New Technologies for Pavement Evaluation

TxDOT 3-D Pavement Survey Technology

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What is High Speed Pavement Evaluation

A combination of following pavement condition measurement

1. Ride quality IRI by longitudinal profiler
2. Rutting by five-point rut measurement device
3. Surface distress (cracking) by downward surface image
4. Surface texture by high speed laser sensor

New Technology for 3-D pavement structure

A combination of surface image and surface elevation data

1. Rutting by high speed continuous transverse profile
2. Surface distress (cracking) by downward surface image and depth information
3. Surface texture by high resolution surface 3-D structure
4. Cross slope, faulting, marking thickness, pothole, and other features
TxDOT 3D Rutting system, VRUT

- Based on high speed 3D technology
- Samples 1536 points of profile for every 1 inch of travel
- Covers 14’ (4.26m) wide surface
- .025” (0.65 mm) rut resolution
- .093” (2.38 mm) transverse resolution
- Works on any type of pavement
- 0 to 70 mph (112 km/h) speed
- Straight edge, string line, and 5 point rut measurement methods

14 feet laser line, 1500/2300 data points
Image capability

Surface Intensity Image and Elevation Image capable

Surface (intensity) image:

Range (elevation) image:
Rut Measurement

- Based on continuous transverse profile
- Lane width detection for correct rut locations
- String line and straight edge rut algorithms
Rut Location and Spacing

- Only measured rut deeper than 1/8” are shown on maps
- Rut spacing is calculated only when left and right rut is measured
- Rut trace changes with distance
- Rut space changes with different traffic patterns
Accuracy: Manual vs. 3D Rut Data Comparison

Manda Rd Left Wheelpath Rut $R^2=0.939$

Manda Rd Right Wheelpath Rut $R^2=0.948$

FM165 Left Wheelpath Rut $R^2=0.423$

FM165 Right Wheelpath Rut $R^2=0.910$

Seal coat G3 rough

ACP Smooth
Repeatability Test, Multiple Runs

Each test was conducted:

- On same test section
- At posted speed
- Three trial runs
- left and right rut on every 10 ft

Excellent correlation between different runs.

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**VRUT Repeatability Test, FM165, Right Wheelpath**

<table>
<thead>
<tr>
<th>R²</th>
<th>RUN#1</th>
<th>RUN#2</th>
<th>RUN#3</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUN#1</td>
<td>0.983</td>
<td>0.984</td>
<td></td>
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<tr>
<td>RUN#2</td>
<td>0.957</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RUN#3</td>
<td></td>
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</table>

**VRUT Repeatability Test, FM967, Right Wheelpath**

<table>
<thead>
<tr>
<th>R²</th>
<th>RUN#1</th>
<th>RUN#2</th>
<th>RUN#3</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUN#1</td>
<td>0.866</td>
<td>0.91</td>
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<tr>
<td>RUN#2</td>
<td>0.867</td>
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<tr>
<td>RUN#3</td>
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</tbody>
</table>
**TxDOT 3D Texture System**

Technology for texture survey has moved to 3D for reliable data!

**TxDOT 3D Texture System**

- Based on high speed 3D technology
- Samples 2048 points for every 2 inches of travel
- Covers 12” (304 mm) wide surface, 100%
- 10 µm texture resolution
- .007” (0.2 mm) spatial (x, y) resolution
- Works on any type of pavement
- Very high resolution 3D texture image for project level test
- Speed independent data.

*Longitudinal Scanning Unit*
*Network level Survey*

*Transverse Scanning Unit*
*Project level Survey*
Accurate, Repeatable, Speed Independent

1. Scan on test targets with known depth at different speed from 0 to 70 mph.
2. Reproduce each target profile accurately
3. Speed independent MPD data

<table>
<thead>
<tr>
<th>Unit mm</th>
<th>8 mm block</th>
<th>5.5 mm block</th>
<th>3 mm block</th>
<th>2.5 mm block</th>
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</thead>
<tbody>
<tr>
<td>8 mm</td>
<td>5.5 mm</td>
<td>3 mm</td>
<td>2.5 mm</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>1.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>55</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 8 mm block, 10 mph
- 8 mm block, 40 mph
- 8 mm block, 70 mph
- 5.5 mm block, 10 mph
- 5.5 mm block, 40 mph
- 5.5 mm block, 70 mph
- 3 mm block, 10 mph
- 3 mm block, 40 mph
- 3 mm block, 70 mph
- 2.5 mm block, 10 mph
- 2.5 mm block, 40 mph
- 2.5 mm block, 70 mph
1. Produce high accurate MPD data on different targets
2. Very low error on large target
3. Acceptable accuracy on small target
Comparison to other Texture Methods

<table>
<thead>
<tr>
<th>Section</th>
<th>Sand Patch</th>
<th>CTM</th>
<th>3D</th>
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<tbody>
<tr>
<td>A</td>
<td>1.31</td>
<td>1.28</td>
<td>1.284</td>
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<tr>
<td>B</td>
<td>1.26</td>
<td>1.40</td>
<td>1.367</td>
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<tr>
<td>C</td>
<td>1.71</td>
<td>1.91</td>
<td>1.936</td>
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<tr>
<td>D</td>
<td>1.23</td>
<td>1.18</td>
<td>1.380</td>
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<tr>
<td>E</td>
<td>0.51</td>
<td>0.48</td>
<td>0.570</td>
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<tr>
<td>F</td>
<td>0.65</td>
<td>0.77</td>
<td>0.779</td>
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<tr>
<td>G</td>
<td>2.56</td>
<td>2.81</td>
<td>2.883</td>
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<tr>
<td>H</td>
<td>0.42</td>
<td>0.46</td>
<td>0.455</td>
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<tr>
<td>I</td>
<td>0.94</td>
<td>1.17</td>
<td>1.078</td>
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<tr>
<td>J</td>
<td>1.19</td>
<td>1.50</td>
<td>1.371</td>
</tr>
<tr>
<td>K</td>
<td>1.02</td>
<td>1.37</td>
<td>1.181</td>
</tr>
</tbody>
</table>

1. Tested on 11 different pavement surface
2. VTexture shows very high correlations to sand patch and CTM data
3. VTexture works on concrete surface
1. During network level survey, VTexture gives an MPD for every 2” of travel.

2. Statistical summary reported every 0.1 mile, includes average, minimum, maximum MPD values and standard deviation.

3. Fully automated, no operator assistance is needed.
Project Level Application

1. Three scan direction at Longitudinal, transverse, and 45 degree mount
2. 5 to 10 mph speed, continuous data collection.
3. High density data at 256 profile per foot of travel
4. Different display images for better analysis
TxDOT 3-D Cracking System

- Built on true 3-D technology
- High speed 0 to 70 mph
- Fully automated
- Works on different pavement
- 2350 Data point
- 10000 scan/sec
- 8.11 profiles/inch
- 3.13 x 1.81 mm resolution
Surface and Depth Image Capable

Intensity and range Images

3-D Display
Automated Image Processing

Intensity Image  Processed Range Image  Crack Detection Result
Pavement Image in 3D Display

Cracks Displayed in Range Image
Crack map
Crack Map
Thank You!

All systems were developed by TxDOT 3-D development team:

Dr. Robin Huang,
Todd Copenhaver,
Phillip Hempel, P.E.

and others from Construction Division, Pavement and Material Branch under the leadership of branch manager

Dr. Magdy Mikhail, P.E.

Thank You!