Intelligent Compaction

Implementation of Intelligent Compaction in Minnesota

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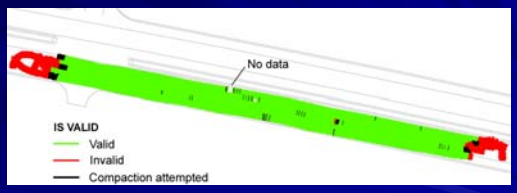
Our Goals

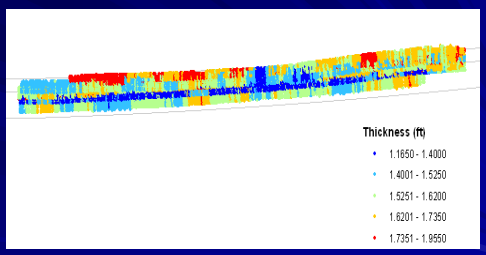
- More Comprehensive Inspection
- Increase Construction Efficiency
- Develop a Link to Design
- Improve Pavement Performance
- Improve Safety

More Comprehensive Inspection



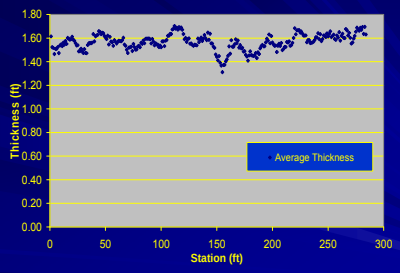
Continuous Coverage

More Comprehensive Inspection



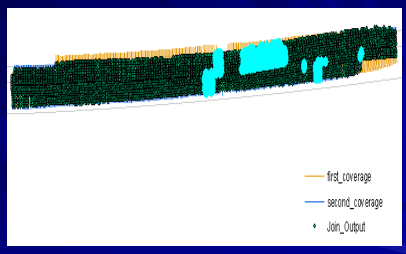
Map of thickness between Coverages One and Two

More Comprehensive Inspection



Average thickness between Coverages One and Two

More Comprehensive Inspection



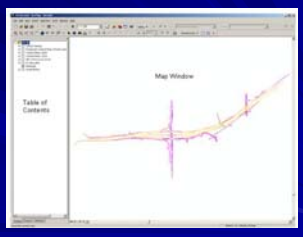
Highlighted Locations Indicate Where Overlying Roller Compaction Value is Less than the Underlying Roller Compaction Value

More Comprehensive Inspection

- LWD
  - Fast
  - Easy to use
  - Calibration
    - Repeatability testing
  - Training
  - User judgment and experience

More Comprehensive Inspection

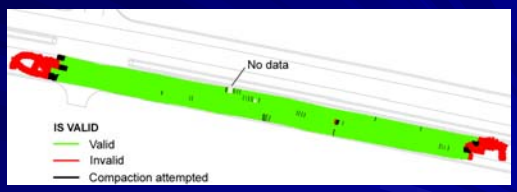
- Permanent Construction Record
  - 100% complete
  - LWD separate record
    - Can be joined



Increase Construction Efficiency

Real-time Feedback

Increase Construction Efficiency



Known areas of coverage

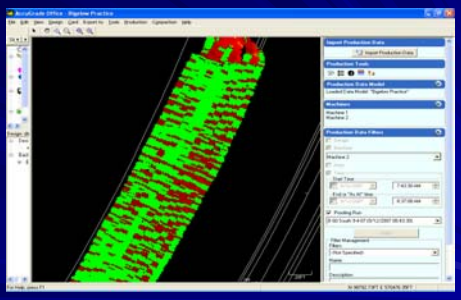
Increase Construction Efficiency

- Increased contractor project management

More Efficient Construction?

New control strips are required for each type of material encountered.

More Efficient Construction?



"Polished" Surface, no other traffic & haul roads are cut off.

More Efficient Construction?

- Increased costs associated with the prep time required immediately prior to obtaining stiffnesss measurements

- Granular $0.20-0.30/cy

Non-granular $0.30-0.40/cy

More Efficient Construction?

- Intelligent Compactor, or more of an Intelligent Tester?

Develop a Link to Design

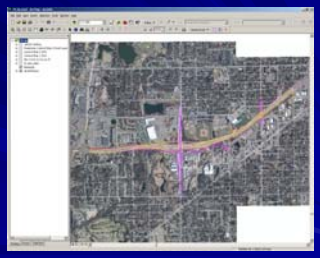
- Ongoing
- Some needs
  - Machine calibration
  - Standardized measurement values & outputs
  - Performance data
  - Correlation models with machine stiffness

Improve Pavement Performance

- Qualitatively Yes!
  - Uniform Grade
  - Full coverage
  - Proper moisture
  - Increased attention to detail
  - Discover "soft spots" sooner
  - Increased Quality
    - The Black Box Effect

Improve Pavement Performance

- Quantitative?
  - Test sections
  - More performance data
  - More cost data
  - Improved analysis tools

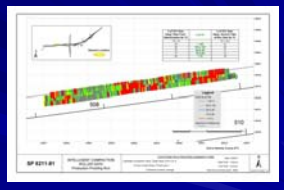


Improve Safety

- MNDOT inspectors are not outside of their trucks as much taking tests

Next Specification

- Equipment Capabilities
  - Where does it work best?
  - Data analysis capabilities
- Contractor feedback
  - Production issues
  - Maximize equipment capabilities
  - Improve efficiency
- Bid item
  - How do we measure the real cost?

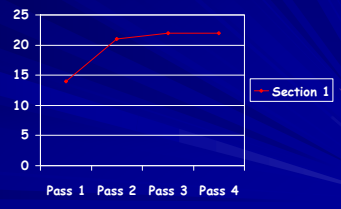


Next Specification

- Goal – Create a QC specification based on a target percent change in stiffness

• Minimum stiffness is achieved

•If the change in stiffness between successive passes over a given area is less than say 5%, compaction is completed



Equipment Requirements

Requirements

- Self propelled, smooth-drum vibratory soil compactor
- Weight ≥ 22,000 lb
- Instrumented
  - Accelerometer-Based System
  - Global Position System
  - Onboard Display
    - Compactor Measurement Value (MV) Output
    - Display of 2-D Design

Equipment Requirements

Accuracy

Operating Parameter	Accuracy
Global Positioning System	± 150 mm (6 in) in the X and Y Direction
Rolling Speed	± 0.5 km/h (0.3 mph)
Frequency	± 2 Hz
Amplitude	± 0.2 mm (0.0008 in)

Measurement Pass ASCII Files

Machine Model	GPS Mode
Machine Type	Travel Direction
Drum Width	Rolling Speed
Drum Diameter	Vibration
Machine Weight	Frequency
File Name	Peak Vertical Amplitude
Date Stamp	Indicator of Double Jumping
Time Stamp	Compactor Measurement Value
XYZ Coordinates	Automatic Feedback Control

Pre-Approval of Compactor

Demonstration
- Schedule 14-Calendar Days in Advance
- Range of Measuring System
- Provide Documentation
  - Manufacturer's recommended compactor operating settings
  - Manufacturer's Users Manual
  - Demonstration Data
    - ASCII File(s)
    - Data Files Downloaded directly from Compactor

Moisture Requirements

- Determine Target Moisture Content
  - Standard Proctor
  - 1-Point Proctor
  - Estimated Optimum Moisture Content Form (for Granular Only)
- Maintain between 65 to 95% of Target Moisture Content

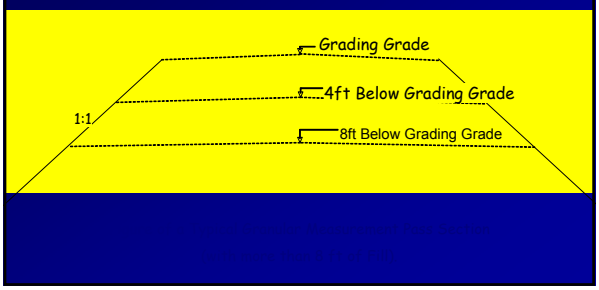
Definition: Measurement Pass

Is a pass where the compactor measurement values and machine position are recorded over the **Measurement Pass Layer**.

Operating Settings must be held within the specified limits.

Definition: Measurement Pass Layer

Is a predetermined layer that requires QC measurements to ensure compliance with this specification.



Measurement Pass Layers

Locations
- Slope gradients > 5% → obtain approval
- Ensure > 4 ft above water table
- Provide locations in writing
- Changes
  - Provide new locations in writing
  - 24-hrs prior to starting measurements

Measurement Pass Layers

- Operate within Approved Operating Settings
- All passes → Forward Direction
- Roller Track Overlap ≤ 10% of drum width

Measurement Pass Layers

TABLE 2				
Case No.	Embankment Thickness	Measurement Pass Layer Number		
		1 (Note 1)	2	3
		Depth Below Grading Grade		
1	≥ 600 mm **(2 feet)** and < 2 m **(6 feet)**	0 feet	(Note 2)	
2	≥ 1.8 m **(6 feet)** and ≤ 2.4 m **(8 feet)**	0 feet	4 feet	(Note 2)
3	> 2.4 m **(8 feet)**	0 feet	4 feet	8 feet

Complete 3 Measurement Passes

Production Usage

Operate continuously during construction of the measurement pass sections.

Submittals

Submit QC data daily

- Measurement Pass and Production Data Files
  - ASCII Files
  - Data files downloaded directly from compactor

Measurement and Payment

- Payment
  - Weekly Rental
  - $30.00/hour for roller operator for information gathering.
  - Item 2123.612 (compactor) at Contract Bid price per week.
- Measurement
  - No. of calendar weeks roller furnished.
- Unauthorized Work (Mn/DOT 1512)
  - Embankment mat'ls are unauthorized when supporting QC data is not submitted.

Some Keys to Success

- Know Your Organization
- Find dedicated people
- It takes time
- Communication with Industry
  - Associations
  - Contractors
  - Suppliers
  - Consultants
- Select "simple" projects
- Select Low Hanging Fruit
- Don't hold new technology to a higher standard

Thank You!