# GRL + PDI

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Information gathered by the engineers of
Goble Rausche Likins and Associates, Inc. and *Pile Dynamics, Inc.*

## "CLASS A" CAPACITY PREDICTIONS
by George Goble

In our May 1999 Newsletter No. 34 (posted on our website or available in hard copy), we discussed potential problems associated with performing and evaluating pile load tests. This time we will present a Class A Prediction case (a capacity prediction without prior knowledge of the load test).

On October 10, 1999, a field demonstration of pile driving for fifty Denver area engineers was performed in the yard of Lawrence Construction Company in Denver, CO to promote driven piles. Two anchor piles were driven to refusal prior to the demonstration. On the demonstration day, the test pile was to be driven with Pile Driving Analyzer® (PDA) testing. After completing the test pile installation, a static load test was to be quickly assembled and performed. This plan would give a capacity correlation between the PDA test and the static load test.

*As we enter a new era ...*

*Dear Clients and Readers,*
*We thank you for your holiday wishes and another year of fruitful cooperation. May the coming year bring us all peace, health and success.*

The pile was a 40 ft (12.2 m) 12HP53 section of A-36 steel. A soil investigation revealed interbedded weathered claystone-sandstone (N > 100) overlain by about 30 feet of silty sand (N = 12). This soil profile is common in the Denver area.

The pile was driven a few feet into the bedrock with a Linkbelt 520 double acting diesel hammer (energy rating 26.3 kip-ft or 35.7 kJ). A wave equation analysis prior to the test suggested that, at a blow count of 10 blows per inch (400 blows/m), the pile capacity would be 200 tons (1,780 kN) and the maximum driving stress 27 ksi (185 MPa), well below a maximum acceptable value of 90 percent of the pile yield stress. Note the Engineering News formula (ENR) yields an ultimate capacity of 263 tons (2340 kN) assuming a factor of safety of 2.

The pile was driven to a blow count of 10 blows per inch and PDA dynamic measurements were made during the entire driving process. End of Drive Case Method capacity was 140 tons based on an assumed damping of J = 0.8 (selected by GRL Colorado's Jay Berger based on his experience with similar soils). The maximum compression stress measured at the pile top was 23 ksi (160 MPa). A CAPWAP analysis, performed immediately following pile installation, indicated 130 tons (1160 kN) capacity. All results from GRLWEAP, Case Method, and CAPWAP were presented to the entire audience during lunch, while the static load test was assembled. These results appear on Table 1.

The pile was statically tested after a two hour wait. Time pressure was great to avoid holding the attendees any longer than absolutely necessary. GRL engineers attached the displacement measuring system, consisting of two dial gages. A load cell was not available so load was measured only by reading the jack pressure. To reduce the time to perform the static test, a modified quick test procedure was chosen. First a load of 40 tons was applied, then 20 tons were added, followed by additional 10-ton increments to failure, all at five minute time intervals. The results of the static test are shown in the figure 1 below with the CAPWAP predicted static load test curve.

**Table 1**

| | |
|---|---|
| ENR | 263 tons; 2340 kN |
| Standard GRLWEAP | 200 tons; 1780 kN |
| Case Method, end of drive | 140 tons; 1250 kN |
| CAPWAP | 130 tons; 1160 kN |
| Static test | 142 tons; 1260 kN |

The differences between CAPWAP predicted and measured static load test curves are due to a combination of effects. The CAPWAP result assumed the full pile length. In reality about 2 m (6 ft) were cut off prior to the static test thus making the pile stiffer. The CAPWAP set should thus be about 15% lower than shown. On the other hand, the rapid static loading procedure and the skipping of some of the lower load increments caused the static test to be stiffer than it would otherwise have been. A slower application of loading would produce additional displacement for the same applied load. In practice, the CAPWAP pile stiffness model is often more accurate than any measurement can be due to the difficulty of making the reference for the displacement readings independent of the loading setup. The PDA and CAPWAP ultimate load predictions compared very favorably to the static test failure load considering the load uncertainty in the static test due to lack of a load cell.

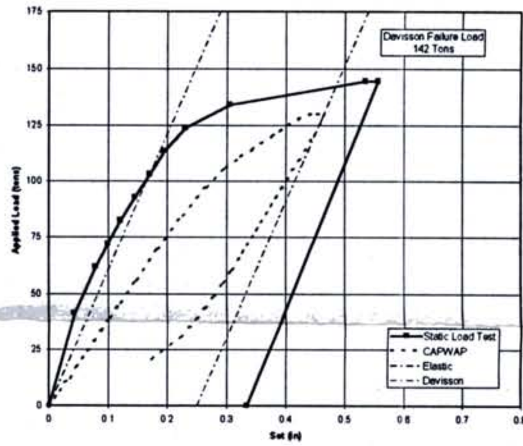


Figure 1

In summary, GRLWEAP over-predicted the pile capacity, primarily because of a low actual hammer performance. The Class A Predictions of Case Method and CAPWAP were 2 and 9% lower than the static test capacity, respectively. However, the static load was measured by hydraulic pressure which often indicates slightly higher loads because of jack friction. Differences between dynamically predicted and statically measured sets were at most 0.16 inches (4 mm).

CAPWAP capacity and soil stiffness also may have been low compared to the static test because of soil setup during the two hour load test preparation. In normal practice some time would be allowed between installation and testing such that soil strength gains (setup) or losses (relaxation) could be more accurately assessed by the dynamic testing.