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CASE HISTORY: SHALLOW FOUNDATION SETTLEMENT PREDICTION USING THE MARCHETTI DILATOMETER

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ABSTRACT: A four-story, steel-framed office building was planned for construction in Jacksonville, Florida. It was hoped that the building could be supported on a shallow foundation system. Test borings revealed the presence of 9 to 14 feet of loose to firm clean sands overlying a 6- to 20-foot thick layer of very loose (N-value ranging from 0 to 5) very silty fine sand. Due to foundation loads ranging from approximately 400 to 1200 kips, combined with up to 2-1/2 feet of permanent structural fill, total settlements of up to 2 inches and differential settlements of up to 1 inch were estimated using conventional standard penetration resistance data and correlations with elastic modulus values. These predicted settlements were considered to be intolerable; therefore, several soil improvement concepts were evaluated to reduce settlement potential, including preloading of the building area, and the use of the vibro-replacement (stone column) technique. These methods, however, were considered to be either too costly or time consuming. Dilatometer testing was subsequently performed to refine the soil compression modulus values and settlement estimates. Total settlements of up to 1-1/4 inch and differential settlements of 3/4-inch or less were predicted using the dilatometer data which were considered to be generally acceptable to the structural engineer. The building was constructed using shallow foundations, and a settlement monitoring program was conducted during a portion of construction. The measured settlements were slightly less than those predicted using the dilatometer data. Use of the dilatometer at this site provided soil compressibility data which enabled the structure to be constructed successfully on a conventional shallow foundation system without utilizing costly and time consuming soil improvement techniques.

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At the completion of the monitoring program, the total measured settlements ranged from about 1/3 to 2/3 inch in the central masonry core area. At the column footing locations, the total measured settlement was about 1/4 inch. Over the last month of the settlement monitoring program, the elevations of the monitoring points had remained relatively constant, indicating that foundation settlements had essentially stopped. A possible reason the measured settlements were less than the predicted settlements include the fact that less than 70 percent of the total load was in place at the end of the monitoring program.

Conclusions

In summary, the following conclusions were drawn from this case history:

1. The actual measured settlements were slightly less than the estimated settlements using dilatometer data and the Westergaard stress distribution with the hard over soft layer analysis. In general, reasonably good agreement was observed between the predicted and measured settlements.

2. Using dilatometer testing, the structure was able to be constructed successfully on a shallow foundation system without utilizing more expensive and time-consuming soil improvement techniques.

3. Use of the dilatometer, and acceptance of this technique by our client, allowed the original desired schedule to be maintained. Also, a savings of roughly $30,000 to $40,000 in foundation costs was realized by eliminating the need for stone columns, and the need for preloading was eliminated, saving approximately $90,000 to $100,000.

4. The standard penetration test cannot measure the strength and compressibility of soils as accurately as the flat-plate dilatometer, which is a more sensitive device. Also, dilatometer testing is typically performed on closer depth intervals than the standard penetration test. For this project, the SPT data underpredicted the modulus of the relatively firm upper sands of Layer 1.

5. The process of driving the spoon in very loose saturated sandy soils can create a temporary quick condition, which may result in low strength predictions.

6. The ratio of the compression modulus values of Layer 1 versus Layer 2 ranged from about 20 to 35, which greatly reduced the loading applied to the lower layer using the hard over soft concept. Use of the hard over soft concept resulted in more accurate settlement predictions, even though the compression modulus values in Layer 2 determined from the DMT soundings were lower than the modulus values estimated initially from SPT N-value correlations. This is believed to be a result of the increased modulus values measured by the DMT soundings for Layer 1, which were approximately 2 to 3 times the modulus values estimated using published SPT N-value correlations.

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