Evaluations of Bridge Foundations Using Non-destructive Testing Methods to Assess the Scour Potential of Bridges with Unknown Foundations in North Carolina

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Geophysicist / Greensboro, NC
FHWA and NCDOT Goals

- Assessing over 6,000 Bridges in North Carolina
- Eliminating Bridges Coded as Unknown Foundations
- Developing a Plan of Action for Bridges Not Recoded
## Item 113: Scour Critical Bridges

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Bridge not over waterway</td>
</tr>
<tr>
<td>U</td>
<td>Unknown foundation</td>
</tr>
<tr>
<td>T</td>
<td>Bridge over tidal waters</td>
</tr>
<tr>
<td>9</td>
<td>Bridge foundations on dry land</td>
</tr>
<tr>
<td>8</td>
<td>Stable bridge for assessed or calculated scour condition</td>
</tr>
</tbody>
</table>
Item 113: Scour Critical Bridges

7. Countermeasures installed to mitigate existing scour problem
6. Scour potential has not been evaluated
5. Bridge foundations are stable based on scour condition
4. Bridge foundations are stable but need protection added
Item 113: Scour Critical Bridges

3. Bridge is scour critical (unstable)

2. Bridge is scour critical, extensive scour has occurred

1. Bridge is scour critical, failure is imminent, closed to traffic

0. Bridge is scour critical, has failed, and is closed to traffic
Bridge Repairs
Schnabel Bridge Locations by County (141 Total Bridges)

State of North Carolina
County Index Map

1. Currituck
2. Camden
3. Pasquotank
4. Perquimans
5. Chowan
6. Washington
7. Northampton
8. New Hanover
9. Mecklenburg
10. Alexander
11. Caldwell
12. Mitchell
13. Henderson
14. Transylvania
Records Search

- Conducted by GEU and included BMU records
  - Requested pile records and other info from bridge maintenance offices
- Also conducted by Schnabel at Raleigh BMU and other offices
- Non-destructive field testing was not necessary when as-built pile records exist
NDE 360 & Accessories

- Manufactured by Olson Instruments
- Stores foundation testing data
- Allows data to be analyzed onsite
- Has data channels for an instrumented hammer and multiple accelerometers
Test Method 1: Sonic Echo/Impulse Response (SE/IR)

- Used when top or part of upper side of a foundation is accessible
- Impact the foundation and record echoes from the base of the foundation
- Columnar foundations are most appropriate (piles and drilled shafts)
- Applicable on wood, concrete, and round steel pipe foundations
Test Method 2: Ultraseismic (US)

- Used when only upper portion of foundation is accessible (not top)
- Impact the foundation and record echoes using many accelerometer locations
- Drilled shafts, driven piles & auger-cast piles are most appropriate
- Also appropriate for an abutment or wall pier with 5’-6’ of exposure
- Applicable on wood, concrete, masonry & stone foundations
Test Method 3: Impact Echo (IE)

- Used to determine the thickness of structures
- Impact the foundation and record echoes
- Can use the internal hammer or an external hammer
- Applicable on wood, concrete, masonry & stone foundations
- Can assess condition of structures (location of cracks, voids, and/or honeycomb)
Types of Bridge Foundations Tested

Concrete, steel & timber piles driven to some depth
Types of Bridge Foundations Tested

Steel, concrete & timber posts on concrete sills/footings
Types of Bridge Foundations Tested

Mass concrete abutments and piers with footings supported by piles driven to some depth
Types of Bridge Foundations Tested

Mass concrete abutments and piers with shallow footings
Other Procedures and Observations

- Rod Driving (Soil Stiffness/Rock Depth & Footing Depth)
- Measure Water Level, Thalweg & Bridge Geometry
- Look for signs of scour, debris buildup, etc.
Example Rod Driving Results

### Piedmont

<table>
<thead>
<tr>
<th>Foundation Element and Reference Location</th>
<th>Rod Drive Depth (feet)</th>
<th>Depth Below Top of Rail (feet)</th>
<th>Blows per Foot</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>EB1</td>
<td>1</td>
<td>14.8</td>
<td>3</td>
<td></td>
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<tr>
<td>Top rail to M.L.</td>
<td>1.66</td>
<td>15.4</td>
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<td>13.8</td>
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<td>15.8</td>
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<td>3</td>
<td>16.8</td>
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<td>18.8</td>
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<td>7</td>
<td>20.8</td>
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<td>Ringing on rock</td>
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<td>17.7</td>
<td>150</td>
<td>Ringing on rock</td>
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<td>15.9</td>
<td>14</td>
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<tr>
<td>13.9</td>
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### Coastal Plain

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<th>Depth Below Reference Location (feet)</th>
<th>Depth Below Top of Rail (feet)</th>
<th>Blows per Foot</th>
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<td>53.4</td>
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Analyzing Bridge Soundings from Various Years

Comparing Rod Drive Results to Tested Foundation Depths
FINAL REPORT OF UNKNOWN BRIDGE FOUNDATION INVESTIGATION
BRIDGE NO. 820056
SCOTLAND COUNTY
US 15-501
DROWNING CREEK

SURMITTED TO:
Jerry Beard, P.E.
North Carolina Dept. of Transportation
Hydraulics Unit
1590 Mail Service Center
Raleigh, NC 27699-1090

AUTHORED BY:
Edward D. Billington, P.G.
and Gerald C. Robbins, P.E.
NC P.E. Registration No. 21395
Schnabel Project: 09210013.16
Example Bridge Report 1

Scotland Bridge 820066 - Downstream Soundings

Horizontal Distance Along Bridge From EB1 to EB2 (feet)

Distance Below Top of Rail (feet)

- 11/22/91
- 12/17/99
- 9/6/01
- 11/3/05
- 2007 (Partial data set)
Example Bridge Report 1

Scotland 820066 Testing Results

1. Velocity Test on B3-P3

Velocity = 6.5 ft/(2.18 ms - 1.68 ms) = 18,000 ft/s

2. US Test on B3-P3

Pile length = 32.6 feet
FINAL REPORT OF UNKNOWN BRIDGE FOUNDATION INVESTIGATION
BRIDGE NO. 750126
RANDOLPH COUNTY
SR 2442
SANDY CREEK

SUBMITTED TO:
Jerry Beard, P.E.
North Carolina Dept. of Transportation
Hydraulics Unit
1590 Mail Service Center
Raleigh, NC 27699-1590

AUTHORED BY:
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and Gerald C. Robbins, P.E.
NC P.E. Registration No. 21395
Schnabel Project 09210013.16
Example Bridge Report 2
Sonic Echo (SE) Test, B1-P4

The results of the SE test on B1-P4 indicate a pile length of 9.1 feet below the test location, using a measured velocity of 12,500 feet/second. The test location was 7.7 feet below the top of the pile, giving a total calculated pile length of 16.8 feet.

TCR to top of pile = 5.3 feet therefore
TCR to bottom of pile = 16.8 + 5.3 = 22.1 feet.

Sonic Echo (SE) Test, B2-P2

The results of the SE test on B2-P2 indicate a pile length of 8.6 feet below the test location, using a measured velocity of 12,500 feet/second. The test location was 7.0 feet below the top of the pile, giving a total calculated pile length of 15.6 feet.

TCR to top of pile = 5.3 feet therefore
TCR to bottom of pile = 15.6 + 5.3 = 20.9 feet.

Impact Echo (IE) Test, B2-P2 Sill

The results of the IE test on the B2-P2 concrete sill indicate a sill height of 3.5 feet, using a measured velocity of 12,500 feet/second.
Conclusions

- NDT Can Provide Valuable Bridge Foundation Information
- Research, Testing, Etc. Assisted the DOT in Assessing Scour Potential
- NCDOT Assessed 6,136 Bridges Containing Unknown Foundations
- Bridges were Recoded or a Plan of Action was Developed
- NCDOT Spent Over 4 Million Dollars Related to Scour
Acknowledgement

- Brian Radakovic, PE
  NCDOT, Hydraulics Unit
  1590 Mail Service Center, Raleigh, NC 27699

- D. Parker Sprinkle II
  Geo Solutions Ltd., Inc.
  900 Eagle Creek Ct. Raleigh, NC 27606