, click the “Apply filter group” speed button. Observe the filtered data map.

Switch the filter group to (Empty group).
Repeat the above process to defined Lane2 and Lane3 for the middle lane and right most lane.

4. Analyze the data and examine the results.
   - Setup:
     Filter : Lane1
     Radius : 3.28 ft

   - Perform analysis and observe the results by selecting menu on the left from top down.

   - Overall Results/CCV
     Select coverage: Final Coverage.
     Observe statistical results, histogram, and accumulated distribution under the Distribution tab.

     Select coverage: All Passes.
     Observe statistical results, histogram, and accumulated distribution under the Distribution tab. Examine the correlation analysis results for all passes combined.
     Examine the compaction curve and observe the trend. Use the “Copy Data to Clipboard” mapping tool and paste to a “Veta outputs” tab in the Excel file at the upper left corner of the yellow coded cells.

     - Repeat the analysis for Lane2 (paste to blue coded cells) and Lane3 (paste to green coded cells).

     Compare the compaction curves for the above 3 results on a spreadsheet and determine the roller settings for producing adequate compaction curves.
Trimble-MOBA-MO-HMA

Learning Objectives:

- Import of asphalt IC data from TOPCON IC system
- Use daily boundary coordinates to define paving section for IC coverage analysis
- Define sublots for detailed IC analysis
- Import thermal profile data from MOBA PAVE-IR system
- Define sublots for temperature segregation analysis

TOPCON IC Retrofit on two steel drum rollers and one rubber tire roller

MOBA PAVE-IR thermal Scanner
<table>
<thead>
<tr>
<th>Site</th>
<th>US NN, MO (all project info is fictitious)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>MODOT US NN</td>
</tr>
<tr>
<td>Test Beds</td>
<td>US NN EB Lift No. 1</td>
</tr>
<tr>
<td>Date</td>
<td>5/9/2017</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>TOPCON and MOBA</td>
</tr>
<tr>
<td>Machine</td>
<td>TOPCON IC Retrofit on two steel drum rollers and one rubber tire roller</td>
</tr>
<tr>
<td></td>
<td>MOBA PAVE-IR thermal scanner</td>
</tr>
<tr>
<td>Material Type</td>
<td>HMA</td>
</tr>
<tr>
<td>Data Files</td>
<td>J1P1234-20170509-Roller1-ICD.pln (roller no. 1 steel drum IC data)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170509-Roller2-ICD.pln (roller no. 2 steel drum IC data)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170509-Roller3-ICD.pln (roller no. 3 rubber tire IC data)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170509-IRD.paveproj (thermal profile data)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170509-bnd.xlsx (paving boundary coordinates)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170509-spt.xlsx (spot test data and coordinates)</td>
</tr>
</tbody>
</table>

**Instructions**

TOPCON IC Retrofit on two steel drum roller (break down compaction in echelon) and one rubber tire roller (finishing). Based on the test strip data, both steel drum rollers operated with 4 vibratory passes while the rubber tire roller operated with 4 static passes.

A: IC Data Viewing and Analysis

1. Import the steel drum IC roller data files using the following settings.

- Coordinate system: UTM (auto-detected)
- UTM zone: 15N (auto-detected)
- State Plane Zone: None
- Minnesota County Zone: None
- Oregon CRS Zone: None
- Location unit: Meters

Save the Veta project file as J1P1234-20170509-IC.vetaproj

2. View the IC maps

- Select "Final Coverage" on the right panel of the Viewer screen. Select tool bar Zoom to/Extent of data.

- Select Pass Counts, Roller Speed, Temperature or CCV. Use the view tools to zoom in/out, pan, etc. Observe the patterns of data of final coverage data and each individual passes data.
3. Use Filters to define paving boundary

- At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “J1P1234-20170509-IC”.

- Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “J1P1234-20170509”

Check this operation filter so that it is linked to the filter group.

Imported file name: (select the IC data files)
Machine ID : (automatically selected)
Design lot name : (select the only option)
Time filter (unused)
Location Filter : (see below)

Select Location Filter and click the “Source” button at lower left panel, and select “Custom”

Open the paving boundary Excel file from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings.

Switch back to Veta. Right click the blank table and select “Paste Location” from the menu.

Click the “Apply filter group” speed button. Inspect the filtered IC map by selecting Final Coverage with viewing tools. Observe the differences between raw data and filtered data.

4. Create sublots
Click the tool bar Sublots button.
Make sure that the created filter group is active.

Click map tool bar Zoom to/Zoom to first location.
Right click the eastern end of the map and select “Add sublots from here” and use default subplot name.

Click chart tool bar Zoom to/Zoom to last location.
Right click the western end of the map and select “Set stop location and create sublots”. Inspect sublots on the map.
5. Spot tests

Switch the Spot tests screen.

Open the spot test Excel file from the file explorer. Highlight/copy the yellow-coded cells including the column headings.

Switch back to Veta. Select File/Final Coverage. Right click the blank table and select “Paste Location” from the menu. Examine the spot location plots on the map.

5. Analyze the data and examine the results.

Click the tool bar Analysis button
Make sure that the created filter group is active.

- Analysis/Setup:
  Filter Group : “J1P1234-20170509-IC”
  Radius : 3.28 ft (area surrounding spot test location to extract IC data for correlation analysis)

- Click Analyze and observe the analysis results

- Coverage
Inspect the coverage report table and charts. The coverage are combined passes from all the machines selected in the filter group.

Since there is only one filter group, the overall and the filtered group result is the same.

Note that the color palette of the pie chart mirror that of the IC pass count map palette. Adjust the palette as needed.

- Overall Results
  Select Pass count, Speed, Temperature and CCV to view the statistical results for final coverage and individual passes.
Examine the correlation results with the final coverage data. Examine the compaction curve of CCV of the all passes data.

- Sublot Results
  Select Pass count, Speed, Frequency, Amplitude, Temperature and CCV to view the statistical results.
- Sublot Details
  Select Pass count, Speed, or Temperature to view the statistical results for all sublots. Select each lot and inspect the corresponding IC map and statistics.

5. Close the IC project.

Homework: Analyze the rubber tire IC roller data.

B: Thermal Profile Data Viewing and Analysis

1. Start a new project to analyze the thermal profile.
   Import the PAVE-IR data file.
   - Coordinate system: GPS (auto-detected)
   - UTM zone : 15N (auto-detected)
   - State Plane zone : None
   - Minnesota County zone : None

   Save the Veta project file as J1P1234-20170509-IR.vetaproj

2. View the thermal profile maps.
   - Observe Paver Speed and Temperature maps. Note the temperature consists of a cold edge and some erroneous data at the eastern end. Also, the data is split into two sections with a gap in between.

3. Use Filters to clean data
   - In the Filters screen, click the “Create” speed button and select “Create filter group”. Name this filter group as “J1P1234-20170509-IR”.

   - Right click the left panel and select “Create Data Filter” in the option menu. Name the Data filter as “> 180F”. Check the box to select this filter to associate it with selected filter group. Select Temperature and set the Minimum be $\geq 180$.

   - Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “Check the box to select this filter.”
     Select the operation filter to associate it with the selected filter group.
Click tool bar Apply Filter Group. Inspect the filtered map. Observe the differences between the raw data and filtered data.

4. Create a subplot
   Click the tool bar Sublots button.
   Make sure that the created filter group is active.
   Click the tool bar Sublots button.
   Make sure that the created filter group is active.

   Click map tool bar Zoom to/Zoom to first location.
   Right click the eastern end of the map and select “Add sublots from here” and use default subplot name.

   Click chart tool bar Zoom to/Zoom to last location.
   Right click the western end of the map and select “Set stop location and create sublots”. Inspect sublots on the map.

   Note that the sublots can also be created automatically by Veta.

5. Analyze the data and examine the results.

   -Analysis Setup:
      Filter Group “J1P1234-20170509-IR”.
      Minimum stop duration (min.): 1.
      Remove paver stop areas from analysis: checked
      …Include Semivariogram: unchecked
      Select Analyze sublots

      Analysis Setup/Temperature
      Check “Differential Specification”
      Moderate start: 25 °F
      Severe start: 50 °F

      - Click Analyze button to perform analysis. Observe the results by selecting menu on the left from top down.
Coverage:
The actual area is the sensors-covered areas excluding the paver stop areas (2-ft before and 8-ft after each stop).

Thermal Profile:
View the thermal profile, Stop Duration, and paver speed vs. distance plots.
Zoom in to paver stop areas and compare the results.

Paver Stops:
View the paver stops map and identify the long paver stop locations. Zoom in any paver stop areas to observe the temperature patterns.

Overall Results/Speed:
Examine the statistical analysis results, histogram, and accumulated distribution of paver speed.

Overall Results/Temperature:
Examine the statistical analysis results, histogram, and accumulated distribution of temperature under the “Distribution” tab.

Sublot Results
Examine the statistical distribution for selected sublots and compare with the temperature maps.
Select the Temperature tab. Click Distribution, Mean, or Differential to examine the results.

Under Distribution: Select any row output of temperature and examine the statistical distribution results for the selected sublot. Compare those results with the heightened temperature map.

Under Mean, compare the mean temperatures for all sublots.

Under Differential, examine of temperature segregation summary table and identify the sublots with severe and moderate temperature segregation under the Category. Examine the corresponding temperature map within a selected sublot with moderate or severe segregation.
**Trimble-CA-CIR**

Learning Objectives:
- Import of Cold-in-Place Recycling (CIR) IC data from Trimble IC retrofit system
- Input spot test data for correlation
- Produce extensive reports
- Analyze single roller data and combined roller data

Trimble IC Retrofit
### Site Information

<table>
<thead>
<tr>
<th>Site</th>
<th>Hwy 198, Armona, CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Caltrans CIR project</td>
</tr>
<tr>
<td>Test Bed</td>
<td>WB</td>
</tr>
<tr>
<td>Date</td>
<td>6/15/2015</td>
</tr>
<tr>
<td>Material Type</td>
<td>Cold-in-Place Recycling (CIR)</td>
</tr>
<tr>
<td>IC System</td>
<td>Trimble IC Retrofit</td>
</tr>
<tr>
<td>Host Rollers</td>
<td>steel drum (ID: 10584), rubber tire (ID: 19390)</td>
</tr>
</tbody>
</table>
| Data Files | All-passes data for the steel drum roller (CA198-20150615-steeldrum.csv)  
All-passes data for the rubber tires roller (CA198-20150615-rubbertires.csv)  
spot test data (HWY198-SpotTests.xlsx)  
boundary file (HWY198-Boundary.xlsx)  
*The above are simplified names instead of following Caltrans file naming convention.* |

### Instructions

1. Import the IC data files (steel drum, target passes: 4) using the following settings.
   - Coordinate system : GPS (auto-detected)
   - UTM zone : 11N (auto-detected)
   - State Plane Zone : None
   - Minnesota County Zone: None
   - Oregon CRS Zone : None

   Saved as CA-HWY198.vetaproj

2. View the IC maps
   - Select "Final Coverage" under the Files on the left panel of the Viewer screen.
   - Select CMV, Frequency, Amplitude, Pass Counts, Roller Speed, and Temperature.
   - Pan the View screen to view the northern portion of the data. Zoom in to observe further details.
   - Unselect Final Coverage, then select each pass consecutively. Observe the accumulated data maps.

3. Analyze the data without filtering (i.e., include all data) and examine the results.
   - Analysis/Setup:
<table>
<thead>
<tr>
<th>Filter Group</th>
<th>(empty group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius</td>
<td>3.28 ft (not used)</td>
</tr>
</tbody>
</table>

- Click Analyze and observe the analysis results. Note that the results include non-compaction data.

4. Use Filters to define paving boundary

- At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “CA198-20150615-IC”.

- Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “CA198-20150615-IC”

Check this operation filter so that it is linked to the filter group.

**Imported file name:** (select the steel drum data file)

**Machine ID** : (automatically selected)

**Design lot name** : (select the only option)

**Time filter** (unused)

**Location Filter** : (see below)

Select Location Filter and click the “Source” button at lower left panel, and select “Custom”

Switch to Excel or open the paving boundary Excel file directly from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings.

Switch back to Veta. Right click the blank table and select “Paste Location” from the menu.

Click the “Apply filter group” speed button. Inspect the filtered IC map by selecting Final Coverage with viewing tools. Observe the differences between raw data and filtered data.

5. Click the tool bar Sublots button.

Make sure that the created filter group is active.

Select the Final Coverage IC map

Click map tool bar Zoom to/Zoom to first location.
Right click the eastern end of the map and select “Add sublots from here” and use default subplot name.
In the lower left panel, Change the longitudinal length to be “100” ft.

Click chart tool bar Zoom to/Zoom to last location. Right click the western end of the map and select “Set stop location and create sublots”. Inspect sublots on the map.

6. Spot tests. Enter the spot test results from the spreadsheet following the trainer’s instructions.

6. Analyze the filtered data (i.e., only include compaction data within the lanes) and examine the results.

   - Analysis/Setup:
     Filter Group: CA198-20150615-IC
     Radius : 3.28 ft

Use the following specification target:
CMV: Cumulative Specification
   Minimum: >= 6 (within 20% of the target CMV determined by test strip data)
   Maximum: None
   Acceptance (%): 90

Pass Count: Cumulative Specification
   Minimum: >= 3 (determined by test strip data)
   Maximum: None
   Acceptance (%): 90

   - Click Analyze and observe the analysis results. Note that the results include only compaction data.

The Coverage report include % coverage for each pass.

Users may adjust the pass count color palette to set the target pass count and above as one color.

Therefore, the coverage report will include the accumulated % coverage for the target pass and above.

Examine results under both Overall and Sublot Summary.

Investigate the areas that fail the target values.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Produce report. Use the Report speed button to generate a PDF report. Scan through this 400+ pages report.</td>
<td></td>
</tr>
<tr>
<td>8. Close the IC project. Repeat a similar analysis with the rubber tire roller (target passes: 7) data.</td>
<td></td>
</tr>
</tbody>
</table>
Trimble-MOBA-MN-HMA

Learning Objectives:
- Import of final coverage asphalt IC data from Trimble IC retrofit system
- Import alignment file and use it to define paving section for coverage analysis
- Import and analyze paver-mounted thermal profile data from MOBA Pave-IR system
- Use MnDOT naming convention
- Compare analysis results between the IC data and thermal profile data
<table>
<thead>
<tr>
<th>Site</th>
<th>TH89, MN (all project info are fictitious)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>MNDOT SP12345-67 TH89</td>
</tr>
<tr>
<td>Test Bed</td>
<td>NB right lane</td>
</tr>
<tr>
<td>Date</td>
<td>5/14/2014</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Trimble and MOBA</td>
</tr>
<tr>
<td>Machine</td>
<td>3 retrofitted rollers with Trimble IC Retrofit Systems</td>
</tr>
<tr>
<td></td>
<td>MOBA PAVE-IR thermal scanner</td>
</tr>
<tr>
<td>Material Type</td>
<td>HMA</td>
</tr>
<tr>
<td>Data Files</td>
<td>SP12345-67 TH89.csv (final coverage IC data)</td>
</tr>
<tr>
<td></td>
<td>SP12345-67 TH89 PMTP.paveproj (thermal profile data)</td>
</tr>
<tr>
<td></td>
<td>SP12345-67 TH89-Alignment.kmz (alignment file)</td>
</tr>
<tr>
<td></td>
<td>SP12345-67 TH89 Paving Boundary.xlsx (Paving Boundary coordinates)</td>
</tr>
</tbody>
</table>

**Instructions**

**A: IC Data Viewing and Analysis**

1. Import the IC data file using the following settings.
   - Coordinate system : Minnesota Counties
   - State Plane Zone  : None
   - Minnesota County Zone: Otter Tail
   - Location unit     : US Survey Feet

   Saved as MN-HMA.vetaproj

2. View the IC maps
   - Select "Final Coverage" on the right panel of the Viewer screen.
   - Select CMV, Frequency, Amplitude, Pass Counts, Roller Speed, and Temperature.
   - Pan the View screen to view the northern portion of the data. Zoom in to observe further details.

3. Add the alignment file
   - At the Alignment screen, click the “Add File” speed button, select Add Alignment and browse/select the alignment file.

   Click on “Alignment” speed button
- On the tree view on the left panel, select “CNST LIM (1)” then Line 1 underneath which is the NB LN1 alignment. Rename the drawing and line to: “CNST LIM (1) (CL-12R)” and “Line 1(CL-12R)”

Pan the View screen to view the northern portion of the data. Zoom in to observe further details of the notes/lines.

4. Use the Filters to define an area based on the alignment and paving boundary files

- At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “01 051414 HMA-L1-CL-12R”.

- Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “01 051414 HMA-L1-CL-12R”

Check this operation filter so that it is linked to the filter group.

Imported file name: (select the only data file)  
Machine ID : (automatically selected for all rollers)  
Design lot name : (select the only option)  
Time filter (unused)  
Location Filter : see below

Select Location Filter and click the “Source” button at lower left panel, and enter the selection as follows:

Selection > Use a Portion of an alignment drawing  
...Alignment > SP21013-35 TH-29-Alignment  
…Drawing > CNST LIM (1) (CL-12R)  
…Object > Line 1 (CL-12R)

Click the Options button on the ribbon and confirm US Survey Feet under Location Unit.

Switch to Excel or open the paving boundary Excel file directly from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings.

Switch back to Veta. Right click the blank table and select “Paste Location” from the menu. The boundaries of the paving is defined based on the portion of the alignment file and the 4 boundary coordinates.
Select the checkbox for the created operation filter and click the “Apply Filter” speed button. Inspect the filtered IC map.

5. Create a subplot
Click the Sublots speed button.
Make sure that the created filter group is active.

Use the map tool, “zoom to the first location”. Click the middle of the northern end of paved lane and select “Add sublots from here” and use the default name.

Use the map tool, “zoom to the last location” and scroll down a little bit (since the roller may not stop the operation at the very end point). Click the middle of the southern end of paved lane and select “Set stop location and create sublots”. Inspect sublots on the map.

5. Analyze the data and examine the results.
Make sure that the created filter group is active.

- Analysis/Setup:
  Filter Group: “01 051414 HMA-L1-CL-12R”
  Radius : 3.28 ft

- Click Analyze and observe the analysis results

- Coverage
Inspect the coverage report table and charts. The coverage are combined passes from all the machines selected in the filter group.

Since there is only one filter group, the overall and the filtered group result is the same.

Note that the color palette of the pie chart mirror that of the IC pass count map palette. Adjust the palette as needed (e.g., use color palette for only 1 to 4 passes).

- Overall Results
Select Pass count, Speed, Frequency, Amplitude, Temperature and CMV to view the statistical results.

- Sublot Summary Results
Select Pass count, Speed, Frequency, Amplitude,
- Sublot Details
  Select Pass count, Speed, Frequency, Amplitude, Temperature and CMV to view the statistical results. Select each lot and inspect the corresponding IC map and statistics.

5. Close the IC project.

B: Thermal Profile Data Viewing and Analysis

1. Start a new project to analyze the thermal profile. Import the PAVE-IR data file.

   - Coordinate system : GPS (auto-detected)
   - UTM zone             : 15N (auto-detected)
   - State Plane Zone    : None
   - Minnesota County Zone : None
   - Oregon CRS Zone          : None

   Saved as MN-IR.vetaproj

2. View the thermal profile maps.

   - Observe Paver Speed and Temperature maps. Note the temperature consists of erroneous data at the left edge.

3. Use the Filters to clean up data

   - In the Filters screen, click the “Create” speed button and select “Create filter group”. Name this filter group as “01 051414 HMA-L1-CL-12R”.

   - Right click the left panel and select “Create Data Filter” in the option menu. Name the Data filter as “> 180F”. Select Temperature and set the Minimum be >= 180. Check the box to select this filter.

   - Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “01 051414 HMA-L1-CL-12R”.

   Under the created operation filter
Import file name: (select the only file)
Sensor location: (leave all in)
Machine ID: (auto selected)
Time filter (unused)
Cold Edge & Ride Bracket Filter: (check the selection)
Location filter (unused)

Click “Apply filter group” on the speed button bar.
Examine the filtered data. Toggle between “Empty Filter Group” and the created filter to compare areas that are filtered by the latter.

4. Create a subplot
Click the Sublots speed button.
Make sure that the created filter group is active.

Use the “Zoom to the first location” map tool and click the intersection of TH 29 and Southern Otter Avenue and select “Add sublots from here” and use the default name

Use the “Zoom to the last location” map tool and click the middle of the southern end of the temperature map. Select “Set stop location and create sublots”. Inspect the sublots on the map.

The sublot creation is automated in Veta 5.0+.

5. Analyze the data and examine the results.

-Setup:
  Filter Group: “01 051414 HMA L1-CL-12R”.
  Minimum stop duration (min.): 1.
  Remove paver stop areas from analysis: checked
  Select Analyze sublots
  …Include Semivariogram: unchecked

  Temperature/Differential Specification
  Check “Use differential target in sublots”
  Moderate start: 25 °F
  Severe start: 50 °F

  - Perform analysis and observe the results by selecting menu on the left from top down.

Coverage:
The actual area is the sensors-covered areas excluding
the paver stop areas (2-ft before and 8-ft after each stop).

Thermal Profile:
View the thermal profile (note that specific locations from 19 to 21 are filtered out), Duration (paver stops), and paver speed vs. distance plots.
Zoom in to paver stop areas and compare the results.

Paver Stops:
View the paver stops map and identify the long paver stop locations. Zoom in any paver stop areas to observe the temperature patterns.

Overall Results/Speed:
Examine the statistical analysis results, histogram, and accumulated distribution of paver speed.

Overall Results/Temperature:
Examine the statistical analysis results, histogram, and accumulated distribution of temperature under the “Distribution” tab.
Switch to the “Differential” tab, examine of temperature segregation summary table and identify the sublots with severe and moderate temperature segregation under the Category.
Map view: Hover over the lots to view data.

Sublot Results/Temperature:
Examine the statistical distribution for selected sublots and compare with the temperature maps.
Select the Mean tab and compare mean temperature for all sublots.

Sublot Details /Temperatures
Select any row output of temperature and examine the statistical distribution results and histogram/accumulated distribution for all sublots. Compare those results with the heightened temperature map.

6. Compare analysis results between the IC data and thermal profile data (e.g., paver stop locations).
**Trimble-MOBA-MO-HMA**

**Learning Objectives:**
- Import of all-passes asphalt IC data from CAT/Trimble IC system
- Use daily boundary coordinates to define paving section for IC coverage analysis
- Define sublots for detailed IC analysis
- Import thermal profile data from MOBA PAVE-IR system
- Define sublots for temperature segregation analysis

Trimble IC Retrofit on a CAT roller and MOBA PAVE-IR Scanner

A Material Transfer Vehicle (MTV) used on Day 2
<table>
<thead>
<tr>
<th><strong>Site</strong></th>
<th>US NN, MO (all project info are fictitious)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project</strong></td>
<td>MODOT US NN</td>
</tr>
<tr>
<td><strong>Test Beds</strong></td>
<td>US NN WB Lift No. 1</td>
</tr>
<tr>
<td><strong>Date</strong></td>
<td>4/24-25/2017</td>
</tr>
<tr>
<td><strong>Manufacturer</strong></td>
<td>Trimble and MOBA</td>
</tr>
<tr>
<td><strong>Machine</strong></td>
<td>1 roller with Trimble IC Retrofit Systems</td>
</tr>
<tr>
<td></td>
<td>MOBA PAVE-IR thermal scanner</td>
</tr>
<tr>
<td><strong>Material Type</strong></td>
<td>HMA</td>
</tr>
<tr>
<td><strong>Data Files</strong></td>
<td>J1P1234-20170424-ICD.csv (Day 1 all-passes IC data)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170424-IRD.paveproj (Day 1 thermal profile data)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170424-BND.xlsx (Day 1 paving boundary coordinates)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170424-SPT.xlsx (Day 1 spot tests)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170425-ICD.csv (Day 2 all-passes IC data)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170425-IRD.paveproj (Day 2 thermal profile data)</td>
</tr>
<tr>
<td></td>
<td>J1P1234-20170425-BND.xlsx (Day 2 paving boundary coordinates)</td>
</tr>
</tbody>
</table>

**Instructions**

A: IC Data Viewing and Analysis

1. Import the Day 1 IC data file using the following settings.
   - Coordinate system: GPS (auto-detected)
   - UTM zone: 15N (auto-detected)
   - State Plane Zone: None
   - Minnesota County Zone: None
   - Oregon CRS Zone: None

   Save the Veta project file as J1P1234-20170424-IC.vetaproj

2. View the IC maps
   - Select "Final Coverage" on the right panel of the Viewer screen. Select tool bar Zoom to/Extent of data.
   - Select CMV, Pass Counts, Roller Speed, or Temperature. Use the view tools to zoom in/out, pan, and etc. Observe the patterns of data of final coverage data and each individual passes data.

3. Use Filters to define paving boundary
   - At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “J1P1234-20170424-IC”.

**Notes**
- Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “J1P1234-20170424”

Check this operation filter so that it is linked to the filter group.
- Imported file name: (select the Day 1 IC data file)
- Machine ID : (automatically selected)
- Design lot name : (select all options)
- Time filter (unused)
- Location Filter : see below

Select Location Filter and click the “Source” button at lower left panel, and select “Custom”

Switch to Excel or open the Day 1 paving boundary Excel file directly from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings.

Switch back to Veta. Select Project/Properties from the menu and select UTM as the coordinate system.

Switch back to Filters. Right click the blank table and select “Paste Location” from the menu.

Click the “Apply filter group” speed button. Inspect the filtered IC map by selecting Final Coverage with viewing tools. Observe the differences between raw data and filtered data.

4. Create sublots
   Click the tool bar Sublots button.
   Make sure that the created filter group is active.

Click map tool bar Zoom to/Zoom to first location.
Right click the eastern end of the map and select “Add sublots from here” and use default subplot name.

Click chart tool bar Zoom to/Zoom to last location.
Right click the western end of the map and select “Set stop location and create sublots”. Inspect sublots on the map.

5. Spot tests

Switch the Spot tests screen.
Select File/Final Coverage.

Open the Day 1 Spot test spreadsheet. Select the highlighted cells and copy-and-paste back to Veta. Inspect the spot tests locations on the map.

5. Analyze the data and examine the results.
Click the toolbar Analysis button
Make sure that the created filter group is active.

- Analysis/Setup:
  Filter Group: “J1P1234-20170424-IC”
  Radius : 3.28 ft (not used)

- Click Analyze and observe the analysis results

- Coverage
Inspect the coverage report table and charts. The coverage are combined passes from all the machines selected in the filter group.

Since there is only one filter group, the overall and the filtered group result is the same.

Note that the color palette of the pie chart mirror that of the IC pass count map palette. Adjust the palette as needed.

- Overall Results
  Select Pass count, Speed, Temperature and CMV to view the statistical results for final coverage and individual passes.
  Examine the correlation results with the final coverage data.
  Examine the compaction curve of CMV of the all passes data.

- Sublot Results
  Select Pass count, Speed, Frequency, Amplitude, Temperature and CMV to view the statistical results.

- Sublot Details
  Select Pass count, Speed, or Temperature to view the statistical results for all sublots. Select each lot and inspect the corresponding IC map and statistics.
5. Close the IC project.

B: Thermal Profile Data Viewing and Analysis

1. Start a new project to analyze the thermal profile.
   Import the Day 1 PAVE-IR data file.

   - Coordinate system: GPS (auto-detected)
   - UTM zone : 15N (auto-detected)
   - State Plane zone : None
   - Minnesota County zone : None

   Save the Veta project file as J1P1234-20170424-IR.vetaproj

2. View the thermal profile maps.

   - Observe Paver Speed and Temperature maps. Note the
     temperature consists of a cold edge and some erroneous data
     at the eastern end. Also, the data is split into two sections
     with a gap in between.

3. Use Filters to clean data

   - In the Filters screen, click the “Create” speed button and
     select “Create filter group”. Name this filter group as
     “J1P1234-20170424-IR”.

   - Right click the left panel and select “Create Data Filter” in
     the option menu. Name the Data filter as “> 180F”. Check
     the box to select this filter to associate it with selected filter
     group. Select Temperature and set the Minimum be >= 180.

   - Right click the left panel and select “Create Operation
     Filter” in the option menu. Name the Operation filter as
     “Check the box to select this filter.”
     Select the operation filter to associate it with the selected
     filter group
     Imported file name: (select the Day 1 IR data file)
     Sensor location : (leave all sensors in)
     Machine ID : (automatically selected)
     Design name : (select the only option)
     Time filter (unused)
     Cold Edge & Ride Bracket Filter: (check to select)
     Location Filter : (unused)
Click tool bar Apply Filter Group. Inspect the filtered map. Observe the differences between the raw data and filtered data.

4. Create a subplot
Click the tool bar Sublots button.
Make sure that the created filter group is active.
Click the tool bar Sublots button.
Make sure that the created filter group is active.

Click map tool bar Zoom to/Zoom to first location.
Right click the eastern end of the map and select “Add sublots from here” and use default subplot name.

Click chart tool bar Zoom to/Zoom to last location.
Right click the western end of the map and select “Set stop location and create sublots”. Inspect sublots on the map.

5. Analyze the data and examine the results.

- Setup:
  Filter Group “J1P1234-20170424-IR”.
  Minimum stop duration (min.): 1.
  Remove paver stop areas from analysis: checked
  Select Analyze sublots
  …Include Semivariogram: unchecked

  Temperature/Differential Specification
  Check “Use differential target in sublots”
  Moderate start: 25 °F
  Severe start: 50 °F

  - Click Analyze button to perform analysis. Observe the results by selecting menu on the left from top down.

  Coverage:
  The actual area is the sensors-covered areas excluding the paver stop areas (2-ft before and 8-ft after each stop).

  Thermal Profile:
  View the thermal profile, Stop Duration, and paver speed vs. distance plots.
  Zoom in to paver stop areas and compare the results.

  Paver Stops:
View the paver stops map and identify the long paver stop locations. Zoom in any paver stop areas to observe the temperature patterns.

Overall Results/Speed:
Examine the statistical analysis results, histogram, and accumulated distribution of paver speed.

Overall Results/Temperature:
Examine the statistical analysis results, histogram, and accumulated distribution of temperature under the “Distribution” tab.

Sublot Results
Examine the statistical distribution for selected sublots and compare with the temperature maps.
Select the Mean tab and compare mean temperature for all sublots.

Sublot Details
Click Distribution, Lean, or Differential to examine the results.

Under Distribution: Select any row output of temperature and examine the statistical distribution results for the selected sublot. Compare those results with the heighted temperature map.

Under Mean, compare the mean temperatures for all sublots.

Under Differential, examine of temperature segregation summary table and identify the sublots with severe and moderate temperature segregation under the Category. Examine the corresponding temperature map within a selected sublot with moderate or severe segregation.

C: (homework)

Analyze Day 2 IC and IR data. Then, compare results between Day 1 and Day 2. Note that a Material Transfer Vehicle (MTV) was used on Day 2 but not Day 1.