Intelligent Compaction
A Brief Summary

Presented by: Todd Mansell, Sakai America, Inc.
Intelligent Compaction - The Vision*

• *IC is an emerging technology that allows greater control of the compaction process*

• *New tool under development for in-situ measurement, next step to implement mechanistic design modulus-based construction*

*FHWA 2005*
IC TPF / FHWA Definition

1. Vibratory rollers with measurement / control system
   - Measurement system, ex. material stiffness
   - Control system automatically changes parameters (amplitude and possibly frequency) based on measurement...
IC TPF / FHWA Definition

2. GPS-based documentation systems

- material stiffness
- roller location
- mat temperature
Why Intelligent Compaction?

Maximize value per construction dollar

• Improve quality
  - Real-time visualization of the compaction process allows changes “on the fly”
  - Improved consistency of compaction
  - Well-compacted pavements last longer

• Maximize productivity
  - The minimum number of roller passes
What data is collected?

• Mat temperature
• Number of passes
• Material stiffness
Roller Factors affecting Drum Acceleration

- Roller Travel Speed
- Amplitude setting
- Vibration frequency
- Drum weight
HMA Factors

• Temperature affects stiffness
• Uniformity of mat placed by paver
  --Material Segregation, Temperature variations
  --Consistent paver speed and lift thickness
• Subbase condition
• Longitudinal Joint
An Example: Sakai CIS

• Sakai’s Intelligent Compaction system is named CIS (Compaction Information System).

• Data collection of:
  - Number and GPS location of roller passes
  - HMA surface temperature data
  - Material stiffness values (correlated to density)
Hardware setup

• One the roller
  - Accelerometer
  - Infrared temperature sensor
  - GPS antenna/receiver
  - Onboard computer
  - Display screen

• On the ground
  - GPS tripod, antenna, receiver
GPS Measuring, Display, Recording & Mapping

Roller
- GPS Antenna
- GPS Receiver
- Radio modem receiver
- I/F unit
- Power source

Signal from the roller:
- Direction
- Vib. On/Off
- Vib. Hi/Lo

Base
- GPS Antenna
- RTK GPS
- Battery
- Radio modem transmitter
GPS Base Station
CIS - Compaction Information System
Inputs before the job

• Plan file of the project from AutoCAD© or other site development software

• Direct input of GPS coordinate data

• Operator or QC person can upload a job file in less than one minute
SR-68, West to Monterey, CA
Uncontrolled breakdown rolling

Shoulder (Supported)

Longitudinal Joint

Paving Direction

Number of roller passes

1 2 3 4 5 6 7 8
Uncontrolled finish rolling

Longitudinal Joint

Shoulder (Median) side

Paving Direction

Number of roller passes

1 2 3 4 5 6 7 8
Surface temperature of pavement during breakdown rolling

Shoulder side (Supported)

Longitudinal Joint

Paving Direction

Temp

60.0  70.0  80.0  90.0  100.0  110.0  120.0  130.0

-10.0  0.0  10.0  20.0  30.0  40.0  50.0  60.0
Pavement stiffness during breakdown rolling

Shoulder side (Supported)

Longitudinal Joint

Paving Direction

Elasticity (psi)

60.0  70.0  80.0  90.0  100.0  110.0  120.0  130.0

-10.0  0.0  10.0  20.0  30.0  40.0  50.0  60.0
Pavement stiffness during finish rolling
Florida test section June 2007
Colors indicate the roller measured compaction value (CCV)
Black dots indicate location of cores cut from the pavement
Correlation between roller-measured stiffness and core densities

\[ R^2 = 0.69 \]
Number of roller passes recorded during the test section
Surface temperature °F at compaction
Kandiyohi County
Road 4
Minnesota, June 2008
SW880 IC roller maps subbase layer
CCV shows relatively weaker area in the south bound lane.

South bound

North bound

Sub base layer mapping
Placing the HMA base course
Compaction/mapping of HMA base course layer
HMA Base Course layer
CCV shows softer areas

South bound

North bound

Black color indicates vibration starts/stops
Compaction/mapping of the wear course
Zone of failure
softer areas reflected in HMA layer

SB lane
HMA

Support lanes

relative
weaker
support

NB lane
HMA
Reflection of hard spots on the HMA layer

HMA non-wearing course layer map
\( \sigma = 0.6 \text{ mm}, \quad f = 3000 \text{ vpm} \)

Class 5 aggregate subbase layer map,
\( \sigma = 0.6 \text{ mm}, \quad f = 2500 \text{ vpm} \)

Reflection of soft spots on the HMA layer

CCV:
- 0 - 3
- 3 - 6
- 6 - 9
- 9 - 12
- 12 - 15
- 15 - 18
- 18 - 21
- > 21

Courtesy ISU
Zone of failure under construction traffic
Output data

1. GPS location (# roller passes)
2. CCV value (stiffness)
3. Surface temperature
4. Time stamp
Output data

- *Can be exported to Excel or AutoCAD for analysis*

- *Can be replayed on screen by the Operator, Paving Super, QC or anyone*

- *Can be stored for future use*
Benefits of IC

- Maximum productivity of the compaction process
- Improved density of pavement materials
- Measurement and record of materials stiffness values
- Identification of non-compactable areas
- Improved depth of compaction
- Reduction in highway repair costs
Benefits

- Collecting compaction bonuses
- Operator training & self-training
  - improved rolling patterns
- Warranty paving - proof rolling
- Documentation
- QC personnel allocation
- Reputation for quality
- Complete record for the project
What are the drawbacks?

- Cost of equipment + GPS
- ROI - company culture dependent
- Obtaining a good $R^2$ correlation of stiffness values to in-place density
How will IC affect QC?

• *IC maps the entire project for a complete record*

• *Allows QC people to focus on the right training of paving crews*

• *More focus in other areas - plant, stockpiles, etc...*
Challenges developing IC for HMA

- Relationship between measured material stiffness, temperature and base stiffness
- Action and reaction of the “intelligent roller”
- How can a roller change settings on what it hasn’t “seen” yet?
Challenges developing IC for HMA

- Temperature affects stiffness, not a linear relationship.
- Uniformity of mat placed by paver
  -- Material segregation
- Sub base condition
- Longitudinal joint (overhanging drum edge)
Where are we, then?

- Systems that measure relative stiffness of the HMA mat that can be correlated to density
- GPS maps number roller passes to millimeter accuracy
- Maps surface temperature at time of rolling
- Automatically adjusting machines
What are contractors doing?

- **Learning phase** - What is IC? How can it help my operation?
- **Looking at number of roller passes**
- **Looking at rolling patterns**
- **Warranty work**
What are manufacturers doing?

- Some manufacturers have machine control – others are purely provide information on the rolling process

- Improving density correlations as more real world experience is gained

- Soils IC is further along than HMA IC
What are the Feds doing?

- Research through the Transportation Pooled Fund (13 states)

- Transportation Pooled Fund #954 - "Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils, Aggregate Base and Asphalt Pavement Material"

- NCHRP 21-09 "Examining the Benefits and Adoptability of Intelligent Soil Compaction"
TPF Implementation of IC

[Map showing various states with some highlighted in orange, including MD, TX, GA, MS, IN, WI, MN, ND, KS, NY, PA, VA, and NY.]
TPF Studies >>> Detailed View

Study Number: TPF-5(129)  
Status: Cleared by FHWA  
Title: Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils, Aggregate Base and Asphalt Pavement Material  
Contract/Other Number:  
Sponsoring Agency: Federal Highway Administration  
Lead Agency: Federal Highway Administration  
Lead Agency Contact: Victor Gallivan (victor.gallivan@fhwa.dot.gov) Phone: 317-226-7493  
FHWA Technical Liaison: Tom Haman (tom.haman@fhwa.dot.gov) FHWA Routing Symbol: HRC-BAL  
Study Partners: GA, IA, IN, KS, MD, MN, MS, ND, NY, PA, TX, VA, WI  
Contract Amount: $725,000  
Commitments Received: $750,000  
100% SP&R Approval: Approved  
Background: The compaction process is a vital final step in the construction of quality, long lasting subgrade soils and pavement materials. Embankments, Subgrades, Base Materials, and Pavement must be well compacted to obtain uniform, optimum density levels that ensure adequate support and strength. Currently used compaction equipment and processes can too often result in inadequate and/or non-uniform material density, which can contribute in short
Welcome

This is your one-stop shop for Intelligent Compaction (IC)! All content posted in this site is by the research team under the US FHWA research project DTFH61-07-C-R0082 "Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils, Aggregate Base, and Asphalt Pavement Materials". This project is to realize the blueprint in the FHWA IC strategic plan.

This site is best viewed with the Mozilla Firefox browser!

Asphalt IC Rollers

Ammann/Case

Caterpillar

Dynapac
Future of IC development

• Further development of machine control?

• Correlating directly with in-place density

• Integration with job management software
  - Tracking costs for compaction work
  - Final grade control data - airports, other
  - Wireless data transmission

• Automated machine guidance
QUESTIONS ?