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Dynamic APPLE Load Testing Over Water

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Approximately 6 years ago, GRL began to design and build a series of dynamic loading systems – called APPLES – for testing the capacity of drilled shafts. Since then APPLE systems have mobilized ultimate test loads of up to 22 MN (2500 tons), utilizing drop heights of up to approximately 2.7 meters (9 ft).

APPLE systems are modular and use ram weights ranging from 7 to 20 tons. The rams are guided by a square lead with a 2.3 m footprint and a height of 6 meters. A hydraulic mechanism allows the ram load to be transferred from the crane to the leads prior to free-releasing the ram, effectively eliminating crane whip.

The APPLE was recently used over water for the first time, in cooperation with Mr. John Bennett of Toledo Caisson. GRL used an APPLE system with a 180 kN (20 ton) ram to test two drilled shafts for a bridge expansion of State Route 2 over the Sandusky Bay in Ohio. The loading system was transported on a barge and

assembled on location. The test shafts were caissons with 2 m (78 in) outside diameter, a 1.8 m (72 inch) diameter rock socket and included a permanent steel casing seated into the top of bedrock. The two caissons tested had lengths of 15.5 and 19.5 m (51 and 64 ft), including socket lengths of 1.8 and 4.9 m (6 and 16 ft), respectively. The required ultimate capacity of the caissons was almost 9 MN (1000 tons). The soil consisted of medium stiff to very stiff silty clay overlying dense gravel and sand. The underlying bedrock formation was hard dolomite.

Dynamic testing normally requires mounting strain and acceleration sensors to the side of the shafts approximately one diameter below their top. In the present case this location was below water level. A 3.2 m (126 inch) diameter steel pipe was installed around the test shafts with a vibratory hammer to provide working space. The water in the space between shaft and pipe was then pumped out to expose the test shaft perimeter. The loading system was supported by H-beams welded to the side of the shaft at the 90 degree points (see Figure 1). For safety, the legs of the APPLE lead were welded to the H support beams.

GRL applied drop heights ranging from 0.3 to 1.2 m (1 to 4 ft) for the load testing. Results from CAPWAP[®] analyses performed on data from the 1.2 m drop tests indicated, respectively for the shorter and longer shafts, mobilized capacities of 18 and 20 MN (2250 tons) with zero permanent set. This exceeded the required ultimate capacity by more than a factor of two. Throughout the testing, impact induced compressive and tension stresses and pile integrity were monitored, to assure a successful test.



Figure 1 (left):
APPLE on
Sandusky shaft
(photo by Anna Klesney)



Figure 2 (right):
APPLE IV ram assembly

The Sandusky test is one of the latest of many APPLE testing projects GRL has performed throughout the United States. GRL currently stations one APPLE system in California and the others in Ohio, trucking them to job sites as needed; plans are to base multiple APPLE systems throughout the US to reduce mobilization costs.

The newest addition to the APPLE family of load testing systems is a 360 kN (40 ton) modular system, the APPLE IV, shown in Figure 2. The APPLE IV tests loads up to 36 MN (4000 tons) capacity thanks to the available energy of 900 kJ (640 kip-ft) with its maximum drop height of 2.5 m (8 ft). (The capacity actually mobilized depends primarily on the soil type. Wave equation analyses prior to testing provide for a check on the adequacy of the system.) APPLE loading systems are an economical solution to test the larger drilled shafts now in use by the deep foundation industry to very high loads.