# TECHNICAL BRIEF

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

## ELEMENTS OF IC SPECIFICATIONS

The common elements of IC specifications include the following:

1. IC System Requirements
2. Quality Control Plan
3. Training
4. Field Operation Requirements
5. Data Requirements and Submission
6. Measures and Payment

## QUALITY ASSURANCE STATEMENT

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

# SPECIFICATION FOR INTELLIGENT COMPACTION

## A REVIEW ON NATIONAL AND STATE SPECIFICATIONS

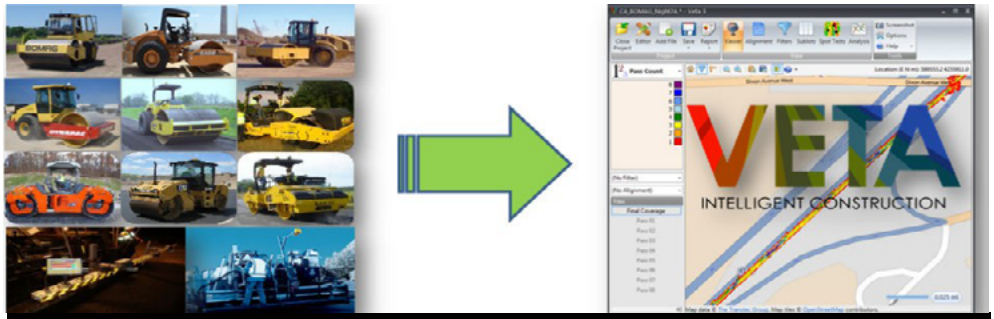
TECHNICAL BRIEF

SUMMER 2017

*FHWA IC and In-Place Asphalt Density Field Study in Idaho*

## BACKGROUND

Adequate and uniform compaction of road materials, such as soils, aggregate bases, or asphalt pavement materials, is one of the most important requirements in roadway construction. It is indispensable to strive for high quality of compaction to ensure long-lasting performance. Intelligent Compaction (IC), which uses modern vibratory rollers equipped with an integrated measurement system, an onboard computer reporting system, Global Positioning System (GPS) based mapping, and optional feedback control, is undergoing its implementation stage to help improve compaction quality control. The FHWA and AASHTO have developed national IC guide specifications. An increasing number of state agencies have also developed their own IC specifications. This Tech Brief will provide a review on those specifications and recommendations for future enhancements.




*Standard IC Data Viewing and Analysis using Veta*

# IC SYSTEM REQUIREMENTS

- Documentation is required for the roller supplier, make, and roller model, along with the number of IC rollers to be provided for the project.
- It is increasingly popular to instrument the entire rolling train with IC systems, including rollers at the breakdown, intermediate and finish positions.
- Some specifications include a list of approved or recommended IC roller brands and models.
- One key requirement is an accelerometer-based measurement system or called generically as ICMV.
- GPS radio and receiver units are required to be mounted on each IC roller to monitor the locations and track the roller passes. The precision requirements are often in real time kinematic (RTK) or survey grade precision. High Precision Positioning System (HPPS) is used to cover all positioning technologies such as GNSS, laser-based and cellular-based systems.
- Handheld GPS is required for measuring the locations of spot tests with conventional devices in order to be correlated to IC data.

# QUALITY CONTROL PLAN

- Contractors are required to prepare and submit a written Quality Control Plan (QCP) to DOT for approval.
- QCPs are contract-specific, stating how the contractor proposes to control the materials, equipment, and construction operations including subcontractors and suppliers as well as production facilities and transportation modes to the project for the asphalt mixture operations.
- The QCP should include the person responsible for operating the IC roller(s) and attached IC equipment, training documentation for the roller operator(s).

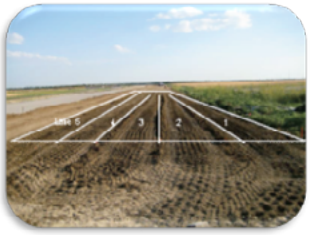
# IC TRAINING

- IC training is critical to any successful IC project due to the fact that most contractors and DOT staff are not familiar with this technology.

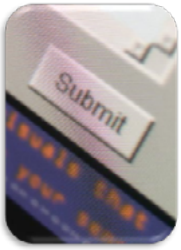
- IC equipment training is normally provided by IC vendors' technical support personnel.
- Minimum training topics include: background information for the specific IC systems to be used, setup and checks for IC systems, GPS receiver, base-station and hand held rovers; operation of the IC systems on the roller (i.e., setup data collection, start/stop of data recording, and on-board display options); transferring raw IC data from the rollers; operation of vendor's software to open and view raw IC data files and exporting all-passes and proofing data files in Veta-compatible format; operation of Veta software to import the above exported all-passes files, inspection of IC maps, input point test data, perform statistics analysis, and produce reports for coverage and other statistics.

# FIELD OPERATION AND ACCEPTANCE REQUIREMENTS

- GPS field validation: Requirements to check the proper setup and verify the accuracy of GPS on IC rollers against hand-held rover are common and critical. The tolerances for the difference between the measurements have also been specified as 6 inches to 12 inches. The frequency of validation is often required at a daily basis.
- Temperature verification: It is required to collect and compare the temperature measurements from an independent device and the instrumented roller with a tolerance of 5°F.
- Pre-paving mapping: Pre-mapping is performed using an IC roller to identify weak areas of the existing underlying materials such as soils subgrade, aggregate bases, or similar. It is not recommended for stabilized base, milled/non-milled existing asphalt pavements, concrete pavements, or similar underlying hard surfaces.
- Test strip: Test section construction is required to establish target pass counts and target ICMV for specific materials or a specific lift. Nondestructive density tests or pavement cores are required to correlate to ICMV.
- Conventional Spot Testing: Acceptance is still based on conventional spot tests such as cores and nuclear density gauge measurements.
- IC Construction Operations Criteria: There are requirements based on IC data. E.g., A minimum coverage of 90 percent of the individual construction area shall meet or exceed the optimal number of roller passes, and 70 percent of the individual construction area shall meet or exceed target ICMV values determined from the test section. Construction areas not meeting the IC criteria (coverage and/or uniformity) are recommended to be investigated by the DOT prior to continuing with the paving operations.



# DATA REQUIREMENTS AND SUBMISSION




- IC data requirement: IC data is the key to leverage benefits of IC technologies. The data header block and data blocks are often required with the most common data elements including roller type and size information, GPS system setting, and IC measurements (roller passes, vibration amplitudes and frequencies, surface temperature, and ICMV).
- Veta-compatibility: All IC data needs to be compatible with Veta. Veta is a standardized software currently sponsored by the Minnesota Department of Transportation (MnDOT) and the Pooled Fund Study TPF-5(334): "Enhancement to the Intelligent Construction Data Management System (Veta) and Implementation." It can import data from various IC systems and paver-mounted thermal profiler systems to perform standardized viewing and analysis.
- IC data submission: IC data submission normally required to include all-passes data at daily basis. Some states also require Veta analysis reports.

# MEASURES AND PAYMENT

- IC based acceptance: The IC construction operations criteria normally does not affect the standard agencies' acceptance processes for the materials or construction operations since IC is mainly used for QC.
- Basis of payment: IC process is normally paid at the contract lump sum price. This item includes all costs related to providing the IC roller(s) including the fuel, roller operator, GPS system, or any other equipment required for the IC process. All quality control procedures including IC rollers and GPS systems representatives support, on-site training and testing facility are also included in the contract lump sum price.

# REVIEW OF CURRENT IC SPECIFICATIONS

The current FHWA IC specifications provide a guideline to various state and local governments for the implementation of IC technology. These can be further modified based on applicability for both soils and asphalt to meet the state specifications.

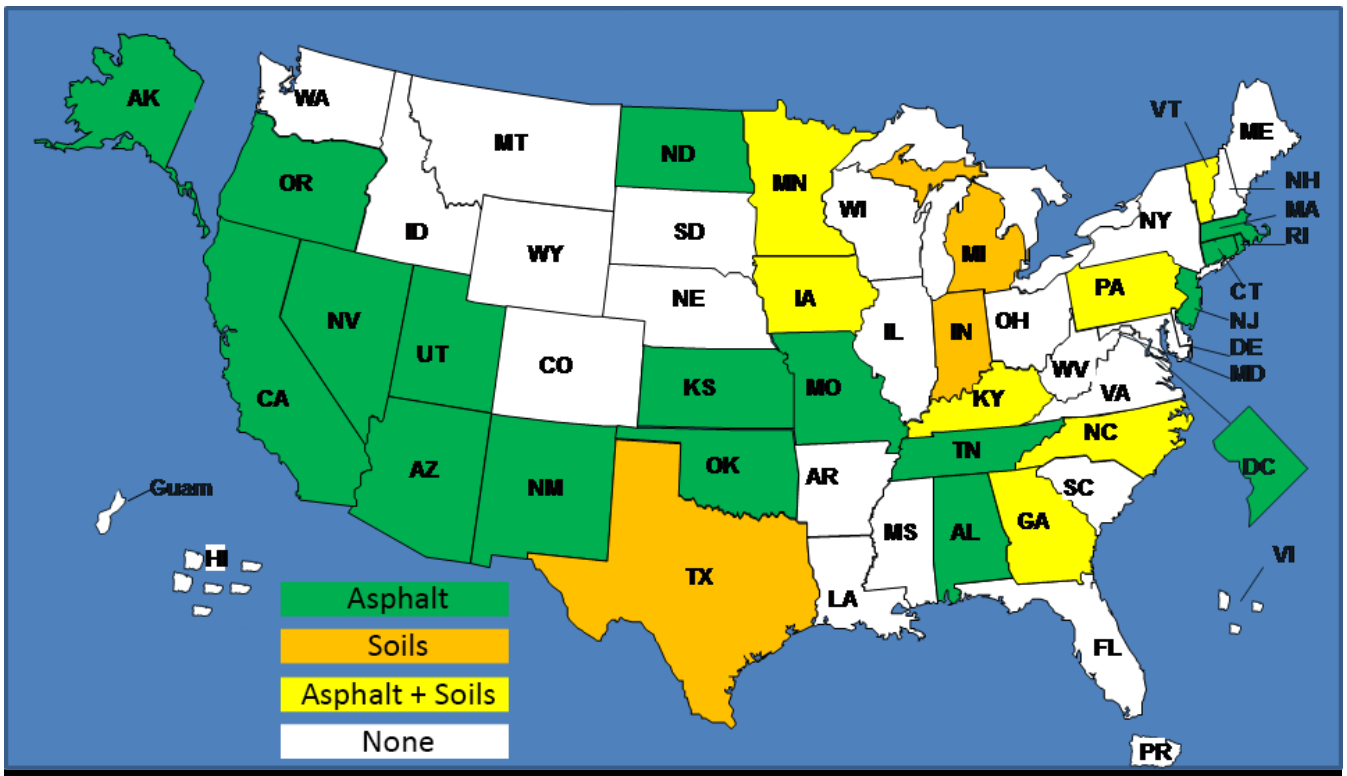
The current AASHTO PP 81-14, "Standard Practice for Intelligent Compaction Technology for Embankment and Asphalt Pavement Applications" is combined specification for both soils and asphalt applications. This specification is currently provided on a provisional basis. AASHTO allows a provision standard for up to 5 years before becoming a full standard.

The table below shows the comparison of a few key features between the FHWA and AASTHO IC specifications. There are many similarities and some minor differences such as alignment file requirement and recommendation for pre-mapping.

Comparison of FHWA and AASHTO IC Specifications

| | FHWA | AASHTO |
|---|---|---|
| GPS Verbiage | HPPS | RTK-GPS |
| GPS Verification Tolerance | ±12 inch | ±6 INCH |
| Temperature Verification Tolerance | No | ±5°F |
| Require Alignment Files | No | Yes |
| Dept. Approval of Rollers | No | Yes |
| Roller Vendors Listed | No | No |
| Test Strip Required | Yes | Yes |
| Pre-Construction Mapping | Yes | No |
| Veta Required | Yes | Yes |
| IC Training | 4-8 hours | Required |
| IC Training Includes Veta | Yes | No |
| Data Submittal | Daily | Daily |
| IC-Based Acceptance | No | No |
| Basis of Payment | Lump Sum | Lump Sum |

The distributions of state IC specifications are illustrated in the following map. The majority of state IC specifications are for asphalt. There are 23 states that developed asphalt IC specifications in addition to the Central and Eastern Federal Lands. There are nine states that developed soils IC specifications. Caltrans also developed an IC specification for cold in-place recycling (CIR). PennDOT includes roller compacted concrete in their IC specifications.




*Current State IC Specifications*

# CONSIDERATION IN IMPLEMENTING IC SPECIFICATIONS

Uniformity across the country: There is a lot of variance among the contents of state IC specifications. Specifications range from two pages (e.g., TNDOT) to 15 pages (e.g., Caltrans).

### Qualification/Certification Process for IC Rollers and Operators

There is an increasing need to have a field procedure to qualify and certify IC systems to ensure valid data collected for calculating pay items. Currently, only the AASHTO IC specification includes certification verbiage in the appendices regarding contractor personnel certification and provides a check list to approve IC rollers.

### Qualification of Onsite Training

Most state IC specifications require onsite or just-in-time training, but it is difficult to provide qualified trainers to conduct such training. One key element is the Veta-related training.

### Qualification of Onsite Technical Support

The current specifications have not spelled out the qualification of the onsite technical support which may causes issues regarding the quality of support.

### Conducting Daily GPS Validation

The GPS validation process is not a turn-key solution but requires rigorous steps to ensure consistency and accuracy of positioning system.

### Pre-mapping Requirement

Cautions should be taken while conducting pre-mapping. Users should follow the guidance of the FHWA Tech Brief: IC Pre-Mapping.

### Conducting Test Strips

Test section evaluations are optional but desirable in most specifications. It is often not practical to conduct a test strip for every lift of materials due to a lot of constraints, including time and changes of support condition.

### Determining Target ICMV Values

Some DOT IC specifications include the requirements to determine target roller passes and target ICMV from test strip data. Due to limitations of certain types of ICMV and uniformity of support conditions and material gradation, this process is often very challenging. Once improved ICMV are available, spot test locations may be able to determine by ICMV (e.g., Three to six tests within the low, medium, and high values) the correlation between ICMV and conventional acceptance tests is expected to improve. The correlation requirement is recommended as $R > 0.7$ or $R^2 > 0.5$.

### Alignment Files

The AASHTO specification requires agencies to produce an alignment file and provide it to the contractor. Currently, Veta requires closed polygon type of alignment files in Google kmz format. As of today, it is still difficult for DOT construction departments to communicate to the design department to produce adequate alignment files. Future Veta enhancements will allow more flexible alignment files such as using a center line to offset of paving width in order to produce a close polygon.

### Data and Report Submission

Current IC systems allow manual and wireless data transmission of IC data. The manual method often results in data loss. The wireless method may be hindered by lack of cellular coverage. It is still a steep learning curve for contractors to learn vendors' software to export IC data in Veta-compatible formats. As for reporting, some DOTs require contractors to perform Veta analysis and submit both IC data and IC analysis reports. Due to lack of training, such requirements are often not met due to delays or other issues.

*FHWA-TPF IC Demo Field Study in Texas*

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## IC WEBSITES

FHWA TSSC IC SUPPORT SITES
http://www.fhwa.dot.gov/construction/ictssc/support.cfm

ONE STOP-SHOP FOR INTELLIGENT COMPACTION
http://www.intelligentcompaction.com/

LIST OF US IC SPECIFICATIONS
http://www.intelligentcompaction.com/projects/specifications/



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**Federal Highway Administration**
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# RECOMMENDATIONS

The following recommendations are provided to facilitate future IC implementation.

- Communication between agencies and industry (contractors and vendors) is essential during the development and revision processes of state IC specifications.
- National guidance for IC roller equipment and personnel certification are recommended.
- Standard small size IC rollers with directional vibration are recommended to be developed to certify production types of IC rollers.
- The GPS validation process is recommended to be automated and simplified.
- Direct import of IC data from the Cloud to Veta is recommended to be implemented to simplify and speed up the data transmission.
- Anticipating results of further IC research, ICMV are expected to be improved to reflect the mechanical properties of layer-specific materials and it would elevate ICMV as a potential acceptance metric.