





Attuazione dell'articolo 11 della legge 24 giugno 2009, n.77

MICROZONAZIONE SISMICA Livello 3

Regione Emilia-Romagna

Comune di Camposanto

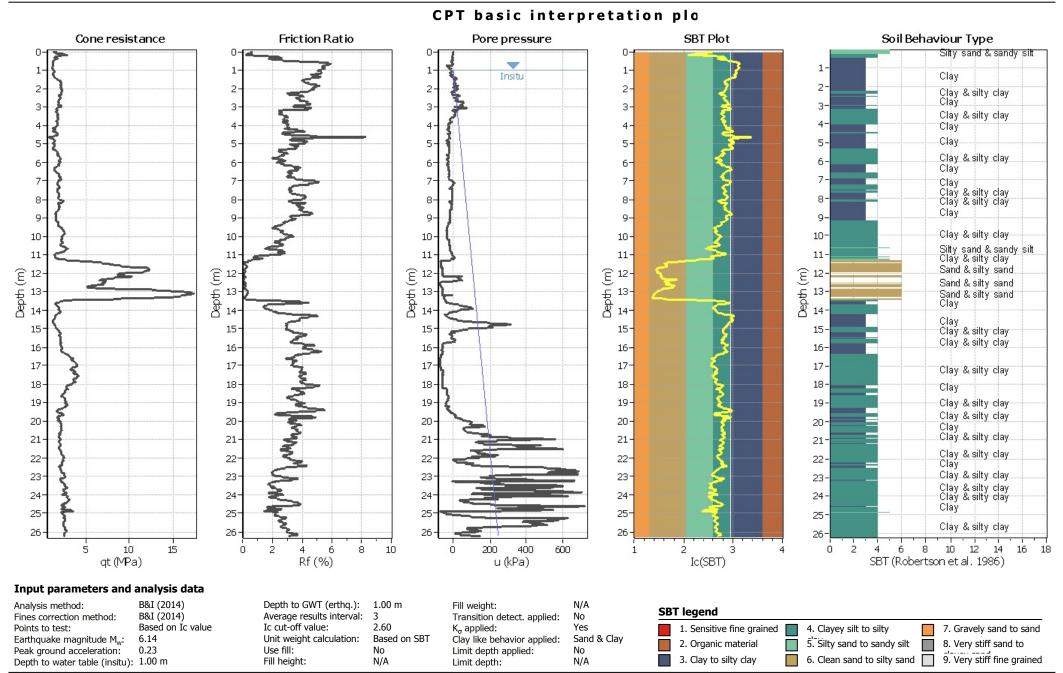


Relazione Illustrativa – Allegato 3

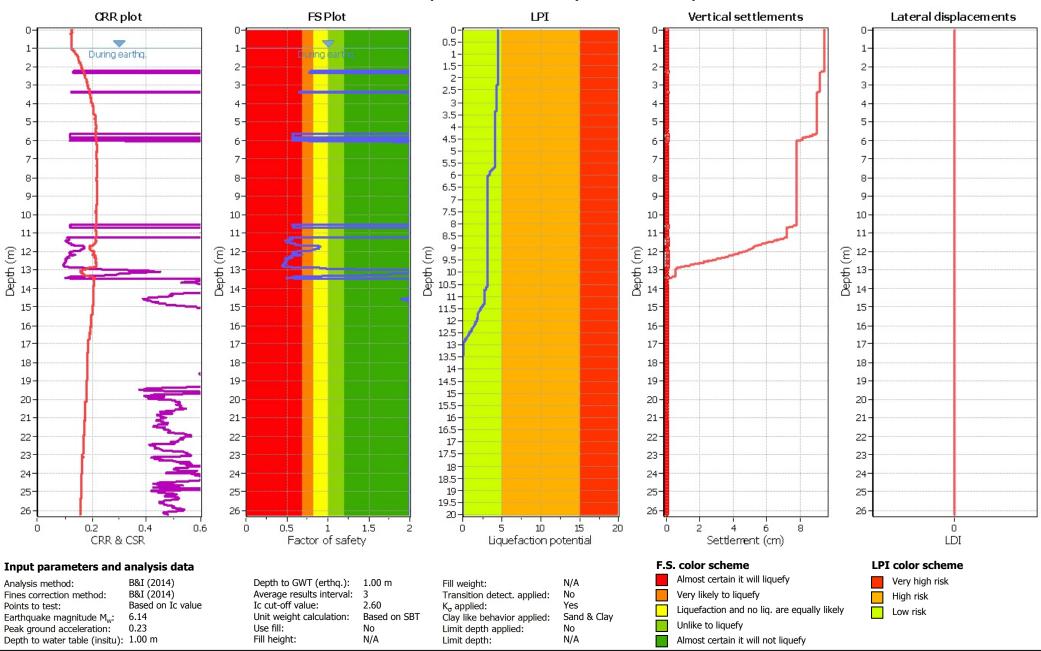
Verifica Potenziale di Liquefazione CPTU

Regione	Soggetto realizzatore	Data
Emilia-Romagna	Geotema S.r.l.	30/10/2018

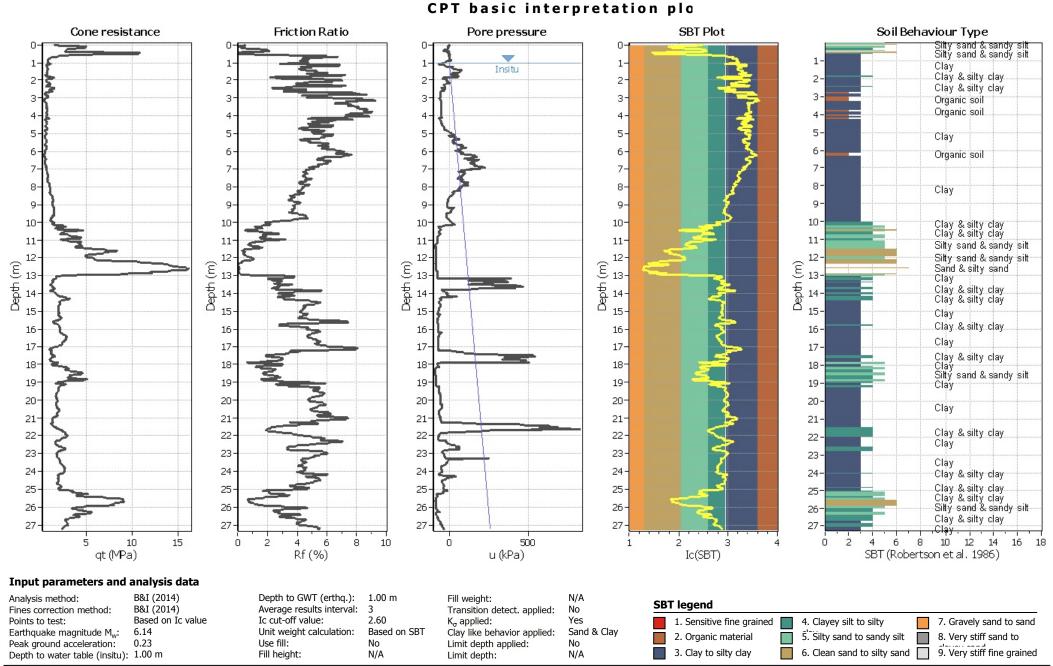
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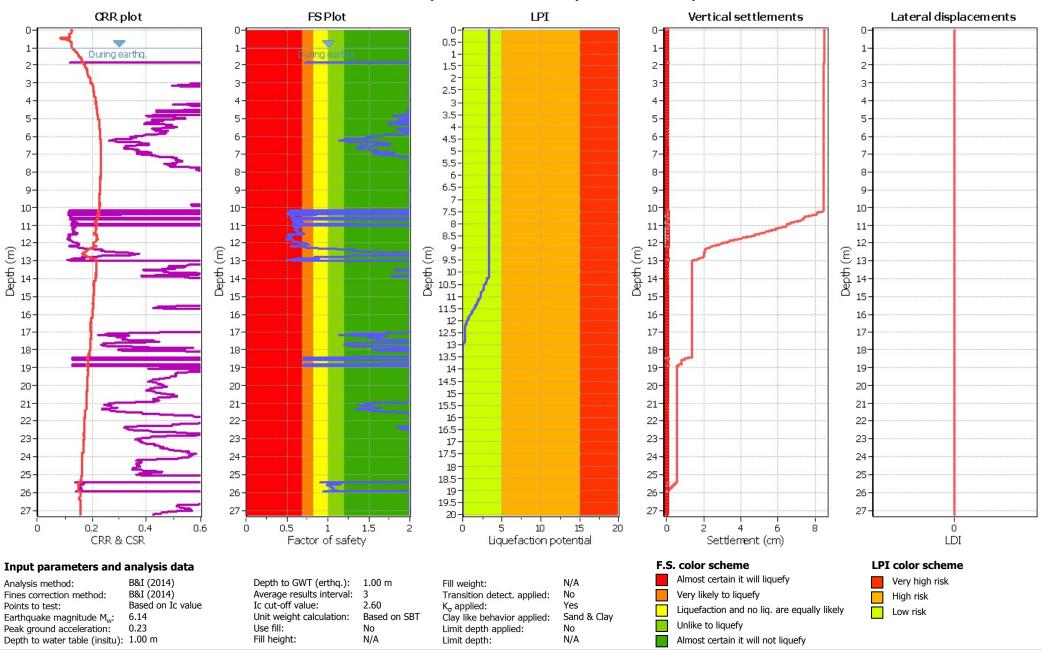
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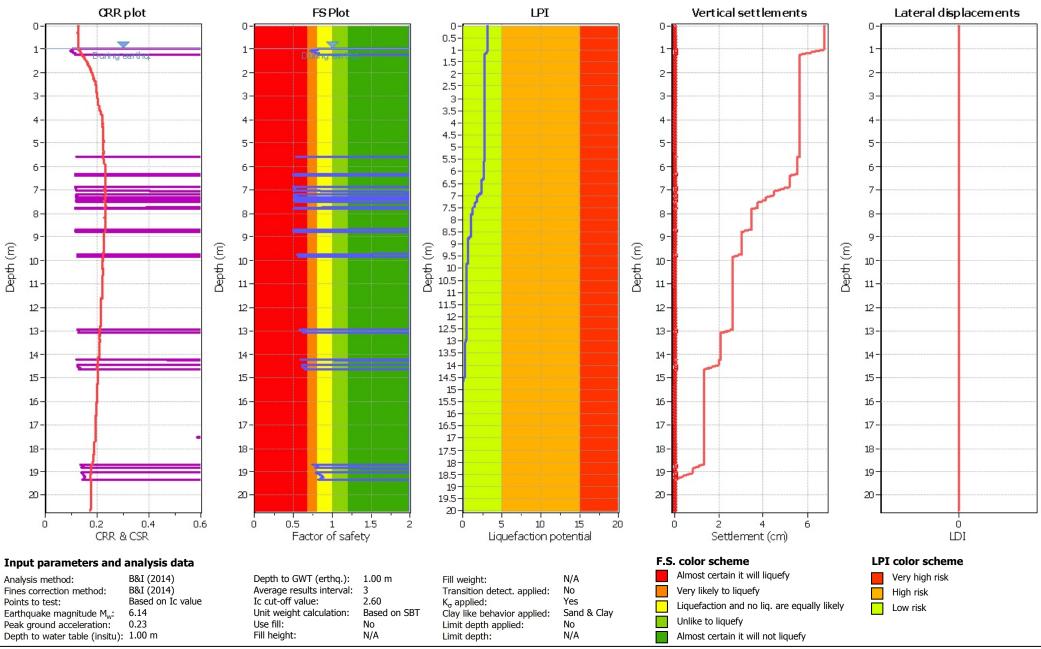


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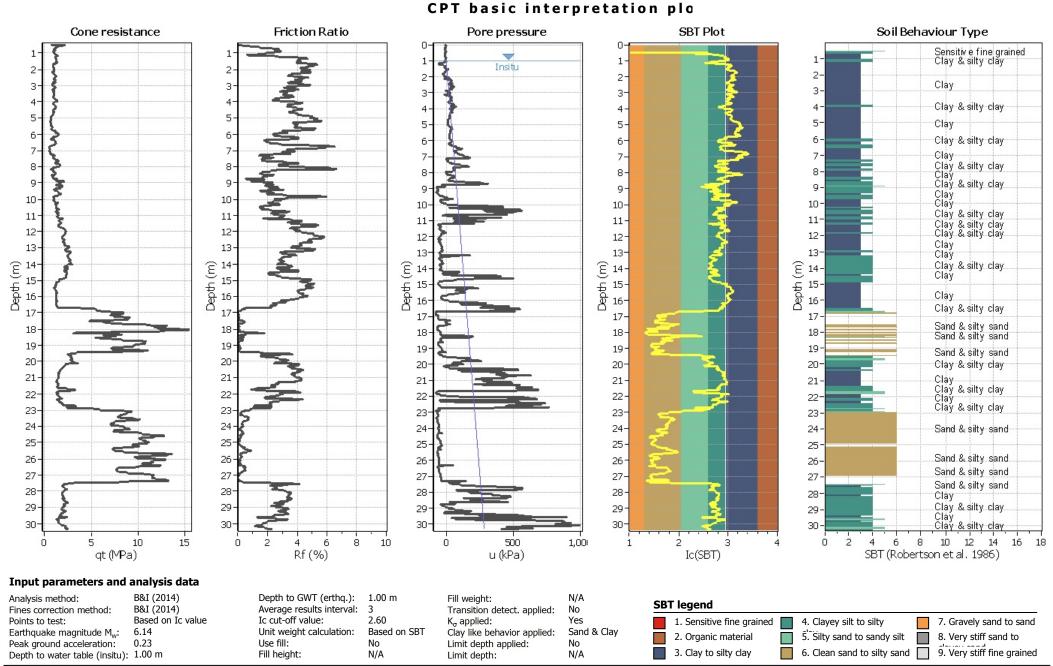
CPT basic interpretation plo

SBT Plot Cone resistance Friction Ratio Soil Behaviour Type Pore pressure Organic soil Sensitive fine grained Silty sand & sandy silt Insitu 1.5 Clay 2-2-2-2.5-Clay & silty clay Clay 3-3-3-3-3. 3.5-4-4-Clay 4.5 Clay & silty clay 5-5. 5-5 5-Clay & silty clay 5.5-6-Clay 6-6-6-6-6.5-Clay & silty clay 7-7. 7-Šilty sand & sandy silt 7.5-8-8-8-8-8. 8.5-Clay & silty clay 9. 9. 9-9-9.5-Depth (m) Depth (m) Depth (m) Depth (m) Clay & silty clay 10 -10 -10 -10 10.5 Clay Clay & silty clay 11 11-11 11 -11 Clay & silty clay 11.5-Clay Clay & silty clay 12-12-12-12 -12-12.5-Clay & silty clay 13-13 13-13-13-13.5-Clay & silty clay 14 14 14 14-14 -Silty sand & sandy silt 14.5 Clay & silty clay 15 15 15 15-15 -15.5-16 16 16 -16 16 -Clay & silty clay 16.5 17 17 -17 17 -17 -Clay 17.5-18 18 18-18-18 Clay & silty clay 18.5 Silty sand & sandy silt Silty sand & sandy silt 19 19 19-19 19 19.5-20 20 -20 20 -Clay & silty clay 20 -20.5-600 6 8 10 12 14 16 18 Ó 0 2 6 8 10 200 400 1 3 0 2 qt (MPa) Rf (%) u (kPa) Ic(SBT) SBT (Robertson et al. 1986) Input parameters and analysis data B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Analysis method: Fill weight: SBT legend Fines correction method: B&I (2014) Average results interval: Transition detect, applied: No Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained Unit weight calculation: Based on SBT Earthquake magnitude M_w: 6.14 Clay like behavior applied: Sand & Clay 5. Silty sand to sandy silt 8. Very stiff sand to 2. Organic material 0.23 Use fill: No Limit depth applied: Peak ground acceleration: No 9. Very stiff fine grained 3. Clay to silty clay 6. Clean sand to silty sand Depth to water table (insitu): 1.00 m Fill height: N/A Limit depth: N/A

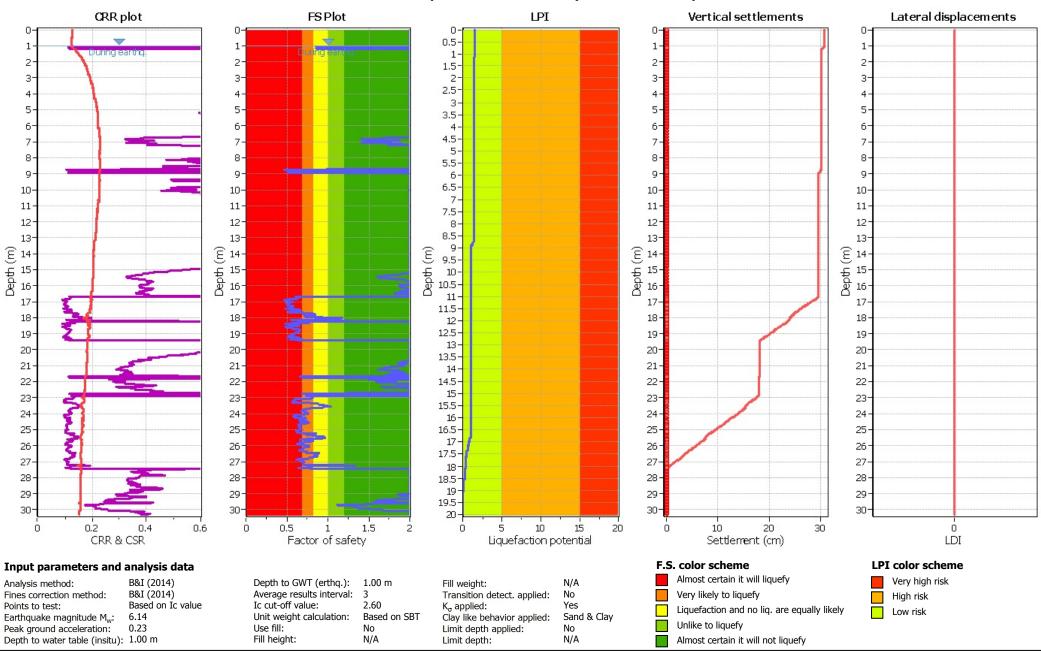
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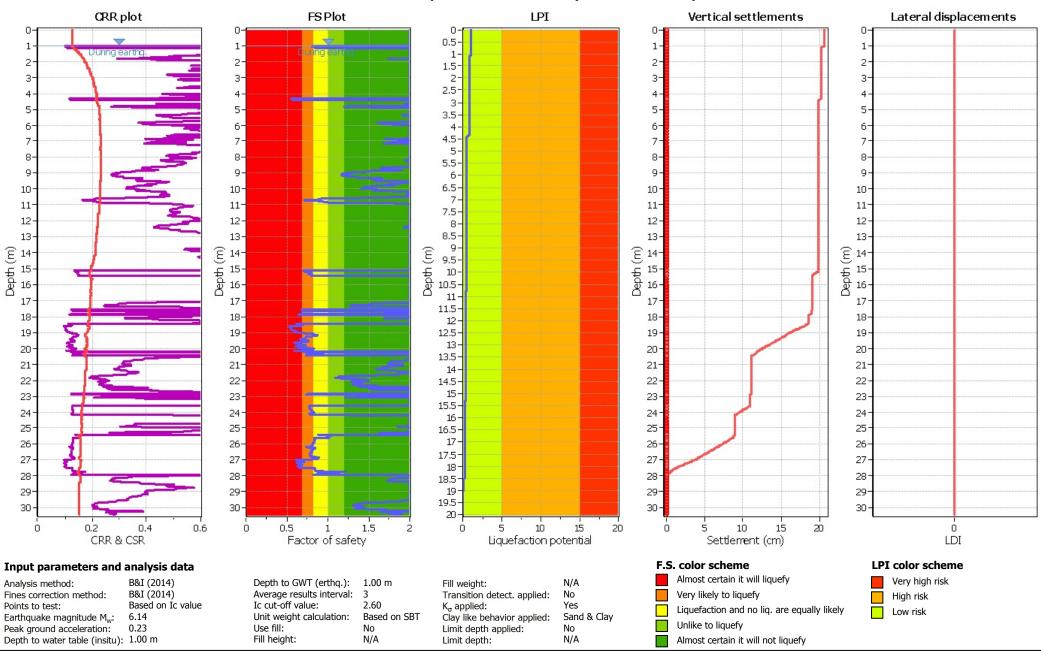
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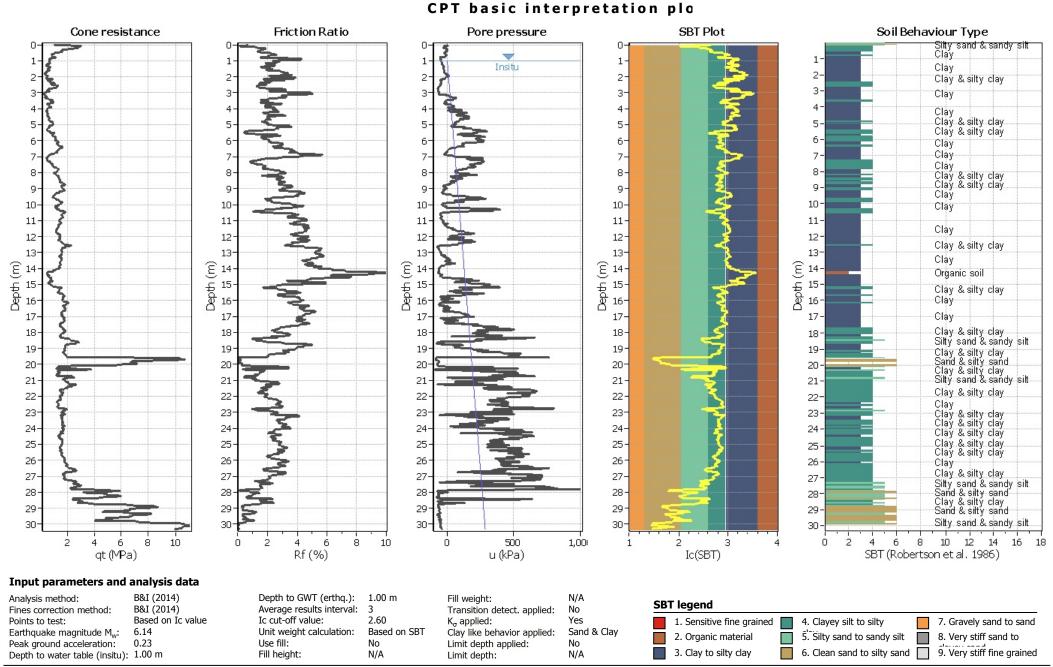
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CPT basic interpretation plo Pore pressure Soil Behaviour Type Sentiamentale (Benned Cone resistance SBT Plot Friction Ratio Sensitive fine grained Insitu Organic soil 2-2-3-2-2. 3-3-Clay 3-3-Organic soil Clay Clay 4-5-5-5 5. 6-Organic soil 6-6-6-6-7-8-8 8-8-9-9 9. 9-9-10-10 10 10-10-Clay 11 11-11 11-11-12-12 12-12-12-13-13 13-13-13-14 (E) 14-15-16-(E) 14-15-16-Depth (m) Ξ Depth (m) 14-15-Clay & silty clay Clay & silty clay 15 Depth (15-16-16 16-Clay 17 17 17 17 17-18 Člaý Clay & silty clay 18 18 18-18 19 19 19-19-19 Sand & silty sand Sand & silty sand 20 20 20 20. 20. 21 21 21-21-21-Clay 22-22 22. 22-22-Clay & silty clay Clay & silty clay 23 23 23. 23-23-24 Silty sand & sandy silt 24 24 24-24. Silty sand & sandy silt 25-25 25-25-25 Clay 26 26 26 26-26: Sand & silty sand Silty sand & sandy silt 27 27 27 27 27 Sand & silty sand 28 28 28 28 28 Clay 29 29 29-29-29-Clay 30 30 30 -30 -30-Clay & silty clay 4 6 8 10 12 14 16 18 2 5 10 0 8 10 500 3 0 Rf (%) SBT (Robertson et al. 1986) qt (MPa) u (kPa) Ic(SBT) Input parameters and analysis data B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Analysis method: Fill weight: SBT legend Fines correction method: B&I (2014) Average results interval: Transition detect, applied: No Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained Unit weight calculation: Based on SBT Clay like behavior applied: Sand & Clay Earthquake magnitude M_w: 6.14 5. Silty sand to sandy silt 8. Very stiff sand to 2. Organic material Peak ground acceleration: 0.23 Use fill: No Limit depth applied: No 9. Very stiff fine grained 3. Clay to silty clay 6. Clean sand to silty sand Depth to water table (insitu): 1.00 m Fill height: N/A Limit depth: N/A

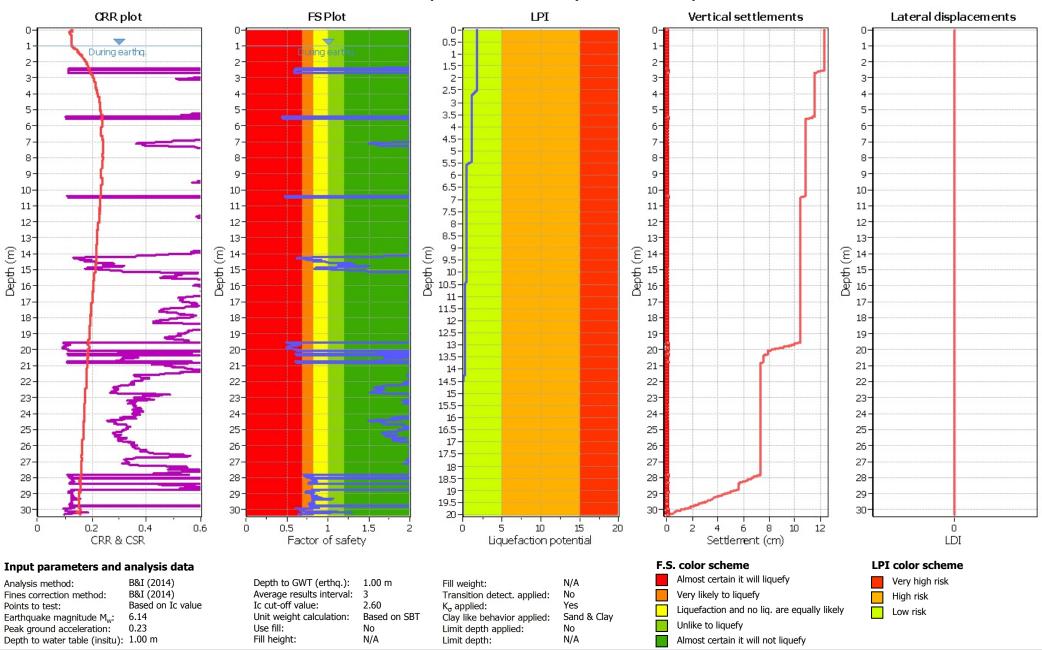
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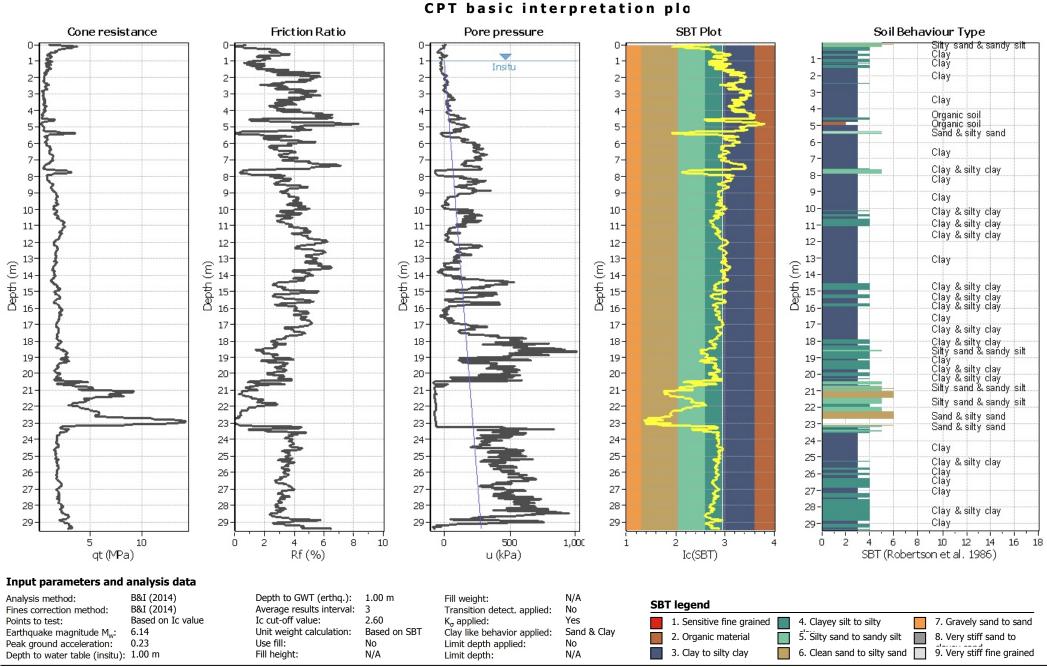
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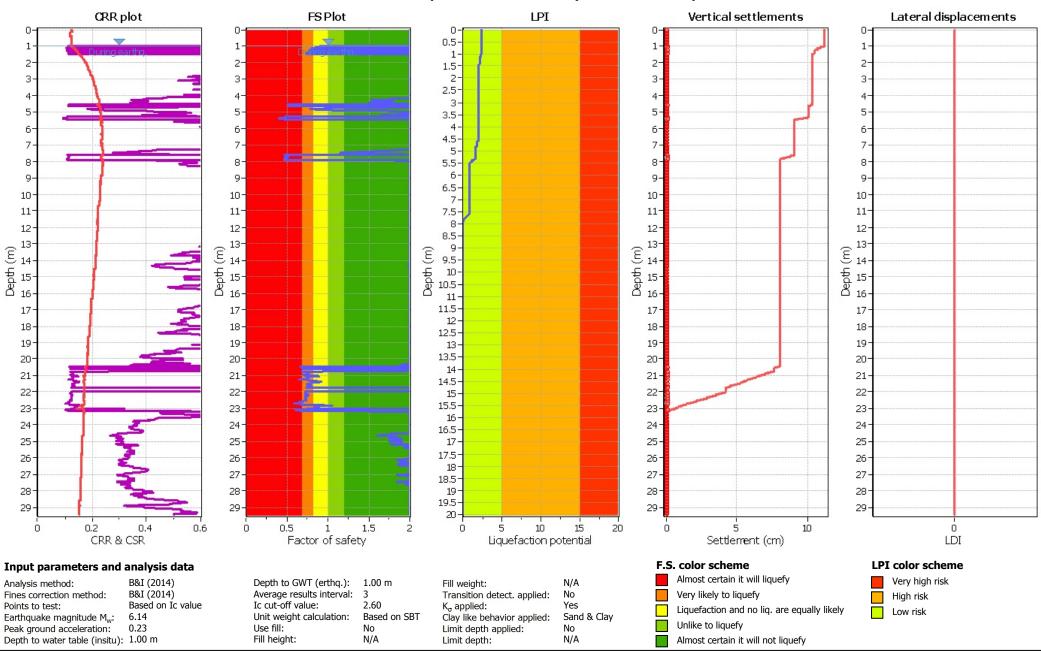
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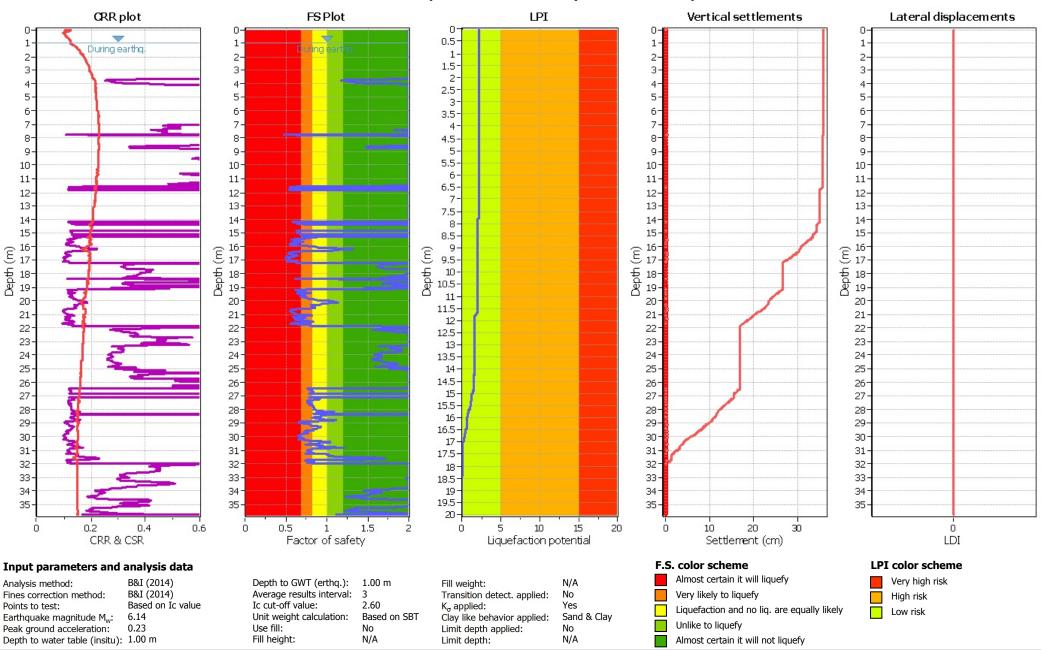
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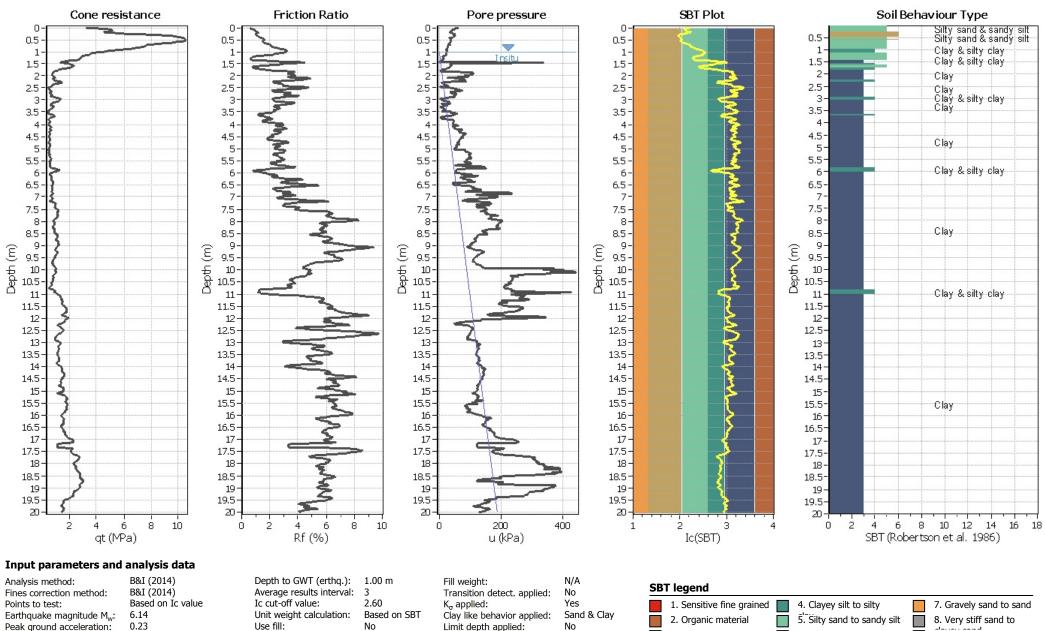
CPT basic interpretation plo SBT Plot Friction Ratio Soil Behaviour Type Cone resistance Pore pressure Sand & silty sand Clay & silty clay 1-Insitu 2-2-2-2-Člay & silty clay 3-3-3-3-Clay & silty clay 4-5-5-5-5-5-6-Clay 6-6-6-6-7-7-Clay & silty clay Clay 8-8-8-8-9-Clay Clay & silty clay Clay & silty clay Clay Clay & silty clay 9 9-9. 10-10 10-10 11 11-11 11. 11-12 12 12-12-12-Clay Clay 13 13 13-13-13-14 14-14-14: 14-Silty sand & sandy silt 15 15 15 15-15 Silty sand & sandy silt (H) 17-18-19-19-(E) 17-18-19-(E) 16-17-18-19-(E) 17-18-19-E 16 Sand & silty sand Silty sand & sandy silt Depth 18 Clay & silty clay Clay & silty clay Silty sand & sandy silt 19 20: 20 20-20-20 Sand & silty sand 21 21 21 21. 21 Silty sand & sandy silt Clay 22 22 22 22. 22-23 23 23 23-23-Clay & silty clay 24. 24 24-24. 24-Clay & silty clay Clay & silty clay Clay & silty clay Sand & silty sand 25 25 25 25 25 26 26 26-26: 26 27 27 27 27-27 Sand & silty sand 28 28 28-28 28-Silty sand & sandy silt 29 29 29-29-29-Sand & silty sand 30. 30 30. 30-30-31 31 31 31 Sand 31-Sand & silty sand Clay & silty clay 32 32 32. 32 32. 33 33 33. 33 33-34 34 34. 34 34 Clay Silty sand & sandy silt 35 35 35. 35 35 Clay & silty clay. 1.000 8 10 12 14 16 18 5 10 15 0 6 8 10 0 500 3 0 2 6 at (MPa) Rf (%) u (kPa) Ic(SBT) SBT (Robertson et al. 1986) Input parameters and analysis data B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Analysis method: Fill weight: SBT legend B&I (2014) Average results interval: Transition detect. applied: No Fines correction method: Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained Unit weight calculation: Based on SBT Earthquake magnitude M...: 6.14 Clay like behavior applied: Sand & Clay 5. Silty sand to sandy silt 2. Organic material 8. Very stiff sand to 0.23 Use fill: No Limit depth applied: Peak ground acceleration: No 9. Very stiff fine grained 3. Clay to silty clay 6. Clean sand to silty sand Depth to water table (insitu): 1.00 m Fill height: N/A N/A Limit depth:

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CPT basic interpretation plo



N/A

3. Clay to silty clay

Fill height:

N/A

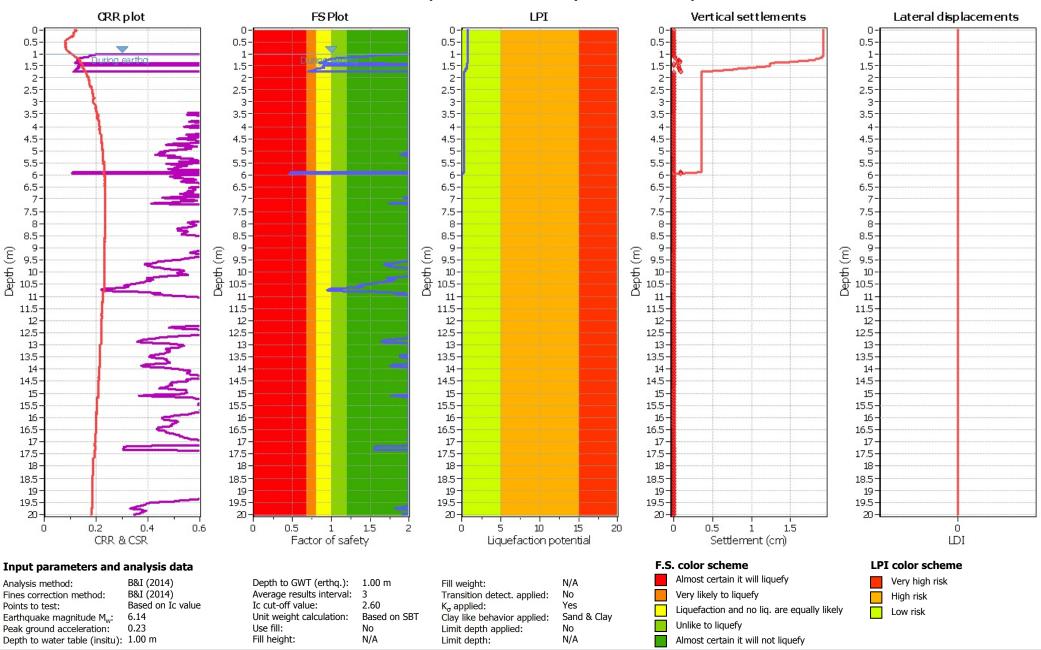
Limit depth:

Depth to water table (insitu): 1.00 m

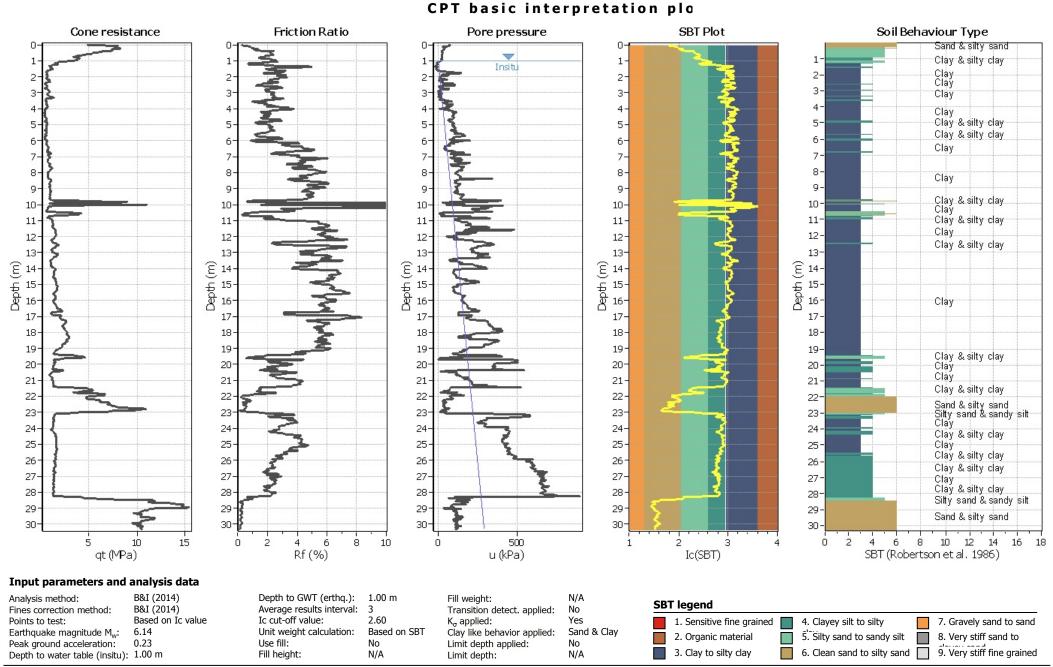
9. Very stiff fine grained

6. Clean sand to silty sand

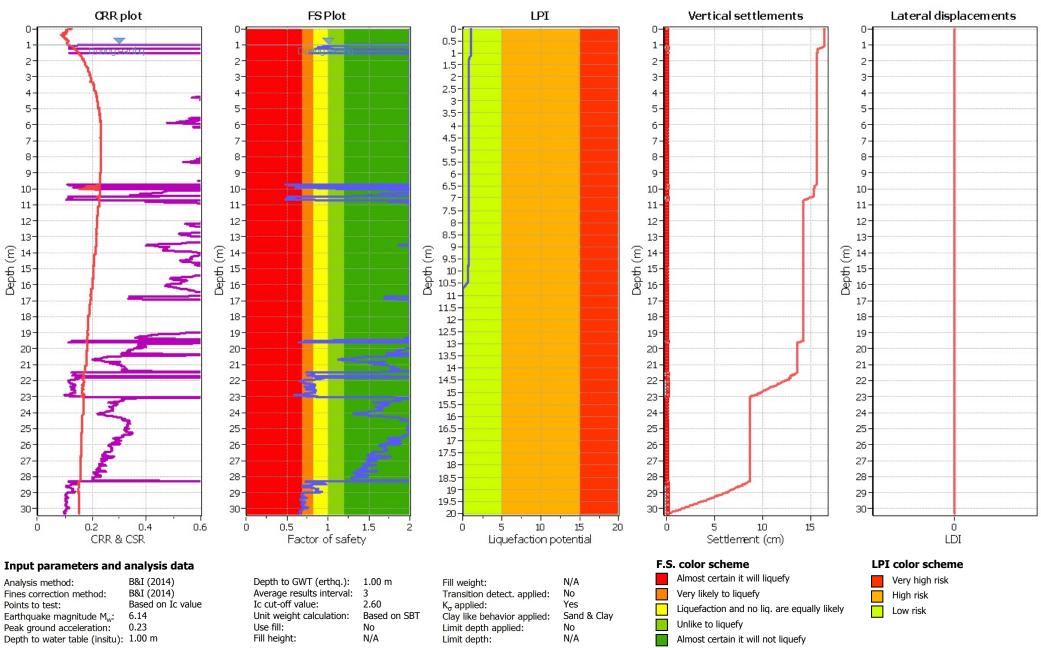
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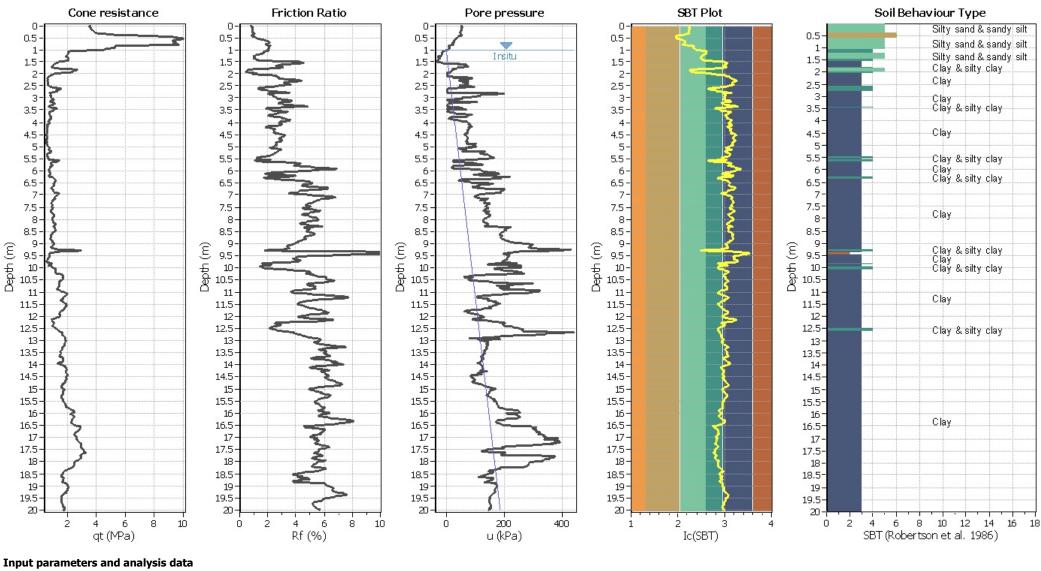


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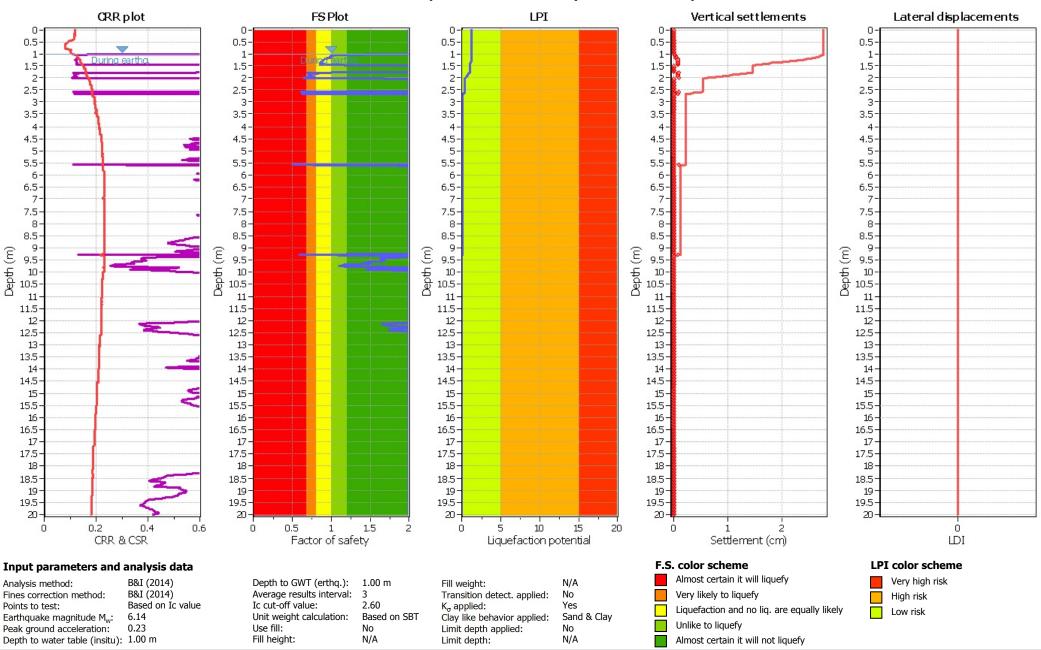
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CPT basic interpretation plo



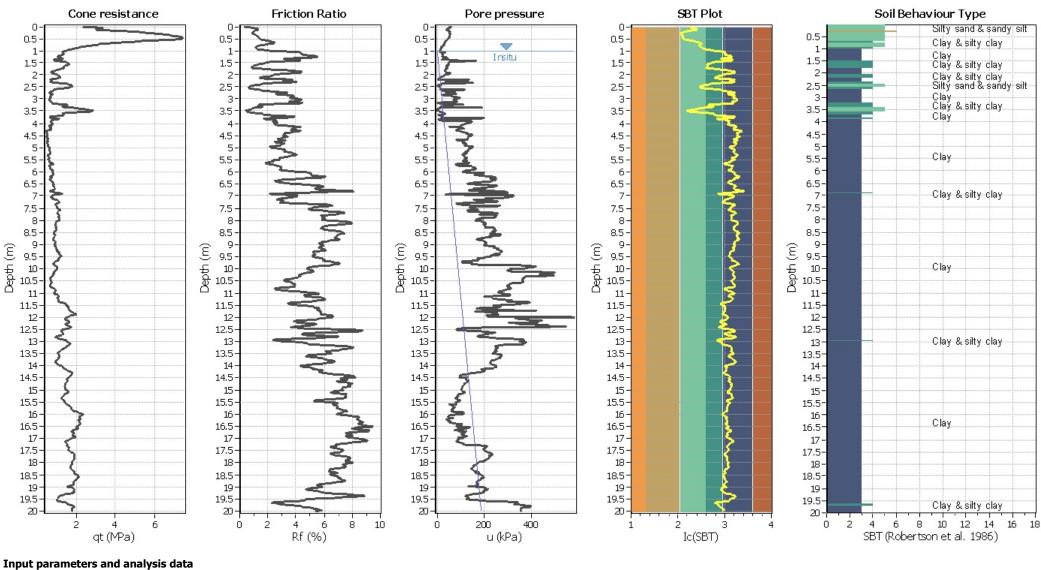
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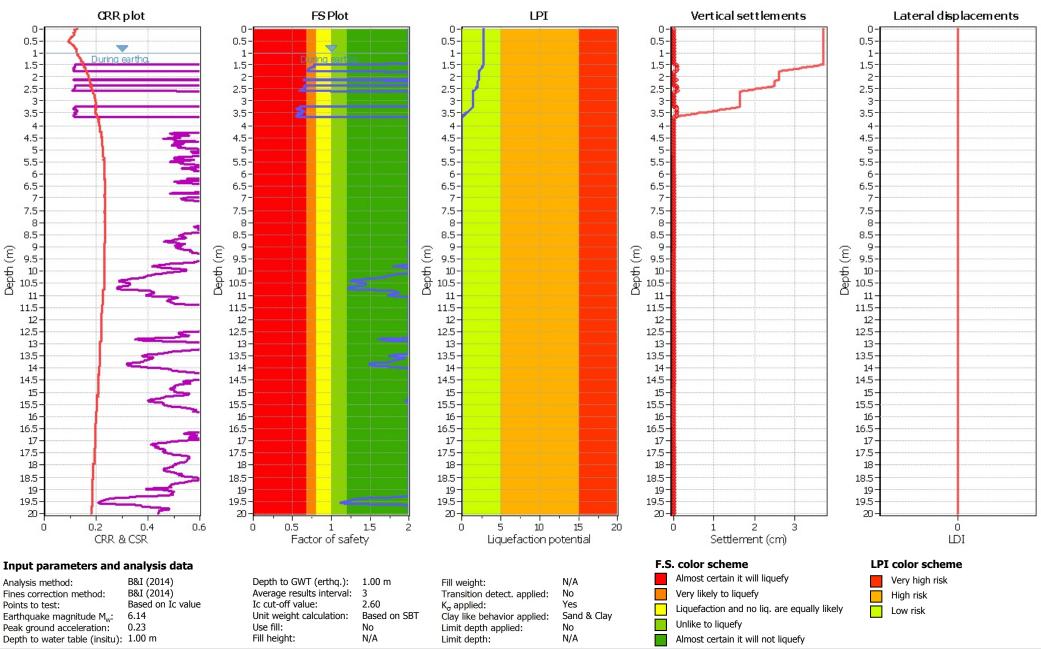
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CPT basic interpretation plo



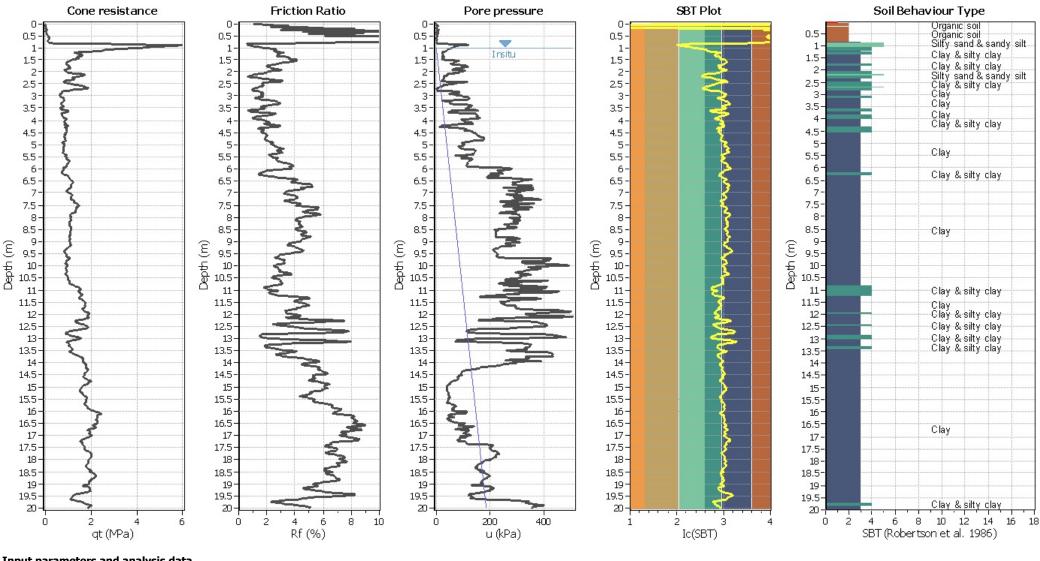
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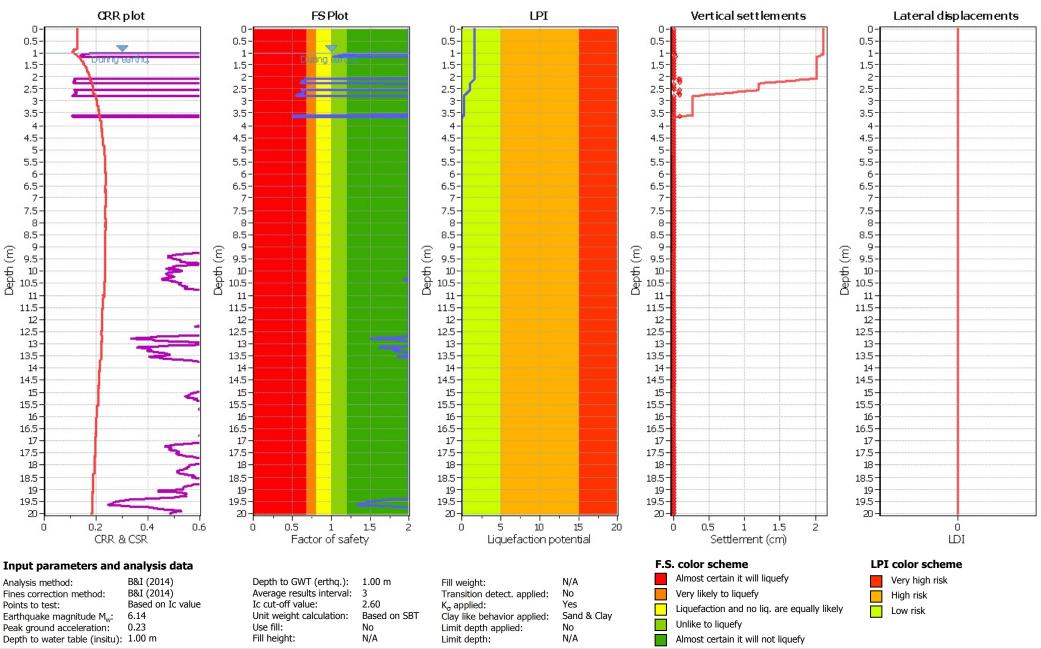
CPT basic interpretation plo



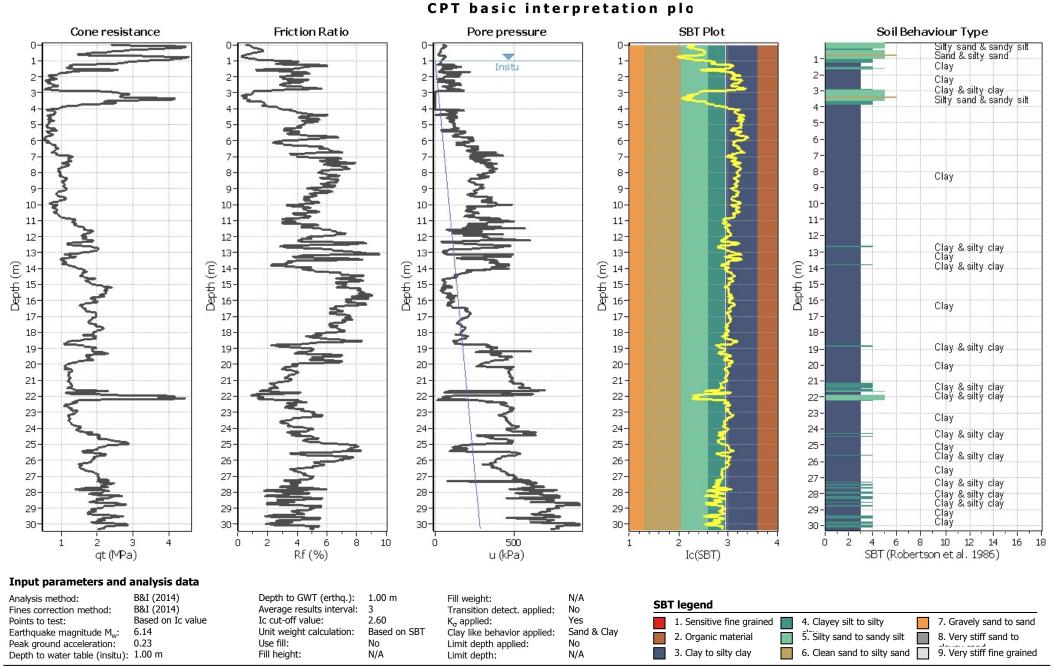
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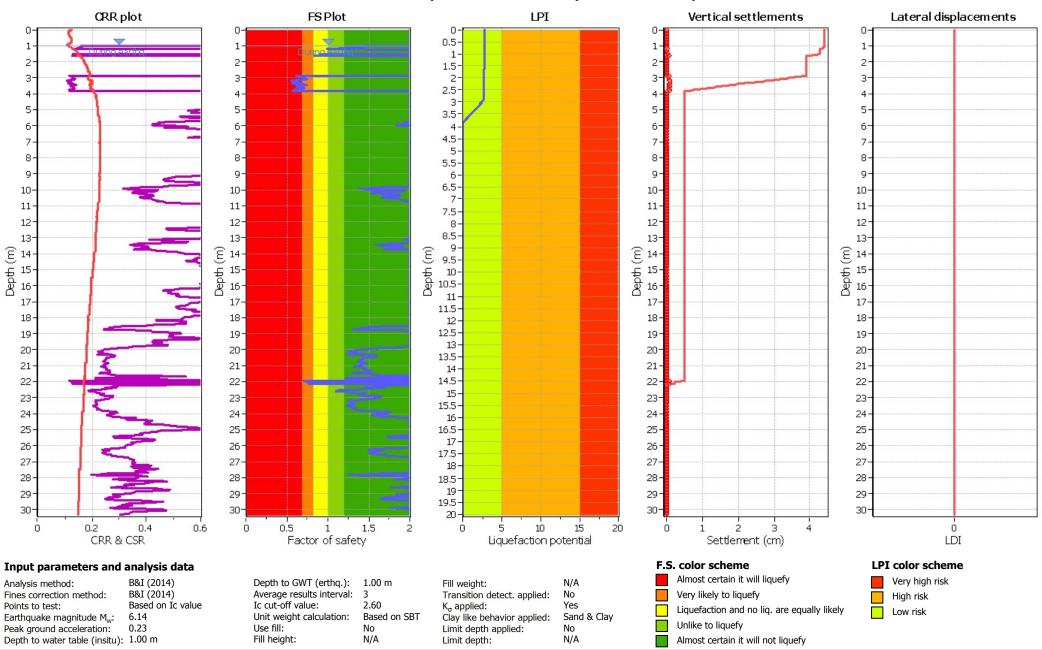
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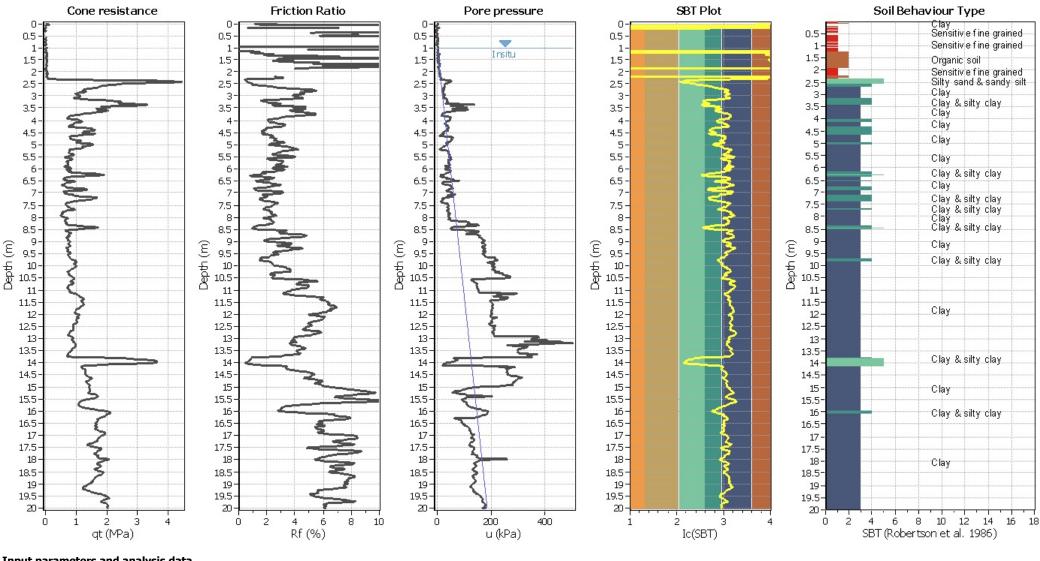


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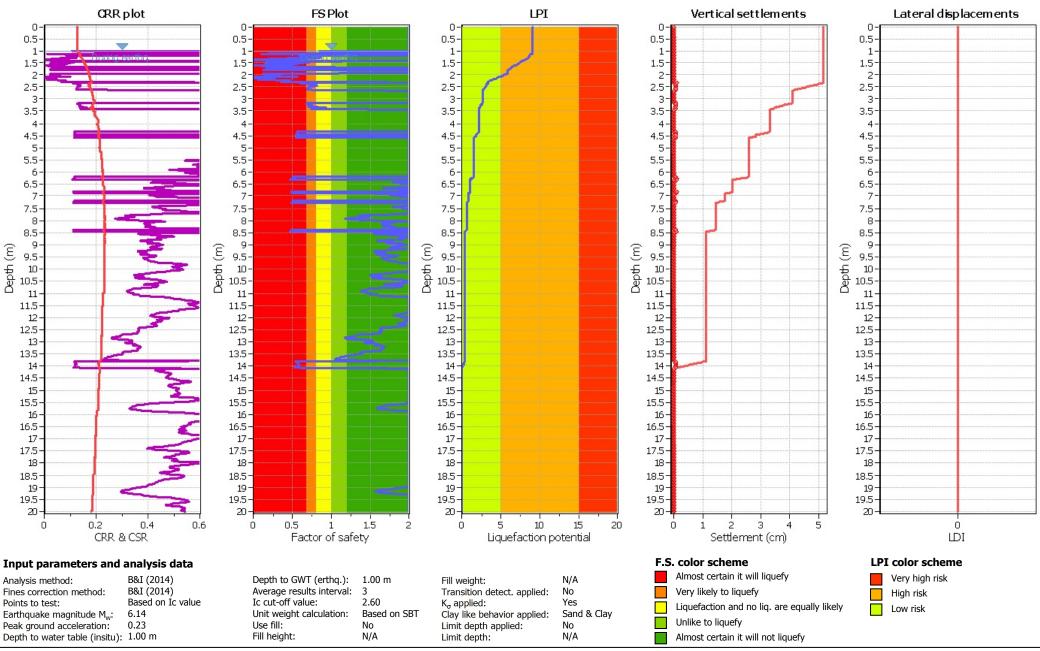
CPT basic interpretation plo



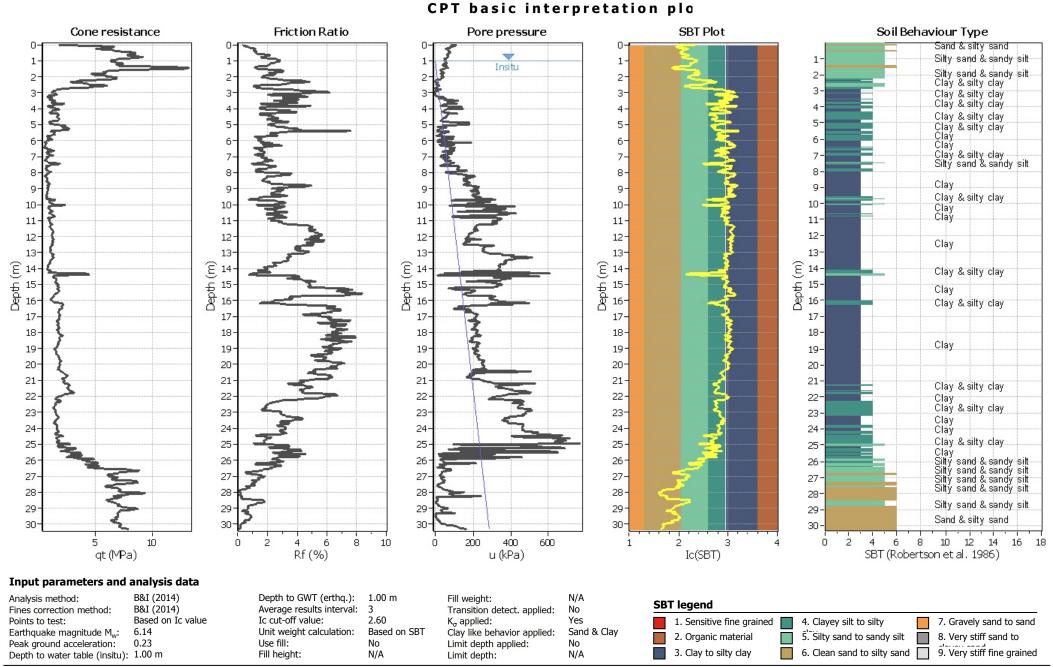
Input parameters and analysis data

B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Analysis method: Fill weight: SBT legend Fines correction method: B&I (2014) Average results interval: Transition detect, applied: No Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained Unit weight calculation: Based on SBT Sand & Clay Earthquake magnitude M...: 6.14 Clay like behavior applied: 5. Silty sand to sandy silt 8. Very stiff sand to 2. Organic material 0.23 Use fill: No Limit depth applied: Peak ground acceleration: No 9. Very stiff fine grained 3. Clay to silty clay 6. Clean sand to silty sand Depth to water table (insitu): 1.00 m Fill height: N/A Limit depth: N/A

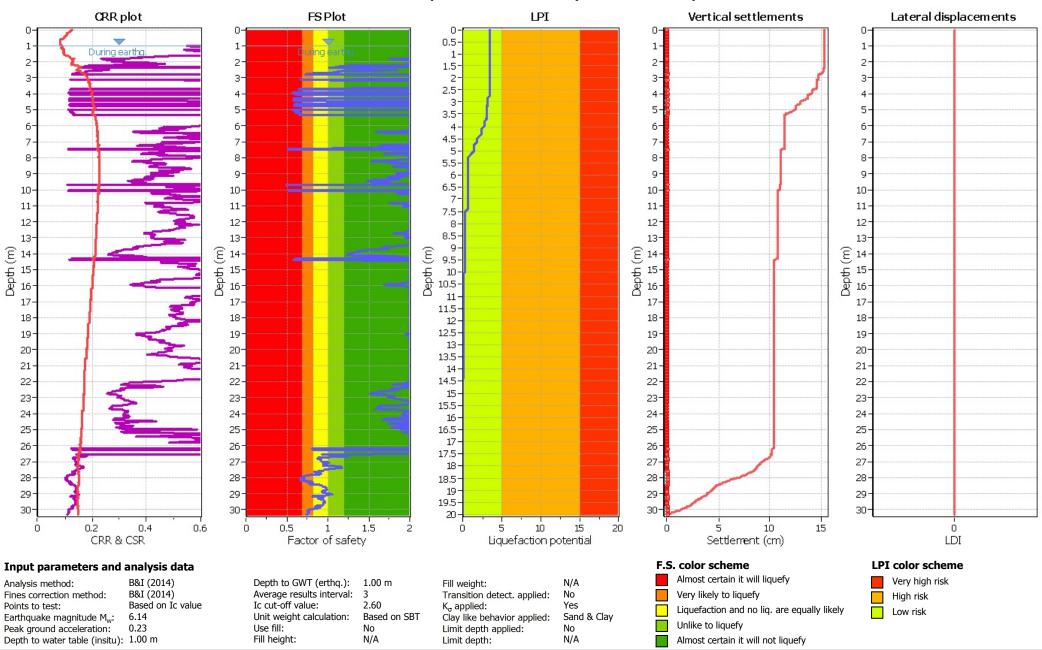
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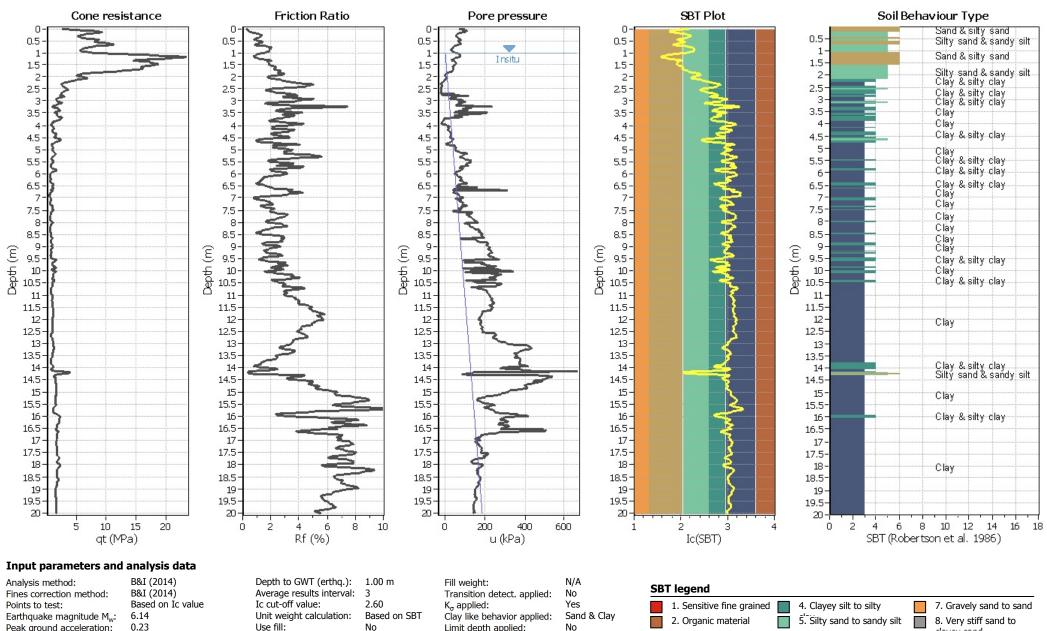


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CPT basic interpretation plo



N/A

3. Clay to silty clay

Fill height:

N/A

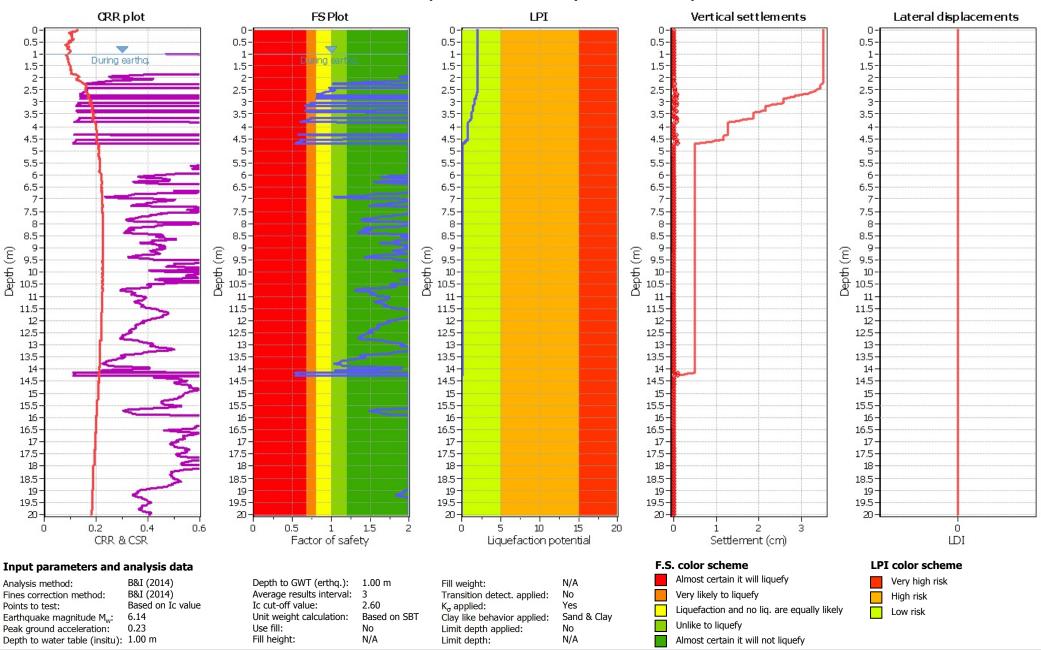
Limit depth:

Depth to water table (insitu): 1.00 m

9. Very stiff fine grained

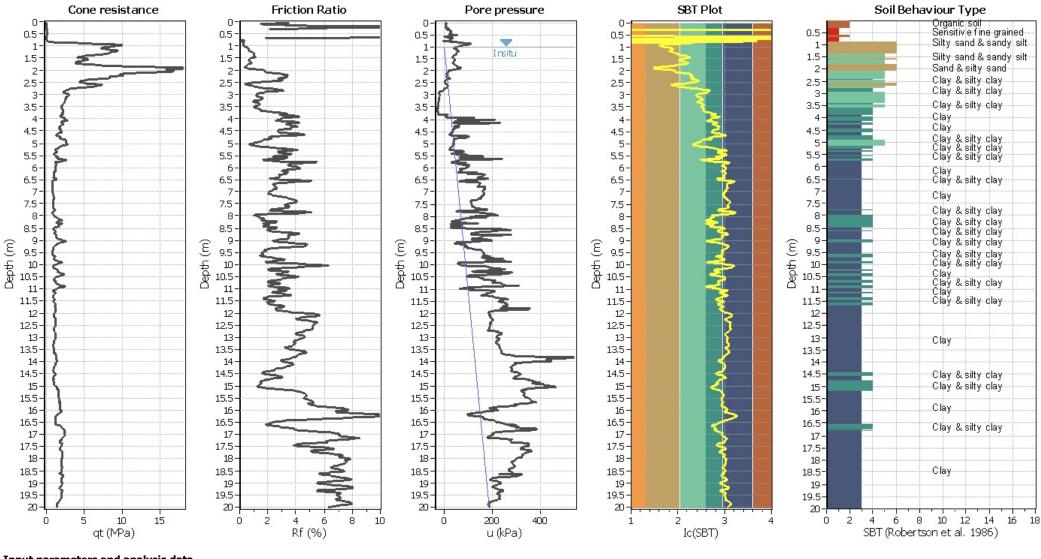
6. Clean sand to silty sand

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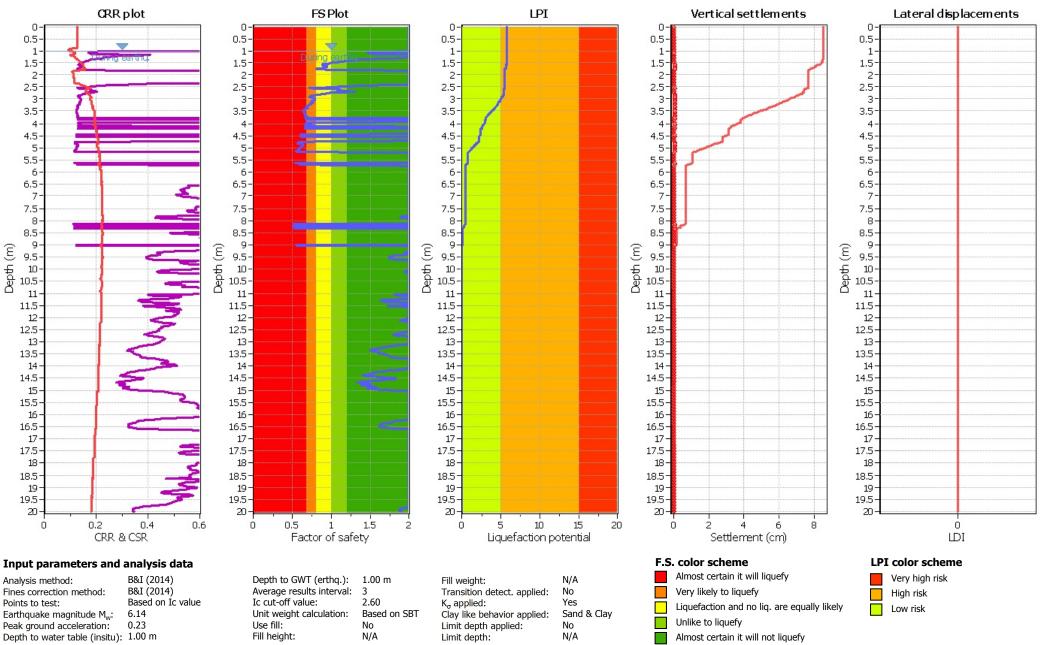
CPT basic interpretation plo



Input parameters and analysis data

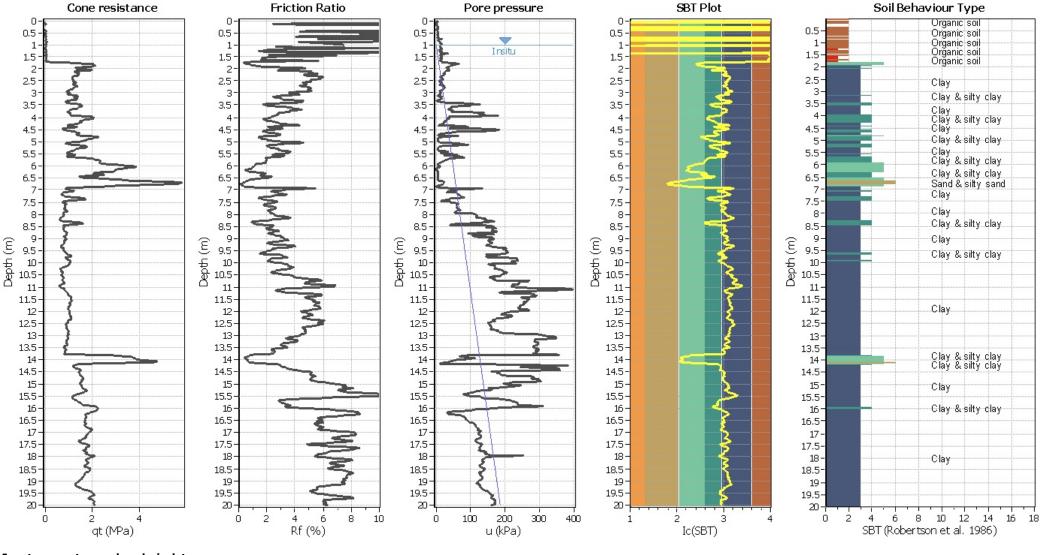
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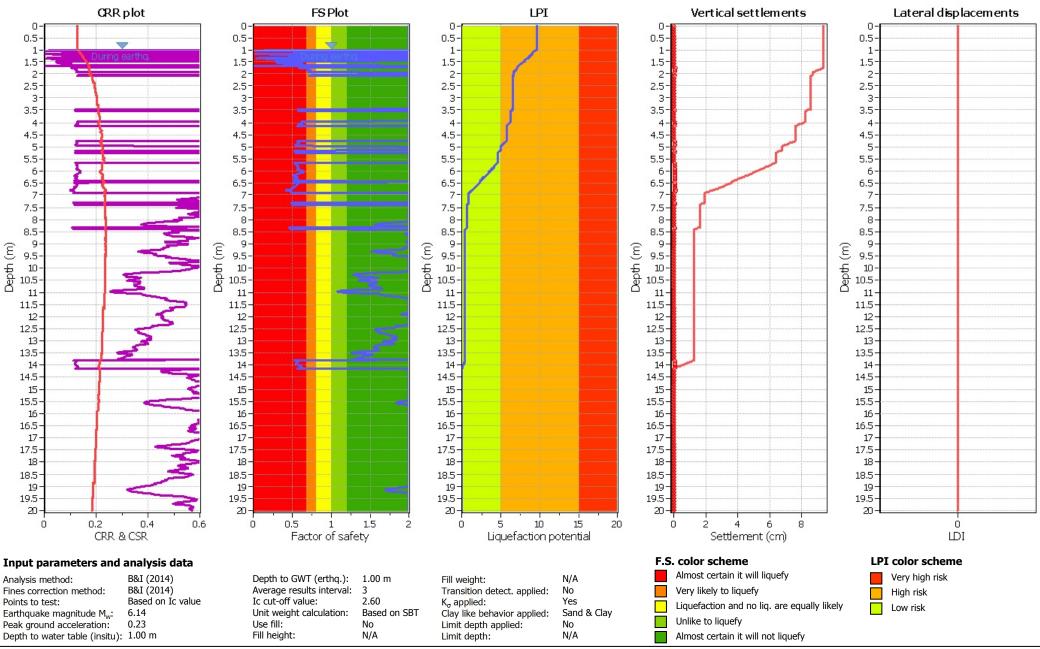
CPT basic interpretation plo



Input parameters and analysis data

B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Analysis method: Fill weight: SBT legend Fines correction method: B&I (2014) Average results interval: Transition detect, applied: No Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained Unit weight calculation: Based on SBT Sand & Clay Earthquake magnitude M...: 6.14 Clay like behavior applied: 5. Silty sand to sandy silt 2. Organic material 8. Very stiff sand to 0.23 Use fill: No Limit depth applied: Peak ground acceleration: No 9. Very stiff fine grained 3. Clay to silty clay 6. Clean sand to silty sand Depth to water table (insitu): 1.00 m Fill height: N/A Limit depth: N/A

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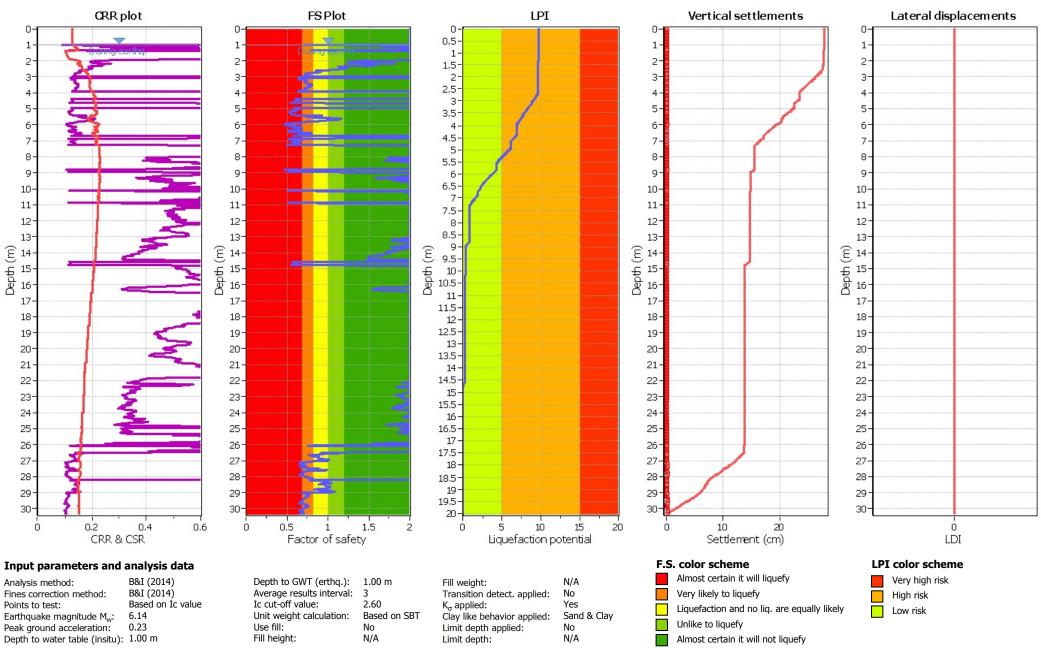


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CPT basic interpretation plo

SBT Plot Cone resistance Friction Ratio Pore pressure Soil Behaviour Type Organic soil Sand & silty sand Clay & silty clay Insitu 2-2. 2. Silty sand & sandy silt 3-3-3-Silty sand & sandy silt Clay & silty clay Silty sand & sandy silt 5. Sand & silty sand Clay & silty clay Sand & silty sand 6 6-6-6-Clay & silty_clay 8-8 8. 8. Clay & silty clay 9-9 9-Clay Clay 10 10-10-10 Clay 11 11 11. 11-11-12-12 12 12: 12-Clay 13: 13-13-13-13-(E) 14-15-16-E 14-(E) 14-15-16-Depth (m) Ξ 14-Clay & silty clay Depth (15-15 Clay 16-Clay & silty clay 17-17-17-17 17-18 18 18-18-18-19 19-19-19-19-Clay 20 20-20-20-20 -21 21 21. 21. 21-Clay & silty clay 22 22. 22. 22. 22-Clay & silty clay 23 23-23-23-23 -Clay 24 24 24 24. 24-Clay & silty clay Silty sand & sandy silt 25 25 25 25. 25 -Clay & silty clay 26 26 26 26 26 Siltý sand & sandy silt 27 27 27 27-27 Sand & silty sand 28 28 28 28 28-Silty sand & sandy silt 29 29 29 29 29-Sand & silty sand 30. 30-30-30-30-2 4 6 8 10 12 14 16 18 5 10 15 20 0 6 8 10 200 400 600 3 0 SBT (Robertson et al. 1986) at (MPa) Rf (%) u (kPa) Ic(SBT) Input parameters and analysis data B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Analysis method: Fill weight: SBT legend Fines correction method: B&I (2014) Average results interval: Transition detect. applied: No Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained Unit weight calculation: Based on SBT Earthquake magnitude Mw: 6.14 Clay like behavior applied: Sand & Clay 5. Silty sand to sandy silt 2. Organic material 8. Very stiff sand to 0.23 Use fill: No Limit depth applied: Peak ground acceleration: No 9. Very stiff fine grained 3. Clay to silty clay 6. Clean sand to silty sand Depth to water table (insitu): 1.00 m Fill height: N/A N/A Limit depth:

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CPT basic interpretation plo Friction Ratio SBT Plot Soil Behaviour Type Cone resistance Pore pressure Insitu 3.5-3.5 1.5 3.5 3.5 2-4-2.5 4.5-4.5 4.5 4.5 -3-5-5 5. 5-3.5 5.5-5.5 5.5 5.5 -6-6 6. 6-4.5 Clay 6.5-6.5 6.5 6.5 -5-7-7-5.5 7.5-7.5 7.5 6-7.5 -6.5 8-8 8. 8-8.5-8.5 8.5 8.5 7.5 9 9. 9-9-8-9.5-9.5 9.5 9.5 -Clay & silty clay 8.5 (E) 10.5 10.5 (E) 10.5 - 11 -Clay & silty clay Clay & silty clay Depth (m) 10 -Depth (m) Depth (m) 10 10 9. 10.5 9.5 10.5 Sand & silty sand Silty sand & sandy silt Silty sand & sandy silt Silty sand & sandy silt 10 11 -11 10.5 11.5 11.5-11.5-11.5 11 12 12 12-12 Sand & silty sand 11.5 12.5-12.5-12.5 12.5 12 Silty sand & sandy silt 13 13-13-13 12.5 Sand & silty sand 13.5-13.5 13.5 13.5-13-Silty sand & sandy silt 14 14 13.5 14 -14 Silty sand & sandy silt 14.5 14.5 14 14.5-14.5-Clay Clay & silty clay 14.5 15 15 -15 15 15 15.5 15.5 15.5-15.5-15.5 16 16 16-16 -16 16.5 16.5 16.5-16.5 Clay 16.5 17 17 17 -17 -17 17.5 17.5 17.5-17.5 17.5-18-18-18 18-18 -200 4 6 8 10 12 14 16 18 5 10 15 0 8 10 0 400 600 800 3 0 qt (MPa) Rf (%) u (kPa) Ic(SBT) SBT (Robertson et al. 1986) Input parameters and analysis data B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Analysis method: Fill weight: SBT legend Fines correction method: B&I (2014) Average results interval: Transition detect, applied: No Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained

Sand & Clay

No

N/A

2. Organic material

3. Clay to silty clay

Clay like behavior applied:

Limit depth applied:

Limit depth:

Earthquake magnitude M_w:

Peak ground acceleration:

Depth to water table (insitu): 1.00 m

6.14

0.23

Unit weight calculation:

Use fill:

Fill height:

Based on SBT

No

N/A

8. Very stiff sand to

9. Very stiff fine grained

5. Silty sand to sandy silt

6. Clean sand to silty sand

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Liquefaction analysis overall plot CRR plot FS Plot ĽП Vertical settlements Lateral displacements 3.5 3.5 3.5 3.5-3.5-4.5 4.5 4.5-4.5-4.5-5-5-5-5.5 5.5 5.5 5.5-5.5 6-6. 6-6. 6.5-6.5 6.5 6.5 6.5 7.5 7.5 7.5 7.5 7.5-8-8. 8-8.5 8.5 8.5 8.5 9-9. 9.5 9.5-9.5-9.5-9.5-(E) 10-5-10.5-11-(E) 10-5-10.5-11-Depth (m) Depth (m) Depth (m) 10 -10 -10 -10.5-10.5 10.5-11 11 -11.5 11.5-11.5 11.5 11.5 12-12-12. 12-12-12.5 12.5-12.5 12.5-12.5 13-13 13-13-13 -13.5-13.5 13.5-13.5 13.5 14 14-14 14 14 14.5 14.5 14.5 14.5 14.5-15-15 15 15-15 15.5 15.5 15.5 15.5 15.5 16 16 16 16 16 16.5 16.5 16.5 16.5 16.5 17 17 17 17 17 17.5 17.5 17.5 17.5 17.5 18-18 -18 18 -18 0.2 0.4 0 CRR & CSR Factor of safety ШI Liquefaction potential Settlement (cm) F.S. color scheme LPI color scheme Input parameters and analysis data Almost certain it will liquefy Very high risk Analysis method: B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Fill weight: Fines correction method: B&I (2014) Average results interval: Transition detect, applied: No Very likely to liquefy High risk Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes Liquefaction and no liq. are equally likely Low risk Unit weight calculation: Based on SBT Clay like behavior applied: Sand & Clay Earthquake magnitude M_w: 6.14 Unlike to liquefy

Limit depth applied:

Limit depth:

No

N/A

Almost certain it will not liquefy

CLiq v.2.1.6.11 - CPT Liquefaction Assessment Software - Report created on: 18/01/2019, 09:49:39 Project file: \\LACIE-2BIG-NAS\Public\Lavori\Microzonazione Camposanto\Relazione\CPTU_Camposanto.clq

Peak ground acceleration:

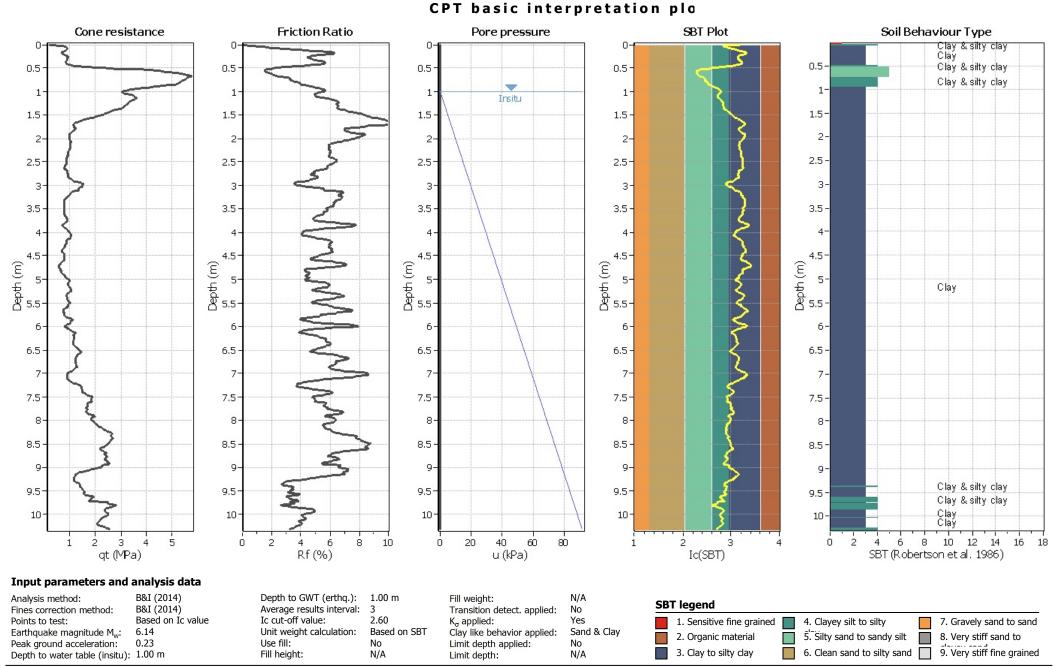
Depth to water table (insitu): 1.00 m

Use fill:

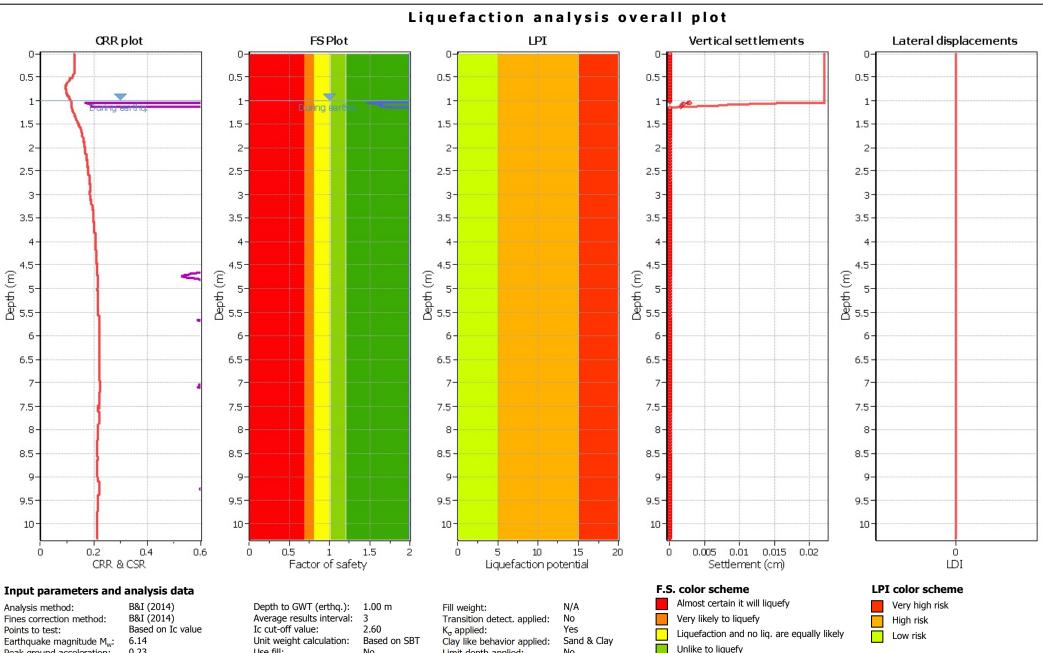
Fill height:

N/A

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Limit depth applied:

Limit depth:

No

N/A

Almost certain it will not liquefy

CLiq v.2.1.6.11 - CPT Liquefaction Assessment Software - Report created on: 18/01/2019, 09:49:48 Project file: \\LACIE-2BIG-NAS\Public\Lavori\Microzonazione Camposanto\Relazione\CPTU_Camposanto.clq

Use fill:

Fill height:

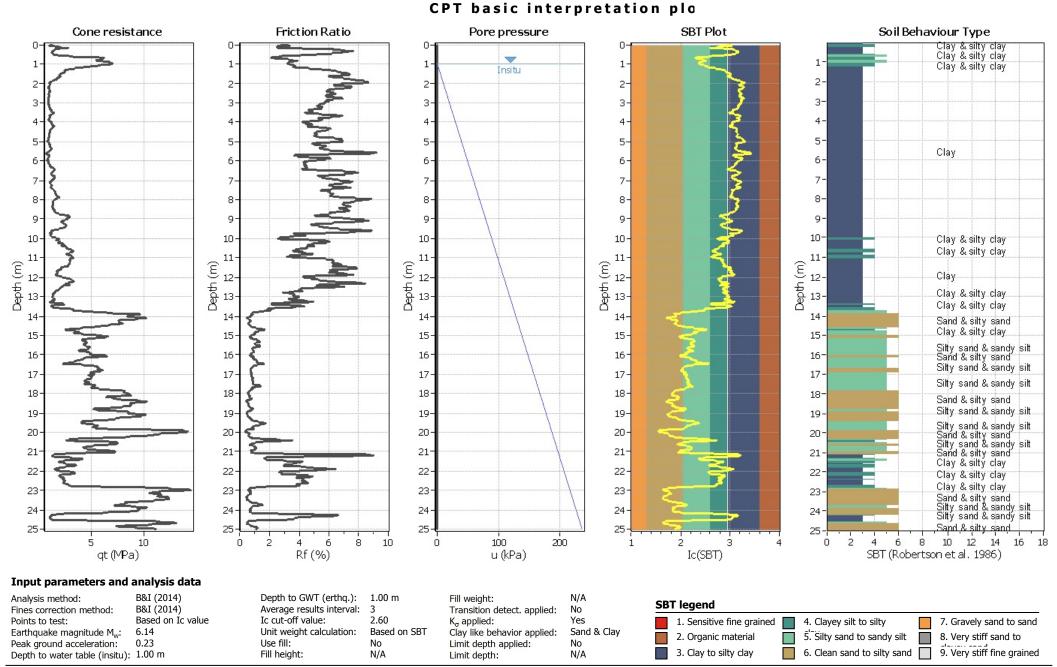
No

N/A

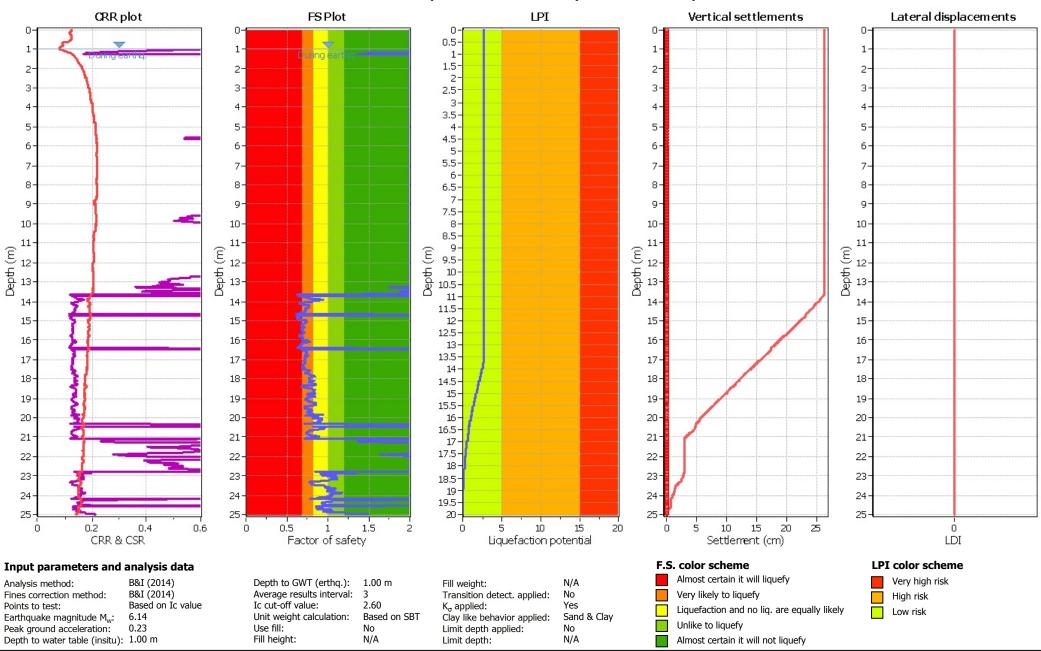
Peak ground acceleration:

Depth to water table (insitu): 1.00 m

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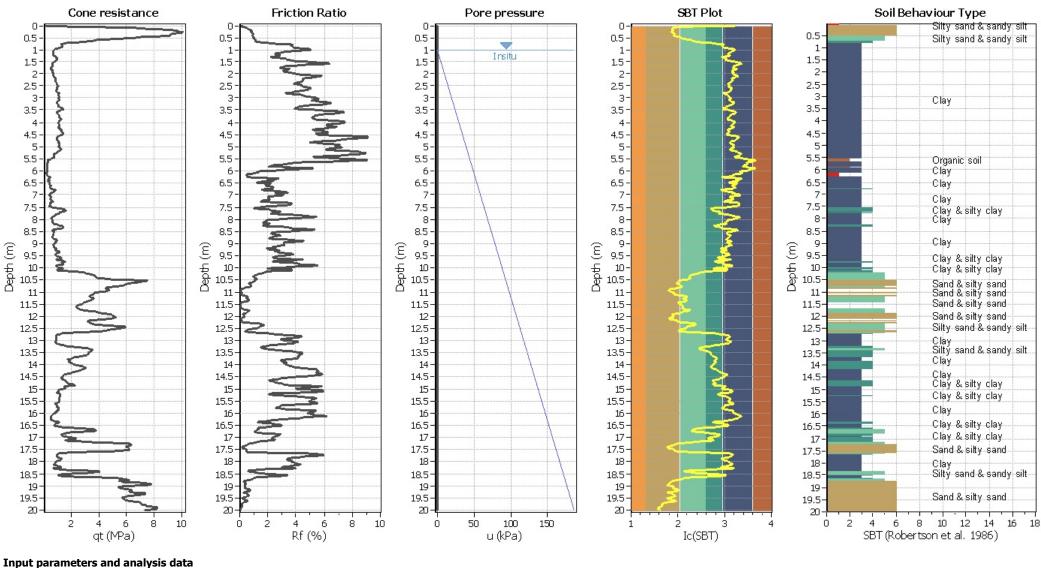


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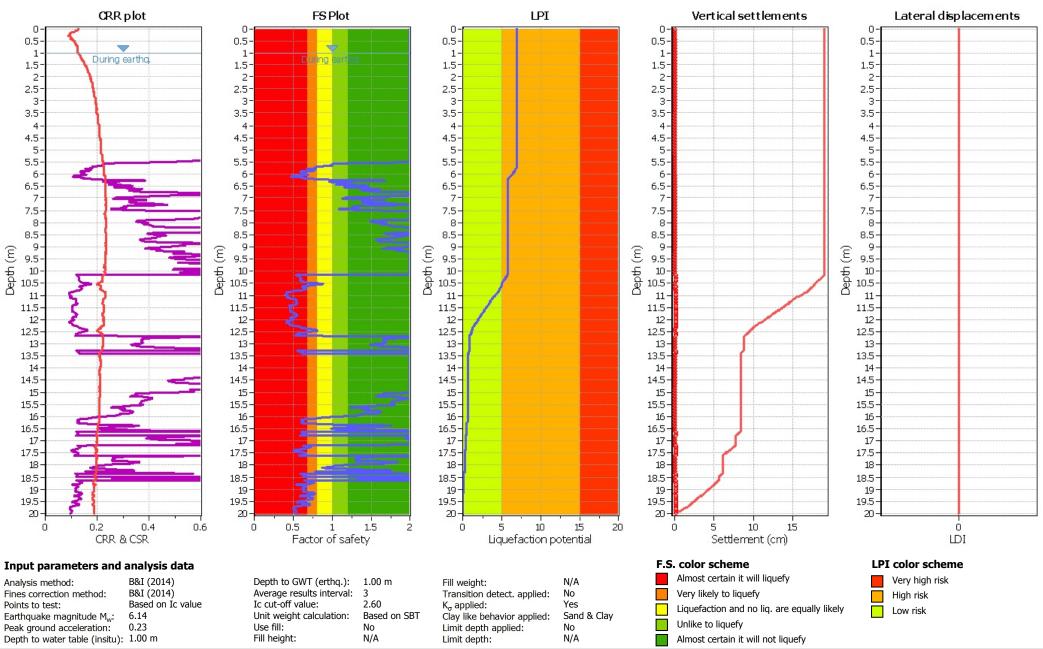
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CPT basic interpretation plo



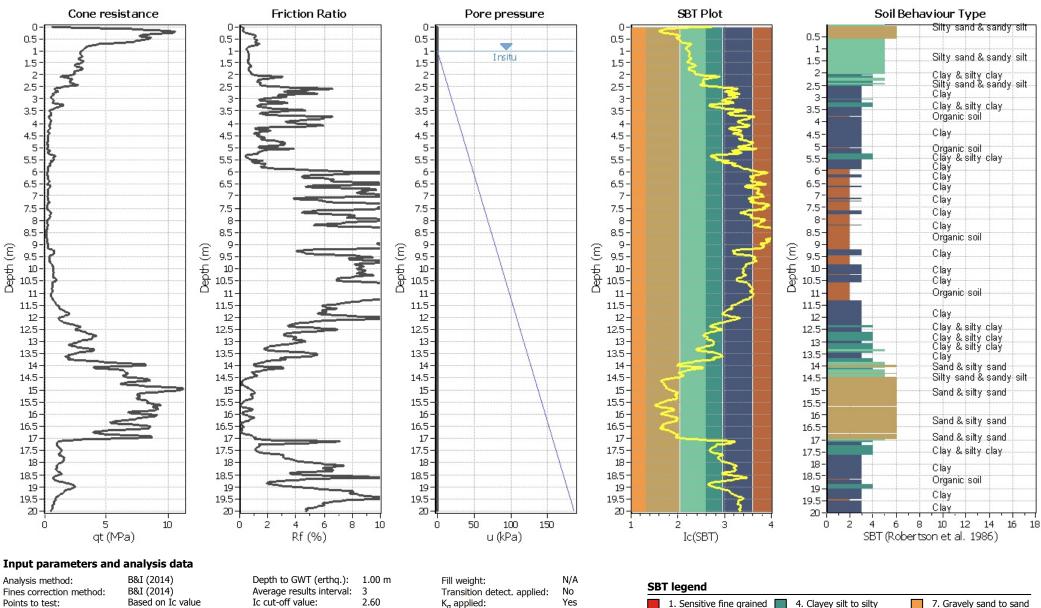
B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Analysis method: Fill weight: SBT legend Fines correction method: B&I (2014) Average results interval: Transition detect. applied: No Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained Unit weight calculation: Based on SBT Earthquake magnitude M...: 6.14 Clay like behavior applied: Sand & Clay 5. Silty sand to sandy silt 8. Very stiff sand to 2. Organic material 0.23 Use fill: No Peak ground acceleration: Limit depth applied: No 9. Very stiff fine grained 3. Clay to silty clay 6. Clean sand to silty sand Depth to water table (insitu): 1.00 m Fill height: N/A Limit depth: N/A

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CPT basic interpretation plo



Earthquake magnitude M...: Peak ground acceleration:

Depth to water table (insitu): 1.00 m

6.14 0.23 Unit weight calculation: Use fill:

Fill height:

Based on SBT No N/A

Clay like behavior applied: Limit depth applied:

Limit depth:

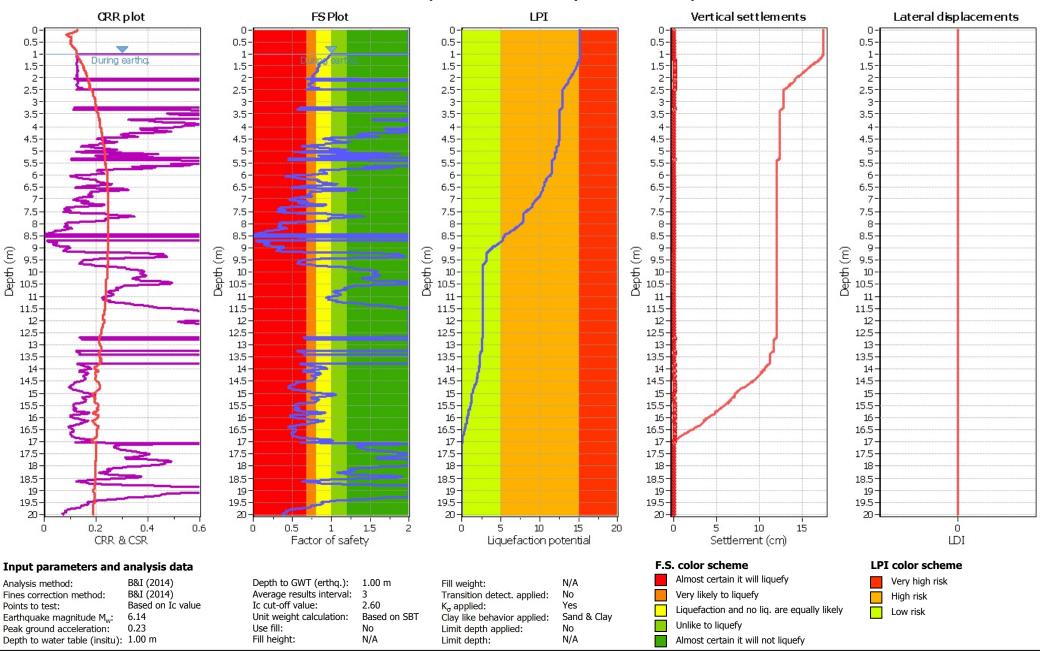
Sand & Clay No N/A

2. Organic material

3. Clay to silty clay

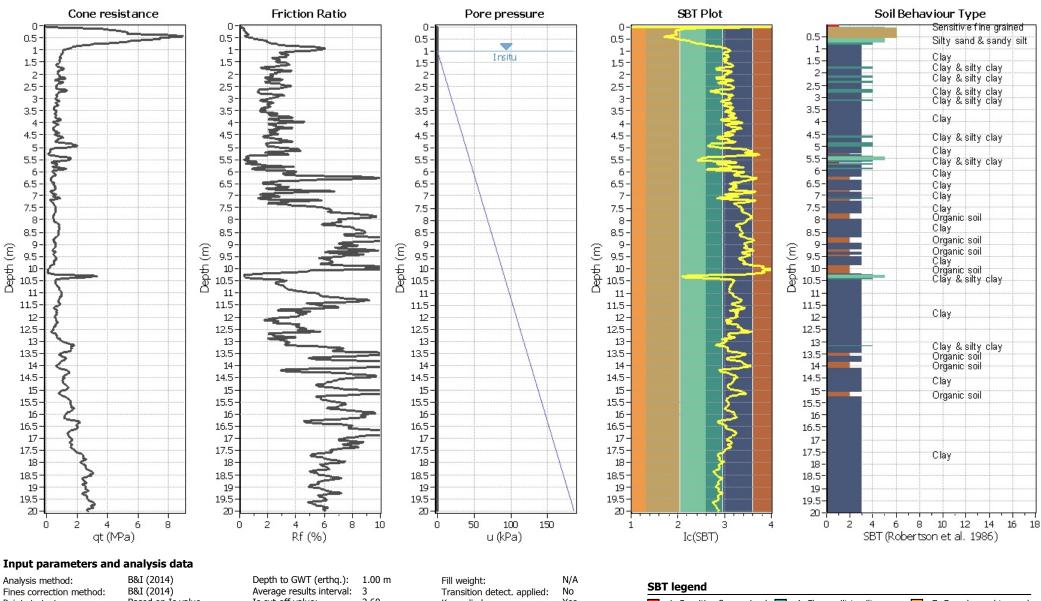
4. Clayey silt to silty 5. Silty sand to sandy silt 6. Clean sand to silty sand

8. Very stiff sand to 9. Very stiff fine grained This software is licensed to: Geotema Srl CPT name: 036004P351CPTU363



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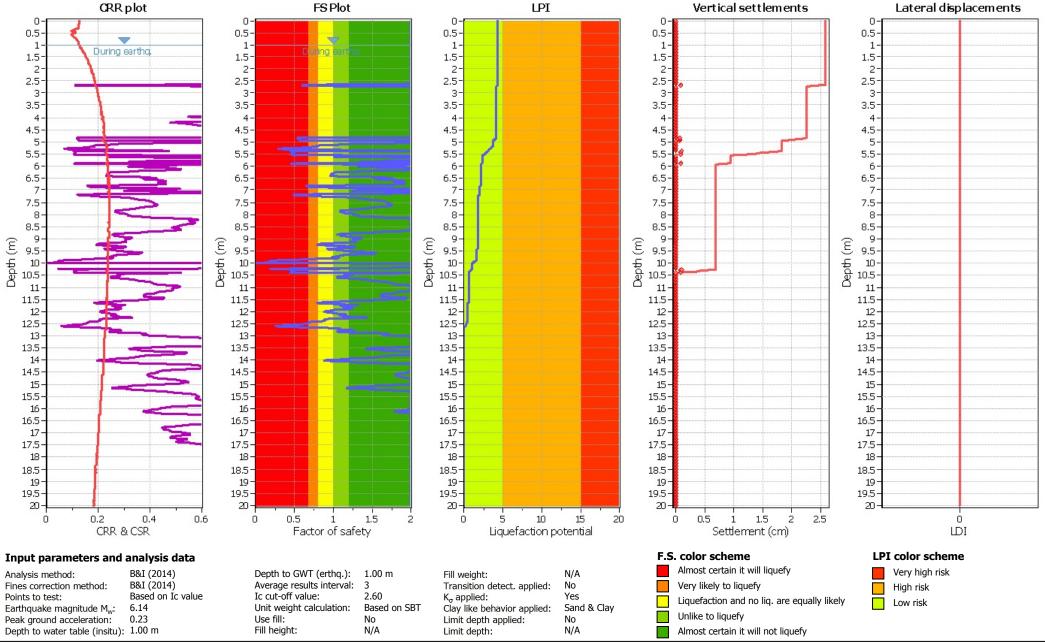
CPT basic interpretation plo



Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained Unit weight calculation: Based on SBT Earthquake magnitude M...: 6.14 Clay like behavior applied: Sand & Clay 5. Silty sand to sandy silt 2. Organic material 8. Very stiff sand to 0.23 Use fill: No Peak ground acceleration: Limit depth applied: No 9. Very stiff fine grained 3. Clay to silty clay 6. Clean sand to silty sand Depth to water table (insitu): 1.00 m Fill height: N/A N/A Limit depth:

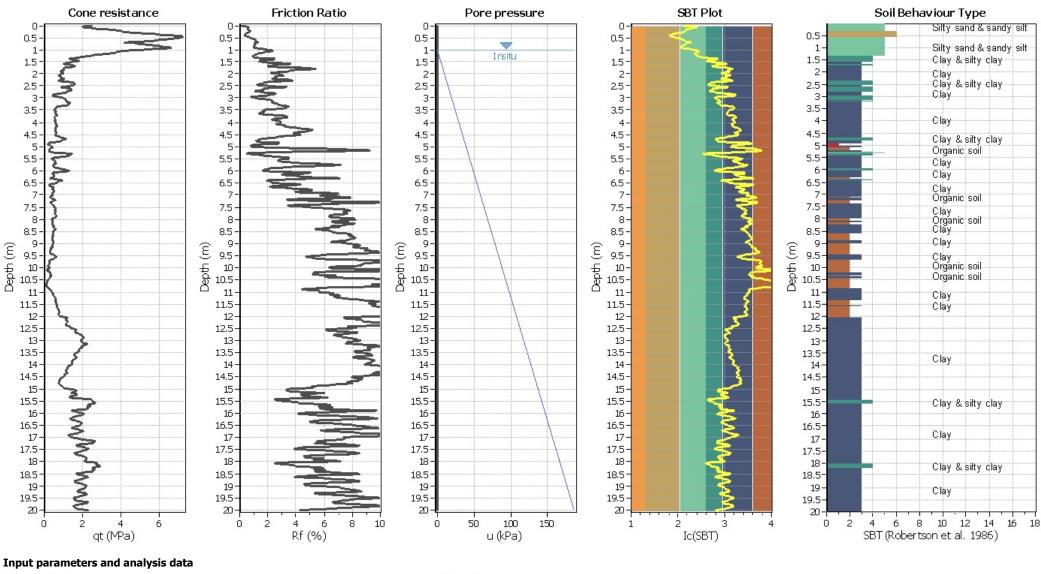
This software is licensed to: Geotema Srl CPT name: 036004P352CPTU364

LPI Vertica



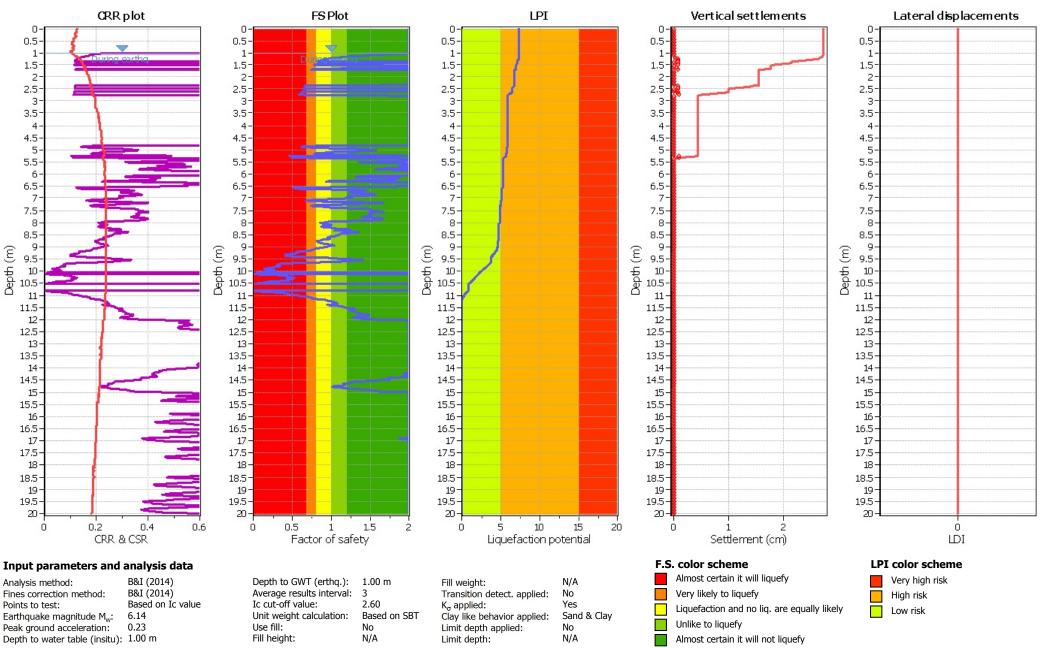
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CPT basic interpretation plo



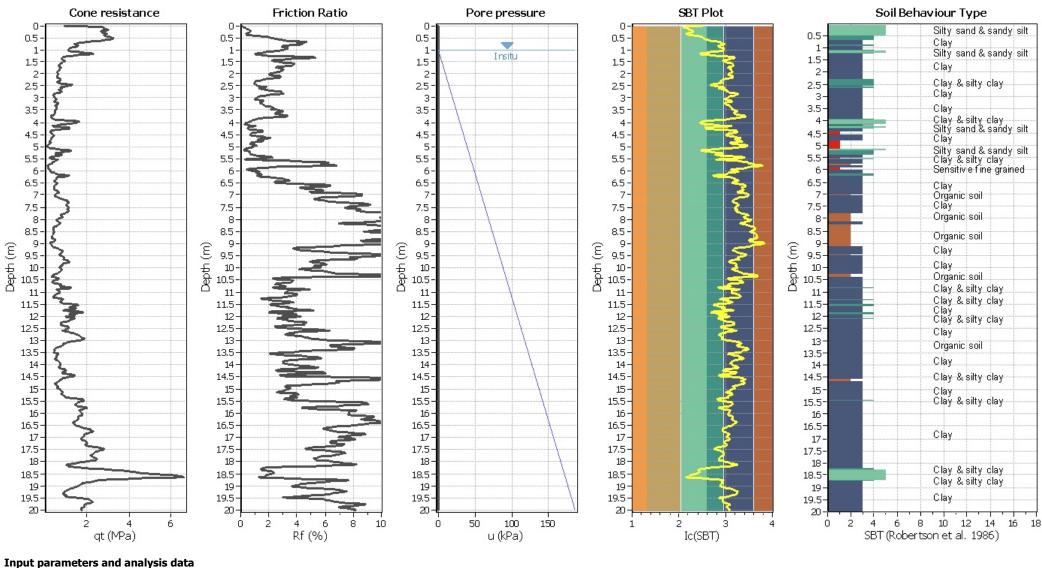
B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Analysis method: Fill weight: SBT legend Fines correction method: B&I (2014) Average results interval: Transition detect, applied: No Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained Unit weight calculation: Based on SBT Sand & Clay Earthquake magnitude M...: 6.14 Clay like behavior applied: 5. Silty sand to sandy silt 8. Very stiff sand to 2. Organic material 0.23 Use fill: No Limit depth applied: Peak ground acceleration: No 9. Very stiff fine grained 3. Clay to silty clay 6. Clean sand to silty sand Depth to water table (insitu): 1.00 m Fill height: N/A Limit depth: N/A

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CPT basic interpretation plo



B&I (2014) Depth to GWT (erthq.): 1.00 m N/A Analysis method: Fill weight: SBT legend Fines correction method: B&I (2014) Average results interval: Transition detect. applied: No Based on Ic value Ic cut-off value: 2.60 Points to test: K_{σ} applied: Yes 4. Clayey silt to silty 7. Gravely sand to sand 1. Sensitive fine grained Unit weight calculation: Based on SBT Sand & Clay Earthquake magnitude M...: 6.14 Clay like behavior applied: 5. Silty sand to sandy silt 8. Very stiff sand to 2. Organic material 0.23 Use fill: No Limit depth applied: Peak ground acceleration: No 9. Very stiff fine grained 3. Clay to silty clay 6. Clean sand to silty sand Depth to water table (insitu): 1.00 m Fill height: N/A Limit depth: N/A

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