INTELLIGENT COMPACTATION

Technology versus Simplicity
Intelligent Compaction

- Intelligent compaction equipment measures and records the quality of compaction during the compaction process.
Intelligent Compaction

- Compactor’s force changes real time to increase where needed, prevent over compaction.
Intelligent Compaction

• The equipment uses GPS (Global Positioning System) to create a ‘map’ that shows the quality of compaction across the entire surface of each lift.
Intelligent Compaction

• Two different applications
  – Intelligent soil compaction systems
  – Intelligent compaction systems for HMA (Hot Mix Asphalt)
Intelligent Compaction

- Commercial systems available from several suppliers:
  - Geodynamik - originator of technologies
  - Ammann - Switzerland
  - BOMAG - Germany
  - Dynapac - Sweden
  - Sakai - Japan
Intelligent Compaction

• Systems under development or being evaluated by several suppliers:
  - Caterpillar - United States of America
  - Hamm - Germany
  - Ingersoll Rand - United States of America
Geodynamik

- 1976 – developed Compactometer design
- 1981 – developed oscillating roller design
- 1988 – developed CDS (Compaction Documentation System) for rollers
Geodynamik

• 1992 - developed prototype of first intelligent roller (shown at Bauma)
• 1997 - developed ACD (Asphalt Compaction Documentation) system
• 2005 - developed CompactoBar (world’s smallest, all-electronic compaction meter)
Ammann

- ACE (Ammann Compaction Expert)
- ACE plus – GPS based compaction control system
BOMAG

- BCM 05 – Compaction Management system for single drum rollers
BOMAG

- Asphalt Manager system
  - Continuous measure of dynamic stiffness of HMA, adjustment of roller’s drum output
Caterpillar

- System currently under development and field testing – not commercially available
Dynapac

- Compaction Meter
- DCA Compaction Analyzer
- DCO Compaction Optimizer
Hamm

- Hammtronic system
  - Control of rolling speed, vibration frequency, et cetera
  - Future development will likely incorporate IC interface
Ingersoll Rand

- SMART drums
  - Eight amplitude eccentric design with manual adjustment at present
  - Future development might incorporate IC capability
Sakai

- CCV – Compaction Control Value suitable only for soil compaction
• Prototype device for HMA applications
  - Alpha system based on Fourier Fast Transfer
  - (FFT) analysis of acceleration of vibrating drum
Historical Perspective

- Proctor test (1933) required 12 inch firm blows of compaction hammer, not 12 inch ‘free-fall’
- “Originally published objective of compaction in earth fills was a saturated penetration resistance of 300 lb per sq in.”
Proctor Test Consequence

• “Soil would then have twice the level of penetration resistance required to permit loaded truck travel when fully saturated.”
What Works?

- Soils at optimum moisture content - good correlation appears to exist between soil stiffness modulus and it’s ability to support applied loads
What Works?

• All soil compaction measuring systems utilize accelerometer(s) [to evaluate soil stiffness]

• Stiffness ‘modulus’ can provide indication of load-bearing capacity of material
What Does Not Work?

• Variations from optimum moisture content compromise reliability of measurements
  – Excessive field moisture content makes soils weak and unstable
  – Current compaction control devices reduce drum force once maximum material stiffness is reached...even if value of stiffness is below ‘target’ for load-carrying ability
What Might Work?

- Granular or mixed soils particle size distribution variables influence measured stiffness modulus
  - Poorly-graded soils?
  - Well-graded soils?
  - Non-plastic soils?
  - Plastic soils?
What Might Not Work?

• Value for measured ‘modulus’ changes depending upon size, weight (and other variables) of vibratory compactor utilized

• Value for measured ‘modulus’ can vary even with compactors of same size from same supplier
What Might Not Work?

- Fine-grained soils with rounded rather than angular particle shape
- Coarse-grained soils with insufficient fractured faces
Correlations

• MN and WI testing indicates correlation between measured density and stiffness
• MN and WI testing indicates correlation between Falling Weight Deflectometer (FWD) value and stiffness
• MN - performance-based IC spec in 2007?
Uncertainty?

- Can plotting of travel path of compaction equipment over material surface (recording number of passes and rolling speed), assure uniformity of material stiffness/strength and eliminate QC testing?
IC for HMA

- Vibratory compactor factors affecting measured value of drum acceleration
  - Drum amplitude
  - Drum dynamic force (energy)
  - Drum weight
  - Rolling speed
  - Vibration frequency
IC for HMA

- Material factors affecting measured value of drum acceleration
  - AC (Asphalt Cement) content and type
  - Aggregate gradation and other properties
  - Environmental conditions during construction
  - Lift thickness and ratio of NMAS to thickness
IC for HMA

- Material factors affecting measured value of drum acceleration...continued
  - Stiffness of base beneath HMA layer
  - Temperature of mix during construction
  - ‘Tender zone’ effect on compaction results
  - Uniformity of variables during construction
More Practical Approach?

• Rather than specify IC for HMA rolling applications, use GPS to confirm roller uniform coverage over surface of panel (with recording of rolling speed, et cetera)

• Train roller operators to follow ‘best practices’ – intelligent operators may be preferred over intelligent compactors
Future Developments

Technology or Training?
Thanks on behalf of...