June 25, 2019

CONSTRUCTION MEMORANDUM
19-06 (Revised)

TO: District Deputy Commissioners
District Construction Directors
District Technical Services Directors
District Area Engineers
District Project Management Director
Project Management Director
District LPA Coordinators
Project Engineers/Supervisors
Field Engineers

FROM: Greg Pankow, Chief Engineer of Construction
Director of Construction Management and District Support

SUBJECT: Modifying IRI Contracts to utilize the Fixed Interval Method to Determine Smoothness Pay Adjustments for HMA.

INDOT has reviewed the Unique Special Provision (USP) for Inertial Profiler with Smoothness Pay Adjustments for HMA.

An alternate Unique Special Provision has been developed for this construction season which allows contractors to use fixed interval IRI reports to calculate the smoothness adjustment payments for HMA.

The alternate Unique Special Provision, IRI Field Guide are attached to this memo. A spreadsheet of Quality Adjustment Pay Factor for Fixed Interval analysis can be found on the INDOT website:

https://www.in.gov/indot/div/construction.htm

The new USP may be applied in place of the existing Fixed Interval-IRI current 401 USP Inertial Profiler for HMA. Revisions to the existing USP are shown highlighted gray.

A no cost change order will need to be prepared to cover the specification changes.

If you should have any questions on the issue please contact your District’s Field Engineer.

GGP/JN/tn
The Standard Specifications are revised as follows:

SECTION 401, DELETE LINES 546 THROUGH 658.

SECTION 401, AFTER LINE 658, INSERT AS FOLLOWS:

401.18 Pavement Smoothness

Pavement smoothness will be accepted by means of an inertial profiler, a 16 ft long straightedge, or a 10 ft long straightedge as described below.

(a) Inertial Profiler with Smoothness Pay Adjustments

When a pay item for Inertial Profiler, HMA is included in the contract, the Contractor shall furnish, calibrate, and operate an approved inertial profiler in accordance with ITM 917 on the mainline traveled way and ramps, including adjacent acceleration or deceleration lane, where all of the following conditions are met:

1. The design speed is greater than 45 mph.

2. The traveled way or ramp lane width and slope are constant and is 0.5 mi in length.

3. The HMA is placed on a milled surface and the planned lay rate for a single lift is 165 lb/sq yd or greater, or the total combined planned lay rate of surface, intermediate, and base courses is 385 lb/sq yd or greater.

The profiles, International Roughness Index, IRI, results including smoothness histograms and areas of localized roughness, and fixed interval IRI results produced shall become the property of the Department. The inertial profiler shall remain the property of the Contractor.

The paving exceptions and areas exempt from inertial profiler operation will be in accordance with ITM 917.

If the posted speed limit for an entire smoothness section is less than or equal to 45 mph, the section will be exempt from IRI operation and the smoothness within the section will be accepted in accordance with 401.18(b).

If the posted speed limit is greater than 45 mph for a portion of a smoothness section and is less than or equal to 45 mph for the remainder, the section smoothness acceptance will be as follows:

1. By inertial profiler for the portion of the section with a posted speed limit greater than 45 mph.

2. In accordance with 401.18(b) or (c) for the portion of the section with a posted speed limit less than or equal to 45 mph.
At locations where the inertial profiler is required, it shall be used on the surface course and on any dense graded intermediate course immediately below the surface course.

(b) Inertial Profiler without Smoothness Pay Adjustments
For contracts which include the Inertial Profiler, HMA pay item, the Inertial Profiler will be used to simulate the 16 ft long straightedge to accept longitudinal smoothness on surface courses at the following locations:

1. All mainline traveled way lanes longer than 0.1 mi and shorter than 0.5 mi.
2. All mainline traveled way lanes within smoothness sections with posted speed limits less than or equal to 45 mph throughout the entire section length.
3. All turn lanes, including bi-directional left turn lanes longer than 0.1 mi.
4. All ramps.
5. All acceleration and deceleration lanes associated with ramps with design speeds of 45 mph or less and longer than 0.1 mi.

(c) 16 ft Straightedge and 10 ft Straightedge
The Department will furnish and operate 16 ft and 10 ft straightedges as described below. The 16 ft straightedge is used to accept smoothness along the direction of mainline traffic and the 10 ft straightedge is used to accept smoothness transverse to the direction of mainline traffic. This includes longitudinal smoothness on public road approaches and median crossovers.

For contracts which include the Inertial Profiler, HMA pay item, the 16 ft long straightedge will be used to accept longitudinal smoothness on surface courses at the following locations:

1. All mainline traveled way lanes shorter than 0.1 mi.
2. All mainline traveled way lanes at locations exempted from inertial profiler operation in accordance with ITM 917.
3. All tapers.
4. All ramps.
5. All turn lanes, including bi-directional left turn lanes shorter than 0.1 mi.
6. All acceleration and deceleration lanes associated with ramps with design speeds of 45 mph or less and shorter than 0.1 mi.

7. All shoulders.

For contracts where the inertial profiler is not used for smoothness acceptance, the 16 ft straightedge will be used to accept longitudinal smoothness on all dense graded courses at the above locations as well as all mainline travel way lanes and ramps with design speeds of greater than 45 mph. Smoothness acceptance on ramp acceleration or deceleration lanes will also be based on operation of the 16 ft straightedge.

The 10 ft long straightedge shall be used to check transverse slopes, across travel lanes and shoulders, approaches, and crossovers.

(d) Smoothness Correction

At locations where the inertial profiler is being used on an intermediate course, all areas having a localized roughness in excess of 150 in./mi utilizing continuous IRI with a 25 ft window shall be corrected. The width of the corrected area may be partial or full lane width, depending on the respective wheel path profiles. After corrective action is taken on an intermediate course, a 16 ft straightedge or inertial profiler may be used to verify the adequacy of the corrective action.

At locations where the inertial profiler is being used on a surface course, all areas having a localized roughness in excess of 150 in./mile utilizing continuous IRI a 25 ft window shall be corrected. The width of the corrected area may be partial or full lane width, depending on the respective wheel path profiles. Underlying courses that are exposed by corrective action shall be milled to a depth of 1 1/2 in and replaced with surface course. After the corrective action is taken on a surface course, the inertial profiler shall be operated throughout the entire affected smoothness section to verify the adequacy of the corrective action.

At locations where the 16 ft straightedge is used, the pavement variations shall be corrected to 1/4 in. or less. When the 10 ft straightedge is used, the pavement variations shall be corrected to 1/8 in. or less.

If grinding of an intermediate course is used for pavement smoothness corrections, the grinding shall not precede the surface placement by more than 30 calendar days if open to traffic.

SECTION 401, DELETE LINES 770 THROUGH 817.

SECTION 401, AFTER LINE 817, INSERT AS FOLLOWS:

(e) Smoothness

Smoothness pay adjustments will only be applied when the smoothness is measured by an inertial profiler in accordance with 401.18(a). The pay adjustment will be based on the continuous IRI smoothness histograms utilizing a 25 ft window generated on the surface course only. The continuous pavement section length will be based on construction phases and will be subject to approval by the Engineer.
Determine the IRI for each lane for each 0.1-mile (0.16 km) section of paving. The IRI for a 0.1-mile (0.16 km) section is the average of the IRI of the two wheel paths. (aka. MRI).

At locations where an inertial profiler is used to accept smoothness, a quality assurance adjustment will be determined for each 0.1 mile section of for each lane. This adjustment will be applied to all QC/QA HMA pay items within the pavement section. The adjustment for each section will be calculated using the following formula:

\[ q_s = (PF_s - 1.00) \sum_{i=1}^{n} \left( A \times \frac{S_j}{T} \times U_j \right) \]

where:
- \( q_s \) = quality assurance adjustment for smoothness for one section
- \( PF_s \) = pay factor for smoothness
- \( n \) = number of layers
- \( A \) = area of the section, sq yd
- \( S_j \) = planned spread rate for material, lb/sq yd
- \( T \) = conversion factor: 2,000 lb/ton
- \( U_j \) = unit price for the material, $/ton.

The quality assurance adjustment for smoothness, \( Q_s \), for the contract will be the total of the quality assurance adjustments for smoothness, \( q_s \), on each section by the following formula.

\[ Q_s = \sum q_s \]

At locations where an inertial profiler is used to accept smoothness, a quality assurance adjustment will be determined for each lane. This adjustment will be applied to all QC/QA HMA pay items within the pavement section. The adjustment will be calculated using the following formula:

\[ Q_s = K \times 0.5 \sum_{i=1}^{n} \left[ (PF_{i,s}^2 - 1)(Y_i + Z_i) \right] \]

where:
- \( Q_s \) = quality assurance adjustment for smoothness
- \( PF_{i,s} \) = pay factor for smoothness for histogram cell \( i \)
- \( m \) = number of layers
- \( n \) = number of cells
- \( A \) = area of the section, sq yd
- \( S_j \) = planned spread rate for material, lb/sq yd
- \( T \) = conversion factor, 2000 lb/ton
- \( U_j \) = unit price for the material, $/ton
- \( Y_i \) = percentage of left wheel path IRI in histogram cell \( i \)
- \( Z_i \) = percentage of right wheel path IRI in histogram cell \( i \).
When smoothness is measured by an inertial profiler, payment adjustments will be made for any 0.1 mile section based on the IRI in accordance with the following table. The IRI will be determined prior to any required smoothness correction in accordance with 401.18(d).

<table>
<thead>
<tr>
<th>PAY FACTORS FOR SMOOTHNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Speed greater than 45 mph</td>
</tr>
<tr>
<td>IRI, in./mi.</td>
</tr>
<tr>
<td>over 0 to 40</td>
</tr>
<tr>
<td>over 40 to 45</td>
</tr>
<tr>
<td>over 45 to 50</td>
</tr>
<tr>
<td>over 50 to 55</td>
</tr>
<tr>
<td>over 55 to 70</td>
</tr>
<tr>
<td>over 70 to 75</td>
</tr>
<tr>
<td>over 75 to 80</td>
</tr>
<tr>
<td>over 80 to 85</td>
</tr>
<tr>
<td>over 85</td>
</tr>
</tbody>
</table>

SECTION 401, BEGIN LINE 887, DELETE AND INSERT AS FOLLOWS:

**401.22 Basis of Payment**

The accepted quantities for this work will be paid for at the contract unit price per ton for QC/QA-HMA, of the type specified, complete in place.

Payment for furnishing, calibrating, and operating the inertial profiler, and furnishing profile information will be made at the contract lump sum price for inertial profiler, HMA.

Adjustments to the contract payment with respect to mixture, density, and smoothness for mixture produced will be included in a quality adjustment pay item in accordance with 109.05.1.

SECTION 401, BEGIN LINE 912, DELETE AND INSERT AS FOLLOWS:

**Profilograph Inertial Profiler, HMA....................................................LS**

SECTION 401, BEGIN LINE 937, DELETE AND INSERT AS FOLLOWS:

The price for Profilograph Inertial Profiler, HMA will be full compensation regardless of how often the inertial profiler is used or how many profilograms are produced often the IRI is determined.

SECTION 402, BEGIN LINE 341, DELETE AND INSERT AS FOLLOWS:

**402.18 Pavement Smoothness**

Pavement smoothness will be in accordance with 401.18 except profilograph requirements will not apply. A straightedge in accordance with 409.03(f) will be used to determine smoothness. The 16 ft straightedge will be used to accept smoothness along the direction of mainline traffic and the 10 ft straightedge will be used to accept smoothness transverse to the direction of mainline traffic. Smoothness correction shall be in accordance with 401.18(d).
ProVAL Applications can be downloaded from FHWA website:

1) Open up ProVAL by either by going to the Start button → All Programs → FHWA → ProVAL or typing ProVAL into the search bar located in the Start menu.

**Desktop (Windows 7)**
or

**HP Mini Elite 2 (Windows 10)**

Type in “proval” into the Start Search bar. Then click on ProVAL 3.61.
**It is important that your screen resolution be set to 100%. If it is not, the program will not display correctly and will be difficult to use.**

2) Select **New** to begin a new project file.

3) The data file, that the Contractor has sent, needs to be downloaded onto this project file. Select **Add Files** and browse the folders where you placed the Contractor’s data file (window below is only an example of a folder location) and open it.

As more data is received, additional files should be added to this one project file to represent all the IRI testing for a contract.
4) The data file will automatically begin in the **Viewer** pane. Each file will have two checkboxes for a left and right wheel path readings. Clicking on these checkboxes will display the IRI readouts for the Section tested. The x-axis is listed in feet starting at 0 feet and up to however long the inertial profiler measured.

5) Next, the section needs to be identified for analysis. Not all sections start at 0 feet as can be seen above for the example. The starting feet on this graph needs to correspond with a station that represents the start of paving. To identify the section, select the **Editor** icon. Now select which file you want to use from the File dropdown.
6) Once the file is selected, you will notice the IRI results appear as they did on the Viewer pane. Click the Navigate dropdown to the right of File dropdown and select Sections. Next, click the Add button and provide a meaningful name that helps identify this exact section (Line/Direction/Lane/etc.).

7) Provide the Start Distance and Stop Distance at which the Surface was measured for the contract. The distances will not always match up to your typical section stations. For example, the inertial profiler started taking measurements 500’ before the construction limits and ended 500’ past the construction limits on the other side of the contract. The total distance measured was 4600. The starting station for paving is 0+00. That means distance 500’ would be station 0+00 since the inertial profiler started measuring 500’ before the paving limits. One of the exceptions for the inertial profiler is the first and last 50 feet of paving. Therefore, the Start Distance would be 550’ and the Stop Distance would be 4050’. You will notice the blue shaded area will now shrink to the limits entered.
Red Flags can be seen right above the graph. These red flags represent **Events**. Events are usually accompanied by spikes in IRI because of a bridge, casting, railroad crossing or other feature that would cause a bump unrelated to the actual pavement. ITM 917 describes these exceptions and exempts 50 ft. before and through 50 ft. after these exceptions from measurement. The contractor should help identify these locations and should already be marked in the file before you receive it.

8) Once these exceptions are identified, these areas need to be excluded from measurement. Click **Add** button within **Editor** and provide a name that describes the exception such as STR 3 for a bridge. The Start Distance should be 50 ft. before the exception and then the Stop Distance should be 50 ft. after the end of the obstruction. For example, there is a bridge that is 160 ft. long with 20 ft. approaches and the first approach begins at 3100 ft. The Start Distance should be entered as 3050 ft. and the Stop Distance should be 3350 ft. The only difference with this section as the previous section is the selection for the dropdown under the Type column. Select **Leave-Out**.
You will notice that the bridge can be seen as the orange shaded area. This area will now be excluded from IRI analysis. Repeat this process for all exceptions located within the section.

9) Now, it is time to analyze the Section for IRI and eventually output to obtain pay factors (PF) for smoothness quality adjustments. Click the Analysis button and select Ride Quality from the dropdown.

10) The Inertial Profiler specification explains that a fixed interval measurement with a 528 ft interval will be used for analysis with 90 in/mi being the threshold for corrective action. To set these parameters, you only need to select “fixed interval” for Analysis Type on the Analysis RQ table. Select “MRI” for Ride Quality Index. The Segment Length is already set at 528 ft. so no change is required there. Under the threshold column, enter 90 for the value for Threshold. Next, select the data files you would want to analyze and check “Apply 250 mm Filter” for all the selected files.
11) Now that the Fixed Interval Analysis has been set to meet the specifications, check the file and select the Section from the dropdown as seen in the screenshot. Click the **Analyze** button in the top right.
12) After that, select the **Report** button in the top right pane. You can click Select to browse folders for the destination of the report. Once a folder is selected, choose the Excel includes analysis tables only option on the left and click Create.

***If you get this screen below, you may have a spreadsheet with the same exact name but by a different user. Either select a different folder or delete the old spreadsheets. ***
13) You are now ready to compute smoothness adjustments with the Excel Spreadsheet. Open the IRI Inertial Profiler Quality Adjustments spreadsheet wherever it is stored on your computer (email attachment or local folder). Open the spreadsheet you created from ProVAL. The spreadsheet should have the project file’s name with columns of start distance, stop distance, length and MRI.
14) Now you can go to INDOT website: [https://www.in.gov/indot/div/construction.htm](https://www.in.gov/indot/div/construction.htm) and select “Alternate Fixed Interval IRI Payment Adjustment Spreadsheet”. Once you have both spreadsheets open, go to the spreadsheet generated by ProVAL and copy and paste the columns of start distance, stop distance, length and the MRI from the spreadsheet generated by ProVAL into the respective columns on the Adjustments spreadsheet as shown below.

15) Fill in all of the Section Data in the spreadsheet such as Profile starting station and Profile ending station, lane width, all Planned spread rates (if HMA), and Unit price per pay items. Once all this information is entered, you will notice the highlighted cell for variable Qs will show the dollar amount for the quality adjustment.

When the next Section has been measured for MRI, simply click the New Section button right next to the Qs cell. This action will save the current section spreadsheet results and will appear at the end of the spreadsheet tab shown at the bottom of the spreadsheet but maintain the profile stations, lane width, planned spread rates, and unit prices per pay item shown at the top of the spreadsheet and clear out the ProVAL spreadsheet data so the next ProVAL section spreadsheet data can be copied to the Adjustment spreadsheet to calculate adjustments for the next section.)
16) Once all Sections are completed, return to the first worksheet tab called “Qsc”. Simply press the **Calc Qsc** button to get the final quality adjustment for smoothness.
**Example 1**

US 50 Contract Information (HMA)

Typicals (Stations correspond to distances on ProVAL)

**EB 60+00 – 200+00**
- Surface - 165 lb/sys @ $100 T
- Intermediate - 220 lb/sys @ $90 T
- Base - 330 lb/sys @ $80 T

**EB 200+00 – 540+00**
- Surface - 165 lb/sys @ $100 T

**WB 15+00 – 500+00**
- Surface - 165 lb/sys @ $100 T
- Intermediate - 275 lb/sys @ $95 T
- Base - 440 lb/sys @ $85 T

**Exceptions**
- STR 5 (Bridge) = 190’ long with 30’ approaches Start Sta. (Dist) – EB 70+50
- STR 6 (Bridge) = 508’ long with 25’ approaches Start Sta. (Dist) – EB 400+50
- STR 7 (Bridge) = 305’ long with 20’ approaches Start Sta. (Dist) – WB 350+00
- STR 300 (Inlet) = 3’ long Start Sta. (Dist) – WB 100+00

**Answer:** $126,542.42.