Embedded Data Collectors

The Virginia Experience

D. Ashton Lawler, P.E.
Virginia Department of Transportation
Real Solutions Web Conference
July 25, 2013
Virginia’s Highway System

Interstate – 1,118
Primary – 8,111
Secondary – 48,305
Frontage – 333
Total Mileage - 57,867
Table 1a – Total Number of Structures (Bridges and Culverts)

<table>
<thead>
<tr>
<th>DISTRICT</th>
<th>Number of Structures (Bridges and Culverts)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interstate</td>
<td>Primary</td>
<td>Secondary</td>
<td>Urban</td>
<td>Total</td>
</tr>
<tr>
<td>Bristol</td>
<td>216</td>
<td>956</td>
<td>2,188</td>
<td>83</td>
<td>3,443</td>
</tr>
<tr>
<td>Salem</td>
<td>217</td>
<td>807</td>
<td>1,943</td>
<td>103</td>
<td>3,070</td>
</tr>
<tr>
<td>Lynchburg</td>
<td>0</td>
<td>665</td>
<td>1,394</td>
<td>59</td>
<td>2,118</td>
</tr>
<tr>
<td>Richmond</td>
<td>511</td>
<td>801</td>
<td>1,146</td>
<td>161</td>
<td>2,619</td>
</tr>
<tr>
<td>Hampton Roads</td>
<td>458</td>
<td>458</td>
<td>515</td>
<td>257</td>
<td>1,688</td>
</tr>
<tr>
<td>Fredericksburg</td>
<td>79</td>
<td>249</td>
<td>474</td>
<td>8</td>
<td>810</td>
</tr>
<tr>
<td>Culpeper</td>
<td>122</td>
<td>495</td>
<td>1,053</td>
<td>23</td>
<td>1,693</td>
</tr>
<tr>
<td>Staunton</td>
<td>429</td>
<td>827</td>
<td>2,140</td>
<td>100</td>
<td>3,496</td>
</tr>
<tr>
<td>NOVA</td>
<td>345</td>
<td>446</td>
<td>1,181</td>
<td>79</td>
<td>2,051</td>
</tr>
<tr>
<td>Grand Total</td>
<td>2,377</td>
<td>5,704</td>
<td>12,034</td>
<td>873</td>
<td>20,988</td>
</tr>
</tbody>
</table>
VDOT’s Annual Budget

$4.19 Billion

$1.830 Billion – Road Maintenance
$1.605 Billion – Construction
$449.7 Million – Support to other agencies, administration, tolls and other programs
$300 Million – Debt service
VDOT’s Annual Budget

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$300 Million – Debt service

A new gas tax will significantly increase these numbers.
VDOT’s first project using **DYNAMIC PILE TESTING** was in the Summer 1984.
This is a sample image. Similar documentation will be posted to the TIG Embedded Data Collectors website in the near future.
EDC

EMBEDDED DATA COLLECTORS
Monitor- Merrimac Memorial Bridge
Interstate Route 664 in Newport News, Virginia

Pile Driving Program

2 Pre-Construction Pile Load Test Programs ($333,000)
16 Construction Load Tests ($387,000)
45 Construction Dynamic Pile Tests ($95,000)
Monitor- Merrimac Memorial Bridge

Interstate Route 664 in Newport News, Virginia

Pile Driving Program

430,000 linear feet of pile
12” Prestressed Concrete Piles
24” Prestressed Concrete Piles
54” Prestressed Concrete Cylinder Piles
Monitor- Merrimac Memorial Bridge
Interstate Route 664 in Newport News, Virginia

Pile Testing Program Costs: $815,000

Estimated savings in Construction Cost due to increased pile capacities: $12 Million

Estimated savings in Construction Cost due to reduced pile lengths through Dynamic Testing: $2 Million
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What followed was 25 Years of productive and cost effective Pile Driving using Dynamic Testing.
Six 24” square prestressed concrete piles were cast with EDC’s in the top and at the tip.

The piles were used as Driving Test Piles.
EDC

EMBEDDED DATA COLLECTORS
EDC

EMBEDDED DATA COLLECTORS
The tests were only partly successful due to the failure of several of the sensors possibly due to the heat of hydration in the concrete.
No new Virginia projects with EDC’s were developed but we followed the progress of Florida DOT’s EDC research.
When the Florida research was completed and the use of EDC’s was allowed in the Florida pile specification, Virginia followed suit.
In December of 2011 VDOT organized a one day new product information transfer workshop on EDC’s for our consultants and contractors.
The first project where EDC’s were chosen for use by the Contractor is the new bridge on Dominion Boulevard in Chesapeake, Virginia, advertised in 2012.
## Pile Driving Program
on Dominion Boulevard

<table>
<thead>
<tr>
<th>Pile Size</th>
<th>Driving Tests</th>
<th>Linear Feet of Pile</th>
</tr>
</thead>
<tbody>
<tr>
<td>12”</td>
<td>2</td>
<td>1,668</td>
</tr>
<tr>
<td>16”</td>
<td>16</td>
<td>15,146</td>
</tr>
<tr>
<td>24”</td>
<td>20</td>
<td>36,657</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>53,471</td>
</tr>
</tbody>
</table>
To: McLean Contracting Company
6700 McLean Way
Glen Burnie, MD 21060-5410

Attn: Mr. Joe Hoffman, PE

Subject: Dynamic Load Test and Production Pile Recommendations
RT77 over Elizabeth River, Chesapeake, VA
Test Pile at EB00 NB Pier 12

Project #: 0607-131-109

Dear Mr. Hoffman,

The following are summary results of our dynamic load testing services for the above referenced test pile and our recommendations for production piles at this location. General test pile information along with results are attached to this letter in tabular and graphical form.

Summary of Dynamic Load Test Results:

<table>
<thead>
<tr>
<th>Test Condition</th>
<th>EDC (Performed)</th>
<th>PDA (Performed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>RS</td>
<td>Units</td>
</tr>
<tr>
<td>Start Depth</td>
<td>0</td>
<td>68.5</td>
</tr>
<tr>
<td>Final Depth</td>
<td>68.5</td>
<td>68.66</td>
</tr>
<tr>
<td>Pile Tip ID</td>
<td>-65.00</td>
<td>60.16</td>
</tr>
<tr>
<td>Jc Assumed</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Required Driving Resistance</td>
<td>568</td>
<td>710</td>
</tr>
<tr>
<td>Avg. U1 Comp. Capacity (c)</td>
<td>499</td>
<td>1085</td>
</tr>
<tr>
<td>Avg. U1 Comp. Capacity (UP)</td>
<td>425</td>
<td>1143</td>
</tr>
<tr>
<td>CAPWAP (total)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>CAPWAP (Tip)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>CAPWAP (Skin)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Max Top Comp. Stress</td>
<td>3.8</td>
<td>3.9</td>
</tr>
<tr>
<td>Max. Top Comp. Stress</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Max Tensile Stress</td>
<td>0.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Blow Count</td>
<td>44</td>
<td>611 inch</td>
</tr>
<tr>
<td>Stroke</td>
<td>8.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Energy</td>
<td>22.5</td>
<td>34.2</td>
</tr>
<tr>
<td>Average Wave Speed</td>
<td>140.08</td>
<td>140.25</td>
</tr>
<tr>
<td>Average Dynamic Jc</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Maximum Loss in Prestress Top</td>
<td>85.3</td>
<td>93.2</td>
</tr>
<tr>
<td>Maximum Loss in Prestress Top</td>
<td>27.7</td>
<td>18.0</td>
</tr>
</tbody>
</table>

Summary of Hammer Information:

- **Bridge No.:** B60 NB
- **Pier #:** Pier 12
- **Pile No.:** 18
- **Pile Type:** 24” PSC, SQ
- **Length:** 78 feet
- **Nom. Bearing Res.:** 710 kips

Notes:
- Ultimate Capacity, stroke, and energy indicated for initial drive are at end of drive.
- Ultimate Capacity, stroke and energy indicated for re-drive are average during re-drive.
- All stresses reported are maximum values.
- NA: Not Applicable
EDC  EMBEDDED DATA COLLECTORS
EDC

EMBEDDED DATA COLLECTORS
EDC

EMBEDDED DATA COLLECTORS

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In What Ways Does VDOT Plan To Use Embedded Data Collectors?
The new Special Provision allows Contractors the choice to use either EDC or PDA.
The new Special Provision allows Contractors to choose to use either EDC or PDA.

We may begin to require that the first Driving Test Pile have a top and bottom sensor.
realization of 200uE shift in static pre-stress level....
Cost Benefits – Advanced Damage Detection
(early detection saves $$)
This is a sample image. Similar documentation will be posted to the TIG Embedded Data Collectors website in the near future.
Driving Tests are usually done on a pile that will be incorporated into the bridge foundation.
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When the Contractor remobilizes to begin production pile driving, the EDC in the Driving Test Pile can easily be reactivated and a second restrike performed, giving us soil setup weeks after initial driving.
This is a sample image. Similar documentation will be posted to the TIG Embedded Data Collectors website in the near future.
Long Term Monitoring using Embedded Data Collectors (EDC) in Bridge Structures
EDC

EMBEDDED DATA COLLECTORS
A pier cap with Embedded Data Collectors installed in it was built for FHWA’s Turner-Fairbank Highway Research Center. It will provide data for ongoing studies into lifecycle monitoring and cost. The work is being done by Carl Ealy.
Remote Monitoring – System Elements

EDC Piles, Beams, Columns, ETC.

Gateway
Remote Monitoring
Harvests sensor data and moves data to the Portal

3G
Internet
Database (Portal)

All raw sensor data processed and reported via Portal

Browser Access

Commercial Users
Governmental Users
Researchers

Localized wireless sensor network
EDC Drilled Shaft Instrumentation Layout – Bridge B606, I-95 Hot lanes Project, Virginia, USA
Strain transducers and temperature sensors are installed on drilled shaft rebar cage.

Preliminary data is collected from the dataport before and after concrete pour in drilled shafts.
Step 3
Cables are installed for cap monitoring

Step 4
Sensors are connected through cables and are connected to data port
**Step 5**
Data port attached to the form work, to collect data after concrete pour

**Step 6**
Cap instrumentation set up before concrete pour
Concrete Pour
Data Collection Equipment

Data port cover on the back wall of abutment
Purpose of using EDC Instrumentation & Monitoring in Drilled Shaft
Purpose of Using EDC Instrumentation & Monitoring in Drilled Shafts

- Static Load measurements at various locations along the shaft and shaft cap.
- Changes in shaft strain during live load, dead load and service loads.
- Temperature of concrete at various stages of the shaft and shaft cap construction and post construction.
- Determine the load transfer along the shaft.
This information will be extremely valuable if States want to revisit and modify load and resistance factors based on their local conditions and practices.
Embedded Data Collectors

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Want more information?

Visit the Embedded Data Collectors webpage at:

tig.transportation.org