The Dynamic Cone Penetrometer "The DCP"

What is it, how does it work, and how can it help you?

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Presentation Objectives:

- What is it?
  - Purpose & Concept
  - Parts
- How does it work?
  - Operation/Technique
  - Data Recording/Analysis
- How can it help you?
  - Layer Stiffness
  - Layer Thickness
  - Acceptance & Verification
  - Forensics
  - Correlations (CBR, Mr, etc.)
What is it?

- Purpose & Concept
  - Dynamic Cone Penetrometer
  - Shallow Pavement Applications
  - Measures Stiffness, mm/blow
  - Simple Concept
    - Like hammering a nail
    - Stiff material requires more drops
    - Weak material requires fewer drops
  - Non Nuclear
  - Possible Method for Acceptance
  - Quick and Cost Effective
  - Another “Tool for the Toolbox”
What is it?

• Parts
  – Handle
  – Upper Rod (5/8” dia)
  – Hammer
    • 17.8 pounds (8kg)
    • 22.6 inch drop
  – Anvil & Lower Rod
  – Cone Tip (60 degree, ¾” dia)
  – Measuring Rod with cm & mm divs.
  – Other
    • Hammer Drill
    • Generator
    • Farm Jack
How does it work?

- **Operation**
  - Assemble DCP
  - Drill thru Asphalt or Concrete if necessary
  - Record reference readings (A)
    - Rod remains stationary
  - Lift hammer to handle
  - Release hammer
  - Record rod reading after each hammer drop (B)
  - Repeat drop, read, and record process thru pavement layers

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How does it work?

- **Technique**
  - Keep straight (vertical)
  - Avoid banging hammer into handle during lift.
    - Can lose disposable cone
    - Damage to device
  - Spin rod after each blow.
  - Keep measuring rod in one spot during test.
  - Record reading after every hammer drop.
How does it work?

• Operation (Prep & Planning)
  – Hammer Drill
    • Quickly thru Asphalt or Concrete
    • Minimal Intrusion
    • Various Length bits
    • Dry vs wet coring rig

• Crew Size
  • Hammer Operator
  • Reader
  • Recorder

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How does it work?

• Data Recording
  – Project Information
    • Site Location
    • Station #
    • Distance from Centerline
    • Elevation (if available)
  – Pavement Information (as available)
    • Cross-Section Thickness Information
    • Material Types (classification and gradation)
    • Compaction Info (Proctor Moisture and Density) as available
    • Nuclear Gauge Information if available
### How does it work?

**• Data Recording, example**

<table>
<thead>
<tr>
<th>Blowing</th>
<th>Rod Reading (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anytown, LA – Hwy 1, Sta. 19+00 RL</td>
<td></td>
</tr>
<tr>
<td>Top of Asphalt/Concrete</td>
<td>0</td>
</tr>
<tr>
<td>Top of Testing Surface (bottom of drilled hole, if applicable)</td>
<td>0</td>
</tr>
<tr>
<td>Reading after First Blow</td>
<td>1</td>
</tr>
<tr>
<td>Reading after Second Blow</td>
<td>2</td>
</tr>
<tr>
<td>Reading after Third Blow</td>
<td>3</td>
</tr>
<tr>
<td>Reading after Fourth Blow</td>
<td>4</td>
</tr>
<tr>
<td>Reading after Fifth Blow</td>
<td>5</td>
</tr>
<tr>
<td>Reading after Last Blow</td>
<td></td>
</tr>
</tbody>
</table>

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How does it work?

• Data Calculations  (without drilling)

<table>
<thead>
<tr>
<th>Blow #</th>
<th>Rod Reading, cm</th>
<th>Distance per Blow cm</th>
<th>Cumulative Penetration cm</th>
<th>Distance below Surface cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NA</td>
<td>0.0</td>
<td>0.0</td>
<td>equal to tip location below surface</td>
</tr>
<tr>
<td>0</td>
<td>46.0</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>1</td>
<td>46.3</td>
<td>0.3</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>2</td>
<td>46.6</td>
<td>0.3</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>3</td>
<td>46.9</td>
<td>0.3</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>4</td>
<td>47.2</td>
<td>0.3</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>5</td>
<td>47.5</td>
<td>0.3</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>6</td>
<td>47.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How does it work?

- Data Calculations (drilling occurred)

<table>
<thead>
<tr>
<th>Blow #</th>
<th>Rod Reading, cm</th>
<th>Distance per Blow cm</th>
<th>Cumulative Penetration Running Total cm</th>
<th>Distance below Surface cm can plot as inches or elev. tip location below pavement surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>38.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>46.0</td>
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<td>9.4</td>
</tr>
<tr>
<td>1</td>
<td>46.3</td>
<td>0.3</td>
<td>0.3</td>
<td>7.9</td>
</tr>
<tr>
<td>2</td>
<td>46.6</td>
<td>0.3</td>
<td>0.6</td>
<td>8.2</td>
</tr>
<tr>
<td>3</td>
<td>46.9</td>
<td>0.3</td>
<td>0.9</td>
<td>8.5</td>
</tr>
<tr>
<td>4</td>
<td>47.2</td>
<td>0.3</td>
<td>1.2</td>
<td>8.8</td>
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<tr>
<td>5</td>
<td>47.5</td>
<td>0.3</td>
<td>1.5</td>
<td>9.1</td>
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<tr>
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<td>47.8</td>
<td>0.3</td>
<td>1.8</td>
<td>9.4</td>
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### Example, cont’d

<table>
<thead>
<tr>
<th>Station Number</th>
<th>0.0 Rod Reading, cm</th>
<th>Distance per blow, cm</th>
<th>Cumulative Penetration, cm</th>
<th>Depth below pavement surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top of Asphalt/Concrete</td>
<td>NA</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Top of Test Layer</td>
<td>0</td>
<td>46.0</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>After First Blow</td>
<td></td>
<td></td>
<td>3 mm/blow</td>
<td>Layer Change</td>
</tr>
<tr>
<td>1</td>
<td>46.3</td>
<td>0.3</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>2</td>
<td>46.6</td>
<td>0.3</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>3</td>
<td>46.9</td>
<td>0.3</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>4</td>
<td>47.2</td>
<td>0.3</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>5</td>
<td>47.5</td>
<td>0.3</td>
<td>1.8</td>
<td>1.8</td>
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<tr>
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<td>47.8</td>
<td>0.3</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>7</td>
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<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>8</td>
<td>48.4</td>
<td>0.3</td>
<td>2.7</td>
<td>2.7</td>
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<tr>
<td>9</td>
<td>48.7</td>
<td>0.3</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>10</td>
<td>49.0</td>
<td>0.3</td>
<td>3.3</td>
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<td>11</td>
<td>49.3</td>
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<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>12</td>
<td>49.6</td>
<td>0.3</td>
<td>3.9</td>
<td>3.9</td>
</tr>
<tr>
<td>13</td>
<td>49.9</td>
<td>0.3</td>
<td>4.2</td>
<td>4.2</td>
</tr>
<tr>
<td>14</td>
<td>50.2</td>
<td>0.3</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>15</td>
<td>50.5</td>
<td>0.3</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>16</td>
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<td>0.3</td>
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<td>5.1</td>
</tr>
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<td>17</td>
<td>51.1</td>
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<td>5.4</td>
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<td>18</td>
<td>51.4</td>
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<td>5.7</td>
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<tr>
<td>19</td>
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<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>20</td>
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<td>6.3</td>
<td>6.3</td>
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<tr>
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<td>0.3</td>
<td>6.6</td>
<td>6.6</td>
</tr>
<tr>
<td>22</td>
<td>52.6</td>
<td>0.3</td>
<td>6.9</td>
<td>6.9</td>
</tr>
<tr>
<td>23</td>
<td>52.9</td>
<td>0.3</td>
<td>7.2</td>
<td>7.2</td>
</tr>
<tr>
<td>24</td>
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<td>0.3</td>
<td>7.5</td>
<td>7.5</td>
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<tr>
<td>25</td>
<td>53.5</td>
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<td>7.8</td>
<td>7.8</td>
</tr>
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<td>26</td>
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<td>0.3</td>
<td>8.1</td>
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</tr>
<tr>
<td>27</td>
<td>54.1</td>
<td>0.3</td>
<td>8.4</td>
<td>8.4</td>
</tr>
<tr>
<td>28</td>
<td>54.4</td>
<td>0.3</td>
<td>8.7</td>
<td>8.7</td>
</tr>
<tr>
<td>29</td>
<td>54.7</td>
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<td>9.0</td>
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<tr>
<td>30</td>
<td>55.0</td>
<td>0.3</td>
<td>9.3</td>
<td>9.3</td>
</tr>
</tbody>
</table>

#### Data Analysis
- Plotting Data
- Layer Changes
- Average mm/blow

**Anytown, LA – Hwy 1, Sta. 19+00 RL**

```
• Data Analysis
  – Plotting Data
  – Layer Changes
  – Average mm/blow
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How can it help you?

Advantages:

- Determines Stiffness in mm/blow
- Plotted slope = Stiffness in mm/blow
  - Flatter Slopes indicate stiffer layers
  - Steeper Slopes indicate weak layers
- Layer Changes identified by Slope Changes
  - Thicknesses can be determined/verified
  - Weak layers identified
- Minimal disturbance
- Test lower pavement layers without removal of upper layers
- Test different materials (Stone, Sand, Clay, and Silt)
- Compare time differences or adjacent sites

Disadvantages:

- Not for use on large stone, shell, asphalt, and concrete
- Damage can occur (repetitive blows in very stiff & improper removal)
- Does not measure moisture content or density – measures stiffness
How can it help you?

• Advantages:
  • Possibly another way to adjust pay, based on Stiffness of in-place layers
  • Non “Nuclear”
  • Not rocket science
  • Correlations to CBR, Mr, etc.
  • Another “tool for the toolbox”… spread the word
  
• Simple reliable, cost-effective tool for shallow pavement applications
LTRC Project: 06-4GT

This is a comprehensive follow-up study after four LTRC research projects on involving DCP applications.

Objectives:

- Develop a comprehensive implementation plan of DCP with procedures that DOTD can use in its daily production
- Develop or modify current DOTD specifications to accommodate such changes.

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ALF Lane 4
Base, Treated Subbase, & Subgrade
Field & Laboratory Test Summary
Cross-Section

- **Asphalt Surface (2”)**
- **Base (8.5”)**
  - Stone
  - BCS with 10% Slag
  - BCS with FlyAsh (small untreated area at end)
  - Foamed Asphalt
- **Treated Subbase (12”)**
  - Lime
  - Cement
- **Untreated Subgrade**
### Subgrade DCP Values

#### Time, Date

<table>
<thead>
<tr>
<th>Date</th>
<th>Average MM/Blow</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-Nov</td>
<td>28.9</td>
</tr>
<tr>
<td>10-Dec</td>
<td>13.6</td>
</tr>
</tbody>
</table>

**November Average = 28.9**  
**February Average = 13.6**
TREATED SUBBASE DCP VALUES

TIME, DATE

<table>
<thead>
<tr>
<th>Time</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-Nov</td>
<td>10-Dec</td>
</tr>
<tr>
<td>30-Dec</td>
<td>19-Jan</td>
</tr>
<tr>
<td></td>
<td>8-Feb</td>
</tr>
</tbody>
</table>

Treated Subbase DCP Values

AVERAGE MM / BLO

1A AVERAGE
2A AVERAGE
2A 0+10
1B AVERAGE
2B AVERAGE
3A AVERAGE
3B AVERAGE

Cement Initial Average = 20.3
Lime Initial Average = 31.8
Cement Average = 5.3
Lime Average = 7.3

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Thanks!

• Questions?