LARGE DROP HAMMER TESTING OF DRIVEN PILES IN DELAWARE

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ABSTRACT

Dynamic load testing requires enough impact energy to activate the specified test load or ultimate capacity. For driven piles, it is of course most economical and convenient to use the pile driving hammer to apply that impact load. However, frequently, a hammer that can safely and efficiently install a pile, may not be sufficient to generate the necessary dynamic load after the soil has set up. Thus, rather than restriking the driven pile with the installation hammer, large drop hammers apply test loads always more effectively and sometimes also more economically.

This paper presents a case study, describing tests with a 20-ton drop hammer on 508 mm square prestressed concrete piles for capacities up to almost 6000 kN. The paper describes details of test site, its soil properties and the soil setup behavior. General conclusions include recommendations for drop hammer sizes for restrike testing.

Keywords: Driven Piles, Bearing Capacity, Load Testing; Drop Hammer

1. INTRODUCTION

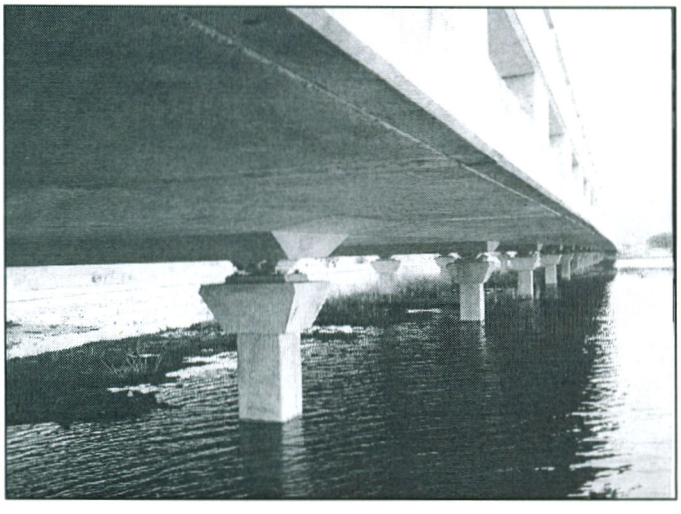

Figure 1. The Elevated Fenwick Island Highway

The SR-54 highway project in Fenwick Island, Delaware is an 820 m long stretch of elevated highway consisting of 2 precast segmental bridges spanning 487 m and 236 m, which was designed to allow for a safe escape route during flooding caused by major hurricanes or high ocean tides. The design of this bridge generally only required two driven piles as a support for each pier. Figure 1 shows the completed structure; two precisely driven concrete piles extend above the ground surface acting as columns to support each pier for the 12 m long spans. Lateral forces were carried by battered piles supporting the abutments and fixed piers located in the middle of each structure. Because of the lack of redundancy of this foundation system, validation of the ultimate capacity of a relatively large number of these piles was necessary.

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For economic reasons, static load tests can only be performed for a limited number of piles and do not lend themselves for routine testing of production piles. Dynamic load testing is therefore a logical alternative. However, as is common on most pile driving sites, the installation hammer often has insufficient energy to activate the full pile capacity. Another, higher energy hammer is therefore needed to perform a meaningful test.

Two pile sizes were installed at the SR-54 site: A smaller 350-mm square concrete pile, tested with the installation hammer achieved the required ultimate capacity of 2220 kN during restrike testing by the installation hammer. However, the larger 508-mm square concrete piles were designed for an ultimate capacity of 4300 kN. Using the installation hammer dynamic load testing typically mobilized not much more than 3200 kN. Another dynamic loading system was therefore needed to proof test this pile.

Because the installation hammer lacked the energy to fully activate the required capacity of the 508-mm pile, a 180-kN drop hammer referred to as APPLE-II (Advanced Pile Proof Loader/ Evaluator) was mobilized to the site. This system provided impacts by the 180 kN ram with drop heights adjustable in 0.1 m increments to a maximum of 2 m. The ram of this drop hammer consists of three segments. The guide-frame is 2.25 m square in plan and 7.3 m high (Figure 2).

2. DYNAMIC LOADING CONSIDERATIONS

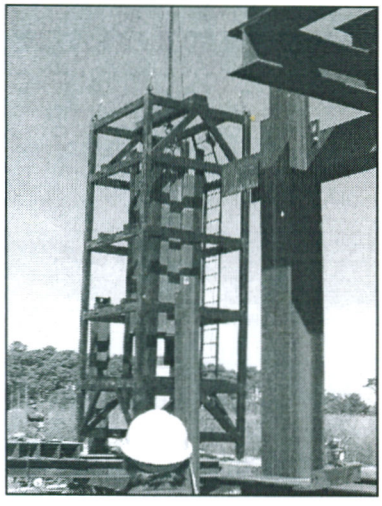

Figure 2. Apple-II Drop Hammer

At the Fenwick Island site, only proof tests were required. In fact, since it would have been very difficult and costly to replace a damaged pile, testing to ultimate capacity, which could have exceeded the structural strength of the piles, was not desired. Thus, if the dynamic load test capacity exceeded 4300 kN, the test would be considered successful. On the other hand if pile sets per impact would exceed 10 mm at calculated capacities less than 4300 kN, then the pile would have failed.

For piles with both friction and end bearing in a granular soil, a rule of thumb is that the ram should at least weigh 2% of the required capacity. This means that, in the present case, an 86 kN ram would have been satisfactory. However, it is even more desirable to work with a somewhat heavier weight and reduced drop heights, which provides an extra margin for higher test load activation at safe stress levels. Since the APPLE-II was available and no cost advantage existed for using a smaller drop weight, its relatively heavy, 180 kN ram was chosen for the job. The installation hammer only utilized a 40 kN ram.

Instead of using the rule of thumb for estimating an optimal combination of drop weight, drop height and cushion properties, a wave equation analysis can be performed. The process of rationally designing a dynamic load testing system has been described by Hussein et al. (1992) for the dynamic load testing of drilled shafts.

3. USE OF THE APPLE AND PDA SYSTEM

The advantage of the APPLE system over a basic drop hammer is its guide-frame which not only aligns the hammer and pile but also allows for supporting the drop weight prior to releasing it so that crane