

Field Cone Penetration Tests with Various Penetration Rates - Test Results

Poulsen, Rikke; Nielsen, Benjaminn Nordahl; Ibsen, Lars Bo

Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

Citation for published version (APA):
Poulsen, R., Nielsen, B. N., & Ibsen, L. B. (2011). *Field Cone Penetration Tests with Various Penetration Rates - Test Results*. Department of Civil Engineering, Aalborg University. DCE Technical reports No. 123

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

Take down policy

If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

Field Cone Penetration Tests with Various Penetration Rates – Test Results

**Rikke Poulsen
Benjaminn Nordahl Nielsen
Lars Bo Ibsen**

Aalborg Universitet
Institut for Byggeri og Anlæg
Sektionen for Konstruktioner, materialer og geoteknik

DCE Technical Report No. 123

Field Cone Penetration Tests with Various Penetration Rates – Test Results

Rikke Poulsen
Benjaminn Nordahl Nielsen
Lars Bo Ibsen

December 2011

© Aalborg Universitet

FIELD CONE PENETRATION TESTS WITH VARIOUS PENETRATION RATES – TEST RESULTS

Contents

Test site description	2
Test setup.....	2
Interpretation of CPT.....	3
Cone Penetration Test results	4
Test A1	5
Test A2	8
Test A3	11
Test A4	14
Test A5	17
Test B1	20
Test B2	23
Test B3	26
Test B4	29
Test B5	32
Test C1	35
Test C2	38
Test C3	41
Test C4	44
Test C5	47
References	50

Test site description

The test site is located at Nordre Ringgade near the town called Dronninglund in the northern Jutland in Denmark. The site area is relatively flat, and was chosen because it has a size of approximately 3 ha and contains a relatively thick deposit of silty soils. Furthermore the groundwater was encountered at approximately 0.2-0.6 m below the ground level.

The soil stratigraphy of the test site was before test start identified by geotechnical borings results. The geotechnical borings indicated that the site contains of sandy silt with clay stripes from approx. 4.0 to 10 m. In the top the silty soil is very sandy with few clay stripes, and gradually the clay stripes increases wherefore the soil from approx. 10 m contains of clay with sandy silt stripes. Large soil sample was also collected from the test site in order to determine basic soil properties in the laboratory.

Test setup

The experimental programme consists of 2 soil strata borings and 15 Cone Penetration Tests. The CPTs were conducted with five different penetration rates; these were 60, 20, 5, 1, and 0.5 mm/s. In order to make sure that the drainage of the CPTs did not influence each other, the CPTs were conducted with a centre to centre distance of approx. 3 m. For the same reason the 2 soil strata borings were places a little outside the area because they could contribute to a larger drainage. A detailed location of the borings and 15 CPTs can be seen in Figure 1.

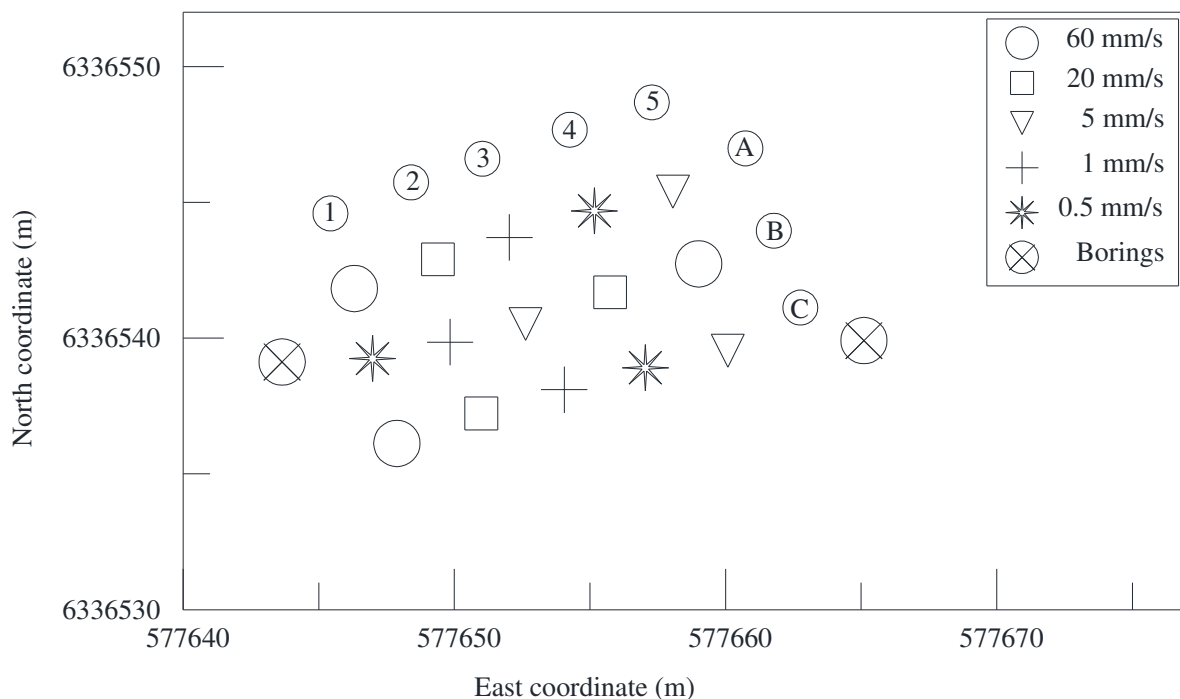


Figure 1. Location of the 15 CPTs with various penetration rates and the 2 soil strata borings. Furthermore, the notation of each CPT can be seen e.g. CPT B3 has been conducted with a penetration rate of 5 mm/s.

The penetration rates of 60, 20, 5, 1, and 0.5 mm/s were chosen on the basis of a supposition that the penetration would be undrained and drained for a penetration rate of respectively 60 and 0.5 mm/s, (Poulsen et. al, 2011). The applied cone is a standard 10 cm² piezocone with an apex angle of 60° from Envi. Besides

the cone resistance, q_c , pore pressure, u_2 (behind the cone), sleeve friction, f_s , and depth, d , the penetration rate, v , were measured during the execution of the CPTs.

In order to keep the penetration rate as constant as possible the CPTs were conducted by a drilling rig which has a trust capacity of 5.5 ton and has an automatic feed, which can be seen in Figure 2.



Figure 2. Picture showing the test setup.

According to McNeilan and Bugno (1985), whenever a stop occurs (rods set-up stops, or stop caused by reaching maximum trust capacity), the excess pore pressure starts to dissipate, and hence an increase in cone resistance occurs. This effect is especially observed in sandy silt where the dissipation occurs faster than in e.g. a clayed soil. Therefore, all stop during the penetration was minimized by using two rods at a time, and also by pre-drilling per 2 m in order to minimize the friction on the CPT rods and thereby avoiding stops and keeping the penetration rate as constant as possible.

Interpretation of CPT

The tests were made with pre-drilling in order to minimize the friction on the CPT rods and thereby keeping the penetration rate as constant as possible. Therefore, some of the soil at the start of each CPT test could have been disturbed. Furthermore, the pore water pressure starts to dissipate after each pre-drilling wherefore the measurements not necessarily is correct. For that reason data corresponding to 200 mm has been deleted after each predrilling. In addition, data has also been deleted whenever a stop caused by reaching maximum trust capacity occurred.

Due to unequal area effects of the cone, the corrected total cone resistance, q_t , is calculated by:

$$q_t = q_c + u_2(1 - a)$$

where q_c is the measured uncorrected cone resistance, u_2 is the pore pressure behind the cone, and a is the cone area ratio, which for the applied cone is 0.68. (Lunne et al., 1997).

The normalized cone resistance, Q_t , is calculated by:

$$Q_t = \frac{q_t - \sigma_{v0}}{\sigma'_{v0}}$$

where σ_{v0} and σ'_{v0} is the total and effective vertical overburden stress, (Lunne et al., 1997). In order to calculate the overburden stress, information of the soil unit weight is needed. In the current CPT interpretation a constant soil unit weight of 18 kN/m³ has been used.

The pore pressure parameter ratio, B_q , is calculated by:

$$B_q = \frac{\Delta u}{q_t - \sigma_{v0}}$$

where Δu is the excess pore pressure given by $u_2 - u_0$, where u_0 is the equilibrium water pressure, (Lunne et al., 1997). At the test site two soil strata borings were conducted in which the groundwater level was measured each day in the test programme. The groundwater level has then been calculated as an average between the two borings measured the day the CPT B4 was conducted. In the current CPT interpretation the ground water level is assumed located in 0.82 meters depth.

The normalized friction ratio, F_r , is calculated by:

$$F_r = \frac{f_s}{q_t - \sigma_{v0}}$$

where f_s is the uncorrected measured sleeve friction, (Lunne et al., 1997). For each set of data the cone resistance and sleeve friction has been measured in different depths because of the location of the sleeve friction. Therefore, the normalized friction ratio has been calculated with an offset of 100 mm for the cone resistance. Because some data has been deleted due to pre-drilling effects, the normalized friction ratio cannot be calculated for the first 100 mm after each pre-drilling, (ASTM, 2007).

In order to compare and interpret the results in a scientific context all CPTs are assumed having same stratum boundary. These boundaries have been found on the basis of the two soil strata boring conducted at the tests site. The soil strata boring show that sand was encountered from 0-4.5 m. Silt was encountered from 4.5-11.1 m and clay from 11.4 and to the end of each soil boring.

Within every layer (stratum boundary and predrilling) the data has been smoothed for every 100 mm. For each depth (for each measurement), the data has been smoothed according to the following equation:

$$Z_n = \frac{Y_{n-2} + Y_{n-1} + Y_n + Y_{n+1} + Y_{n+2}}{5}$$

Each depth (each measurement) is then substituted with calculated mean value, Z_n . From the smoothed data Q_t , B_q , and F_r has been calculated.

Cone Penetration Test results

In the following the test results for the 15 conducted tests with various penetration rates are presented. Further, information on how each test was executed can be seen.

Test A1

Table 1. Information of the conducted CPT test.

CPT no.:	A1						
Rate of Penetration:	60 mm/s						
Date:	16.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577646.314			N: 6336541.828			
	Z: 22.4						
Cone type:	Envi standard 10 cm ² piezocone						
Stops:	1	2	3	4	5	6	7
	4.688	5.688	7.368	8.748	11.288	12.088	-
Comments:	Stops are caused by back pulling the cone.						

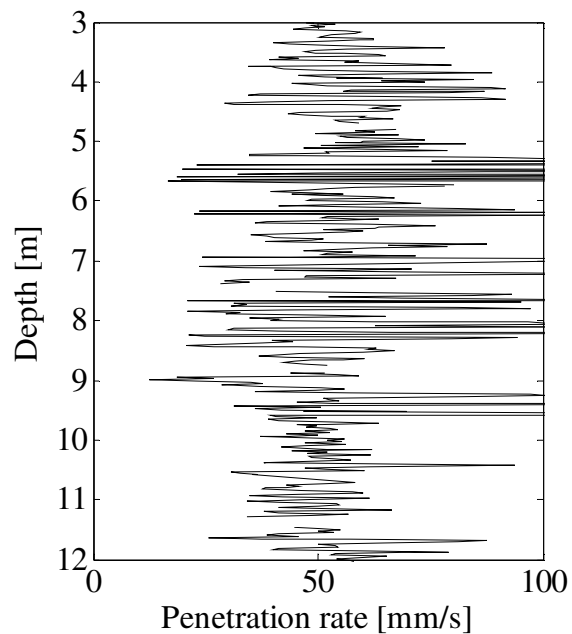


Figure 3. Rate of penetration for the conducted CPT A1.

Statistical data	
Mean value, \bar{v}	55.2
Coefficient of variation, δ	0.43

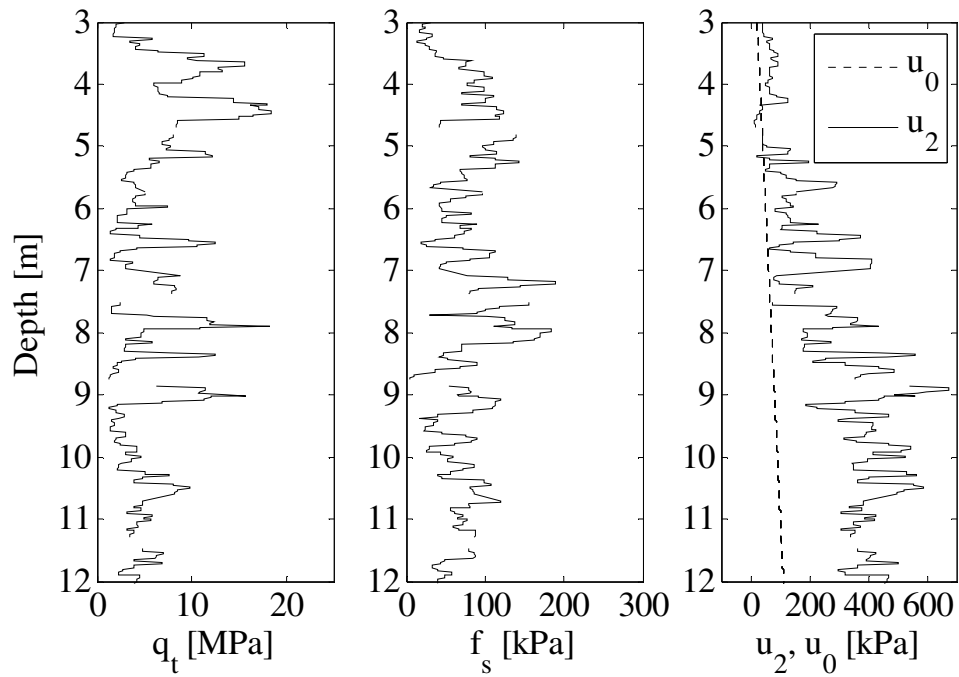


Figure 4. Cone resistance, sleeve friction, pore pressure for the conducted CPT A1.

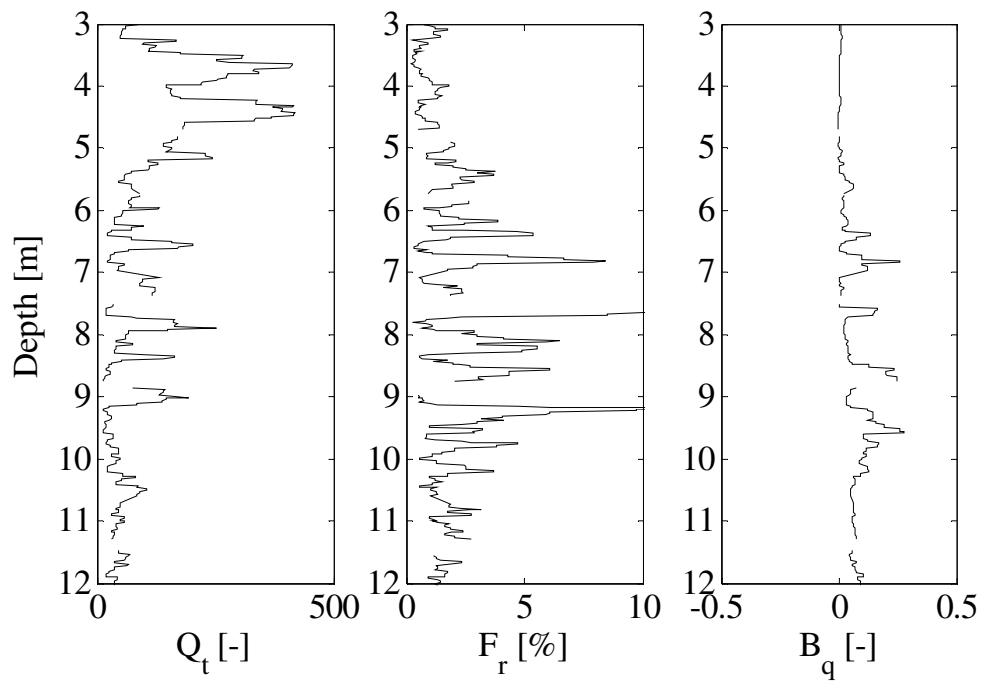


Figure 5. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT A1.

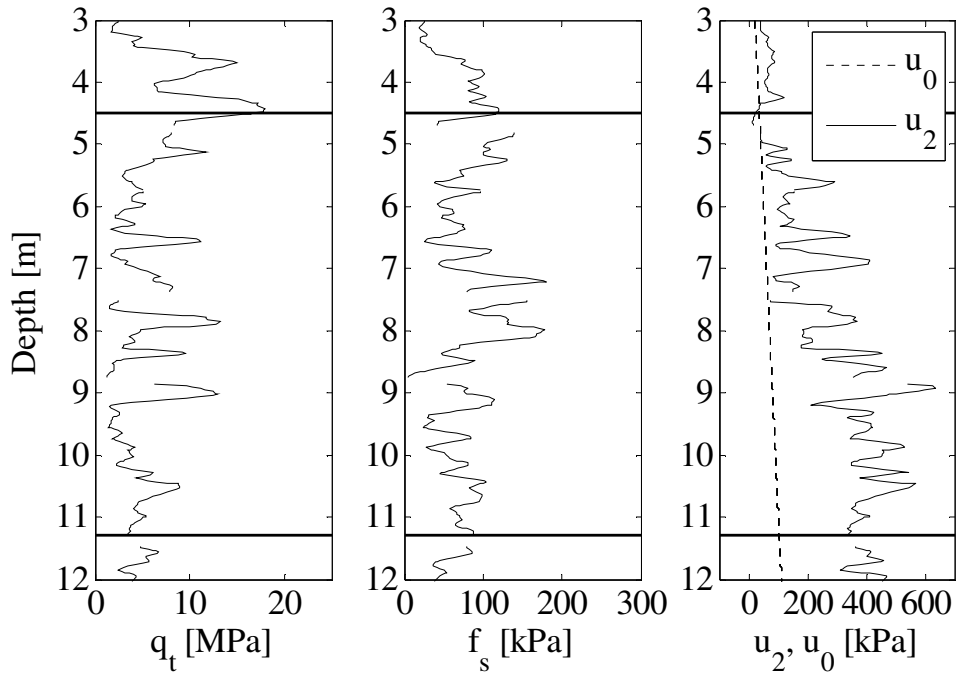


Figure 6. Smoothed cone resistance, sleeve friction, pore pressure for the conducted CPT A1.

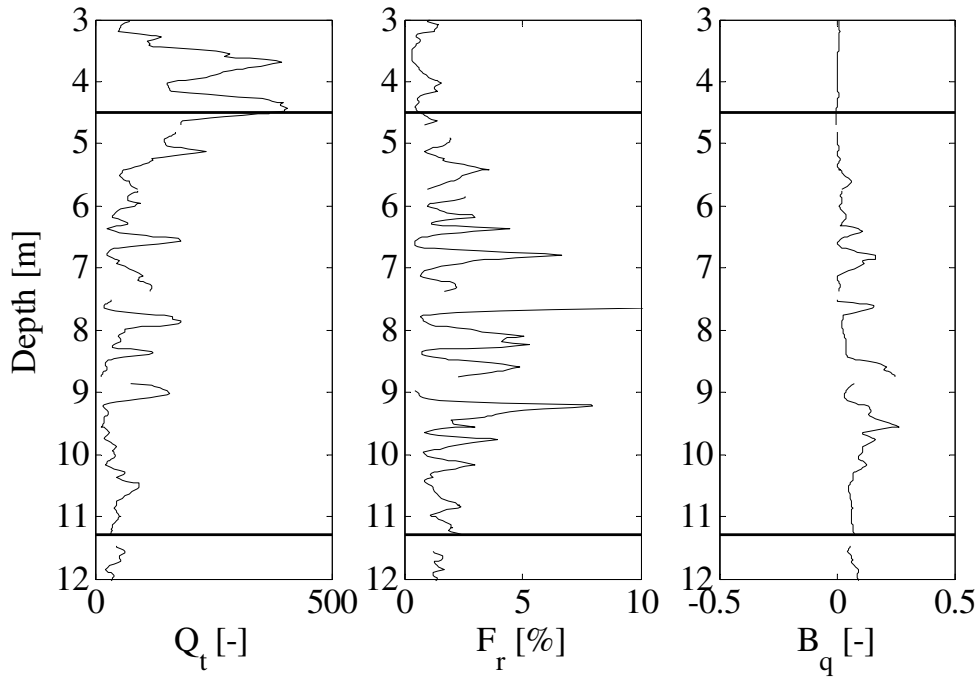


Figure 7. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT A1.

Test A2

Table 2. Information of the conducted CPT test.

CPT no.:	A2						
Rate of Penetration:	20 mm/s						
Date:	15.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577649.394			N: 6336542.905			
	Z: 22.579						
Cone type:	Envi standard 10 cm ² piezocone						
Stops:	1	2	3	4	5	6	7
	7.189	8.009	9.069	10.249	11.449	11.669	12.169
Comments:	Stops are caused by back pulling the cone.						

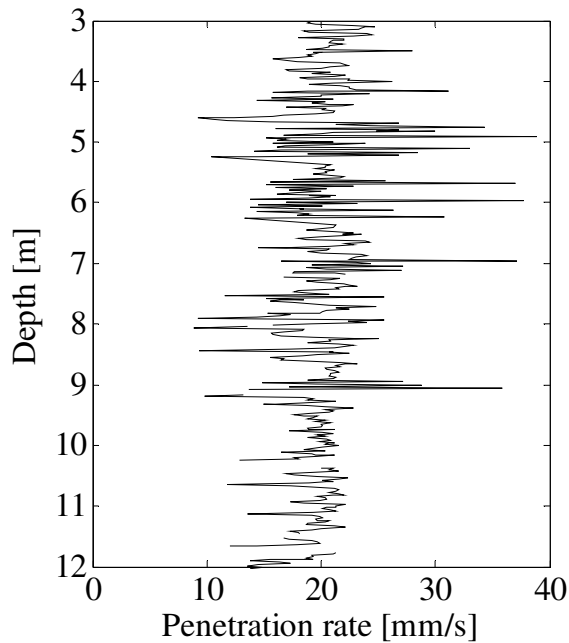


Figure 8. Rate of penetration for the conducted CPT A2.

Statistical data	
Mean value, \bar{v}	19.9
Coefficient of variation, δ	0.18

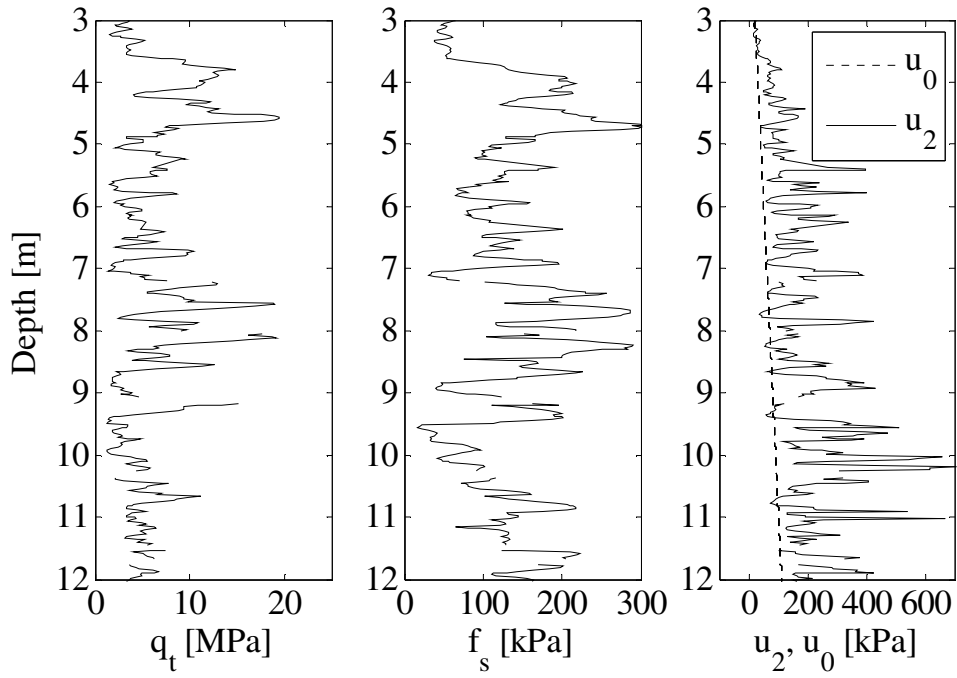


Figure 9. Cone resistance, sleeve friction, pore pressure for the conducted CPT A2.

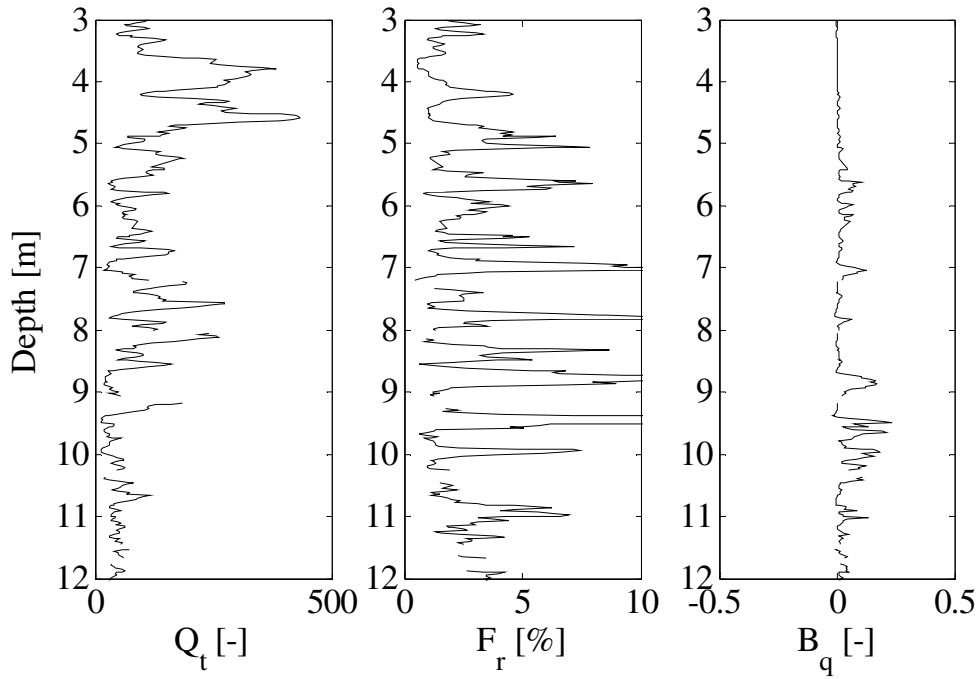


Figure 10. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT A2.

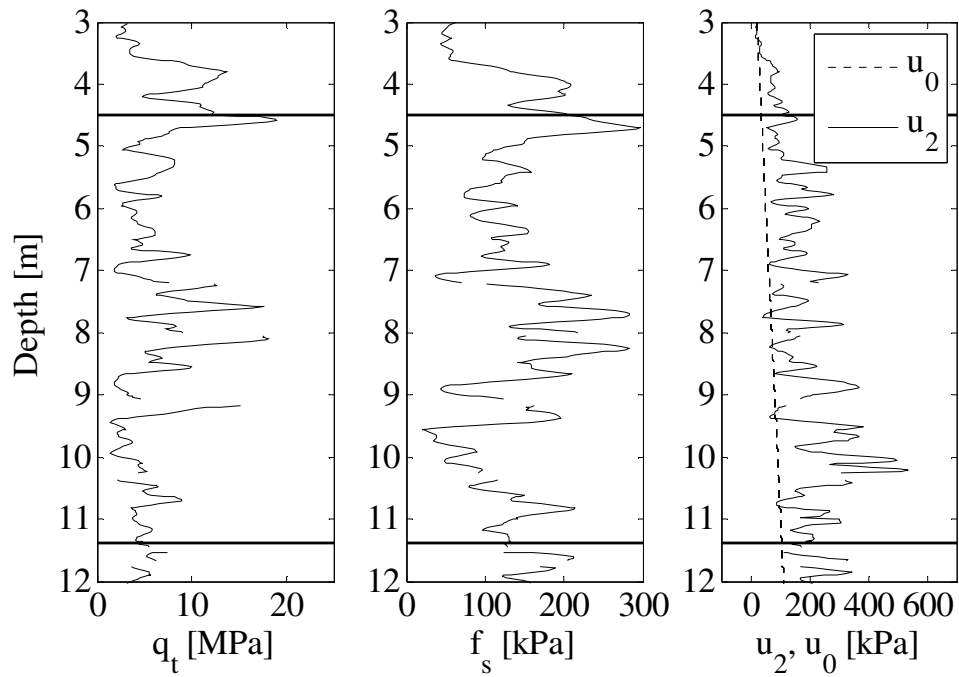


Figure 11. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT A2.

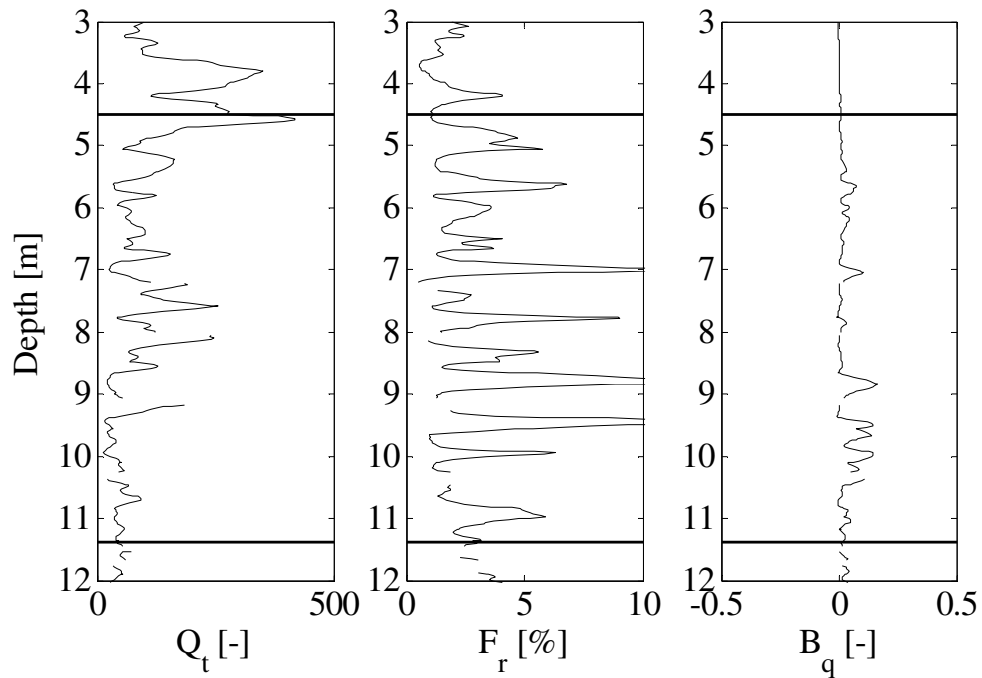


Figure 12. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT A2.

Test A3

Table 3. Information of the conducted CPT test.

CPT no.:	A3						
Rate of Penetration:	1 mm/s						
Date:	17.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577652.029			N: 6336543.709			
	Z: 22.701						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	4.587	5.487	7.547	8.207	10.107	-	-
Comments:	Stop 2 and 4 are caused by pre drilling.						

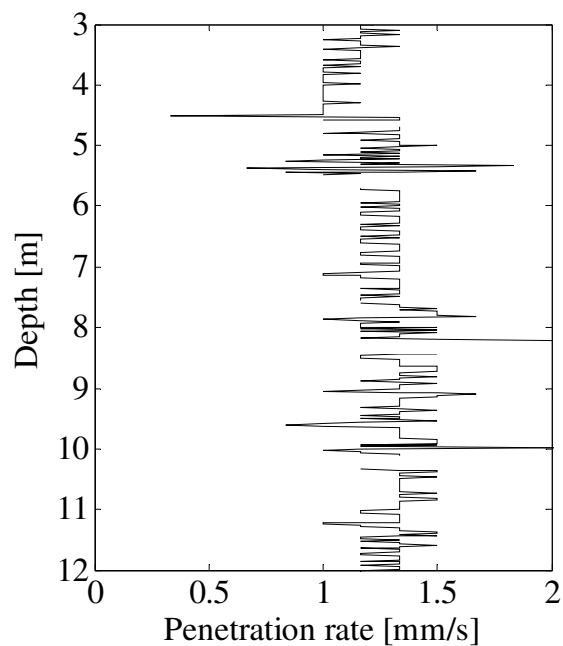


Figure 13. Rate of penetration for the conducted CPT A3.

Statistical data	
Mean value, \bar{v}	1.3
Coefficient of variation, δ	0.14

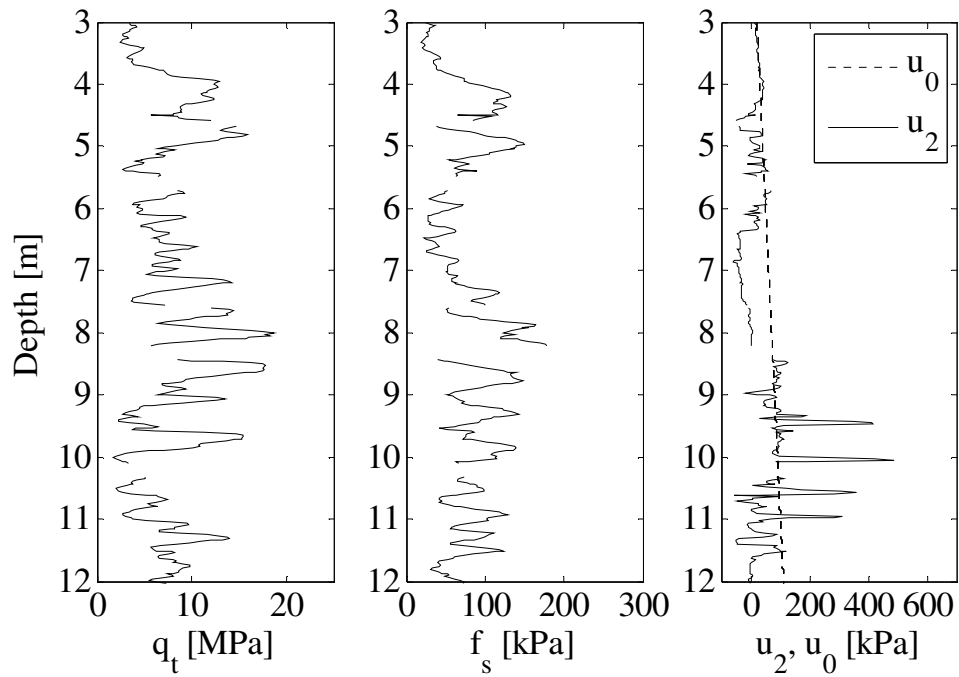


Figure 14. Cone resistance, sleeve friction, pore pressure for the conducted CPT A3.

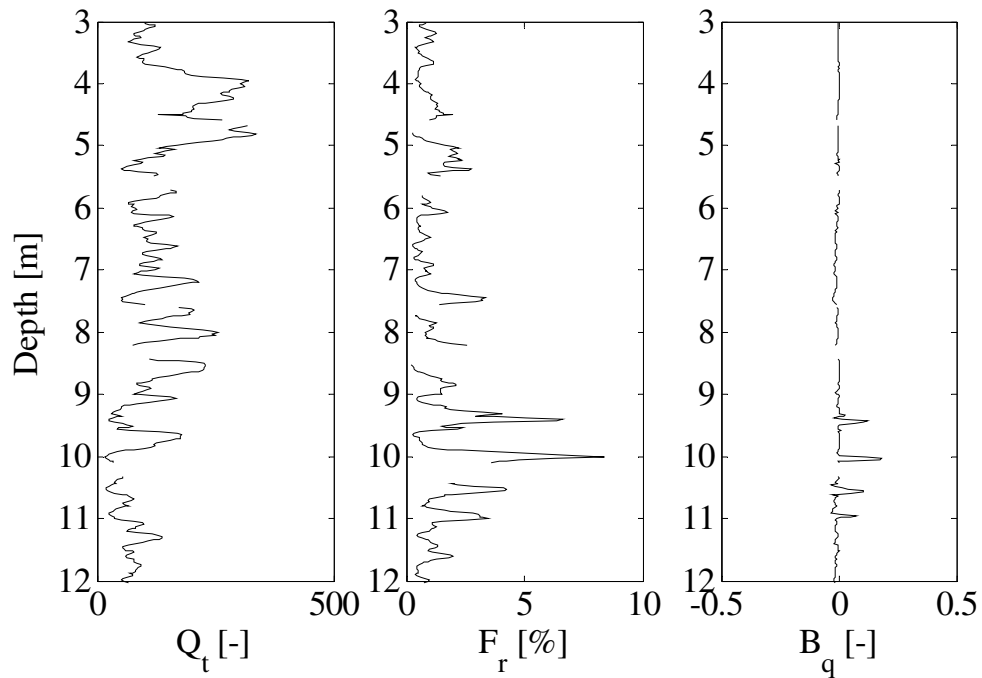


Figure 15. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT A3.

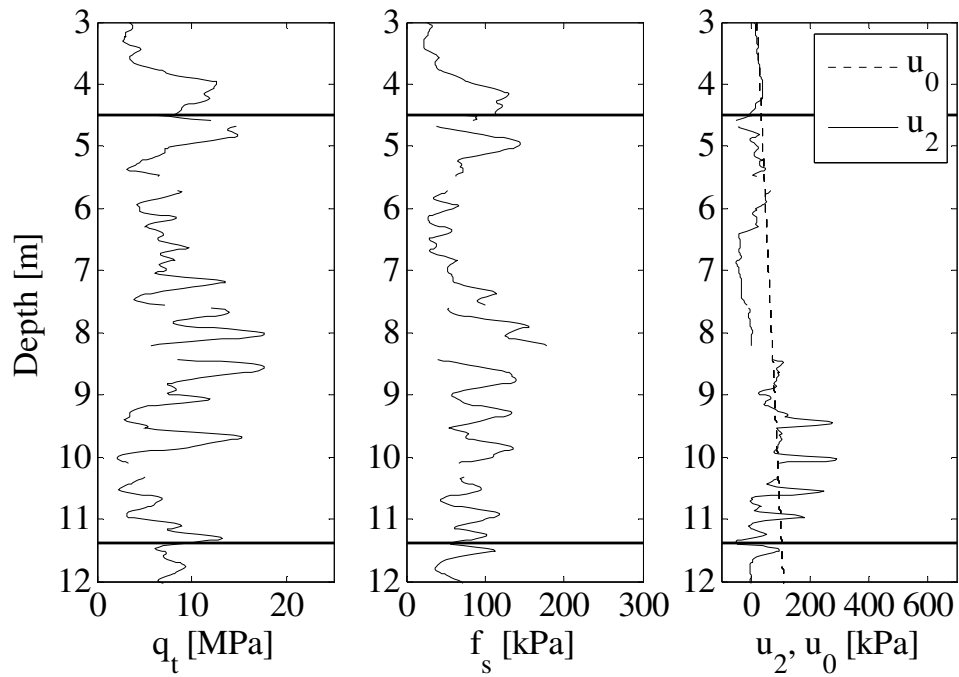


Figure 16. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT A3.

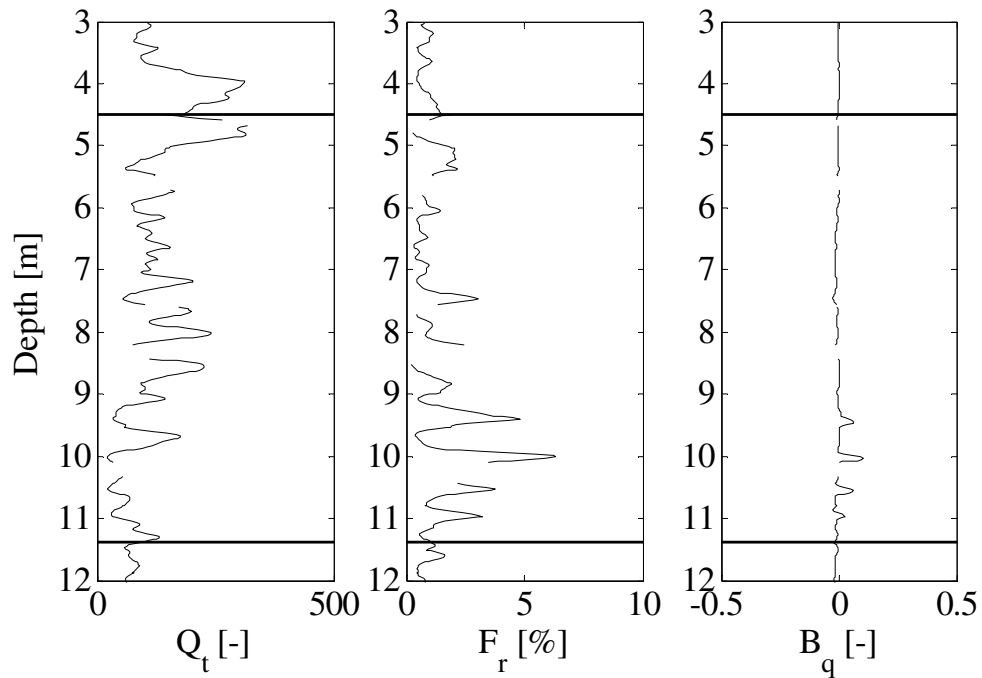


Figure 17. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT A3.

Test A4

Table 4. Information of the conducted CPT test.

CPT no.:	A4						
Rate of Penetration:	0.5 mm/s						
Date:	21.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577655.175			N: 6336544.689			
	Z: 22.831						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	2.817	3.157	5.077	7.617	10.057	-	-
Comments:	Stop 1, 3, 4, 5 are caused by pre drilling.						

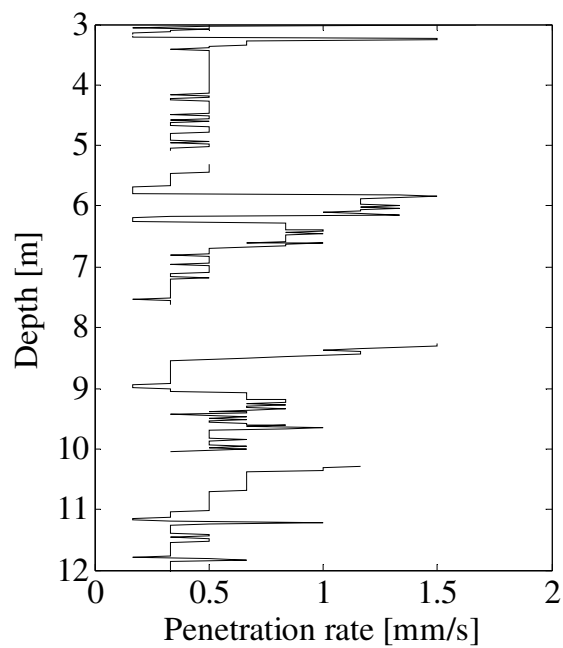


Figure 18. Rate of penetration for the conducted CPT A4.

Statistical data	
Mean value, \bar{v}	0.7
Coefficient of variation, δ	0.94

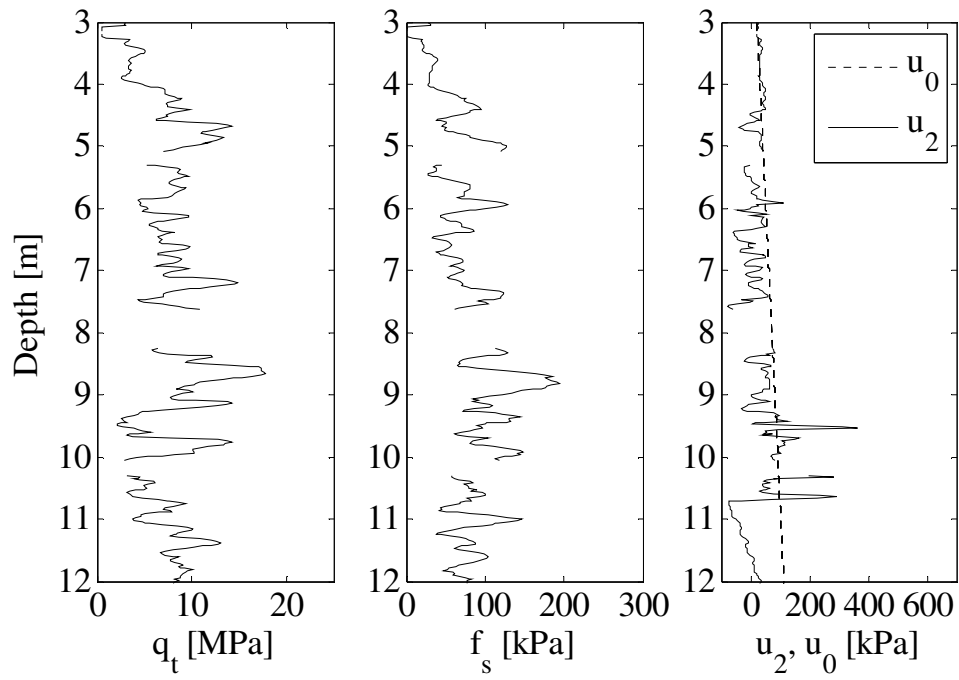


Figure 19. Cone resistance, sleeve friction, pore pressure for the conducted CPT A4.

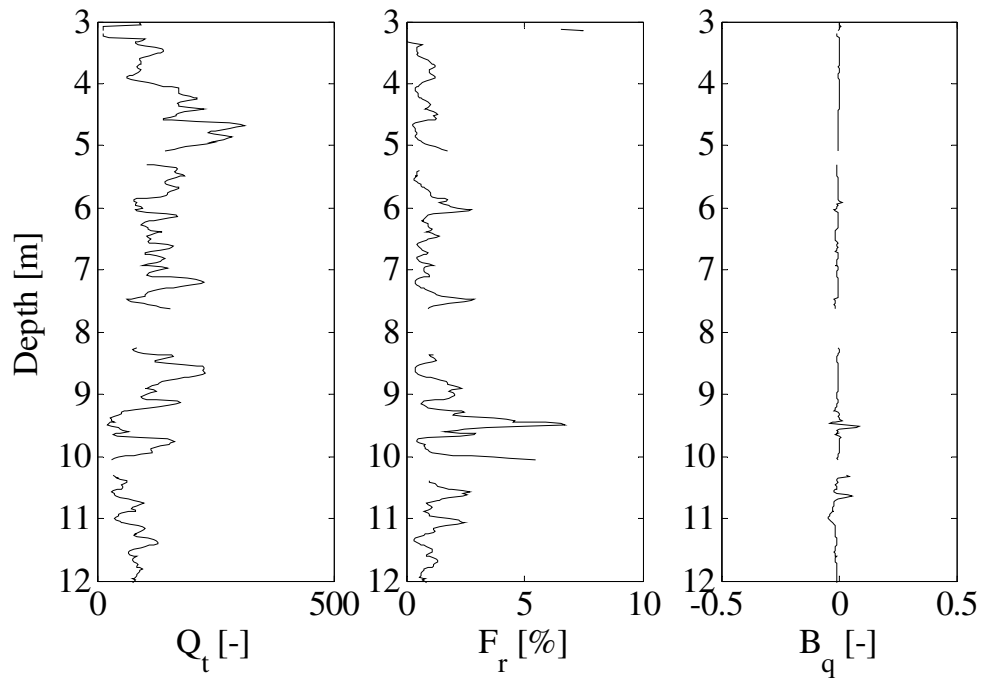


Figure 20. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT A4.

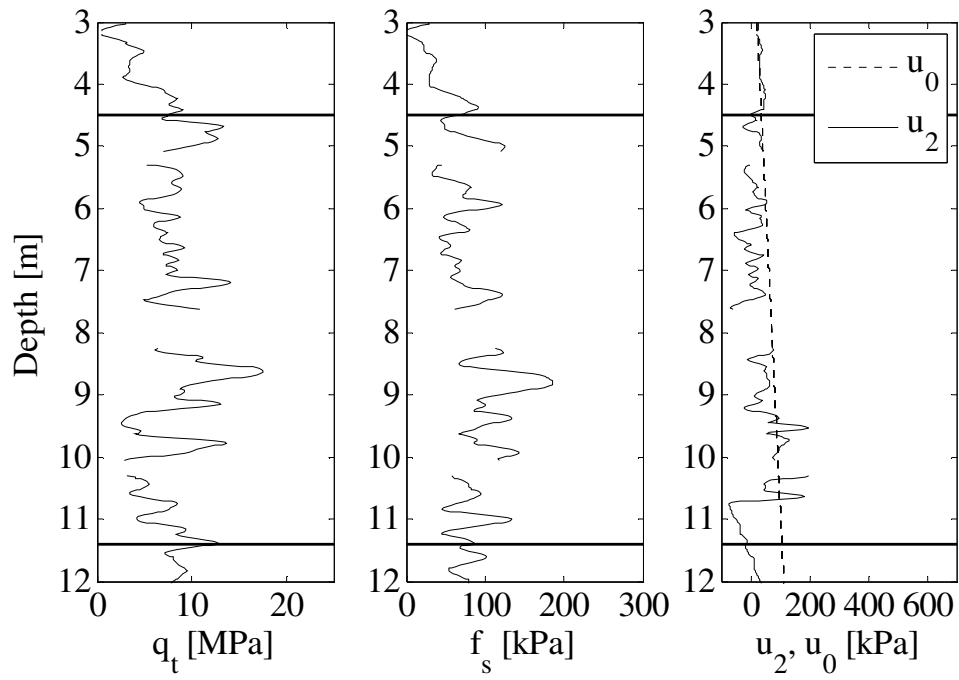


Figure 21. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT A4.

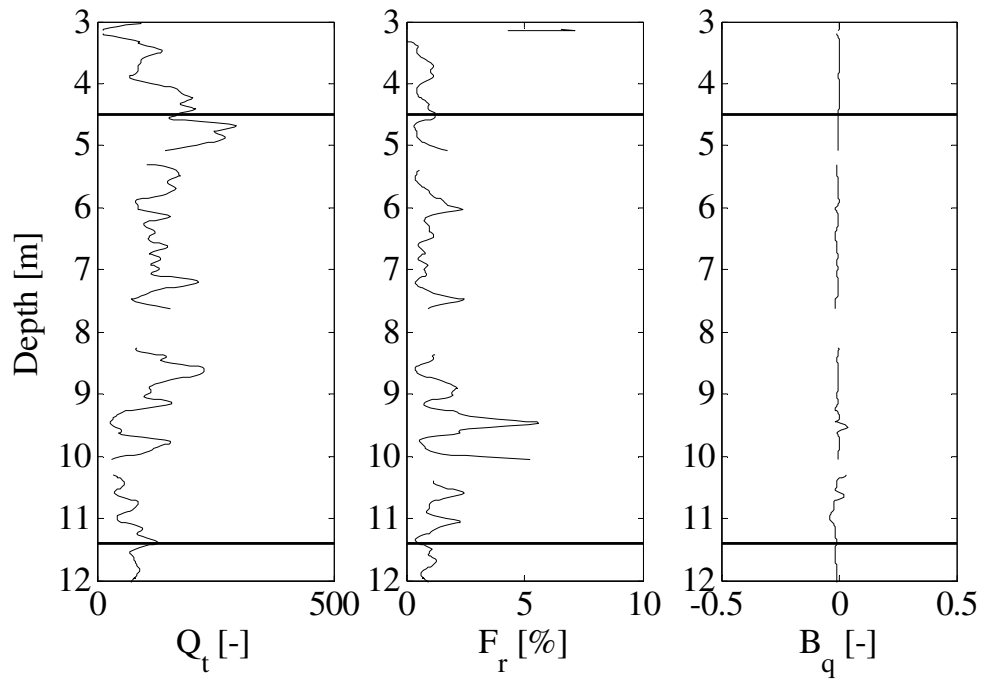


Figure 22. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT A4.

Test A5

Table 5. Information of the conducted CPT test.

CPT no.:	A5						
Rate of Penetration:	5 mm/s						
Date:	23.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577658.063			N: 6336545.61			
	Z: 22.968						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	4.94	7.88	9.94	-	-	-	-
Comments:	Stop 1 and 2 are caused by pre drilling.						

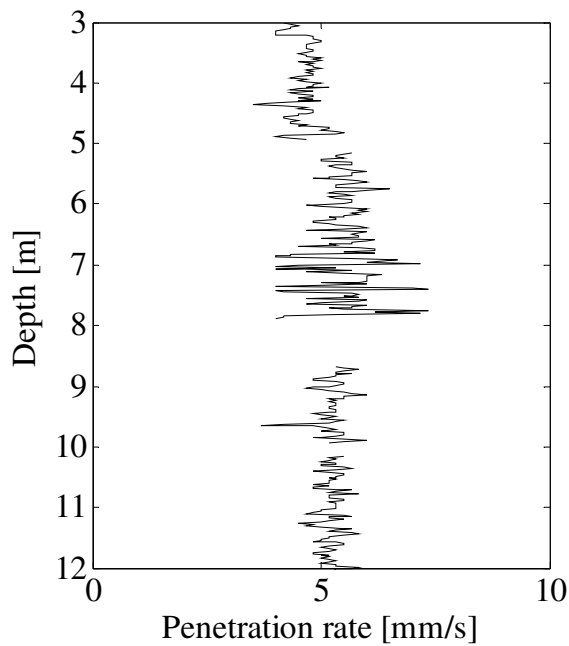


Figure 23. Rate of penetration for the conducted CPT A5.

Statistical data	
Mean value, \bar{v}	5.1
Coefficient of variation, δ	0.12

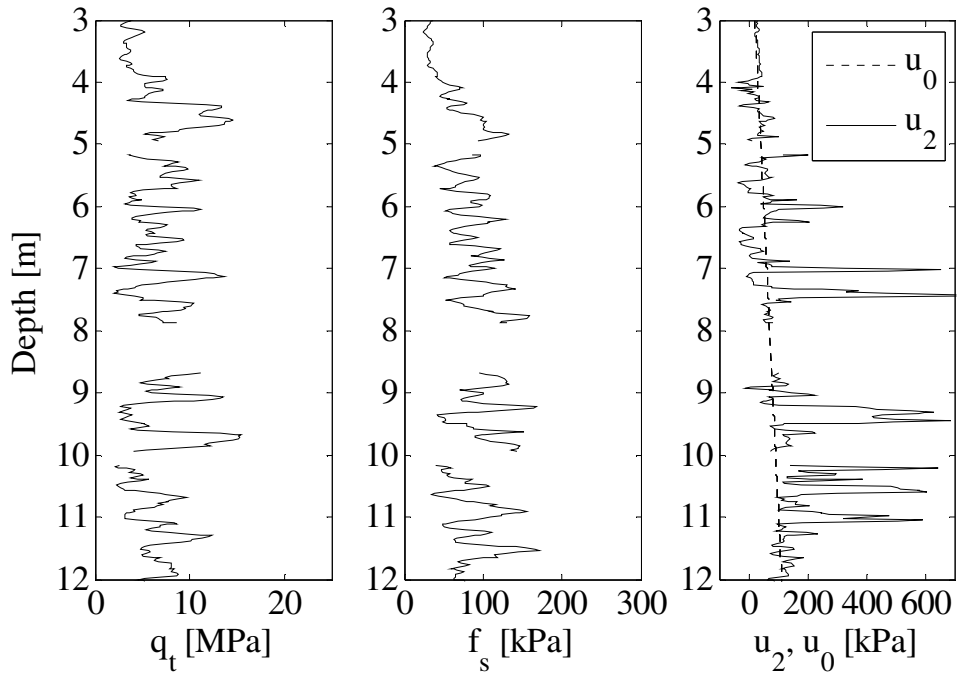


Figure 24. Cone resistance, sleeve friction, pore pressure for the conducted CPT A5.

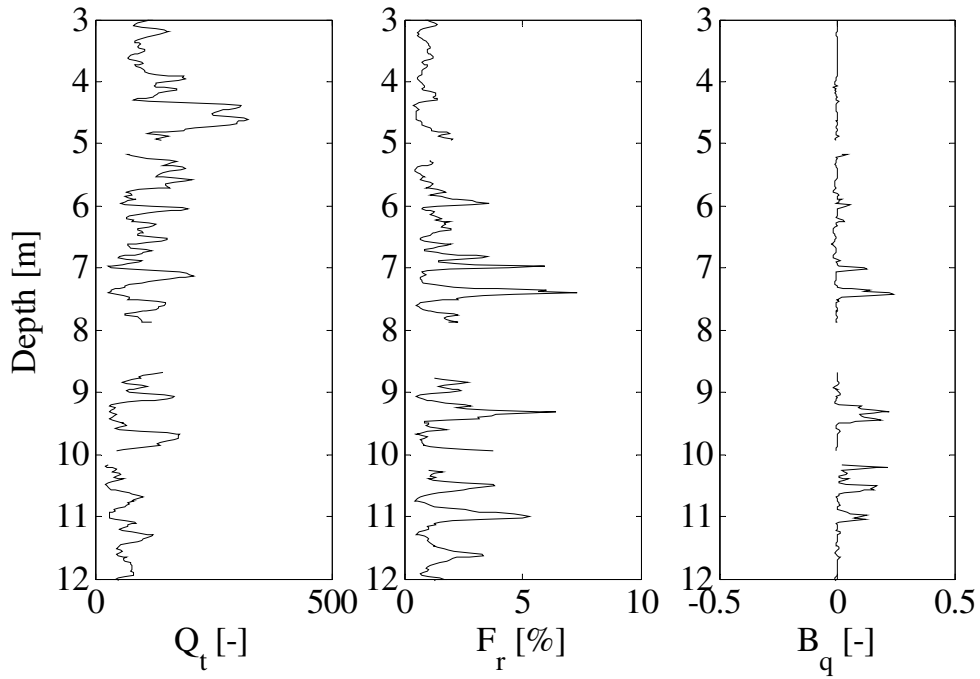


Figure 25. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT A5.

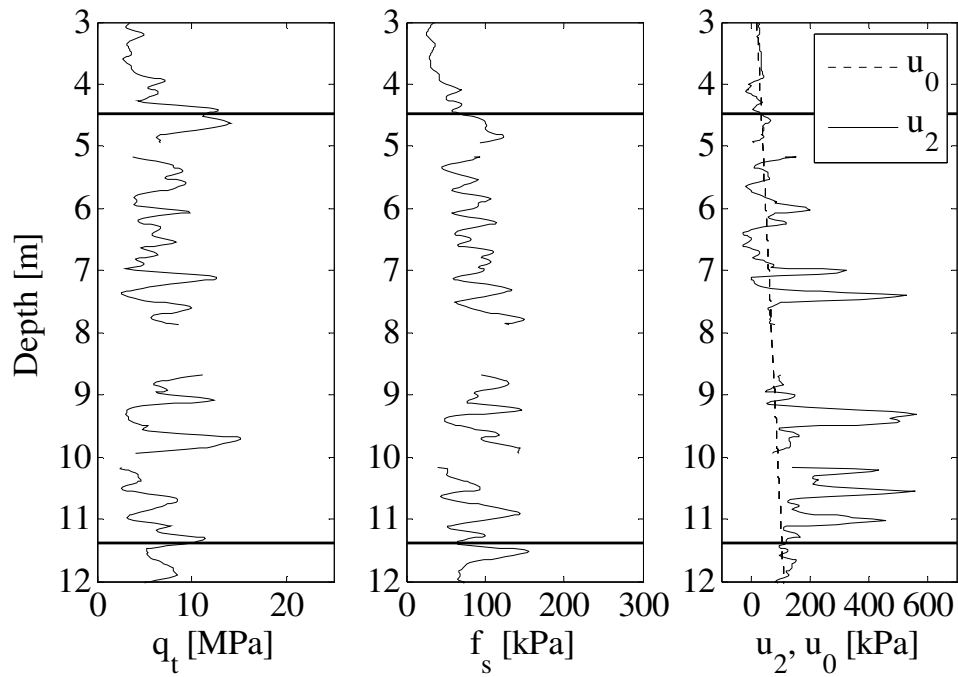


Figure 26. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT A5.

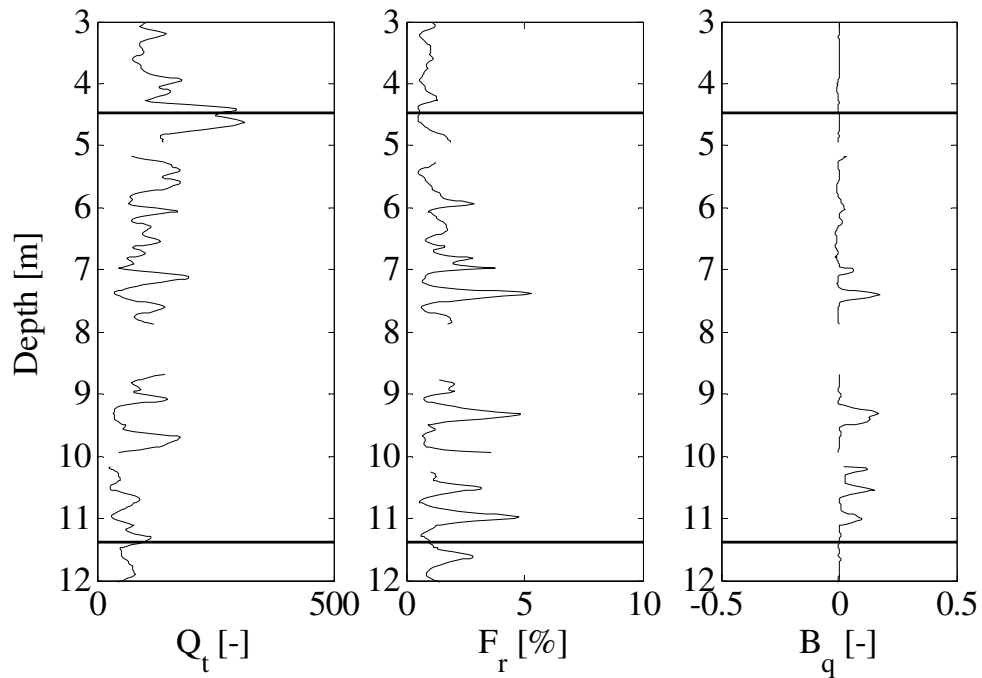


Figure 27. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT A5.

Test B1

Table 6. Information of the conducted CPT test.

CPT no.:	B1						
Rate of Penetration:	0.5 mm/s						
Date:	24.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577646.994			N: 6336539.250			
	Z: 22.292						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	4.596	6.161	8.616	10.556	-	-	-
Comments:	Stop 1,3 and 4 are caused by pre drilling.						

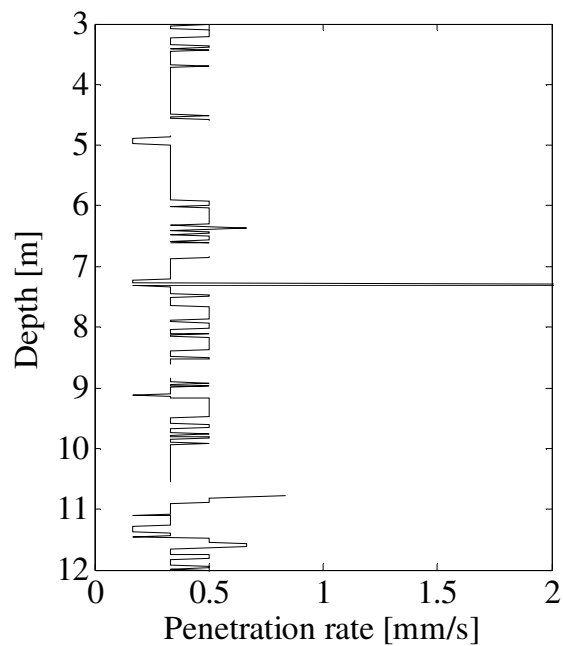


Figure 28. Rate of penetration for the conducted CPT B1.

Statistical data	
Mean value, \bar{v}	0.4
Coefficient of variation, δ	0.67

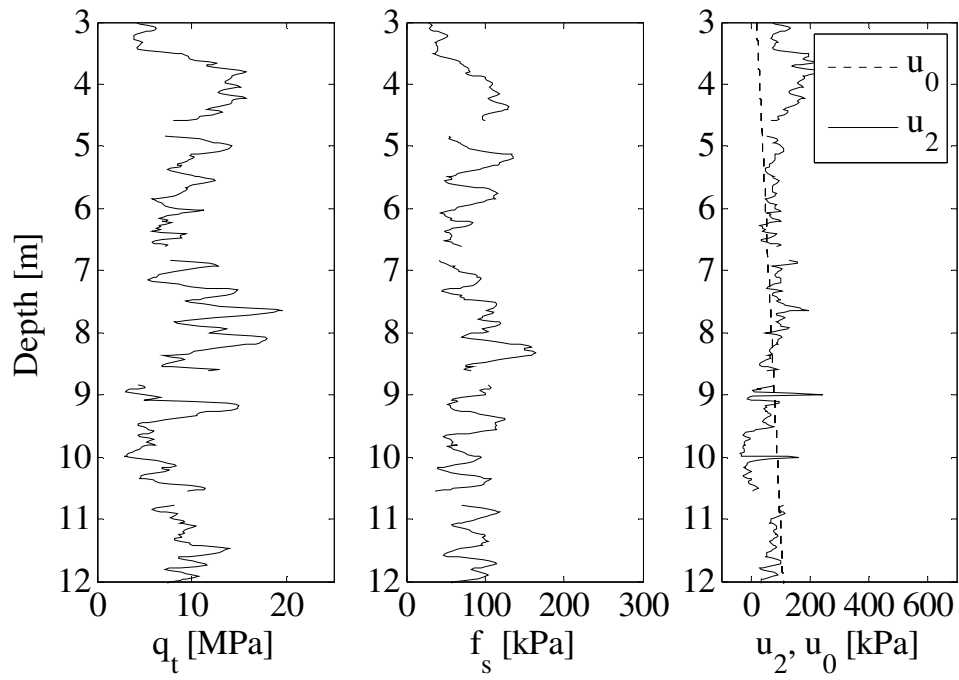


Figure 29. Cone resistance, sleeve friction, pore pressure for the conducted CPT B1.

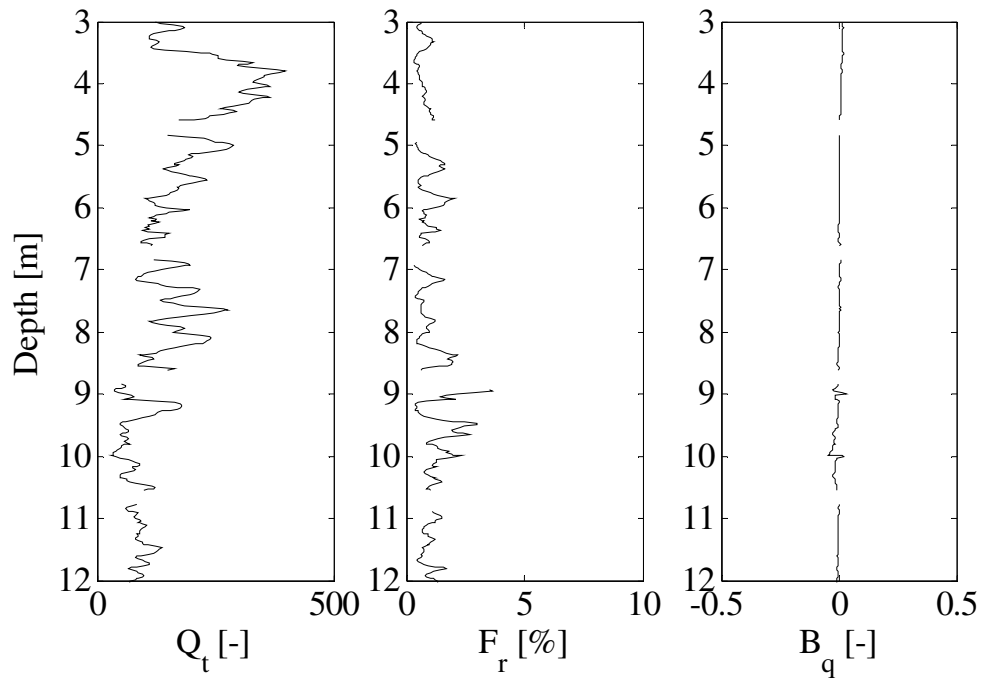


Figure 30. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT B1.

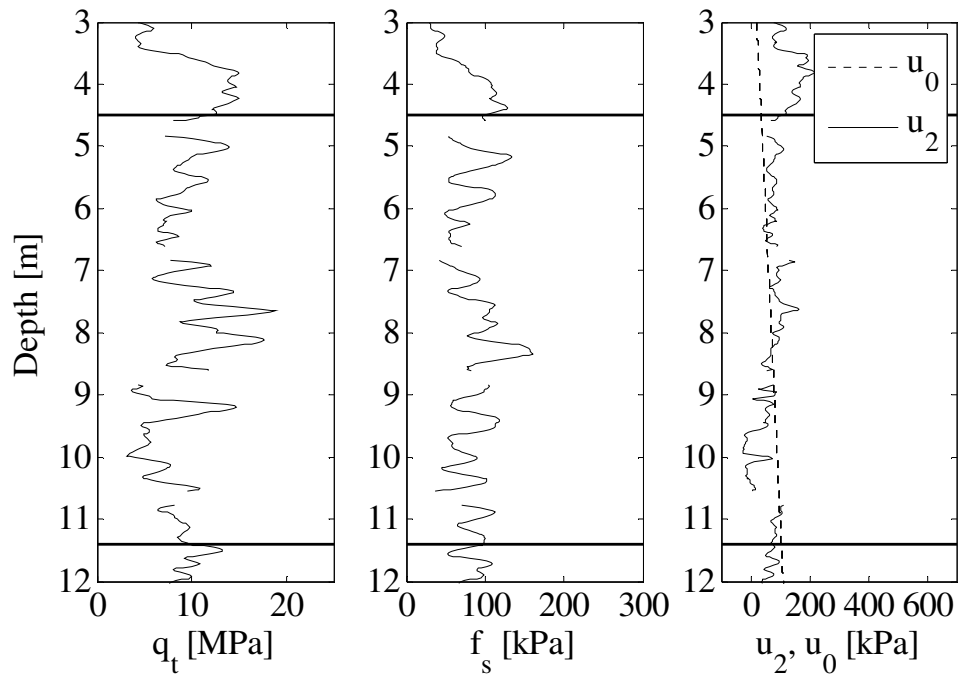


Figure 31. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT B1.

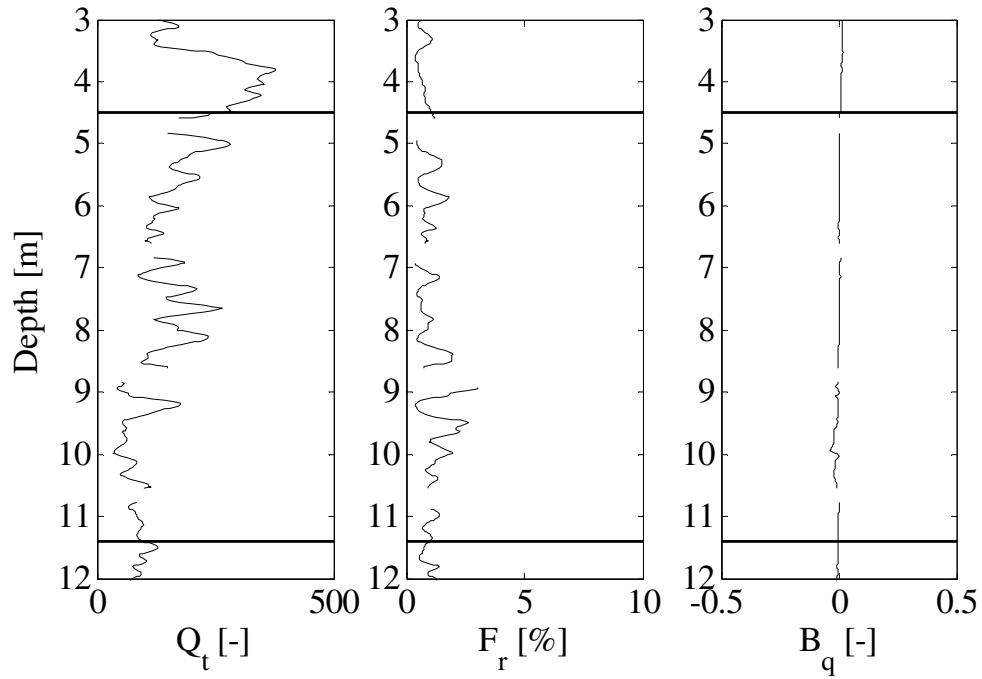


Figure 32. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT B1.

Test B2

Table 7. Information of the conducted CPT test.

CPT no.:	B2						
Rate of Penetration:	1 mm/s						
Date:	23.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577649.844			N: 6336539.856			
	Z: 22.476						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	4.412	6.432	7.052	7.452	7.832	8.412	10.432
Comments:	Stop 1, 2, 6 and 7 are caused by pre drilling.						

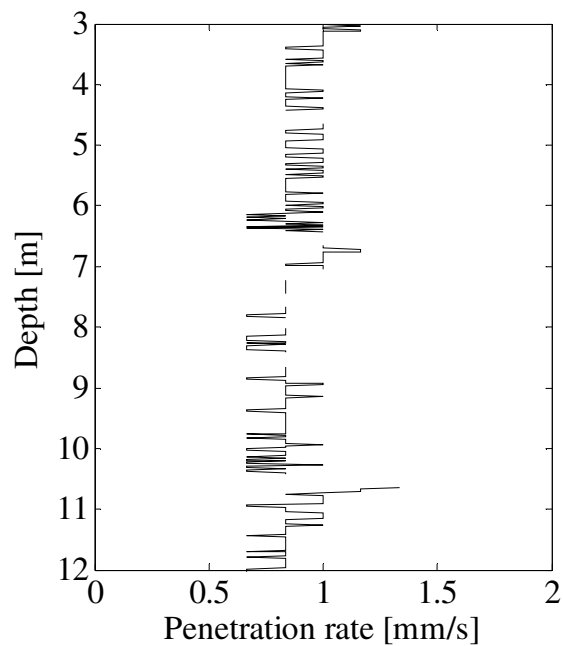


Figure 33. Rate of penetration for the conducted CPT B2.

Statistical data	
Mean value, \bar{v}	0.9
Coefficient of variation, δ	0.15

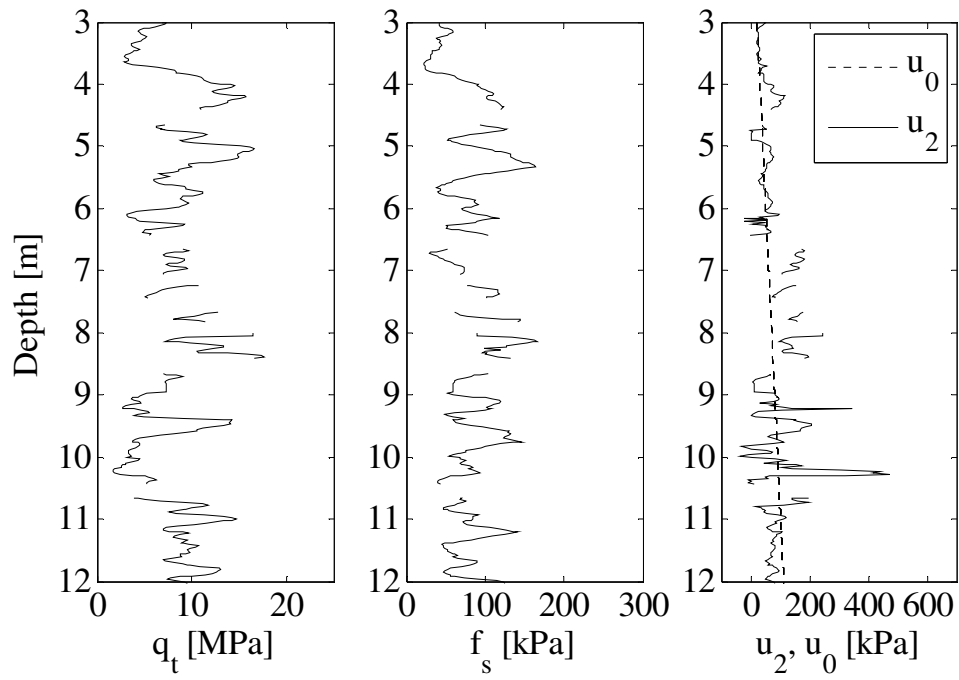


Figure 34. Cone resistance, sleeve friction, pore pressure for the conducted CPT B2.

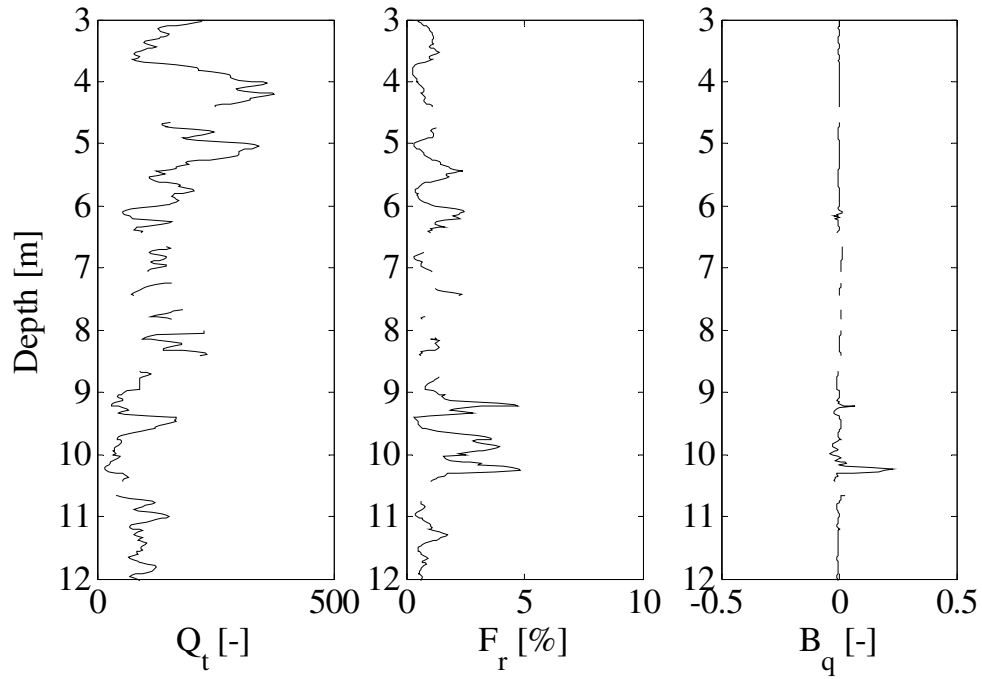


Figure 35. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT B2.

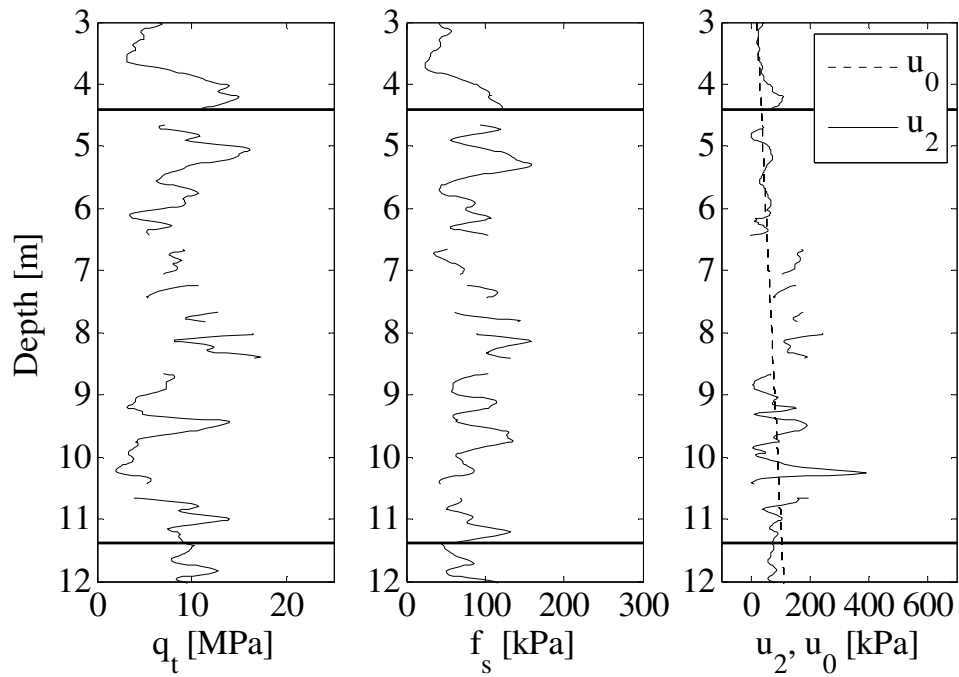


Figure 36. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT B2.

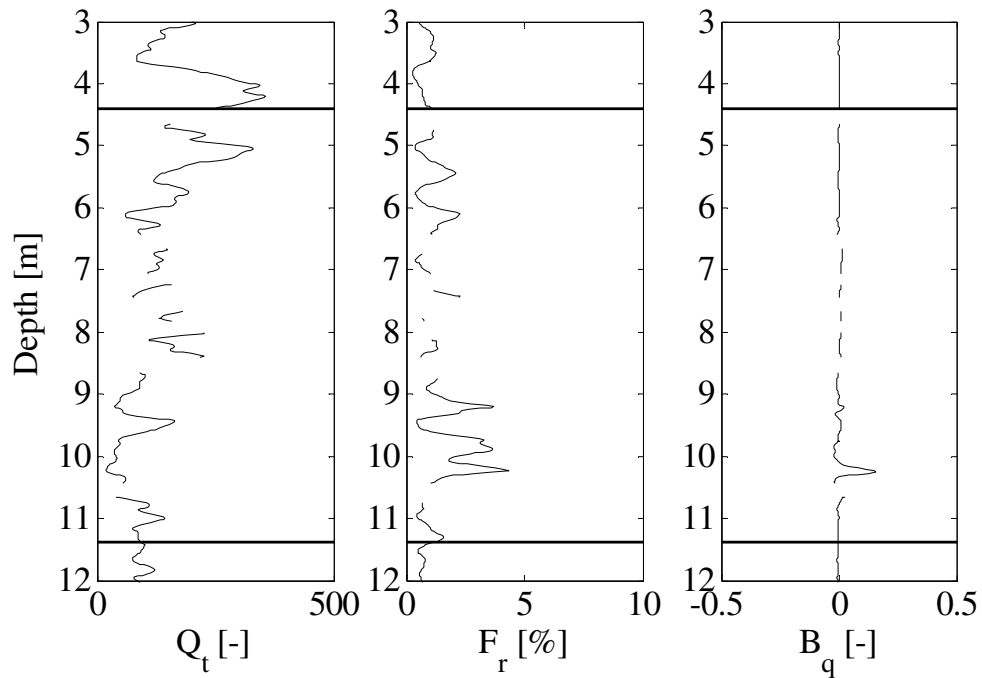


Figure 37. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT B2.

Test B3

Table 8. Information of the conducted CPT test.

CPT no.:	B3						
Rate of Penetration:	5 mm/s						
Date:	21.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577652.627			N: 6336540.731			
	Z: 22.528						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	5.38	8.00	8.34	10.38	-	-	-
Comments:	Stop 1, 3 and 4 are caused by pre drilling.						

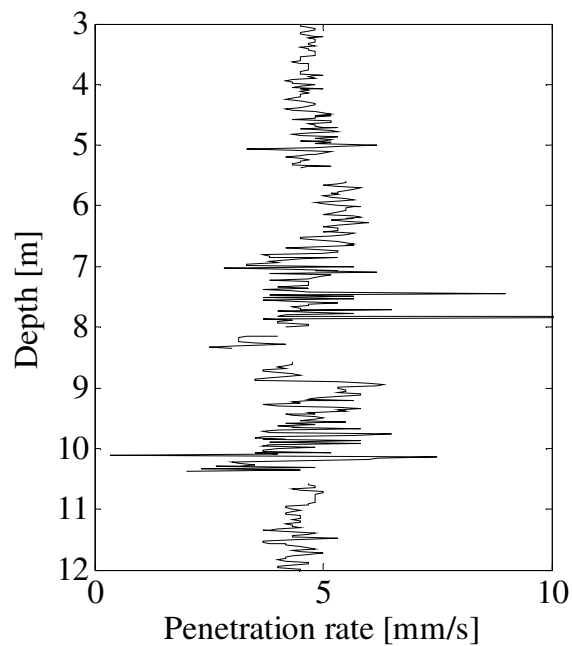


Figure 38. Rate of penetration for the conducted CPT B3.

Statistical data	
Mean value, \bar{v}	4.7
Coefficient of variation, δ	0.21

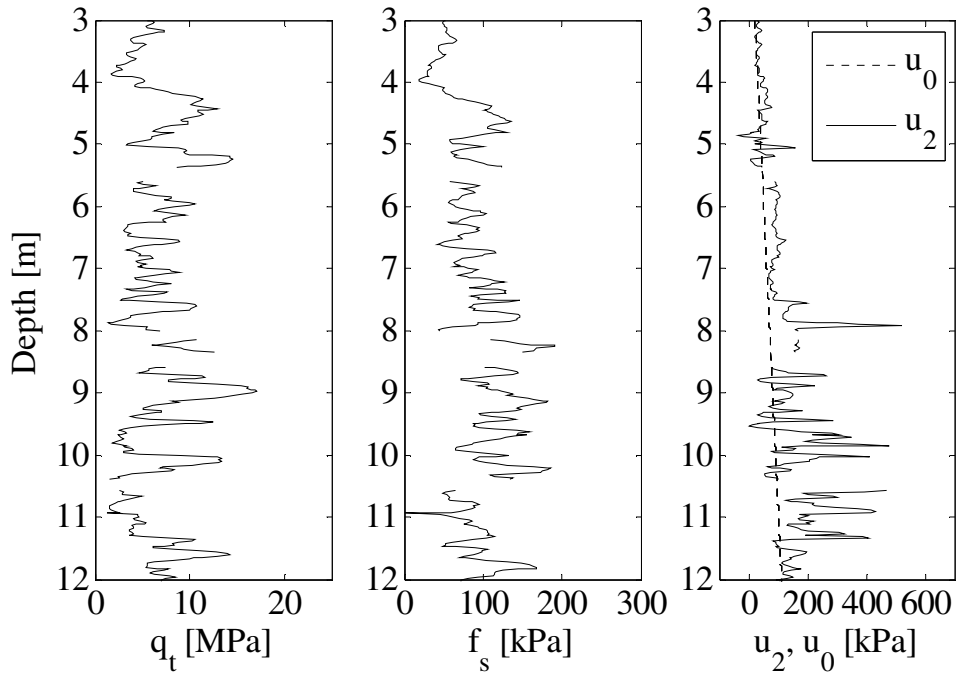


Figure 39. Cone resistance, sleeve friction, pore pressure for the conducted CPT B3.

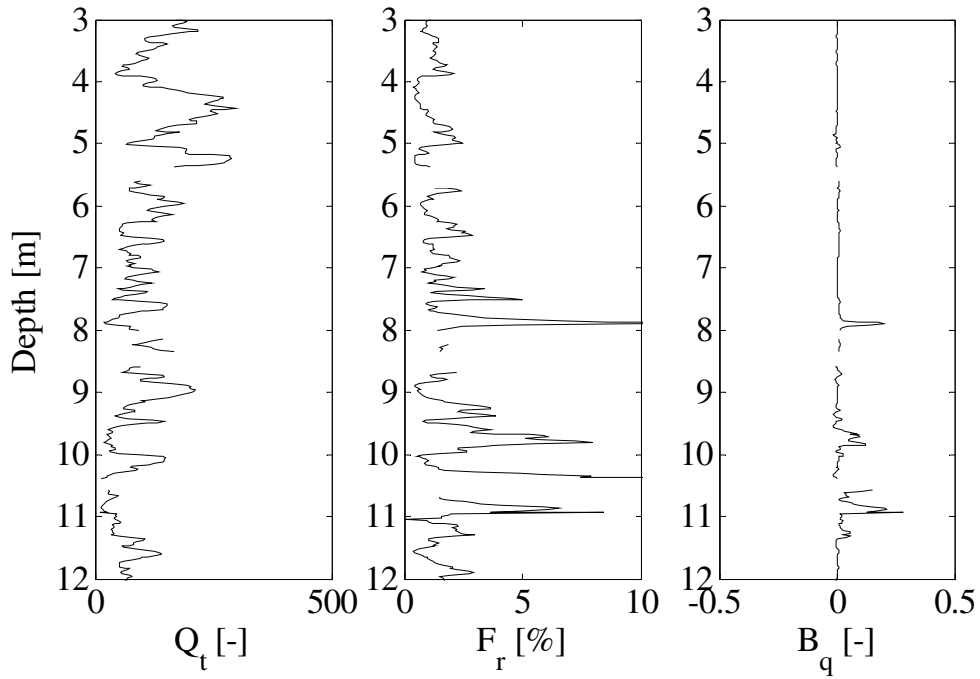


Figure 40. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT B3.

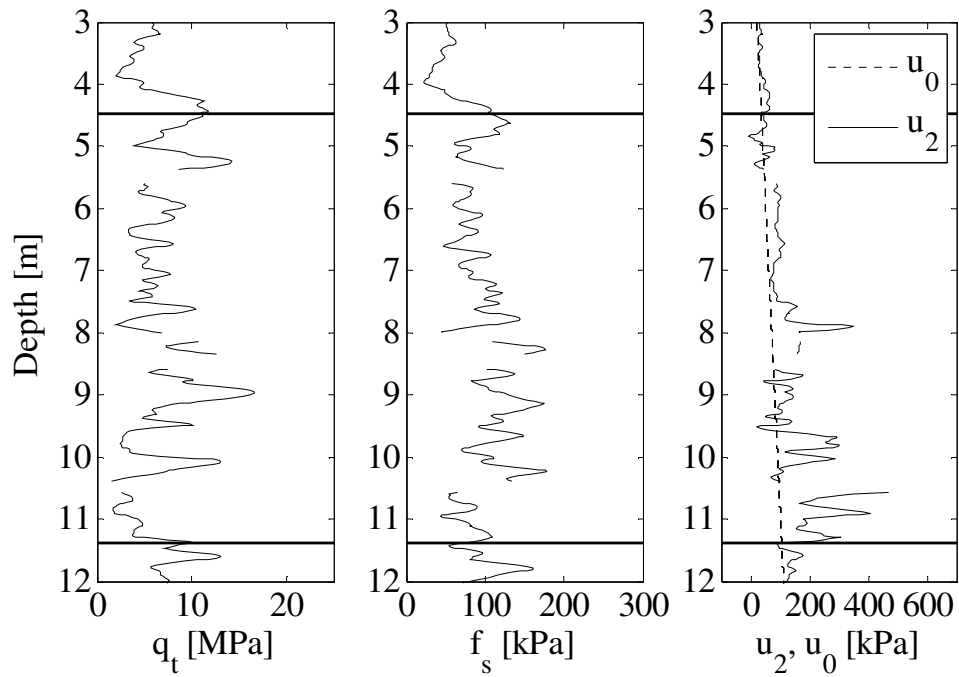


Figure 41. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT B3.

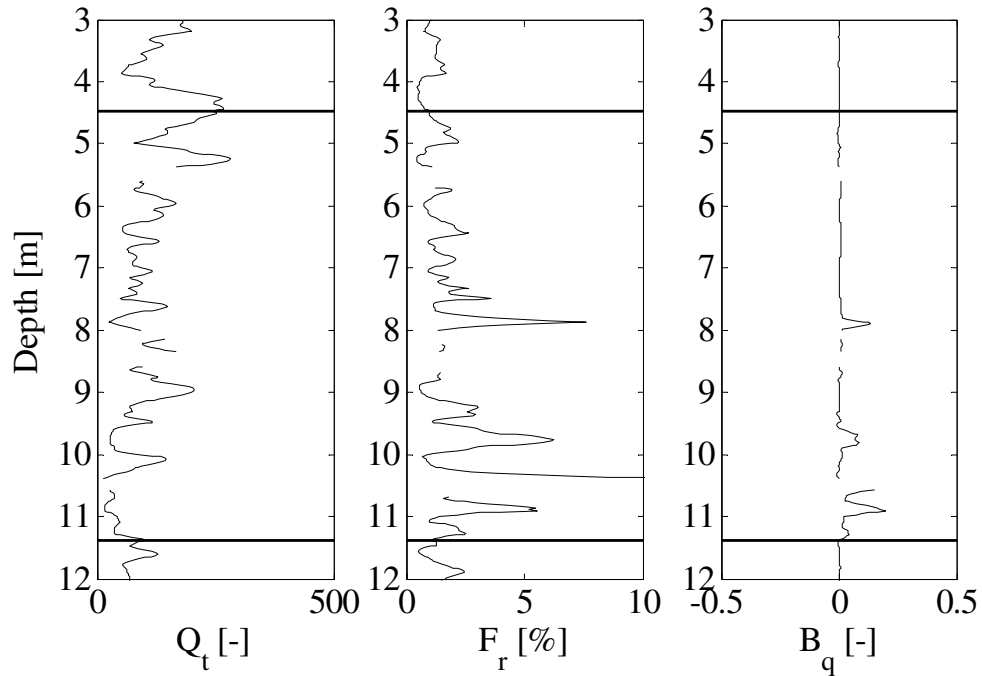


Figure 42. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT B3.

Test B4

Table 9. Information of the conducted CPT test.

CPT no.:	B4						
Rate of Penetration:	20 mm/s						
Date:	23.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577655.745			N: 6336541.69			
	Z: 22.655						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	4.253	6.253	8.253	10.233	-	-	-
Comments:	The stops are caused by pre drilling						

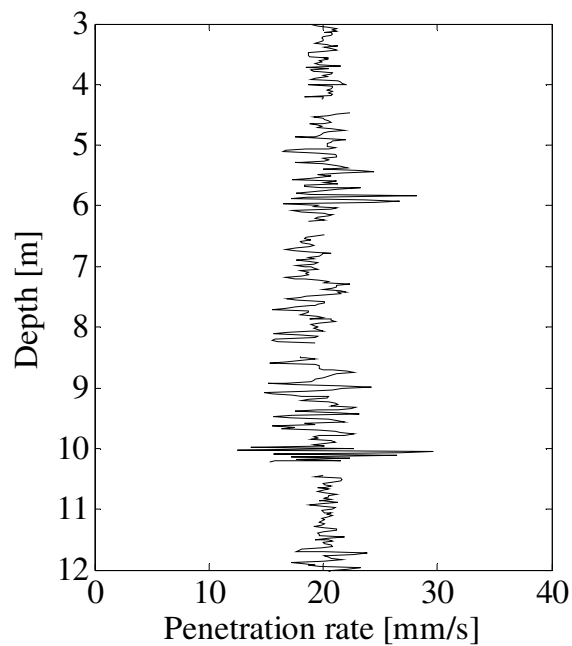


Figure 43. Rate of penetration for the conducted CPT B4.

Statistical data	
Mean value, \bar{v}	19.8
Coefficient of variation, δ	0.09

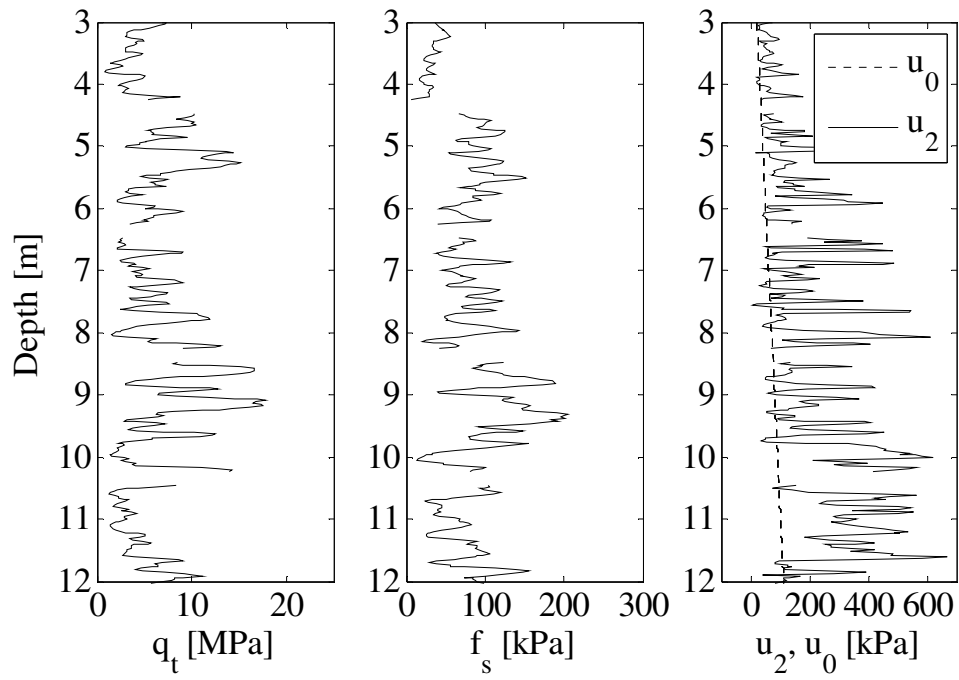


Figure 44. Cone resistance, sleeve friction, pore pressure for the conducted CPT B4.

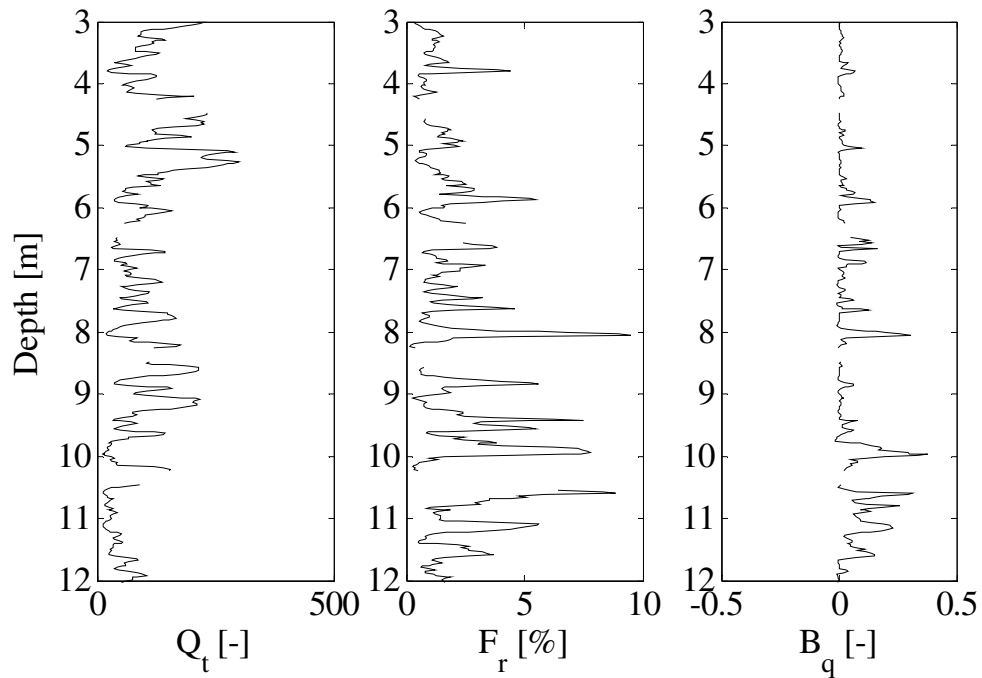


Figure 45. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT B4.

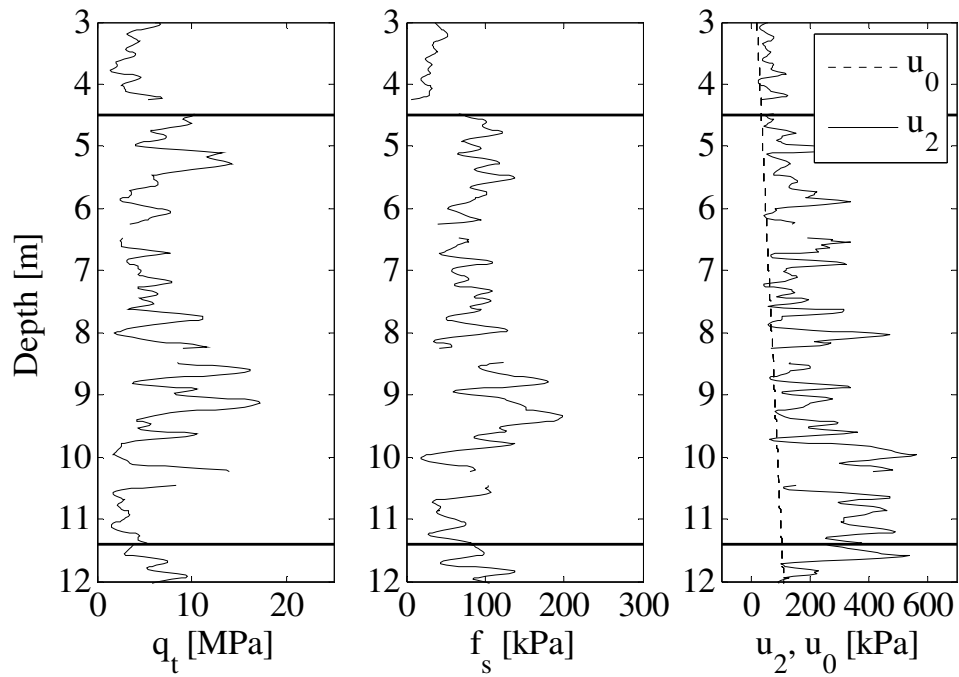


Figure 46. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT B4.

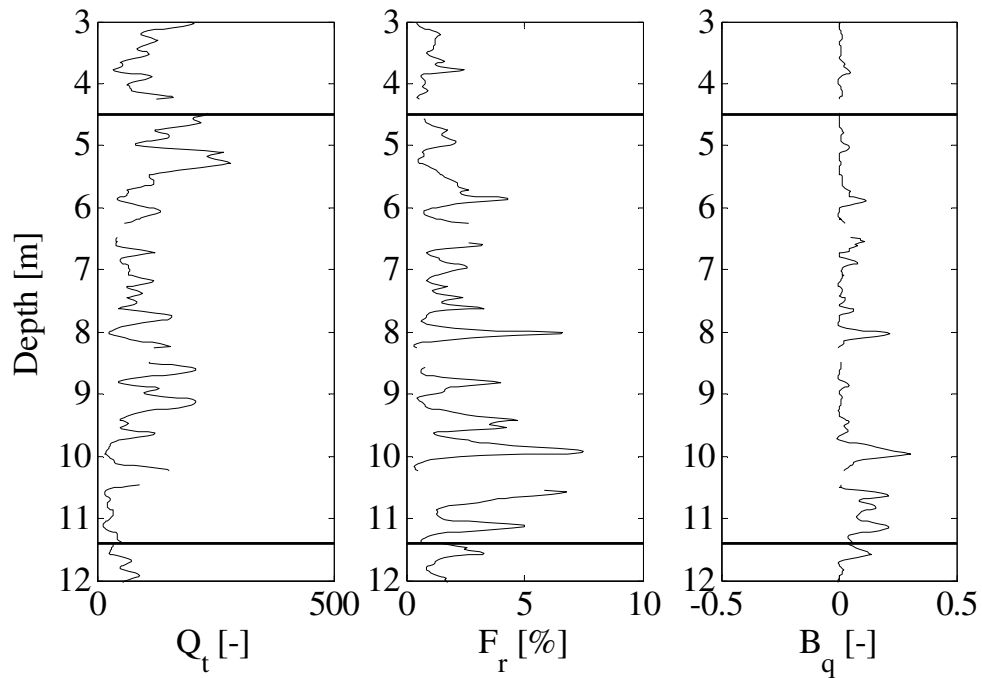


Figure 47. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT B4.

Test B5

Table 10. Information of the conducted CPT test.

CPT no.:	B5						
Rate of Penetration:	60 mm/s						
Date:	21.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577659.008			N: 6336542.736			
	Z: 22.813						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	5.115	8.075	10.055	-	-	-	-
Comments:	The stops are caused by pre drilling						

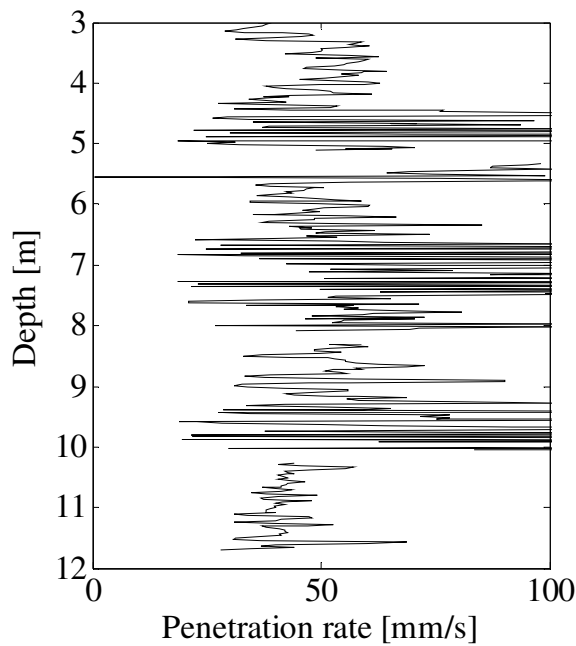


Figure 48. Rate of penetration for the conducted CPT B5.

Statistical data	
Mean value, \bar{v}	58.7
Coefficient of variation, δ	0.57

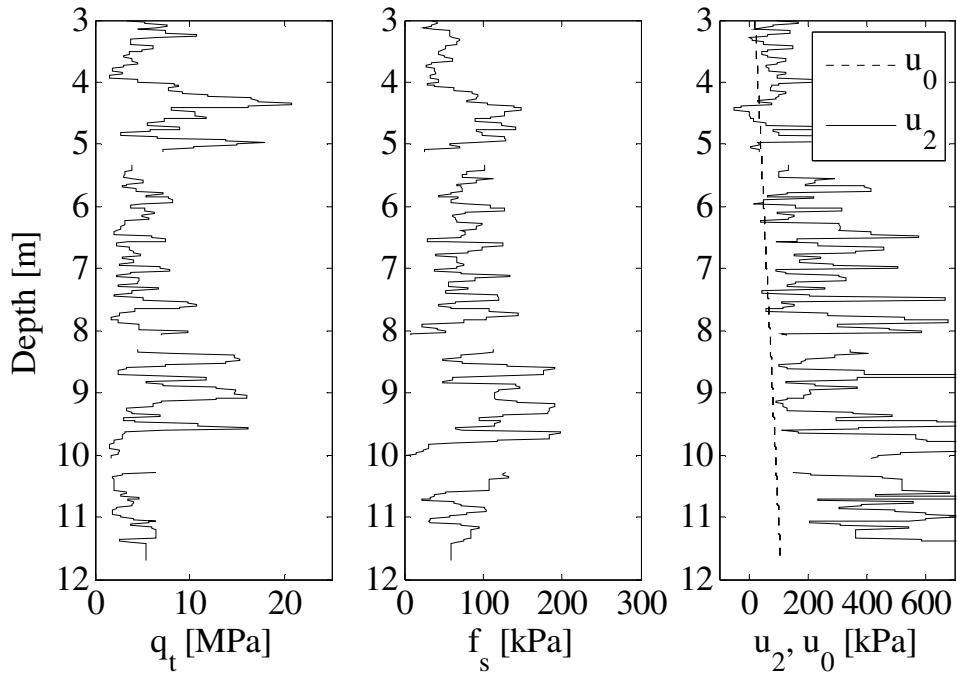


Figure 49. Cone resistance, sleeve friction, pore pressure for the conducted CPT B5.

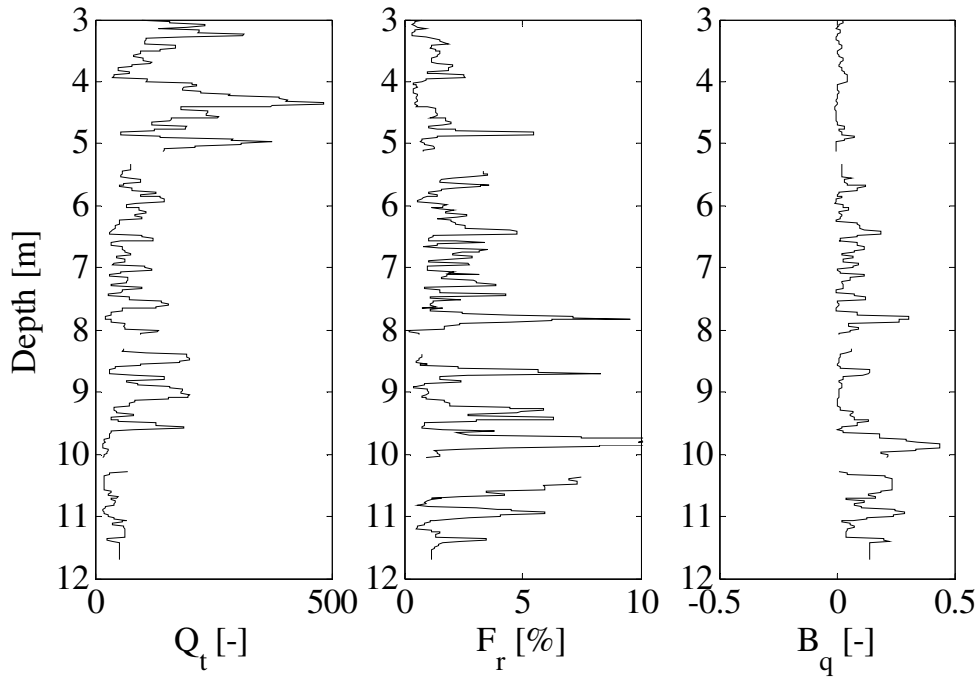


Figure 50. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT B5.

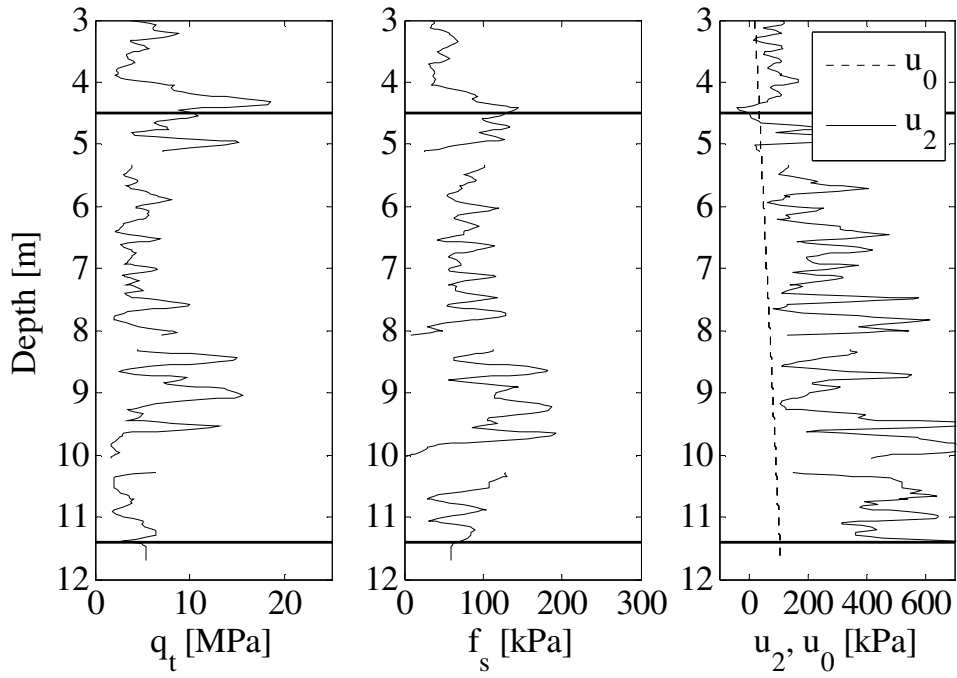


Figure 51. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT B5.

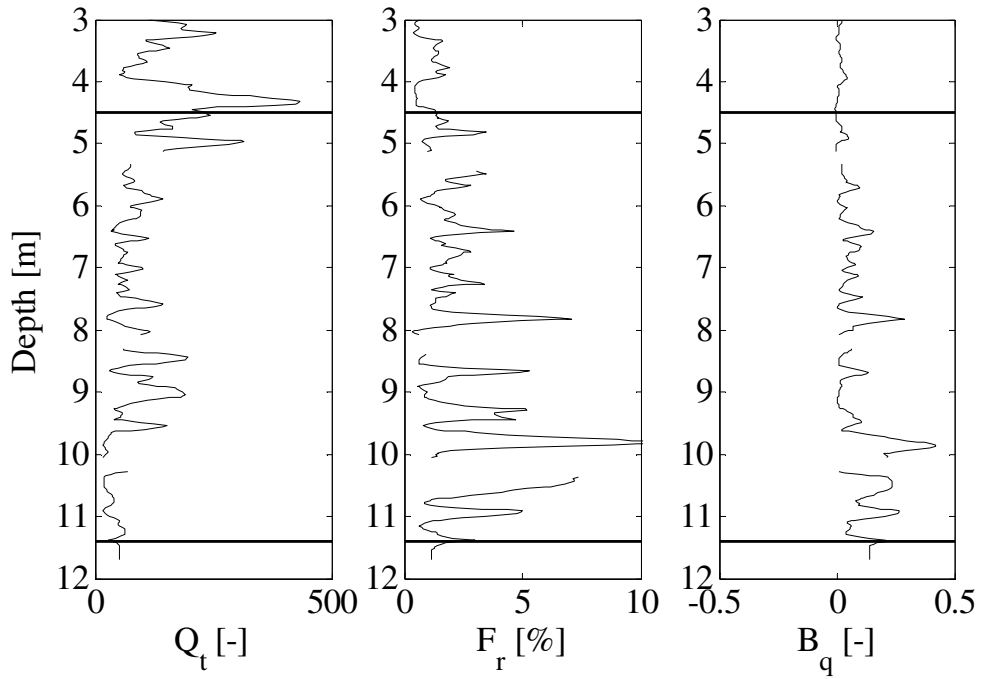


Figure 52. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT B5.

Test C1

Table 11. Information of the conducted CPT test.

CPT no.:	C1						
Rate of Penetration:	60 mm/s						
Date:	24.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577647.884			N: 6336536.122			
	Z: 22.237						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	4.671	6.651	7.551	10.691	-	-	-
Comments:	Stop 1, 2 and 4 are caused by pre drilling. Data are missing between 8 and 9 meters depth.						

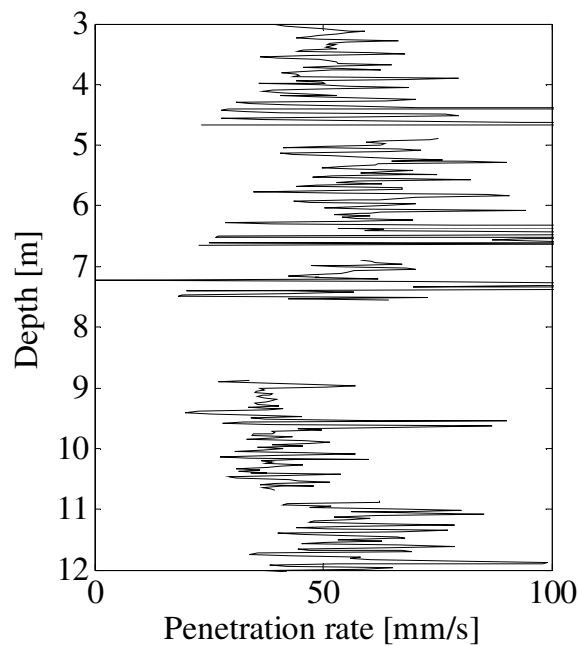


Figure 53. Rate of penetration for the conducted CPT C1.

Statistical data	
Mean value, \bar{v}	55.5
Coefficient of variation, δ	0.40

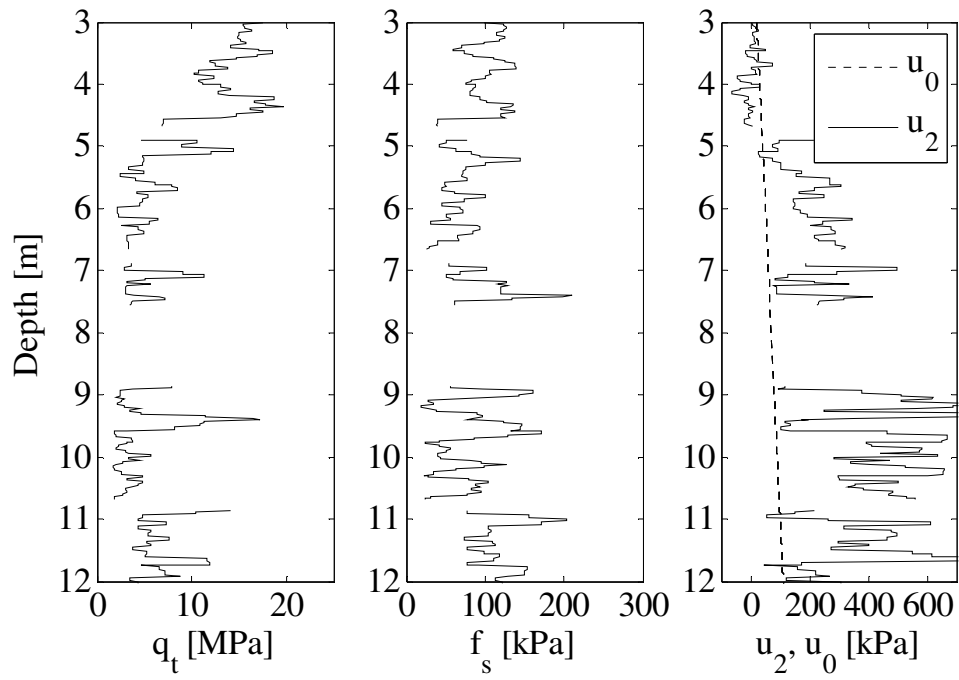


Figure 54. Cone resistance, sleeve friction, pore pressure for the conducted CPT C1.

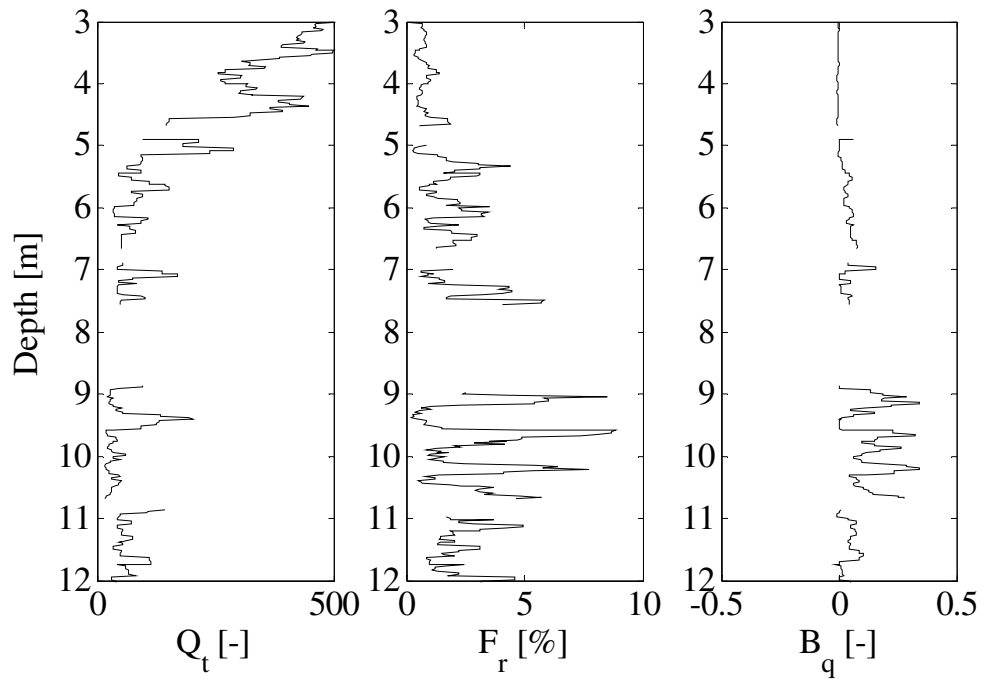


Figure 55. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT C1.

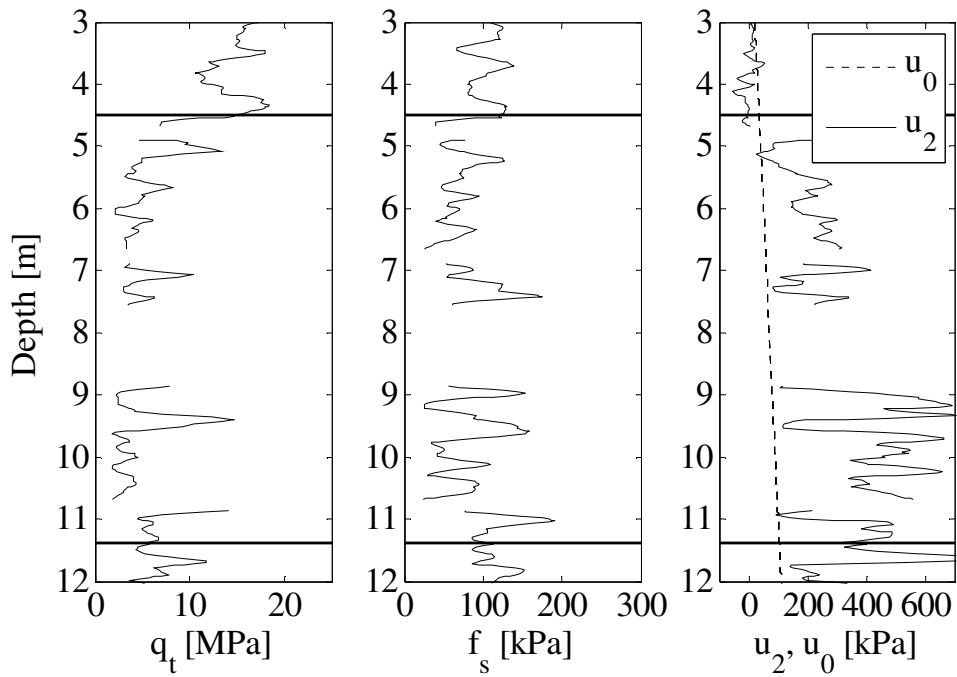


Figure 56. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT C1.

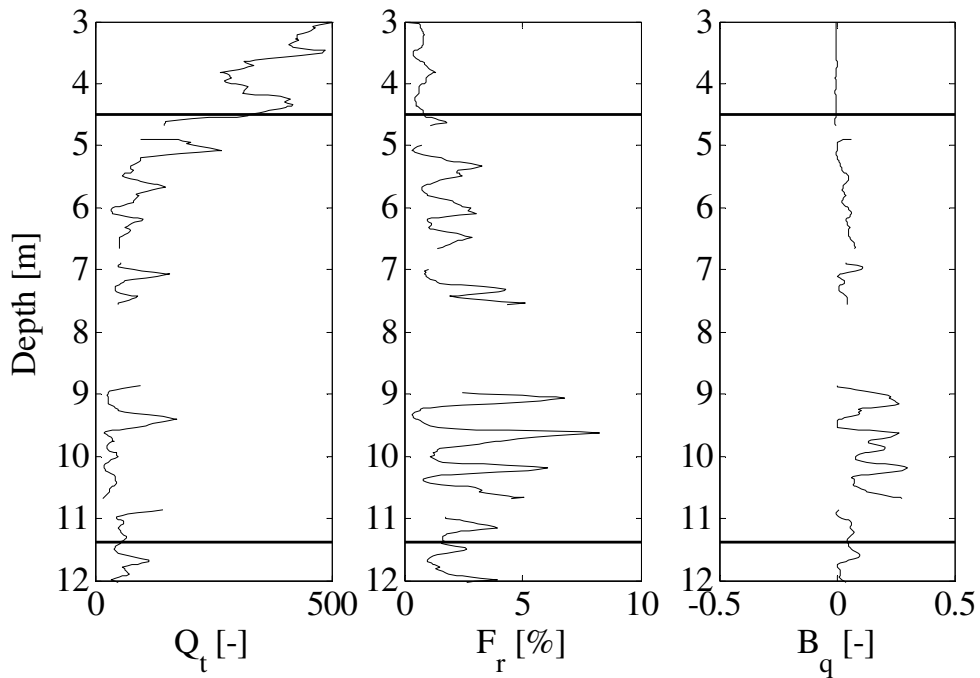


Figure 57. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT C1.

Test C2

Table 12. Information of the conducted CPT test.

CPT no.:	C2						
Rate of Penetration:	20 mm/s						
Date:	30.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577650.994			N: 6336537.222			
	Z: 22.281						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	4.567	6.627	7.507	7.767	7.927	8.287	10.627
Comments:	Stop 1, 2, 6 and 7 are caused by pre drilling. Some data are missing between 6.6 and 8.8 meters depth.						

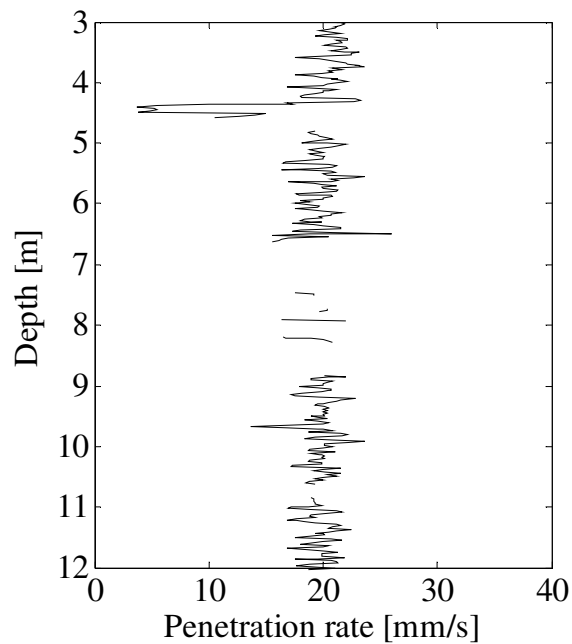


Figure 58. Rate of penetration for the conducted CPT C2.

Statistical data	
Mean value, \bar{v}	19.5
Coefficient of variation, δ	0.14

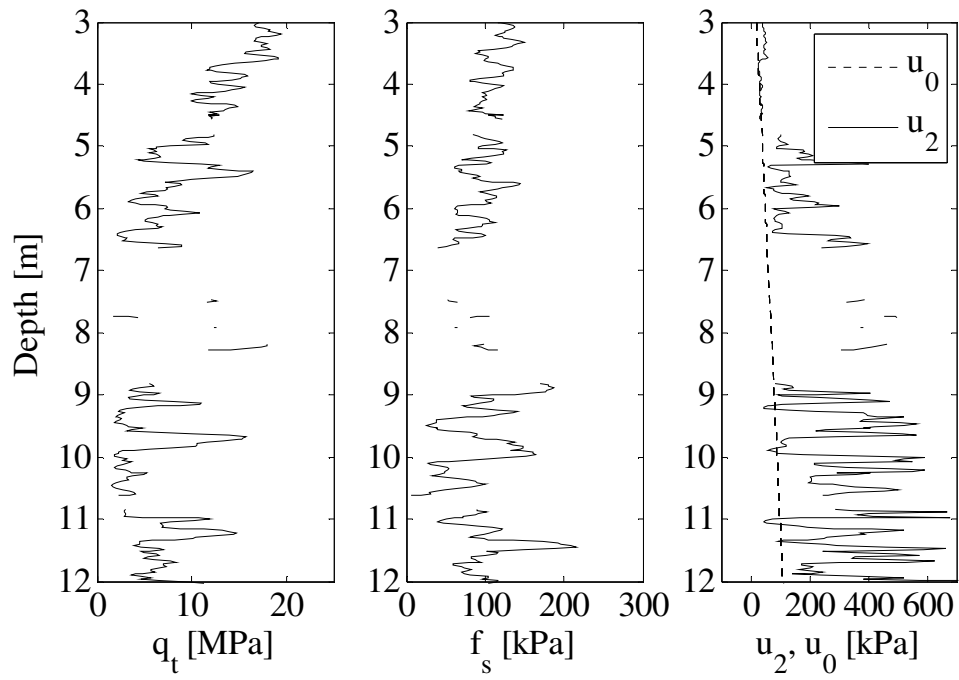


Figure 59. Cone resistance, sleeve friction, pore pressure for the conducted CPT C2.

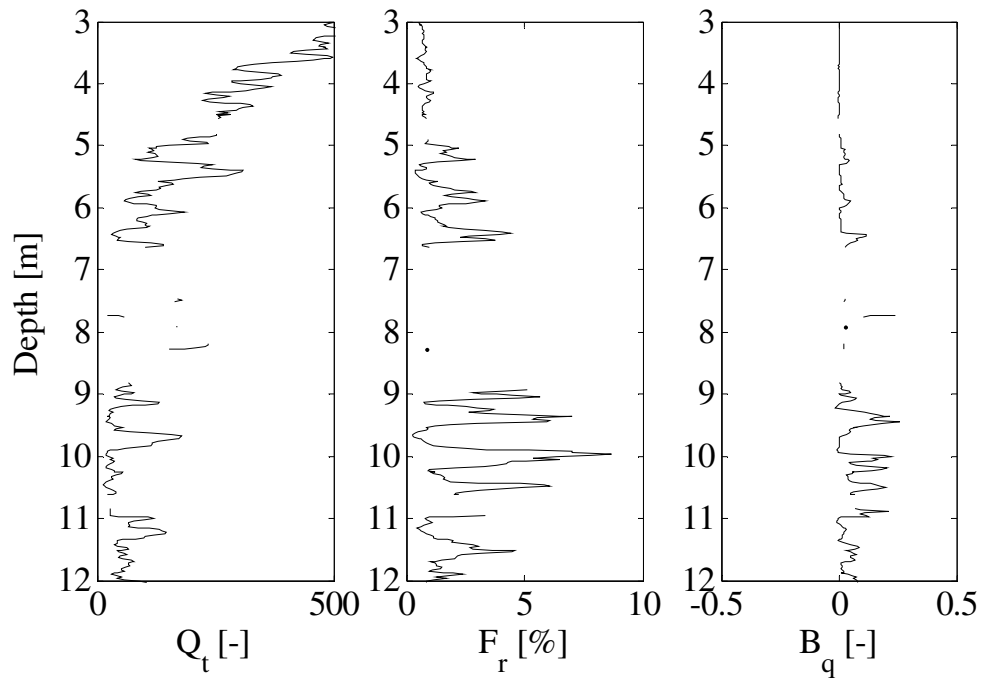


Figure 60. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT C2.

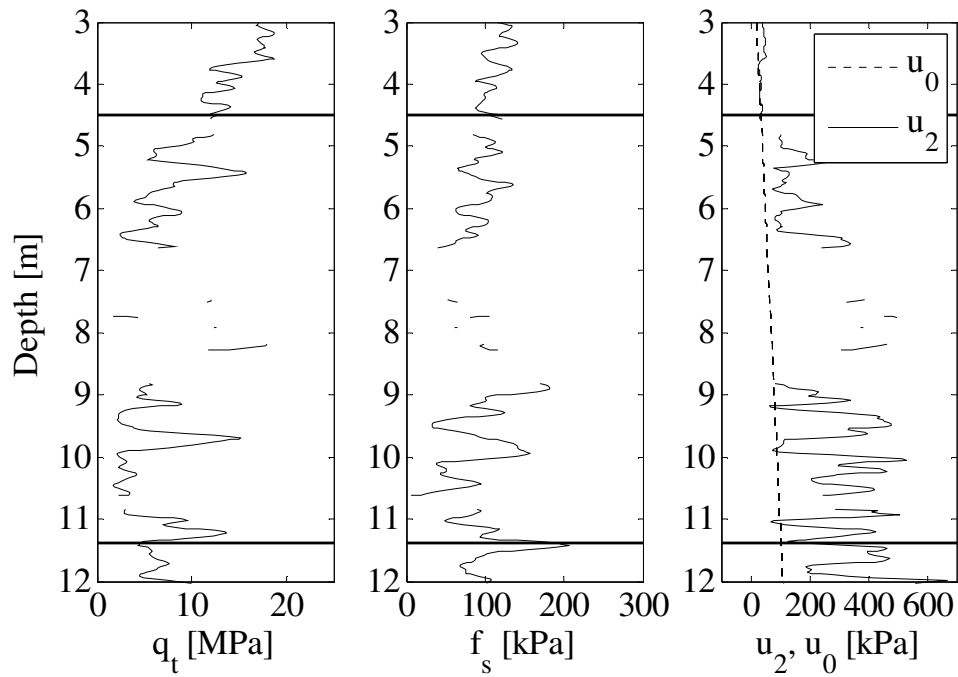


Figure 61. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT C2.

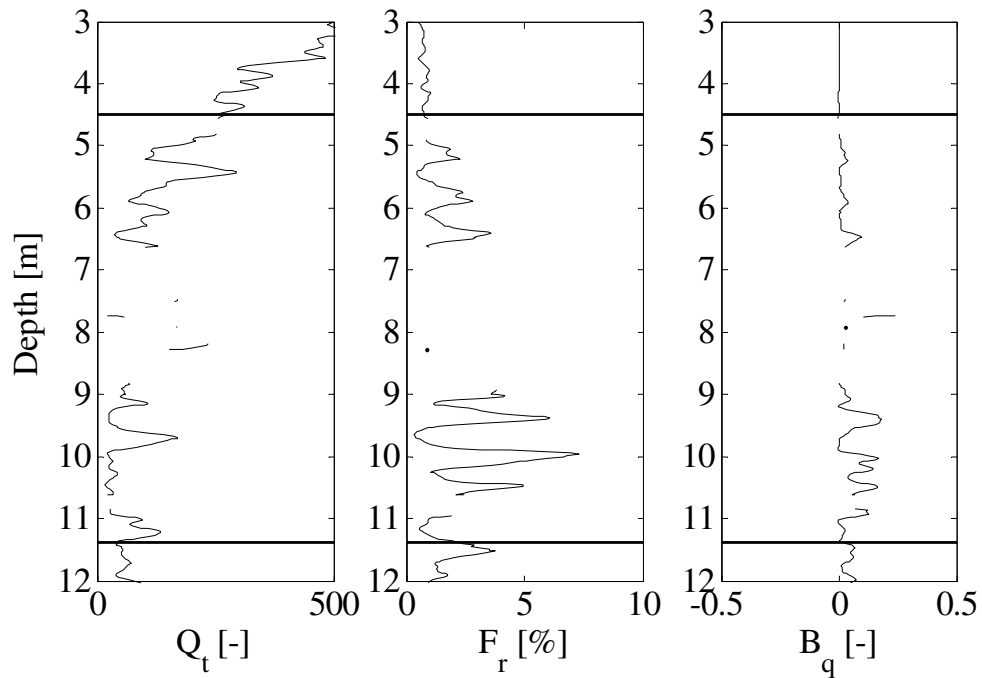


Figure 62. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT C2.

Test C3

Table 13. Information of the conducted CPT test.

CPT no.:	C3						
Rate of Penetration:	1 mm/s						
Date:	29.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577654.051			N: 6336538.104			
	Z: 22.461						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	4.427	6.447	8.447	10.447	10.747	-	-
Comments:	Stop 1, 2, 3 and 4 are caused by pre drilling.						

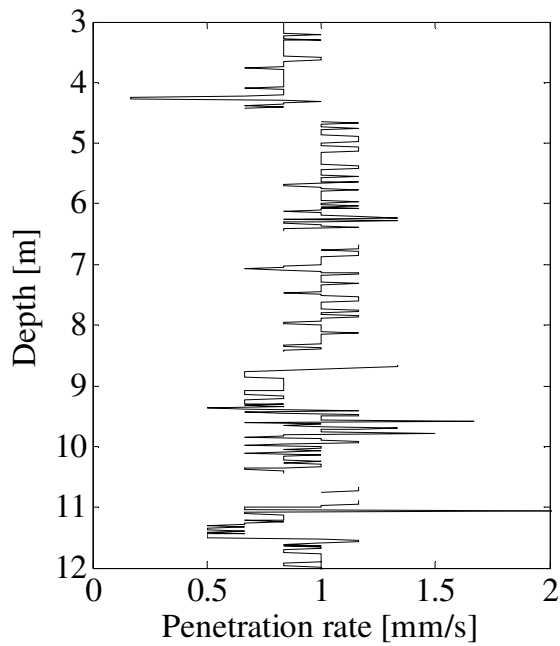


Figure 63. Rate of penetration for the conducted CPT C3.

Statistical data	
Mean value, \bar{v}	0.9
Coefficient of variation, δ	0.20

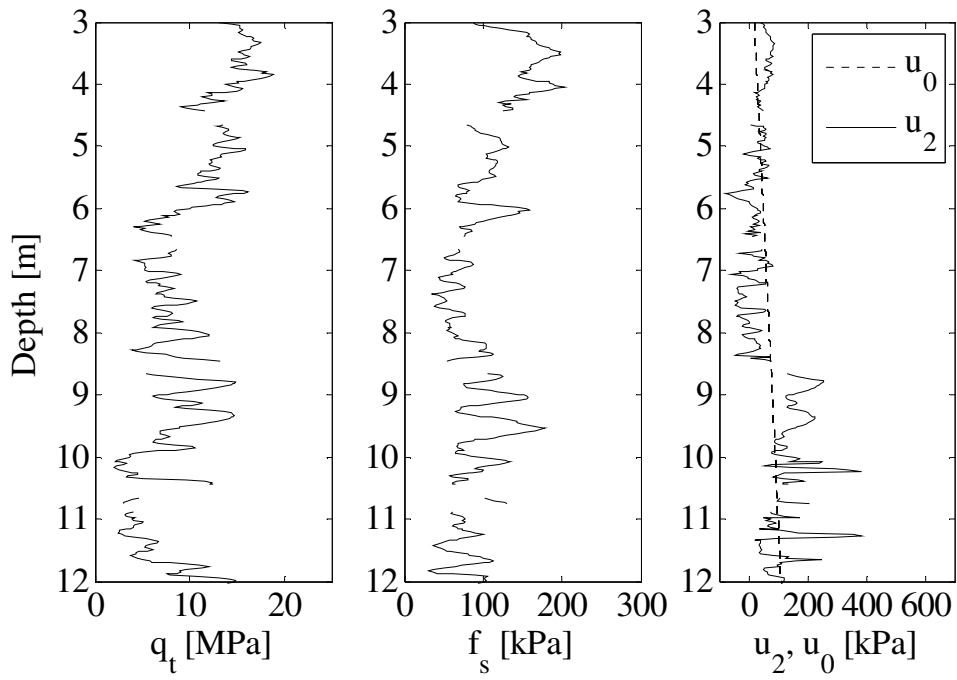


Figure 64. Cone resistance, sleeve friction, pore pressure for the conducted CPT C3.

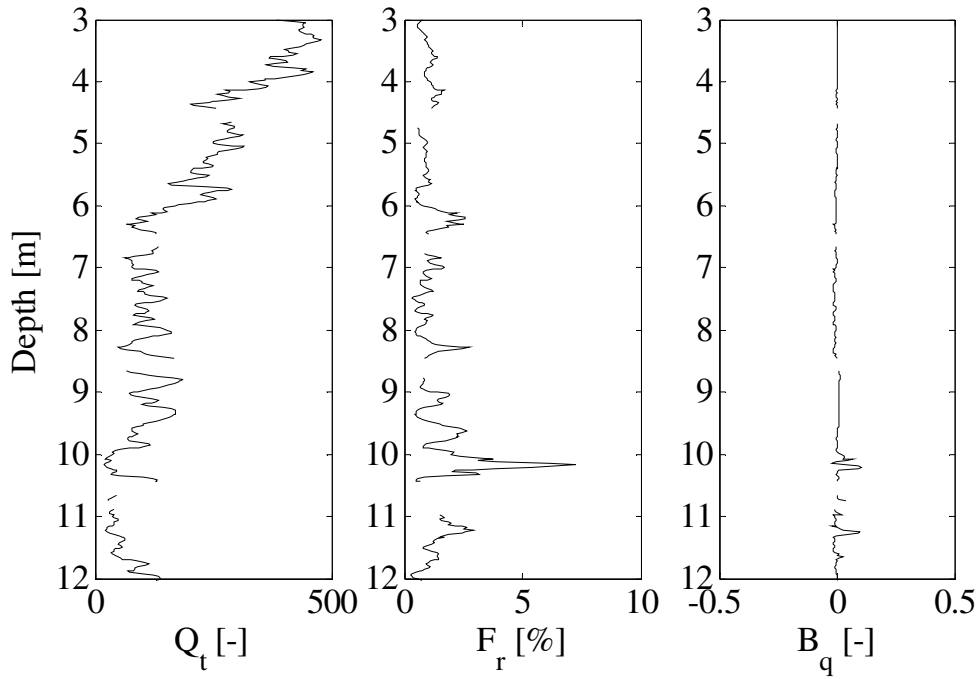


Figure 65. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT C3.

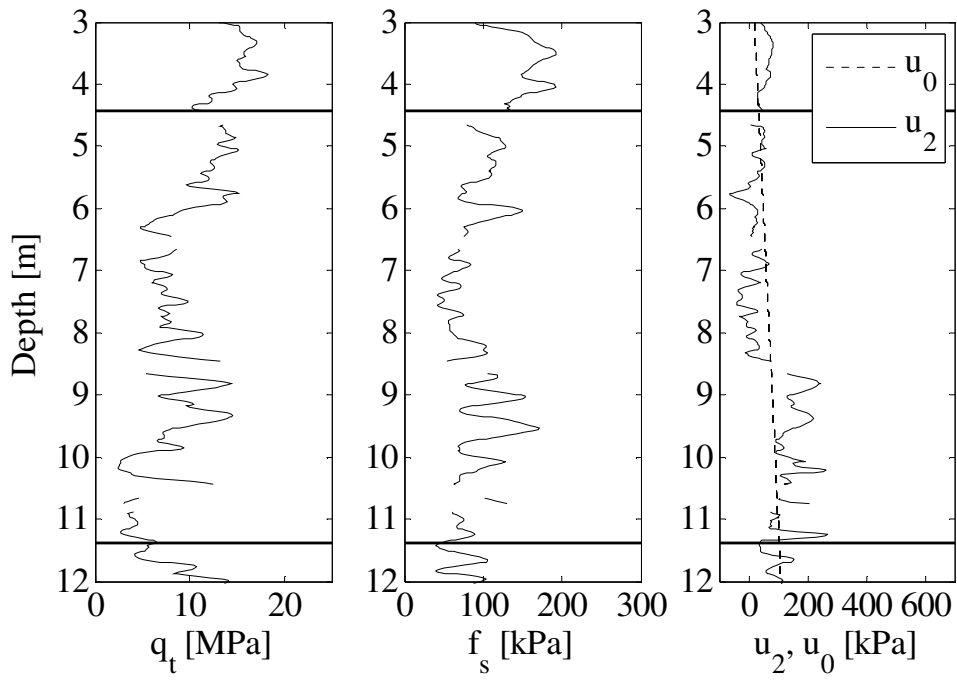


Figure 66. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT C3.

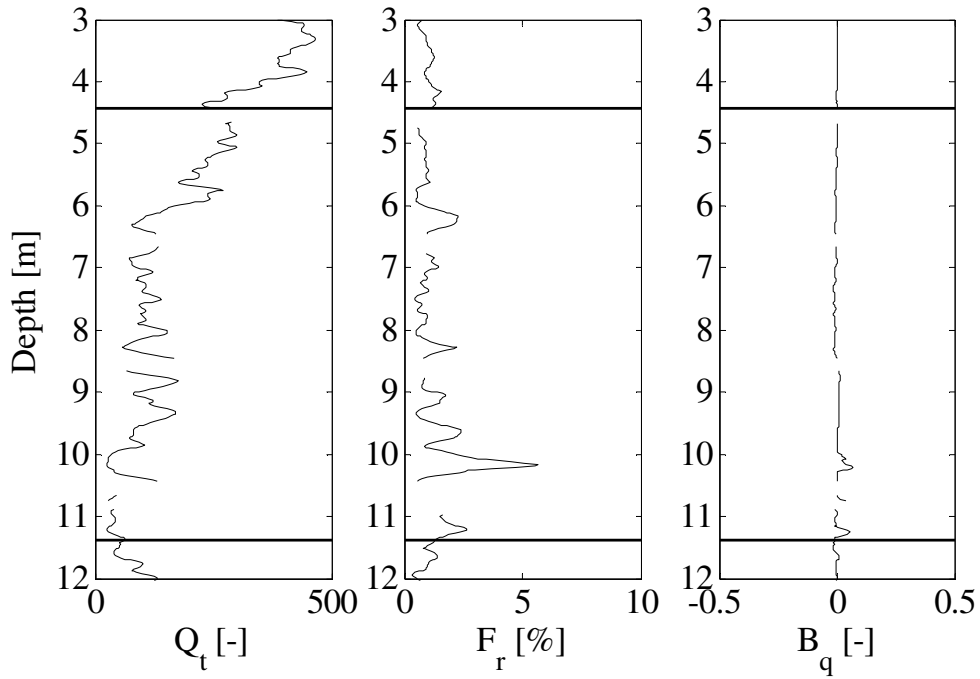


Figure 67. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT C3.

Test C4

Table 14. Information of the conducted CPT test.

CPT no.:	C4						
Rate of Penetration:	0.5 mm/s						
Date:	28.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577657.054			N: 6336538.911			
	Z: 22.526						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	2.922	4.342	6.102	6.382	6.742	10.382	10.902
Comments:	Stop 2, 4, and 6 are caused by pre drilling. Some data are missing between 6.0 and 8.6 meters depth.						

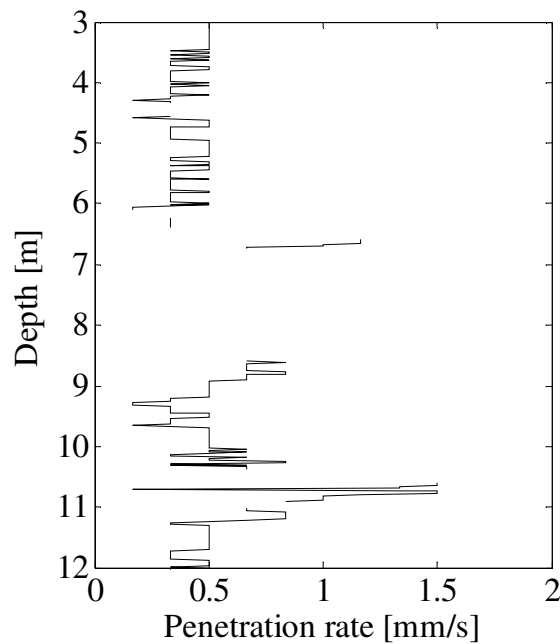


Figure 68. Rate of penetration for the conducted CPT C4.

Statistical data	
Mean value, \bar{v}	0.5
Coefficient of variation, δ	0.46

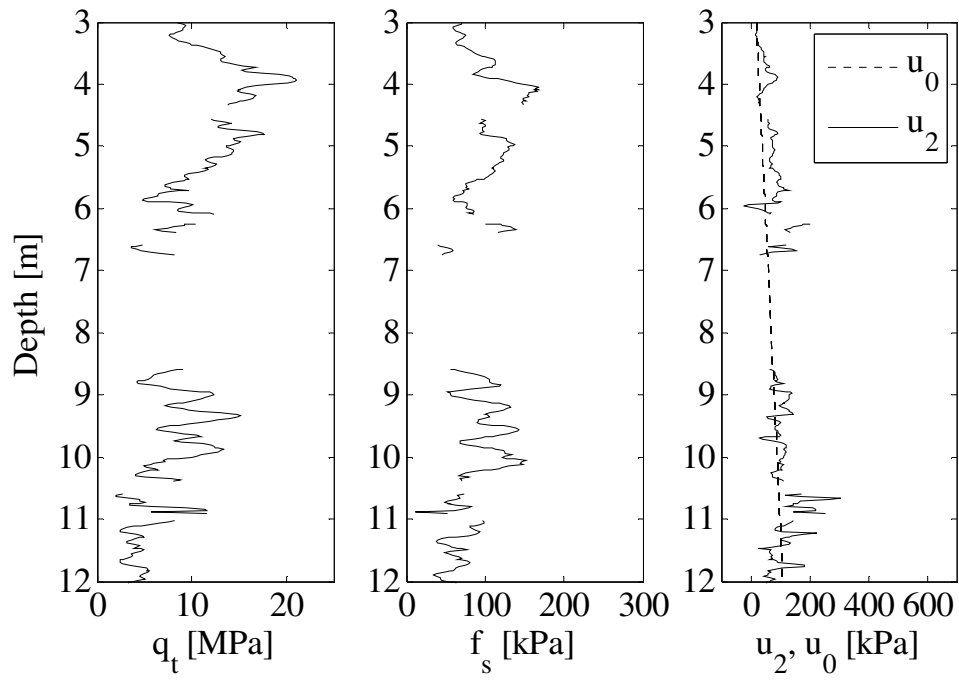


Figure 69. Cone resistance, sleeve friction, pore pressure for the conducted CPT C4.

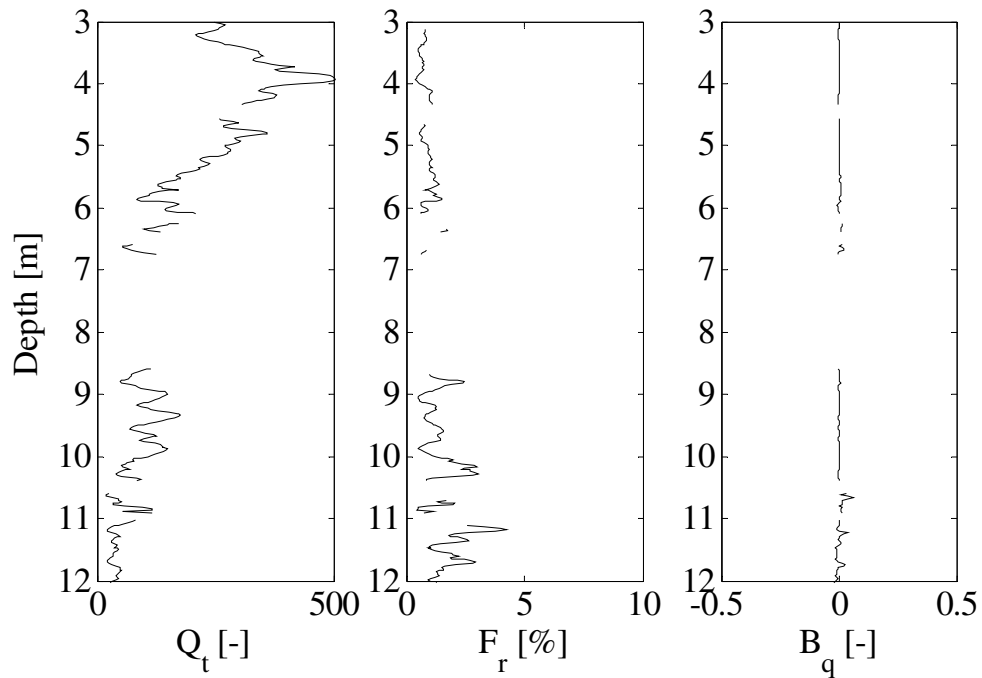


Figure 70. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT C4.

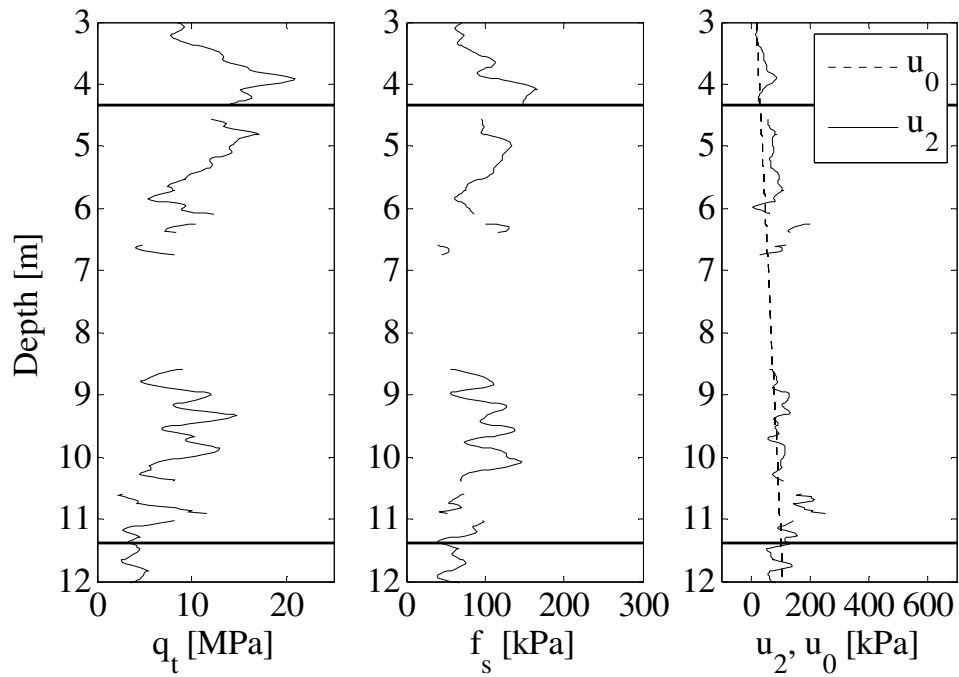


Figure 71. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT C4.

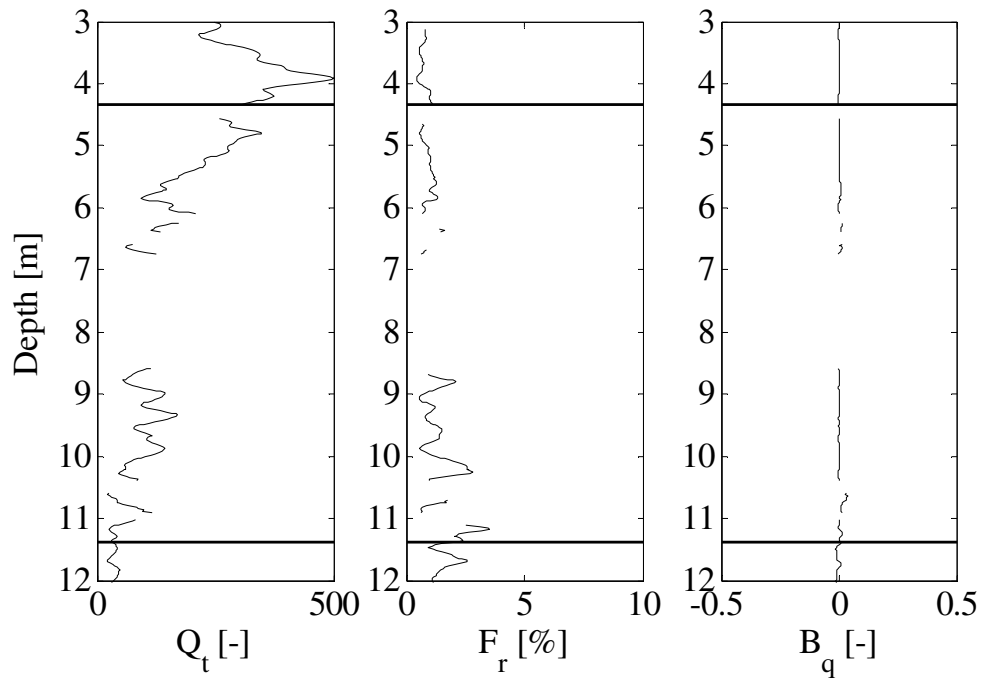


Figure 72. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT C4.

Test C5

Table 15. Information of the conducted CPT test.

CPT no.:	C5						
Rate of Penetration:	5 mm/s						
Date:	30.03.2011						
Location:	Dronninglund						
Coordinates:	E: 577660.081			N: 6336539.743			
	Z: 22.619						
Cone type:	Envi standard 10 cm ² piezocone						
Stops (meters depth):	1	2	3	4	5	6	7
	4.269	6.289	8.289	-	-	-	-
Comments:	The stops are caused by pre drilling. Some data are missing between 8.0 and 10.5 meters depth.						

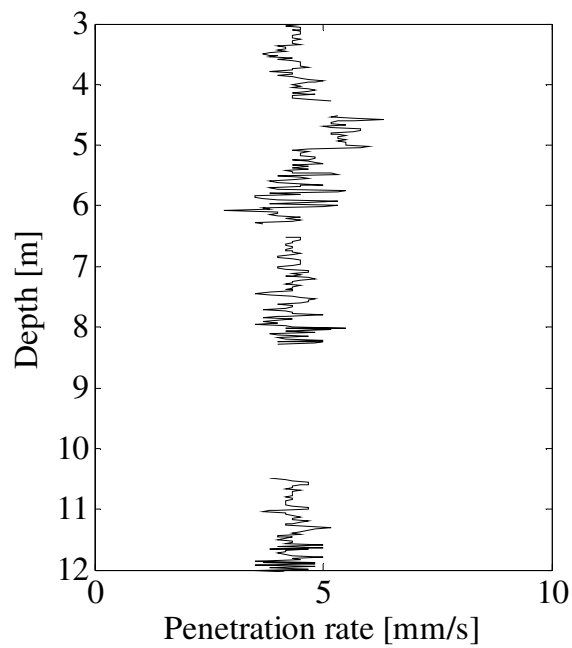


Figure 73. Rate of penetration for the conducted CPT C5.

Statistical data	
Mean value, \bar{v}	4.4
Coefficient of variation, δ	0.11

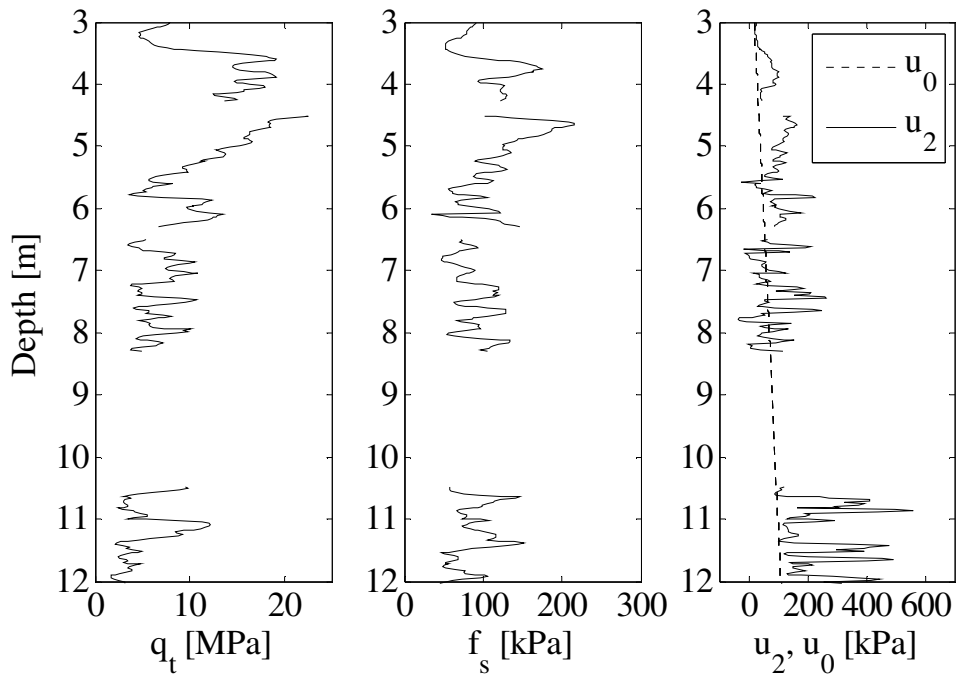


Figure 74. Cone resistance, sleeve friction, pore pressure for the conducted CPT C5.

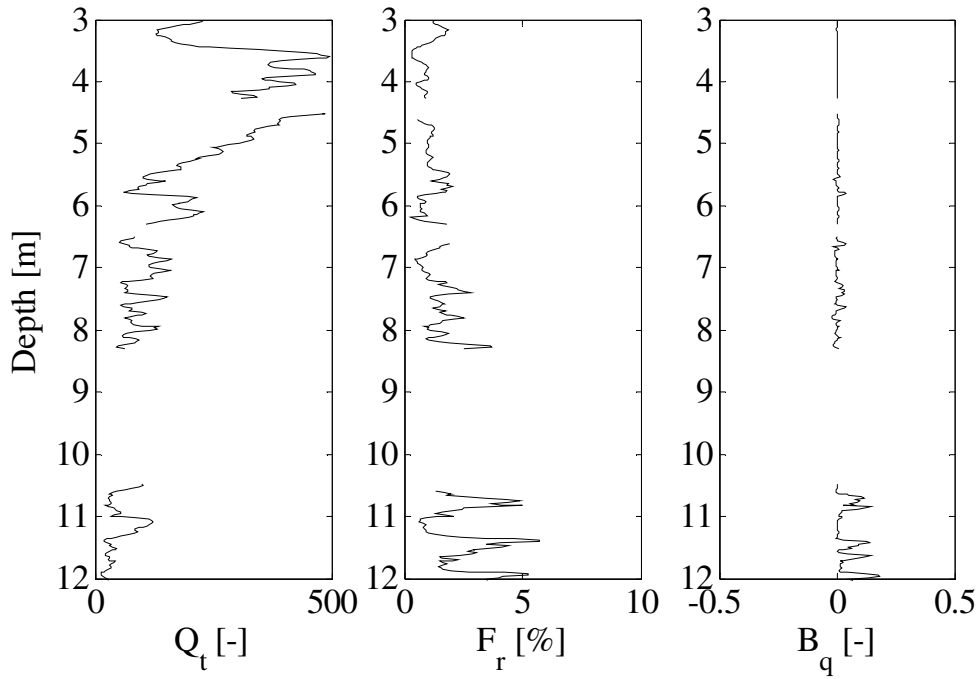


Figure 75. Normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT C5.

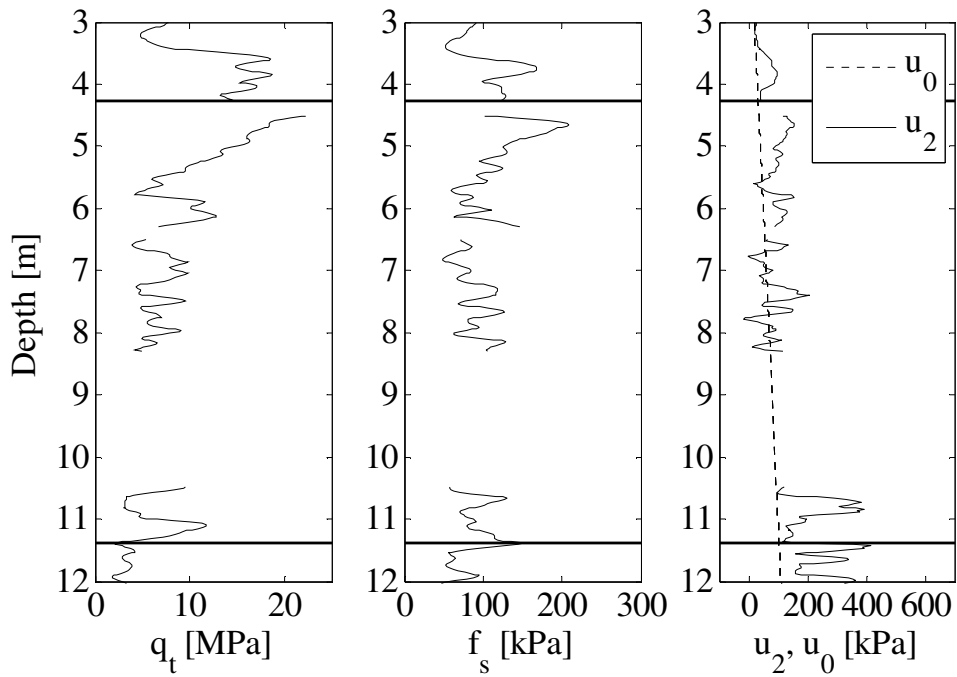


Figure 76. Smoothed cone resistance, sleeve friction, pore pressure, for the conducted CPT C5.

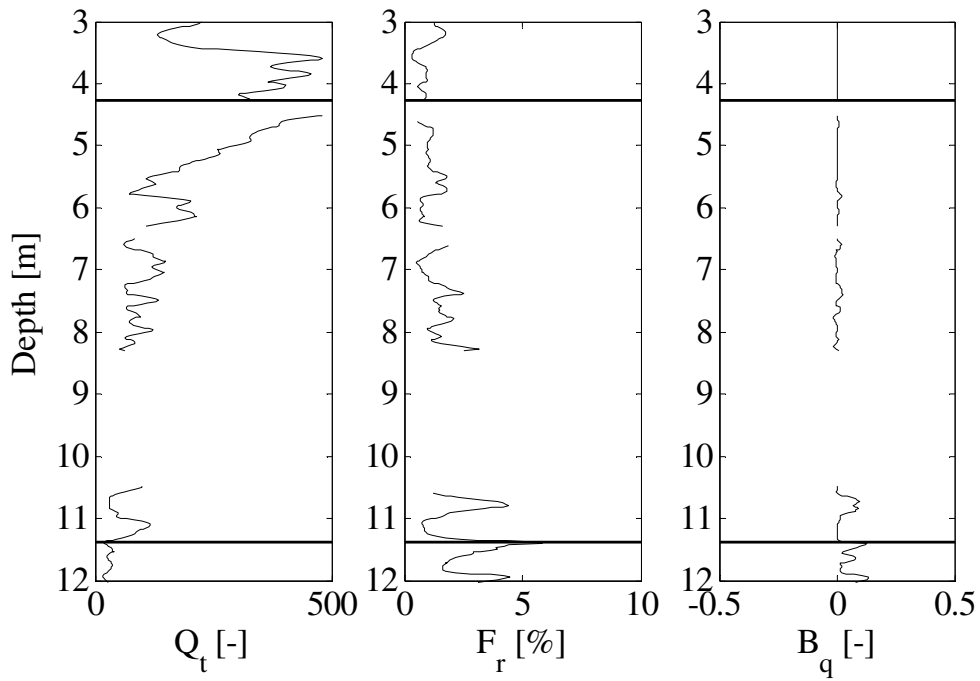


Figure 77. Smoothed normalized cone resistance, normalized friction ratio and pore pressure ratio for the conducted CPT C5.

References

- ASTM. (2007). "Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils". *D5778-07*, ASTM, Pennsylvania.
- Lunne, T., Robertson, P. K., and Powell, J. J. M. (1997). *Cone penetration testing in geotechnical practice*, Blakie Academic and Professional, Melbourne, Australia.
- McNeilan, T. W., and Bugno, W.T. (1985). "Cone Penetration Test Results in Offshore California Silts". *Strength Testing of Marine Sediments: Laboratory and In-Situ Measurements*, ASTM STP 883, ASTM, Philadelphia, 55-71.
- Poulsen, R., Nielsen, B. N., Ibsen, L. B. (2011). "Effect of Drainage Conditions on Cone Penetration Testing in Silty Soils". *Proc. 64th Canadian Geotechnical Conference and 14th Pan-American Conference on Soil Mechanics and Engineering*, Toronto, ON, Canada

Videnskabelige publikationer ved Institut for Byggeri og Anlæg

Technical Reports anvendes til endelig afrapportering af forskningsresultater og videnskabeligt arbejde udført ved Institut for Byggeri og Anlæg på Aalborg Universitet. Serien giver mulighed for at fremlægge teori, forsøgsbeskrivelser og resultater i fuldstændig og uforkortet form, hvilket ofte ikke tillades i videnskabelige tidsskrifter.

Technical Memoranda udarbejdes til præliminær udgivelse af videnskabeligt arbejde udført af ansatte ved Institut for Byggeri og Anlæg, hvor det skønnes passende. Dokumenter af denne type kan være ufuldstændige, midlertidige versioner eller dele af et større arbejde. Dette skal holdes in mente, når publikationer i serien refereres.

Contract Reports benyttes til afrapportering af rekvireret videnskabeligt arbejde. Denne type publikationer rummer fortroligt materiale, som kun vil være tilgængeligt for rekvirenten og Institut for Byggeri og Anlæg. Derfor vil Contract Reports sædvanligvis ikke blive udgivet offentligt.

Lecture Notes indeholder undervisningsmateriale udarbejdet af undervisere ansat ved Institut for Byggeri og Anlæg. Dette kan være kursusnoter, lærebøger, opgavekompendier, forsøgsmanualer eller vejledninger til computerprogrammer udviklet ved Institut for Byggeri og Anlæg.

Theses er monografier eller artikelsamlinger publiceret til afrapportering af videnskabeligt arbejde udført ved Institut for Byggeri og Anlæg som led i opnåelsen af en ph.d.- eller doktorgrad. Afhandlingerne er offentligt tilgængelige efter succesfuldt forsvar af den akademiske grad.

Latest News rummer nyheder om det videnskabelige arbejde udført ved Institut for Byggeri og Anlæg med henblik på at skabe dialog, information og kontakt om igangværende forskning. Dette inkluderer status af forskningsprojekter, udvikling i laboratorier, information om samarbejde og nyeste forskningsresultater.

Udgivet 2011 af
Aalborg Universitet
Institut for Byggeri og Anlæg
Sohngårdsholmsvej 57,
DK-9000 Aalborg, Danmark

Trykt i Aalborg på Aalborg Universitet

ISSN 1901-726X
DCE Technical Report No. 123

Seneste udgivelser i DCE Technical Report serien

