Intelligent Compaction

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What is "Intelligent Compaction"?

- FHWA definition
- Individual States’
- Manufacturers (OEM’s)
IC defined as a combination of:

a) Integrated compaction measurement technology (and other machine parameters, e.g., temperature)

b) Jobsite positioning data tied to the measurements being recorded

c) Ability to store and analyze the data collected to document for future purpose
What are the benefits of IC?

Quality Control & Process Control

- **Increased Operator Awareness**
  - Real-time compaction (soils), temperature (asphalt), pass count data, early notice of problem areas, etc.

- **Improved Density & Smoothness** (asphalt)
  - Better understanding of mat conditions

- **Improved Rolling Pattern** (asphalt)
  - Optimized pass coverage; easier night-time operation

- **Lower Operating Costs**
  - Maximized machine utilization with better efficiency

- **Documentation**
  - Quality control and post-process data analysis
Equipment

1. GPS – multiple solutions

2. Rollers – Soils, Asphalt

1. Office software
   - VisionLink (Trimble/CAT)
   - VEDA (FHWA)
   - other OEM solutions
GPS MAPPING CAPABILITY

• Utilizes Global Navigation Satellite System (GNSS)

• Correlates measurements to a location
  – Rolling pattern (pass count), frequency, amplitude, temperature

• Choice of GPS accuracy
  – SBAS (1 meter accuracy)
  – RTK (millimeter accuracy)
How GPS Works – the Basics

- SVs broadcast where they are
- SVs broadcast code (rate = speed of light)
- Receiver measures travel time of signal
- Compute ranges from at least 3 satellites
  - Intersection of all these gives “autonomous” position on earth
Standalone - How Accurate?

Standalone (Autonomous) GPS: 5–10 m
How Does it Work?
Correction Sources

• DGPS – “Differential GPS” – refers to code-based solution receiving code corrections
  – Ground-based (e.g. “Beacons”)
  – Satellite-based (SBAS)

• SBAS – Satellite-Based Augmentation Systems
How Accurate?

Standalone GPS: 5–10 m

DGPS: 0.1–3 m
How SBAS Works

- Corrections based on ground stations with known positions
- Corrections broadcast via geostationary satellites
Real Time Kinematic (RTK)

- Trimble DGPS: 0.1–3 m
- RTK: 1–3 cm
- Standalone GPS: 5–10 m
How does RTK work?

Rover(s):
- Machine
- Range Pole
Caterpillar machine on I-95 Maine
I-95 Caterpillar machine
Current Offering from Caterpillar

Intelligent Compaction on asphalt is currently used as a **process control tool**, and **not necessarily a direct measure of compaction**. Value is seen when utilized to:

1. **Count and map number of passes** in order to get proper coverage and compaction passes on the entire road surface as to improve rolling patterns

2. **Measure and map the temperature of the mat while compacted** in order to be certain compaction passes take place at a temperature where compaction is effective
Positioning Data – required

- Utilizes GPS
- Correlates measurements to a location
  - Compaction, frequency, pass count, temperature, etc.
  - Documents work
  - Can provide picture of overall compaction consistency

- Choice of accuracy
  - SBAS: provides accuracy to 1 meter; this is the standard package
  - RTK – provides millimeter accuracy; this is an upgrade to standard package
Intelligent Compaction - ASPHALT

Operator Display

- Display provides real-time pass-count and temperature readings
- Operator can see where he/she is on the mat and how many passes have been made
- Operator can determine when to begin rolling and when to end, based on mat temperature

A warning indicator alerts the operator if the asphalt temperature exceeds or falls below the target temperature
Compactor Data Collection

Data Collection

The Compaction Control system displays and records the following:

- Machine Position (GNSS)
- Machine Pass Count/Coverage
- Compaction Width
- Asphalt Temperature
- Compaction Measurement (soils)
- Vibratory Status (on/off/rear/both)
- Vibratory Frequency
- Machine Speed
- Direction or travel (forward, reverse)
Accelerometer – front drum only
Accelerometer based technology measures deeper than the freshly laid lift of asphalt.

ICMV value is a *composite of the current lift and the layers below it.*
In-field reporting: Printer option
Intelligent Compaction on Asphalt

Make Every Pass Count
What does it take to compact asphalt?

Mix Temperature – or nothing else matters…

Machine

• vibratory systems
• dynamic forces

Operator – performs the rolling pattern

• Where did I stop on the previous pass?
• Did I go back far enough on the return pass?
• Did I provide enough overlap on the previous pass?
• Is the mat temperature too hot, too cold?
• Night paving?
Rolling Patterns

- Take density measurements to establish a rolling pattern
- Established patterns will vary as environmental changes occur throughout the day
- Changes in the mix can affect rolling pattern
Definition: Rolling Pattern (asphalt)

“A rolling pattern is the number, type, and sequence of rollers used in a specific, repetitive pattern that will meet or exceed the density and ride quality specifications for the project.”
Conventional measurement - asphalt

- Density gauge
- Cores
Temperature mapping

Not a direct measure of compaction, rather, data for process control on asphalt

- Dual infra-red sensors mounted on the front and rear of machine deliver real-time readings
- Keep operator informed of when to begin rolling and when to stop
- Help avoid tender-zones that often occur in the 95° to 115° C (200° to 240° F) temperature range
This illustration provides the pass-count mapping that occurred in the Minneapolis Global Paving parking lot. The colors signify the number of times that the drums hit a specific area.

Green – Target pass-count was met
Blue – Target pass-count not met;
    1 more passes needed
Red – Target pass-count not met;
    2 more passes needed

* Note: The red slivers within the paved areas indicate that there wasn’t proper drum overlap
Why is Pass-Count mapping important?

- Following established rolling pattern
- Efficiency – fuel, machine wear
- Eliminate excessive overlap
- Prevent incomplete passes, stopping short or missed
- Roller stops and bumps in the mat
- Easier night-time operation
Mapping Temperature

This illustration provides asphalt temperatures as the roller passed over the fresh mat. The color pattern signifies the different temperature ranges that were present.

Green – optimum temperature met
Blue – Target temperature met, lower range than green
Red – Temperature below target
Why is temperature important?

Understanding the asphalt temperature helps operators and supervisors determine when the asphalt can be compacted.

- Monitoring plant/trucking temperature management
- Upper temperature limit that permits compaction is normally around 149°C (300°F)
- Lower limit that permits compaction is normally around 80°C (175°F)
- Avoid “tender zones” if one is present
What are the benefits of IC?

Quality Control & Process Control

- Increased Operator Awareness
  - Real-time compaction (soils), temperature (asphalt), pass count data, early notice of problem areas, etc.
- Improved Density & Smoothness (asphalt)
  - Better understanding of mat conditions
- Improved Rolling Pattern (asphalt)
  - Optimized pass coverage; easier night-time operation
- Lower Operating Costs
  - Maximized machine utilization with better efficiency
- Documentation
  - Quality control and post-process data analysis
VisionLink Software

• Compaction module is what we are interested in today

• Web-based only – no ‘standalone’ version

• Data can be uploaded wirelessly from machine

• Must have a paid subscription and user-account and “register” each machine

• Login at www.myvisionlink.com
Data: VisionLink

- VisionLink – must have an internet connection to view & analyze the data
I-95
I-95 Satellite view of roller passes
VisionLink mobile app
Data: VisionLink

- Data can be exported in *.csv (MS Excel) format
www.intelligentcompaction.com

- www.intelligentcompaction.com
Now, what do we do with all the valuable data that we have created and collected?
Caterpillar Application Training

1. Compaction Theory Basics – soils & asphalt
2. Compaction Measurement
3. GPS Mapping
4. Data Management & Analysis
Simulator consists of 2 components:

1. **Display box emulator**
   - Executes a version of the CB4XX firmware that has been modified to run on a personal computer
   - Works the same as if you were using a real CB4XX control box

2. **Machine control simulator**
   - Provides a virtual set of configurable system components such as GPS receivers, slope sensors, grade sensors, etc…
   - Controls forward/reverse/stop and turning direction of the machine
Resources:

Resources listed below are not Caterpillar-specific

www.intelligentcompaction.com

VisionLink – Trimble website

Check equipment manufacturer websites:
www.bomagamericas.com
www.wirtgenamerica.com
www.sakaiamerica.com

Google search: “Intelligent compaction asphalt” (or soils)
IC Summary

1. Intelligent Compaction (IC) provides benefits over traditional testing methods:
   i. Increased Operator Awareness – “self training”
   ii. Improved Density & Smoothness (asphalt) – real time actionable info
   iii. Improved Rolling Pattern (asphalt) – real time
   iv. Lower Operating Costs by more efficient rolling patterns
   v. Documentation – for the Owner and the Contractor

2. IC includes:
   i. Compactor integrated data measurement
   ii. GPS Positioning tied to collected data
   iii. Ability to analyze & document data

3. IC on Soils is more a direct measure of compaction

4. IC on Asphalt is more process control at this point
What are contractors doing?

- Learning phase – What is IC? How can it help my operation?
- Finding soft spots
- Trying to establish correlations with density
- Looking at consistent rolling patterns & temperature
- Not sure how to use office software/data analysis
Some questions to ask on bids…

1. What accuracy of GPS is required?
2. What happens if/when GPS signal is lost?
4. What data collection/processing software is required?
5. Does it need to be VEDA-compatible?
6. Is training required? By the Dealer? OEM?
7. Is a “Work Plan” required by the Contractor?
8. Are accelerometers specified, or only IC-MV (can MDP be used?)
Summary

1. Intelligent Compaction (IC) provides benefits over traditional testing methods:
   i. Increased Operator Awareness
   ii. Improved Density & Smoothness (asphalt)
   iii. Improved Rolling Pattern (asphalt)
   iv. Lower Operating Costs
   v. Documentation (statistically significant)

2. IC includes:
   i. Compactor integrated data measurement
   ii. GNSS Positioning tied to collected data
   iii. Ability to analyze & document data

3. IC on Soils is more a direct measure of compaction

4. IC on Asphalt is more process control at this point

5. Data (types) and documentation is the future (QA?)
Thank you for your attention.
Discussion... Questions??