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LOAD-MOVEMENT MEASUREMENTS AND FAILURE LOAD DETERMINATION

Load-Movement Measurements

A typical setup for an axial compression static load test is presented in Figure 1; and an axial tension static load test is illustrated in Figure 2. In a static load test, the load applied to the deep foundation element is measured with a load cell and a jack pressure gage. A spherical bearing plate is also incorporated in the loading system to minimize eccentric loading.

Figure 1. Compression Load Test Arrangement on a 48 Inch Diameter, Open End Pipe Pile.

Figure 2. Tension Load Test Arrangement on a 54 Inch Diameter, Open End Pipe Pile.

Steel plates of an appropriate size and thickness are also incorporated into the loading system to reduce load measurement errors associated with diameter changes in the loading system components. A photograph of a high capacity loading system is included in Figure 3. The high capacity loading system consists of two jacks, two load cells, two steel spherical bearing plates, and appropriately sized steel plates for load transfer.

Figure 3. High Capacity Loading System on 48 Inch Diameter, Open End Pipe Pile

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The movement of the deep foundation element during a static load test is measured using electronic dial gages, linear variable differential transformers (LVDTs), mechanical dial gages, string potentiometers, or a combination of these devices. For each load increment, these devices measure the pile head or shaft top movement at multiple locations around the foundation element relative to stationary reference beams.

A representative setup for measuring movement is presented in Figure 4. The pile movement monitoring instrumentation shown in the figure includes diametrically opposite mounted LVDTs (left) as the primary movement monitoring system, and diametrically opposite mounted mechanical dial gage for a backup system (right).

Below the movement measuring system, anchor block mounted vibrating wire strain gages can be seen. For non-composite section foundations, above grade external strain gages are used to independently check the applied load determined from the load cell and jack pressure gage readings. For composite section foundations, use of above grade external strain gages aid in determining the foundation's elastic modulus which is required for load-transfer determinations.

Figure 4. Pile Movement Monitoring Instrumentation Setup on 18 Inch Diameter, Closed End Pipe Pile.

Compression Load Test: Load-Movement Plot and Failure Load Interpretation

Pile head or shaft top movement is plotted against the applied load. A representative load-movement plot from an axial compression load test is presented in Figure 5. A number of methods have been proposed to define the "failure load" of a deep foundation element under axial compression loading. For driven piles, the Davisson criterion (1972) is often used to define the failure load for piles less than 24 inches in diameter or width. The Davisson criterion defines the failure load as the load at which the load-movement curve crosses an offset limit line determined by the pile's elastic deformation and its diameter.

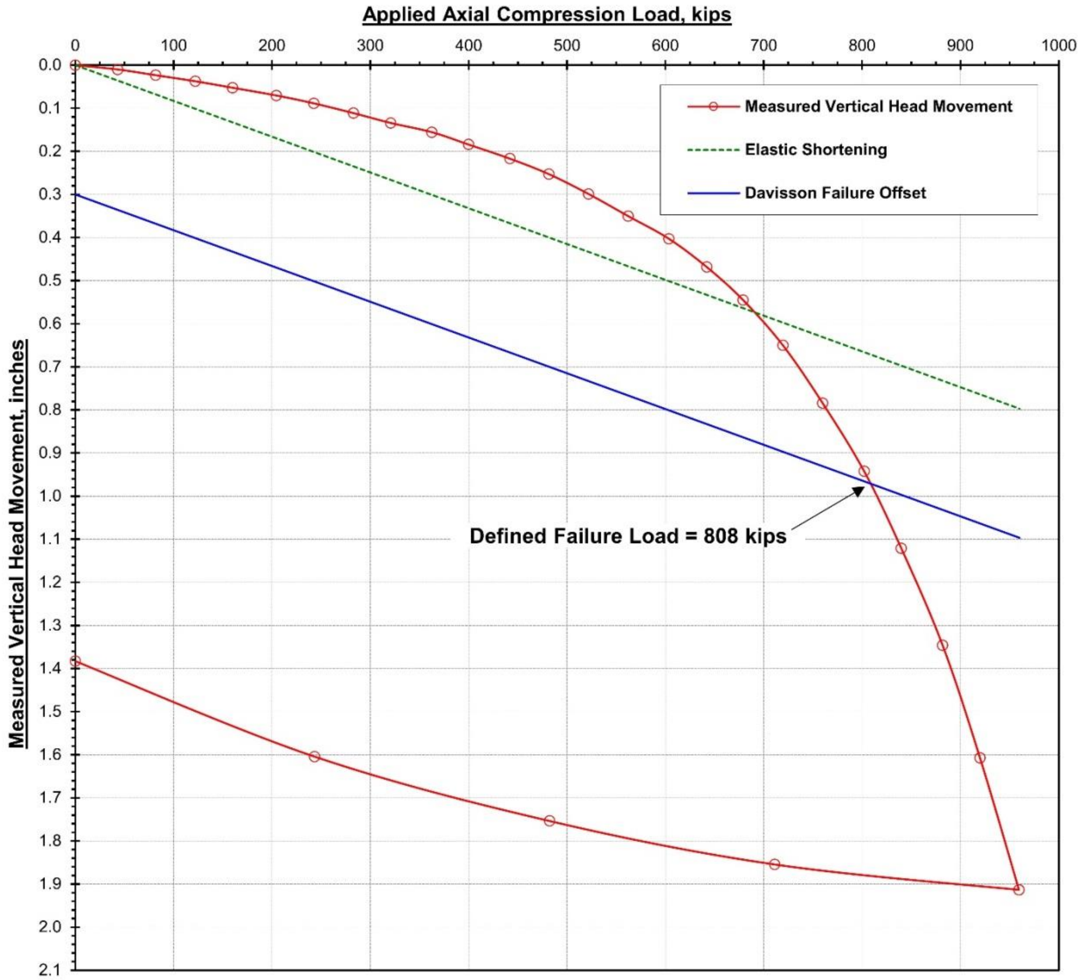

Figure 5. Typical Load-Movement Plot for an Axial Compression Load Test.

For driven piles greater than 36 inches in width or diameter, AASHTO (2014) design specifications recommend the offset limit line be defined as the elastic deformation plus the pile diameter, in inches, divided by the 30. For driven piles between 24 and 36 inches in width or diameter, AASHTO specifications recommend linear interpolation between these two criteria. AASHTO specifications state that the failure load for drilled shafts is generally defined as the load at which the gross shaft top settlement exceeds 5% of the shaft diameter, unless plunging failure occurs.

Tension Load Test: Load-Movement Plot and Failure Load Interpretation

A representative load-movement plot from an axial tension load test is presented in Figure 6. For driven piles, an offset limit line is typically used to define the failure load in a tension load test. The offset limit line criterion defines the tension failure load as the load at which the load-movement curve crosses an offset limit line determined by the piles elastic lengthening plus an offset of 0.15 inches. For drilled shafts, the tension failure load is often defined as the load at which the gross movement equals 5% of the diameter of the shaft, unless pullout failure occurs.

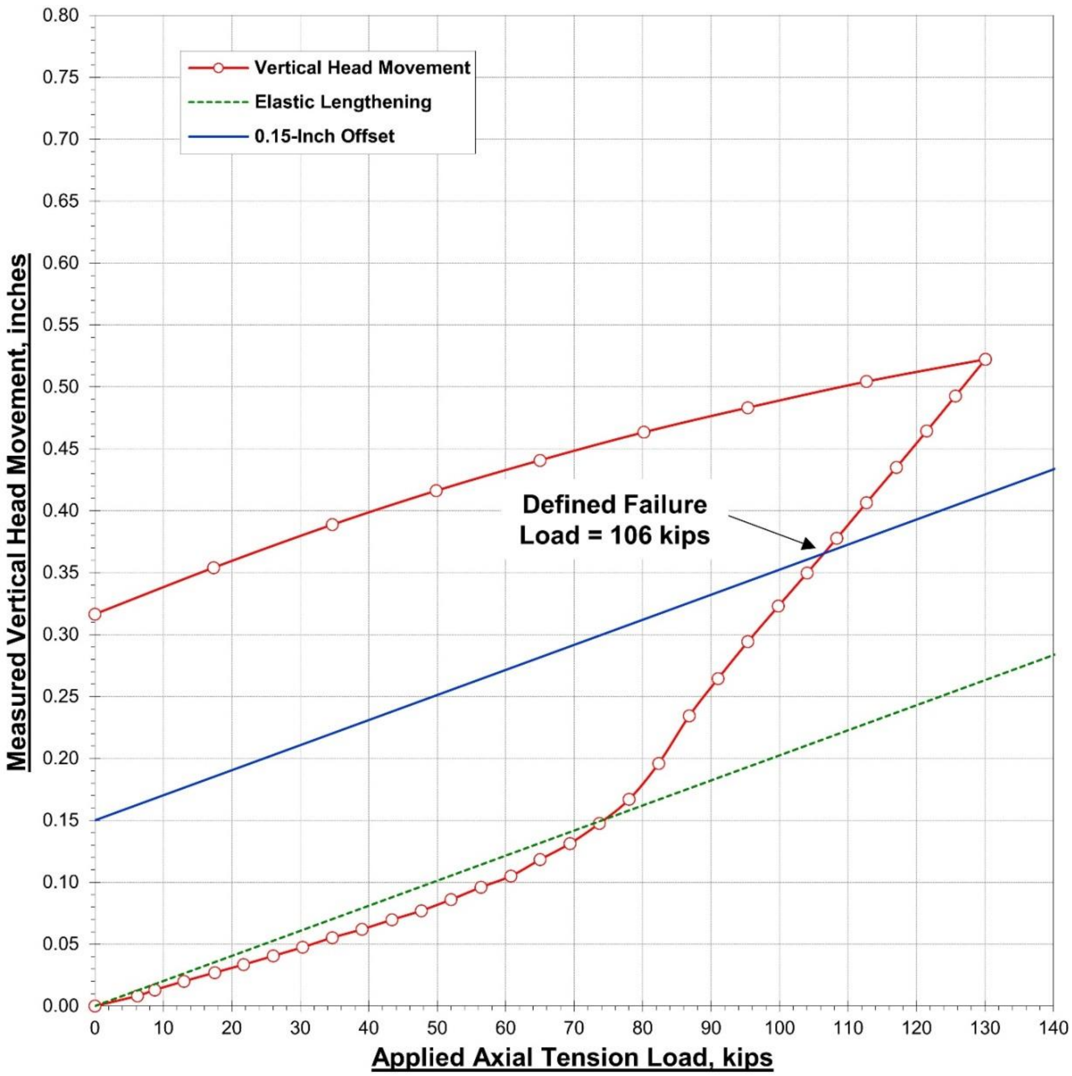

Figure 6. Typical Load-Movement Plot for an Axial Tension Load Test.

Lateral Load Test: Load-Movement Plot and Interpretation

Lateral static load tests can be configured to test two deep foundation elements at the same time (pushing the two elements away from each other, or pulling them toward each other), providing “two-for-one” economy of results. A representative lateral test load-deflection plot is presented in Figure 7. A failure load is generally not determined from a lateral static load test. Instead, load-movement behavior is characterized, from which loads that satisfy strength and serviceability limits are established. For lateral tests, GRL can characterize a range of load-movement behavior, including head deflection, head rotation, and full-length deflected shape. This information can be used to refine lateral soil response, thus improving the modelling of an in-service fixed-head group installation from the test results on a free-head single element.

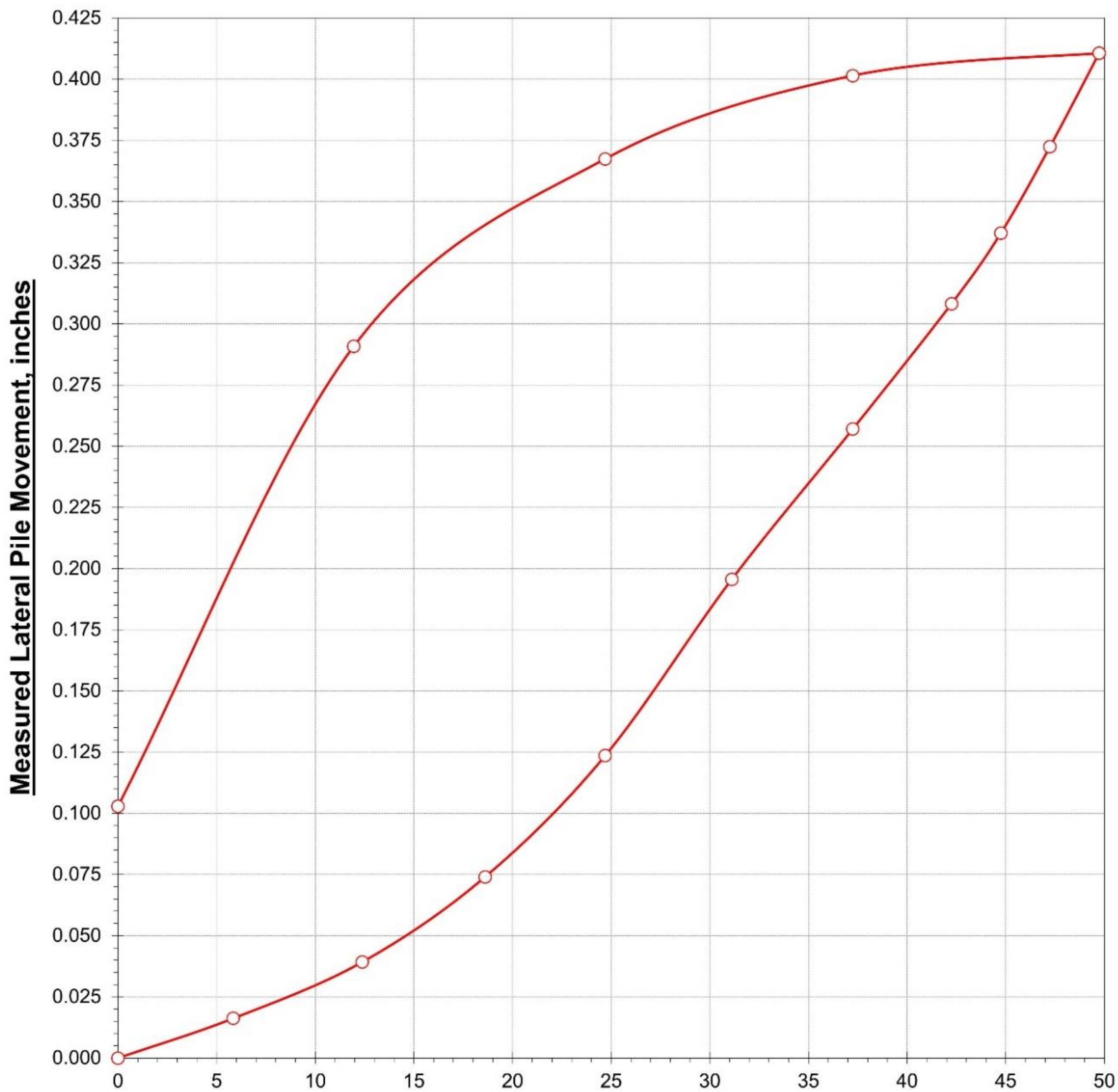

Figure 7. Typical Load-Movement Plot for a Lateral Load Test.

References

American Association of State Highway and Transportation Officials. (2014). AASHTO LRFD Bridge Design Specifications, Seventh Edition. American Association of State Highway and Transportation Officials, Washington, DC, 1960 p.

Davisson, M.T. (1972). High Capacity Piles, Proceedings, Soil Mechanics Lecture Series on Innovations in Foundation Construction. American Society of Civil Engineers, ASCE, Illinois Section, Chicago, pp 81-112.

