

Project datasheet: Ground improvement by stone columns

Project name: Tarmac, taxi and parking area, GRU airport

Location: São Paulo, Brazil

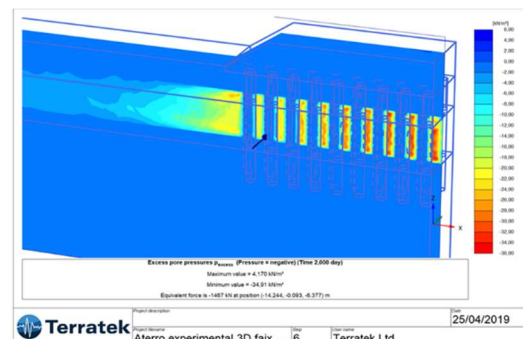
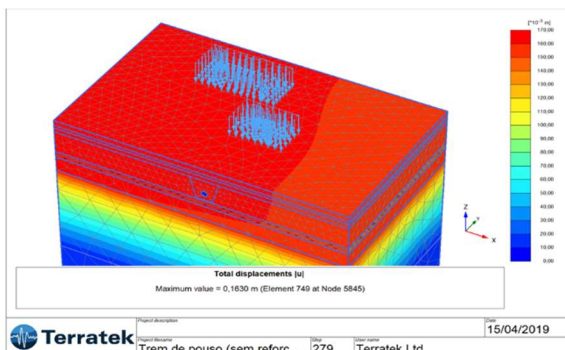
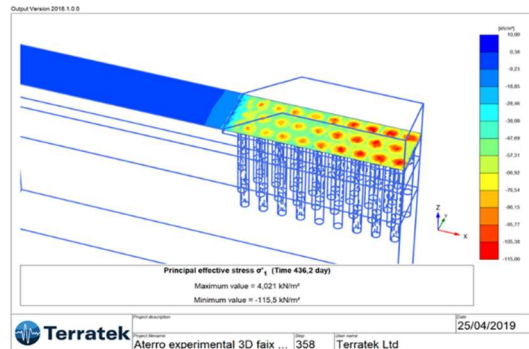
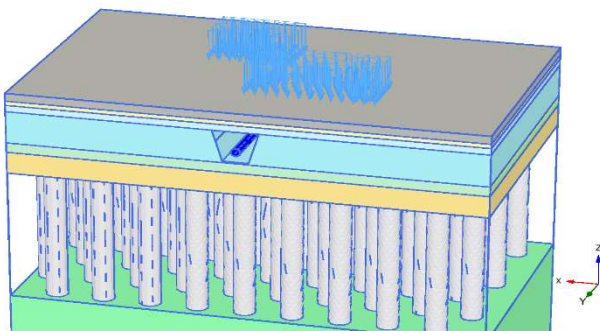
Client: GRU Airport

Description: GRU Airport expansion project in 2018-2019 included an extension of the tarmac and taxi area, where a new tarmac area was built on 4 to 7 m deep soft lacustrine clay. The design adopted 900 mm diameter 1.8 m spaced stone columns and installed with an electric vibrator. A trial embankment was built to check design assumptions and to validate a Plaxis 3D model which was, then used to analyse the effect of aircraft loading.



Services provided by Terratek

- Geotechnical consultancy and design review;
- Plaxis 3D modelling;



Project datasheet: Design review and liquefaction assessment

Project name: Sir Solomon Hochoy Highway

Location: Trinidad

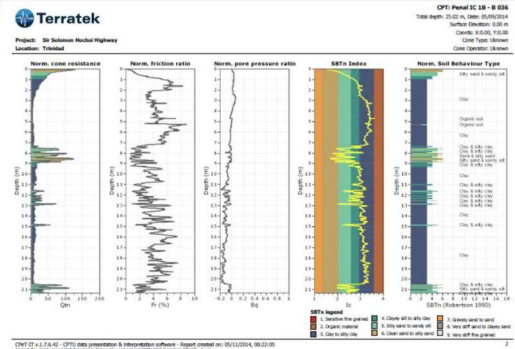
Client: OAS Contractors



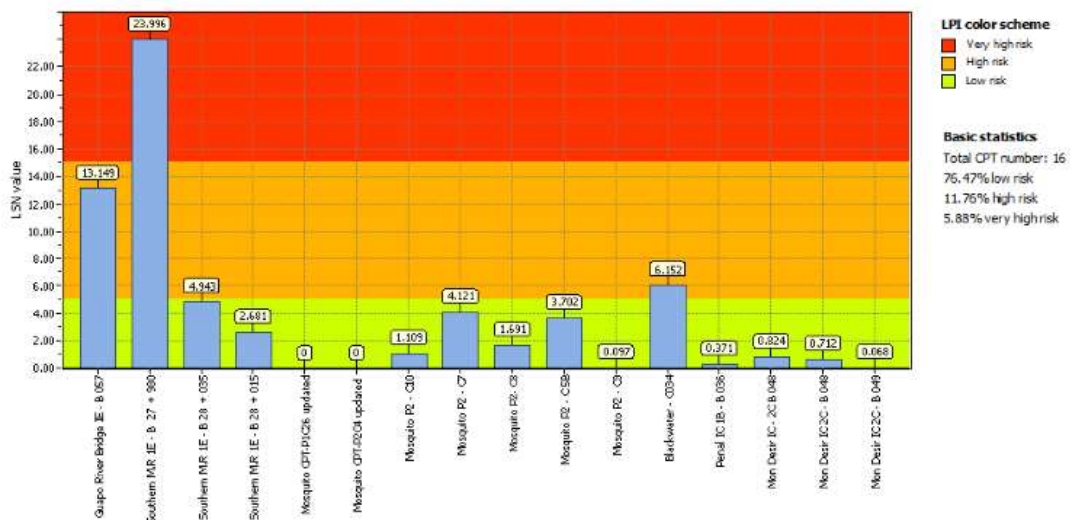
Description: This project was a 50 km extension of this highway crossing Trinidad Island North to South. Soil conditions were poor with several metres of soft clay deposits. Earthquakes are a major issue, as the design horizontal acceleration is about 0.55 g. The project involved 18 viaducts and their abutments on soft soils.

Services provided by Terratek

- Analysis of site investigation including CPTU and VST data;
- Probabilistic seismic assessment and analysis of design value for horizontal acceleration;
- Liquefaction assessment and recommendation that only two viaduct abutments, out of 13, needed ground improvement, leading to £ 10 m savings
- Geotechnical consultancy to all geotechnical structures and embankments on soft soils
- Pile foundation design review;



Overall Liquefaction Potential Index report



Project datasheet

Wick drains & foundations design

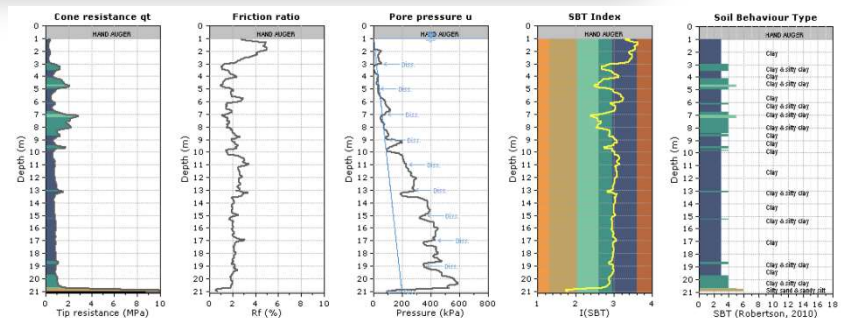
Project name: Pericumã Bridge and access road embankments



Location: Maranhão, Brazil

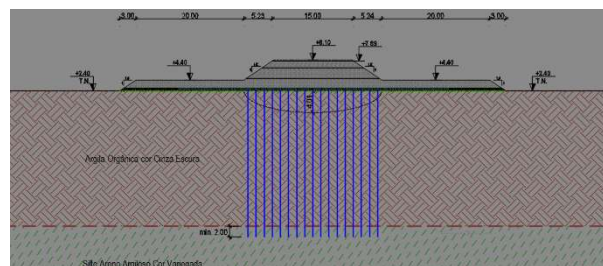
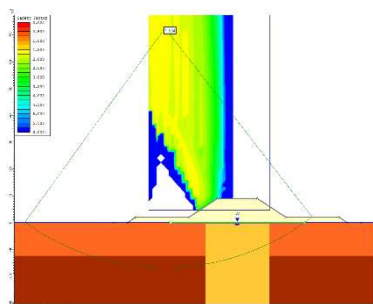
Client: Epeng Contractors

Description: This is a 500 m long bridge over Pericumã River. Terratek was responsible in 2018 and 2019 for the onshore site investigation and detailed foundation design, as well as the bridge abutments embankments and an additional 7 km of roads.



Services provided by Terratek:

- Site investigation including in situ CPTU and VST and lab testing;
- Bridge foundation design;
- Embankment design: geogrid reinforced embankments with temporary surcharge and soft soil improvement with 1.5 m spaced wickdrains;
- Instrumentation design.



Project datasheet Vale Carajás railway

Project name: Duplication of Carajás railway

Location: Maranhão, Brazil

Client: Vale Mining

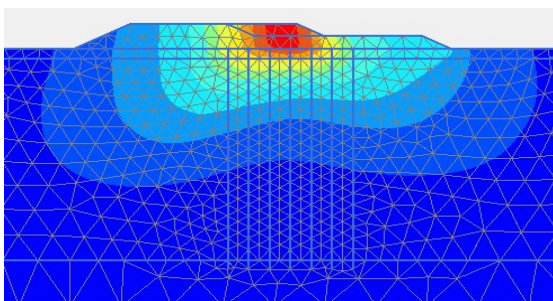
Description: This was a huge 1000 km long railway line stretching from the Amazon to São Luis Harbour. The first single railway line was built back in 1980, was enlarged to support the new one. One main challenge of this project is to cross 30 km long, 8 to 17 m deep very soft marine clay. The old single line was placed on an embankment with lateral berms.



Vale designed this new line 16 m apart, far from the existing embankment. Based on a comprehensive site investigation, Terratek carried out consolidation analyses through Plaxis 2D and found out that the effect of the new line on the old one was minimal. Therefore, Terratek proposed to change the design and to build the new line only 5 m apart from the old one without the need for any ground improvement. This solution led to a savings of US \$ 50 M.

Services provided by Terratek:

- Site investigation;
- Geotechnical consultancy;
- Plaxis 2D consolidation numerical analysis;
- Instrumentation and monitoring.



Project datasheet Embankment on soft soils

Project name: Oil States factory

Location: Santa Cruz, RJ, Santa Cruz

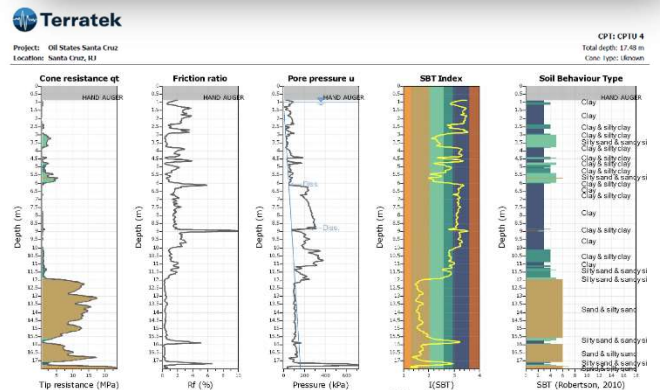
Client: Gercon Contractors

Description: This factory was built on 12 m deep soft soils. Terratek designed a 2 m high geosynthetic reinforced embankment on wick drains and 1.5 m high temporary surcharge. Also, Terratek provided foundation analysis and design for the buildings, which employed pre-cast centrifuged concrete piles.



Services provided by Terratek:

- Site investigation, including CPTU and VST;
- Geotechnical design of embankment on soft soils and foundation for the buildings;
- Instrumentation and monitoring;
- Static and dynamic pile testing.



Project datasheet Embankment on soft soils

Project name: Tiplam Harbour

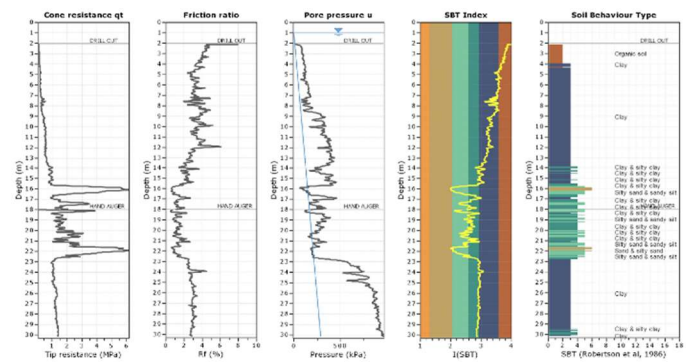
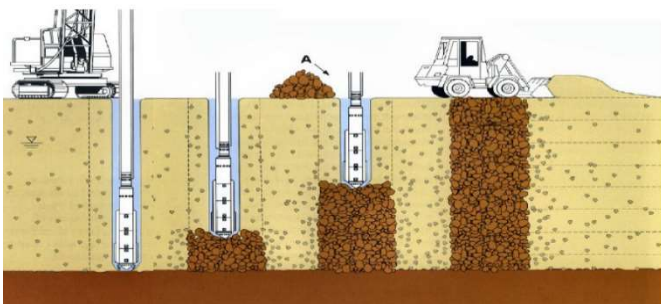
Location: Cubatão, SP, Brazil

Client: Progen Engineering

Description: This is a very large Vale harbour for grain export. It lies on a 20 m thick soft clay deposit. Terratek provided in 2011 geotechnical consultancy services for the embankments and building, warehouses and silos foundations.

Services provided by Terratek:

- Site investigation programme and data analyses;
- Geotechnical preliminary design of embankment on soft soils using wick drains and all roads on stone columns;
- Preliminary design of all deep foundations using steel H section piles.



Project datasheet

Embankment failure on soft soils repair works with jet grouting columns

Project name: Curimataú Bridge abutment failure, BR 101 RN

Location: Rio Grande do Norte, Brazil

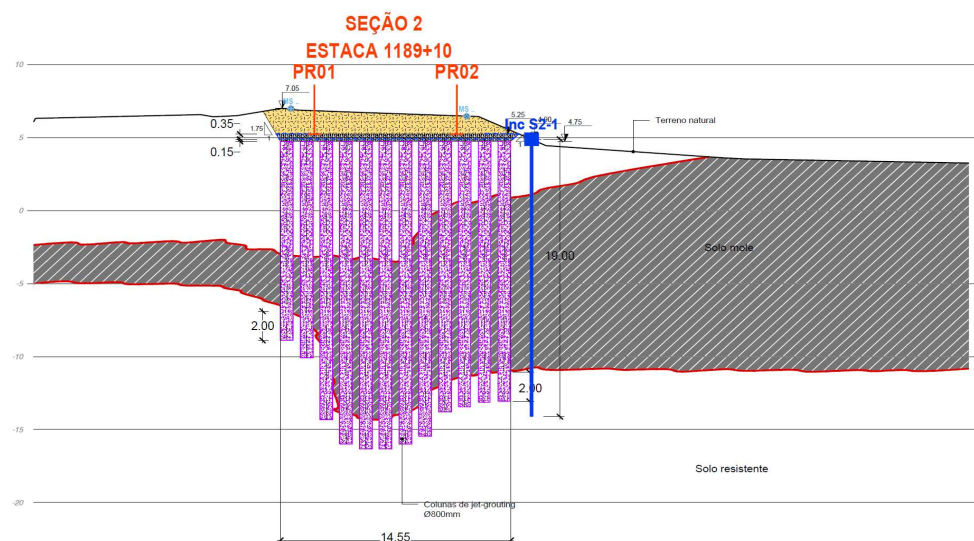
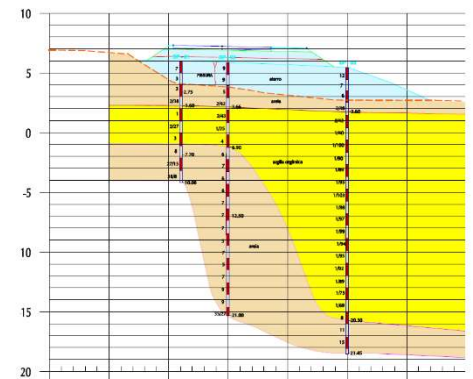
Client: Construcap Constran JV



Description: The abutment embankments of the River Curimataú bridge failed during construction. Post-failure site investigation indicated thicker soft soils than expected. Terratek was awarded the contract for the repair works.

Services provided by Terratek:

- Post-failure site investigation programme;
- Data analyses;
- Geotechnical consultancy and design of jet grouting columns
- And geosynthetic reinforcement



Project datasheet Embankment on soft soils

Project name: Jansen
Lagoon Park embankment

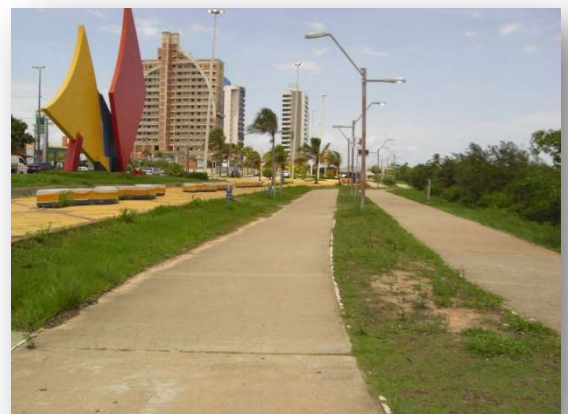
Location: São Luis, MA,
Brazil

Client: Coesa Contractors

Description: in 2003 the City of São Luís decided to build a recreational park around Jansen Lagoon. The lagoon periphery is about 6 km long and lies over 3 to 12 m soft soil deposits. A 2 m high embankment was placed over the area. To accelerate settlements, Terratek designed a drainage system including 1.5 m spaced wick drains and a sand blanket. Besides, a 1.5 m high temporary surcharge was placed over the area and remained for six months.

Services provided by Terratek:

- Consultancy and design;
- Instrumentation and monitoring



References

- Ortigão J A R & Costa-Filho (1982) Discussion on Cam Clay prediction of undrained strength, *ASCE Journal of Geotechnical Engineering*, vol 108, no 1, pp. 181-183, January 1982.
- Ortigão J A R & Palmeira E M (1982) Geotextile performance at an access road on soft ground near Rio de Janeiro, Proc. 2nd *Int. Conf. on Geotextiles*, Las Vegas, vol 1, section 3B, pp. 353-358
- Almeida M S S & Ortigão J A R (1983) Performance and finite element analysis of a trial embankment, Proc. *Int. Symp. on Numerical Models in Geomechanics*, Zürich, pp. 548-558, Balkema, also Report CUED/D-TR 121, 1982, Cambridge University Engineering Department
- Ortigão J A R, Werneck M L G & Lacerda W A (1983) Embankment failure on Rio de Janeiro clay, *ASCE Journal of Geotechnical Engineering*, vol. 109, no. 11, pp. 1460-1479, November.
- Ortigão J A R, Lacerda W A & Werneck M L G (1983) The behaviour of the instrumentation of an embankment on clay, Proc. *Int. Symp. on Field Measurements in Geomechanics*, Zürich, Balkema, vol. 1, pp. 703 - 707.
- Ortigão J A R, Werneck M L G & Lacerda W A (1985) Closure on Embankment failure on Rio de Janeiro clay, *ASCE Journal of Geotechnical Engineering*, vol 111, no. 2, pp. 262 - 264, February 1985.
- Ortigão J A R & Collet H B (1987) Errors caused by friction in field vane testing, ASTM Symp. on *Laboratory and Field Vane Shear Strength Testing*, Tampa, Florida, STP 1014, pp 104-116
- Ortigão J A R, Coutinho R Q & L A M Sant'Anna (1987) Discussion on Embankment failures on soft clay in Brazil, Proc. *Int. Symp. on Geotechnical Engineering of Soft Soils*, Mexico, vol 2.
- Ortigão J A R & Almeida M S S (1988) Stability and deformation of embankments on soft clay in *Handbook of Civil Engineering Practice*, editors: P N Cheremisinoff, NP Cheremisinoff & S L Cheng, Technomic Publishing Co., New Jersey, vol III, Geotechnics, pp 267 - 336.
- Almeida M S S, Collet H B, Ortigão J A R & Terra B R (1989) Settlement analysis of embankment on Rio de Janeiro clay with vertical drains, *Supplementary Contributions by the Brazilian Society for Soil Mechanics to the 12th ICSMFE*, Rio de Janeiro, pp 105 - 110.
- Ortigão J A R (1991) Embankment failures on soft clay in Brazil, *Geotechnical News*, December, Vol 9, no 4, Bitech Publishers, Vancouver, pp 68-70.
- Ortigão J A R, Campanella R G, Crawford C B and Jackson S (1993) The UBC Mini-inclinometer and settlement system, *Solos e Rochas* vol 16 no. 2, Agosto, pp 115-121.
- Ortigão J A R & Sayão A S F J (1994) Consolidation characteristics of soft clay, Proc. *Settlement 94, Vertical and Horizontal Deformations of Foundations and Embankments*, Texas A & M University, College Station, ASCE Geotechnical Special Publication no. 40, vol 2, pp 1415-1424.
- Campanella R G, Jackson S, Ortigão J A R & Crawford C B (1994) Design and installation of a new settlement-inclinometer device, Proc. Conf. *Settlement 94, Vertical and Horizontal Deformations of Foundations and Embankments*, Texas A & M University, College Station, ASCE Geotechnical Special Publication no. 40, vol 1, pp 911-922
- Ortigão J A R (1995) Soil mechanics in the light of critical state theories, A A Balkema, Rotterdam, 299 p.



Fahel A R S, Palmeira E M & Ortigao J A R (2000) Behaviour of Geogrid Reinforced Abutments on Soft Soil in the BR 101-SC Highway, Brazil, *Proc ASCE SPG Special Geotechnical Publication, GeoDenver 2000 Conference*, August, Denver, CO

Ortigao J A R, Fahel A R, Palmeira E M and Simmonds A J (2001) Stability and deformation monitoring of geogrid reinforced embankments, Presented at the TRB Meeting on Geo-Construction Processes, Paper 01-2392, January 2001, Washington DC

Ortigao J A R, Falk E, Felix M, Koehler T (2015) Deep soil mixing trials at Porto Alegre Airport, Brazil, DFI Deep Foundation Institute Conference, San Francisco, pp 997-1004

