Lessons Learned from Forensic Investigations of Premature Failures and Pavement Rehabilitation Strategies in Texas

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If we do what we did, we will get what we got.
Negative signal indicates possible void under slab.

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If we do what we did, we will get what we got
Abandoned 24 inch sewer line was later filled.
Antenna Frequencies (in air)

2 GHz
0.5 ns (5.9 in)
High Resolution
Low Depth Penetration

1 GHz
1 ns (11.8 in)

400 MHz
2.5 ns (29.5 in)
Antennas may be Ground Coupled or
Air Coupled

200 MHz
5 ns (59 in)
Low Resolution
High Depth Penetration
Major defect
inversion
Transverse Rebar

inversion
Major defect
<table>
<thead>
<tr>
<th>Shoulder</th>
<th>Inside Lane</th>
<th>Middle Lane</th>
<th>Outside Lane</th>
<th>Shoulder</th>
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</thead>
<tbody>
<tr>
<td>Concrete Barrier</td>
<td><img src="image1" alt="Car" /></td>
<td><img src="image2" alt="Car" /></td>
<td><img src="image3" alt="Car" /></td>
<td>150 mm asphalt</td>
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<tr>
<td>Steel Rebar</td>
<td>3.82 cubic meter void</td>
<td>8ft</td>
<td></td>
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<tr>
<td>200 mm CRCP</td>
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</table>
Settlement
US190
Waco District – Coryell Co.
CSJ 0231-19-002

2" AC Ty C

PRIME COAT & 1CST

10" FB
...ting on the wheel path.

by 10 feet before and after the settlement.

ion length is 200 feet.
The test section length is 200 feet. The coupled Radar test section length is 180 feet.
EBOL RWP – Patch
(used 15” thickness)

TTI FLEXIBLE PAVEMENT DEFLECTION BASIN ANALYSIS PROGRAM

<table>
<thead>
<tr>
<th>FWD TESTED FILE NAME</th>
<th>E:\ongoing\US190</th>
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<tr>
<td>DISTRICT</td>
<td>9--waco</td>
</tr>
<tr>
<td>COUNTY</td>
<td>14--BELL</td>
</tr>
<tr>
<td>HIGHWAY</td>
<td>US190</td>
</tr>
<tr>
<td>TEMPERATURE(&quot;F) start</td>
<td>106.0 knd: 114.0</td>
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<tr>
<td>AVERAGE RUT DEPTH(in)</td>
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<tr>
<td>ALLIGATOR CRACKING</td>
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</tr>
<tr>
<td>ASPH. THICKNESS</td>
<td>****</td>
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<tr>
<td>MONTH TESTED</td>
<td>JUN</td>
</tr>
<tr>
<td>DESIGN LOAD (lbs)</td>
<td>9000</td>
</tr>
<tr>
<td>20 year 18 KIP(m)</td>
<td>8.23</td>
</tr>
<tr>
<td>LANES</td>
<td>2</td>
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<tr>
<td>SENSORS</td>
<td>0 12 24 36 48 60 72</td>
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</table>

<table>
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<tr>
<th>STATION</th>
<th>** NORMALIZED DEFLECTION (mils)**</th>
<th>ASPH DESIGN</th>
<th>LAYER</th>
<th>REMAINING LIFE (yrs)</th>
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<tr>
<td></td>
<td>**</td>
<td>R1</td>
<td>R2</td>
<td>R3</td>
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<td>3.02</td>
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<td>4.73</td>
<td>2.91</td>
<td>1.83</td>
<td>1.34</td>
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</tbody>
</table>

| MEAN: | 7.65 | 5.13 | 3.14 | 2.18 | 0.98 | -0.01 | VG | VG | GD |
| STD DEV: | 4.94 | 3.21 | 1.50 | 0.80 | 0.23 | 0.22 |
| COF VAR | 64.65 | 62.61 | 47.90 | 36.60 | 23.40 | 0.00 |

* 0-2:Failed 2-5:Problem 5-10:OK for Now 10+:Good
East & West Bound Thickness

Asphalt Thickness (mm.)
- 400-450
- 350-400
- 300-350
- 250-300
- 200-250
- 150-200
- 100-150
- 0-100

June 22, 2015
East & West Bound Thickness

![3D Graph of Asphalt Thickness vs Road Length and Width]

Asphalt Thickness (mm.)
- 400-450
- 350-400
- 300-350
- 250-300
- 200-250
- 150-200
- 100-150
- 50-100
- 0-50

Road Length (m.)
- 0-15
- 15-30
- 30-61
- 61-76
- 76-91
- 91-122
- 122-137
- 137-152
- 152-168
- 168-183
- 183-198

Road Width (m.)
- 0
- 15
- 30
- 45
- 60
The settlement is occurring at this slant
<table>
<thead>
<tr>
<th>C-3</th>
<th>C-2</th>
<th>Surface</th>
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</thead>
<tbody>
<tr>
<td>16.89</td>
<td>10.11</td>
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<td>5.76</td>
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</table>

Diagram with depth markings 0 to 180 feet and surface indicating C-3 and C-2 locations.
Path of Radar Data @34ft offset
IH 37
Voided Area on Main Lanes
Thick Asphalt Overlay
Possibly sagging concrete
Major reflection beneath slab
If we do what we did, we will get what we got.
Patched area settled and it had been leveled up for 4 times for a total of about 4 inches. The patched area has 6 times higher deflection than the adjacent area. It is structurally inadequate for this roadway. Please email us future information/pictures.
Shoulder

Outside Lane

Sinkhole repair

Inside Lane

Shoulder

N
Shoulder Outside Lane
Sinkhole repair
Shoulder Inside Lane
Outside Lane
Shoulder
N
Shoulder

Outside Lane

Sinkhole repair

Inside Lane

Outside Lane

Shoulder
Shoulder

Shoulder

Inside Lane

Outside Lane

Sinkhole repair

Shoulder

N
and type “B” hot mix. A little settlement at first, but we burned a patch over it with the lay down machine before we completed the paving operation.
Deflection (mils) vs Distance (ft) graph showing a significant change from "Before" to "After." The graph includes data points for distances ranging from 130 to 180 feet, with deflection values marked at intervals of 0.00 to 60.00 mils. The graph indicates a notable increase in deflection at certain distances, with a peak around 155 feet, followed by a sharp decrease after an intervention noted as "After."
Cover-collapse sinkholes

Sediments spall into a cavity. As spalling continues, the cohesive covering sediments form a structural arch.

Overburden (mostly clay)
Carbonate bedrock

The cavity migrates upward by progressive roof collapse.

1. Overburden
   Sand
   Clay
   Limestone Bedrock

   The carbonate in the rain water dissolves the limestone bedrock.

2. Thus, a cavity is formed in the bedrock.

The cavity eventually breaches the ground surface, creating sudden and dramatic sinkholes.

3. Overburden
   Sand
   Clay
   Limestone Bedrock

   Soil and rocks start falling into this cavity, and the void continues to grow upwards.

4. Eventually, the overburden collapses, leading to a sinkhole.
Depth ~ 2.5’

~ 2.0’ to Top of Subgrade

Depth ~ 2.5’
Figure 1.2. Schematic of deformation resulting from test roller wheel penetration
Request made to use Ground Coupled Radar to identify pavement distress source.
From the Edge of the Shoulder: 28’
Radar scans on asphalt pavement.
No anomalies present.

Radar scans on asphalt pavement. The anomaly shows a positive reflection which is typical of a change in material.

Radar scans on asphalt pavement. There are two anomalies.
1. Negative reflection, typical of a void.
2. Positive reflection, a change in material.
Radar Imaging in Austin
TRAD Mobile Platform
Adapted from a Minivibe

Side View Dimensional Drawing of the 'minivib' II mounted on the 'minibuggy'