Dynamic Passive Pressure on Abutments and Pile Caps

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During this quarter a draft summary report on the work associated with Task 3 was completed and is attached as a pdf file with this report. This report summarizes the salient points of the study within about 30 pages so that the basic findings can be easily accessed. Some additional tests data from the tests using the UCLA shaker remain to be summarized to complete this work task.

In addition, a detailed draft final report for the work associated with Task 4 is also attached as a pdf document. The report points out that two of the connection details with shallow pile embedment (6 to 12 inch and reinforcing cage) were predicted to fail but were found to have much greater moment capacity than expected. Similar results have also been recently reported by Xiao (2006). As noted in the report, uplift of the test piles in the field prevented the development of the full moment capacity of the connections. As a result, we feel that some additional laboratory testing is necessary to further define the moment capacity provided by the reinforcing cage. We would appreciate the opportunity to discuss this matter with the technical advisory committee in the future.

After the completion of the full-scale load testing in the previous quarter, the focus of work this quarter has been on reducing the voluminous test data and preparing the desired plots of the test results. Plots being developed include: (1) Total force vs. deflection, (2) Passive force vs. deflection, (3) Pile cap rotation vs. Defection, (4) Passive pressure vs. depth curves from earth pressure cells, (5) Profiles of horizontal deflection within each backfill from string pots and shape arrays, (6) Contours of heave/settlement of the backfill from survey measurements, (7) Force distribution in MSE wall reinforcements from strain gauges, and (8) Deflection vs. depth profiles for piles from inclinometers and shape arrays.

As indicated in the work plan for Task 6, lateral load tests were performed on the pile cap (5.5 ft high x 11 ft wide) for one case where the sand backfill extended beyond the edge of the pile cap (see Fig. 1) and for another case where MSE walls were used to support the backfill on either (see Fig. 2). Analyses suggest that the “effective width” of the pile cap with sand beyond the edge would be increased to about 19.5 ft due to shear zones extending outward from the edge of the cap. Plots of the passive force vs. deflection curves for these two tests are provided in Fig. 3. The ultimate passive force with the MSE wall is about 75% of the ultimate passive force for the pile cap without the MSE wall. Based only on the “effective widths” of the pile caps (19.5 ft without the MSE wall and 11 ft with the MSE wall), the passive force of the pile cap with the MSE would only have been about 56% of the capacity of the cap without the wall. This preliminary result suggests that the confinement provided by the MSE wall is increasing the passive force provided by the pile cap beyond what would be expected based on the width of the pile cap alone.

The passive force-deflection curve in Fig. 3 also shows an offset in the curve of about 0.25 inch at a deflection of about 0.25 inch. At this point, significant lateral movement of the MSE walls was observed which likely contributed to this intermediate plateau in the passive force. The lateral movement of the MSE walls led to longitudinal cracking as illustrated in Fig. 4. Additional lateral movement of the MSE wall was observed throughout the test, but the rate of movement was not as severe. Additional analysis will be necessary to determine how these lateral movements are related to load development in the reinforcing grids. Some lateral movement may be necessary to fully mobilize the soil-reinforcing interface friction. Both pile caps developed their ultimate passive resistance with a horizontal deflection of about 3.5% of the pile cap height. This movement is consistent with previous test results (Rollins and Cole, 2006)

Another focus of the backfill testing program was an examination of the effect of a narrow gravel zone adjacent to a pile cap or abutment on the passive force. Fig. 5 provides plots of the total force vs. deflection curves for 3 tests. One curve is for a backfill consisting entirely of loose sand (90% of standard Proctor) while a second curve is for a backfill consisting entirely of dense road base gravel (97% of modified Proctor). The third curve is for a backfill consisting of a 3 ft zone of the dense gravel road base with loose sand behind the gravel. Placement of the 3 ft gravel zone dramatically increased the passive force relative to the loose sand. In addition, the narrow gravel zone provided more than 50% of the passive force provided when the entire backfill consisted of gravel. This result for the 5.5 ft high pile cap confirms the observations from previous testing with a 3.67 ft high pile cap and highlights the cost effectiveness of narrow gravel zones adjacent to pile caps and abutments when additional lateral resistance is desired.

Plans for the Next Quarter

During the next quarter we will continue the process of reducing data, plotting test results and making comparisons of the behavior of the various test geometries. During the previously quarter, work has primarily focused on the static load test results. In the next quarter we will begin processing the dynamic testing data to evaluate dynamic stiffness and damping values.

Budget Considerations

We estimate that approximate $154,000 will have been spent at the end of the quarter on work associated with Tasks 1-6. The total budget associated with all the project tasks is $265,395. Therefore, approximately 59% of the budget has been spent for these tasks. We estimate that approximately 66% of the work on the project has now been completed. Therefore, the project appears to be on track from a budget standpoint.

Fig. 1. Dense sand backfill extending about six feet beyond the edge of the pile cap on either side. Orange grid lines are 2 ft x 2 ft. Shear cracks are painted in blue and indicate an effective pile cap width of approximately 19.5 ft.

Fig 2. Dense sand backfill compacted between two MSE walls which are flush with the outside edge of the 11 ft wide pile cap and extend 24 feet behind the pile cap.

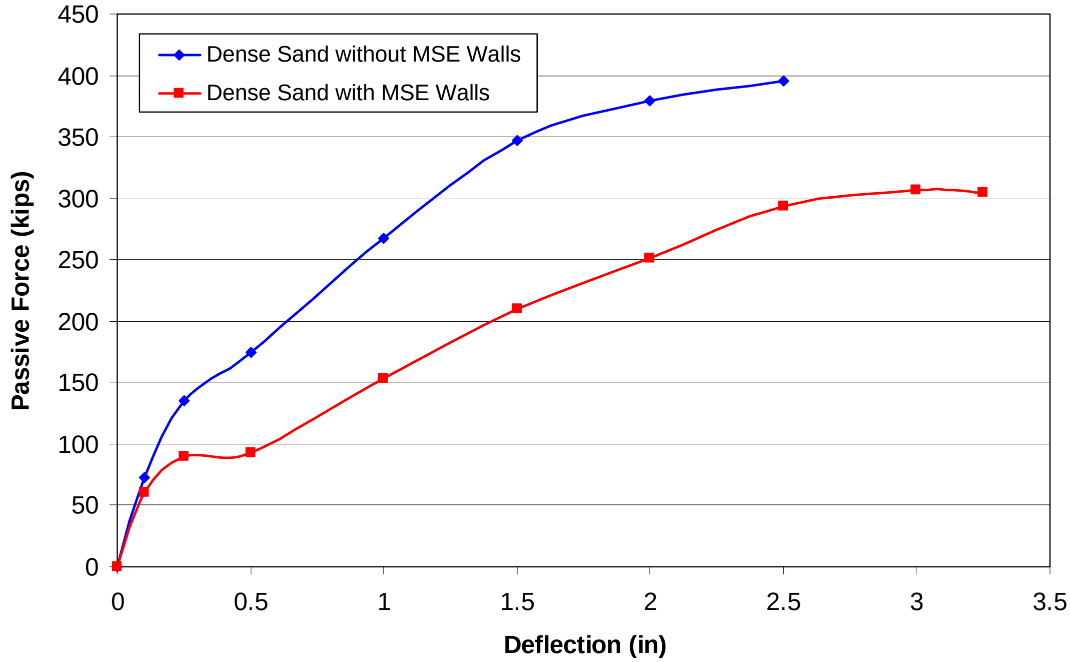

Fig. 3. Passive force vs. deflection curves for dense sand backfills with and without MSE side walls.

Fig. 4 Longitudinal cracking due to lateral displacement of the MSE wall during passive pressure testing.

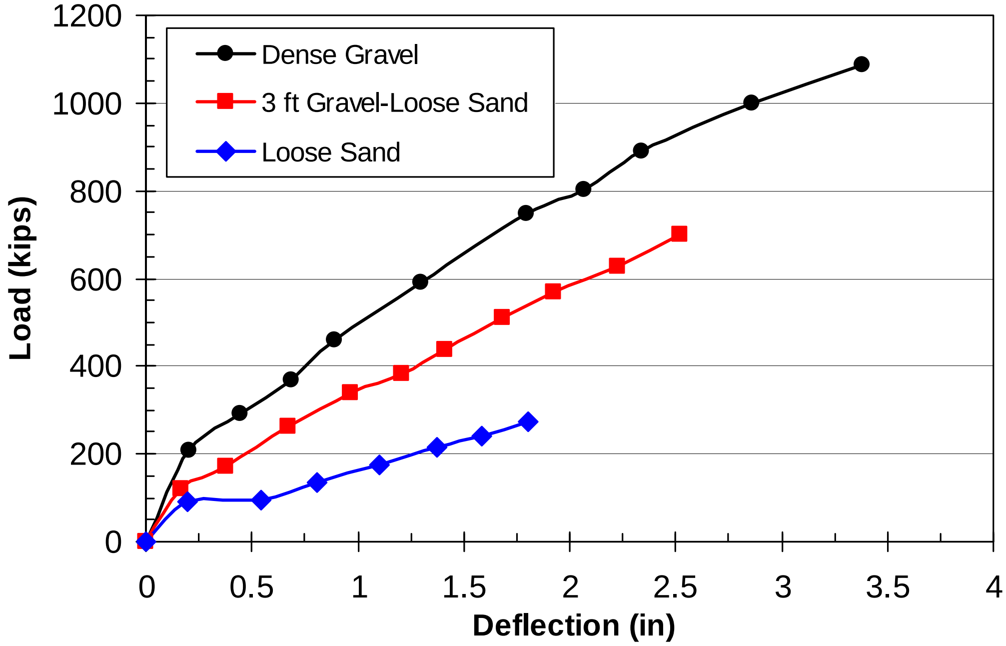

Fig. 5 Comparison of total force vs. deflection curves for pile cap with backfill consisting (a) entirely of loose sand (90% of std. Proctor), (b) entirely of dense road base gravel (97% of mod. Proctor), and (c) a 3 ft zone of dense gravel in front of loose sand.