Case Studies - Bridge Scour Inspection and Repair

Edward P. Foltyn, P.E.
Senior Hydraulic Engineer
ODOT Bridge Unit

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• REFERENCES
  • *River Engineering for Highway Encroachments-Highways in the River Environment*, Federal Highway Administration, Publication No. FHWA NHI 01-004, Hydraulic Design Series Number 6, December 2001
  • *Bridge Inspector’s Reference Manual*, Federal Highway Administration, Publication No. FHWA NHI 03001, October, 2002
  • *Bridge Inspector’s Manual*, Oregon Department of Transportation, January 2013
  • *2009 Bridge Inspection Pocket Coding Guide*, Oregon Department of Transportation Bridge Engineering Section, 2009
17 Bridges throughout New England and New York were damaged or destroyed in spring floods in 1987. This included the Schoharie Creek Bridge on the NYS Thruway. There were 10 fatalities as a result of this bridge collapse. A total of 4 cars and a tractor-trailer drove into the gap. This bridge was foundations were large spread footings (82’ long x 18’ wide) cut in to ice contact drift, considered non-erodible by the designers. Subsequent studies showed erodible velocities at 4 ft/s and prototype velocities of 10.8 ft/sec with scour depths of 15 ft.

South elevation - Schoharie Creek Bridge showing key structural features and a schematic geological section (Richardson et al. 1987).
• A national scour evaluation program as an integral part of the NBIS was established in 1988 by Technical Advisory (TA) T5140.20 (USDOT 1988). This TA was published following the April 1987 collapse of New York’s Schoharie Bridge due to scour.
  
  • Developing and implementing a scour evaluation for designing new bridges
  • Evaluating existing bridges for scour vulnerability
  • Using scour countermeasures
  • Improving the state-of-practice for estimating scour at bridges

• CFR 650.313(e) directs each agency to “Identify bridges that are scour critical”. CFR 650.313(e)(3) – For bridges that are scour critical, the agency is directed to “prepare a plan of action to monitor known and potential deficiencies and to address critical findings. Monitor bridges that are scour critical in accordance with the plan.” In accordance with this provision, ODOT evaluated each bridge over a waterway as to its scour potential in accordance with the “FHWA Technical Advisory - 5140.23 “Evaluating Scour at Bridges” - dated October 28, 1991”.

Office Review

- Has an engineering scour evaluation been completed? If so, is the bridge scour critical?
- If the bridge is scour critical, has a plan of action been made for monitoring the bridge and/or installing scour countermeasures?
- What equipment is needed (rods, poles, sounding lines, sonar, etc.) to obtain streambed cross sections?
- Are there sketches and aerial photographs to indicate the plan location of the stream and whether the main channel is changing direction at the bridge?
- What type of bridge foundation was constructed? (Spread footing, piles, drilled shafts, etc.) Do the foundations appear to be vulnerable to scour?
- Do special conditions exist requiring particular methods and equipment (divers, boats, electronic gear for measuring stream bottom, etc.) for underwater inspections?
- Are there special items that should be looked at? (Examples might include damaged riprap, stream channel at adverse angle flow, problems with debris, etc.)
Physical Bridge Inspection

During the bridge inspection, the condition of the bridge waterway opening substructure, channel protection, and scour countermeasures should be evaluated, along with the condition of the stream.

• **1.)** NBI Item 60: Substructure
• **2.)** NBI Item 61: Channel and Channel Protection
• **3.)** NBI Item 71: Waterway Adequacy
River Types

• **Types of Channels:** Knowledge of the type and profile of a waterway or river channel is essential to understand the hydraulics of the channel and its potential for change. The type of river may dictate certain tendencies or responses that may be more adverse than others. To aid in this understanding, various key river forms are briefly explained. Rivers can be broadly classified into four categories:
  • Meandering rivers
  • Braided rivers
  • Straight rivers
  • Steep mountain streams
Meandering Rivers

• Meandering rivers consist of a series of bends connected by crossings. In general, pools exist in the bends.

• Such rivers are fairly predictable and experience relatively small velocities. They change plan form at a relatively slow rate and in a predictable manner, except during catastrophic flood events.
Braided Rivers

Braided rivers consist of multiple channels that are intertwined in braided form. At flood stages, the appearance of braiding is less noticeable. The bars dividing the multiple channels may become submerged, and the river will appear to be relatively straight. When compared with other forms of rivers, this type of channel:

• Has a steeper slope
• Experiences higher velocities
• Transports larger quantities of sediments
• Causes larger scour or erosion problems
• Is more difficult to “train”
• Requires careful engineering and continual maintenance of bridges subjected to this environment.
Braided Rivers (cont.)
Straight River

Straight rivers are something of an anomaly. Most straight rivers are in a transition between meandering and braided types. In straight rivers, any development that would flatten the gradient would accelerate change from a straight system to a meandering system. Conversely, if the gradient were increased, the channel may become braided. Therefore, in order to maintain the straight alignment over a normal range of hydrologic conditions, it may become necessary to utilize channel control measures, such as riprap or spurs.
Straight Rivers (cont.)
Characteristics of rivers

Stream Power, Velocity x Shear Stress, $Pm = VYdS$
Steep Mountain Streams

Steep mountain streams are controlled by geologic formations, rock falls, and waterfalls. They experience very small changes in either plan form or profile when subjected to the normal range of discharges. The bed material of such river systems can consist of gravel, cobbles, boulders, or some mixture of these different sizes. Even though these rivers are relatively stable, they can experience significant changes during episodic flood events.
Steep Mountain Streams (cont.)

Note: Some areas have significant flows without scour issues, but deposition issues
Bridge Inspections For Scour

During the bridge inspection, the condition of the bridge waterway opening substructure, channel protection, and scour countermeasures should be evaluated, along with the condition of the stream.

- NBI Item 60: Substructure
- NBI Item 61: Channel and Channel Protection
- NBI Item 71: Waterway Adequacy
Bridge Substructure

NBI Item 60, Substructure, is the key item for rating the bridge foundations for vulnerability to scour damage. When a bridge inspector finds that a scour problem has already occurred, it should be considered in the rating of Item 60. Both existing and potential problems with scour should be reported so that a scour evaluation can be made by others. The scour evaluation is reported in NBI Item 113 – Scour Code. If the bridge is determined to be scour critical, the rating of NBI Item 60 should be evaluated to ensure that existing scour problems have been considered. The following items are recommended for consideration in inspecting the present condition of the bridge foundations:

- Evidence of movement of piers and abutments:
  - Rotational movement (check for plumb line)
  - Settlement (check lines of substructure and superstructure, bridge railing, etc., for discontinuities; check for structural cracking or spalling)
  - Check bridge bearing for excessive movement
  - Check the deck joints for differential movements
- Damage to scour countermeasures protecting the foundations (riprap, guide banks, sheet piling, sills, etc.)
- Changes in streambed elevation at foundations (undermining of footings, exposure of piles)
- Changes in streambed cross section at the bridge, including location and depth of scour holes.

In order to evaluate the conditions of the foundations, the inspector should take cross sections of the stream, noting location and condition of streambanks. Careful measurements should be made of scour holes at piers and abutments, probing soft material in scour holes to determine the location of a firm bottom. If equipment or conditions do not permit measurement of the stream bottom, this condition should be noted for further action.

This may also require an underwater inspection.
Channel and Channel Protection

Channel & channel protection condition rating such as stream stability and the condition of the channel, riprap, slope protection, or stream control devices including spur dikes. The inspector should be particularly concerned with visible signs of excessive water velocity which may affect undermining of slope protection, erosion of banks and realignment of the stream which may result in immediate or potential problems.

• Three items of primary importance that needs to be integrated into the condition assessment:
  - The condition of the “banks”
  - The condition of the “control devices”
  - The amount of vegetation or “debris accumulation”

• ODOT implemented three more items of primary importance, which is the basis of the Channel Supplemental Rating Guidelines:
  - Channel Alignment
  - Amount of Scour present immediately adjacent to the substructure unit
  - Obstructions

• When assessing the condition of the channel, the inspector will use the following boundary parameter:
  - 4 stream channel widths upstream
  - 4 stream channel widths downstream
Waterway adequacy guidelines

This item appraises the waterway opening with respect to passage of flow through the bridge. Where overtopping frequency information is available, the chance of overtopping descriptions mean the following:

- Remote: > 100 years
- Slight: 11 to 100 years
- Occasional: 3 to 10 years
- Frequent: < 3 years
Case Studies

• **Dog River Bridge, OR 35, Hwy 026, MP77.65, BR# 16006**
  - During a post flood inspection after the November 2006 debris flow and flooding events on Hwy 26 (Mt Hood Highway), Mike Pulzone, RBI, noted that there was a “boil” on the backside of the web-wall of Bent 3. This bridge is a three span bridge, a center span with two cantilevered end spans.
  - East Fork of Hood River, in this area, is a highly braided channel and to maintain the roadway embankment, a series of rock groins was constructed along the east side of the embankment to prevent lateral movement of the river. Apparently, somewhere between the bridge’s construction in the late 1950s and the early 1980s, scour occurred near Bent 2. The bridge was repaired by extending Bent 2 and lowering the footing of Bent 2 in 1981 by almost 6 ft.

• **Alder Creek, US 26, Hwy 026, MP 33.24, BR# 19957**
  - This bridge is a single span bridge constructed in the early 2005 as part of the OTIA_III program (Bundle 2). This bridge is a single span bridge with shallow spread footings located approximately 20’ above the creek bottom. The geology consists of a basalt stream bottom, while the overlying stream banks in this area are gravel and sand. During a site visit for environment compliance (tree planting), the environmental monitor noted that there was severe scour along the left bank (near Bent 1). This information was originally passed on to the erosion control specialist at ODOT who forwarded the information after a site visit to Region 1. In August 2009, Region 1 Bridge and bridge maintenance units visited the site and determined that the bridge needs repair before the upcoming rainy season.
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