Dynamic Passive Pressure on Abutments and Pile Caps

PI's Profs. Rollins and Gerber

Quarterly Report March 2008 - May 2008

Work Tasks

Task 1-Literature Review and Collection of Existing Test Data
Task 2-Notification to Residents of Testing
Task 3-Pile Cap Testing and Analysis for South Temple Site
Task 4-Pile Cap Testing and Analysis to Evaluate Connection Details
Task 5-Pile Cap Testing and Analysis for SLC Airport Site
Task 6-Pile Cap/MSE Wall Testing and Analysis for SLC Airport Site
Task 7-Preparation of Final Report

This quarterly report provides an overview of the progress on the work tasks associated with this study and the work completed this quarter. Finally, plans for the next quarter are discussed. The literature review described in Task 1 has typically been associated with each work task and is reported in the report on a given task. Notifications in Task 2 were performed during the testing program. The work associated with Task 3 has been essentially completed and a final report is in preparation. An interim summary report is attached to this quarterly report which provides the basic results of the static and dynamic tests involving narrow gravel backfill zone. Some additional information on site conditions must be added to the final report along with test result for the test involving homogeneous backfills only. (loose sand and dense sand only.)

Task 4 work is also complete and a revised final report is attached to this quarterly report. The report has been modified to indicate that the connection detail with the one foot pile embedment did not include the vertical pile cap steel that is typical of Oregon DOT practice. The pile cap steel was kept consistent throughout the various tests to isolate the effects of pile cap embedment and reinforcing connections. 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 completely define the moment capacity provided by the various connections.

We would appreciate the opportunity to discuss this matter with the technical advisory committee in the future.

Task 6 testing and analysis is complete and a final report is under preparation. An interim summary report is attached to this quarterly report. Some additional information regarding geotechnical site conditions will be added to the final report along with data analysis associated with strain measurement on the MSE reinforcing straps. Utah and California TAC members have suggested that additional testing involving skewed pile caps with MSE wingwalls would be desirable since the test set-up is still available and additional testing can be performed with a minimum cost. We also feel that one additional test on the pile cap with additional of conventional wingwalls would provide a very useful comparison with the test involving MSE wingwalls. We would appreciate the opportunity to discuss the potential for expanding the scope of the study with the technical advisory committee members in the future.

During this quarter, work has continued on processing the cyclic/dynamic test results associated with work task 5. Other work associated with this task has included 1) analysis of data from pressure plates on the pile cap face to determine the distribution of earth pressures within the backfill and 2) analysis of data from string potentiometers extending from the pile cap to points within the backfill in order to determine the distribution of compression strain within the backfill during loading.

The cyclic/dynamic response of the pile cap is being assessed by examining load-displacement loops from both cycling of the load actuator and operation of the eccentric mass shaker. Fig. 1 through Fig. 10 show results from cyclic loading by the actuator. These figures show the magnitude of the cyclic displacement (peak-to-peak amplitudes can be found by doubling the values shown) as well as the associated stiffness and damping. Generally, the hysteresis or equivalent viscous damping exhibited by these low frequency (~ 0.75 Hz) load-displacement loops is on the order of 15 to 30%.

The dynamic viscous damping associated with loadings from the eccentric mass shaker has been interpreted using the half-power bandwidth method. The damped natural period of the pile-cap-backfill system, as determined from peak dynamic displacement amplitudes normalized by shaker force, varied from 5.5 to 8 Hz, generally increasing with the stiffness of the backfill conditions. As shown in Fig. 11 through Fig. 18, the amount of damping for the pile cap-backfill system is relatively constant for all displacement levels and backfill conditions, being on the order of 40 to 45%.

Passive earth pressure distributions were developed from the pressure cell data for each of the backfill conditions. The resulting distributions are shown as a function of pile cap displacement level in Fig. 19 through Fig. 26. Some of the profiles, particularly those with the fine gravel backfill, exhibit significant variations from the equivalent fluid pressure distribution commonly assumed. These variations are believed to be attributable in part to effects of cohesion and, in the case of the partial-width gravel backfills, potential interactions between the two soil types. To help assess the accuracy of the distributions, the pressure distributions occurring at the end of each incremental push of the cap were converted to equivalent forces using the tributary area for each pressure cell. These forces were then compared to the passive force acting of the pile cap (calculated using the measured actuator loads minus the baseline response of the cap without any backfill pressure). A preliminary summary of these results is shown in Fig 27. In general, the pressure cell-based forces are 60% to 70% of the passive earth forces. A number of individuals have noted the difficulty of obtaining representative pressures from earth pressure cells under all load conditions. Systemic differences may be attributable in part to differing pressure conditions outside the spatial coverage provided by the pressure cells. Also affecting the contact pressure on the pile cap face is the soil resistance acting in three dimensions and the relative rigidity of the pile cap.

String potentiometers extending horizontally from the face of the pile cap to points on the backfill surface were used in order to evaluate the distribution of compression strain within the backfill during loading. Fig. 28 and Fig. 29 illustrate results from the dense clean sand backfill condition. It can be observed that the backfill located more than 18 feet away from the pile cap is affected by the moving pile cap. In Fig. 29, average compressive strains are shown for discrete increments of distance away from the pile cap face, and it can be seen that those strains are highest within the 2 feet closest to the cap, and then very rapidly become uniform at greater distances. The amount of strain increases for all distances monitored as pile cap displacement increases.

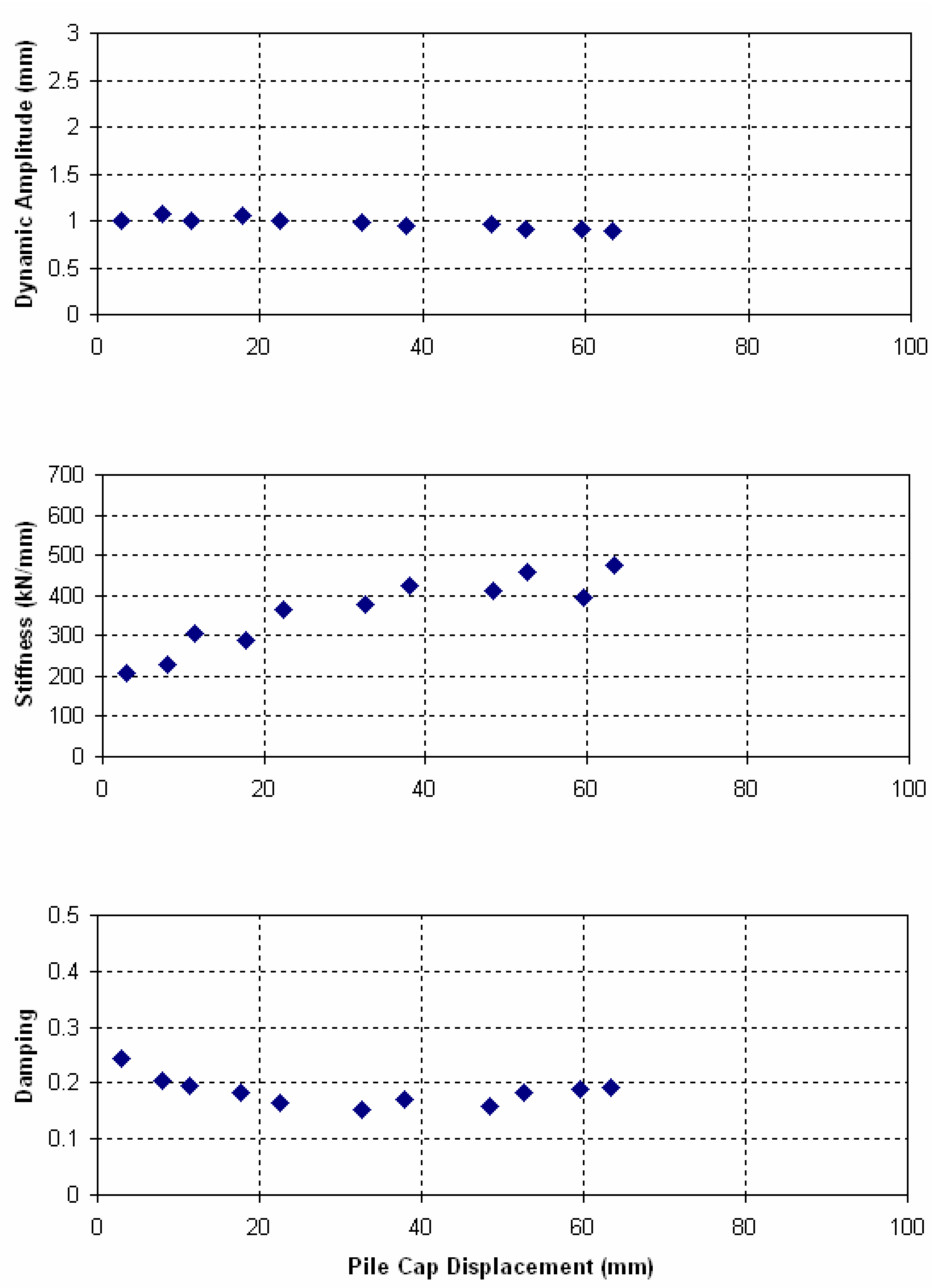

Fig. 1 Results for cyclic loading with actuator for Dense Clean Sand backfill conditions

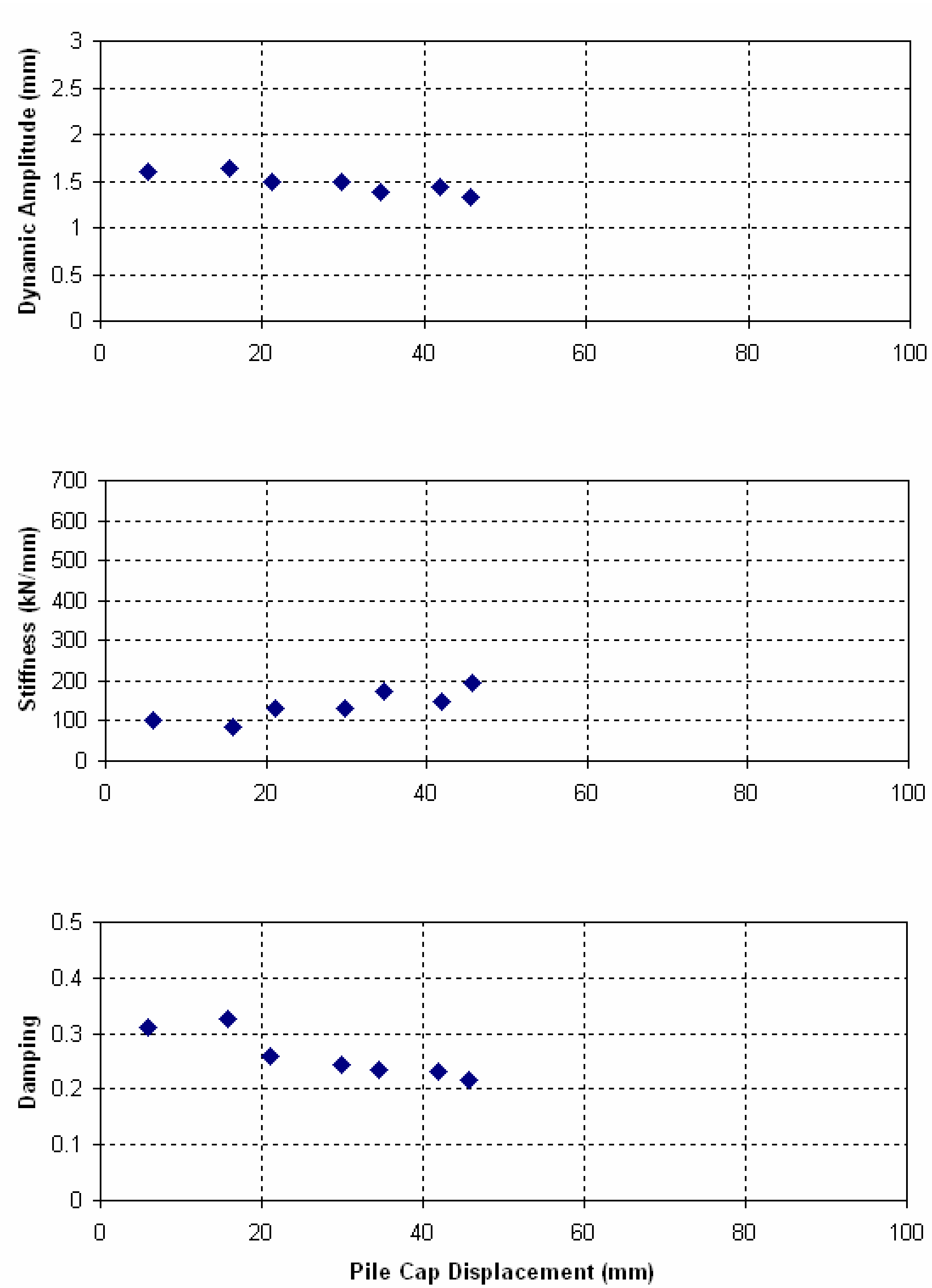

Fig. 2 Results for cyclic loading with actuator for Loose Clean Sand backfill conditions

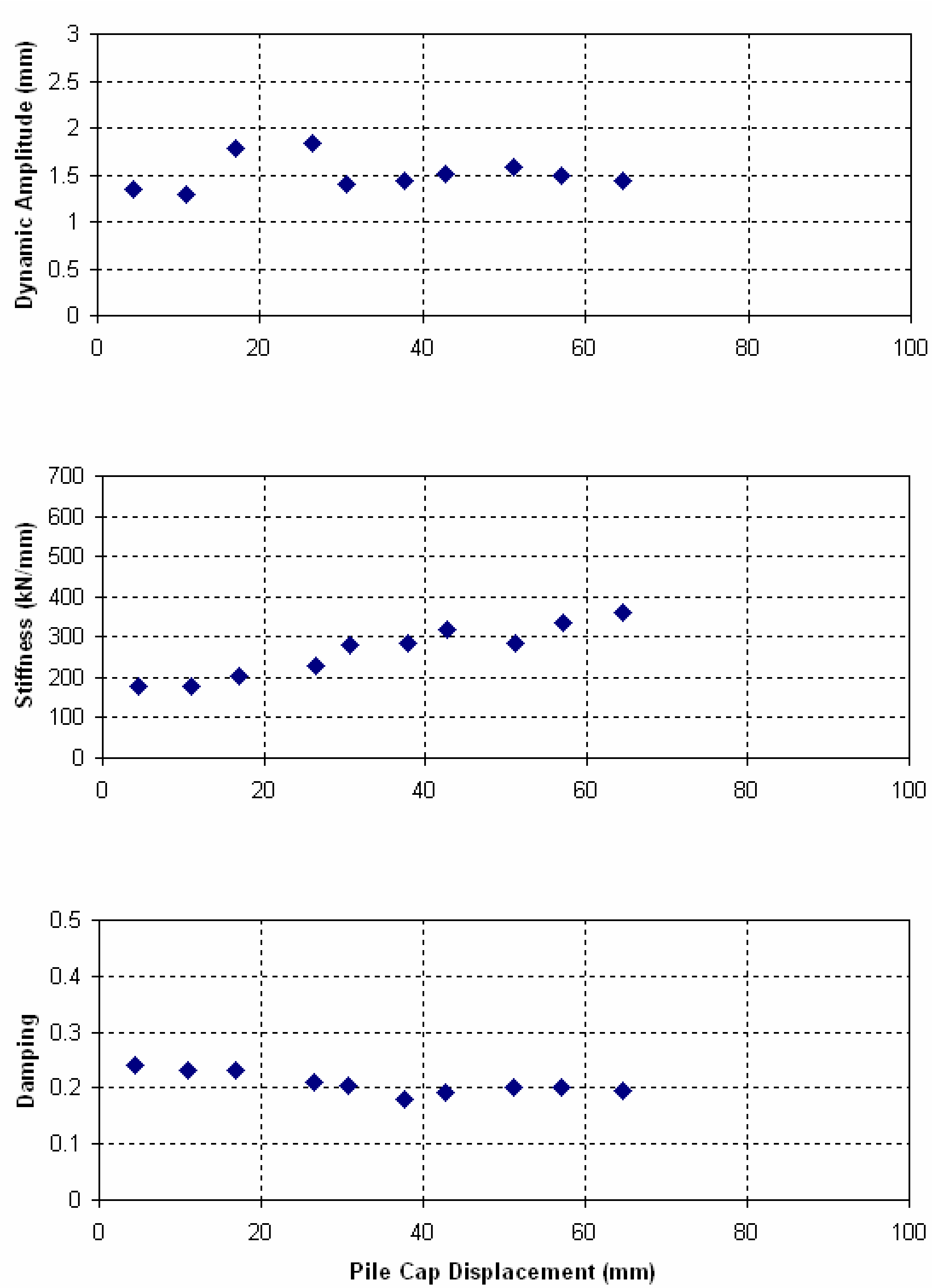

Fig. 3 Results for cyclic loading with actuator for 0.91-m wide Fine Gravel zone in front of Loose Clean Sand backfill conditions

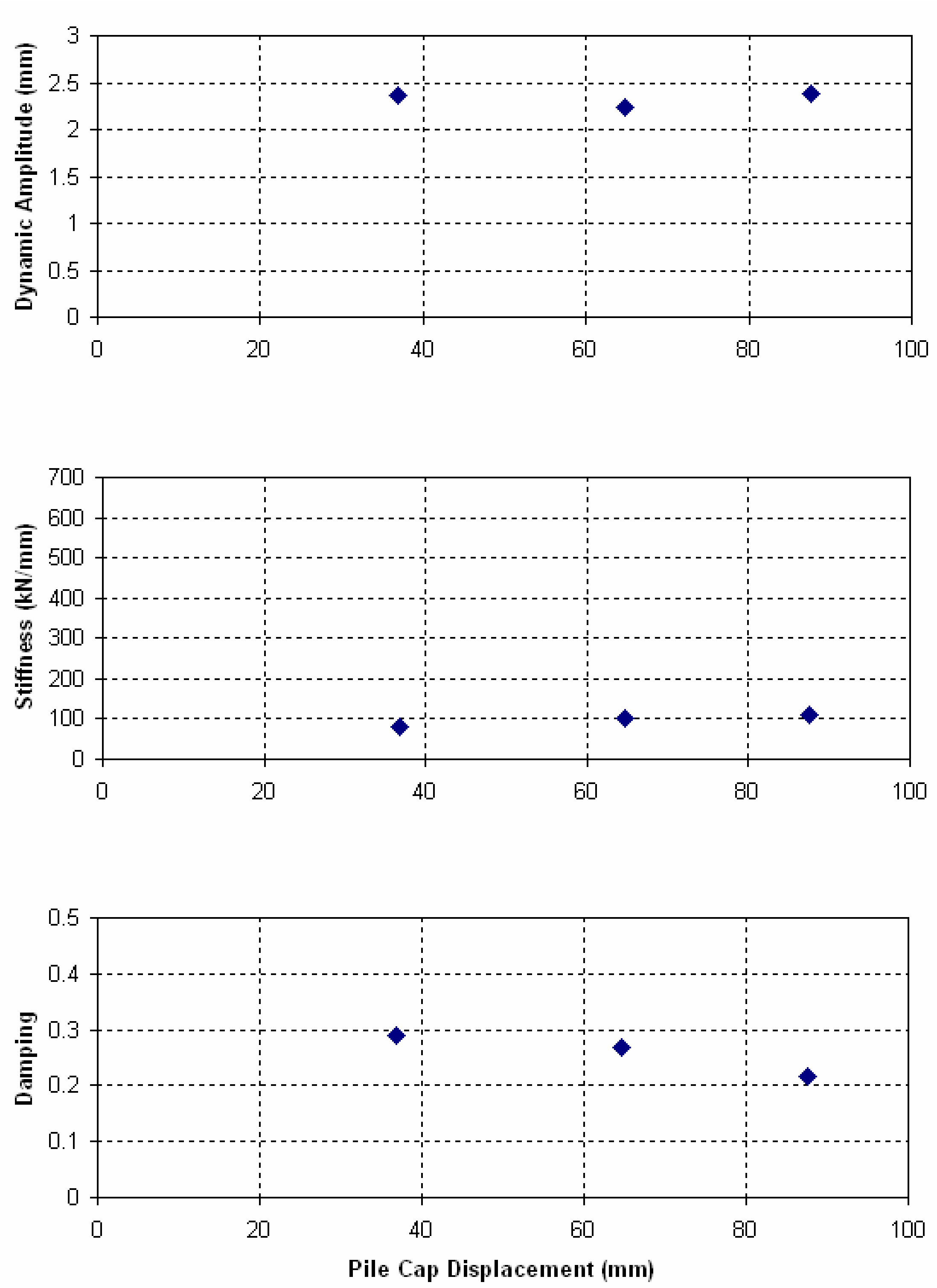

Fig. 4 Results for cyclic loading with actuator for Free Response backfill conditions

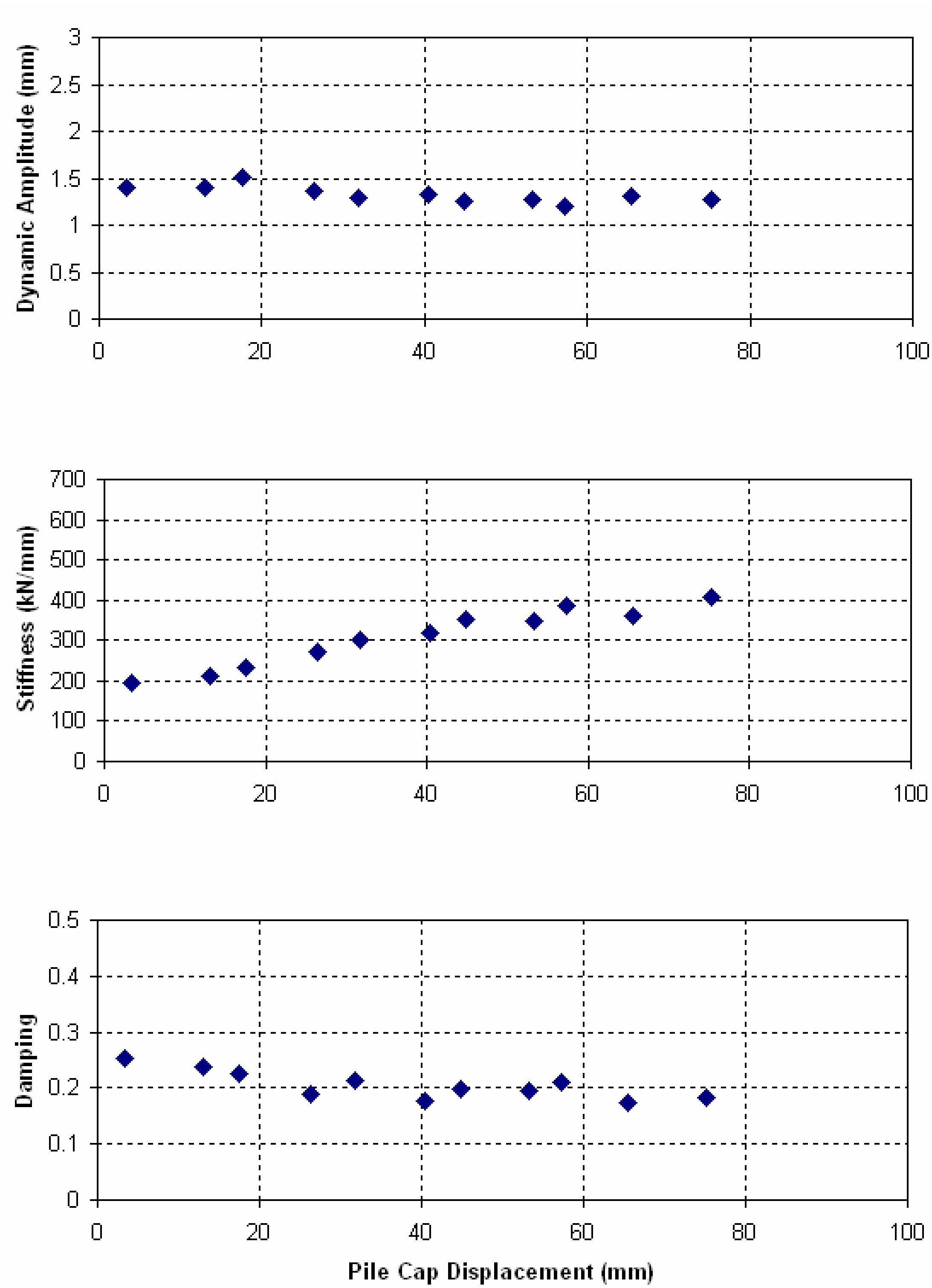

Fig. 5 Results for cyclic loading with actuator for 1.83-m wide Fine Gravel zone in front of Loose Clean Sand backfill conditions

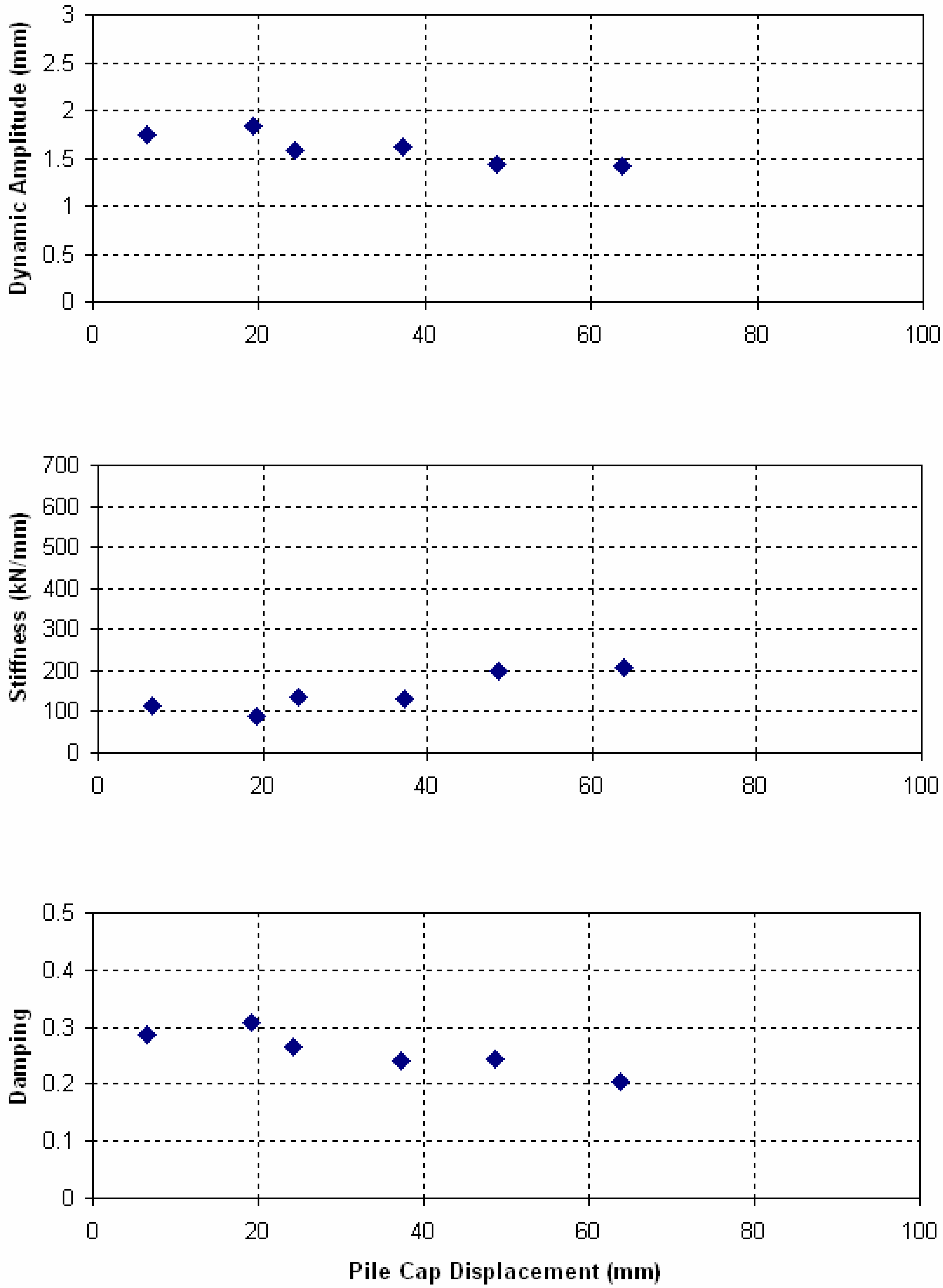

Fig. 6 Results for cyclic loading with actuator for Loose Fine Gravel backfill conditions

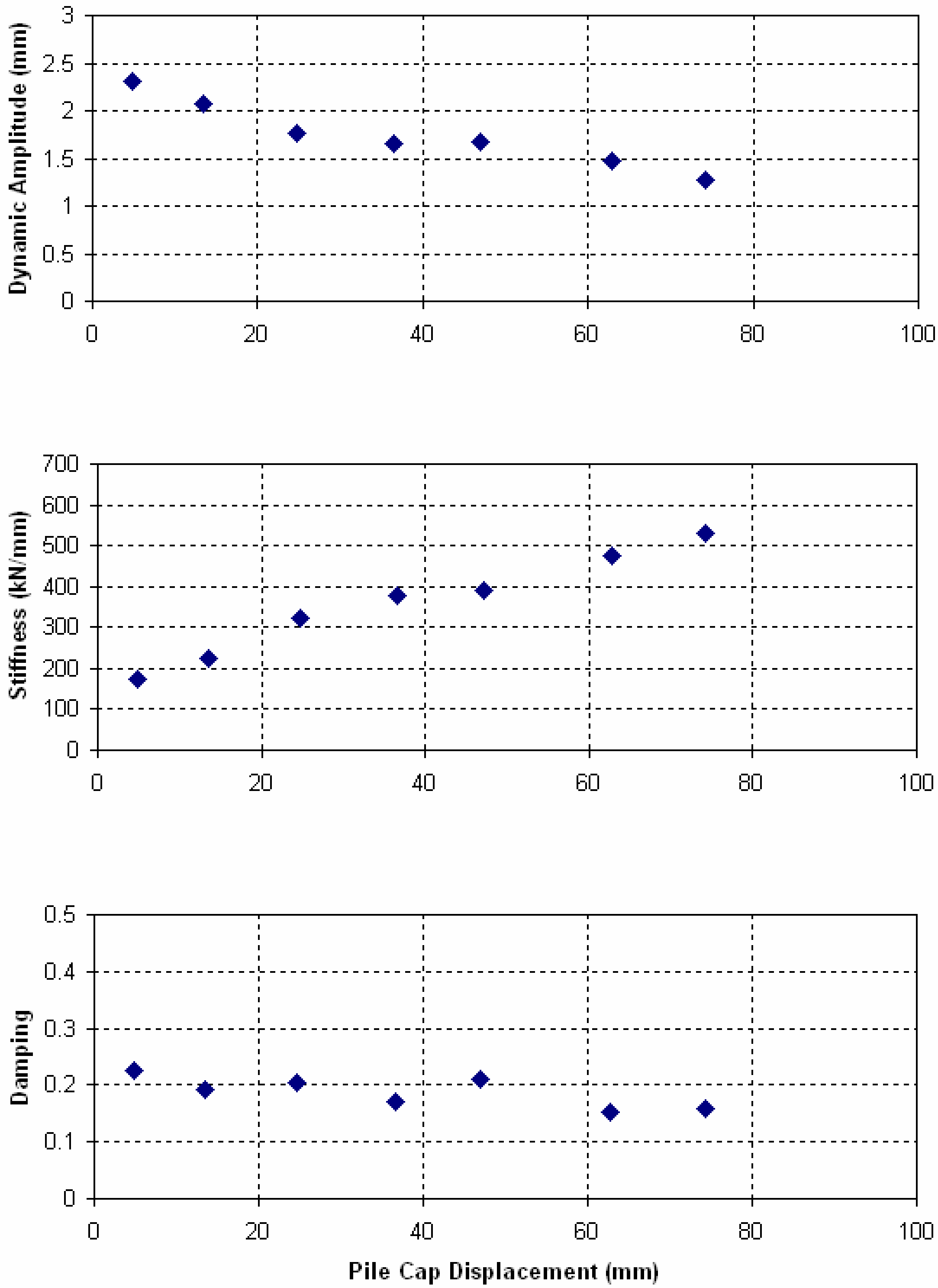

Fig. 7 Results for cyclic loading with actuator for Dense Fine Gravel backfill conditions

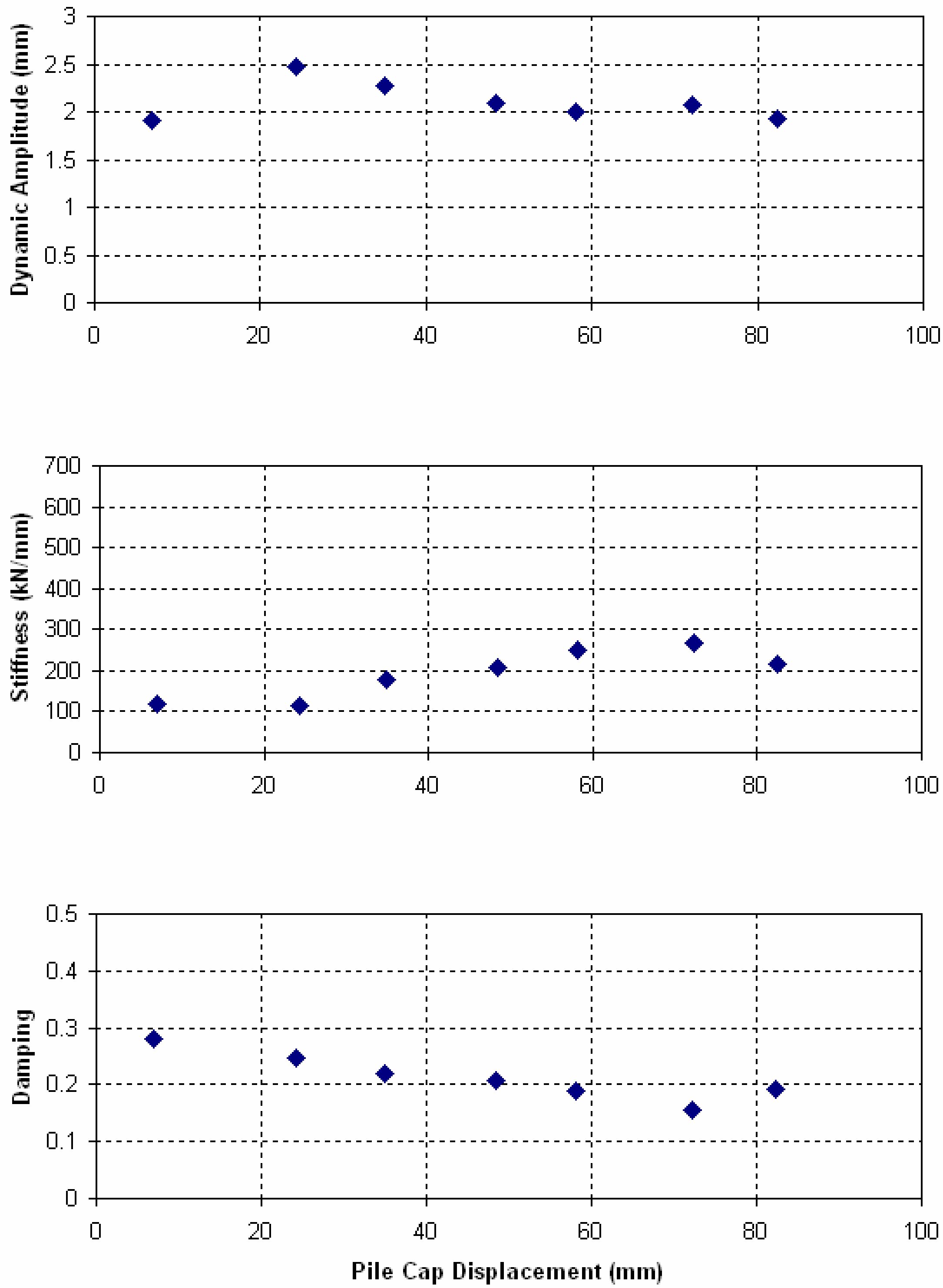

Fig. 8 Results for cyclic loading with actuator for Loose Coarse Gravel backfill conditions

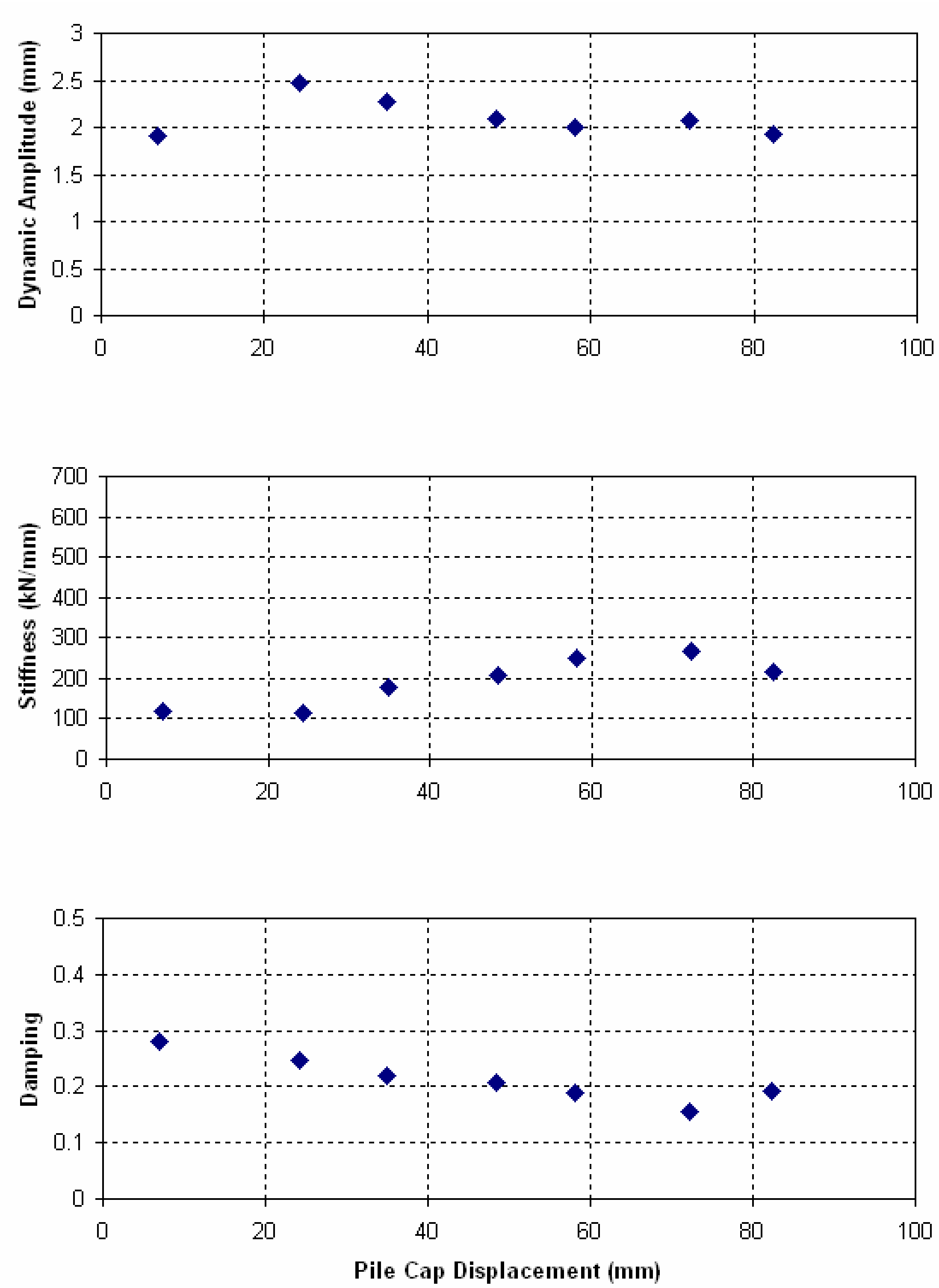

Fig. 9 Results for cyclic loading with actuator for Free Response backfill conditions

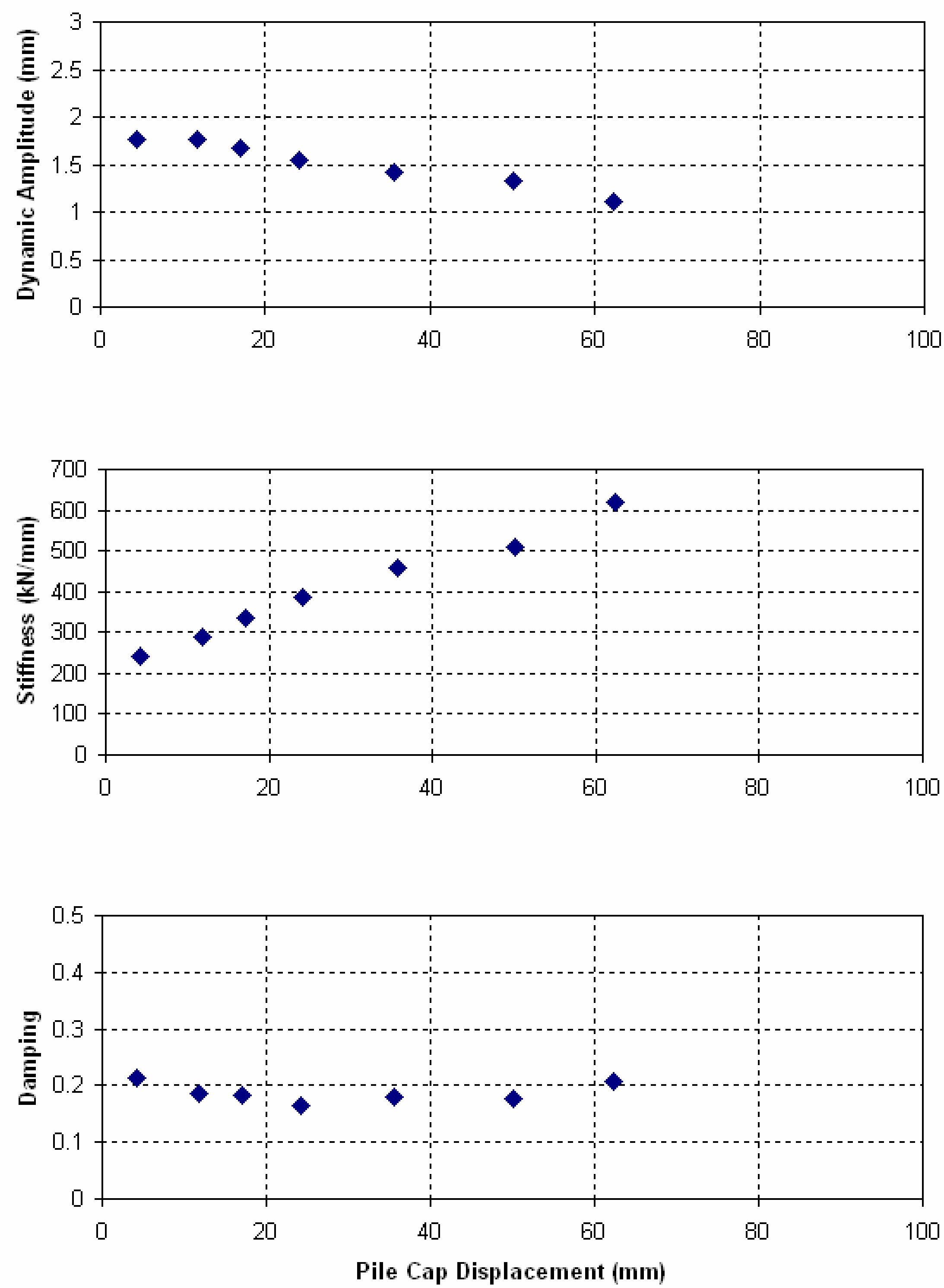

Fig. 10 Results for cyclic loading with actuator for Dense Coarse Gravel backfill conditions

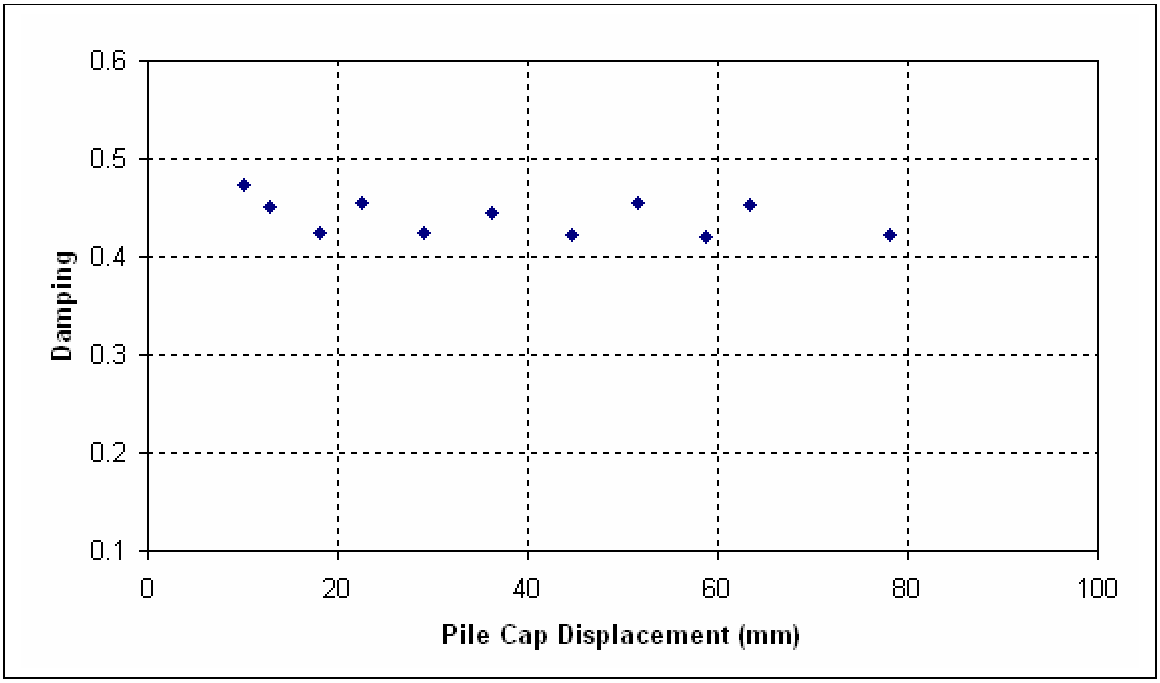

Fig. 11 Results for dynamic loading with eccentric mass shaker for Dense Clean Sand backfill conditions

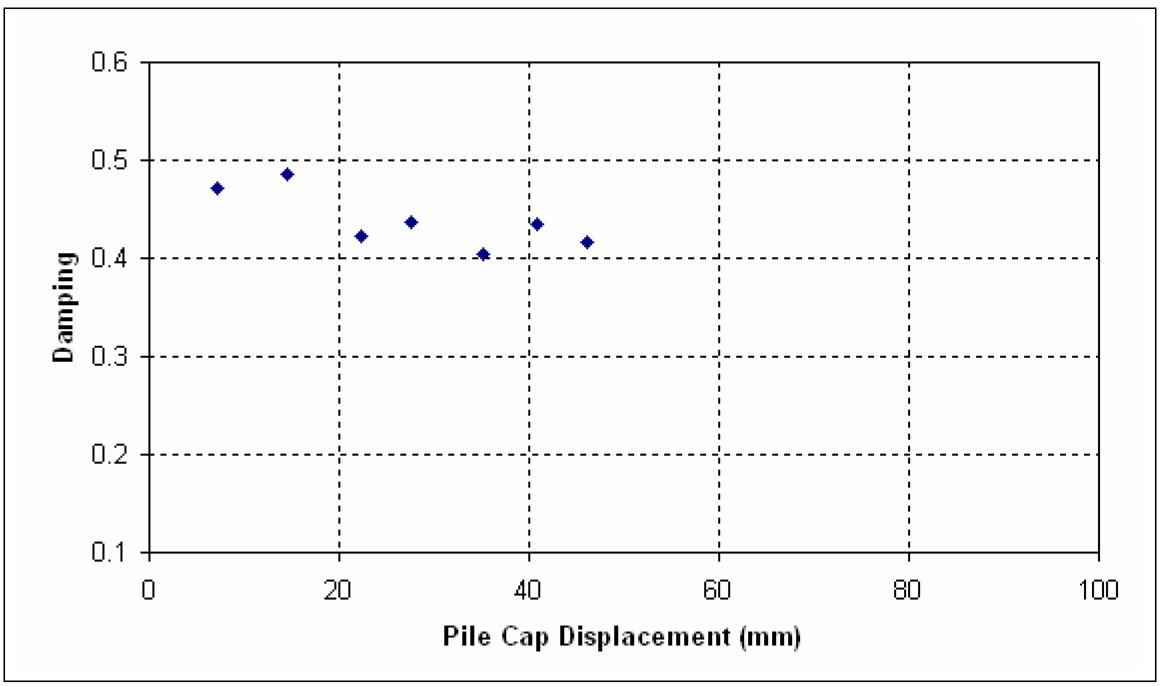

Fig. 12 Results for dynamic loading with eccentric mass shaker for Loose Clean Sand backfill conditions

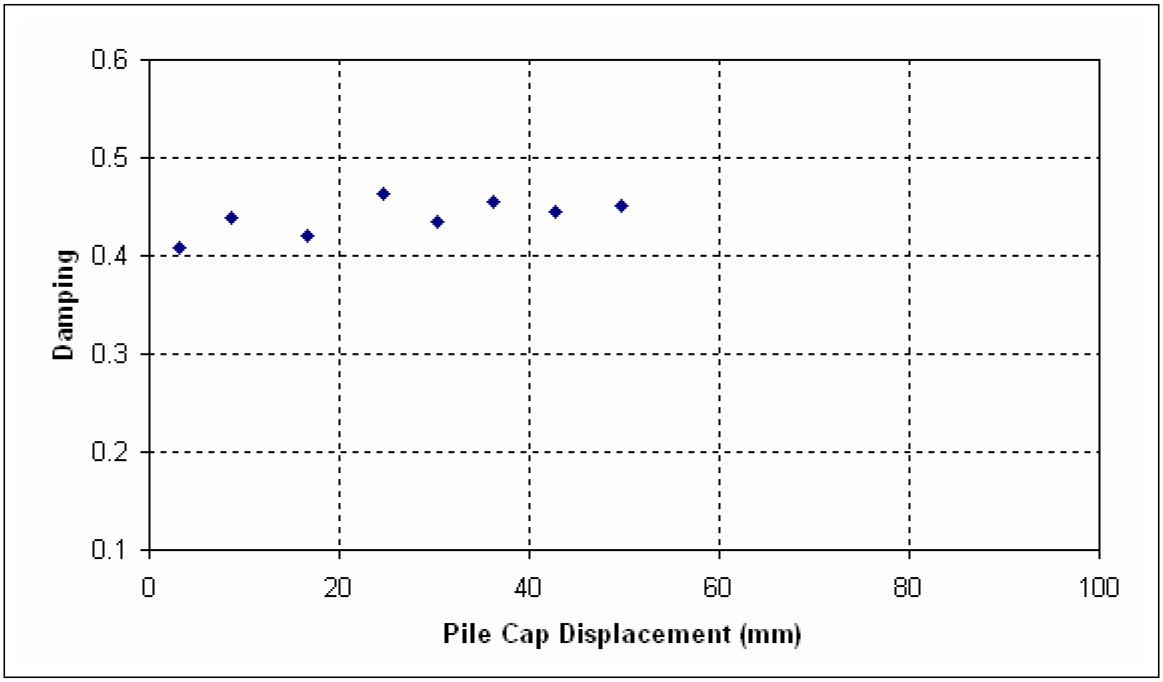

Fig. 13 Results for dynamic loading with eccentric mass shaker for 0.91-m wide Fine Gravel zone in front of Loose Clean Sand backfill conditions

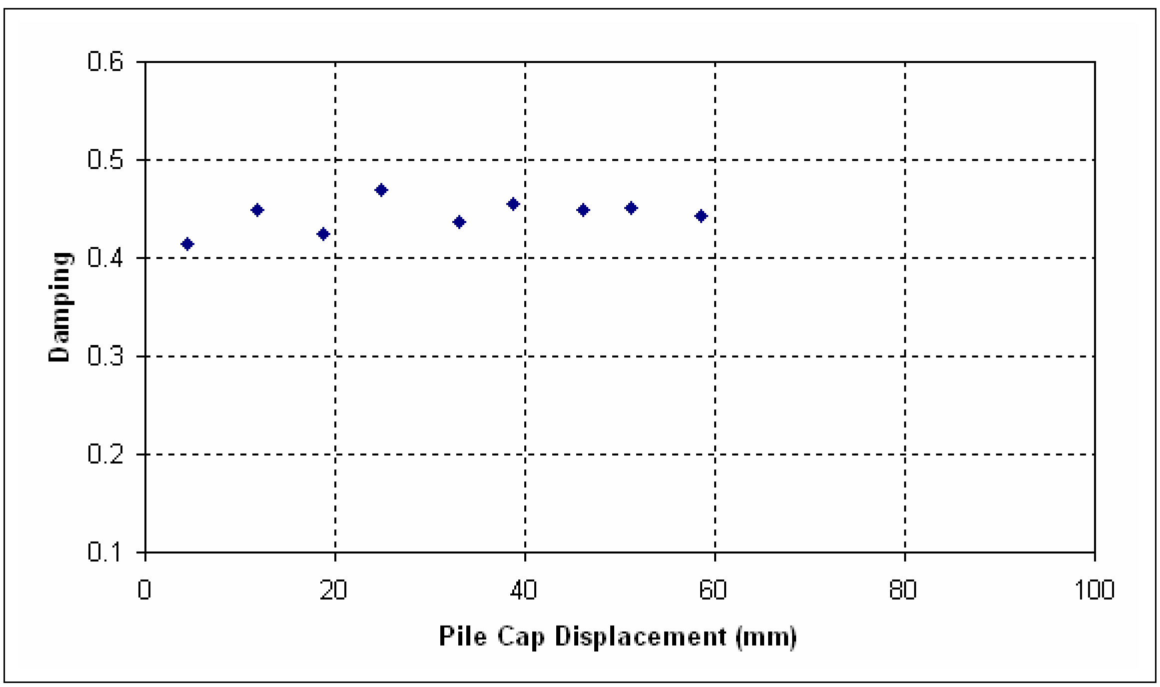

Fig. 14 Results for dynamic loading with eccentric mass shaker for 1.83-m wide Fine Gravel zone in front of Loose Clean Sand backfill conditions

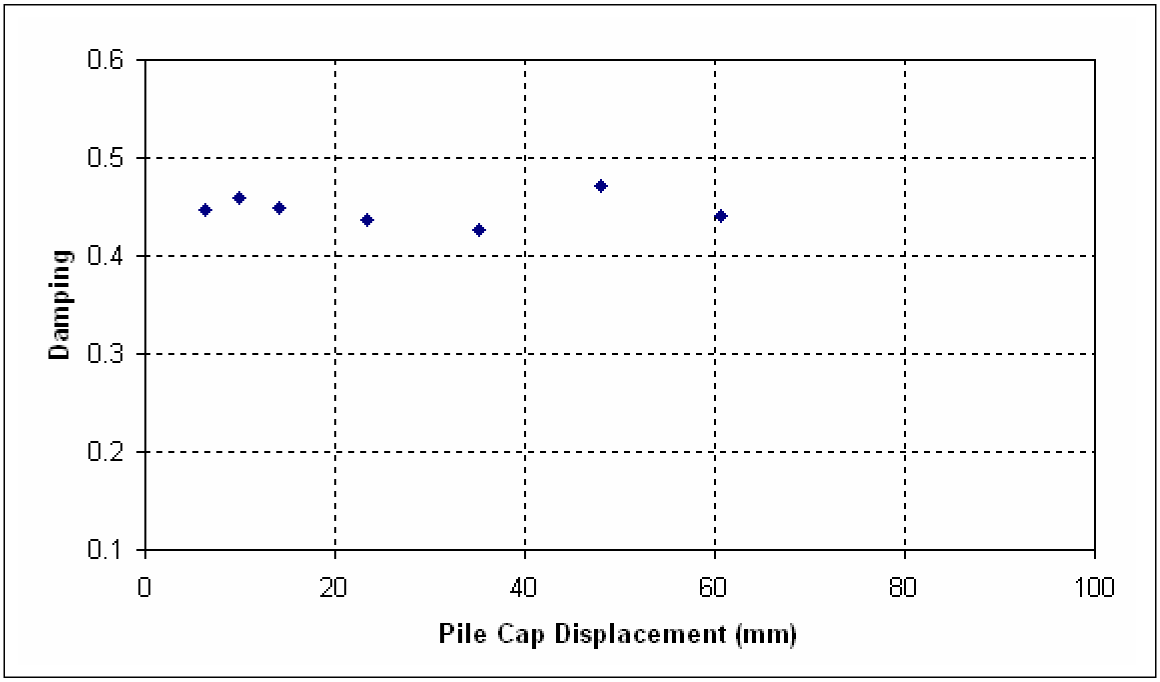

Fig. 15 Results for dynamic loading with eccentric mass shaker for Loose Fine Gravel backfill conditions

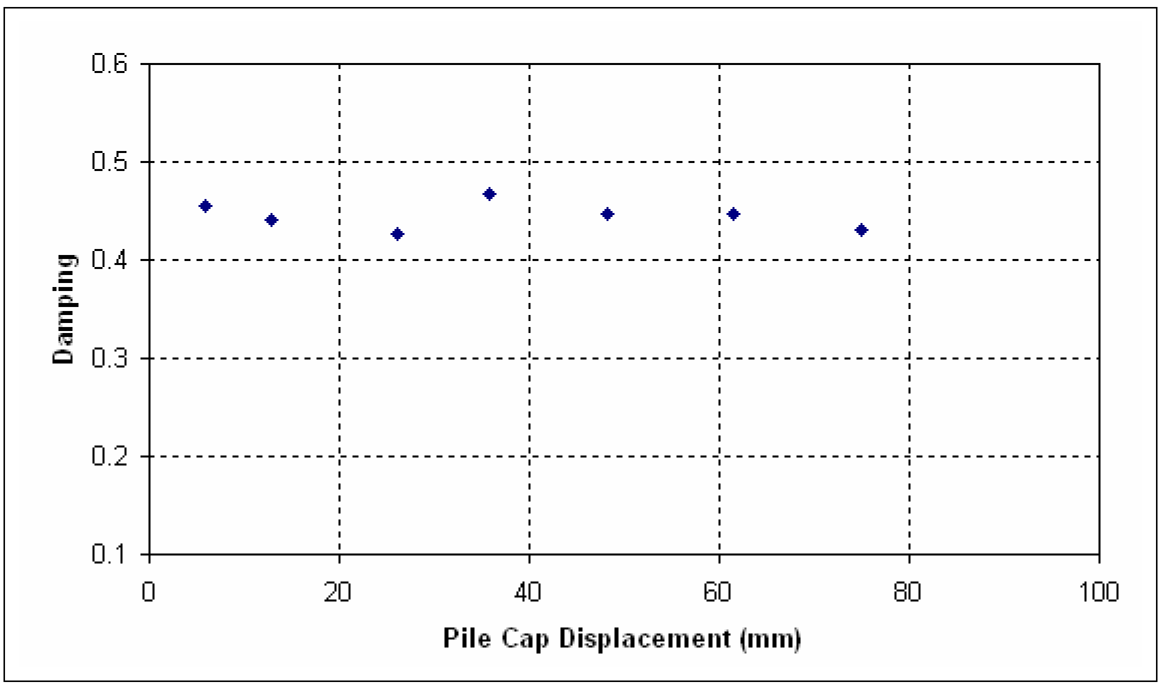

Fig. 16 Results for dynamic loading with eccentric mass shaker for Dense Fine Gravel backfill conditions

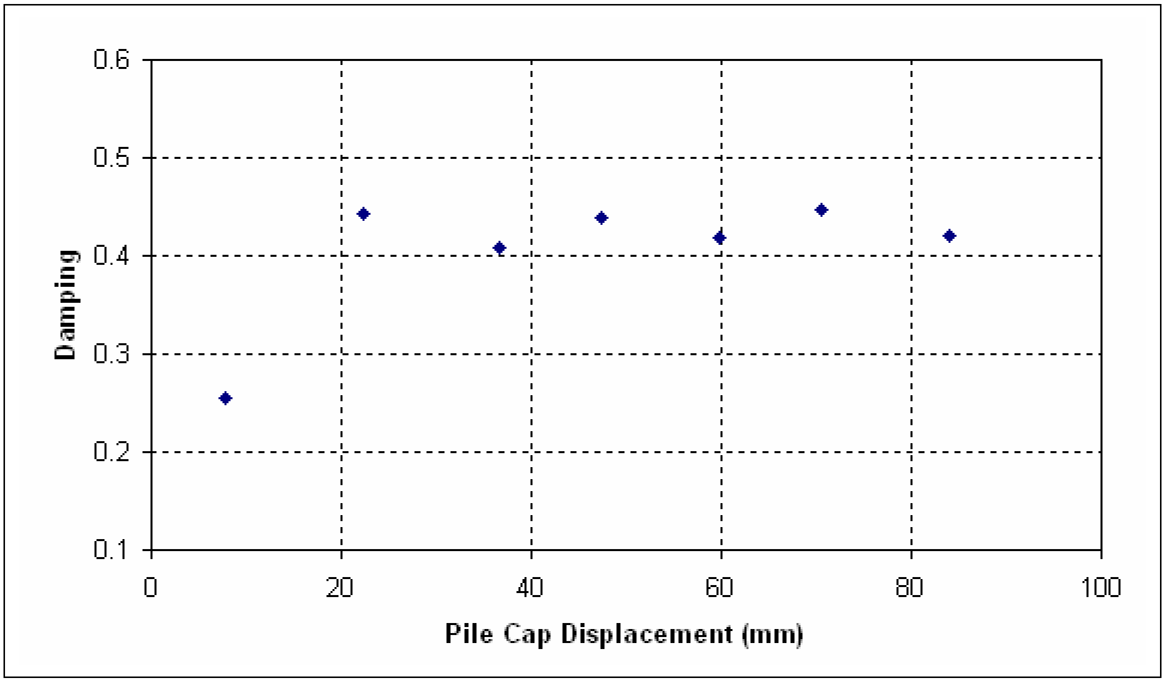

Fig. 17 Results for dynamic loading with eccentric mass shaker for Loose Coarse Gravel backfill conditions

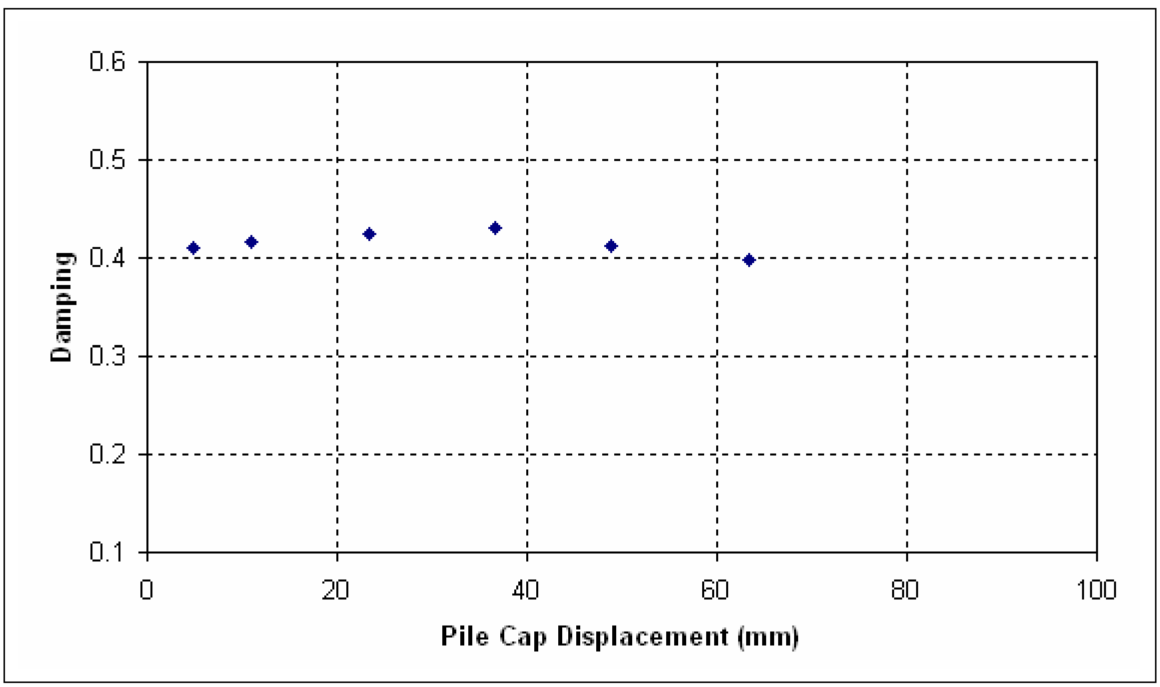

Fig. 18 Results for dynamic loading with eccentric mass shaker for Dense Coarse Gravel backfill conditions

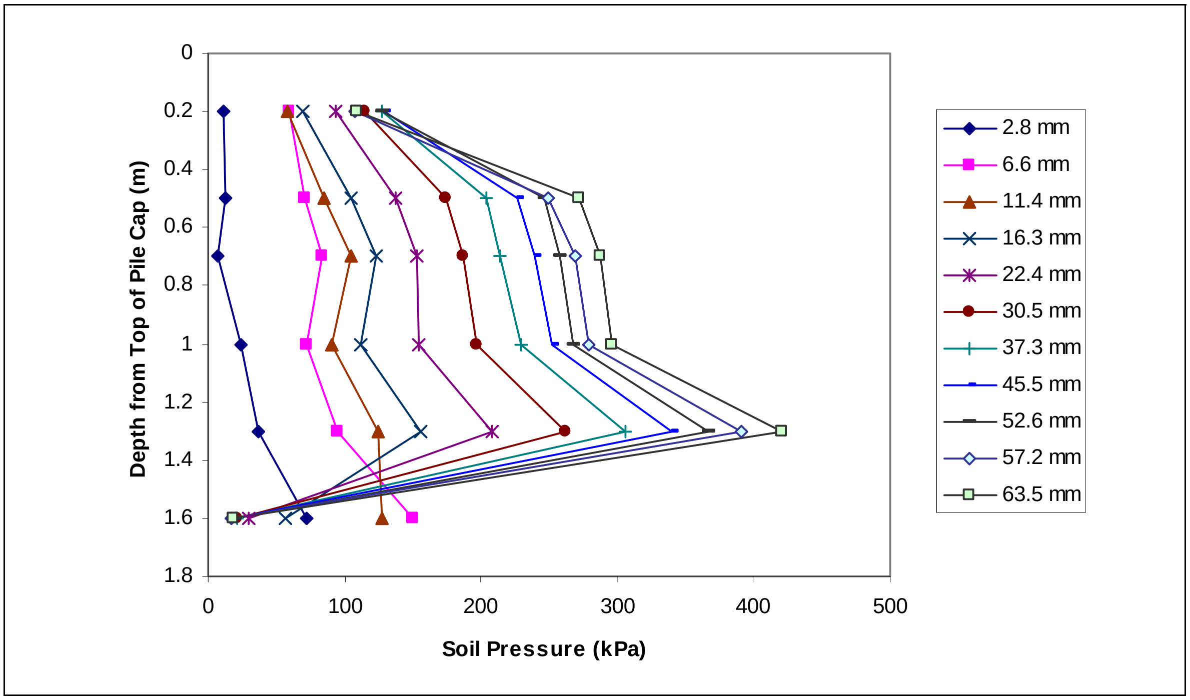

Fig. 19 Pressure distribution for Dense Clean Sand backfill conditions

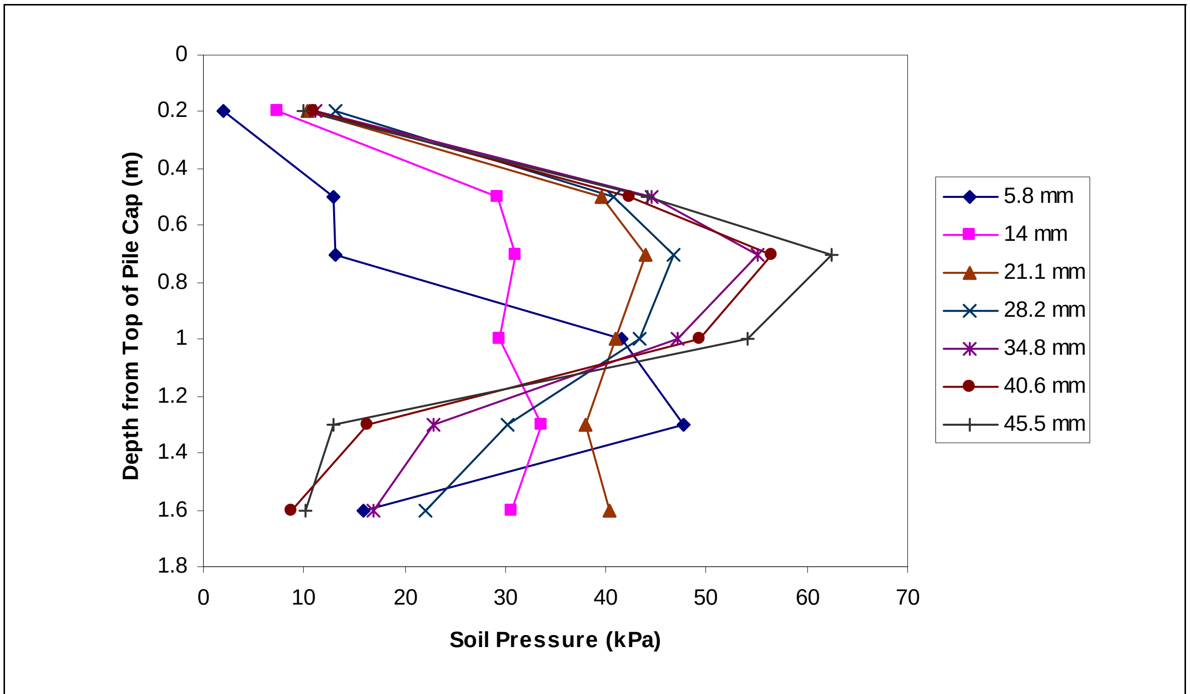

Fig. 20 Pressure distribution for Loose Clean Sand backfill conditions

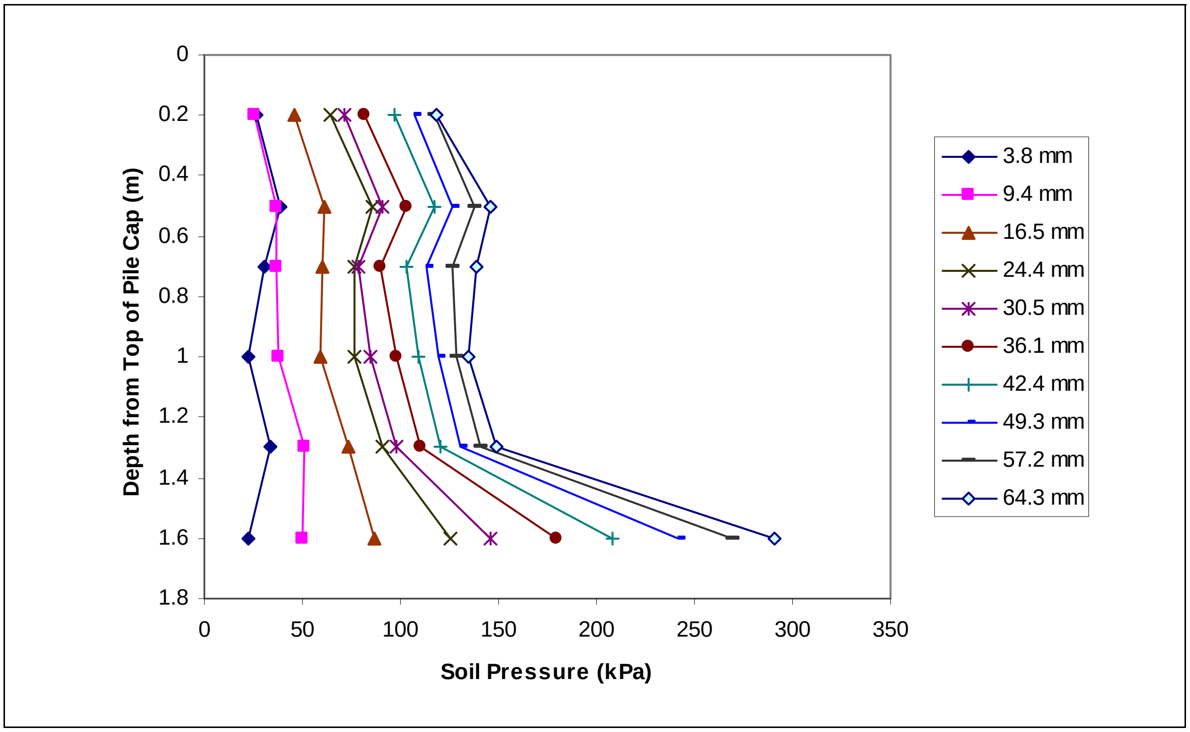

Fig. 21 Pressure distribution for 0.91-m wide Fine Gravel zone in front of Loose Clean Sand backfill conditions

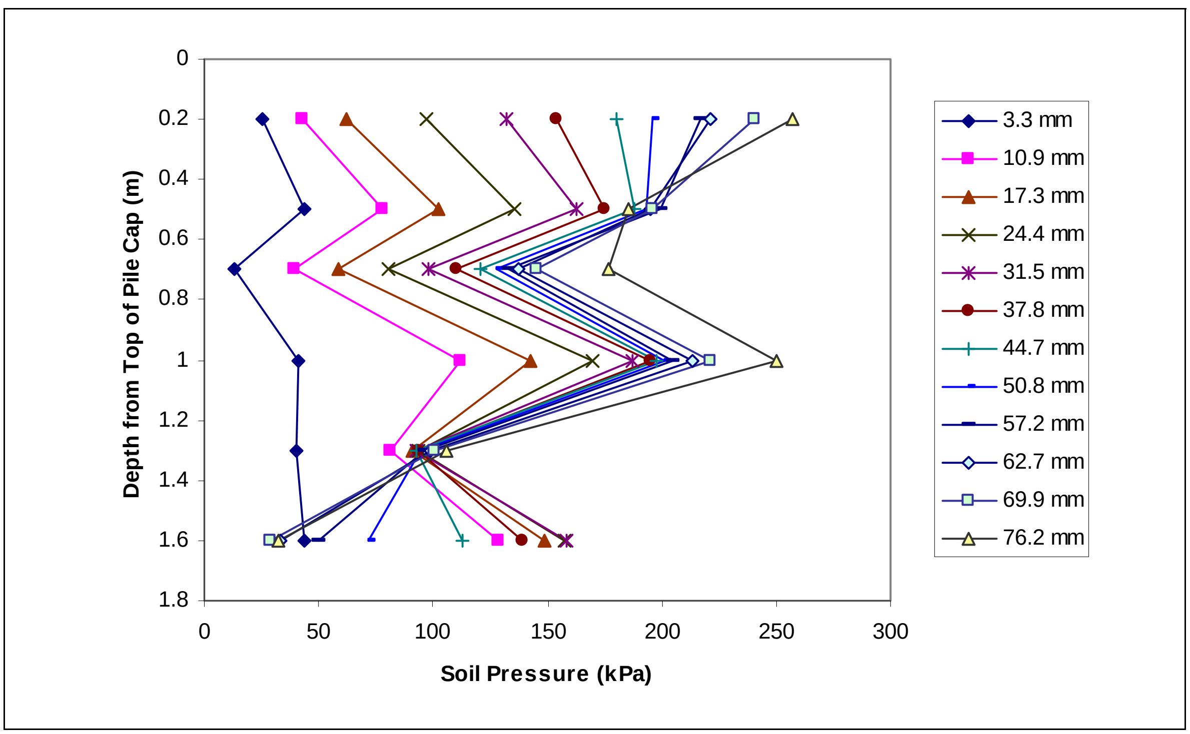

Fig. 22 Pressure distribution for 1.83-m wide Fine Gravel zone in front of Loose Clean Sand backfill conditions

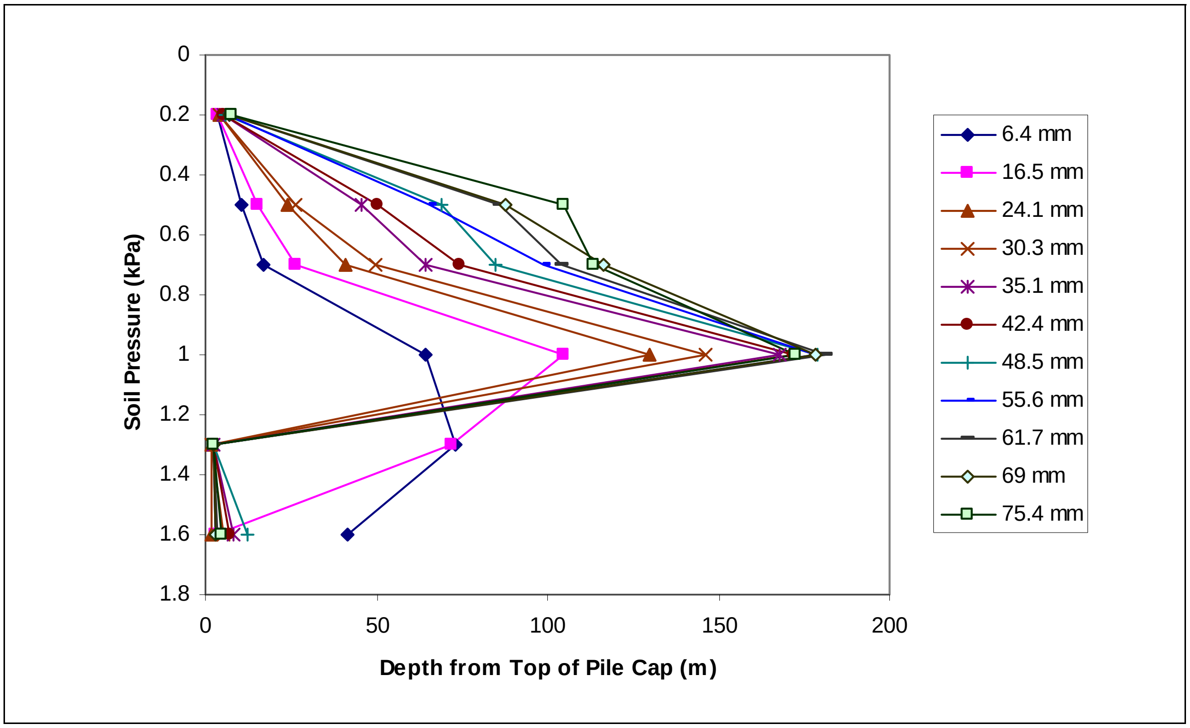

Fig. 23 Pressure distribution for Loose Fine Gravel backfill conditions

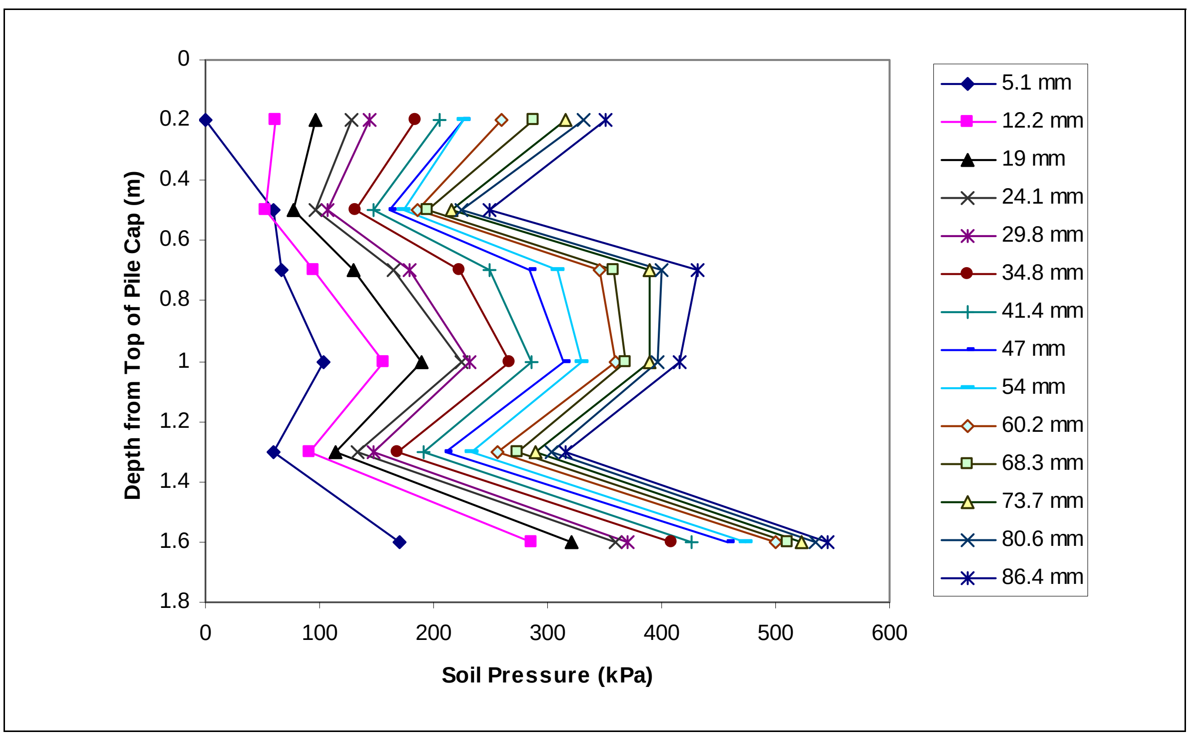

Fig. 24 Pressure Distribution for Dense Fine Gravel backfill conditions

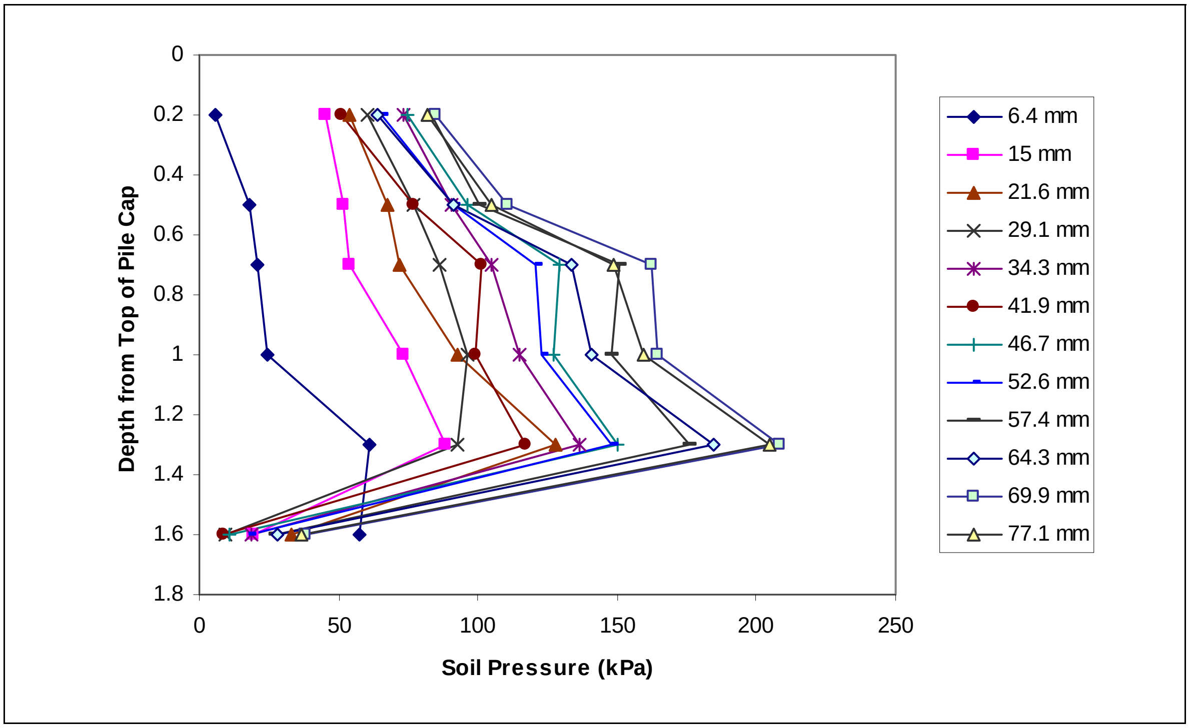

Fig. 25 Pressure Distribution for Loose Coarse Gravel backfill conditions

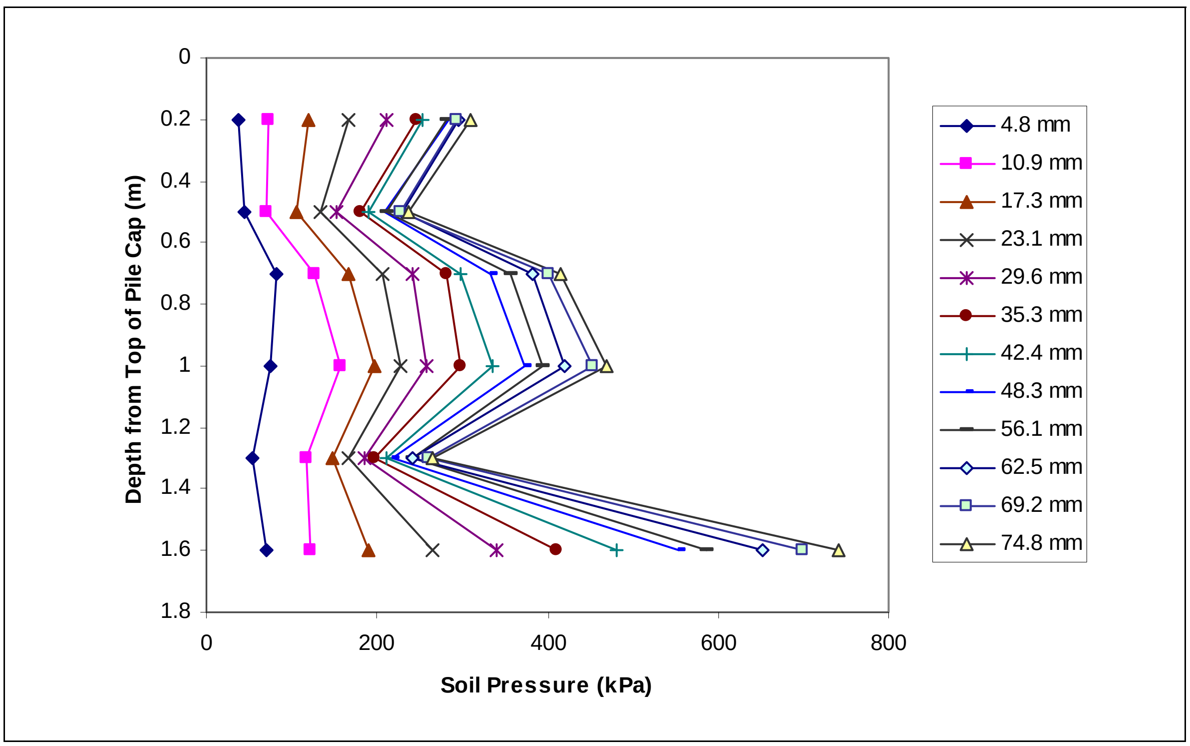

Fig. 26 Pressure Distribution for Dense Coarse Gravel backfill conditions

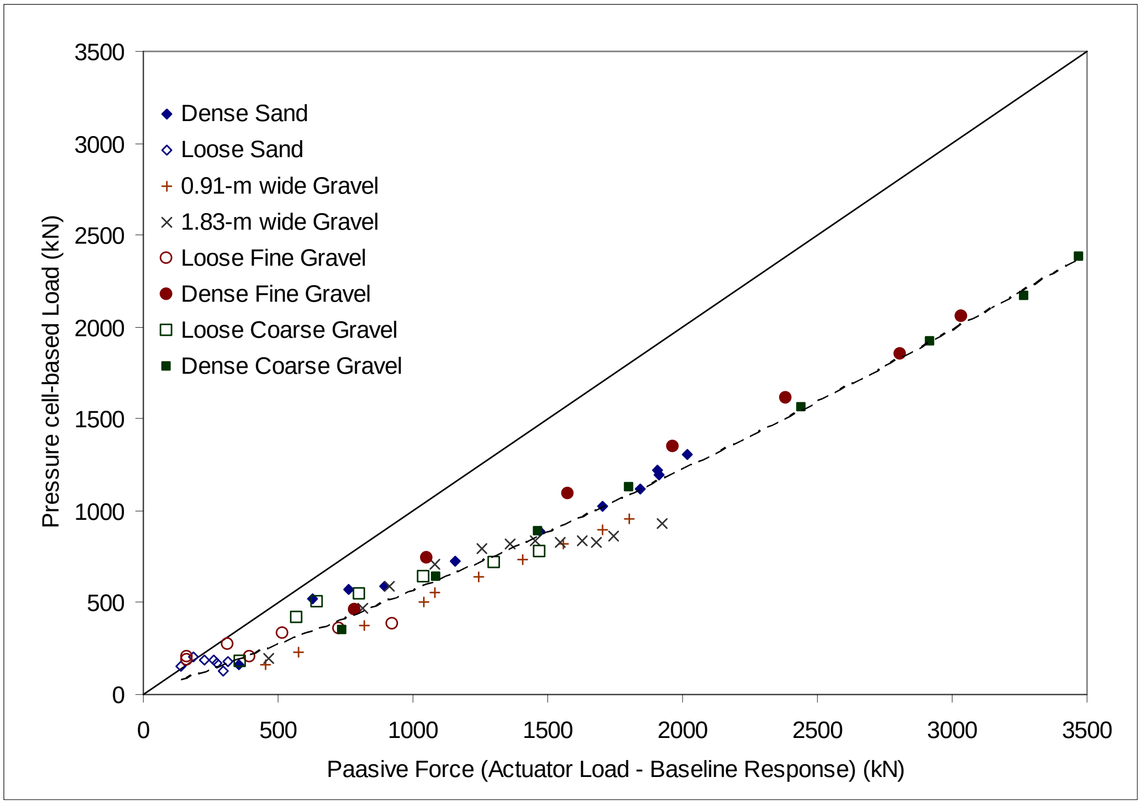

Fig. 27 Comparison of passive forces based on measured actuator load minus the baseline response and the pressure cells

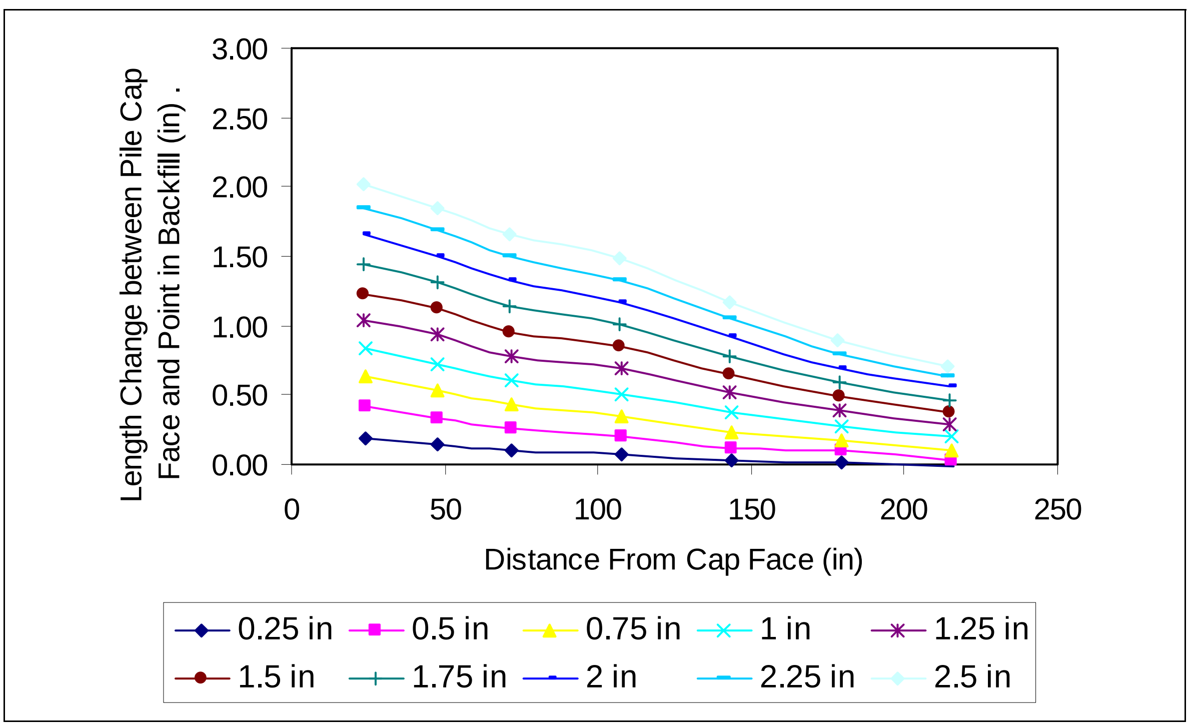

Fig. 28 Compressive behavior of Dense Clean Sand backfill as a function of distance from the pile cap face and of pile cap displacement level

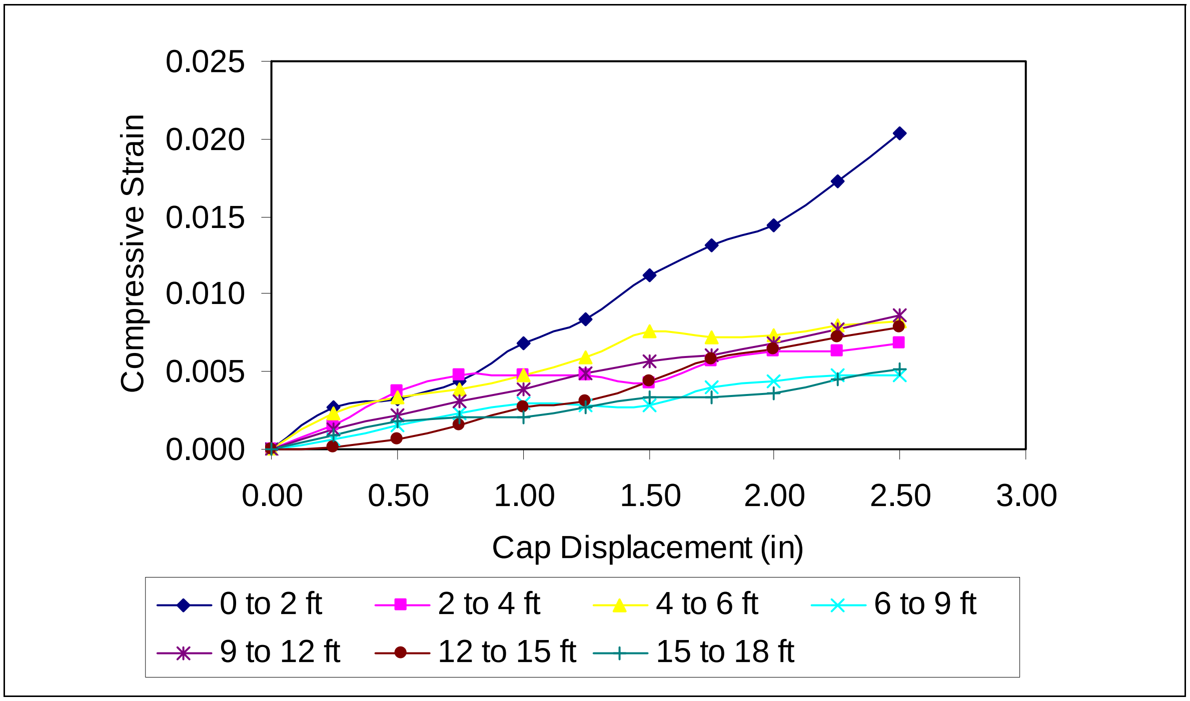

Fig. 29 Distribution of incremental horizontal strain along the ground surface as a function of pile cap displacement for Dense Clean Sand backfill

Budget Considerations

We estimate that approximate $180,000 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 68% of the budget has been spent for these tasks. We estimate that approximately 80% of the work on the project has now been completed. Therefore, the project appears to be on track from a budget standpoint.

Plans for the Next Quarter

We anticipate that the final reports will be completed for work tasks 3 and 6 during the next quarter. In addition, we anticipate that most of the analysis associated with Tasks 5 will be completed during the next quarter so that an interim summary report can be completed.