March 2019 ABC-UTC Webinar Featured Presentation: Foundation Reuse for Highway Bridges

#	Questions	Responses
	Design: General (Ratings)	
1	Should substructures be "rated" for current LRFD criteria prior to assessing reuse?	Inspection rating prior to assessment for reuse could play a significant role in deciding the potential for reuse. If the substructure has been rated highly because of its good condition, then detailed evaluation for reuse may be warranted. Load rating of substructure for current LRFD criteria priority use may be needed if the loading after reuse is going to change. Detailed information on load assessment of substructure can be found in Chapter 6 and reference (17).
2	Do you analyze the existing foundations in LRFD if they were originally designed in either LFD or ASD?	Yes. On page 153 of the report, in chapter 6 under the title of "CHANGES TO CODE REQUIREMENTS", this issue has been addressed. Substructures of bridges being reused need to be compliant with the current AASHTO LRFD specifications or other codes currently applicable. Essentially, reused components should be subjected to the same code requirement as the components of a new bridge.
3	What design standards (AASHTO LRFD?) should be used to determine if the existing substructure units are adequate?	All components of reused foundation should satisfy the current AASHTO LRFD specifications.
4	If a substructure is re-used, how is the crossing managed with respect to NBIS and FHWA reporting?	The bridge will be continued to be inspected based on condition after reuse. The superstructure, which may be completely new, may have a rating consistent with its new condition. Substructure may have improved rating depending on the level of rehabilitation performed during reuse.
5	Is hydraulic scour analysis to be conducted for reuse of pre-1988 bridge foundations and only appraised for scour since 1990?	Scour prone bridges that are expected to reuse their foundations should be evaluated for detailed scour analysis, stream stability, and countermeasures as outlined in FHWA HEC 18, HEC 20 and HEC 23 publications, respectively. Chapter 3 and 4 of the report address the scour issue.
6	Do you reuse existing abutments for scour protection?	Yes. There have been cases where existing abutment has been left in front of a new abutment as scour protection measure. Page 9 of reference (5) discusses a case example related to this question.
7	Should new design include a durability plan for the life of the structure?	Design standards have been perfected over decades and are generally expected to produce designs with acceptable durability. Older designs may have inherent durability issues that impact their suitability for reuse. However, all reused foundations should be analyzed and, if needed, repaired and rehabilitated to have desired durability and useful service life. This has been addressed in chapter 5 of the report.
	Design: Evaluation - General	
8	Is in-field testing required for structural capacity of existing foundations?	Depending on the foundation condition and availability of original load testing data for piles/shafts, in-field testing may be necessary. This issue has been addressed in detail in Chapter 6 of the report.

9	Is there any other way to determine unknown capacity of existing piles, besides load testing on the bridge or exposure of existing piles?	Some foundations lack design drawings, plans, as-built records, and driving logs. These foundations are often referred to as "unknown foundations" for scour vulnerability assessments (reference 6). Considering them for reuse will require significantly greater risk and expenditures involving field investigation including NDT, geophysical methods, and so forth. What is more common than the "unknown foundations" bridges are the population of bridges where design drawings are available but not in full detail (bridges with missing critical documents). For instance, drawings may show reinforcement size and layout, but may not show lap splices details, development length details, etc. In these circumstances, additional nondestructive evaluation may be necessary to ensure that the rebar layout is compliant with modern codes. In the current state of the technology, there is no other reliable approach to determine unknown capacity of existing piles. However, Davis et al. (reference 20) have proposed an approach where past permit loading history can be used to develop estimates of observed capacities of unknown foundations. This observed capacity may be completely different than actual capacity, which can only be found through field load testing.
10	What are recommended practices for foundations of unknown design details, but acceptable performance (local roads, gravity abutments)?	For the pile foundations showing an acceptable performance with unknown details, Davis et al. (reference 20) presented a methodology to update the resistance factor, ϕ, that can be used to find nominal capacity from static or dynamic design equations. Please refer to answer for Question 9 or reference (18).
11	What in-depth field investigation methods are often necessary to establish verification of existing construction?	Chapter 4 of the report discusses the available methods for integrity assessment of an existing foundation in details. Wireline logging method has significant potential for reliable assessment of existing foundations and has been used in many foundation reuse projects, such as Milton Madison Bridge project. For unknown foundations or verifying as-built construction details, NDT methods are commonly used. For more detailed information refer to references (14, 15, and 16).
12	What kinds of equipment can be used to assess the existing bridge foundations? What are the costs and percentage of accuracy of equipment?	This is covered in detail in Chapter 4 of the report that includes wireline logging from coreholes drilled into the foundation and geophysical and NDT imaging from the exposed surface of the foundation. The approximate average cost of 50 ft, 3-in diameter coring is $5000 per corehole. The average cost of geophysical logging is about the same. We found the geophysical logging very accurate and representative of in-situ condition. We also found the use of seismic tomography or volumetric imaging of wall foundations to be useful. The cost of such surveys is various with complexity.
13	How do you confirm capacities of existing foundations? Load testing? As-built plan notes?	Chapter 6 of the report provides an overview of the procedures that can be employed to ensure that adequate capacity is available for the reused foundation to comply with modern codes.

14	How can you use existing substructure when length, width, and substructure depth is dictated by current design standards/policy?	The existing foundation cannot be reused if current design standards/policy require substantial change in the footprint of substructure/foundation. However, existing foundation can be enhanced/strengthened to meet the current design standards/policy if there is not a significant change in the footprint. This may require detailed field assessment of the substructure to design enhancement/strengthening.
15	Explain means and methods and testing for pile assessment: steel shells, H-pile, and timber for pile assessment.	Please see answer to question No.11 for NDT and geophysical testing of piles. Generally speaking, for steel foundations, surface resistivity and borehole magnetic logging methods are used. For timber piles, stress wave methods, such as Ultraseismic and borehole parallel seismic methods are used. Please see references (9) to (16).
16	Is there a typical difference in additional dead load where reanalyzing a foundation is neglected?	There is not a specific agreed-upon percent increase in dead load that makes the capacity assessment necessary, but some State DOTs have policies on assessing substructure/foundation if the additional dead load is increased by 10% or more. The detailed discussion can be found in Chapter 6 of the report.
17	What is the limit on service life for the various types of foundations (timber/steel/concrete piles, concrete footings, etc.)?	Chapter 5 of the report provides (for example Table 26 for steel elements and Table 28 for timber piles) detailed information on durability estimate of existing piles.
18	How do you assess the capacity of existing piles? How do you assess corrosion?	For the first question, please see answer to question No.13. The corrosion assessment issues have been addressed in chapter 5 of the report.
	Design: Evaluation - Steel Piles	
19	Please comment on recommended practice for evaluating pile corrosion for concrete footings on piles.	Please refer to the Chapter 5 of the report.
20	How do you estimate the corrosion rate of steel H piles supporting bridge abutments and piers?	Please refer to the Chapter 5 of the report. For example Table 26 of report shows the loss in thickness of steel elements.
	Design: Evaluation - Timber Piles	
21	What is your opinion on timber pile abutment reuse where such abutments show no signs of issues subsequent to 50 years of successful use?	If timber piles are fully buried underwater, they can be in a good condition in terms of structural integrity and can be considered for reuse pending other analysis outlined in the report. However, it is a good practice to expose few piles to observe their condition and perfume NDT. For exposed pile bents, careful inspection of the piles, including field NDT, should be considered especially if signs of timber deterioration are evident in the dry-wet zone.
22	What can be done to determine if timber piles can be reused, and what their capacity is? Plans usually only indicate applied load.	Please refer to the Chapter 6 of the report.

23	Please advise on FHWA's current policy / practice for reuse of timber piling BELOW the water table or for abandoned RR structures?	The FHWA does not currently have a policy for foundation reuse. This report is not a FHWA policy document and just provide some technical guidance on evaluation for potential reuse. Timber piling below the water table is not typically affected by wood decay, although boring insects are still a possibility. Timber piling should be evaluated to assess their eligibility for reuse. The same applies for other structures.
	Design: Evaluation - Spread Footings	
24	Have you done any research about spread footings?	One main concern with spread footings is the corrosion of reinforcement steel within the footing. Investigation of these issues is discussed in the durability Chapter 6. Absent of scour, the geotechnical capacity of a spread footing would not be expected to be reduced substantially over time. Settlement that has already occurred may reduce future possible settlements. A core can be driven through the footing to test the foundation bearing capacity.
	Design: Evaluation - Miscellaneous	
25	Have you seen cases where high pressure grout may be incorporated when core samples of foundation show high potential of significant cracking?	Yes, an example for Lake Mary, AZ bridge is presented in the report where pressure grouting was performed to fill air voids in the stone masonry foundations that where discovered as part of the field testing.
26	Masonry abutments rarely fail, but calculations often say they are unstable. How do you deal with this when trying to reuse them?	If masonry abutments have been observed to be stable during current service life, then earth pressures are unlikely to be factors that can cause instability. However, masonry foundations need to be evaluated for seismic loads for future reuse. Reliability of modeling approach and parameters of the foundation are very important in performing such evaluation. If needed, masonry foundations will need to be strengthened for their lateral resistance. Since codes have changed significantly in the last 75 years, many masonry foundations may not have been designed for seismic loads originally.
27	How do you retrofit an existing concrete abutment with low air content (much less than 2%) for durability?	Concrete without proper air entrainment may not be effective at resisting freeze thaw action as there is no room for freezing water to expand into. As a solution, it may be possible to encase the existing abutment in enough concrete to protect the underlying concrete without proper air entrainment. Using FRP wrapping could be another retrofit option.
28	What is your recommended means for converting existing conventional abutments to semi-integral abutments?	We have not observed a case example, though it seems possible in theory. You would need to start with a compatible foundation that has enough flexibility to behave as an integral foundation.
29	What are some of the age-related issues of deep foundations?	Primarily it is the corrosion of steel elements / reinforcement / prestressing tendons, and decay of timber elements. These issues are most prominent above the water table. Excessive settlement due to geo-hydraulic conditions is another age-related issue for deep foundations.
	Other:	
30	Please comment on cost analysis for foundation reuse.	Chapter 2 of the report discusses this issue in detail. In general, the cost during the foundation reuse includes detailed integrity, durability, and capacity assessment;

		rehabilitation/repair of reused components if needed; construction of new superstructure.
31	Do you want to comment on costs of reuse versus replacement?	In general, the cost of reusing should be less than construction of a new foundation, but depending on the project specifications, it could be comparable. Please note that there are other cost saving besides construction costs such as user costs, environmental, permitting, scour countermeasure, right of way costs, etc.
32	Under what circumstances and how have delay claims been resolved (access, weather, material delay, etc.)?	Common construction management practices should be followed to handle delays which is not in the scope of this report.
33	How much impact does time (design and/or construction) have on the foundation reuse choice?	Time is a very important consideration when reusing foundations as reuse can allow for much shorter construction schedules and lower user impacts; i.e. accelerated construction.
34	How do you evaluate an existing foundation after an earthquake, when you want to construct a new bridge on top	Post-earthquake inspection typically considers issues like the extent of concrete cracking, permanent deflection and yielding of steel elements. These effects may lower the capacity of elements and should be evaluated thoroughly. In-depth evaluation of concrete/masonry foundations or piers can be done by coring through the substructure element and performing geophysical logging.
35	Could you talk about surprises, problems, and implementation recommendations?	During the planning phase, frequent communication between structural, geotechnical, hydraulic, corrosion, and NDE engineers is important. A significant challenge may be encountered in collecting all relevant information on the bridge. Assessment of detailed condition of the foundation may depend on field conditions. The most important implementation recommendation is to have a team of experts in evaluation / assessment that can look beyond traditional tools. Use of wireline logging has been found to be very useful in assessing condition of foundation. However, logging needs to be done and evaluated by an expert with many years of experience.
36	How are local DOT's responding to the new FHWA manual? Many DOT jobs currently abstain from existing foundation investigation.	Many DOTs have shown interest in this report, especially those with a backlog of aging infrastructure. DOTs have in the past abstained from analyzing foundations in part due to perceived risks.
37	What will the future of transportation look like in 20 years?	In general, the industry is shifting more towards performance-based metrics that consider the whole life cycle of infrastructure. Because of the growing population around megacities, we are likely to see a preference for foundation reuse and ABC.
	Questions during the Webinar:	
38	In your research, has anyone reused a roadway bridge foundation for a new Light Rail Transit (LRT) bridge?	We have not come across any examples of foundation reuse for a LRT bridge.
39	How was tension on the grouted bars assessed?	The presenters were not involved in the field work and don't have information on this question.

40	How will you determine capacity for piled foundation without driving records?	Either through testing, static design equations, and possibly by considering past loading. Static equations tend to have low resistance factors. Chapter 5 of the report addresses this issue.
41	If you are reusing only the bottom section of an existing pier, what is the best way to attach the new upper pier section to the existing lower section?	This is highly dependent on the details of the foundation. Bars can be grouted into existing concrete, plates can be welded onto existing steel, and timber elements can be bolted. UHPC can also be used between pier stem and new pier head.
42	It seems like there must be a number of load tests to establish the statistically relevant sample size. How many pile load tests do you think would be required?	AASHTO provides a resistance factor for at least one pile test per site condition. This factor considers potential variability between individual piles based on previous test data.

REFERENCES:

General Information and Case Studies				
Row	**Article Title**	**Author(s)**	**Publication Year**	**Location**
1	Foundation Reuse in Accelerated Bridge Construction	Nathan Davis, Ehssan Hoomaan, Anil Agrawal, Masoud Sanayei, Frank Jalinoos	2019	ASCE Journal of Bridge Engineering Special Issue on ABC, Vol. 24, Issue 10
2	Foundation Reuse for Highway Bridges	Anil Agrawal, Frank Jalinoos, Nathan Davis, Ehssan Hoomaan, Masoud Sanayei	2018	FHWA Report HIF-18-055
3	Foundation Reuse: An Option for Bridge Reconstruction Projects	Frank Jalinoos	2018	ASPIRE Magazine, Summer 2018, Vol. 12, No 3., Pg. 36-37
4	Reuse of Foundations of Existing Bridges	Anil Agrawal, Nathan Davis, Ehssan Hoomaan, Masoud Sanayei, Frank Jalinoos	2017	Proceedings, 2017 National Accelerated Bridge Construction (ABC) Conference
5	Foundation Reuse and Enhancement: A Viable Option for Bridge Widening and Replacement Projects	Frank Jalinoos, Mohammed Mulla, Vernon Schaefer	2016	Geo-Strata Magazine, Geo Institute of ASCE, Vol. 20, Issue 3, Pg. 52-57
6	Reusing Bridge Foundations	Frank Jalinoos	2015	Public Roads Magazine, FHWA-HRT-16-001, Vol. 79, No. 3
7	Workshop Report on the Reuse of Bridge Foundations	James Collin, Frank Jalinoos	2014	FHWA TechBrief HRT-14-072
8	Characterization of Bridge Foundations Workshop Report	Vernon Schaefer, Frank Jalinoos	2013	FHWA Report HRT-13-101

FHWA Reuse Report - Chapter 4: Integrity Assessment and Unknown Geometry				
Row	**Article Title**	**Author(s)**	**Publication Year**	**Location**
9	Evaluation of bridge abutment with ultraseismic waveform tomography: field data application	Khiem Tran, Frank Jalinoos, Trung Nguyen, Anil Agrawal	2019	Journal of Nondestructive Evaluation, *in press*

10	Characterization of Pile Groups with 2-D Seismic Waveform Tomography	Khiem Tran, Frank Jalinoos, Anil Agrawal	2019	Journal of Nondestructive Evaluation, Springer, Vol. 38, No. 25
11	Imaging of Concrete and Steel Piles using the Electrical Resistivity Tomography and Induced Polarization Geophysical Methods	Mark Everett, Frank Jalinoos, Anil Agrawal	2019	Journal of Environmental and Engineering Geophysics, *in press*
12	Testing Seismic Techniques for Imaging Structural Defects in Engineered Drilled Shafts – A Case Study	Jozef Descour, Frank Jalinoos, Anil Agrawal	2018	Proceedings, Structural Material Testing Conference
13	Foundation Reuse in ABC Projects	Frank Jalinoos, Nathan Davis, Ehssan Hoomaan, Anil Agrawal, Masoud Sanayei	2017	Proceedings, 2017 National Accelerated Bridge Construction (ABC) Conference
14	Evaluation of Bridge Abutments and Wall Type Structures with Ultraseismic Waveform Tomography	Frank Jalinoos, Khiem Tran, Trung Nguyen, Anil Agrawal	2017	Journal of Bridge Engineering, ASCE, Vol. 22, No. 12
15	Application of Geophysical Methods to Highway Related Problems	Ed Wightman, Frank Jalinoos, Philip Sirles, Kannan Hanna	2003	FHWA Report IF-04-021
16	Determination of Unknown Subsurface Bridge Foundations	Larry Olson, Frank Jalinoos, Marwan Aouad	1998	FHWA Geotechnical Engineering Notebook Issuance GT-16. NCHRP 21-5 Interim Report Summary

FHWA Reuse Report - Chapter 6: Capacity Assessment				
Row	**Article Title**	**Author(s)**	**Publication Year**	**Location**
17	Integrated Superstructure-Substructure Load Rating for Bridges with Foundation Movements	Nathan Davis, Ehssan Hoomaan, Masoud Sanayei, Anil Agrawal, Frank Jalinoos	2018	ASCE Journal of Bridge Engineering, Vol. 23, No. 5
18	Determining the Capacity of Reused Bridge Foundations from Limited Information	Nathan Davis, Masoud Sanayei, Anil Agrawal, Frank Jalinoos	2018	ASCE Journal of Bridge Engineering, Vol. 23, No. 12