CHAPTER 5

SUMMARY AND CONCLUSIONS

Four non-destructive foundation integrity tests which are based on the propagation of stress waves through concrete medium have been described. These tests included sonic echo, impulse response, parallel seismic and sonic logging. All the tests are limited to some degree in their application.

The parallel seismic method relies on measuring the first arrival of stress waves generated at the surface of the structure with a transducer lowered down a core hole placed adjacent to the structure under evaluation. The main limitation of this method is the cost of installing the core hole. The sonic logging method involves measuring the propagation time of ultrasonic signals between vertical tubes cast into a shaft during construction. The main limitation, as with the parallel seismic method, is the cost of installing the access tubes.

The sonic echo and impulse response methods rely on measuring reflections of stress waves generated at the surface of the structure that reflect off anomalies. The main limitation of these two methods is the signal attenuation which inevitably occurs, especially in structures founded in very stiff soils. The impulse response method was described and evaluated in much greater detail than the other three methods. The testing equipment and software used to perform the test and process the data were presented.

The impulse response method is typically used for evaluating drilled shafts in a free-head condition, and is a particularly useful tool to evaluate the integrity of a newly-placed concrete shafts. To further advance the applicability of the method, a field study was undertaken to evaluate the effectiveness of the impulse response method for testing drilled shafts with inaccessible heads. All the shafts in the field study were covered by concrete grade beams of various sizes and configurations. The field results were compared with simulated results and the following conclusions were made:

1) The toe could be identified for free-headed shafts with (L/D) ratios from 10 to 16.

2) The toe could be identified for inaccessible-head shafts with one grade beam leg, connected to the shaft head, for L/D ratios from 11 to 19 and B/D ratios from 0.9 to 2.3.

3) The toe could be identified for inaccessible-head shafts with two grade beam legs, attached to the shaft head at the same elevation, for L/D ratios from 8 to 16 and B/D ratios from 0.5 to 1.

4) The toe could be identified for inaccessible-head shafts with two or three stacked grade beams legs, attached to the shaft head, for L/D ratios from 14 to 15 and B/D ratios from 2.6 to 2.7, where the top grade beam was not surrounded by soil.

5) The toe could be identified for an inaccessible-head shaft with three grade beam legs, attached to the shaft head at the same elevation, for an L/D ratio of 10 and B/D ratio of 0.6.

6) The more rigidly a shaft head is held, the greater the signal attenuation. Larger grade beams and multiple grade beams attached to the same shaft head increased the attenuation of the shaft response.

7) The ability to measure shaft lengths in the inaccessible-head condition was possible given that signal attenuation was not excessive due to a combination of a very rigidly held shaft head and a small diameter shaft.

8) The dynamic stiffness measurement, commonly used to compare similar size free-head shafts, becomes very unreliable for inaccessible head shafts covered by grade beams.

Future work in developing the impulse response method should focus on several areas. First, further investigation should be made into the cause of the signal rise that was occurring to many of the responses and a determination made as to whether this really is due to geophone housing resonance. If geophone resonance is the problem, improvements to the geophone/concrete coupling need to be further investigated to obtain a more rigid connection. The simulation program should be modified to handle non-axisymmetric conditions such as the prismatic shapes of the grade beams or a bridge pier. The effect of wave travel paths other than down the shaft should also be investigated. Finally, analyzing the ability of the impulse response method to detect shaft defects would provide beneficial uses, especially for forensic investigations.

The results of this work shows promise for solving the problem of unknown foundation types. Further investigations should be made to determine if the impulse response method is a viable approach for identifying whether or not deep foundations exist below a footing for a bridge pier.