MODIFICATION OF LA DOTD SPECIFICATION ON HIGHWAY CROSS-DRAIN TRENCH BACKFILL

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Problem

Unexpected pavement surface dips at highway cross-drain sites
Field Investigation Indicates

Pavement surface “dips” at highway cross-drain locations are mainly due to weak trench backfill compared to adjacent subgrade.
Field Testing Scheme

Diagram:

- Pavement Structure
- Subgrade Soil
- Trench Backfill
- Pipe
- Bedding Material

- Optional DYNAFLECT
- DCP
- DCP
- DCP

1.5 m
Penetration Resistance Ratio (PRR)

$$PRR = \frac{\text{Penetration Resistance in Trench}}{\text{Penetration Resistance out of Trench}}$$
PRR with or without surface “dip”

![Graph showing Penetration Resistance Ratio (PRR) with and without dip, where PRR < 0.7 indicates a significant difference between the two conditions.]
Prevention of Pavement Dips

To prevent pavement surface “dips” at highway cross-drains, we should make trench backfill stronger than adjacent subgrade soils.
Backfilling

- **Type A backfill material**
  Stone, recycled Portland cement concrete, or flowable fill

- **Type B backfill material**
  Stone, recycled Portland cement concrete, flowable fill, selected soils, or granular material

- Type A for pipes/trenches subject to traffic; Type B for others

- More details
BM-01 Detail – Type A Backfill

Concrete Pipe

Base Course

Embarkment as Required

- Reinforced Concrete Pipe
- Thickness As Shown On Plans (6" Min.) Or As Directed By The Project Engineer
- Backfill Material
- Original Ground
- Bedding Material
- Plastic Filter Cloth
BM-01 Detail (cont.)
– Type B Backfill

Concrete Pipe

- Embankment as Required
- Reinforced Concrete Pipe
- Backfill Material
- Bedding Material
- Original Ground
- 1/10 D Min. Shaping
- Plastic Filter Cloth

Thickness As Shown On Plans (6" Min.) Or As Directed By The Project Engineer
BM-01 Detail (cont.)

- Type A Backfill

**Metal or Plastic Pipe**

- Embankment as Required
- 12”
- 18”
- Thickness As Shown On Plans (6” Min.) Or As Directed By The Project Engineer
- Metal Pipe, Or Plastic Pipe
- Bedding Material
- Backfill Material
- Original Ground
- 1/10 D Min. Shaping
- Plastic Filter Cloth
BM-01 Detail (cont.)
– Type B Backfill

Metal or Plastic Pipe

- Metal Pipe, or Plastic Pipe
- Backfill Material
- Bedding Material
- Plastic Filter Cloth
- Original Ground
- \( \frac{1}{10} D \) Min. Shaping
- Embankment as Required

Thickness As Shown On Plans (6" Min.) Or As Directed By The Project Engineer

Thickness As Shown On Plans (6" Min.) Or As Directed By The Project Engineer
BM-01 Detail (cont.)
– Type A Backfill

Cover Layer Less Than 5'

- Base Course
- Embankment
- Original Ground
- Plastic Filter Cloth
- Reinforced Concrete, Metal, or Plastic Pipe
- Backfill Material
- Thickness As Shown On Plans (6" Min.) Or As Directed By The Project Engineer
- Bedding Material
- 1/10 D Min. Shaping
- < 5'
BM-01 Detail (cont.) – Type A Backfill

Cover Layer Greater Than or Equal to 5'

- Bedding Material
- Backfill Material
- Embankment
- Original Ground
- Base Course

Compaction with good quality
BM-01 Detail (cont.)
– Type B Backfill

- Bedding Material
- Backfill Material
- Embankment
- Original Ground
- 1/10 D Min. Shaping
- Reinforced Concrete, Metal, Or Plastic Pipe
- Plastic Filter Cloth

Thickness As Shown On Plans (6" Min.) Or As Directed By The Project Engineer
RAP – Type A Backfill

- Not in the new specs, but can be tried on a project basis
- To be added to the new spec
- Equipment:
  Wacker packer compactor
- Lift thickness:
  8 inches (200 mm) - 12 inches (300 mm) compacted thickness
RAP – Type A Backfill

- Quality control
  - Start with 8 coverage passes
    Can be reduced to, but not less than 6 passes
  - Dry density probably be 90 to 92% of the maximum dry density (102 to 104 pcf)
    DCP tests should be conducted for every 3 foot backfill
  - Below the springline of pipe: 12 mm/blow
    Above the springline of pipe: 10 mm/blow

- Pay attention to the compaction quality of layers that cover the pipes because that is the location for the settlement of backfill to occur
Field Testing - Program

- Number of Trenches: 19
- Pipe size and type: 36” – 54”, concrete
- Backfill Materials:
  Sand, Kentucky/Mexican crushed limestone, RAP, sand gravel mixture, and Selected soil
- Compaction Equipment
  Vibratory Plate, Vibratory Roller, and Wacker Packer Compactors
Field Testing - Results

Poor backfill was related to

- Construction conditions
- Workmanship and inspection
- Backfill material and compaction
Construction Conditions

Conditions that make it difficult to compact backfill include:

- Tight schedule
- Under traffic
- Poor weather
- Wrong moisture
- Poor drainage
- Confined construction space
- etc.
Tight Construction Schedule

10:00 am

3:00 pm

6:00 pm

8:00 pm
What Weather Can Do
Work under Traffic
Too Much Moisture
In summary, creating and maintaining a good construction environment is important to the quality control of trench backfills at highway cross-drains.
Workmanship & Inspection

- Is the most important factor in quality control
- Most contractors are experienced
- Tension can build in the field when under pressure due to construction delays, under traffic, bad weather, wrong moisture content of backfill, poor drainage conditions
- Communication and cooperation are very important
- All should share the consequences of their construction products, good or bad
Backfill Material

- Material Compaction
- Moisture Adjustment
- Seepage Stability
Field Compaction Equipment

Wacker Packer  
Vibratory Roller  
Vibratory Plate
## Summary of Compaction – Standard Proctor

<table>
<thead>
<tr>
<th>Material</th>
<th>Maximum Dry Density pcf</th>
<th>Working Moisture Range, %</th>
<th>Compaction in field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>105 - 107</td>
<td>4 – 7</td>
<td>Difficult</td>
</tr>
<tr>
<td>Kentucky limestone</td>
<td>135 - 139</td>
<td>5 – 7</td>
<td>Very easy</td>
</tr>
<tr>
<td>Mexican limestone</td>
<td>116 - 121</td>
<td>8 – 12</td>
<td>Very easy</td>
</tr>
<tr>
<td>Bedding (Sand gravel)</td>
<td>125 - 128</td>
<td>5 – 8</td>
<td>Better than sand</td>
</tr>
<tr>
<td>RAP</td>
<td>102 - 104</td>
<td>5 – 9</td>
<td>Easy</td>
</tr>
<tr>
<td>Selected soil</td>
<td>106 - 109</td>
<td>15 – 18</td>
<td>Not easy</td>
</tr>
</tbody>
</table>
Backfill Material

Material Compaction
- Moisture Adjustment

Seepage Stability
Moisture Adjustment

- How fast a backfill material can be dried out in the field
- Laboratory dry-out test
Laboratory Dry-Out Test Results

Limestone takes the least time to dry out
Backfill Material

Material Compaction

Moisture Adjustment

- Seepage Stability
**Seepage Stability**

- Resistance to erosion caused by the water that leaks out from the joints or cracks of cross-drain pipes
  - Backfill dry density
  - Material cohesion or particle interlock

**Material comparison**

<table>
<thead>
<tr>
<th>Material</th>
<th>Density</th>
<th>Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky limestone:</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Mexican limestone:</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>RAP:</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>Bedding:</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Selected soil:</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Sand:</td>
<td>low</td>
<td>low</td>
</tr>
</tbody>
</table>
Summary for Backfill Material

- Kentucky limestone: The best choice
  - Easy to compact to a high dry density and stiffness
  - Narrow moisture range to deal with in the field
  - Strong particle interlock with good seepage stability

- Followed by Mexican limestone, RAP, bedding material (sand gravel mixture), Selected soil, and sand
Field Testing - Results

Other factors for the occurrence of pavement surface dips

- Pipe cover layer
- Configuration of cross-drain trench
Pipe Cover Layer

- Refers to the subgrade soil over pipes
- It is a buffer zone between a pavement structure and pipes for construction and traffic loading
- A thick and well compacted cover layer will spread traffic loading well over trench area
Pipe Cover Layer – 4.4 feet

N-DCP (blows/10cm)

Cover Layer

DCP 1  DCP 2  DCP 3  DCP 4  DCP 5  DCP 6

Subgrade  Crushed Stone  Crushed Stone  Subgrade  Subgrade  Subgrade

Pipe

47" (119 cm)  53" (135 cm)  = >15
Cover Layer Spread Traffic Loading
– Embedded pressure cells

- 8" Asphalt Pavement
- 8.5" Mexican Limestone
- 42" Subgrade
- Layer 1: 12"
- Pressure cell: 26.4"
- Selected Soil
Summary for Pipe Cover Layer

A **well compacted thick** cover layer will “bridge” traffic loading over trench area and prevent overloading cross-drain pipes and backfill.
Compaction in subgrade backfill area is important

- If properly compacted, it can provide a smooth transition in stiffness
- Otherwise, it can be a weak area causing pavement surface dips
Field Example of Subgrade Backfill Area
Conclusion

- Field experience indicates that we will have to build highway cross-drains under different (good and bad) conditions.

- We need to make backfill stronger than adjacent subgrade soils to prevent pavement surface dips at highway cross-drains.
Conclusions (cont.)

- To prevent pavement surface dips
  - Use backfill materials that can be properly compacted under different construction conditions
  - Try to avoid bad construction conditions that affect construction quality
  - Have good project inspections
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Alternative Methods to Trench Backfill
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Questions?