

FHWA FOUNDATION CHARACTERIZATION PROGRAM (FCP)

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Abstract

The Federal Highway Administration (FHWA) has initiated a new research program entitled 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.

To narrow the focus of the program and to solicit key stakeholder input, a workshop was held in Arlington, VA, from April 30 to May 1, 2013. The cross-discipline workshop involved key staff from the FHWA hydraulics, geotechnical and structural disciplines brainstorming with stakeholders in separate breakout sessions. Subsequent and in support of the FHWA workshop recommendations, a workshop and a separate session on the reuse of bridge foundations were held at the 2014 TRB 93rd annual meeting. Two additional sessions on foundation reuse are planned for the upcoming TRB 2015 meeting summarizing recent research activities.

In this paper, the main purpose, scope, objective, and anticipated outcome of the FCP research program are presented.

Background

Bridge owners face the potential problem of not being able to characterize the foundations of bridges over dry land and waterways. This information is critical in their decision making process for determining whether they can rely on the existing foundations to continue to carry increasingly heavier loads; and/or to withstand geotechnical and hydraulic hazards for an additional 25-, 50-, 75-, or 100-year of service as they may consider a major bridge rehabilitation, replacement, reuse, or widening of a bridge.

In 2013, the Federal Highway Administration (FHWA) approved a renewed effort for the development of a multi-year strategic research program to address the “unknown foundation” problem. The unknown foundation has been associated with the population of existing bridges over waterways that cannot be evaluated against the hydraulic vulnerability related to scour due to missing bridge plans. The primary interest of unknown foundation investigation is determination of the bottom depth of the foundation (pile-tip elevation.) However, there are other engineering risks with unknown foundation besides scour. As such, it was decided to broaden the scope of the research program from “unknown foundation” to “foundation

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characterization” to include bridge foundations over land as well as waterways and incorporate Geo-Hydraulic hazard issues, changes in service loads, and foundation reuse.

Purpose

Foundation characterization is essential in three engineering applications:

1. Geotechnical & Hydraulic Hazards –
 - Hydraulics Vulnerability – scour evaluation for the population of bridges with unknown foundations.
 - Post-Hazard (Extreme Events) Assessment
 - Post-Seismic - Foundation depth and integrity evaluation of bridges.
 - Post-Flooding /Hurricane Assessment – Evaluation of foundations after flooding and high-flow events that can cause large lateral and hydrodynamic forces.
2. Changes in Service-Loads
 - Foundation Reuse - Reuse of foundations for bridge replacement, widening, or rehabilitation.
 - Truck Size and Weight (TS&W) - Use of heavier truck loads and increase in frequency of trucks.
 - Heavy Industrial/ Mining / Military Loads - use of heavier loads, and frequency.
3. Foundation Condition Assessment – Environmental and age-related degradation such as decay of timber piles, corrosion of steel piles, or degradation of concrete piles.

Program Objective

The objective of the FHWA Foundation Characterization Research Program is to develop and/or evaluate new and existing technologies and methodologies for characterizing existing bridge foundations for the determination of unknown geometry, material properties, integrity, and load carrying capacity. The emphasis is on developing guidance and best practice for foundation reuse. Many foundation characterization decisions will likely be made in the framework of life cycle cost and risk management analysis.

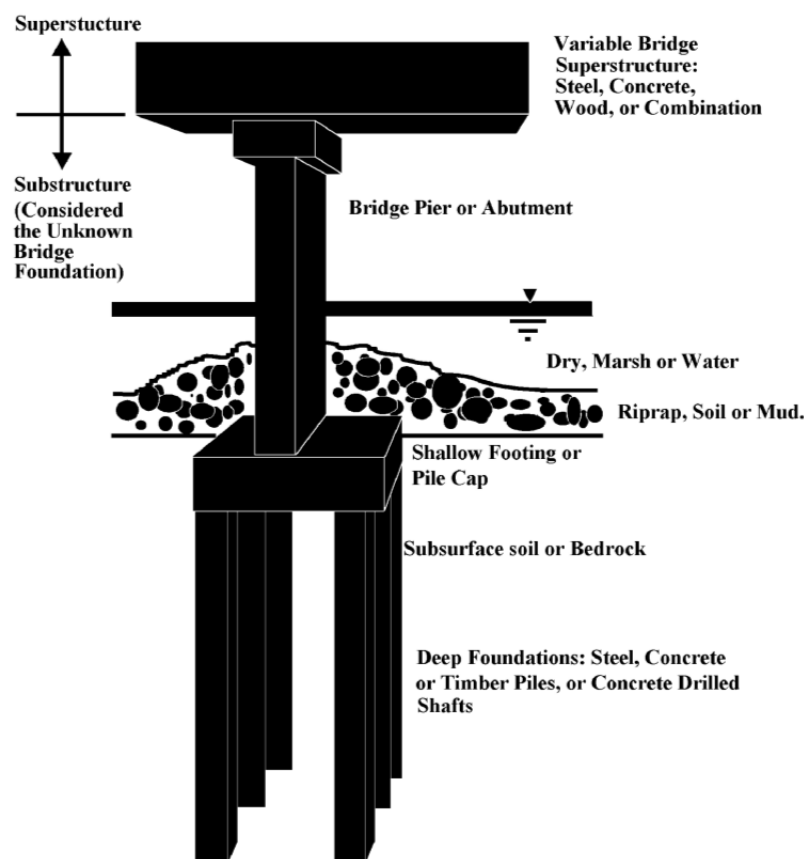
Problem Scope

The nature of the problem with the characterization of bridge foundation is complex. Bridges can be supported by shallow or deep foundations of varying footing geometries and material types. Footings can be square, circular, or rectangular in shape. They may also be pedestal masonry stone footings or massive cofferdam footings. Piles may be present with or without pile caps and may be battered or vertical. Piles can be made of concrete (round, square, cylinder, or octagonal), steel (H-piles or round pipe sections), or timber. Deep foundations can be pre-cast concrete piles, drilled shafts, and auger-cast concrete piles. The top of footings or pile caps may be buried underneath riprap, backfill mud and/or channel soils. Additionally, design or as-built drawings of foundations are sometimes not available and technologies for determining foundation condition are expensive and sometimes not reliable. The FHWA’s goal is to identify ways to accurately quantify and clarify these unknowns.

The scope of the program covers determination of one or more of the following information:

1. Foundation type (shallow vs. deep, or a combination).
2. Elevation of the base of the foundation (e.g. pile tip elevation).
3. Foundation geometry (width, length, and depth); including checking the accuracy of as-built plans.
4. Material type (foundation material(s) which can include concrete, masonry, stone, steel and/or timber).
5. Integrity (foundation condition such as corroded steel, rotted wood, or cracked or defective concrete).
6. Foundation load bearing capacity.
7. Pile distribution – Target avoidance for foundation rehabilitation or underpinning.
8. Remaining service life of the foundation.
9. Subsurface characterization and imaging of soil and rock.

Figure 1 illustrates the complexity in evaluating foundation condition as well as multitude of site variables—such as differing soil/rock material, level saturation and existence of scour countermeasures—that needs to be considered in a typical field investigation.



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Figure 1. Diagram. Typical foundation conditions (Olson et al., 1998).

The target of the field investigation for foundation characterization is dependent on the application. The base of the foundation elevation and the foundation type are considered to be the two most critical items for scour evaluation. For foundation reuse application, evaluation of foundation integrity; understanding nominal resistance and load-deflection criteria for all design loads; and quantifying reliability and establishing acceptable risk thresholds for bridges are critical.

Program Outcomes

The outcome of this research program will be improved characterization of existing bridge foundations through evaluation and development of technologies and guidance documents in order to assist bridge owners with more accurate data in assessing condition, load capacity, and decision making to ultimately improve bridge safety and reliability.

Program Outreach

In order to initiate the research program, initially a multi-disciplinary task force was created by FHWA and met on January 16, 2013 during the Transportation Research Board (TRB) 92nd annual meeting. The 14 member task force of FHWA and state department of transportation (DOT) stakeholders were selected based on their recognized expertise in the areas of unknown foundation and foundation assessment issues. During this meeting, members of this task force brainstormed on steps needed to move forward with a multi-year 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 foundation” to “foundation characterization” to include bridge foundations over land as well as waterways and incorporate multi-hazard issues, 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) (Schaefer and Jalinoos, 2013). The workshop initially discussed the issue of unknown foundations as it relates to hydraulic vulnerability for bridge scour. To determine the susceptibility of a bridge to scour, information on the foundation type and depth is needed. The participants next discussed the impact of multiple hazards on unknown foundations including other extreme events (seismic, post-event inspection, ship impact, etc.) as well as the issue of load testing of bridges with the unknown foundations. Finally, the participants focused on the foundation reuse issue which impacts all bridge foundations.

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.

The Workshop provided a platform to discuss pertinent issues as it relates to foundation characterization with key players, both at the State and Federal level. In support of the FHWA workshop recommendations, a workshop and a separate session on the reuse of bridge foundations were held at the 2014 TRB 93rd annual meeting. The result of the discussions of TRB 2014 has been recently published in a FHWA TechBrief report (Collin and Jalinoos, 2013).

The workshop presentations and panel discussions highlighted different aspects of the reuse of bridge foundations. Workshop presenters discussed project case histories involving the reuse of existing bridge foundations. Many workshop participants believed that it is important to develop guidelines on standard of practice for foundation condition evaluation and for mitigating the risks involved.

For the upcoming TRB 2015 meeting, two additional sessions on Foundation reuse are planned. This activity has been co-sponsored by 5 main TRB geotechnical committees.

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