Project Summary
Texas Department of Transportation

# 0-6604: Unknown Foundation Determination for Scour

## Background

There are approximately 60,000 bridges across the United States identified as having unknown foundations as of 2005. Most of the bridges were built between 1950 and 1980, which coincides with the construction of the Interstate Highway System. Texas alone has over 9,000 bridges with unknown foundations. 85 percent are over local roads. These bridges, often categorized as “off-system” bridges, were typically designed and constructed by local government entities such as counties or private companies. The missing substructure information associated with unknown foundations has made the safety monitoring of bridges very difficult, especially the scour critical bridges.

The Federal Highway Administration (FHWA) has required all states to eliminate their unknown foundations from the National Bridge Inventory (NBI). Specifically, this means updating Item 113 – Scour Critical Bridges that are coded as “U,” bridges with unknown foundations that have not been evaluated for scour. The methods developed in this project are intended to be new mediums through which the Texas Department of Transportation (TxDOT) can determine the substructure characteristics for unknown bridge foundations to accommodate the scour evaluation for these bridges.

## What the Researchers Did

The approach to solve this problem has two components: an evidence-based approach and an experiment-based approach. The evidence-based approach includes deterministic and probabilistic predictions about unknown foundations. These predictions are based on a case study defined by river-crossing bridges in the TxDOT Bryan District. The working database includes 185 bridges with known foundations, which helps to train both the deterministic and the probabilistic models. The aim is to make predictions about the foundation’s type, geometry and about the soil conditions (substructure), based on characteristics of the superstructure. The deterministic predictions are generated by the use of Artificial Neural Networks (ANN), while the probabilistic predictions are generated by the use of Bayesian probability.

The proposed experiment-based methodology consists of electrical resistivity imaging and induced polarization imaging. Through laboratory and field experiments, both of these methods aim to identify the depth of bridge foundations.


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Deterministic forward modeling of bridge foundations is used for resistivity and induced polarization surveys. Simplified field testing of known foundations at the National Geotechnical Testing Site is completed using resistivity and induced polarization surveys. Full scale testing of bridge foundations in the TxDOT Bryan District is done using resistivity and induced polarization surveys.

## What They Found

The deterministic approach helps to determine the type of the foundation, to classify it (i.e., deep or shallow), and to predict its depth. The ANN model approximates the pile embedment depth based on the bridge load, soil properties, location, and year built. The probabilistic approach also selects the appropriate ANN model based on the foundation type and soil boring data availability in order to make a prediction on the bearing capacity of the foundation.

Electrical resistivity imaging provides a fast and efficient geophysical method for determining whether a foundation is embedded to 5 m (16.40 ft) depth or greater. The method can be deployed in moderate to heavily vegetated, water-covered environments using underwater electrodes, such as those specially designed for this project. While 3D resistivity imaging can be done, it is not recommended for routine bridge foundations. Similarly, induced polarization imaging can be used in moderate to heavily vegetated environments. Induced polarization provides the depth of foundations when the depth of penetration is deeper than the foundation and provides a minimum depth of foundations when the depth of penetration is shallower than the foundation.

## What This Means

Results of the evidence-based approach show that the deterministic predictions are able to accurately predict the embedment depth of deep foundations. The probabilistic predictions populated posterior probability distributions for the foundation's type, dimensions, and for soil properties.

2D resistivity imaging can be used for determining whether a foundation is embedded 5 m (16.40 ft) or greater; however, the quality of the data will be dependent on unidentifiable soil and foundation conditions. Similarly, 2D induced polarization provides a minimum depth of foundations.

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