

CHAPTER 1

INTRODUCTION

Bridges play a key role in the national transportation system, and the ability to assess their present condition is vital for safe transportation operations. Some of the bridges that comprise the system traverse waterways, where bridge failures most commonly occur due to scour damage. When scour occurs at a bridge pier supported by deep foundations, the temporary removal of soil increases the bending moments in the upper portion of the deep foundation and can result in damage. This damage is not easily detected. Furthermore, there are many older bridges in the United States where no plans of the foundation system exist. It would be quite beneficial to have a method which can detect and evaluate the structural conditions beneath bridge piers. One promising approach is non-destructive testing.

Several methods currently exist for the evaluation of deep concrete foundations by non-destructive methods. These include two methods of testing where access is only necessary at the surface of the foundation. The other two methods require that access tubes be placed within or adjacent to the structures under evaluation.

The surface methods are the sonic echo (also called echo, seismic, sonic, or TNO) method and the impulse response (also called impedance, shock, mobility, or transient dynamic response) method. Both involve impacting the shaft head and "listening" for reflections with an electronic recording device.

The two tests requiring access tubes are called direct transmission methods. These tests are the parallel seismic method and the sonic logging (also called sonic coring) method. The parallel seismic method involves impacting the structure and "listening" for the first arrival of the impact waves by means of a recording device lowered down an access shaft adjacent to the structure. The sonic logging method involves sending ultrasonic signals across the structure from a transmitter in one access tube to a receiver in another access tube to build up a profile of the structure. The next chapter provides more detail about these methods including some of the underlying theory and gives some examples of situations in which they have been successfully used.

Of the methods for evaluating deep foundations, only the parallel seismic method is currently used in evaluating foundations covered by a superstructure. The sonic logging method is generally employed when access tubes are pre-placed in the shafts during construction. It can also be utilized for testing inaccessible foundations, but two access holes must be drilled through the shaft in contrast to the one needed adjacent to the shaft for the parallel seismic method. The sonic echo and impulse response tests have been successfully used for testing piles or piers that have free access to the head of the shaft, and have occasionally been successful through limited superstructure such as slabs.

For multiple span bridges that traverse waterways, piers transmit the loads of the superstructure to the foundation or to a foundation substructure, typically piles. To evaluate the condition of the foundation substructure, access is typically limited to the bridge pier. Matters are further complicated by the presence of the superstructure that lies on top of the piers. What then is an effective method for evaluating the foundation

structure of a bridge? It is the focus of this research to determine the feasibility of the impulse response method to address this problem.

Chapter 2 presents a literature review which evaluates the parallel seismic, sonic logging, sonic echo and impulse response methods. Chapter 3 provides a more detailed analysis of the testing equipment used for the impulse response method. Field testing was conducted in the course of this work to evaluate how impulse response results are affected when shaft heads are inaccessible. This test is typically used to determine shaft integrity for free-head shafts. Chapter 4 describes the results of the testing program. Additionally, it includes comparisons between responses computed by a shaft response simulation program and the observed test results. Finally, Chapter 5 summarizes the work and presents its conclusions.