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EFFECTS OF VIBRATION AND SOUND DURING THE INSTALLATION OF DEEP FOUNDATIONS

PROBLEM STATEMENT

The construction of drilled shafts using the casing method often induces ground vibrations with varying intensities, in addition to the noise generated by the pile driving. The casing method of construction is very common in Florida, especially for deep foundations in waterways. The casing method in drilled shaft construction may be used on a temporary or permanent basis. Specifications of the Florida Department of Transportation (FDOT) require that all drilled shaft casings be removed except for those intended to be permanently placed in the boreholes ***(FDOT Specifications 455-15.4 and 455-15.5)***. If the permanent casing method is specified for certain site conditions, then the deeper shafts have to be constructed to compensate for the reduced skin friction due to the presence of the casings. In any case, vibrations are induced during the processes of driving the casings and of extracting them, in addition to other construction related vibrations.

Current specifications provide regulatory procedures for the protection of existing structures from the drilled shaft construction induced vibrations. Under article ***455-1.1,*** structures within a distance of ten shaft diameters or the estimated shaft depth, whichever is greater, should be monitored for settlement and the possible development of structural cracking. Existing footings within a distance of three times the depth of the excavation should also be monitored. Vibration monitoring equipment should be capable of detecting velocities of *2.5* mm/sec (0.1 in./sec) or less. It is mandatory that the source of vibrations cease immediately when structural settlement reaches 1.5 mm (0.06 in.), vibration levels reach 13 mm/sec (0.5 in./sec), or damage to existing structures occurs.

However, current specifications do not provide acceptable levels of construction induced vibrations for drilled shafts with freshly placed concrete. A waiting period of about 12 to 24 hours may be required before construction proceeds although FDOT specifications do not necessitate such a time span for every project. Delay periods are usually set by the project engineers at the sites. The rationale behind these restrictions is to allow additional curing time for freshly placed concrete to avoid any possibility of change in its physical or mechanical properties.

Despite the fact that uncontrolled vibrations are usually not allowed during concrete placement, such restrictions have been considered by contractors as subjective and unsubstantiated.

OBJECTIVES

This project was divided into two parts: (1) the primary objective was to study the effects of vibration on green concrete (freshly placed and maturing, within twenty-four hours of initial placement), and (2) a secondary objective was to study the effects of and means for mitigating noise generated during the installation of piles.

FINDINGS AND CONCLUSIONS

Part 1 of the research consisted of laboratory testing, field testing, and data analysis. The laboratory investigation addressed the determination of the damage threshold particle velocity by shake table vibration testing concrete cylinders at predetermined time delays (0,1,2,3,4, and 24 hours), ultrasonic testing for compression moduli before compressive strength testing, and testing cored cylinders from full-scale drilled shafts. The principal finding from laboratory testing was that construction vibrations that produce particle velocities of less than 8 in./sec would not have any effect on the compressive strength or compression modulus of the concrete aged between the time of placement through the first 24 hours.

In the field investigation, the peak particle velocities were monitored during the drilling of the shaft to determine their effect on "green concrete." The principal findings from the field study were: (1) vibrations with peak particle velocities of up to 2.5 in./sec do not cause damage to the "green concrete" at a distance of two times the shaft diameter and beyond, and (2) in general, a spacing of three times the shaft diameter is a safe specification for ensuring that shaft vibration does not damage the concrete.

Part 2 of the research consisted of tests conducted in a laboratory chamber, using an acoustic curtain. The tests indicated noise level reductions of more than 16dB, identifying the strong need for field testing. In the field, the propagation of noise generated from driving concrete piles was measured and the effect of mitigation through the use of an acoustic curtain was evaluated. The acoustic curtain was constructed of a combination of absorptive and reflective materials to provide a complete enclosure of the source. A full-scale experiment was conducted by evaluating noise levels generated from the installation of concrete piles, with and without the aid of the acoustic curtain--a reinforced polyvinyl chloride outer shell for added mass, with a specially developed inner lining of 2 inch thick fiberglass acoustic insulation (1.5 lb/ft). The results indicated that noise levels were reduced by up to 10dB by using the curtain to enclose the diesel hammer.

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