

# APPLICATION NOTES



U.S. Department of Transportation  
**Federal Highway Administration**

## BACKGROUND

Because soils compaction is moisture dependent, construction teams find it difficult to ensure adequate compaction using traditional efforts based solely on roller passes. To improve soils compaction, teams can use the advanced real-time monitoring offered by intelligent compaction (IC). IC takes all the guesswork out of compaction.

With IC, teams can identify soft spots during construction and make corrective actions. If the soft spot was caused by excess moisture in the soil, the materials can be disked and aired out before recompaction. If the soft spot occurred due to insufficient moisture, water can be added to the materials before recompaction.

Traditional soils moisture-density tests have several drawbacks: they are insensitive to in situ moisture content, they are limited to specific locations within the compacted area, and they provide only partial information about compaction progress. IC takes an innovative approach to measuring stiffness-related values by providing many types of information about the entire compacted area, offering 100% coverage.

IC can drastically improve quality control and advance implementation towards modulus-based compaction acceptance. By helping construction teams achieve consistent and uniform soils embankment and subbase compaction, implementing IC on a project can produce a superior platform for the pavement layer placed above it. IC improves the entire roadway construction process, benefitting agencies and contractors alike.

# INTELLIGENT COMPACTION FOR SOIL

## APPLICATION NOTES: INTELLIGENT COMPACTION IMPLEMENTATION ON IOWA I-80/US 65 PROJECT

*In 2013, Iowa DOT's I-80 and US 65 Interchange mainline and ramp widening project served as an intelligent compaction (IC) testing ground. The 2.5-mile construction project in Polk County near Altoona included more than 400,000 cubic yards (CY) of soil compaction.*



## IOWA I-80/US 65 PROJECT DESCRIPTION

The grading contractor provided the construction services for a field trial comparing Iowa DOT's Type A Compaction Specification with compaction results from an IC roller. The soils used for the project are glacial till and were placed in 8-inch lifts.

The Type A Compaction Specification requires a minimum of one roller pass per inch depth of each lift with a padfoot (or sheepsfoot) roller with pad projections of 6 ½ inches or more. The material must be compacted until the roller is supported entirely on its feet, which is defined as when the tamping feet penetrate no more than 3 inches into an 8-inch lift, or 33% of the depth of the layer being placed. The specification requires quality control (QC) testing every 1,300 CY to evaluate the moisture content and in-place density using a nuclear density gauge (NDG).

The project included the use of a padfoot single drum roller weighing more than 12 tons (T); a Real Time Kinematic (RTK) Global Positioning System (GPS); IC data flow protocol which identifies the data to be reported, data format for electronic submission, and daily data submittal; a test strip for calibration; and proof area mapping for quality acceptance. During proofing runs or mapping, the IC roller operation needs to be at constant speed and vibration settings (frequency and amplitude) in the forward direction.

## IC TECHNOLOGY ON THE I-80/US 65 PROJECT

To complete the project's IC operations, McAninch Corporation used:

- A 16-ton single drum IC roller equipped with a padfoot shell kit
- A Compaction Control system using RTK GPS and capable of Compaction Meter Value (CMV) and Machine Drive Power (MDP) measurements
- VisionLink data-managing software



*Onboard color-coded display.*

CMV is an accelerometer-based ICMV system. The measurement uses the frequency analysis of the vertical drum acceleration to compute CMV that relates to the ground stiffness. For cohesive soil applications, MDP is used based on the concept of rolling resistance, to relate to the ground stiffness. The test strip data was used to correlate ICMV and conventional spot tests in order to determine a target value for ICMV and/or roller passes for the given materials of the specific lift of compaction.

The target ICMV and/or roller passes can be entered into the roller's onboard display software. Then, the software uses color-coded maps to indicate each segment's compaction progress—e.g., segments with soil that has achieved the specified compaction are displayed as green, and segments with soil that requires further compaction effort are displayed as red. The color-coded map can also be switched to view the number of roller passes and other IC-related measurements.

The IC data was automatically uploaded to the Cloud in near real time using a cellular data modem, so that compaction progress could be monitored using web-based, VisionLink software.

## PROJECT IMPLEMENTATION

Of the 2.5-mile project, IC technology was applied during the construction of approximately 0.75 miles, including the US 65 Interchange. During embankment construction, working the soils at the optimum moisture content is key. To control in-situ moisture content, the soils material is disked and tilled to lower the moisture content when it is too wet, or water is added via water trucks to raise the moisture content when it is too dry. ICMV would help identify these conditions, “soft spots”, when the values are lower than the target after desired roller passes.



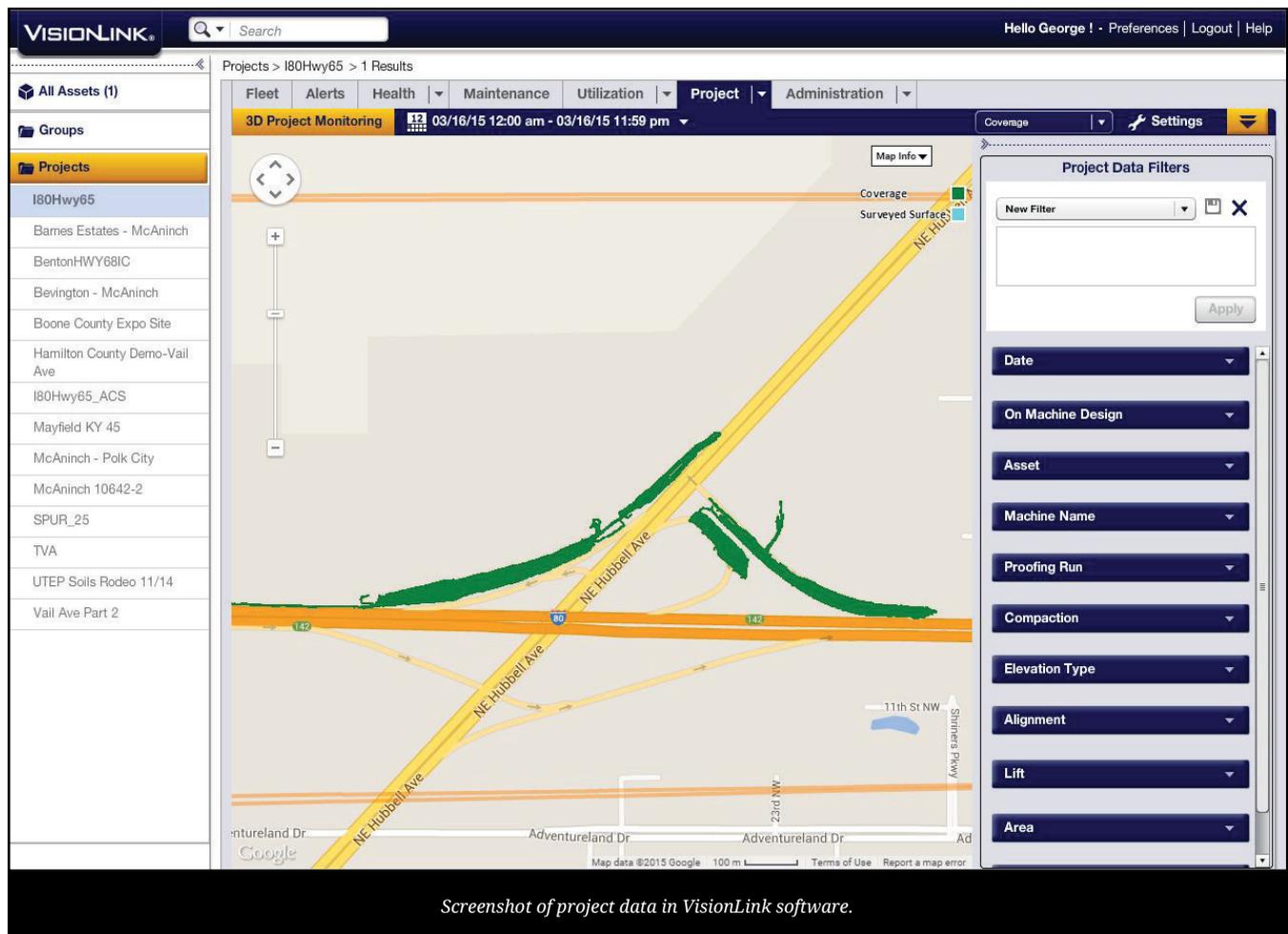
While roller operator could manage the soil moisture content control operations, the third-party QC testing augmented the test strip calibration information. The roller operator gained confidence in the IC system's ability to reliably monitor the soil compaction in real time. Historically, approximately 60 to 70% of the QC tests passed the first time. After becoming comfortable with the CMV and MDP target values, almost 100% of the QC tests passed the first time, reducing delays and idle time and increasing production.

## PROJECT BENEFITS FROM IC

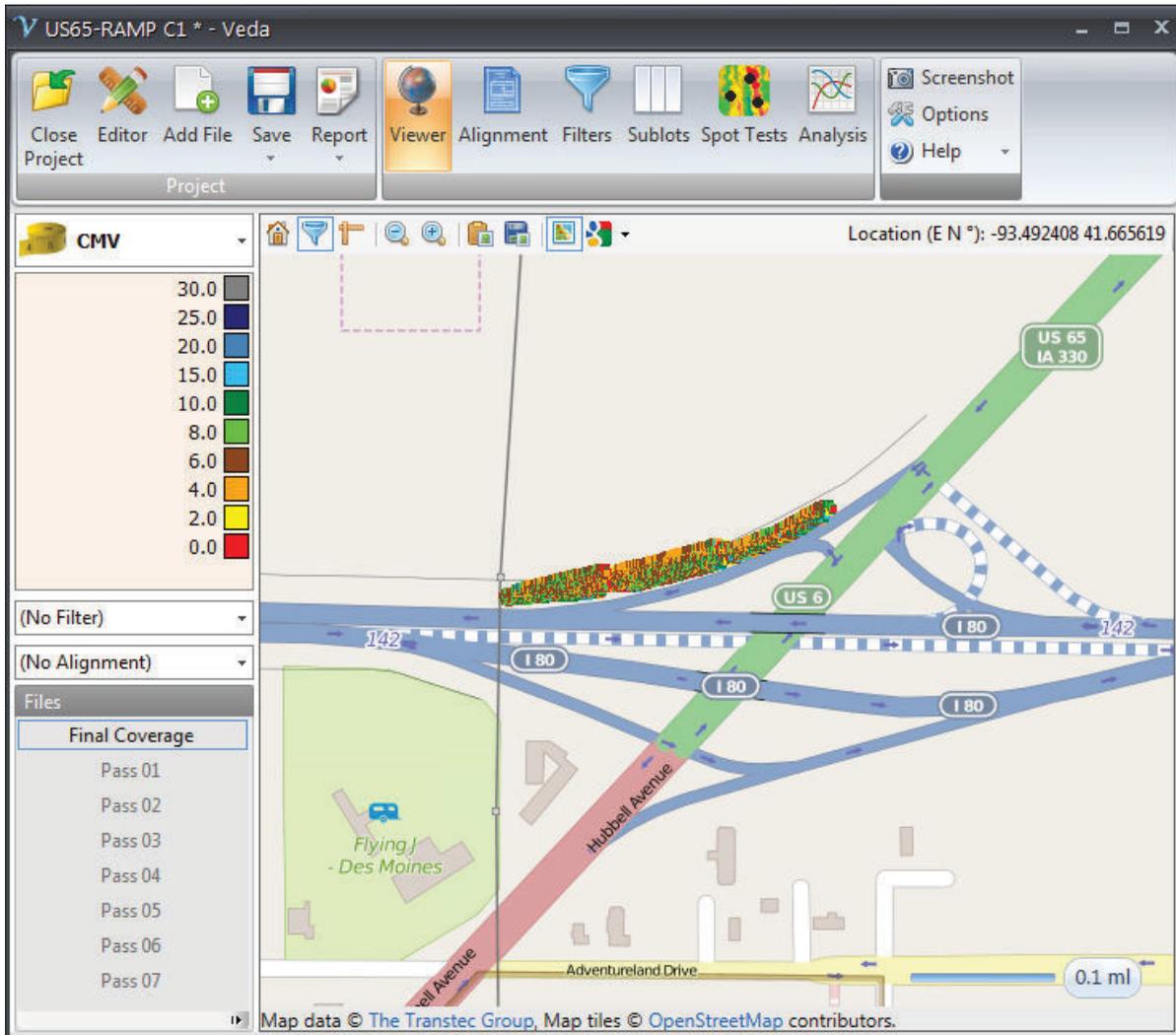
The field trial was beneficial to both the agency and the contractor. Agency benefits included increased quality control evaluation coverage and documentation, reduced frequency of undetected soft spots, and increased confidence that the compaction specification was being achieved.

The contractor reported increased construction efficiency and cost savings as benefits of using IC on the project. The construction efficiency was identified as “just right” effort being applied—the contractor was able to reduce the number of roller passes necessary to achieve the specified compaction because the material was not “over-worked,” while still identifying any trouble or soft spots. The contractor’s experienced roller operators reported that the IC learning curve was steep but short.

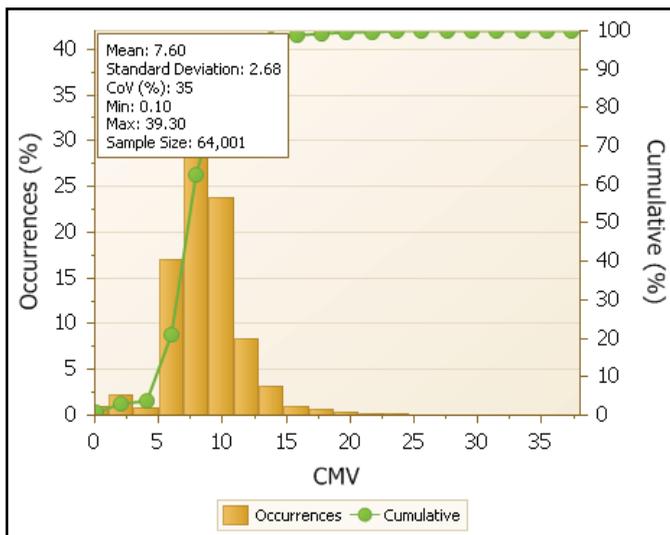
Contractor’s efficiency gains also took the form of smoother operations with less downtime. The contractor saw a reduction in the amount of idle roller time as on typical compaction projects, rollers must sit idle while quality control test results are gathered. With IC, operators spend less time waiting for test results. IC also reduced the amount of time the contractor had to spend re-testing areas.



Screenshot of project data in VisionLink software.



Screenshot of project data in Veda data management software: CMV values displayed on the map of the project.



Screenshot of project data in Veda data management software: CMV Stats.

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## IC'S OVERALL IMPACT ON I-80/US 65

The contractor reported savings of:

- 75% reduction in roller compaction time: the test strip validation indicated that fewer roller passes were necessary to achieve specified compaction
- 75% reduction in quality control re-testing

Both the contractor and the agency agreed that the I-80/US 65 Interchange mainline and ramp widening project benefited from IC's potential to increase quality control, efficiency, and cost savings.

