TECHBRIEF

Foundation Characterization Program (FCP): TechBrief #1—Workshop Report on the Reuse of Bridge Foundations

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Introduction

This TechBrief presents the results of a workshop held at the 2014 Transportation Research Board (TRB) 93rd annual meeting on the reuse of bridge foundations. The workshop is the continuation of ongoing effort by the Federal Highway Administration (FHWA) to identify research and development needs with respect to foundation characterization program (FCP). This program includes the development and/or evaluation of new and existing methodologies for characterizing existing bridge foundations for the determination of unknown geometry, material properties, integrity, and load-carrying capacity.

The transportation system in the United States includes more than 600,000 bridges built for grade separation, interchange configurations, and crossings over natural barriers such as rivers. The operation and functionality of the highway network depends on the performance of these structures. As of December 2012, the National Bridge Inventory (NBI) included 607,380 structures (bridges and culverts) with a span greater than 20 ft (6 m).[1] Of those structures, 36,076 bridges over waterways (riverine and tidal) are identified as having unknown foundations. The term “unknown foundation” has been associated with the population of existing bridges over waterways that cannot be evaluated for hydraulic vulnerability related to scour. The number of bridges over land with unknown foundations, however, is not known because this qualifier is not a reportable item in the NBI.

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On January 16, 2013, a multidisciplinary taskforce was formed by FHWA at the TRB 92nd annual meeting consisting of 14 FHWA and State transportation department stakeholders. The taskforce members were selected based on their recognized expertise in the areas of unknown foundation and foundation assessment issues. During this meeting, the taskforce met and brainstormed on steps needed to move forward with a multiyear strategic research plan for unknown foundations. The consensus of the taskforce and FHWA management was to broaden the scope of the research program from "unknown foundations" to "foundation characterization" and incorporate several related issues such as multihazard concerns, changes in service loads, and foundation reuse.

A workshop was held in Arlington, VA, from April 30 to May 1, 2013, to solicit key stakeholders' input and was summarized in the *Characterization of Bridge Foundations Workshop Report* (FHWA-HRT-13-101).[2] The following summary and recommendations are a result of that workshop:

1. A key issue with unknown foundations is their characterization.

2. Much good work is being done in the States with the reuse of foundations. States have their own individual procedures; there is no ready means of assessing the present practice.

3. The main issues for foundation reuse are their condition assessment, their load-carrying capacity, their remaining service life, and how the reuse of foundations interacts with new codes.

4. Research and development on foundation reuse will also benefit unknown foundations.

In support of foundation characterization and reuse, the following specific recommendations were made:

1. Research is needed for load testing of existing foundations and better methodologies for condition assessment.

2. Research is needed for instrumenting new foundations ("smart piles") or existing foundations for on-demand assessment of condition.

3. A synthesis of common practices on foundation reuse should be developed as soon as possible.

4. Guidelines for field evaluation of unknown and known foundations should be developed to include site investigation, destructive and nondestructive testing or monitoring, numerical modeling, and load testing.

5. Guidance for the reuse of foundations is needed and should include consideration of structural, hydraulic, and geotechnical issues in a holistic manner.

In support of the workshop recommendations, an open workshop (workshop 160) and a separate session (session 395) on the reuse of bridge foundations were held at the 2014 TRB 93rd annual meeting. Table 1 lists the presentation topic and speakers for the TRB workshop, and table 2 lists the speakers for the separate session.

The presentations are available on the TRB Committee on Soil and Rock Properties (AFP30) Web site.(3) It is accessible at https://sites.google.com/site/trbcommitteeafp30/characterization-of-bridge-foundations.[1]

Table 1. Topics and speakers for workshop 160, "Characterization of Foundations of Bridges and Other Structures for Reuse."

Paper Number	Presentation Title	Author/Speaker
W160-01	FHWA Characterization of Bridge Foundation Workshop	Frank Jalinoos, FHWA
W160-02	Research on Foundation Reuse at BAM (presented by Dr. Herbert Wiggenhauser)	Ernst Niederleithinger, Federal Institute for Materials Research and Testing (BAM)
W160-03	Issue and Challenges with Foundation Reuse at North Carolina DOT	Mohammed A. Mulla, North Carolina Department of Transportation
W160-04	Experience with Evaluation and Reuse of Bridge Foundations at Massachusetts DOT	Peter Connors, Massachusetts DOT
W160-05	Virginia DOT I-95 Bridge Rehabilitation: Substructure Repairs	Joe Hardee, URS Corporation
W160-06	Henley Bridge Rehabilitation Project with Emphasis on Original Historic Design	Saieb Haddad, Tennessee DOT
W160-07	Reuse of Foundation at Arthur Mills Crossing Railroad Bridge, Salt Lake Valley, Utah	Jon E. Bischoff, Utah DOT
W160-08	Ohio DOT Experience with Foundation Reuse	Jawdat Siddiqi, Ohio DOT
None	Workshop Roundup	Jerry A. DiMaggio, TRB

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Table 2. Topics and speakers for session 395, "Reuse of Bridge and Other Structural Foundations."

Paper Number	Presentation Title	Author/Speaker
S395-01	Evaluating Foundations for Reuse: Looking Ahead	Benjamin Rivers, FHWA
S395-02	Issues of Risk and Liabilities Relating to Reuse of Existing Foundations	Dan Brown, Dan Brown and Associates
S395-03	Reuse of Structural Foundations: Engineering and Program Management Considerations	Jerry A. DiMaggio, TRB
S395-04	Testing and Modeling of Pile and Shaft Foundations for Reuse	Michael C. McVay, University of Florida
S395-05	Potential of Structural Identification Method for Reusing Existing Bridge Foundations	A. Emin Aktan, Drexel University
S395-06	Henley Bridge Rehabilitation Project with Emphasis on Original Historic Design	Pamela Moore, GCI Incorporated

This TechBrief summarizes the key issues, findings, and recommendations that were a result of the TRB workshop 160 and session 395.

Drivers for Bridge Foundation Reuse

U.S. Transportation Sector Perspective

In both the workshop and panel discussion session, numerous speakers identified the following drivers and reasons for reuse of bridge foundations:

- **Asset management.** Existing foundations are assets with a functional value.
- **Technical drivers.** Replacing piles may be difficult.
- **Time savings.** Using existing foundations would minimize impacts on mobility.
- **Economic drivers.** Reusing bridge foundations would lead to direct and indirect cost savings.
- **Efficiency.** Reusing bridge foundations is a viable option for replacing structurally deficient superstructures.[2]
- **Past performance.** The foundation has performed adequately in the past; in essence, it has been load tested.
- **Environmental benefits.** The use of existing foundations would have a more limited impact on the environment.
- **Sustainability issues.** Reusing bridge foundations would save resources.
- **Historic preservation considerations.** Existing foundations would be better suited for structures with historical value.

European Perspective

The Reuse of Foundations for Urban Sites (RuFUS) was a European Union-funded research project centered on setting guidelines to allow foundations (predominately building foundations) to be reused more often; the project was completed

[2]Given that close to one-quarter of bridges in the NBI are identified as deficient (either structurally deficient or functionally obsolete), the potential savings for the bridge owners in reusing existing bridge foundations is significant.

in 2006.(4,5) The project partners were BRE (coordinator), Arup and Cementation Foundations Skanska from the United Kingdom, Soletanche-Bachy from France, the Technical University of Darmstadt and BAM from Germany, Stamatapoulos Associates from Greece, and the Swedish Geotechnical Institute.

A major part of the RuFUS initiative was to demonstrate to construction teams that foundation reuse is a viable, reliable alternative that is not completely novel (i.e., a research project). The end result of RuFUS was a set of guidelines for the reuse of existing foundations.(4,5)

Dr. Niederleithinger presented the results of the RuFUS research at the workshop. From the European perspective, he identified the following reasons for reuse of existing foundations:

- Ground congestion (utilities, tunnels, neighboring foundations).
- Archaeology (e.g., long-term delays after Roman structure discovery).
- Construction technical drivers (difficulty in replacing piles).
- Economic drivers (cost savings).
- Environmental/sustainability issues (limited use of resources).

Reuse Applications and Challenges

Reuse applications for bridge foundations identified by the participants of the workshop and panel discussion included replacement of the superstructure of an existing bridge because of structural deterioration, widening of an existing bridge, repurposing (i.e., using an existing railroad bridge foundation for a pedestrian/bike path), and reuse with enhanced/strengthened foundation and accelerated bridge construction (ABC)/prefabricated bridge elements and systems (PBES).

However, there are many challenges to the reuse of existing foundations. The evaluation of the suitability of an existing bridge foundation for reuse is a multidisciplined task that needs to involve structural, hydraulic, geotechnical, and construction expertise. The following list is composed of the challenges for reuse as presented by the speakers at both the workshop and the panel discussion:

- Normally, the current design specifications and geometric standards require a larger structure and therefore an increase in foundation loads.
- Foundations may lack critical documentation.
- There is a lack of confidence in as-built plans.
- Construction and monitoring standards at the time of the original construction were different.
- Foundations set on soft, compressible soils may not be suitable for reuse.
- States lack means to reduce and account for uncertainty.
- Existing foundations may have experienced critical levels of deterioration.
- There is a lack of reliability of existing and new field methods to characterize current conditions and remaining service life.

- Cultural change and its impact may affect the use of existing foundations.
- States must determine the standard of care for designers in evaluating reuse.
- States must determine how and/or if to incorporate load and resistance factor design (LRFD) into reuse of foundations.
- Risk and liability issues may be associated with the reuse of existing foundations, not only for the State but also the design consultant (if outside services are used) and the contractor.
- There is a lack of existing State and/or Federal guidelines.

Selective State Practice and Policies

Prior to the workshop, several State transportation department workshop participants briefly collected information from a few nearby States on the extent of foundation reuse. The North Carolina Department of Transportation (NCDOT) created a simple spreadsheet with specific questions regarding reusing existing foundation for rehabilitation, replacement, or improvement. Table 3 summarizes the results.

From this limited dataset, it is clear that the majority of State transportation departments have reused existing foundations in one form or another. However, as discussed below, very few State transportation departments have established specific policies or guidelines.

Table 3. Summary of foundation reuse by NCDOT and other State transportation departments.

State transportation department	Has your State reused existing foundations for bridge replacement?	Has your State improved or fixed existing bridge foundations to mitigate for additional load, scour, seismic activity, etc.?	Are policies and guidelines available to evaluate existing foundations?
ALDOT	No	Yes	No
CDOT	Yes	No	No
Caltrans	No	Yes	No
INDOT	No	Yes	No
KYTC	Yes	Yes	No
MnDOT	Yes	Yes	No
NYSDOT	Yes	Yes	No
NCDOT	Yes	Yes	No
TDOT	Yes	Yes	No
UDOT	Yes	No	No

ALDOT = Alabama Department of Transportation.
CDOT = Colorado Department of Transportation.
Caltrans = California Department of Transportation.
INDOT = Indiana Department of Transportation.
KYTC = Kentucky Transportation Cabinet.
MnDOT = Minnesota Department of Transportation.
NYSDOT = New York State Department of Transportation.
NCDOT = North Carolina Department of Transportation.
TDOT = Tennessee Department of Transportation.
UDOT = Utah Department of Transportation.

Massachusetts

Foundation reuse is written into the Massachusetts bridge manual.[6] Massachusetts Department of Transportation (MassDOT) policy on reuse of existing foundations is represented in bridge replacement, bridge rehabilitation, or superstructure replacement projects. Reuse of bridge foundations is allowed if the existing foundations have no scour issues or structural deficiencies, or if they can be rehabilitated to meet current American Association of State Highway and Transportation Officials (AASHTO) LRFD specifications and have their service life extended for at least another 75 years. The reuse strategy is evaluated during preliminary engineering, when as many of the project parameters as possible are optimized without violating the project constraints. This evaluation includes investigation, testing, and analysis. The merits and cost of rehabilitating the existing foundation are presented in a preliminary structures report. If the existing foundation is not deemed to be serviceable for reuse in the new bridge structure, then the merits of reusing the existing abutments and wingwalls as an earth-retaining structure or scour protection independent of the new bridge structure are considered. In addition, if the bridge to be replaced is historic, found in a historic area, or is in sensitive wetlands, then the abutments may be retained without being incorporated into the new structure to minimize the impacts on those resources. For superstructure replacement projects or bridge rehabilitation projects involving a historic structure, the requirements to design these projects in accordance with the current AASHTO LRFD specifications are modified to meet the anticipated truck traffic loadings or past editions of the AASHTO specifications. These exemptions require prior written approval from MassDOT.

North Carolina

NCDOT has no specific guidelines or policy for reuse of existing foundations. Current state of practice for NCDOT for low-impact bridges (i.e., bridge maintenance bridges) founded on timber piles is to reuse the foundation from the pile cap or column down, and repair damage to the cap or column if necessary. However, the majority of bridges in North Carolina are replaced with new foundations.

Ohio

Based on the 2006 FHWA LRFD guidance that states, "For modification to existing structures, States would have the option of using LRFD specifications or the specifications which were used for the original design," the Ohio Department of Transportation has elected to use the specification for driven piles that was in place at the time of the design of the original structure. However, for drilled shafts and spread footings, Ohio uses the following LRFD specifications:

- **Driven piles.** For driven piles to bedrock, reuse is based on the structural capacity of the pile. For friction piles, if they were originally designed based on the pile driving formula, then the geotechnical limit/capacity is verified by dynamic testing.
- **Drilled shafts.** For drilled shafts socketed into bedrock, the State controls structural limits. For friction drilled shafts, the State controls geotechnical limits, and reuse is generally not permitted.

- **Spread footings.** For spread footings on rock, the State controls structural limits. For spread footing on soil, the State controls geotechnical limits and both structural and geotechnical analysis.

Illinois

As described in the previous FHWA workshop report, Illinois has a formal and elaborate methodology for evaluating foundation reuse.(2) The new policy, issued in 2008, allows an abbreviated analysis when the substructure is in good or repairable condition and the dead load increase is less than 15 percent.

Utah

Utah does not have a specific policy on the reuse of existing foundations and has only completed two projects to date in which existing foundations were reused.

Field Testing

The workshop and panel discussion did not focus directly on methods to verify foundation conditions. However, the presenters briefly discussed the following options:

- Pile integrity testing.
- Parallel seismic.
- Ultrasonic echo.
- Half-cell potential.
- Ground-probing radar.
- Surface resistivity testing.
- Material testing.
- Unload monitoring (example presented by Michael C. McVay[3]).
- Load rating of foundations based on finite element method analysis and settlement criteria (example presented by Pamela Moore).
- Structural identification for bridge load testing (as presented by Ahmet Emin Aktan).
- Foundation static load test.
- Foundation dynamic load test.

Foundation Options for New and Existing Bridges

Four options for new developments on bridge sites with existing deep foundations are presented here and illustrated in figure 1 through figure 4.

Option 1 features a new foundation built adjacent to an existing foundation. This option is perhaps the simplest from an engineering and implementation perspective. However, in river crossings, analysis is required to account for scour vulnerability due to the pier interference. Vortices shedding of adjacent piers can cause scour holes to overlap that are deeper than from a single pier. Accordingly, the old piers are typically removed to an elevation of 2 ft (0.6 m) below the mud line.

Option 2 features a new in-place foundation. The existing foundation is demolished and replaced with a new one. When the location of the new structure is required to be in the same place as the existing structure, removal and replacement of the existing foundation is an option, albeit a costly one.

[3] Please refer to the AFP30 Committee Web site for workshop presentations: https://sites.google.com/site/trbcommitteeafp30/characterization-of-bridge-foundations.

Option 3 features the complete reuse of the existing foundation. This option requires characterization of the existing foundation.

Option 4 features the reuse of existing foundation while at the same time strengthening and enhancing the capacity of the foundation by extending the pile cap, including drilled shafts; using micropiles; implementing soil improvement measures such as compaction grouting and permeation grouting; and so forth. The enhancement of the existing foundation is an obvious way to reduce the risk associated with option 3.

Innovative ABC/PBES techniques can be implemented with option 4, as seen in the Milton-Madison Bridge.[4] Figure 5 shows a preassembled steel truss superstructure (placed on temporary piers) that was moved laterally 55 ft (16.7 m) on refurbished piers.[(7)] Four of the five main piers were reused, but the pier stem had to be widened. Soil structure interaction was evaluated for the existing foundations, which were ultimately strengthened by coring and adding supplemental reinforcing to the existing pneumatic caisson foundation.

Table 4 lists case histories from the workshop presented in the next section and the foundation reuse option that was used in each case.

Case Histories from the Workshop

Hurricane Deck Bridge, Missouri (Option 1)

An example for option 1 is the Hurricane Deck Bridge at Lake of the Ozarks, MO. Hurricane Deck Bridge crosses the main channel of the Lake of the Ozarks at approximately mile marker 35. It carries Missouri Highway 5 between Versailles and Camdenton. The bridge was built in 1936, 5 years after the new Lake of the Ozarks was filled; prior to that time, traffic crossed by ferry. Because of deterioration of the bridge and increased traffic volume, a replacement/widening project was initiated by the Missouri Department of Transportation in 2005. After extensive study of the existing foundation, the project was bid with the option to reuse the existing foundation or use a new foundation. The low bid contractor chose to use a new foundation. The photo in figure 6 was taken during demolition, indicating pier position of the replacement bridge in relation to an old pier.

Bridge B-23-005-M-18-002, Massachusetts (Option 2)

MassDOT replaced a two-span bridge between the towns of Bridgewater and Middleborough in Massachusetts. Bridge B-23-005-M-18-002, which carries Summer Street over the Taunton River, was replaced with a single-span, integral abutment bridge. The new pile-supported integral abutments eliminated bridge joints and were placed behind the existing abutments and wing walls (figure 7). Placing them behind these existing structures minimized work in water, provided temporary earth support to build the new bridge, and provided additional scour protection. The existing structures were modified by cutting them down to an elevation that would allow future inspection of the new bridge.

[4]One of the reasons to reuse foundations is ABC/PBES. For a complete bridge replacement, a full environmental impact statement may be required, which can delay the project significantly. This requirement is avoided by replacing only the superstructure.

Figure 1. Bridge foundation, option 1.

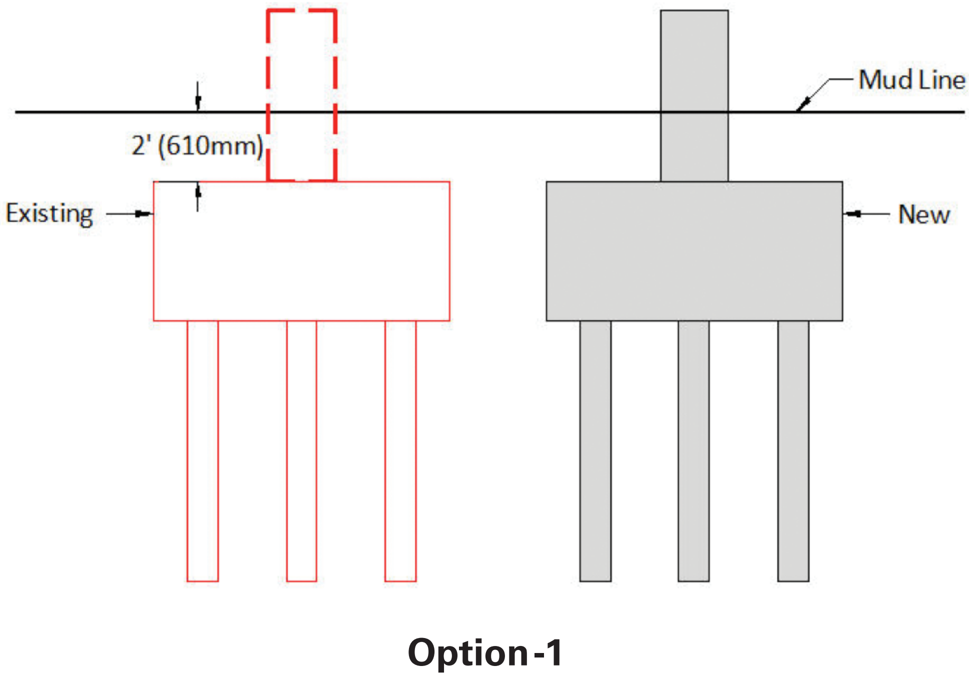


Figure 2. Bridge foundation, option 2.

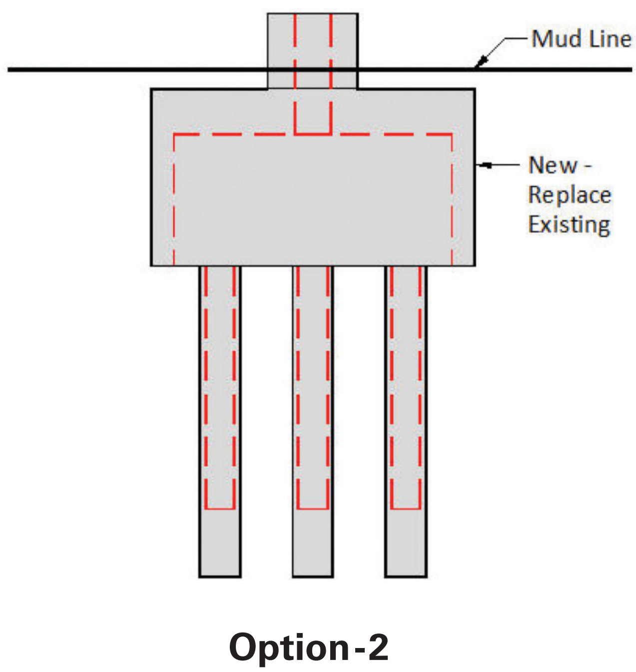


Figure 3. Bridge foundation, option 3.

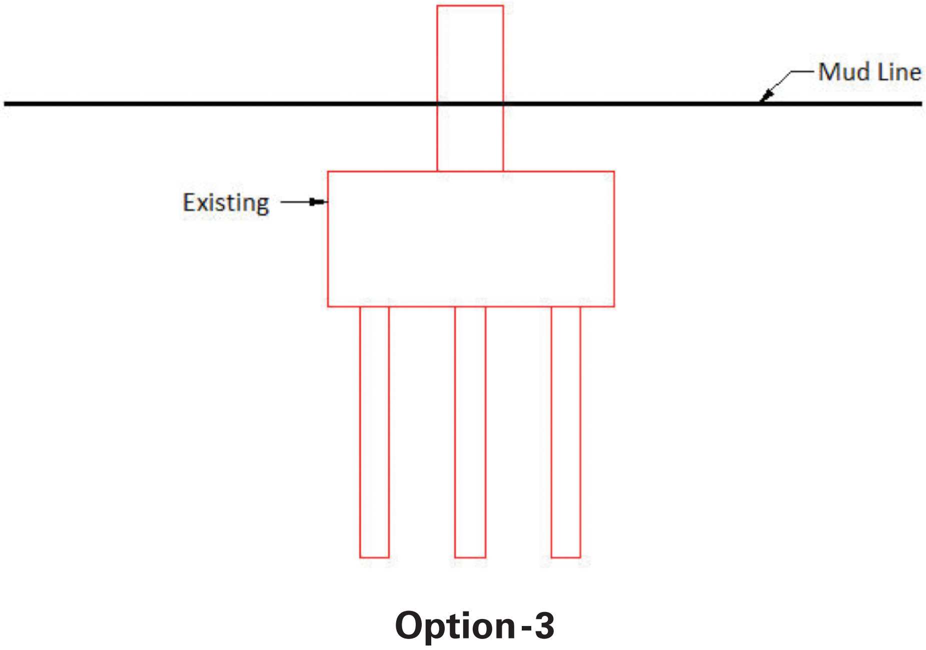


Figure 4. Bridge foundation, option 4.

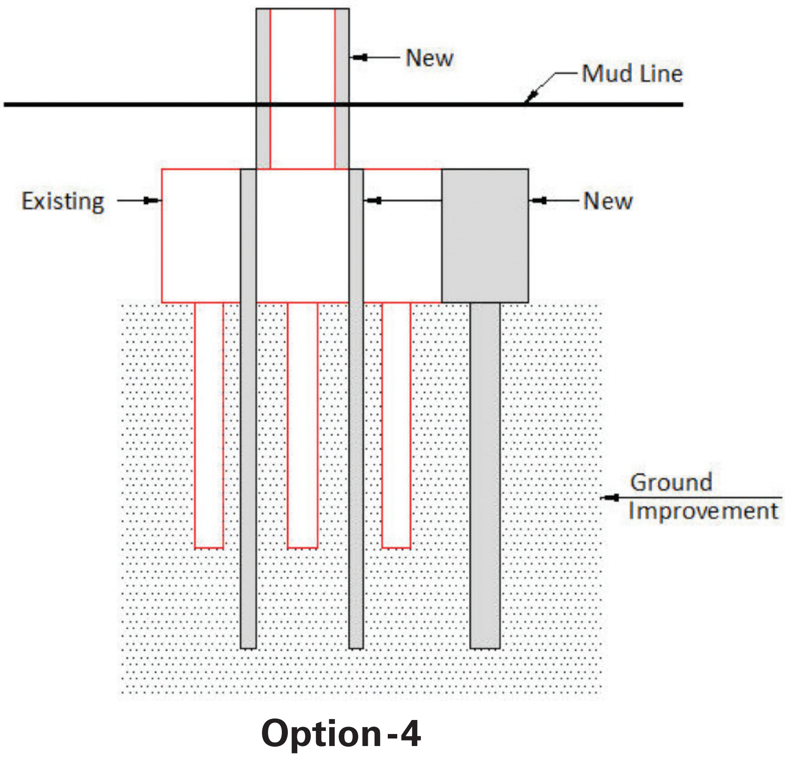


Table 4. Case history examples of foundation reuse.

Case History	State Transportation Department	Foundation Option No.
Hurricane Deck Bridge	Missouri Department of Transportation	1
Bridge B-23-005-M-18-002	Massachusetts Department of Transportation	2
Arthur Mills Bridge	Utah Department of Transportation	3
Clipper City Rail Trail	Massachusetts Department of Transportation	3
Virginia I95 Corridor	Virginia Department of Transportation	3
Yadkin River Bridge 91	North Carolina Department of Transportation	4
Henley Street Bridge	Tennessee Department of Transportation	4

Figure 5. The Milton-Madison Bridge after the new steel truss superstructure was laterally moved from temporary piers to permanent refurbished piers.[7]

Figure 6. Hurricane Deck Bridge, Lake of the Ozarks, MO.[8]

©JB Simpson/www.lakeexpo.com.

Figure 7. Bridge B-23-005-M-18-002, Bridgewater, MA.

Source: MassDOT.

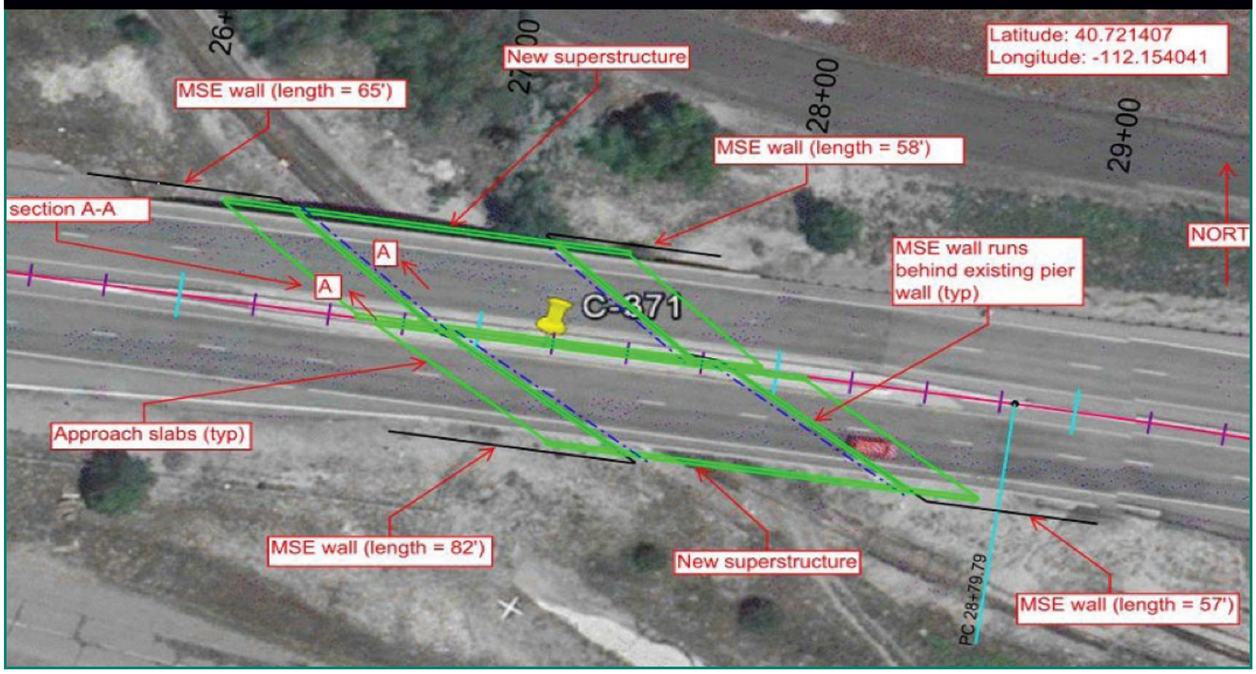
Arthur Mills Bridge, Utah (Option 3)

The Arthur Mills Bridge in Salt Lake Valley, UT, was constructed in the 1960s to allow vehicular traffic on State Route 201 to pass over an existing railroad line. The original bridge was a three-span, reinforced-concrete bridge; the center bents and abutments were supported by spread footings designed for an allowable bearing capacity of 4,000 psf (192 kPa). The bridge was reconfigured in 2013 to eliminate the existing abutments and shorten the bridge from three spans to one span. The existing bents were to be converted into abutments with the addition of mechanically stabilized earth (MSE) walls (figure 8). Four new borings were performed as part of the geotechnical evaluation for the reconfiguration. The geotechnical report concluded that the existing bridge foundations were not anticipated to be adversely affected by the MSE wall backfill, and a strength limit bearing resistance of 14,000 psf (670 kPa) may be used for existing bridge footings, assuming a resistance factor of 0.45 is used. Settlement was estimated to be between ½ and ¾ inch (1.3 and 1.9 cm) owing to the MSE fill.

Justification for using the existing foundation for the reconfiguration was based on the following factors:

- New footings would require excavation and shoring at tight locations supporting the railroad.
- A larger span to avoid the railroad would be costly.
- A new structure would impose less load than the old structure.
- Builders had confidence in as-built plans of existing structure.
- The performance of existing footings was excellent.
- The existing foundation was on excellent soil.

Figure 8. Reconfiguration of the Arthur Mills Bridge.[9]



Source: Utah Department of Transportation.

Clipper City Rail Trail, Massachusetts (Option 3)

MassDOT repurposed the existing railroad bridge to carry the Clipper City Rail Trail over Merrimac Street in Newburyport, MA. The granite block abutments were originally built in 1850. Because of the good condition and past performance of the existing granite block abutments (figure 9), they were reused. The anchor bolts that secured the rehabilitated superstructure were replaced, railroad tracks and ballast were removed, and hardwood decking was installed as a riding surface (figure 10).

Figure 9. Clipper City Rail Trail Bridge.

Source: MassDOT.

Figure 10. Clipper City Rail Trail bridge deck replacement.

Source: MassDOT.

Virginia I95 Corridor (Option 3)

The Virginia Department of Transportation (VDOT) made the decision to reuse the existing foundations with ABC/PBES (figure 11) on 10 bridges along the I95 corridor for several reasons. First, the dead load was reduced by about 7 percent with the use of lightweight concrete decks in the replacement superstructures. The original foundations were analyzed with this reduction in dead load and the proposed loading. The analysis indicated that the existing foundations were adequate to support the new superstructure and the imposed loads. The second item considered was cost. Substructure repair and corrosion-protection costs were computed and compared against replacement cost. The most cost-effective solution was to repair and provide the corrosion protection for the existing foundations. Finally, VDOT did not want to disrupt traffic for the length of time that would have been required to rebuild the existing foundations. Because the existing foundations were found to be adequate for the proposed loads, the decision was made to repair and provide corrosion protection for the existing foundations and reuse them. The corrosion protection for the prestressed concrete and steel H-pile foundations included electrochemical chloride extraction and sacrificial corrosion protection systems.

Figure 11. ABC/PBES on I95 in Virginia.

Source: URS Corporation.

Yadkin River Bridge 91, North Carolina (Option 4)

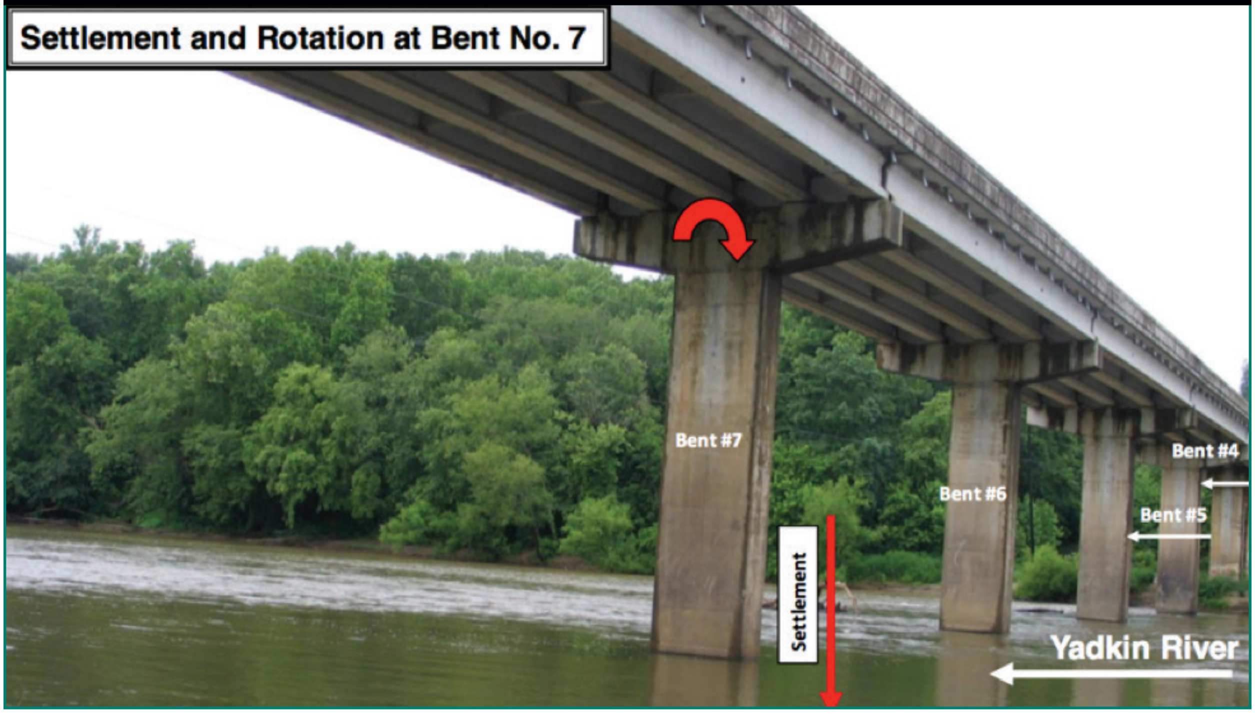
The Yadkin River Bridge 91 is located in Forsyth County, NC. In 2005, distress in the superstructure was observed (figure 12). It was determined that bent #7 had settled and rotated, causing the distress in the superstructure (figure 13). A team of structural, geotechnical, and hydraulic engineers was tasked with evaluating the problem. Divers inspected the foundation of the pier and assessed the bearing materials and scour. Divers were instructed to use an airlift to try to remove any loose material below the foundation, down to the bedrock. Using the airlift, the divers were able to reach below the footing. However, 4 ft (1.2 m) below the bottom of the footing, no bedrock was found. Material under the footing consisted of cobble, sand, and silt. The original design was to have the footing for the piers embedded 6 inches (15.2 cm) into rock. However, at pier #7, the footing was founded on residual soil, and scour over the years had removed support, resulting in the pier tilting (figure 14). The remedial solution for this bent was to enhance the foundation with micropiles to provide the additional support lost due to the scour (figure 15 and figure 16). No discussion was presented on how the design load for the micropiles was determined or what the capacity of the existing pier foundation was. This case history presents the remediation of an existing foundation because of the effects of scour and raises the question or perhaps points out the need for a definition of foundation reuse, because many engineers would suggest this action is remediation and not reuse.

Figure 12. Yadkin River Bridge superstructure distress.

1 inch = 2.54 cm

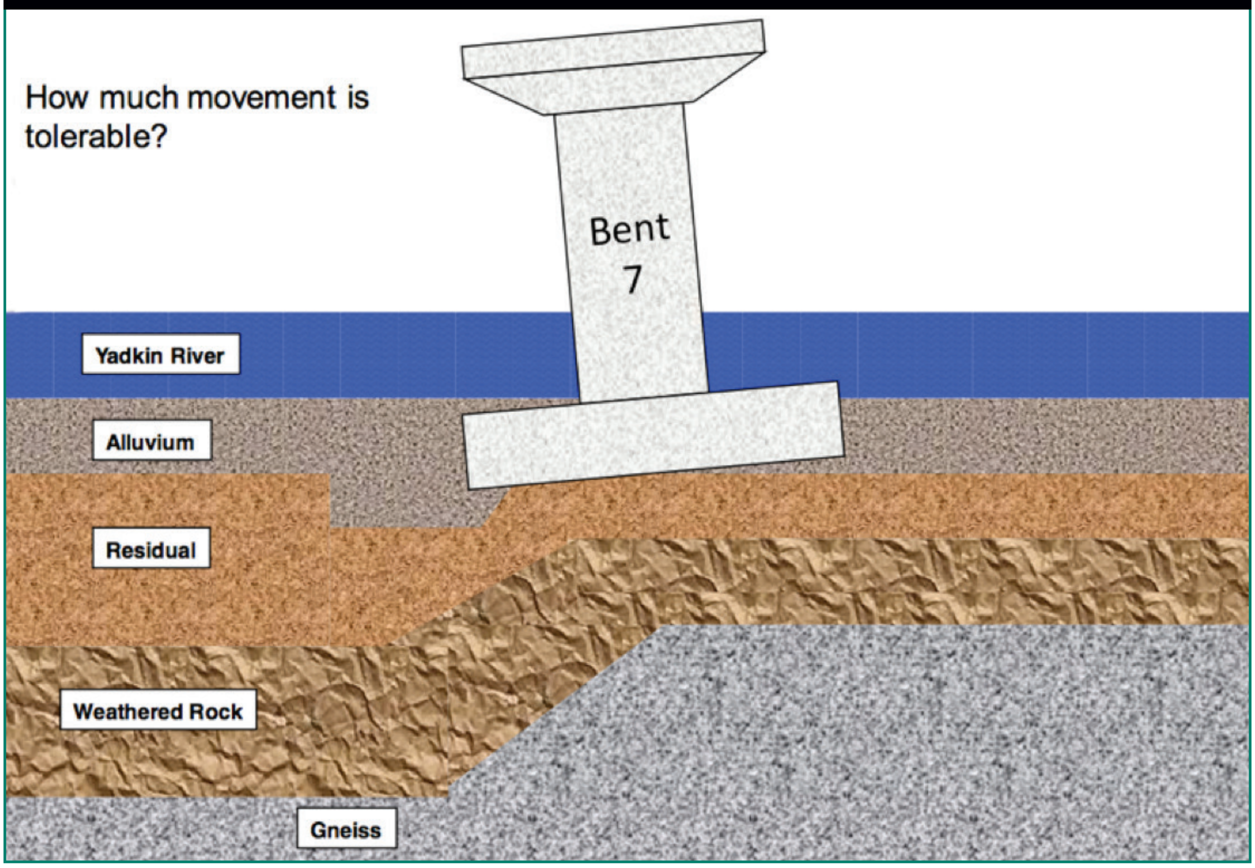
Source: NCDOT.

Figure 13. Yadkin River Bridge Bent #7 settlement and rotation.



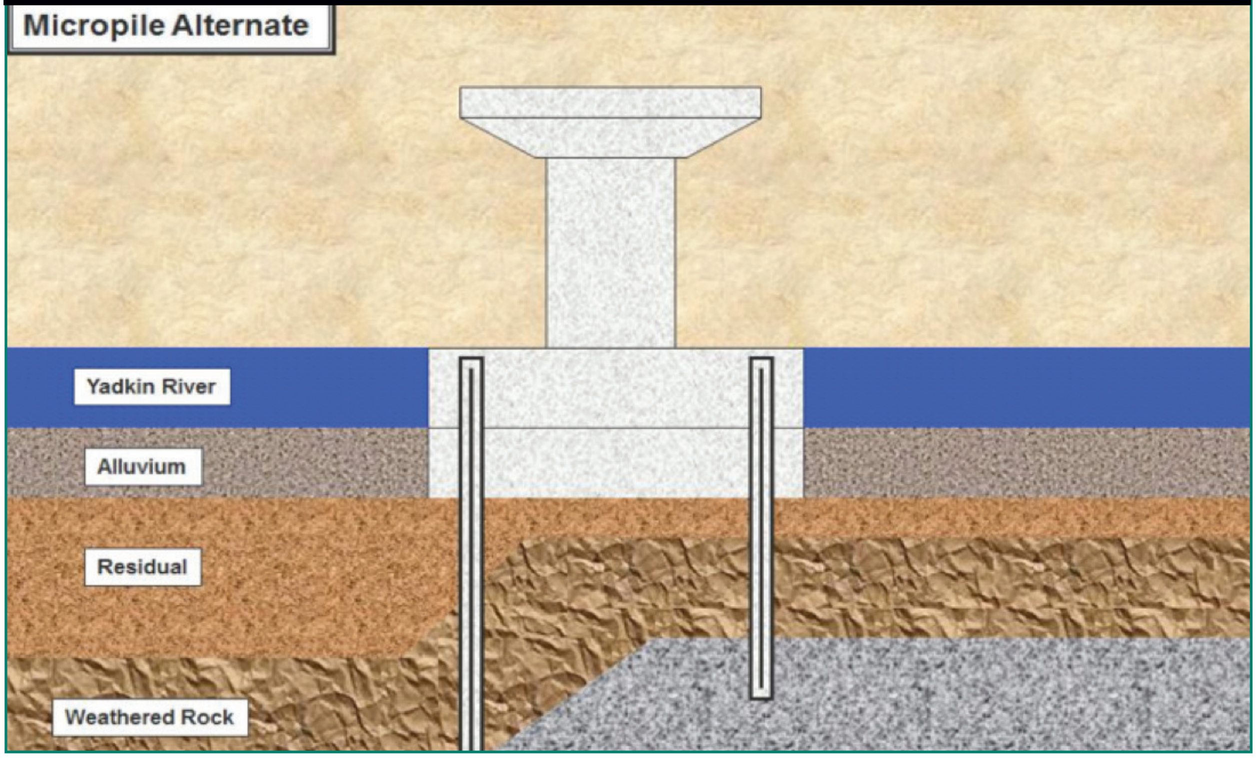
Source: NCDOT.

Figure 14. Scour at the upstream edge of the pier.



Source: NCDOT.

Figure 15. Yadkin River Bridge micropiles remediation.



Source: NCDOT.

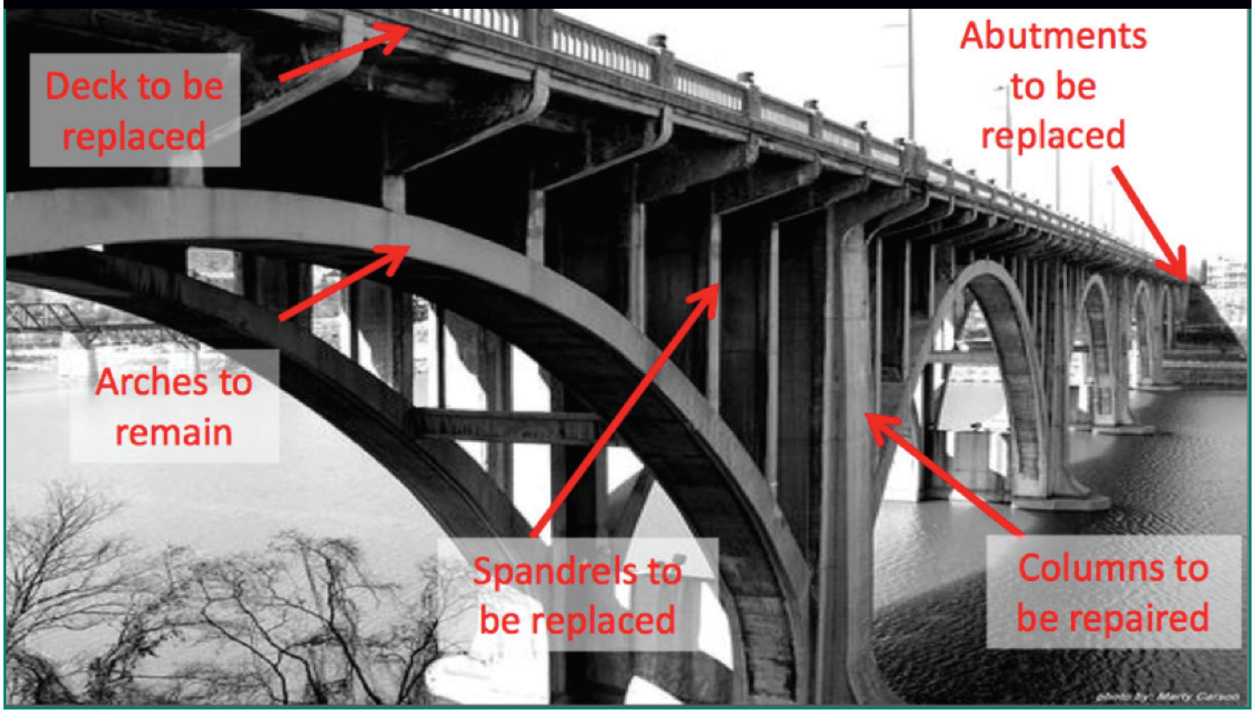
Figure 16. An existing foundation strengthened with micropiles.

Source: NCDOT.

Henley Street Bridge, Tennessee (Option 4)

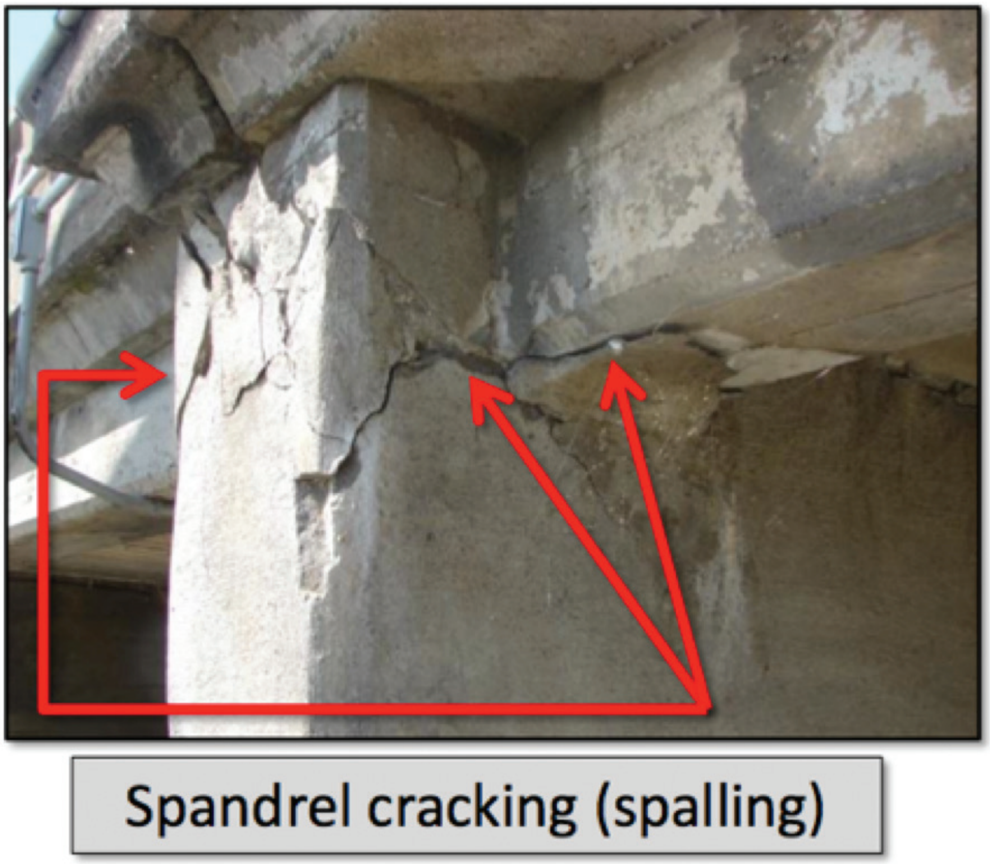
The Henley Street Bridge, constructed in 1931, is a six-span, reinforced concrete bridge across the Tennessee River. The bridge required significant structural repair and seismic upgrade. In addition, the width of the bridge was expanded. Figure 17 shows the bridge before rehabilitation, and figure 18 shows some of the structural deterioration. This rehabilitation project was in reality a complete superstructure replacement. The original bridge foundation consisted of driven piles. To support the added load from the bridge widening, additional drilled shafts were incorporated into the foundation system (figure 19). Underwater inspection of the existing piers was performed and given a structural and scour rating of 7 out of 10. Based on this inspection and engineering judgment, the existing foundation was considered to be adequate for reuse. The load-carrying capacity of the existing foundation was assumed to be 20 percent of the total foundation load. Therefore, the drilled shafts were designed to carry the remainder of the load. How the load capacity of the existing foundation was determined was not included in the presentation of this case history. Figure 20 shows the bridge after rehabilitation.

Figure 17. Superstructure repair, Henley Street Bridge rehabilitation project.



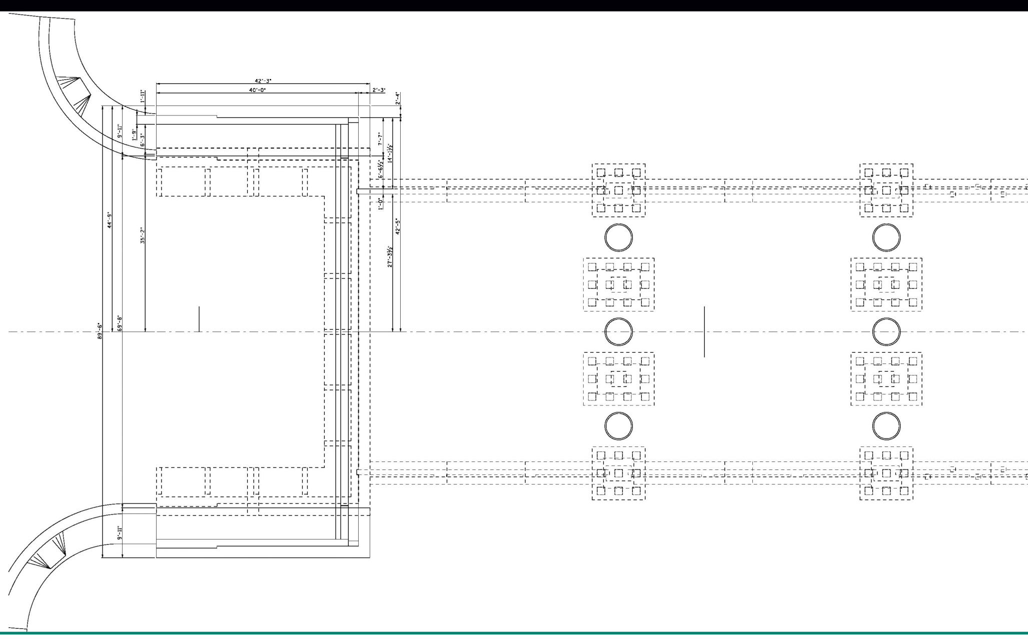
Source: Tennessee Department of Transportation.

Figure 18. Structural deterioration of Henley Street Bridge superstructure.



Source: Tennessee Department of Transportation.

Figure 19. Combined foundation system for Henley Street Bridge rehabilitation.



Source: Tennessee Department of Transportation.

Figure 20. Henley Street Bridge after completion of the rehabilitation.

Source: Tennessee Department of Transportation.

Discussions

It is a common practice in the United States to undertake significant improvements on existing bridges (new decks, major rehabilitation, widening, and load capacity improvements) without consideration and study of the current condition and remaining service life of the substructure, including the foundations. As the specialty topic of bridge preservation becomes more mature, a growing number of bridge owners are questioning the soundness of this practice and are in need of guidance at both a bridge-program level and a project-specific level to develop and implement consistent practices. This topic was addressed at recent workshops and sessions at the 2014 TRB meeting. The workshop and sessions were very well attended, validating the importance of the topic and the need for further research and development work in this area. FHWA is just beginning a research program that focuses on foundation characterization to provide answers to meet this challenge.

At first examination, the question of whether to reuse existing foundations appears simple and, in fact, is often seen as a non-issue. If the existing structure is visually sound and not experiencing lateral, vertical, total, or differential deformation, then one may logically assume that substructure is sound and may serve in a satisfactory manner for long extended service life. However, in some cases, this assumption needs to be corroborated through field testing.

The workshop presentations and panel discussions highlighted different aspects of the reuse of bridge foundations. The frequency with which this topic is raised in practice (although under a variety of different titles and terms) is increasing. Workshop presenters addressed their personal and organization experiences to date. Collectively, this workshop demonstrated that the apparently simple question of whether to reuse existing foundations has broad and far-reaching implications for owner agencies, designers, and construction staff. For the most part, the topic has been considered from a "bottom-up" approach, centering on a question raised in conjunction with a specific project rather than a "top-down" programmatic directive.

Although the individual presenters did not intentionally compare notes or collaborate in advance, they suggested that technical and management needs in this area are many and include the following topics: terminology, historical and new data collection and analysis, investigative tools to assist in evaluation of structural and geotechnical limit state performance, the in situ condition of the foundation material (time deterioration and construction placement damage), and policies and design protocols.

Research Needs

From a programmatic level, bridge owners require policy, process, and technical guidance and tools to adopt a consistent approach that ensures public safety, minimizes future risk, and optimizes study scope of their bridge inventory. As an example, reuse of an existing substructure for a bridge deck replacement may not require any indepth study as would bridge widening and a completely new superstructure.

It is clear that the majority of the presenters believe that the most important need to advance the reuse of bridge foundations is the development of FHWA guidelines on what is the required standard of practice to evaluate an existing foundation and mitigate the risks involved. Each project should not be approached as a research project but rather as a sustainable construction project. The guidelines should clearly define reuse because different State transportation departments have different definitions of reuse. The guidance should also include well-defined approaches to evaluating the existing condition of a foundation. How much and what type of testing is adequate/appropriate to define the unknown? What disciplines should be involved in the foundation assessment?

Additional research into methods of assessing the integrity and capacity of existing foundations should also be pursued. However, specifics of this research were not provided by the presenters at the workshop or panel discussion.

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