BOLIVIAN EXPERIMENTAL SITE FOR TESTING

Presentation of Field Testing Programme

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1. BACKGROUND

The purpose of the "*Bolivian Experimental Site for Testing*" (B.E.S.T) is to provide well-documented, comprehensive geotechnical information from a site where different types of pile tests have been performed. The results from the field investigations and the full-scale pile loading tests are intended to augment the current state-of-the-art of pile design. The results of the field studies are being presented in connection with the *3rd International Conference on Deep Foundations, Bolivia* (C.F.P.B.), held in Santa Cruz from April 27 through 30, 2017.

Pile design methods have advanced significantly. However, they still rely greatly on empirical correlations. In spite of significant recent improvements made in identifying the complex actions occurring when a pile is installed or constructed, as well as the process of long-term load-transfer, the interaction between structure, piles, and soil to consider in the design of piled foundations, needs much further study. Currently, new types of piles, installation and construction methods have emerged. Such new pile types are, for example, drilled displacement piles, full displacement piles, Expander Body piles, Toe Box piles, helical piles, injected micro piles, etc. Although these new pile types, potentially, offer significant savings and improved quality, design methods are still based on simplified concepts. Better knowledge regarding their validity in relation to existing practice is needed by the deep foundation industry.

The current state-of-the-art of piled foundation design relies on empirical correlations and emphasizes capacity, that is, ultimate shaft and toe resistances. An important development of piling technology has been the possibility to monitor and control the installation process. This information can be used to determine the required depth of installation and to estimate, based on empirical correlations, the bearing capacity of piles after installation.

Settlement analysis is rarely included and less understood. The design analysis is usually limited to the response to load applied to single piles and, while verification tests on single piles are common, tests on pile groups are extremely rare—only a handful reports are available and they are frequently based on results of model studies. Therefore, the understanding of pile group response in piled foundation design is limited.

Moreover, current design practice relies primarily on soil description from samples obtained from boreholes (BH) and Standard Penetration tests (SPT) N-indices and, in some areas, also Cone Penetration Tests with pore water pressure measurement (CPTU). The use of other in-situ tests, such as dilatometer (DLT), pressuremeter (PMT), shear wave velocity measurements (also in combination with CPT and DMT) or seismic surface wave measurements (MASW) is still rare.

2. PILE TEST PROGRAMME

The pile test programme reported herein aims to determine the load movement relationship of the pile head and pile toe for the different pile types, which includes determining the axial load distribution in the piles for different loads applied to the pile head. Loading tests are performed on individual piles and pile groups. In addition, pile integrity tests and dynamic tests are being carried out. Full-scale instrumented pile tests to study load transfer and settlement will be performed on single piles and on a pile group. Three single piles and the pile group will be used for a prediction event. A few piles are installed with intentional defects to serve as a base for assessing the application and limitations of integrity testing methods. The detailed test programme and scheduling is presented in subsequent sections.

The results of the pile loading tests and a compilation of pile predictions submitted prior to the loading tests is presented in Volume 3 of the proceedings.

3. GEOLOGY AND SOIL PROFILE

The city of Santa Cruz de la Sierra, lies in the southern part of the Amazonas and the B.E.S.T. site is situated in the Warnes municipality, 24 kilometers North-east of Santa Cruz de la Sierra (see Figure 1). The geology of the area is characterized by a Paleozoic (250 million years old) sedimentary basin. The soils of interest to civil engineering construction, the surficial soils, are quaternary with the dominant minerals being calcite, silica, and feldspar. The main agent is the Piray River and its tributaries, which past meandering over the area has resulted in a sedimentation-erosion-sedimentation process and a geological profile dominated by fine to medium sands with intermittent layers of clay or clayey sand. The geology in and around the city, with intermittent layers of compressible soils, is such that even light buildings need to be supported on piles.

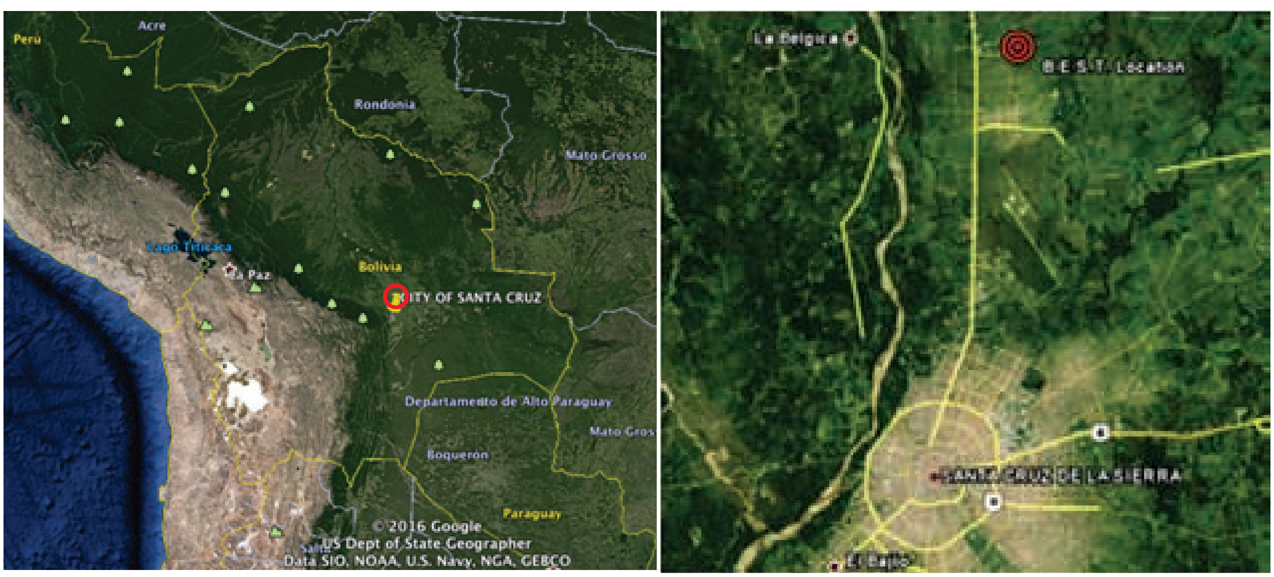

Fig. 1. Location of the city of Santa Cruz and the B.E.S.T. site in reference to Santa Cruz.

In summary, the upper about 10 to 20 m part of the profile consists of normally consolidated layers of clays, silts, sands, in various combination and thickness. The upper about 5 to 6 m consists of loose silt and sand. Hereunder lies a 6 to 7 m layer of compact silt and sand. At about 11 m depth lies an about 1 m thick layer of soft silty clay followed by an about 1 m thick layer of compact sand. Below about 12 m depth, the profile alternates between about 2 m thick layers of compact to dense silty sand and about 2 m thick layers of loose sand. The groundwater table at the site ranges seasonally between the ground surface and about 0.5 m depth.

4. SOIL EXPLORATION

The B.E.S.T. site is about 40 m wide and 100 m long. The geotechnical conditions of the site have been investigated using conventional in-situ and laboratory methods. At each single pile location and at the location of two piles of the group (E-piles), the following in-situ tests have been performed:

- SPT (standard penetration test) and SPT-T (SPT plus torque measurement). Dynamic measurements are made to determine the transferred energy ratio (ETR)
- SCPTU (seismic piezocone penetration test with pore water pressure measurement)
- SDMT (seismic dilatometer test)
- PMT (pressuremeter tests)
- SASW and REMI geophysical tests

Each borehole and field test is identified with the letter of its designated test pile and located at 0.80-m radial distance from the test pile. The first four in-situ tests are placed in the corners of a square inscribed in an octagon with the designated pile in its center and its sides parallel with the line between the test piles; Figure 2 shows the locations and denotations for in-situ tests around Pile A-1. Any additional in-situ tests will be placed in the opposite corners of the octagon.

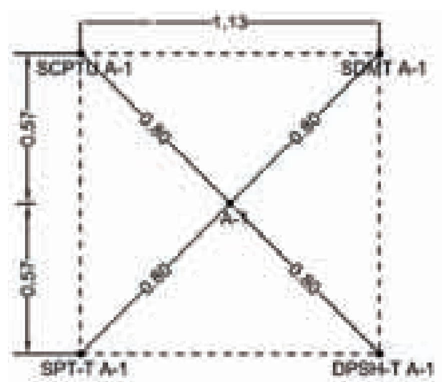

Fig. 2. Example of layout of tests performed adjacent to Pile A-1.

When possible, water content and grain size distribution were determined for samples. The samples were classified for soil type per the Unified Soil Classification System (USCS). For cohesive samples, consistency limits (*LP* and *LL*) were also determined. Section 9 shows the compilations from all site borehole data, and SPT and CPT tests at the B.E.S.T. site.

5. SINGLE PILE TESTS

5.1 Placement and Construction Details

Different types of single piles and one pile group will be constructed and tested at the site. Figure 5.1 shows the pile locations and Table 5.1 shows a summary of the different piles and tests. The head-down tests will be using four reaction piles placed in a square configuration with a 5 m center to center distance with the test pile in the center (the distance between test pile and anchor pile is 3.5 m). The piles intended for static testing will be installed to a depth of 9.5 m, i.e., about 1.5 m above the about 1 m thick soft clay layer. (The length of the piles intended for integrity testing demonstration will be disclosed only after the demonstrations are completed).

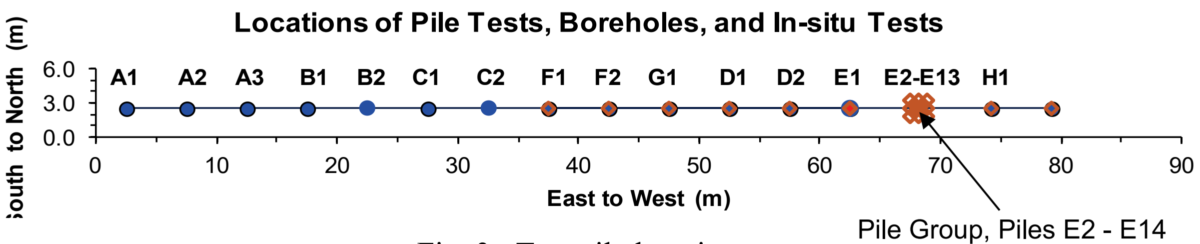

Fig. 3. Test pile locations.

All piles subjected to static testing are instrumented with strain-gages for measurement of axial load distribution. Piles A1, B1 and B2, C1 and C2, D1 and D2, and all E-piles will have the reinforcement cage equipped with an Expander-Body (EB) to ensure a toe resistance larger than the shaft resistance. The EB is constructed by expanding a folded steel cylinder by injecting grout. The 9.5-m installation depth is the depth of the EB end before inflation. A bidirectional cell (BD) is placed above the EB in all EB-equipped piles with the BD bottom plate at 8.3-m depth, as shown in Figure 4. The EB width prior to expansion is 160, 140, 120, and 110 mm in Piles A3, B2, C1, D1, and E-piles, respectively. After installation and concreting the pile shaft, the EB is pressure-grouted expanding the diameter to 815, 600, 500, and 300 mm for Piles A3, B2, C1, D1, and E-piles, respectively. Pressure-grouting the soil below the EB completes the installation. Piles B2, C2, E1, and the E-pile group will be included in a prediction event.

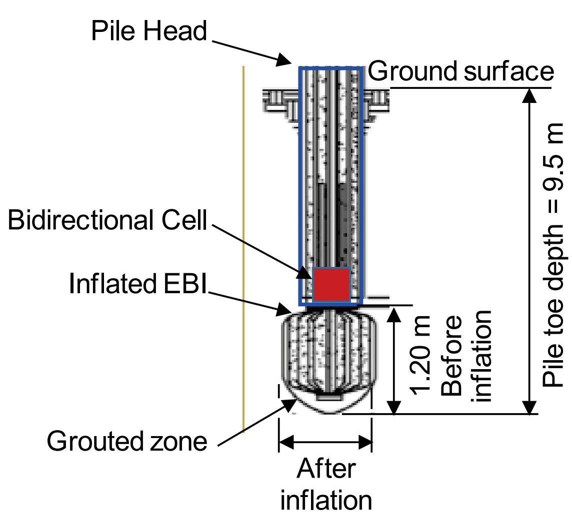

Fig. 4. Sketch showing the EB and BD arrangement (not to scale).

The pile construction procedures are as follows: The cylinder strength of concrete and mortar is designed to be 30 MPa (H4,300 psi). The reinforcement cage consists of six 16-mm bars in Piles A3, B2, and C1 and four 12-mm bars in Piles E. All reinforcement cages have a 6-mm spiral with a 250-mm pitch. All test piles are intended to be constructed to 9.5 m depth. All reinforcement cages are instrumented with strain-gages and bidirectional cell at the bottom end.

A. Three 620-mm diameter, bored piles, A1, A2, and A2, constructed using a slurry. Once the final depth is reached, the 500-mm reinforcement cage is placed in the pile. Thereafter, the concrete is tremied (pumped into the shaft starting at the toe of the pile). Pile A1 will have an EB800 placed below the BD. Pile A2 will have a "Toe Box" (TB) placed below the BD, which is a 500-mm diameter and 300 mm high steel telescopic device installed with the reinforcing cage. After the shaft concrete is hardened, grout is pumped into the TB expanding the height of the box and compressing the soil below the pile toe and introducing a compressive strain in the pile shaft. The TB will be equipped with a "Shaft Box" (SB), which is a folded steel belt welded to the outside of the TB. When the TB grout has hardened, grout is pumped into the SB expanding the width of the TB-SB to about 800 mm diameter compressing the soil around the TB. Pile A3 has neither EB nor TB. Pile A3 is a part of the prediction event.

B. Two 450-mm diameter continuous flight auger (CFA), partial displacement piles, B1 and B2. The central stem of the auger is 250 mm of O.D. Mortar is used instead of concrete in order to allow the subsequent installing the reinforcement cage. Pile B-1 has a bidirectional cell (BD) and an Expander Body (EB800) placed below the BD. Pile B2 are straight (have no EB) and are a part of the prediction event.

C. Two 450-mm diameter Full Displacement Piles (FDP) with "lost bit", C1 and C2. The equipment is illustrated in Figure 5 and consists of a 450-mm O.D. displacement body (pipe) with a 800 mm long bulb attached to a 1.15 m long auger with a 350-mm diameter. The auger rotation pulls down the displacement body. The drill equipment is a Bauer BG18PL with a 180-kMm maximum torque. The auger has a short conical tip that is left in the hole upon completion ("lost bit"). Pile C1 will have an Expander Body (EB600) at the toe and Pile C2 is straight. After placing the reinforcement cage in the casing, concrete is pumped into the shaft starting at the toe of the pile gradually withdrawing and the casing. The "lost bit" remains in the ground. Pile C2 is a part of the prediction event.

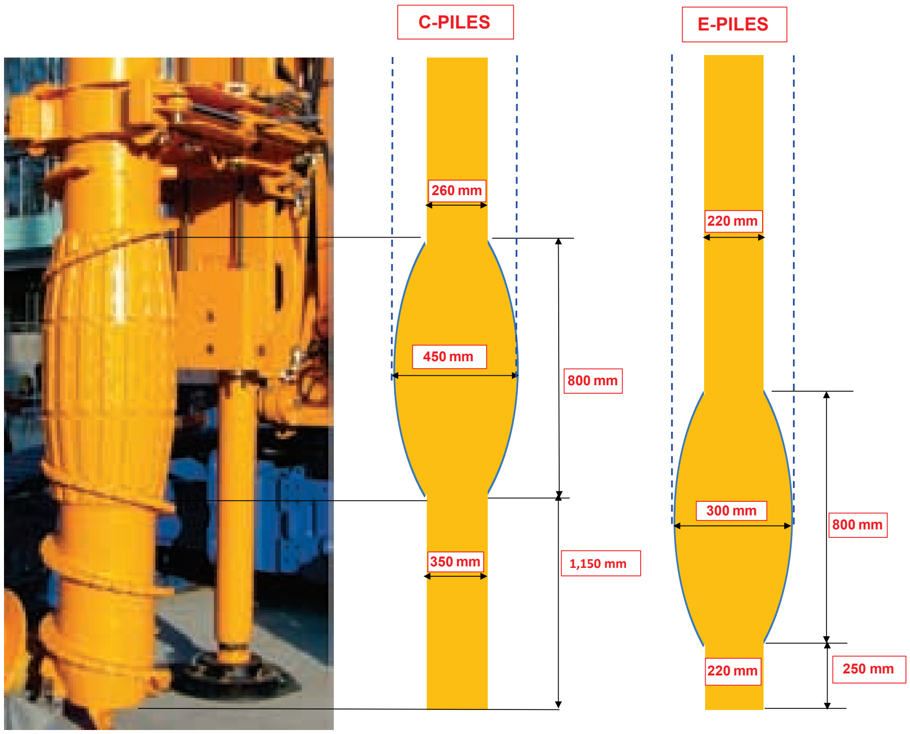

Fig. 5. Sketch showing equipment and geometry of the full displacement pile (not to scale).

D. Two 150-mm diameter self-boring micropiles, D1 and D2, with a 75-mm diameter drilling pipe and a cutting tool at the pipe end. Fluid grout is injected as the pile penetrates the soil. Pile D1 will have an Expander Body (EB600) at the toe and Pile D2 will be straight. The reinforcement cage consists of six 12-mm bars inside a 6-mm spiral with a 250-mm pitch. The drilling pipe remains in the pile. A solid 32-mm diameter bar will be placed inside the Pile-D1 drilling pipe to increase the axial stiffness of the shaft.

E. Fourteen 300-mm diameter FDP piles, E1 through E14. The equipment is illustrated in Figure 5.3 and consists of a 220-mm O.D. displacement body (pipe) with a 800 mm long bulb attached to a 0.25 m long auger with a 220-mm diameter (no lost bit). The auger rotation pulls down the displacement body. The drill equipment is a Bauer BG18PL with a 180-kNm maximum torque. All piles to have an EB300 at the toe and a BD above the EB. After placing the reinforcement cage in the casing, concrete is pumped into the shaft starting at the toe of the pile gradually withdrawing the casing. Pile E1 test will be a part of the prediction event.

F. Three bored piles with different diameter, 450, 600, and 1,200 mm, respectively, F1 - F3, constructed using a slurry. Once the final depth is reached, the reinforcement cage with attached gages and bidirectional cell (BD) is placed in the shafts of F1 and F2, but not in F1. Thereafter, 30-MPa strength concrete is tremied (pumped into the shaft starting at the toe of the pile. Static loading tests will be carried out on Piles F1 and F2. Pile F3 is intended for integrity testing, only.

G. 300 mm diameter long helical pile, G1.

H. Spare test locations for use for potentially needed back-up piles.

I. Five piles denoted DC1200-1 through DC1200-5 will be installed with intentional, but undisclosed, defect(s) and various integrity testing methods will be used for comparing the results of the tests to the actual defects.

The results of the tests on Pile Types A through D are intended to be used for comparing the response of same type piles with and without toe enhancement (EB, TB, and SB) and to the other pile types in terms of stiffness, shaft and toe responses, and ultimate resistance. The results of the test on Pile E1 will serve as reference to the results of the tests on the E-piles. Phase 1 is a bidirectional test. The BD test on the E-pile group will apply equal force to the piles, while measuring the upward and downward movements for each pile at the cell level and the pile head (the movements will differ depending on the position in the group). The second, Phase 2, is a head-down test. For the E-pile group, the piles are encased in a rigid pile cap cast on the ground. Thus, the head-down test will involve equal movement of all pile heads and measuring the resulting pile forces by means of a load cell placed on the pile heads immediately below the pile cap (before casting the cap).

5.2 Pile Instrumentation

The pile head movement is measured against two reference beams supported on the ground at a 2.5 m distance from the test pile and placed parallel to the pile center line.

Each BD-equipped pile will have two pairs of telltales placed diametrically opposed. One pair will measure the movement between the pile head and the bottom of BD plate and one will measure between the pile head and the upper BD plate. Subtracting one from the other will give the opening of the BD cell.

TABLE 1. Pile and Test Summary**.**

PILE ID	PILE TYPE	PILE DIAMETER (mm)	ATTACHED DEVICE	TEST and SEQUENCE	THERMAL INTEGRITY PROFILER (TIP)	CROSS-HOLE CHECK pvc or steel pipe	GAGE TYPES and LEVELS	
							VW	RESISTIVE
A-1	Bored Pile	620	EB (800)	BD+HD+DT	2wires		L1, L2, L3	L1, L2, L3
A-2			TB + SB	BD+HD+DT			L1, L2, L3	L1, L2, L3
A-3*				HD+DT				L1, L2, L3
B-1	CFA	450	EB (600)	BD+HD+DT			L1, L2, L3	L1, L2, L3
B-2*				HD+DT				L1, L2, L3
C-1	FDP	450	EB (600)	BD+HD+DT			L1, L2, L3	L1, L2, L3
C-2*				HD+DT	2 wires			L1, L2, L3
D-1	Self boring Micropile	150	EB (500)	HD			L1, L2, L3	L1, L2, L3
D-2				HD				L1, L2, L3
E-1*	FDP	220	EB (300)	BD+HD			L1, L2, L3	L1, L2, L3
E-2 to E-14			EB (300)	BD+HD			L1, L3	L2
F-1	Drilled with slurry	450		BD+HD+DT	2 wires	1 pvc	L1, L2, L3	L1, L2, L3
F-2		600		BD+HD+DT	4 wires	3 pvc	L1, L2, L3	L1, L2, L3
F-3		1,200			6 wires	5 pvc		L1, L2, L3
G-1	Helical	300		HD			L1, L2, L3	L1, L2, L3
DC1200-1	Bored Pile with retrievable casing	1,200			6 wires	5 steel	L1, L2, L3	L1, L2, L3
DC620-1		620			4 wires		L1, L2, L3	L1, L2, L3
DC620-2		620			4 wires	3 steel	L1, L2, L3	L1, L2, L3
DC620-3		620			4 wires	3 pvc	L1, L2, L3	L1, L2, L3
CFA450-1	CFA	450			2 wires		L1, L2, L3	L1, L2, L3
CFA450-2		450			2 wires	1 pvc	L1, L2, L3	L1, L2, L3
FDP450-1	FDP	450			2 wires		L1, L2, L3	L1, L2, L3
FDP360-1	FDP	360			2 wires		L1, L2, L3	L1, L2, L3

NOTES:

Length: All piles intended for static testing will be installed with pile toe at 9.5 m below grade
For pile with EBI unit, the depth is measured to bottom of the EBI before expansion

* PREDICTION PILE

BD: BIDIRECTIONAL STATIC LOADING TEST

HD: HEAD-DOWN STATIC LOADING TEST

SG: INSTRUMENTED WITH STRAIN GAGES

DT: DYNAMIC TEST

(blue) PILES FOR LOADING AND INTEGRITY TESTS

(orange) PILES FOR INTEGRITY TESTS ONLY

EB: EXPANDER BASE
TB: TOE BOX
SB: SHAFT BOX

L: GAGE LEVEL
L1 at 2.0 m depth
L2 at 5.0 m depth
L3 at 7.5 m depth

Pairs of sister-bar strain-gages manufactured by Geovan Geotechnical Instruments (www.Geovamn.com) are placed in each of the single test piles at 2.0, 5.0, and 7.5 m depths.

Toe accelerometers are placed in piles Type A, B, C, F, and G in order to indicate the toe movement during the dynamic testing performed after completion of the static loading test programme.

Pipes for Cross Hole Test are provided in Piles A, B, and C

Thermal Wires are installed in Piles A, C, and E.

The BD pressure (load) and the upward and downward movement of the pile at the BD level and at the pile head will be measured using two pairs of telltales.

At the E-group piles, the soil is instrumented to measure movement between the pile and the soil and soil strain during Phases 1 and 2. They are placed at 0.5 m depth below the slab and at the pile toe level using a soil anchor system at two points: mid-way between Piles E5 and E6 and Piles E10, and E11. Two earth-stress cells are also placed to measure contact stress in Phase 2 of the E-group test: below the pile cap at mid-way between Piles E5 and E10 and Piles E6, and E11

One soil anchor is also installed near the single pile, Pile E1 before the pile is installed and placed at the pile toe level at an about 0.35-m distance from the pile surface.

5.3 Pile Test Methods and Procedures

The test procedure is according to the "quick method" consisting of a series of equal load increments applied at 15-minute time intervals and held constant (electrically operating, automatic pressure-holding pump is required) during each interval until excessive movements have developed, whereupon the pile is unloaded in five or six about equal decrements, each maintained for 5 minutes.

The load increments are about 5 % of estimated maximum load. N.B., the test will continue until reaching either the pile plunges or the limit of available force, or the limit of expansion of the BD cell or of the jack is reached. The total test duration is, therefore, about 5+ hours. All gage readings will be recorded in a common data logger (multi-channel) and 30-s scan intervals. (All tests must have a data logger capable to record all data simultaneously in order to ensure that the data logger will scan and record all gages to a common file and time stamp).

6. PILE GROUP TESTS

The pile group is made up of 13 Type E piles (Piles E2-E14) installed by as FDP piles at a c/c of 2.5b (0.6 m) configured as shown in Figure 6. The soil within the E-piles is instrumented with gages measuring strain (soil shortening over a short distance) underneath the pile cap and at the pile toe level.

After the completion of the BD tests, Phase 1, the single pile and the group piles are subjected to a head-down test with, Phase 2, open BD and, Phase 3, closed BD.

Phase 2 will start after the completion of Phase 1 by placing a load cell on each pile head, then, a 0.2 m thick compacted sand layer is placed around the piles and a rigid reinforced concrete slab connecting the piles is cast on the ground encompassing all piles. The slab is cast directly on to the sand layer so as to ensure a contact between the group slab and the soil. Before casting the slab, a 200 mm thick sand layer is placed on the ground and compacted. The slab is loaded by means of weights or by jacking it against a loaded platform, engaging all 13 group piles. The BD units are open (free-draining) in the Phase-2 test.

Potentially, a Phase 3 will be performed as a repeat of Phase 1 with the pile rigid cap (platform) remaining but unloaded.

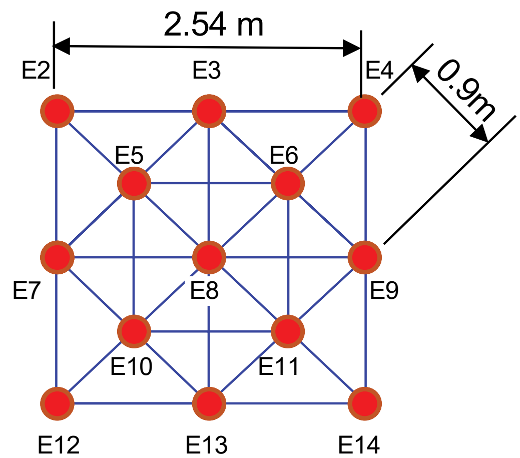

Fig. 6. B.E.S.T. Pile group configuration (E2 – E14).

7. PREDICTION EVENT

Single Piles, A3, B2, C2, and E1, and group Piles E2 - E14 are part of a prediction event addressing the pile response in terms of load-movement. The event will be reported in Volume 3 of the conference proceedings.

8. INTEGRITY TESTS and DEMONSTRATION

An integrity testing field demonstration is held on Friday April 28 immediately before the conference. The piles intended for the demonstration will have been supplied with intentional flaws of different types. The design of the flaws has been discussed with the participating commercial laboratories specializing in pile integrity test, but how the flaws are arranged in the test pile and, indeed, if an intentional flaw is included in a specific pile, is not disclosed to the participants in the demonstration. All "integrity" piles will include thermal wires. The Integrity Demonstration is reported separately. The pile types included are:

- Pile DC1200-1, 1,200-mm diameter bored pile with retrievable casing
- Piles DC620-2 and DC620-3, 620-mm diameter bored pile with retrievable casing
- Piles CFA450-1 and CFA 450-2, 450-mm FDP piles

9. COMPILATION OF BOREHOLE INFORMATION AND IN-SITU TESTS

9.1. Boreholes

Eight boreholes were drilled with SPT split-spoon sampling. Three (BH-B2, BH-F1, BH-G1) to 9.5 m depth and five (BH-A3, BH-C1, BH-D1, BH-E1, and BH E2)to 25 m depth. The distributions of grain size, water content, plastic and liquid limits, and SPT N-indices (with q_t-diagram) have been compiled in a single set of diagrams from each borehole as shown below. Electronic format information is available for downloading.

The SPT hammer weight was 62.5 kg and the free-fall height was 760 mm according to the ISSMGE reference procedure. Nominal hammer energy is 466 J. Dynamic tests were carried out at BH-B2 at 6 through 09.5 m depth. The transferred energy ratio (ETR) for the test are shown in Figure 7.1. The ETR mean value is 44 %.

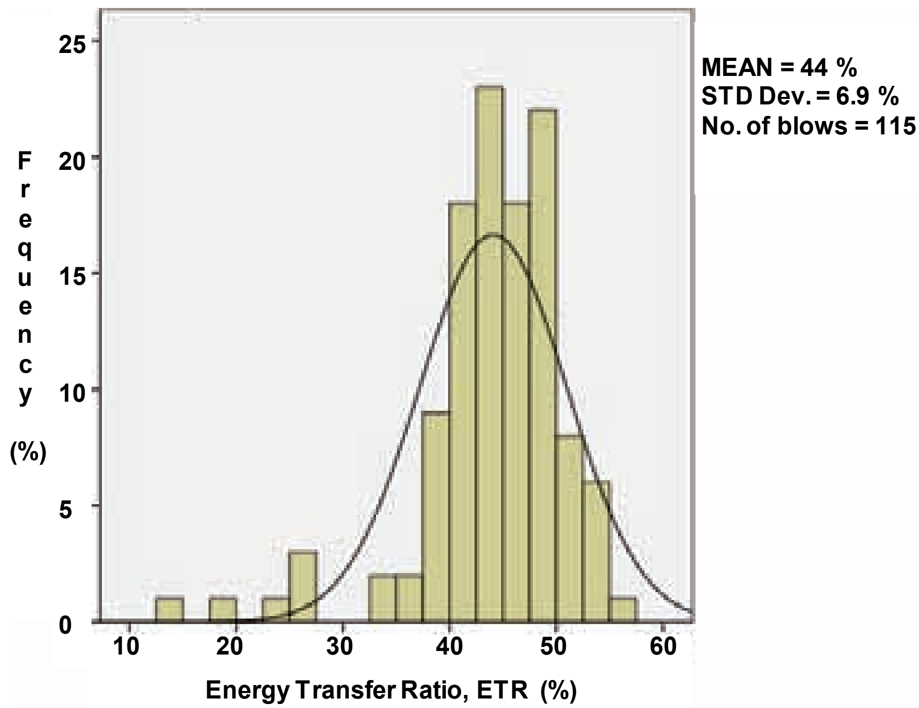

Fig. 7. Histogram of transferred energy at BH-B2, depths 6 m through 9.5 m.

Water content was determined on a sample from all depths. Plastic and liquid limits were determined on samples where visual inspection suggested cohesive condition. The water content values and Atterberg limits together with the fines contents show most of these samples to be silt more than clay.

The "Soil Type Fraction" indicates the amount of fines in percent of total sample (Sieve #200). No gravel was found in the samples.

9.2. Summary of Borehole Data

The results of the laboratory and SPT investigations of boreholes: BH-A3, BH-B2, BH-C1, BH-D1, BH-E1, BH-E2, BH-F1 and BH-G1 are shown Figures 8 through 15.

The as-recorded SPT *N*-indices are shown in bars and the CPTU q_t-curve is overlaid the *N*-index diagram. Note, as the boreholes and the CPTU soundings (15 in total) are about 1 to 2 m apart, the soil boundary depths indicated by the N-index bar and water content curve do not always agree with boundary depth suggested by the q_t-curve.

All the five 25-m deep boreholes, show an about 1 m thick clay and silt layer at about 11 m depth (12 m in BH-D1) immediately above a same thickness sand layer.

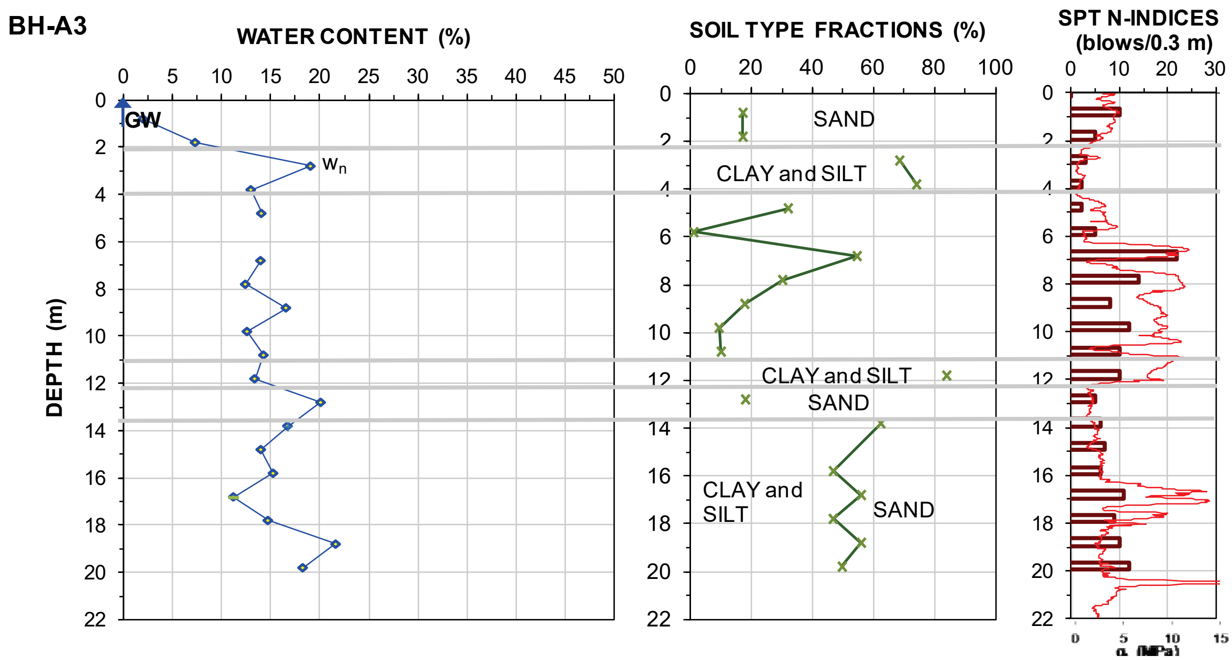

Fig. 8. Borehole data and SPT N-values, BH-A3.

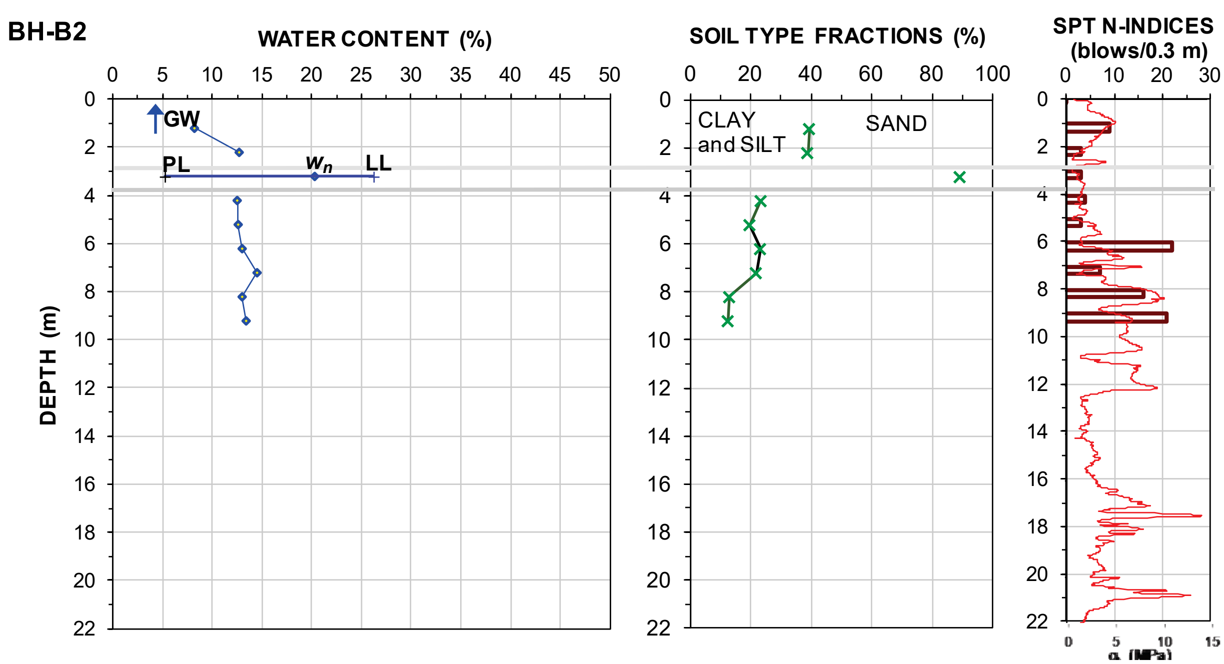

Fig. 9. Borehole data and SPT N-values, BH-B2.

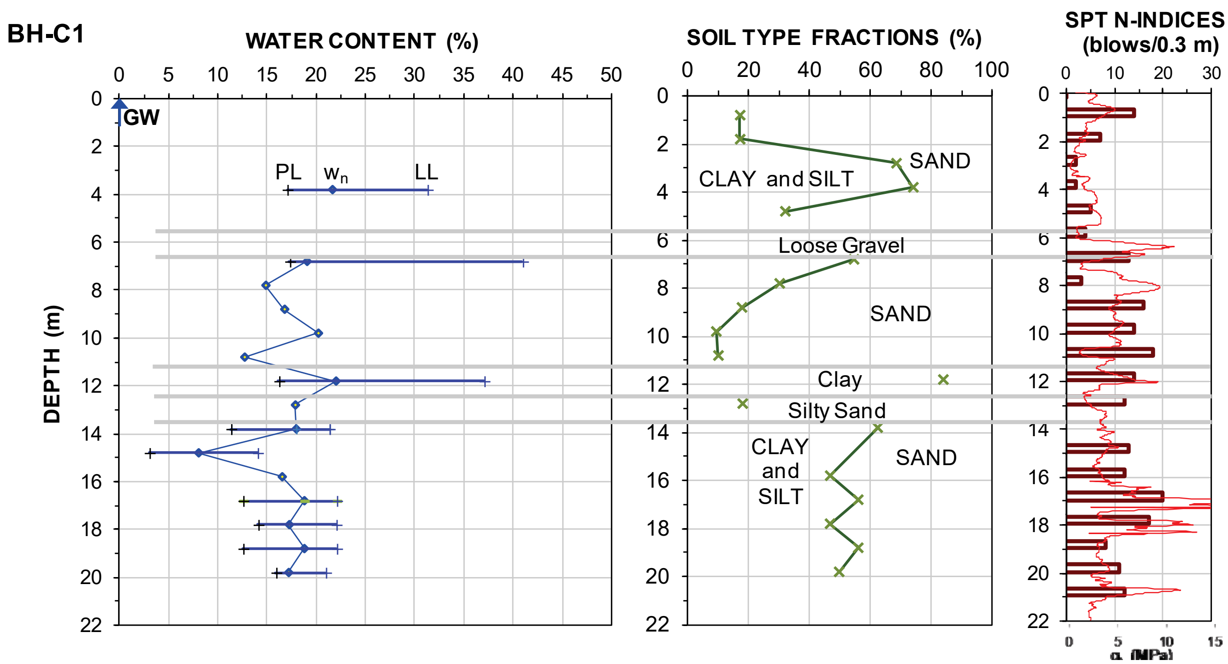

Fig. 10. Borehole data and SPT N-values, BH-C1.

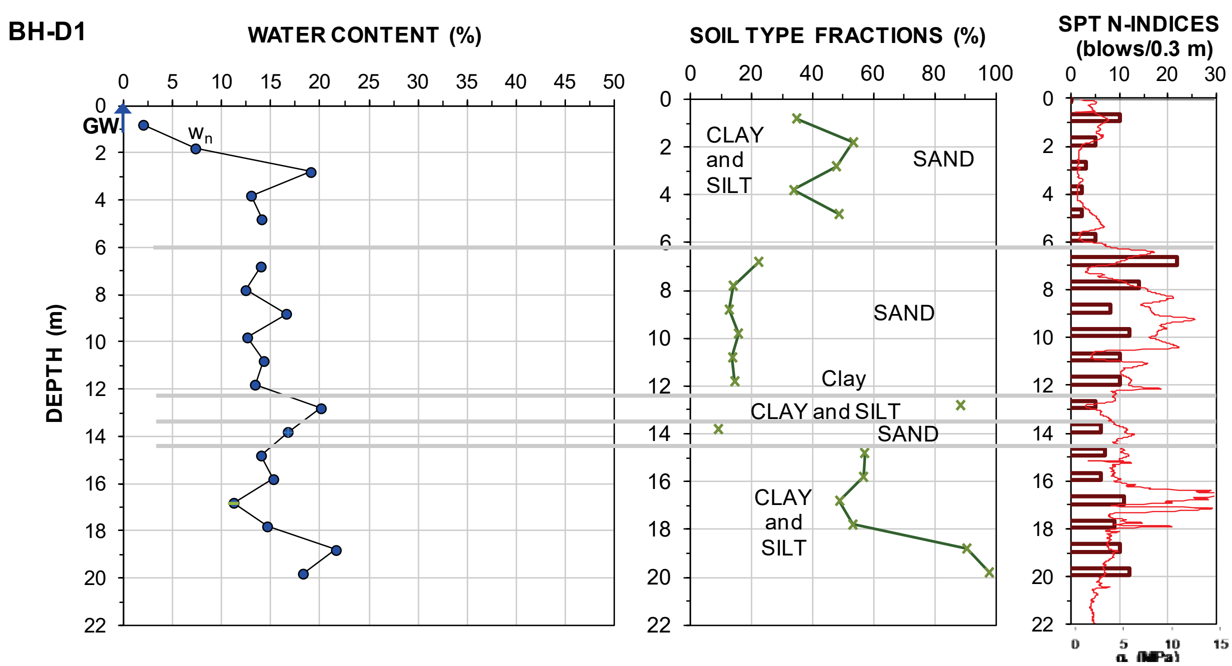

Fig. 11. Borehole data and SPT N-values, BH-D1.

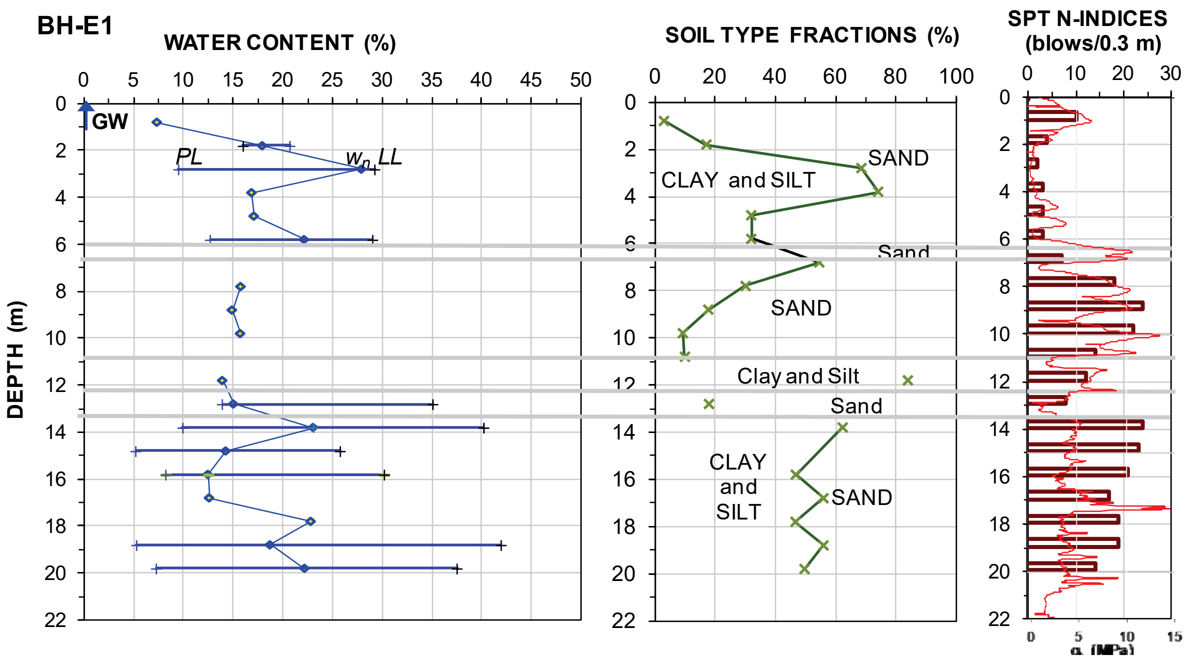

Fig. 12. Borehole data and SPT N-values, BH-E1.

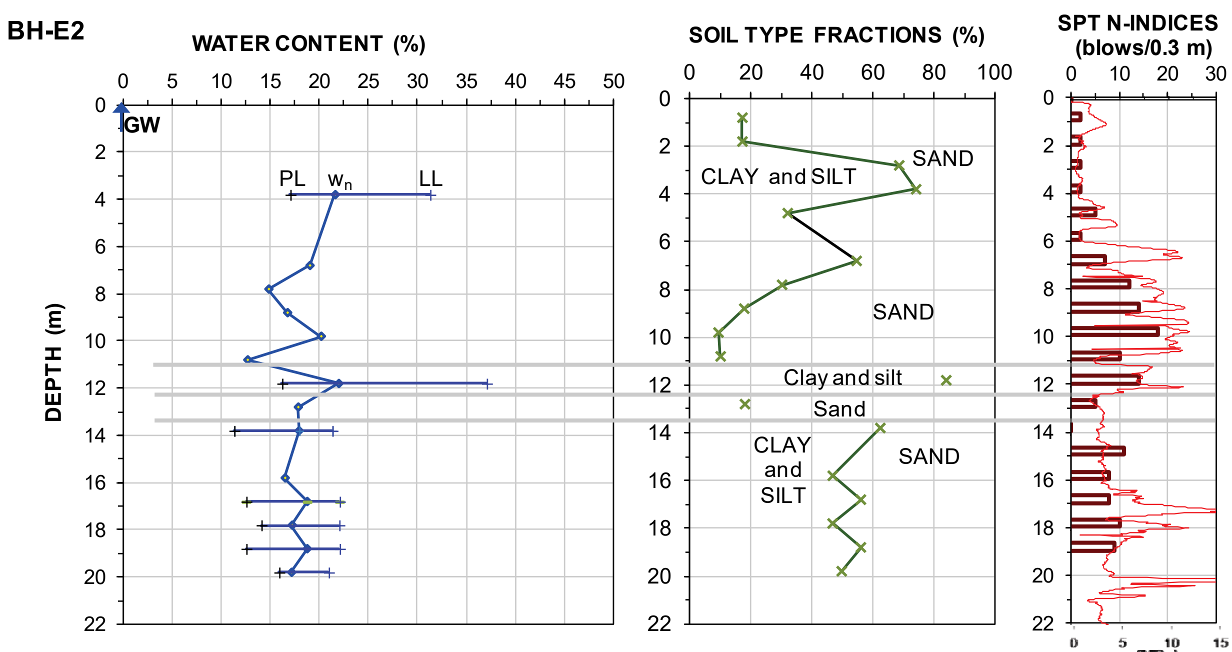

Fig. 13. Borehole data and SPT N-values, BH-E2.

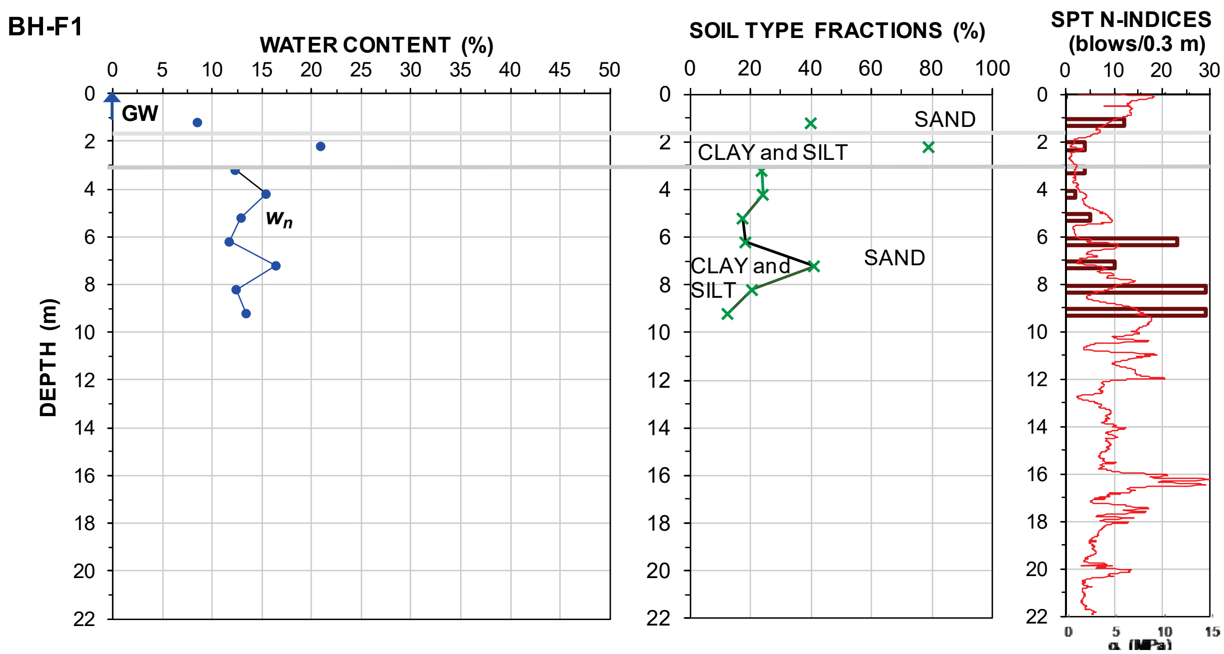

Fig. 14. Borehole data and SPT N-values, BH-F1.

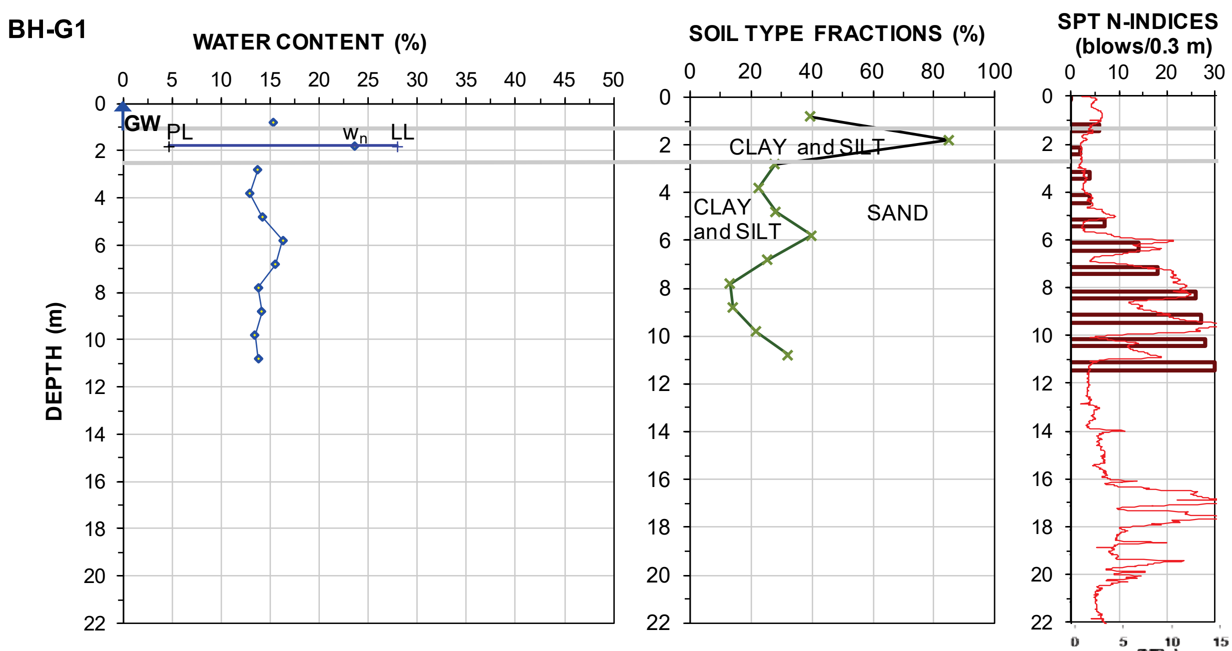

Fig. 15. Borehole data and SPT N-values, BH-G1.

9.2 Cone Penetrometer Soundings

The cone penetrometer soundings with pore water pressure measurements are presented in the following diagrams, Figures 16 - 30. For text files with the results of the cone penetrometer tests, see the conference web site. Figure 16 is a compilation of all cone stress measurements, q_t, corrected for pore water pressure. Note that the line indicating the neutral pore pressure distribution is only a fit to the U2-pressure and does not necessarily indicate the depth to the groundwater table.

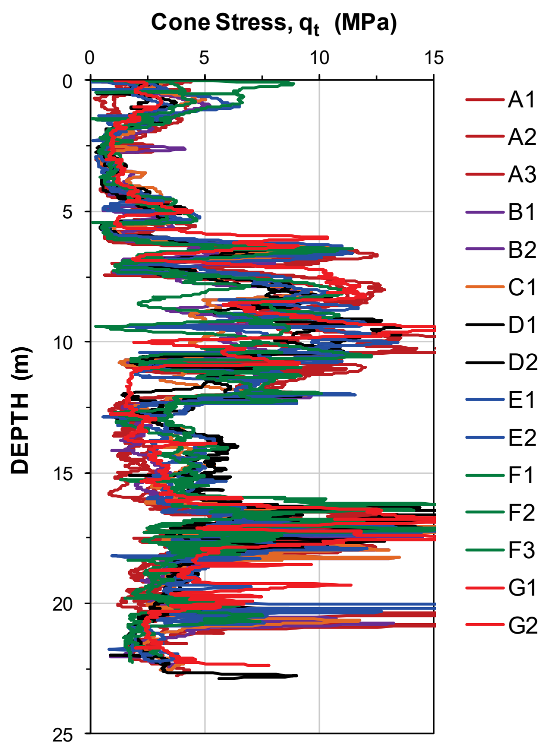

Fig. 16. CPT q_t records from 15 tests.

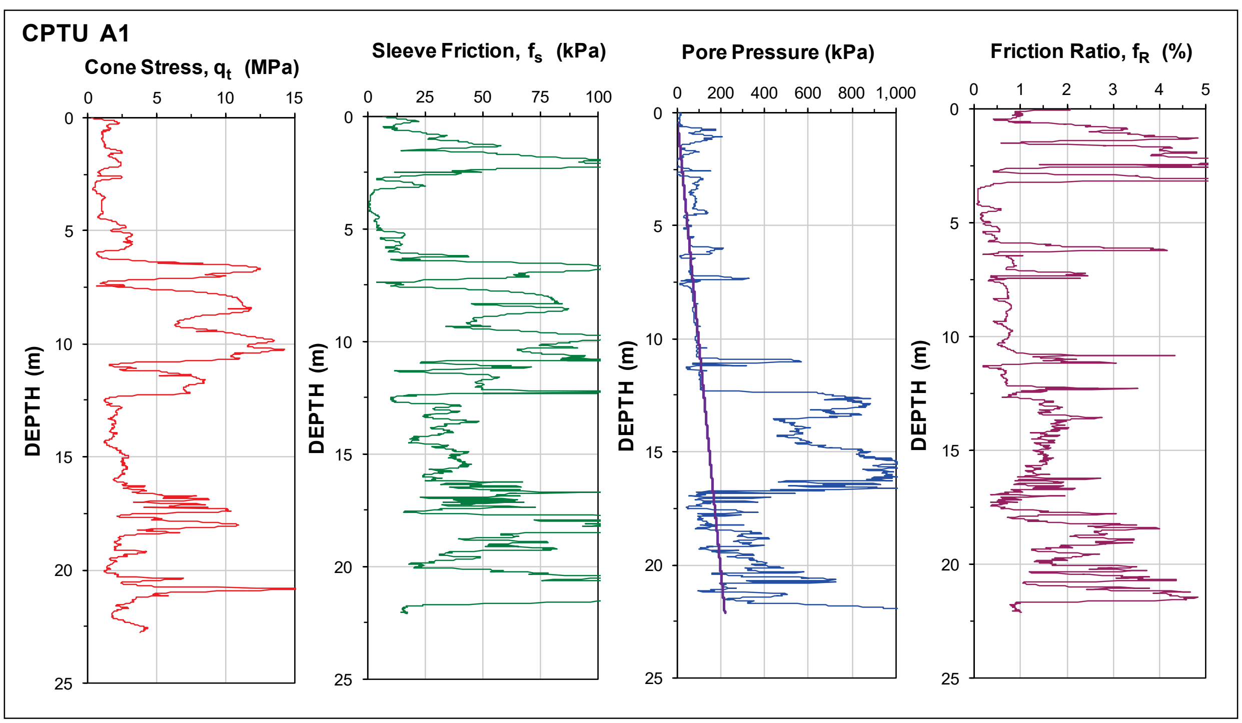

Fig. 17. Results of CPTU A1.

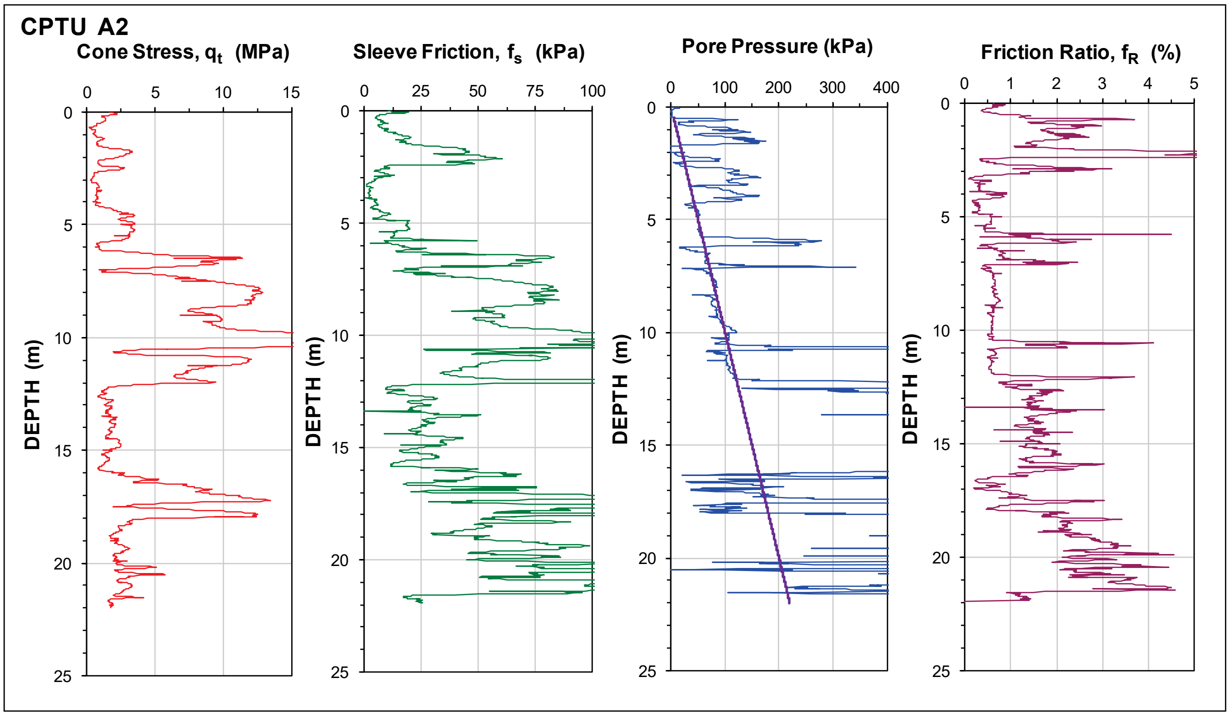

Fig. 18. Results of CPTU A2.

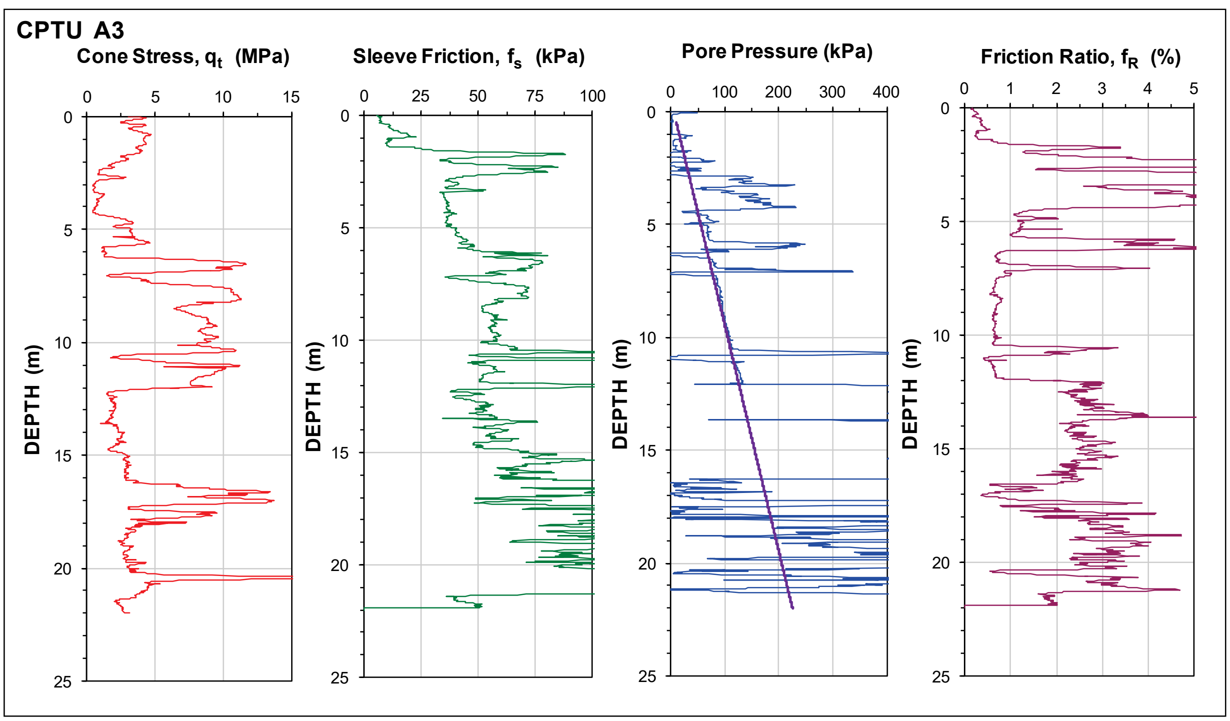

Fig. 19. Results of CPTU A3.

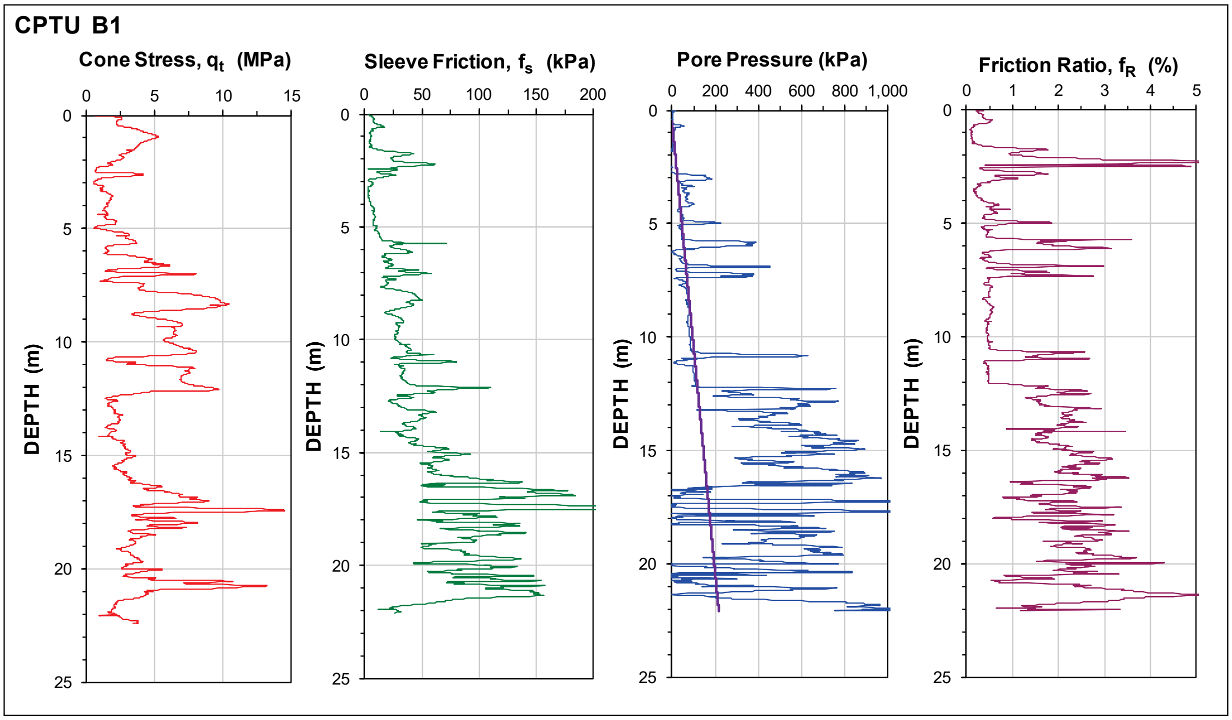

Fig. 20. Results of CPTU B1.

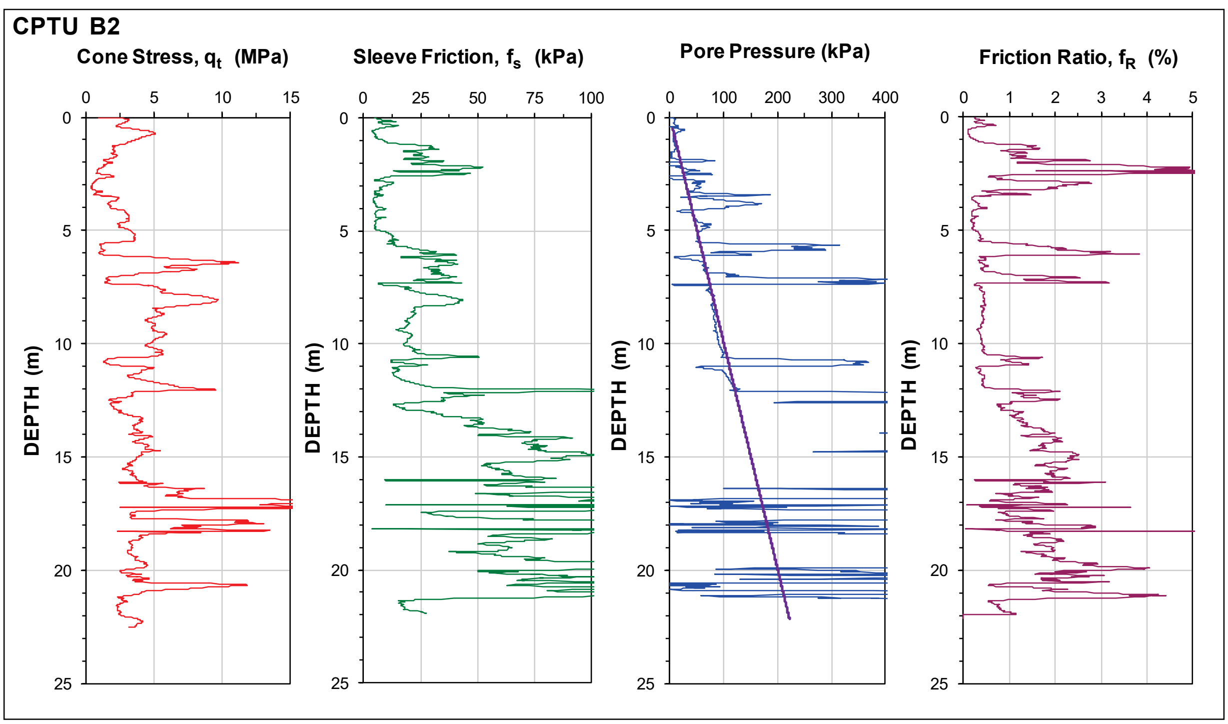

Fig. 21. Results of CPTU B2.

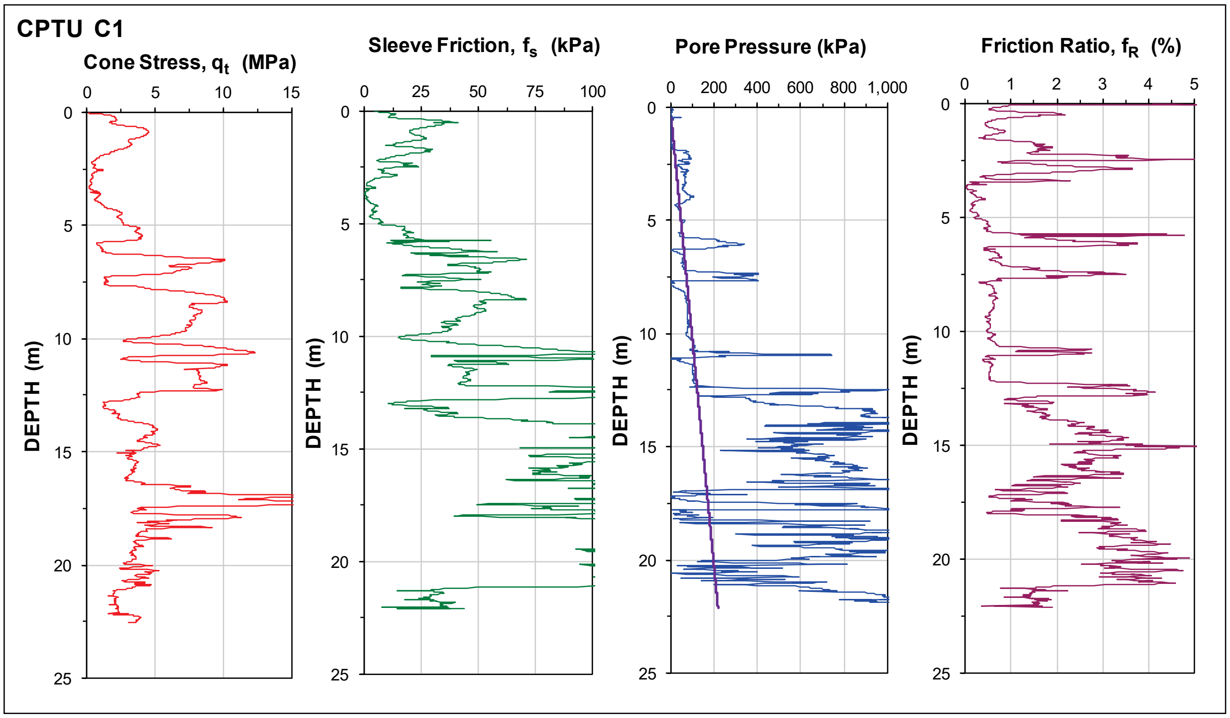

Fig. 22. Results of CPTU C1.

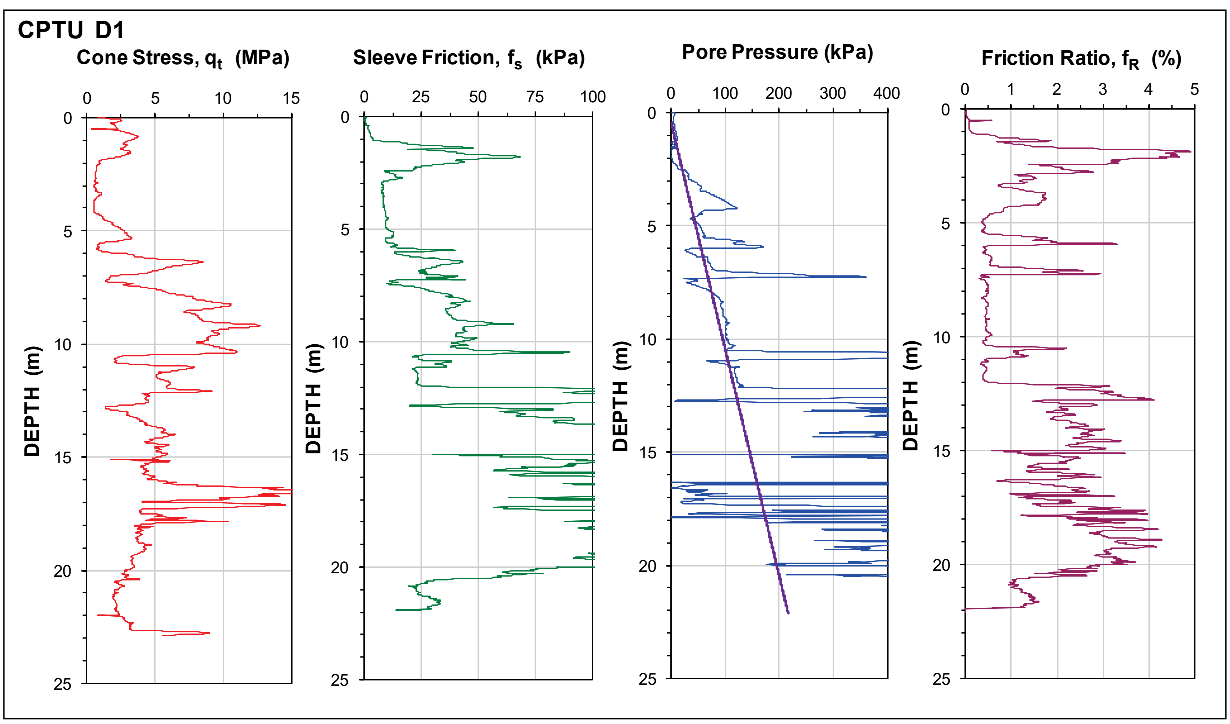

Fig. 23. Results of CPTU D1.

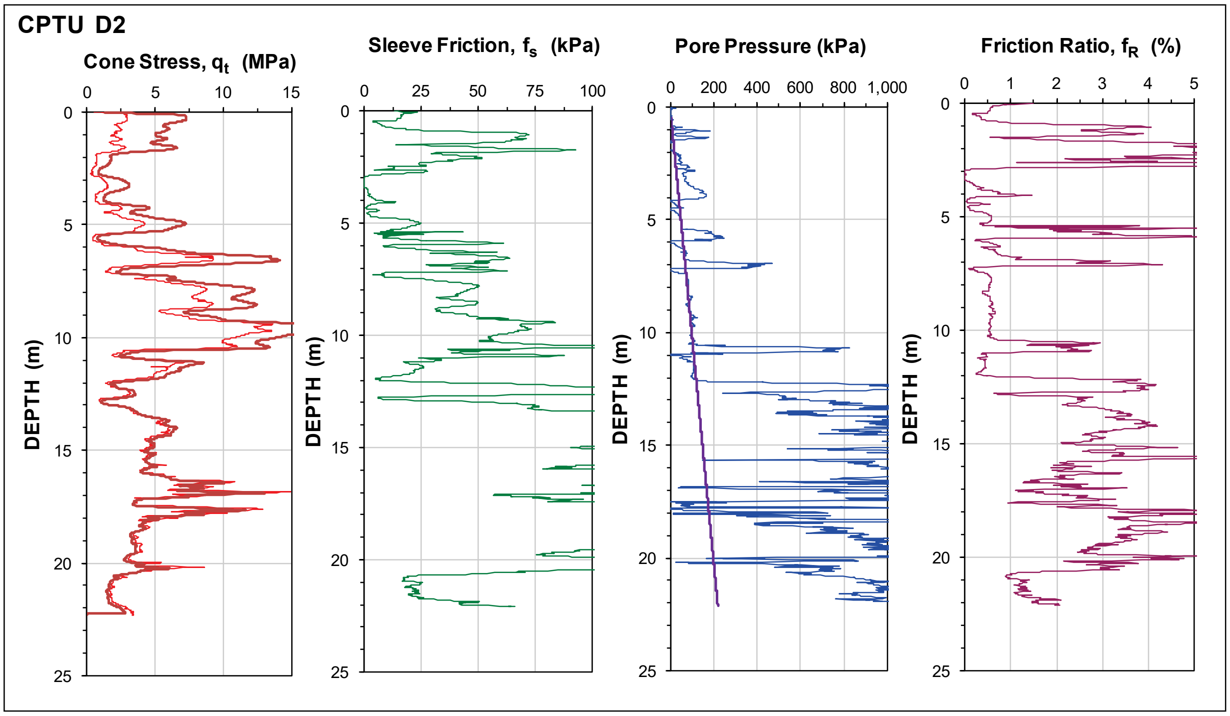

Fig. 24. Results of CPTU D2.

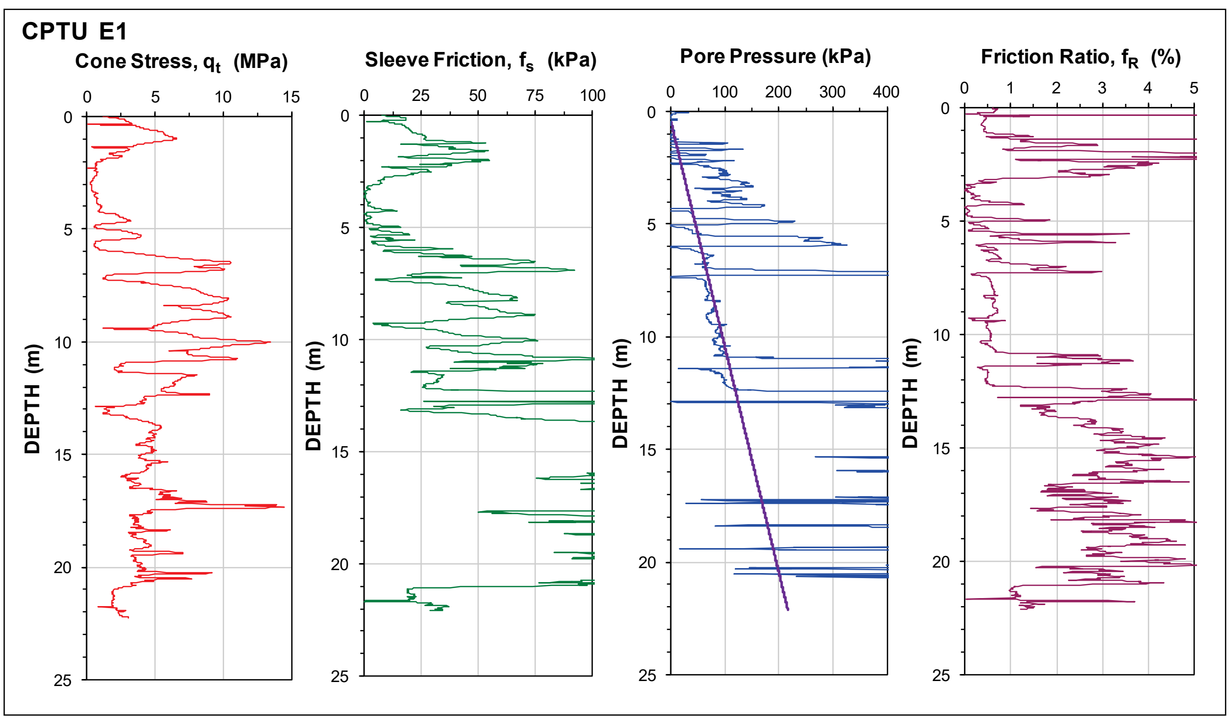

Fig. 25. Results of CPTU E1.

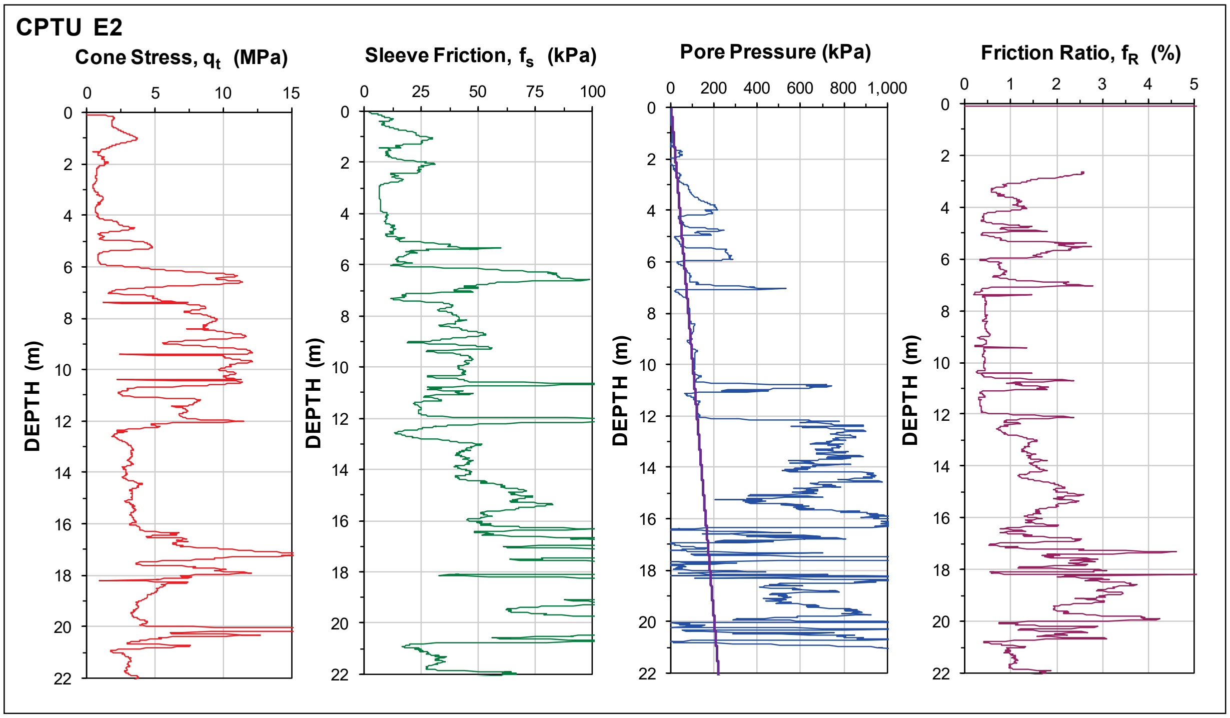

Fig. 26. Results of CPTU E2.

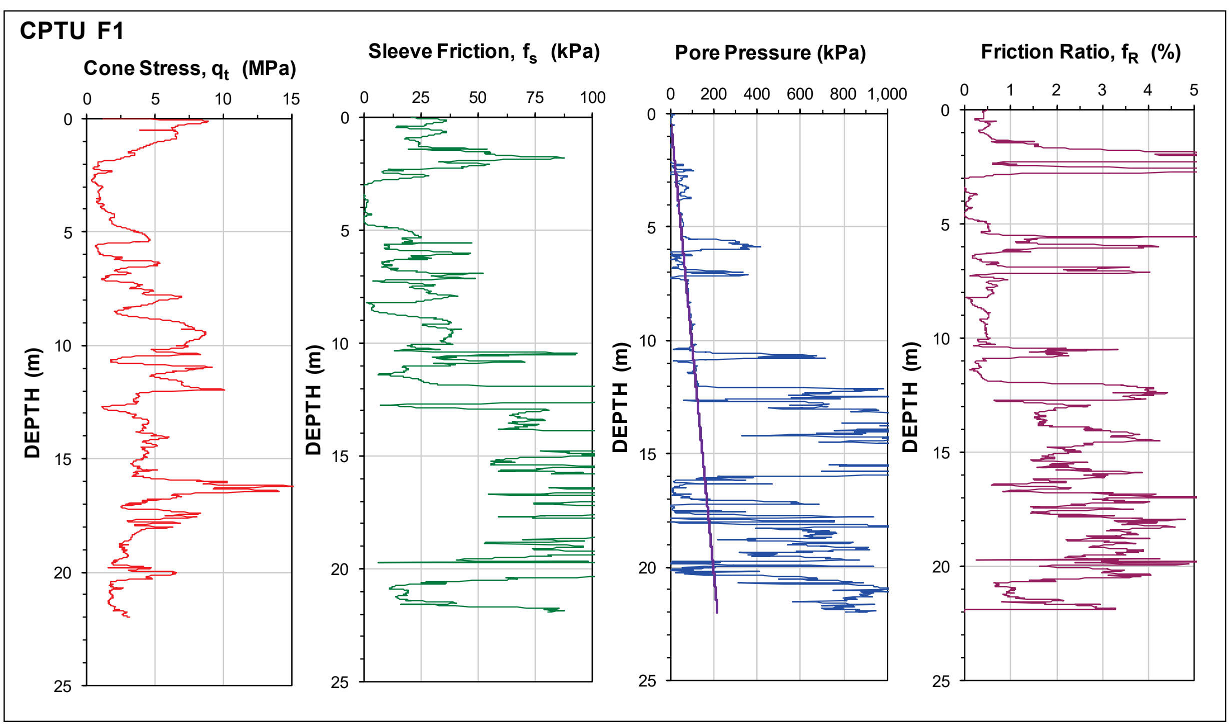

Fig. 27. Results of CPTU F1.

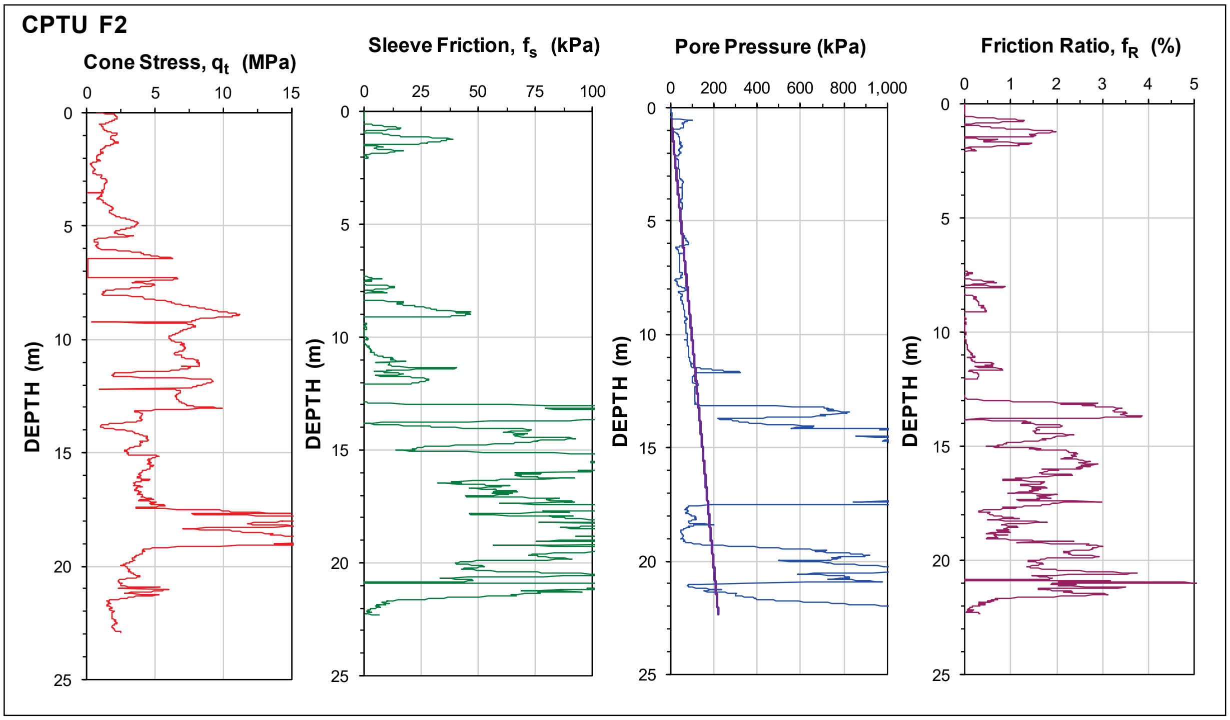

Fig. 28. Results of CPTU F2.

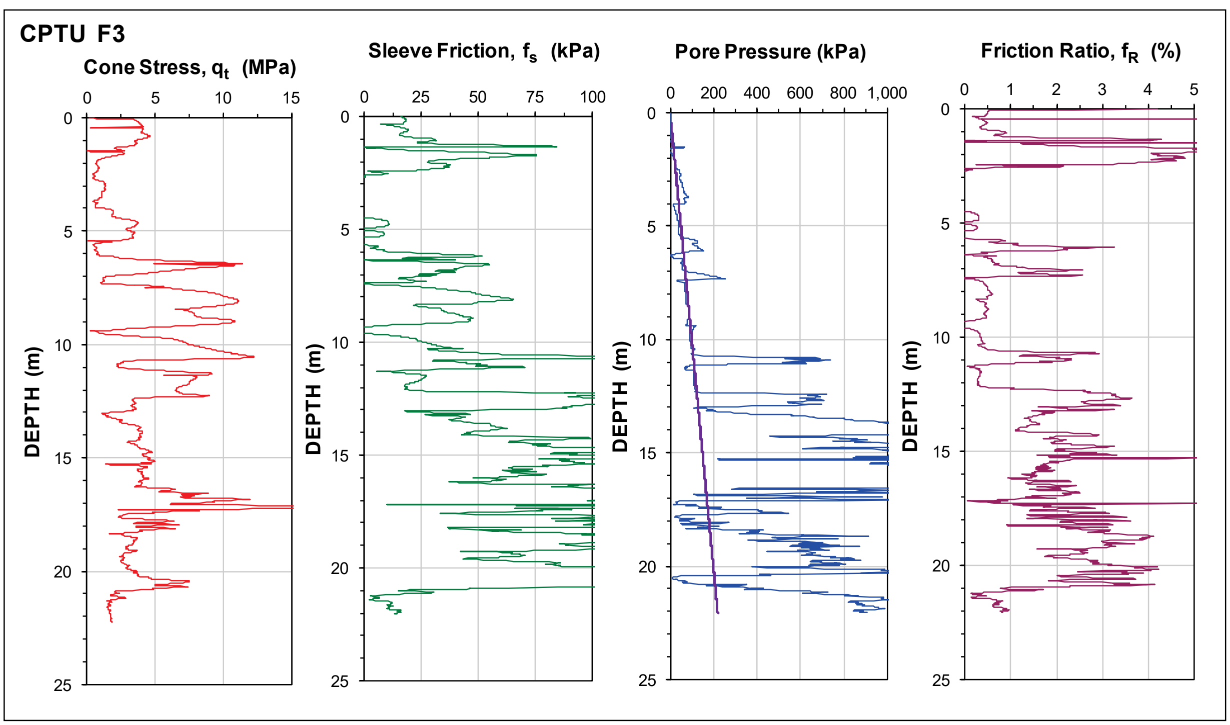

Fig. 29. Results of CPTU F3.

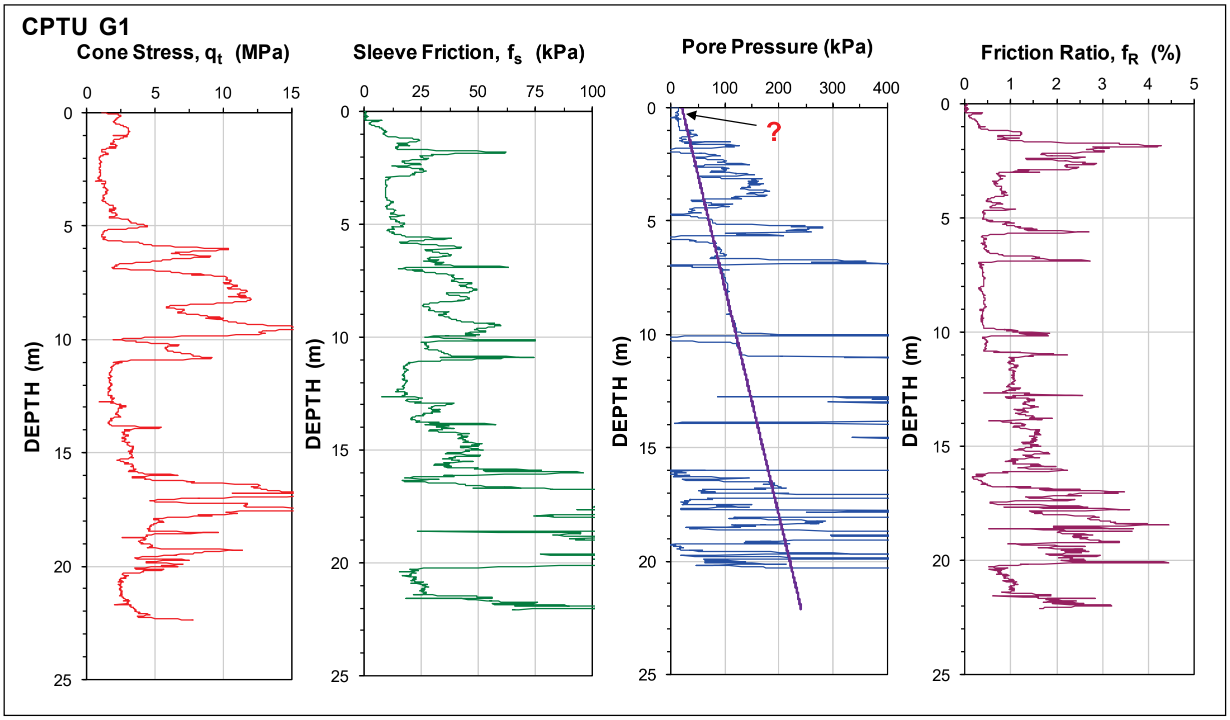

Fig. 30. Results of CPTU G1.

9.3 Dilatometer Tests

Figure 31 is a compilation of all DMT results. For graphic and text files with the results of the dilatometer tests, see the conference web site.

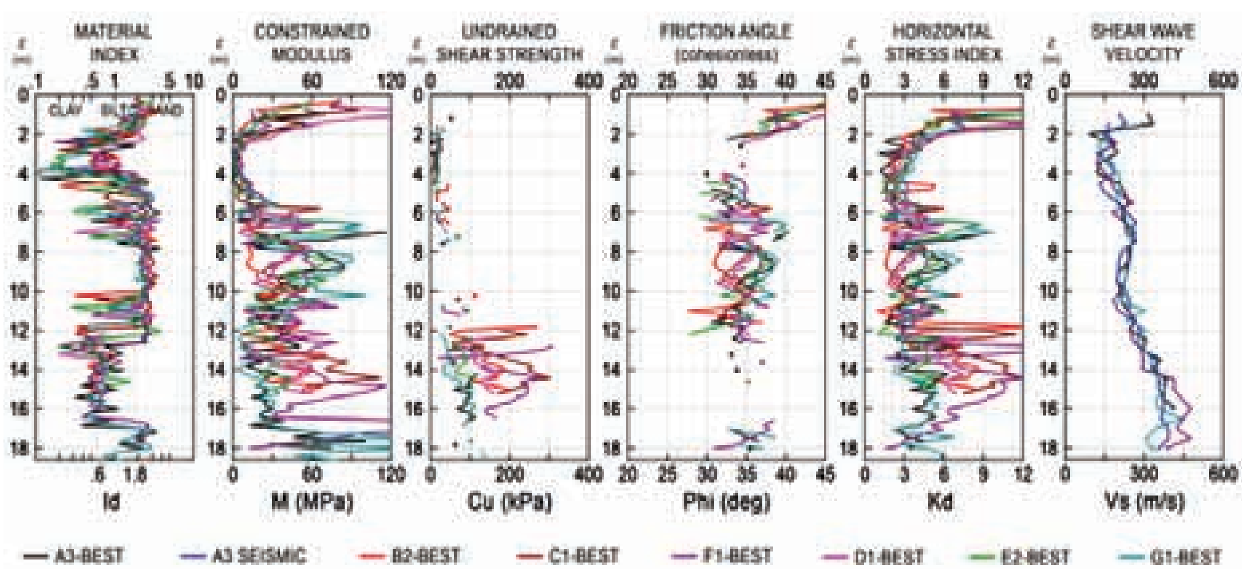

Fig. 31. Compilation of all DMT results.

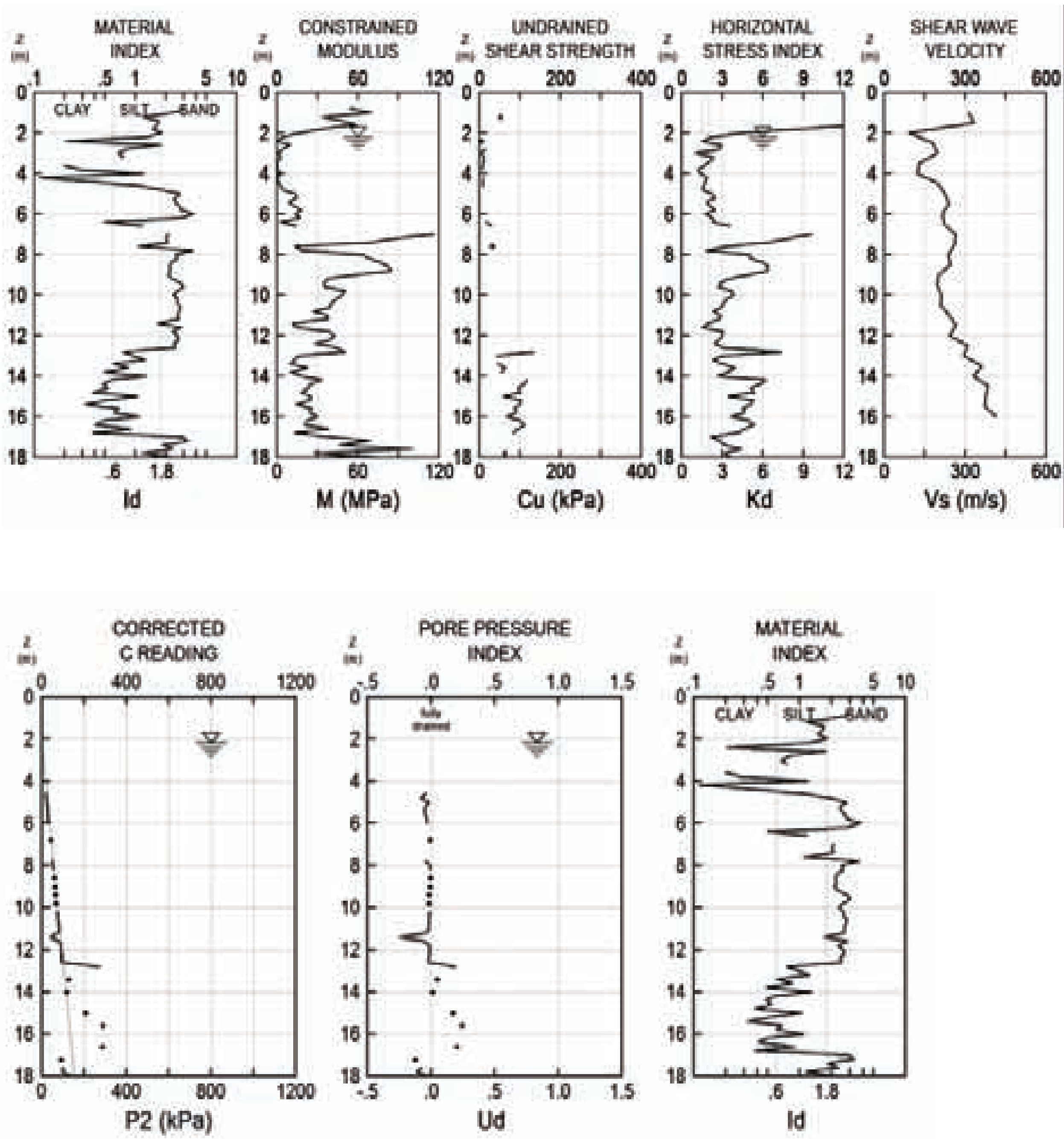

Fig. 32. DMT results, A3.

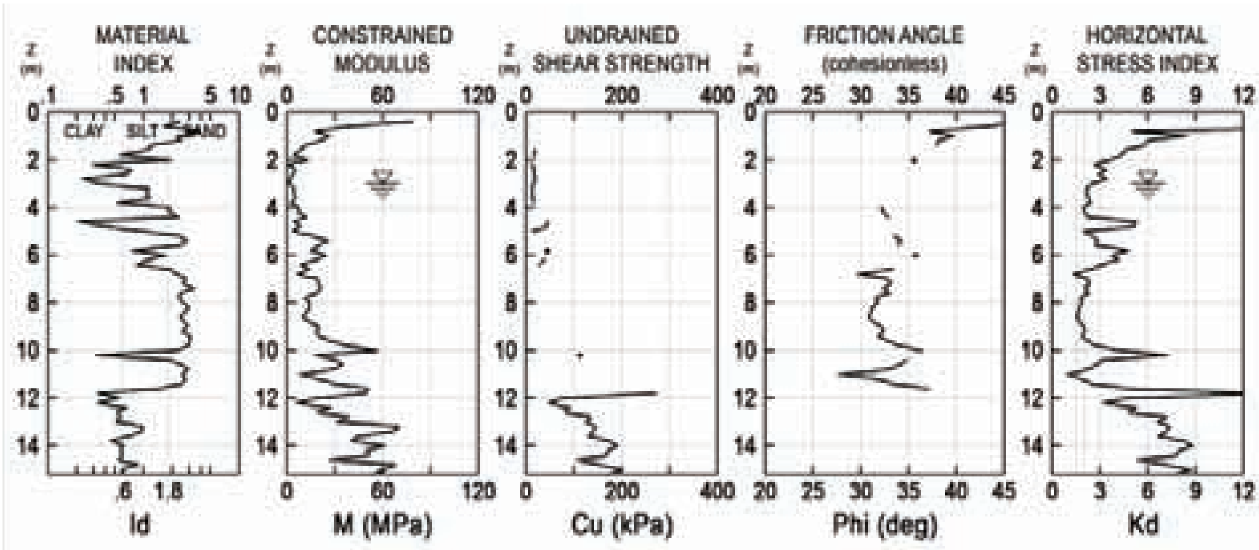

Fig. 33. DMT results, B2

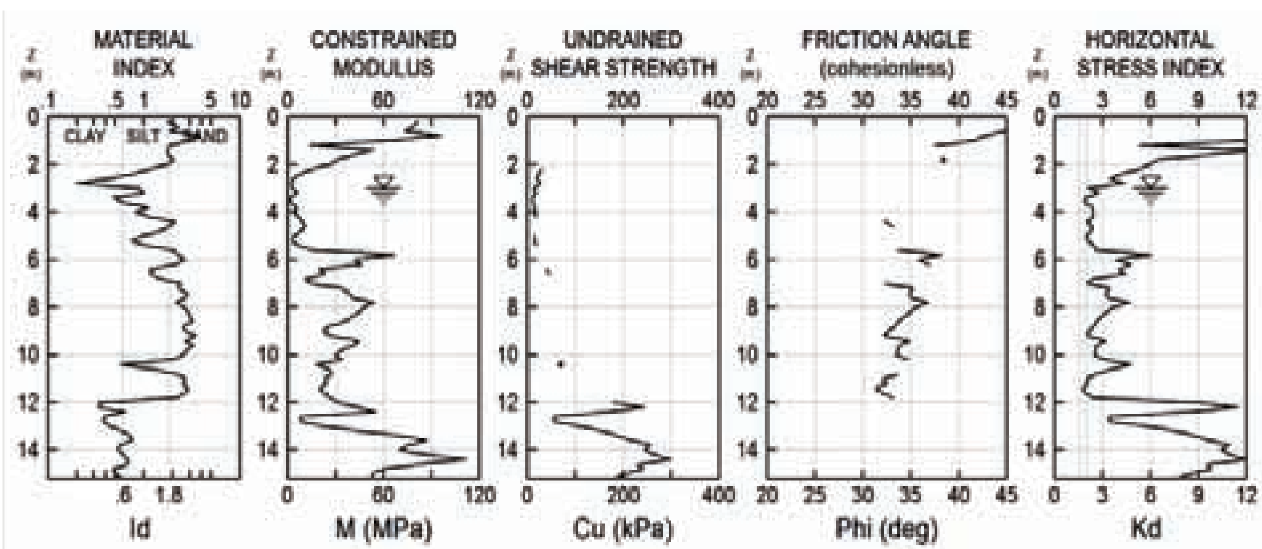

Fig. 34. DMT results, C1.

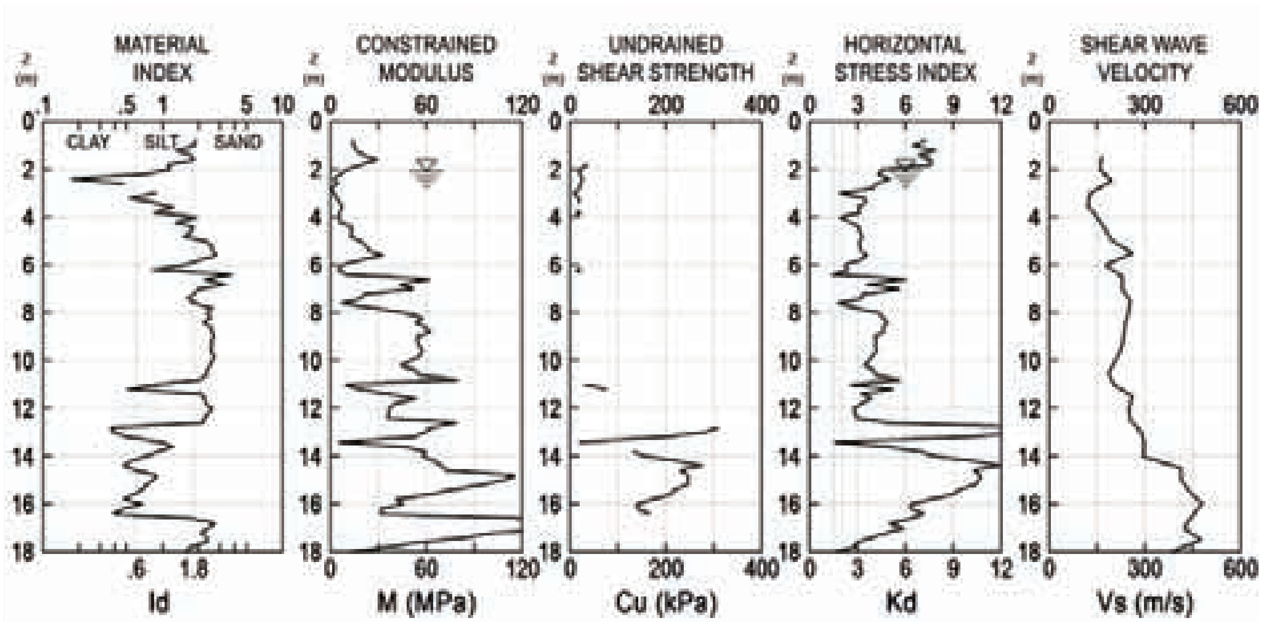

Fig. 35. DMT results, F1.

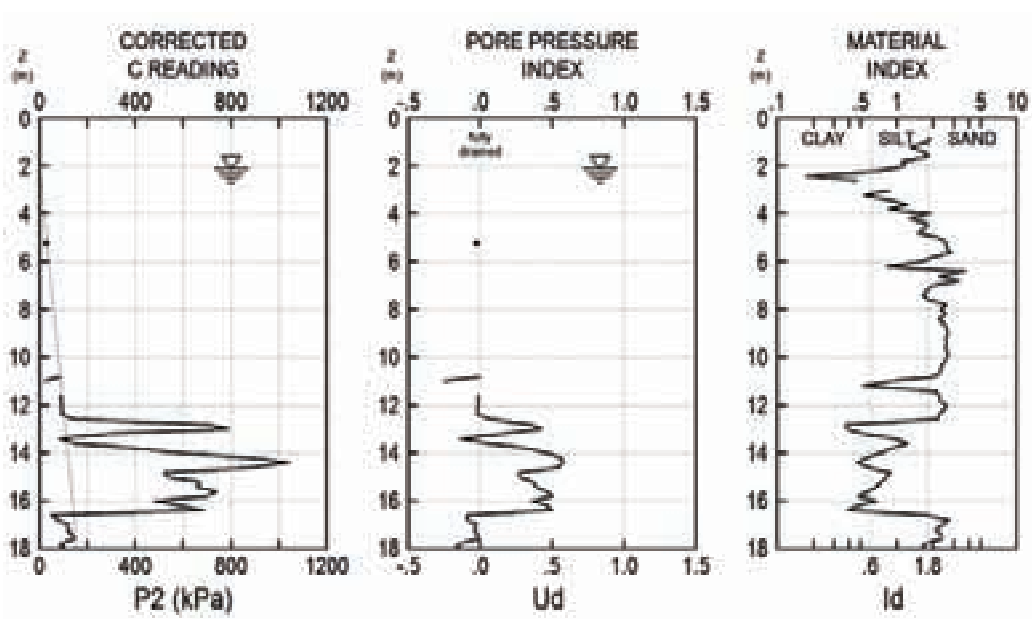

Fig. 36. DMT results, F1.

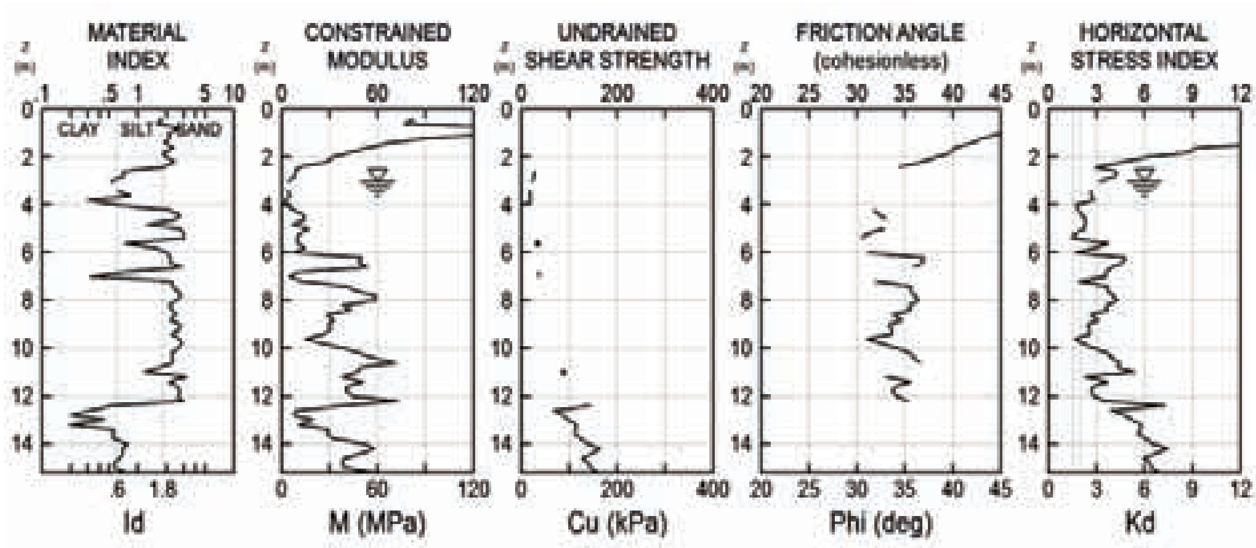

Fig. 37. DMT results, D1.

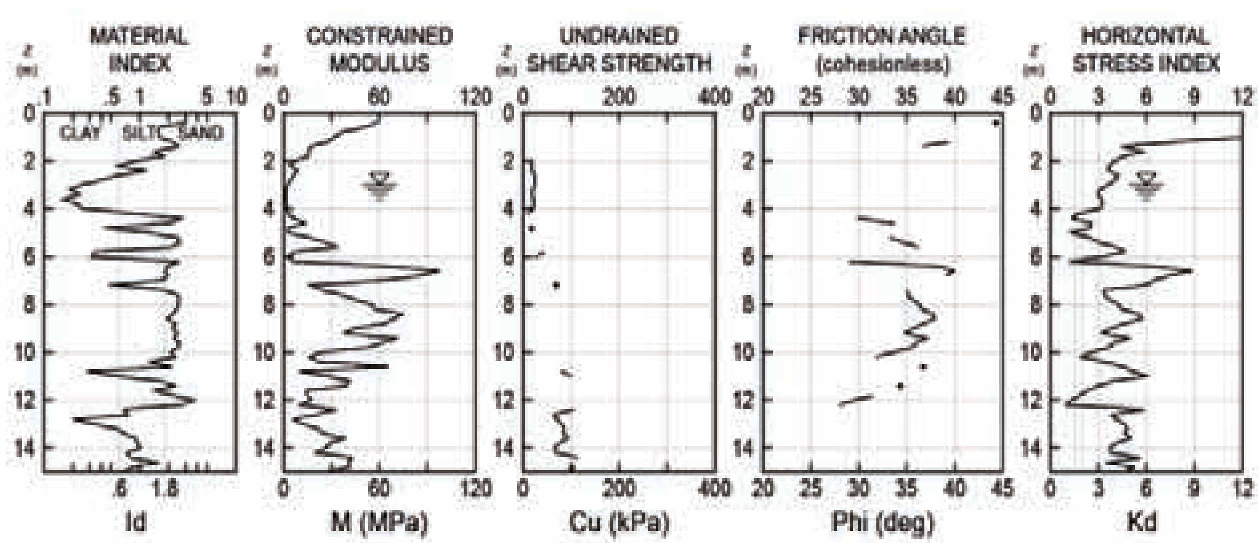

Fig. 38. DMT results, E2.

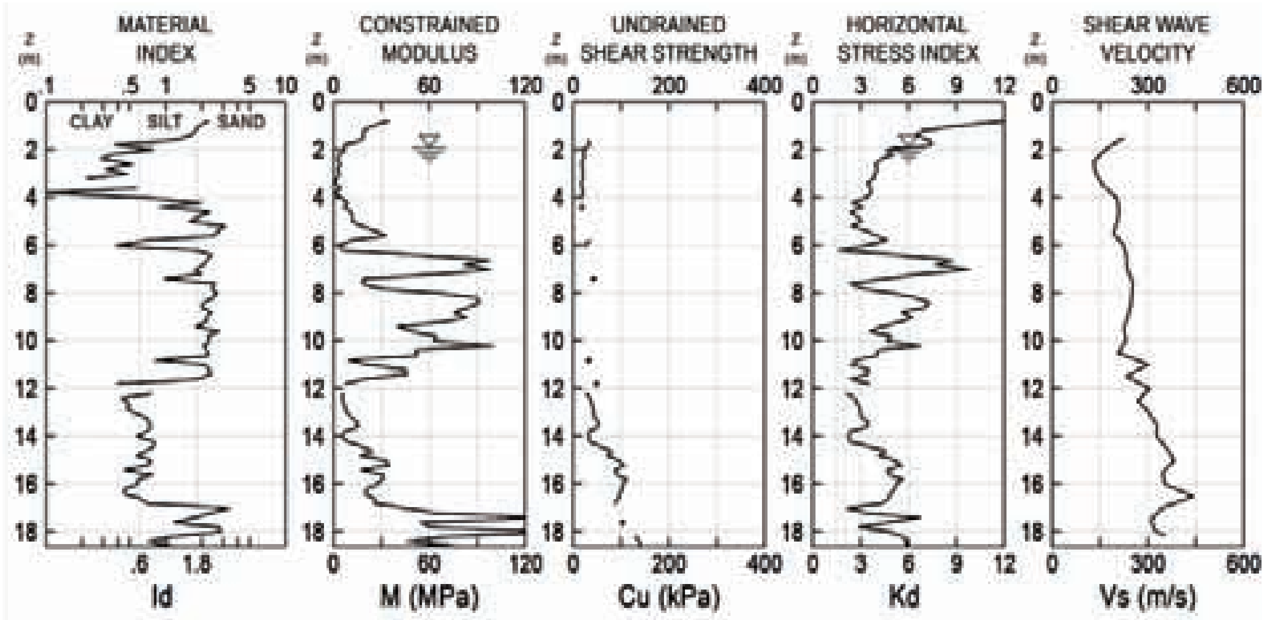

Fig. 39. DMT results, G1.

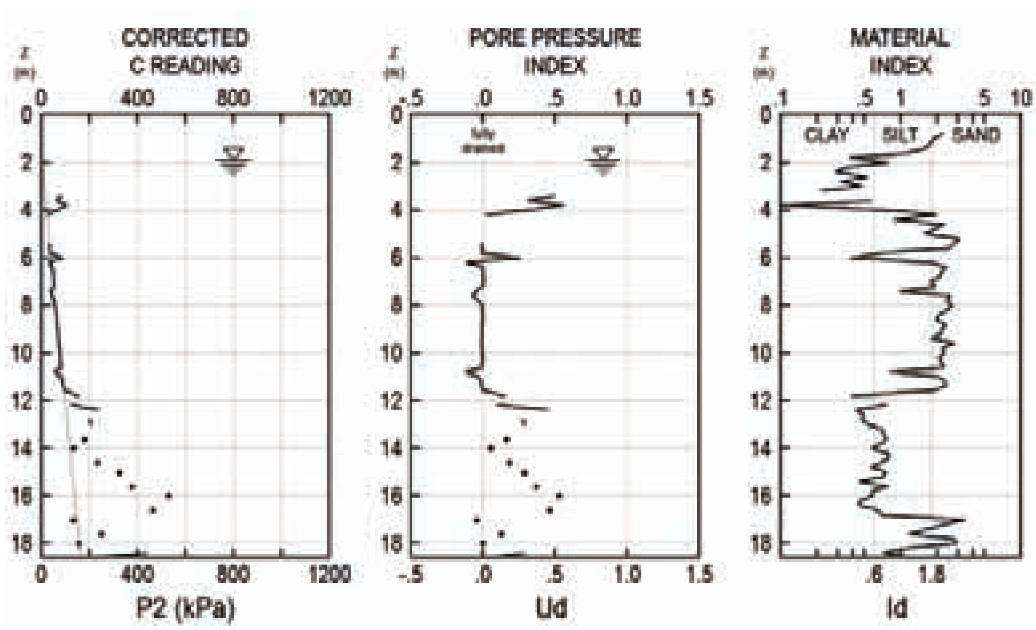

Fig. 40. DMT results, G1.