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START – SINES TRANSATLANTIC RENEWABLE & TECHNOLOGY CAMPUS, LDA

NEST DATA CENTER - SINES

GEOLOGICAL AND GEOTECHNICAL INVESTIGATION

PROC. 37321

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START – SINES TRANSATLANTIC RENEWABLE & TECHNOLOGY CAMPUS, LDA
NEST DATA CENTER - SINES
GEOLOGICAL AND GEOTECHNICAL INVESTIGATION - REV 01
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1. INTRODUCTION

By decision of **START – Sines TransAtlantic Renewable & Technology Campus, LDA,** Geocontrole – Geotecnia e Estruturas de Fundação S.A. was mandated to conduct the Geological and Geotechnical Investigation of the designs involved in the construction project for the new Nest Data Center, in Sines, Portugal.

This descriptive document provides a detailed description of the development and implementation of the prospection plan, namely the set of works that were carried out and the methodology on which their execution was based, presenting the obtained results in a systematized way.

The considerations below are a result of the analysis of all the information that was collected; they objectively detail the zoning and characterization of the geotechnical diversity found in the area under study in order to define the conditions of the future structure's foundations.

To assist in the conduction of this study, the Client provided a location plan in an editable digital format (DWG), which served to prepare the interpretive geotechnical profile and locate the works.



Figura 1.1 - Aerial view (adapted from Google Earth) of the intervention area – no scale

2. WORKS

In order to proceed with the recognition of the geotechnical conditions associated with the geological grounds involved in the construction project for the new structures, the planned geotechnical investigation campaign was developed in line with the Customer's needs.

The work plan involved the conduction of sixteen (16) geotechnical boreholes: S1 to S16, accompanied by *in situ* characterization tests, SPT. Furthermore, six (6) open-circuit hydraulic piezometers were installed in an attempt to monitor eventual hydrogeological deviations that may occur.

A set of eight (8) Trial Pits were also performed with disturbed samples collection. These samples were conducted to Soil and Rock Mechanics Laboratory facilities in Lisbon in order to be tested. In order to complete the boreholes information eight (8), CPTu tests were carried out on job site.

From the hydraulic open circuit piezometers 4 water samples were collected and according the program laboratory tests were also performed, that will be described through this document.

Eight (8) electrical resistivity profiles were also performed on job site in order to determine the electrical conductivity of the occurrent soils.

This section describes the works that were carried out and the methodology on which their execution was based, presenting, as an attachment, the results of the prospection campaign undertaken, summarized in individual test diagrams.

2.1 Geotechnical Boreholes

In order to characterize the geotechnical behavior associated with the local geological environment, we have conducted sixteen (16) vertical geotechnical boreholes at the locations marked in the attached location plant. To carry out the drilling, a *Mobile Drill B47 HD* drilling equipment mounted on a 4x4 vehicle (figure 2.1) was required.



Figura 2.1 - Mobile Drill B47 HD equipment mounted on a 4x4 vehicle

The drilling was made with a *hollow stem auger* with an external diameter of 200 mm. The free internal diameter of the augers allowed conducting the SPT dynamic penetration tests without the need to extract the rod train that drills and braces the pit. We were able to use this methodology thanks to the softness of the Plio-Pleistocene and Carbonic substrate and to the shallow nature of the landfill deposits.



Figura 2.2 - Hollow Stem Auger Method Scheme

During the drilling process, we systematically conducted standardized SPT dynamic penetration tests, spaced approximately 1.5m apart, according to the recommendations of the *International Reference Test Procedure for the Standard Penetration Test*, (*ISSMFE*, 1989). So, the aim was to assess the compactness and consistency of the surveyed soils *in situ* and, consequently, define the geotechnical zoning of the surveyed sequences.

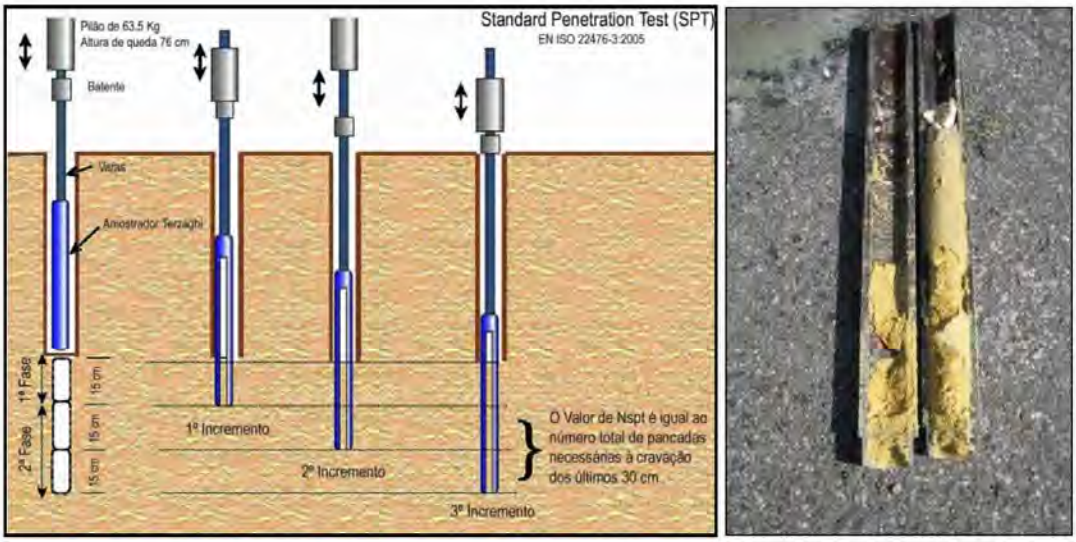


Figura 2.3 - Execution scheme of the SPT test and detail of the SPT-Terzaghi split-barrel sampler.

The classification of the sands, in terms of compactness, and clays, in terms of consistency, was made as indicated in Tables 2.1 and 2.2, respectively.

Table 2.1 - Classification of sands by compactness.

N_{SPT}	Compactness	Relative Density (%)
0 - 4	*too loose*	15
4 - 10	*loose*	15 - 35
10 - 30	*medium dense*	35 - 65
30 - 50	*Dense*	65 - 85
>50	*very dense*	85 - 100

Table 2.2 - Classification of clays by consistency.

N_{SPT}	Consistency	1.1.1.1.1 Unconfined compression strength (kPa)
0 - 2	*very soft*	< 24
2 - 4	*soft*	24 – 48
4 - 8	*firm*	48 – 96
8 - 15	*hard*	96 – 192
15 - 30	*very Hard*	192 – 388
>30	*stiff*	>388

The results of the drilling campaign are summarized in individual survey diagrams presented in Annex I - Geotechnical Prospection In addition to information on the drilling and the identification of the surveys, they mention the following aspects:

- Lithostratigraphic sequencies crosse;
- Results of the *SPT* tests (N_{SPT} values); and
- Position of the water level at the end of drilling.

Table 2.3 - Geotechnical Surveys; amounts of work performed

Prosp.	Litho.	Depth (m)	SPT	Water Level	Piezometer	Location			Remarks
		Soil	(un)		(m)	M	P	Z	
S1	Os / PQ / H_{MI}	9.07	6	Dry	9.00	-59989.807	-192168.740	17.997	--
S2	Rec / PQ / H_{MI}	9.08	6	7.50	--	-59874.213	-192214.813	18.998	--
S3	Os / PQ / H_{MI}	9.12	6	6.40	9.00	-59821.252	-192213.031	21.067	--
S4	Rec / PQ / H_{MI}	13.75	9	5.00	--	-59764.970	-192246.920	19.300	--
S5	Os / PQ / H_{MI}	12.08	8	2.70	12.00	-59703.590	-192285.130	20.250	--
S6	Rec / PQ / H_{MI}	13.61	9	8.30	--	-59900.360	-192144.126	19.234	--
S7	Rec / PQ / H_{MI}	9.09	6	Dry	--	-59790.308	-192166.127	21.731	--
S8	Os / PQ / H_{MI}	9.42	6	4.80	--	-59737.580	-192198.329	21.906	--
S9	Rec / PQ / H_{MI}	10.92	7	Dry	--	-59673.389	-192235.369	22.690	--
S10	Rec / PQ / H_{MI}	9.24	6	Dry	9.00	-59748.963	-192112.044	22.936	--
S11	Rec / PQ / H_{MI}	9.13	6	7.50	--	-59709.438	-192162.452	23.591	--
S12	Os / PQ / H_{MI}	9.34	6	3.00	9.00	-59666.423	-192187.846	22.220	--

Prosp.	Litho.	Depth (m)	SPT	Water Level	Piezometer	Location			Remarks
		Soil	(un)		(m)	M	P	Z	
S13	Rec / PQ / H_{MI}	9.22	6	2.50	--	-59689.380	-192129.774	22.693	--
S14	Rec / PQ / H_{MI}	9.20	6	7.10	--	-59648.285	-192155.001	22.093	--
S15	Os / PQ / H_{MI}	9.09	6	2.50	--	-59685.064	-192089.032	23.101	--
S16	Os / PQ / H_{MI}	9.10	6	1.70	9.00	-59639.026	-192113.060	22.492	--
Total		**160.46**	**105**	--	**57.00**	--	--	--	--

2.2 Open-Circuit Hydraulic Piezometer

As predicted in tender stage, six (6) open-circuit hydraulic piezometers were installed whenever there were signs of hydrogeological productivity. Therefore, and given that some moisture was detected in almost all boreholes, at depths that ranges from 1.00 to 4.19m, standpipe piezometers were installed in boreholes S1, S3, S5, S10, S12 and S16.

This ensures a direct access to the groundwater layer and the possibility of monitoring its variation over time. This instrument will be able to take readings after the geological investigation is conducted, thus enabling the monitoring of groundwater layers that may arise and also the possibility of collecting water samples for laboratory tests, if necessary.

The piezometric pipe is made of factory-threaded, rigid PVC with nozzles (splined) and includes filters; the circular gap between the walls of the drill and the piezometric pipe is filled with a highly permeable material (calibrated gravel or washed sand). The top of the filter is insulated with a bentonite-based grout. On top of the piezometer (on the surface), a new seal was made, this time using a concrete-based grout.

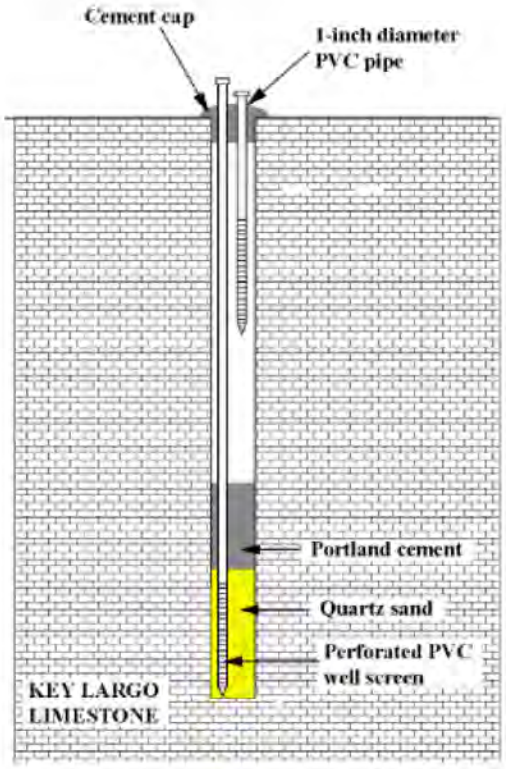


Figura 2.4 - Illustrative scheme of an open-circuit hydraulic piezometer

In all piezometers a 6.0m length of filter was applied, from the bottom.

2.3 Trial Pits

Shallow test pits provide an economical method of examining *in-situ* conditions also allowing the collection of disturbed samples.

The eight (8) trial pits allowed expose the shallower lithological sequences and provide disturbed sampling representative of the encountered soils, for further laboratory processing, with a view to the identification and characterization of occurring materials.




Figura 2.5 - Detail of trial pits execution

Table 2.4 - Trial Pits; amounts of work performed

Prosp.	Litho.	Depth (m)	Water Level	Location			Lab. Reference
		Soil		M	P	Z	
PC1	Os / PQ	1.80	Dry	-59944.562	-192191.821	17.758	66771
PC2	LF / PQ	1.60	Dry	-59844.714	-192255.537	18.456	66772
PC3	LF / PQ	2.55	Dry	-59717.380	-192336.708	18.756	66773
PC4	Os / PQ	3.00	Dry	-59854.394	-192152.622	20.438	66774
PC5	Os / PQ	3.00	Dry	-59621.912	-192262.349	21.471	66775
PC6	Os / PQ	3.00	Dry	-59788.650	-192082.210	22.596	66776
PC7	LF / PQ	2.40	Dry	-59607.960	-192184.820	21.786	66777
PC8	LF / PQ	2.50	Dry	-59687.960	-192042.270	23.875	66778

2.4 Cone Penetration Tests - CPTu

Static cone penetration testing CPT(U) were performed using a Pagani 200 KN equipment, mounted on a trailer.

The cone penetration test consists of the drive into the site by means of a hydraulic system with constant penetration speed of an instrumented cone shoe with standard dimensions. Depending on the type of ground, an axial thrust capacity of 200 kN can be reached, if necessary. An associated electronic system carries out the measurement and recording of the variation in the following parameters with the increase in depth:

- Tip resistance, qc (MPa);
- Local side friction, fs (MPa);
- Pore pressure, uT (=u2);
- Friction ratio Rf=fs/qc (%),
- Inclination (º)



Figura 2.6 - Piezocone probes aspects

A 10 cm^2 cone was used, suitable for the measurement of the tip resistance and local friction, being fitted with a pore pressure measurement cell (u2). The equipment is fitted with a data acquisition system that allows the permanent display of the results obtained concurrently with its acquisition. The reading interval is 20 mm, which, for the standardized penetration speed, will correspond to the frequency of one reading per second.

To ensure a good saturation of the cone (porous ring and internal cavities) to obtain correct readings of the pore pressure, a vacuum pump with silicone oil was used.



Figura 2.7 - Aspects of the CPTU PAGANI 200 kN.

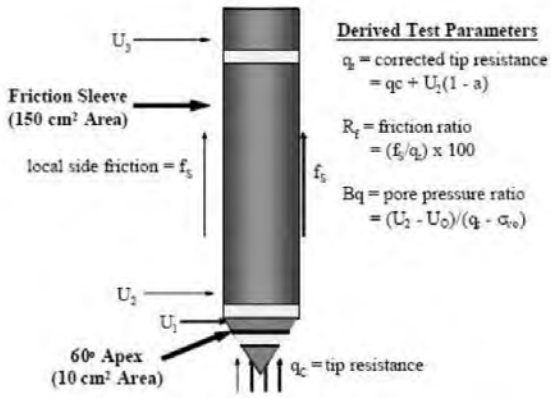




Figura 2.8 - Diagram of the parameter measurement sites registered by the CPTu cone.

During the CPTu tests, a set of pore pressure dissipation tests were performed, namely, two (2) per test. Clear reference on the dissipation plots should be made to zero time which shall refer to the stopping of the cone penetration. During the dissipation test the cone resistance was monitored continuously.

Table 2.5 - Cone Penetration Tests: amounts of work performed

Prosp.	Depth (m)	Location			Remarks
	Soil	M	P	Z	
CPTu1	4.00	-59658.825	-192106.133	22.566	--
CPTu2	5.40	-59731.734	-192145.090	22.728	--
CPTu3	3.20	-59645.202	-192200.983	21.949	--
CPTu4	2.00	-59799.141	-192179.257	21.651	--
CPTu5	7.00	-59702.598	-192222.257	22.235	--
CPTu6	5.60	-59836.425	-192227.306	19.181	--
CPTu7	3.20	-59743.281	-192264.409	18.947	--
CPTu8	3.60	-59705.203	-192302.769	19.645	--

1.2 Electrical resistivity profiles

A set of eight electrical resistivity profiles, PR1 to PR8, with an individual length around 45 m and depths up to 8 m were carried out.

The method of electrical resistivity is based on the production of an electric field through the injection of electric current into the ground by means of two metal electrodes (A-B) and measurement of the electric potential difference between two other electrodes (M-N) a tetra-electrode chain.

However, the equipment used in the surveys made possible the use of the multi-electrode methodology, distributing equidistantly a series of 19 electrodes, with 2.5m spacing and along the rectilinear alignments of interest.



Figura 2.9 - General view of performance of electrical resistivity profiles

These electrodes are an integral part of the ActEle system which, via a multi-conductor cable, connect to the LGM 4point light hp resistivimeter. In the chosen configuration, the resistivimeter is controlled by an IT platform that controls the geoelectric device and all the logistics involved in the execution of the electrical tomography.

For the injection of electric current in the subsoil we used a 12V battery that allowed to inject electric current up to 100mA of intensity. In order to ensure the best possible contact at the electrode/ground interface, these connections were tested prior to data acquisition in order to obtain a diagnosis of the contact resistances of each electrode. Whenever necessary, aqueous and salt mixtures were used which were added to the surrounding soil at the base of the electrodes.

Considering the objectives proposed for this prospection, the Wenner geoelectric device was chosen, which defines the tetra-electrode distribution A/M/N/B symmetrically with respect to a central point of reading, causing a progressive change in the distance of the injection electrodes AB. This

methodology presents greater sensitivity to vertical variations of resistivity, which favours its application in the definition of horizontal contrasts of resistivity.

The following figure shows the simplified reading acquisition scheme, symbolizing A-B the current electrodes and M-N the reading electrodes.

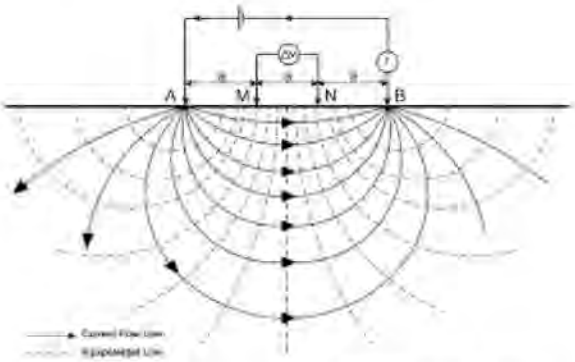


Figura 2.10 - Simplified sketch of Wenner array.

Obtaining a model of electrical resistivity presupposes the algorithmic inversion of the pseudo-sections obtained with the field readings using the Res2DInv software of M.H. Loke (1999).

The final model resulted from the adjustment between an apparent resistivity model and a calculated resistivity model, being presented on the form of a two-dimensional section of electrical resistivity of the terrain, which arises after a minimum RMS error difference in the iterative calculation. The RMS error resulted from the calculation of the quadratic difference between all points of the field pseudo-section and that calculated by inversion.

Additionally, the numerical values associated with the central point of the tomography scans obtained by interactive calculation were projected in a semi-logarithmic graph. Thus, it was intended to highlight the variation of electrical resistivity as a function of the depth in the axis with greater number of vertical readings.

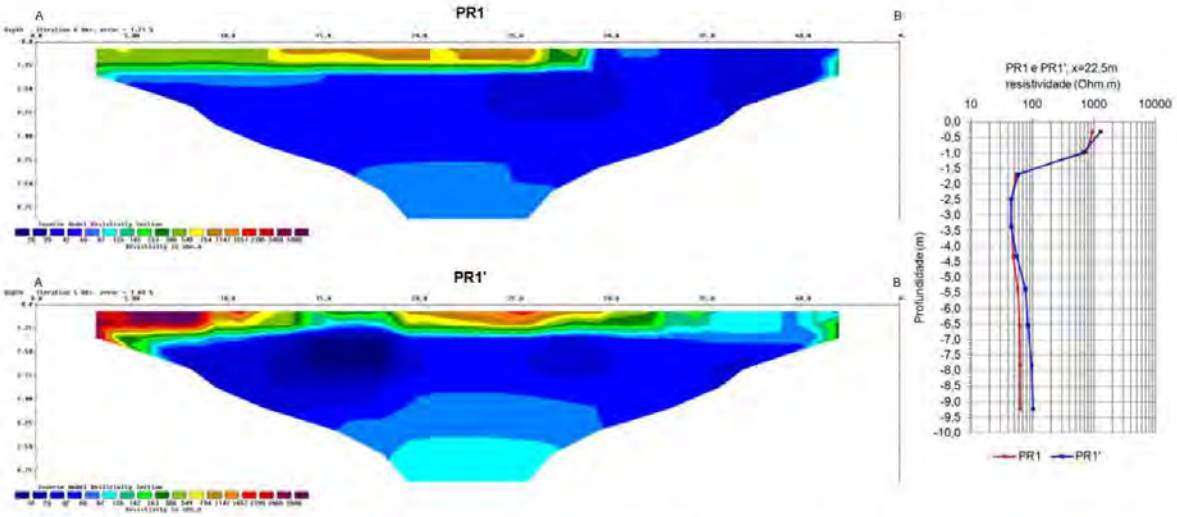
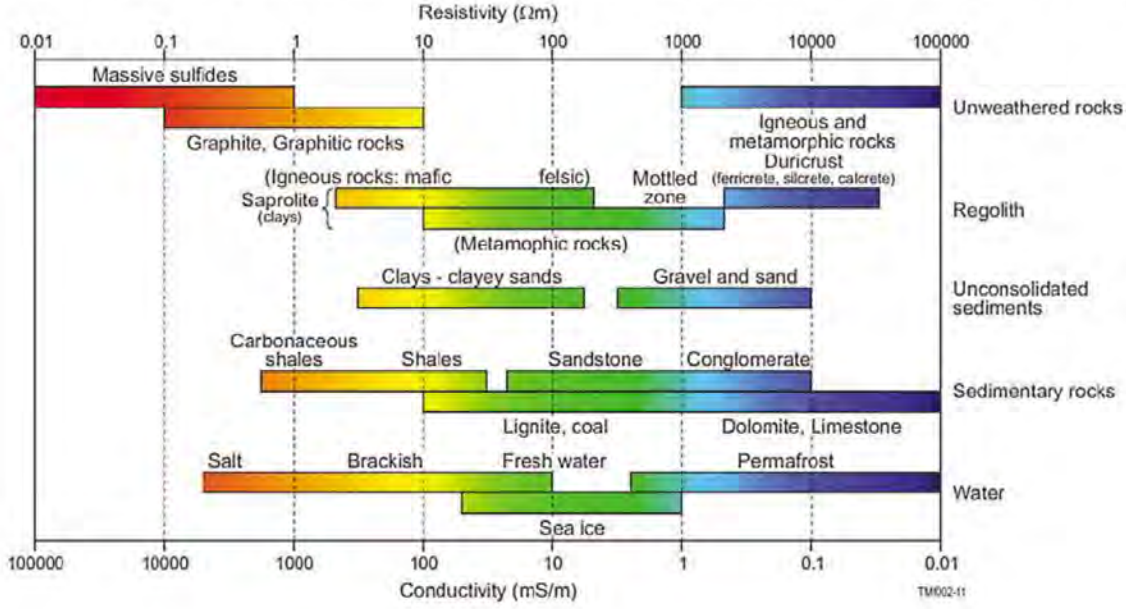


Figura 2.11 - Profile of an electrical resistivity, namely PR1.

In the geological environment, different type of lithologies present as one of its fundamental properties the electrical resistivity parameter, which reflects some of its physical characteristics, serving to characterize them in terms of alteration, fracturing, saturation, etc., and even identify them lithologically. The following table shows the typical resistivity associated with some types of materials.

Table 2.6 - Typical ranges of electrical resistivity or conductivity for selected Earth materials (Palacky 1988).



2.5 Laboratory Tests

In order to identify local soils and inquire about mechanical properties, a set of eight (8) disturbed samples considered representative of the local geology, which were collected in the trial pits, were subjected to the following tests, carried out in the laboratory of soil Mechanics of Geocontrole, in Lisbon:

Laboratory Tests on soil samples

- Sieve analysis (ASTM D422);
- Atterberg limits (ASTM D4318) (LL and PL);
- Natural moisture content (ASTM 2216);
- Normal Proctor Compaction Test;
- Thermal Resistivity tests;

Laboratory Tests on water samples

- pH;
- Content of sulfates, nitrates, magnesium and ammonium, carbonic acid;

The natural groundwater water was chemically analyzed in order to be classified in terms of grade of environmentally aggressiveness to structural elements, nowadays called *exposure class,* and a set of tests was performed in accordance with regulations, namely Portuguese regulation NP EN 206-1, 2005, Concrete – Part 1: specification, performance, production and conformity " and LNEC E378-1996. The alkalinity and pH determinations were made before and after contact with $CaCO_3$, to determine the aggressive CO_2, also it were determined the levels in aggressive ions: SO_4^{2-}, NH_4^+ and Mg^{2+}

Table 2.7 - Summary Table with the soil lab tests results

Borehole (Nº)	Sample (Nº)	Depth (m)	Description	Liq.-str.	Classif. Unified / RTR / AASHTO	W / Sr / SE (%)	ρ / ρd (g/cm³) / Dens. Part. G	I_L / I_P / S_L (%)	VB (g/100g) / OM (%) / pH	Particle size Characteristics <2.0 mm <0.42 mm (%)	<0.074 mm <0.002 mm (%)	dim. bigger part. Max. Min. (mm)	Comp. Wopt (%) γdmax (kN/m³) Standard / Modified
P1	66771	0.15 1.00	Greyish, slightly silty, medium grain size sand.		(SP-SM) A-3(0)	0.6		NP		100 69	8 3		11.9 1.75
P2	66772	1.00 1.60	Light brown, silty, medium grain size sand.		(SP-SM) A-2-4(0)	2.4		NP		99 75	12 6		13.1 1.75
P3	66773	1.60 2.55	Greyish brown, silty, medium grain size sand.		(SP-SM) A-2-4(0)	2.0		NP		98 75	11 6		13.9 1.73
P4	66774	0.15 1.30	Greyish, silty, medium grain size sand.		(SP-SM) A-2-4(0)	3.6		NP		100 75	12 4		
P5	66775	0.30 3.00	Light brown, slightly silty, medium grain size sand.		(SP-SM) A-3(0)	2.2		NP		99 73	9 6		12.6 1.76
P6	66776	2.20 3.00	Light brown, sligtly silty, medium grain size sand.		(SP-SM) A-3(0)	2.1		NP		98 75	7 6		13.3 1.77
P7	66777	0.60 2.00	Light brown, slightly silty, medium grain size sand.		(SP-SM) A-2-4(0)	1.7		NP		98 70	11 6		12.8 1.76
P8	66778	1.00 2.50	Light brown, slightly silty, medium grain size sand.		(SP-SM) A-3(0)	2.6		NP		99 75	10 6		13.0 1.75

Table 2.8 - Summary Table with the water lab tests results

BORING nº	SAMPLE nº	DEPTH (m)	pH			Alkalinity		Agressive Ion		
			Original sample $CaCO_3$	After contact with $CaCO_3$	Incrusting power	Dissolution capacity of calcium hydroxide	Aggressive CO_2 concentration	Sulfate content (mg/l)	Magnesium Content (mg/l)	Ammoniac Nitrogene content (mg/l)
PZ 1	66787	---	5.78	6.22	0.4	28	22	158	25	0.10
PZ 5	66788	---	5.74	6.51	0.8	0	0	43	43	0.12
PZ 12	66789	---	5.75	6.16	0.4	95	75	31	39	0.03
S3 PZ	66790	---	5.75	6.36	0.6	-48	-37	59	49	0.04

3. NEOTECTONICS AND SEISMICITY

According to the ***Safety Regulations and Measures for Building and Bridge Structures*** (RSAEEP), the action of more or less severe earthquakes can be divided into two main types:

- Seismic action *type 2* corresponding to *distant earthquakes* of great magnitude and epicenter in the sea - Eurasia/Africa interplate seismicity -, generated in the Azores-Gibraltar Fracture Zone; and,

- Seismic action *type 1* associated with *local earthquakes* of moderate magnitude and short focal length - Eurasia intraplate seismicity -, resulting from the accumulation of stress and the development of current tectonic deformations inside it.

This regulatory document divided Mainland Portugal into four areas: A, B, C and D, in order of decreasing seismicity. The seismicity coefficient (α) takes the values 1.0, 0.7, 0.5 and 0.3 for seismic zones A, B, C and D, respectively, and the area of **Sines** is integrated into Zone A, which corresponds to a value of α = 1.0.

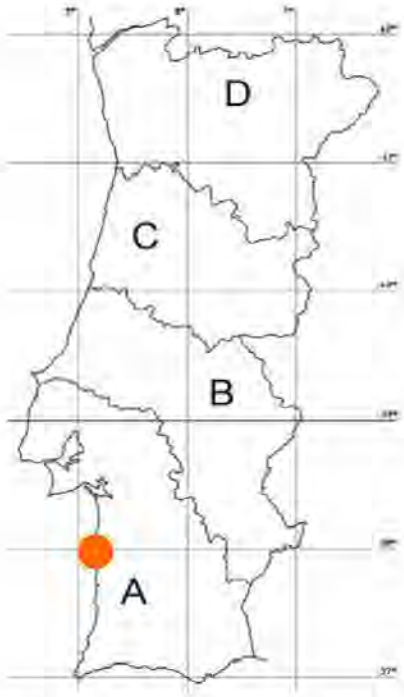


Figura 3.1 - Seismic zoning map of Mainland Portugal.

According to the aforementioned Regulation, the nature of the ground was divided into three main types. Table 3.1 shows the type of geological grounds surveyed in the area under investigation, according to the above-mentioned regulation.

Table 3.1 - Ground type according to the RSAEEP.

GEOLOGICAL UNIT	GROUND TYPE		
	I	II	III
	rocks and soils stiff cohesive soils	very hard cohesive soils, hard soils with a medium consistency; compact cohesionless soils	soft and very soft cohesive soils; loose cohesionless soils
Landfills		o	•
Plio-Pleistocene (silty sands sometimes with gravel and sometimes somewhat clayey)	o	•	o
Carbonic (completely weathered Schist – silty clay residual soils)	•	o	

• most likely o least likely

The ***Anexo Nacional NA*** of NP EN 1998-1:2010, prepared by the Portuguese Technical Standardization Committee CT 115 - Structural Eurocodes, lays down the conditions for implementing NP EN 1998-1:2010 - "Eurocode 8: Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings."

Based on that document, the possibility that Portugal may be affected by two earthquake-generating scenarios makes it necessary to consider two types of seismic action on the mainland:

- Seismic action Type 1, for the "distant" earthquake scenario (interplate earthquake), related to earthquakes with an epicenter in the Atlantic region, which intends to represent a seismic action of high magnitude and long focal length; and,

- Seismic action Type 2, for the "close" earthquake scenario (intraplate earthquake), covering, in general, earthquakes with an epicenter on the mainland or in the Azores, and intends to represent the action of an earthquake of moderate magnitude and short focal length.

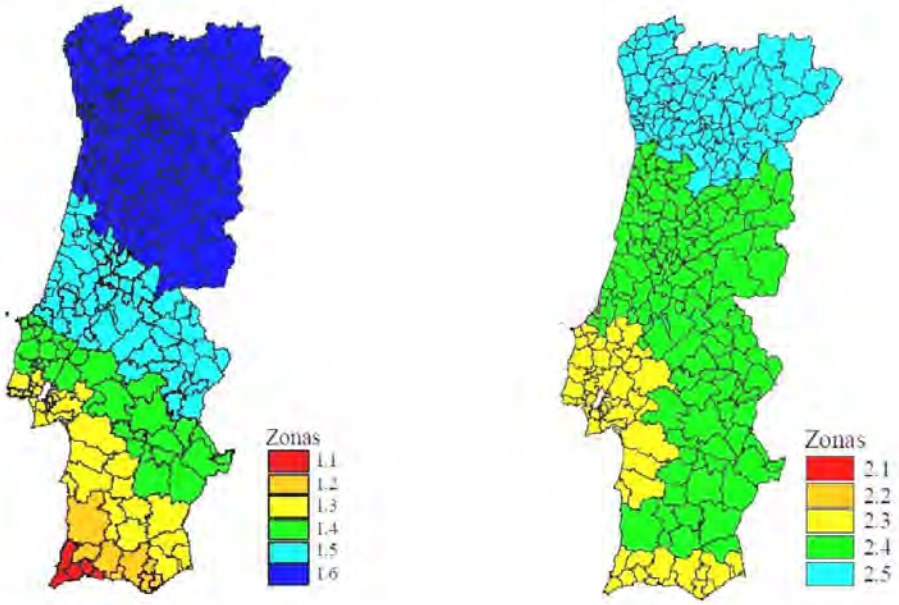


Figura 3.2 - Seismic zoning in Mainland Portugal for distant (left) and close (right) earthquake scenarios. (Anexo Nacional NA, 2010).

The reference peak acceleration values for each of the seismic zones defined according to the two types of *seismic activity* that should be considered are shown in Table 3.2.

Table 3.2 - Reference peak acceleration a_{gR} (m/s^2) in the different seismic zones.

Seismic action Type 1(distant)		Seismic action Type 2(close)	
Seismic Zone	**a_{gR} (m/s^2)**	**Seismic Zone**	**a_{gR} (m/s^2)**
1.1	2.5	2.1	2.5
1.2	2.0	2.2	2.0
1.3	1.5	2.3	1.7
1.4	1.0	2.4	1.1
1.5	0.6	2.5	0.8
1.6	0.35	--	--

With regard to *local geological effects*, EC8 considers the ground types shown in Table 3.3 for defining the elastic response spectra that should be considered for each Seismic Zone.

Table 3.3 - Ground Types

Type of Ground	Description of the lithostratigraphic profile	$v_{s,30}$ (m/s)	N_{SPT}	c_u (kPa)
A	Rock or other rock-like geological formation, including at most 5 m of weaker material at the surface	> 800	-	-
B	Deposits of very dense sand, gravel, or very stiff clay, at least several dozens of meters thick, characterized by a gradual increase of mechanical properties with depth	360 – 800	> 50	> 250
C	Deep deposits of dense or medium-dense sand, gravel or stiff clay with thickness ranging from several dozen to many hundreds of meters	180 – 360	15 – 50	70 – 250
D	Deposits of loose-to-medium cohesionless soil (with or without some soft cohesive layers), or of predominantly soft-to-firm cohesive soil	< 180	< 15	< 70
E	A soil profile consisting of a surface alluvium layer with vs values of type C or D and thickness ranging from about 5 m to 20 m, located just above stiffer material with v_{vs} > 800 m/s	-	-	-
S_1	Deposits consisting of or containing an at least 10-m-thick layer of soft clays/silts with a high plasticity index (PI > 40) and high water content	< 180 (indicative)	-	10 – 20
S_2	Deposits of liquefiable soils, of sensitive clays, or any other soil profile not included in types A – E or S_1	-	-	-

The site surveyed in the prospection campaign fits into seismic Zones 1.3 and 2.3, for seismic actions Type 1 and Type 2, respectively; the surveys that were conducted define a stratigraphic profile corresponding to a *Type C/B* ground, according to the EC8 classification.

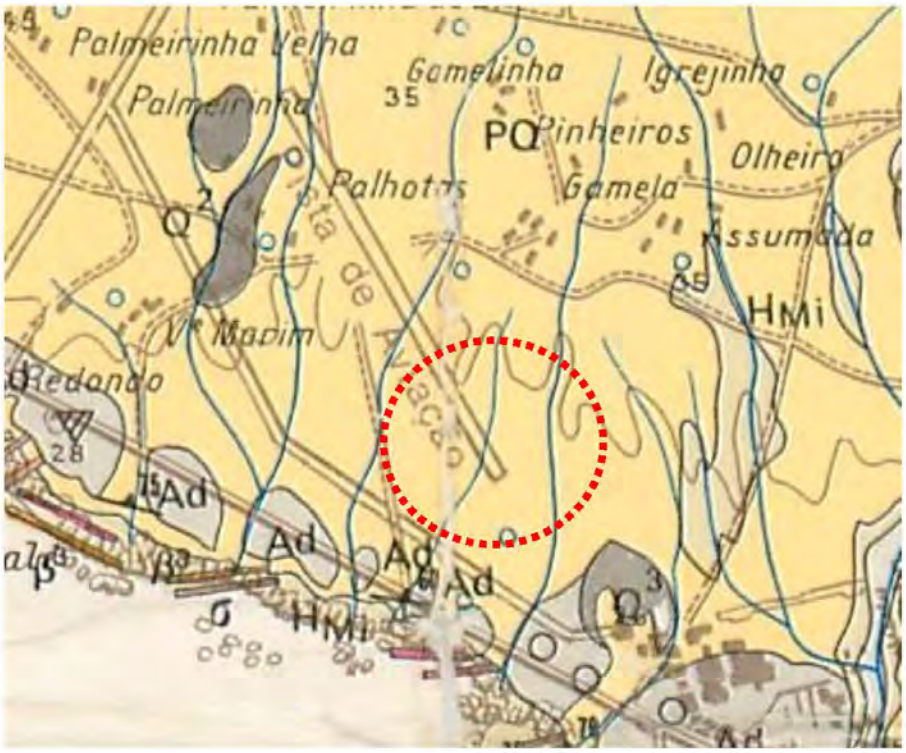
4. GEOLOGICAL AND GEOTECHNICAL CONDITIONS

The geological environment found in the investigated area is characterized by a sedimentary facies substrate attributed to the **Plio-Pleistocene (*PQ*)**, represented by the lithostratigraphic units known as *Cascalheiras e Areias de Antigas Praias e Terraços* and *Areias com Seixo de Planície Litoral*. On the surface there are erratic, contemporary **landfill deposits (LF),** and/or **organic soils (Os)**. Completely weathered schist (**Carbonic Formation - H_{MI}**), were also recognized as silty clay residual soils, in depth, below plio-pleistocene formation.

The interpretive geotechnical profiles attached to the text show a graphic outline of the expected spatial development for the surveyed lithological trails and geostructural device, supported on the systematization proposed in this investigation, which should be analyzed together with the text for a better understanding of this document.

This systematization, whose column is reproduced in Table 4.1, defined the limits for the subsequent geotechnical zoning, defined from a standardizing and geotechnical consistent point of view, without any academic pretensions, being solely and exclusively aimed at defining the foundation conditions that should be respected by the structural stability project.

However, we should note the absolutely unavoidable fact that the experimented interpretation can only translate a conceptual approach to a natural entity that is surely more complex and not fully understandable due to the occasional nature of the surveys; this fact is heightened by the anthropic intervention that affected the area in terms of shape and occupation.



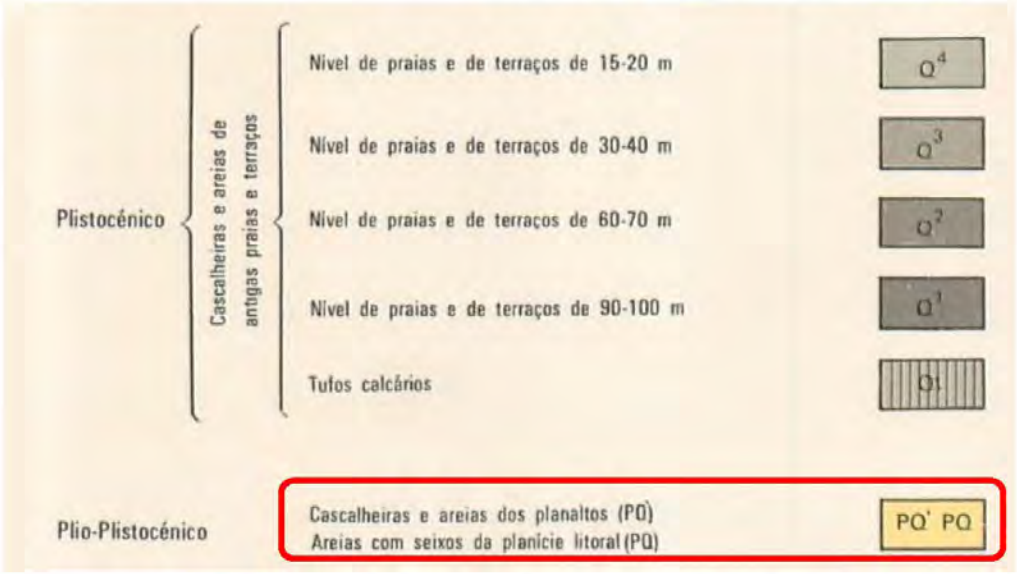


Figura 4.1 - Geological framework of the site under investigation (adapted from the Geological Map of Portugal, Sheet 42C – Santiago do Cacém, at the original 1:50 000 scale), undefined scale.

Table 4.1 - Local Lithostratigraphic Column.

STRATIGRAPHY	Symbol	FORMATION	LITHOLOGY
RECENT	Os	Organic soils	Brown, organic sandy soils with vegetable remains
	LF	Landfill Deposits	Brown and grey, fine to coarse grain size silty, SANDY LANDFILL
PLIO-PLEISTOCENE	PQ	***Cascalheiras e Areias de Antigas Praias e Terraços*** and ***Areias com Seixo de Planície Litoral***	Brown, somewhat orangish, sometimes reddish and/or grey, fine to medium grain size silty SAND. Sometimes occurs somewhat clayey
			Orange, with variable grain size (fine to coarse), silty SAND. Fine caliber gravel occurs
CARBONIC	H_{MI}	***Formação de Mira***	Grey, sometimes brownish grey, foliated silty CLAY residual soils. Completely weathered SCHIST. Remaining rock fragments occurs

In the area under study, there are **landfill deposits (LF),** related to the anthropic occupation of the site, which seems to have been affected by topographic shaping and levelling works that were probably carried out when the existing, or older, constructions were built.

Their thickness ranges from 0.80 meters (PC7) to 3.60 meters (S10), and they are essentially silty sandy. Not rarely occurs, on the top, with some organic component associated.

In terms of bearing capacity this environment fits into the category of *loose* to *medium dense* soils with $8 \leq N_{SPT} \leq 19$.

However, in this context, we should not rule out the possibility of interferences with landfills whose thicknesses are lower than the ones found in the boreholes and trial pits, namely in areas that were not directly investigated. So, this should be a latent concern in the characterization of the existing geotechnical formations, necessarily extended to the construction stage, and not limited to the presentation of this report or of the other elements of the geotechnical prospection plans.

Some part of the investigated area is also covered with a skin of **organic soils (Os)**, sandy, sometimes somewhat silty, in nature. These soils are predominantly with scattered pebbles, abundant organic matter, vegetal remains on top level and typical brown to grey tones. The thickness ranges from 0.15 to 0.40 meters depth.

Under the recent formations, namely organic soils and landfills, a sedimentary substrate attributed to the **Plio-Pleistocene - PQ**, represented mostly by sands, sometimes somewhat silty, with fine to medium grain size. In terms of bearing capacity, it was possible to include this formation on the spectrum of *loose* to *very dense* soils with $9 \leq N_{SPT} \leq 56$, with predominance of medium dense to *denser* soils with $12 \leq N_{SPT} \leq 48$. On borehole S4, from 2.20 to 4.0 meters depth, *dense* ($N_{SPT}=30$), orange, with variable grain size silty sand, with fine caliber gravel occurs.

Trial pits allowed, among other parameters, to obtain disturbed samples to be tested in laboratory. All the tested samples were collected on plio-pleistocene formation, on a range of depths between 0.15 and 3.0m

.

In figure 4.2 is possible to observe percentage distribution according the particles that pass in #200 (<0.074mm) and percentage distribution according IP (index plasticity) to the tested plio-pleistocene soils – sample 66771 to 66778. There was obtained an PI=0% in all samples, therefore plio-pleistocene soils can be considered non plastic, and 7 to 12% of soils that pass in #200 (<0.074mm).

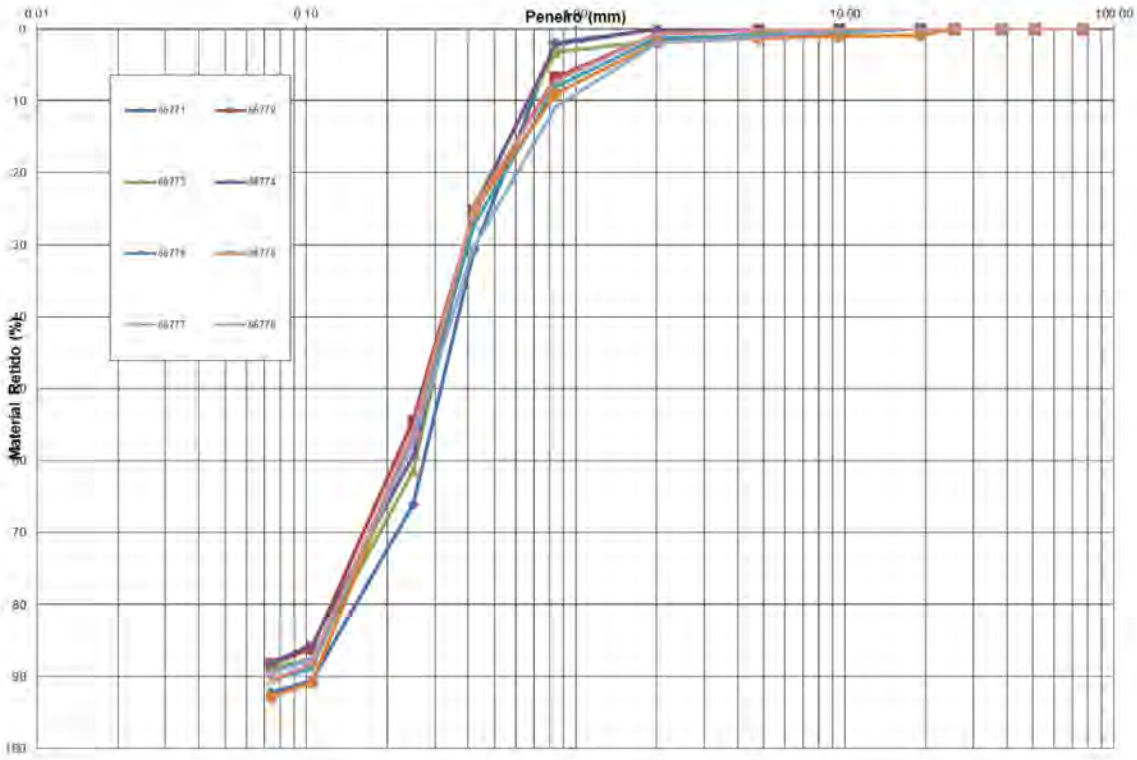


Figura 4.2 - Grain size distribution of plio-pleistocene soils (samples 66771 to 66778)

Coinciding with the end of all boreholes **Carbonic** genesis formation was investigated, namely **Formação de Mira – H_{MI}**, debiting in foliated silty clayey residual soils, often with some schist rock fragments remains (completely weathered Schist).

This horizon is mainly defined as values of N_{SPT}≥60 (*stiff* soils), mainly in the end of the borehole, however in the top of this formation some decompression was detected with N_{SPT} values ranging from 14 to 43 blows – *firm* to *stiff* soils.

Regarding the CPTu tests, with ending at depths that's ranges from 2.0 to 7.0m, respectively to CPTu4 and CPTu5 it was considered that all tests penetrate on completely weathered schists (Formação de Mira – H_{MI}). The tests ended when lack of reaction from the anchors (augers), were obtained or when the instrumentation limit was achieved (qc or fs).

Regarding the dissipation tests, its important to refer that the difference between the water level and the depth of the test, was always very low (modest). On the other hand, the behavior reveled by the tests correspond to dense to very dense soils, with pore-pressures, u2, usually negatives and with completely recovery times very long, that is typical from strongly overconsolidated materials. In the next figures (4.3 to 4.8), it's possible to observe the dissipation curve on the tests possible to carry out.

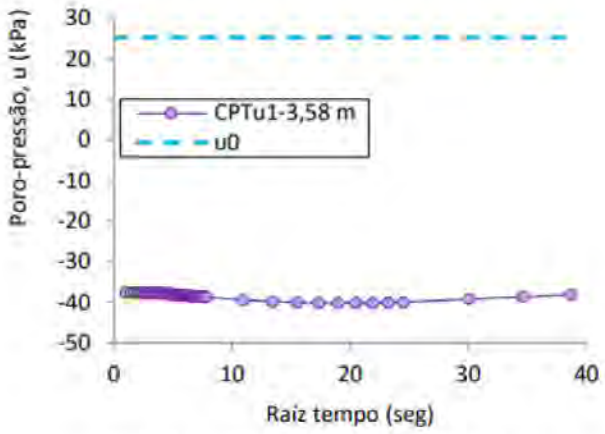


Figura 4.3 - Dissipation test on CPTu 1

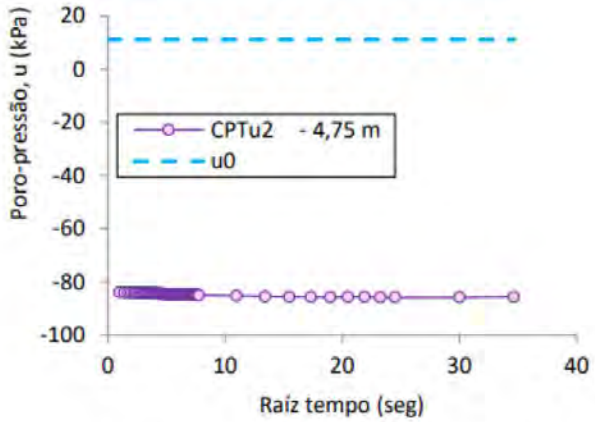


Figura 4.4 - Dissipation test on CPTu 2

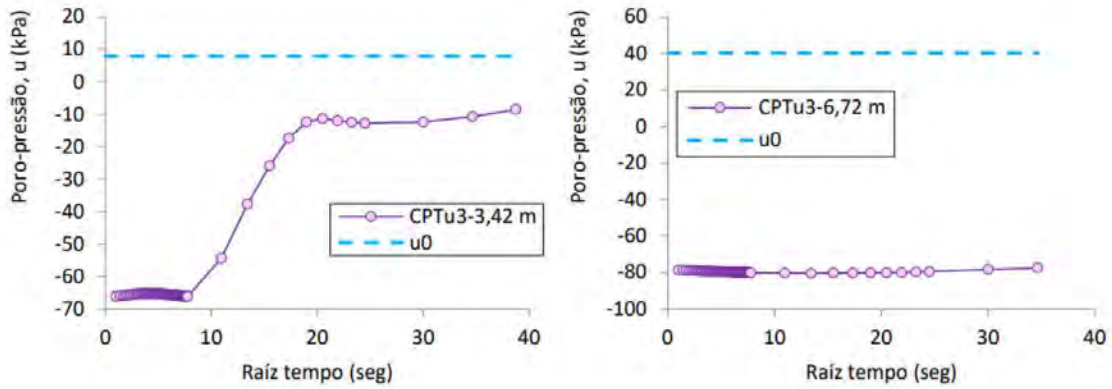


Figura 4.5 - Dissipation tests on CPTu 3

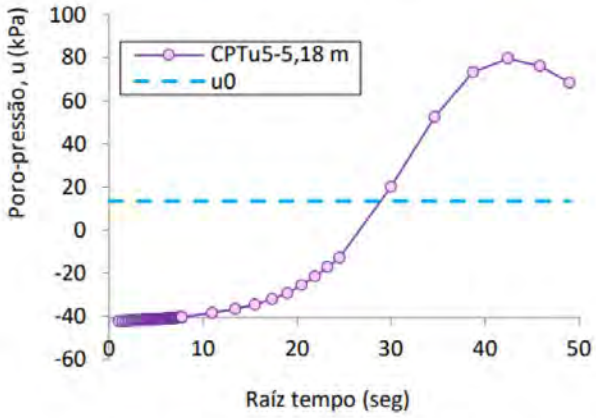


Figura 4.6 - Dissipation tests on CPTu 5

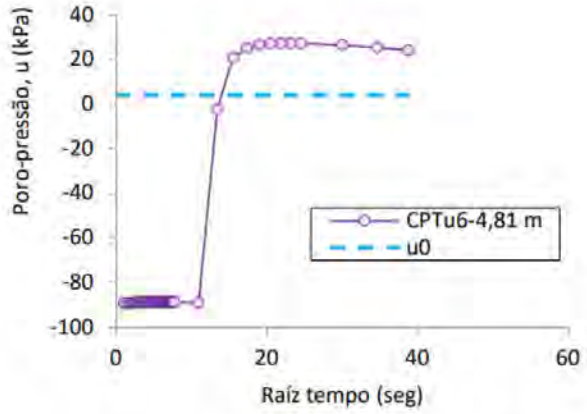


Figura 4.7 - Dissipation tests on CPTu 6

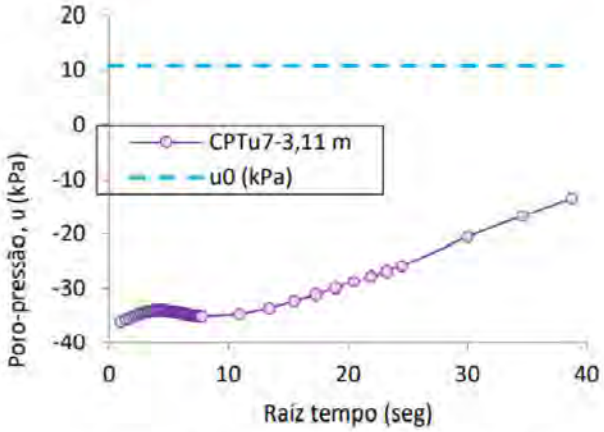


Figura 4.8 - Dissipation tests on CPTu 7

As it's possible to observe only on CPTu5 dissipation test was possible to see a tendence to the pore-pressure restoration, however it was needed to perform the dissipation test about 40 minutes.

This geological device under investigation was shown to be **productive** from the hydrogeological point of view, having been registered hydrostatic water levels during the prospection campaign (September 2021), ranging from 1.0m (S16) to 4.19m (S3), measured on September 21st.

With the increase of periods of heavy rainfall, these levels may rise to more superficial depths, however, and because are so shallow, is not expected to change significatively. Is recommend a periodic monitoring of the piezometers installed in boreholes S1, S5 and S8, namely in the period before the beginning of construction.

5. RECOMMENDATIONS

The conduction of boreholes, CPTu tests and trial pits, supported with laboratory tests, allowed simulating the geotechnical performance associated with the geological device found below the perimeter under study, revealing the presence of landfills whose maximum thickness is approximately 3.60 meters, which cover the Plio-Pleistocene substrate represented mostly by silty sands, sometimes with gravel, and/or with clayey component associated. The main depth recognized was 4.30m. Below, carbonic genesis formation was investigated represented by residual silty clay soils (completely weathered schist).

Landfills are traditionally deformable materials with a low resistance and, consequently, with characteristics that are not suitable for the support of foundations for new structures. The main N_{SPT} values obtained ranges from 8 to 19 (loose to medium dense soils).

The Plio-Pleistocene materials found below the landfills sometimes have some superficial decompression being characterized by $9 \leq N_{SPT} \leq 17$ values (loose to medium dense soils). This formation could still be compatible to a direct foundation methodology, however in the modest layers some special recommendations should be applied, like ensure that the more conditionate layers are not used to support the future foundation structures.

Generally geotechnical conditions investigated are only compatible with induced stresses around 100 to 120kPa, mobilizing unequivocally the top layer of plio-pleistocene formation. If the recommended stresses are not compatible with the future structures needs, an indirect foundation solution such as conventional concrete piles, or eventually micropiles should be considered. On the S6, S12 and S13 surrounding areas it would be very difficult to adopt a direct foundation mostly because of the decompression on top layer of plio-pleistocene formation. In other areas, with a ticker layer of landfills, such as on borehole S10, a direct foundation should be well thought out, probably with an alternative foundation methodology.

To a more detailed analysis, in the next table is possible to analyze the foundation recommendations based on the geotechnical boreholes, distributed by building and/or area.

Table 5.1 - Foundation Recommendations

Boreholes	Foundation Solution	Remarks
S1	Direct foundations of structures with an admissible tension value of 120 kPa at 1.50m depth, mobilizing unequivocally plio-pleistocene formation.	If the recommended admissible tension is not compatible with the structure foundation needs it could be considered a tension value of 250 kPa starting at 3.0m depth
S2	Direct foundations of structures with an admissible tension value of 350 kPa, mobilizing unequivocally plio-pleistocene formation.	–
S3; S4; S5; S7; S8; S9; CPTu5	Direct foundations of structures with an admissible tension value of 100 to 120 kPa, mobilizing unequivocally plio-pleistocene formation.	If the recommended admissible tension is not compatible with the structure foundation needs it could be considered a tension value of 200 kPa starting at 3.0m depth
S6	Direct foundations of structures with an admissible tension value of 100 kPa at 2.0m depth, mobilizing unequivocally plio-pleistocene formation.	If the recommended admissible tension is not compatible with the structure foundation needs it could be considered indirect foundation methodology such as piles and/or micro-piles / helicoidal piles with the bondage length in the N_{SPT}≥60 layers
S13; S14	Direct foundations of structures with an admissible tension value of 100 KPa at, mobilizing unequivocally plio-pleistocene formation.	The unequivocally mobilization of the carbonic formation top layers will allow to adopted admissible tension values of 220KPa
S15; S16	Direct foundations of structures with an admissible tension value of 180 to 200KPa at 1.50m depth, mobilizing unequivocally plio-pleistocene formation.	–
S10	Direct foundations of structures with an admissible tension value of 350 kPa at 3.60m depth, mobilizing unequivocally carbonic formation.	The difficulties in mobilize the top of the carbonic formation could set aside this solution; therefore, it could be considered indirect foundation methodology such as piles and/or micro-piles with the bondage length in the N_{SPT}≥60 layers
S11	Direct foundations of structures with an admissible tension value of 200 kPa at 2.20m depth, mobilizing unequivocally plio-pleistocene formation.	–
S12	Direct foundations of structures with an admissible tension value of 100 kPa mobilizing unequivocally plio-pleistocene formation.	If the recommended admissible tension is not compatible with the structure foundation needs it could be considered indirect foundation methodology such as piles and/or micro-piles with the bondage length in the N_{SPT}≥60 layers.

When a direct foundation could be applied, and depending of the depth, the water level could be encountered. This situation could offer some difficult to maintain the hauls open, therefore it's recommended to install some containment structures and water pumps that should be compatible with the permeabilities detected on job site.

For the structures foundation design, the following characteristic geotechnical parameters are proposed, extrapolated from the N_{SPT} values (taking into account the respective representation), considering the correlations suggested in the literature, namely Terzaghi-Peck and Osaki, also pondering the geological nature of the materials and laboratory tests results, as well. Were also conveniently seconded by Geocontrole experience accumulated over 4 decades, in several studies and geotechnical works developed in correlated geotechnical conditions, including in Sines area.

Table 5.2 - Soil Geotechnical Parameters

	Lithological Unit	N_{SPT}	Unit Weight γ (kN/m³)	Internal Friction angle ϕ'	Cohesion C' (kPa)	Static Deformation Module - E' (MPa)
LF	Landfills – silty sands	8 – 19	18	21 – 23	--	5
PQ	Somewhat silty sands	9 – 56	19 – 20	26 – 30	0 – 3	5 – 35
	Somewhat silty sands, with gravel	30	20	30	0 – 3	25
H_{MI}	Silty clayey residual soils – Completely weathered Schist	14 – 43	20	25 – 27	5 – 10	10 – 35
		60	21	28	15	50

Environmental aggressiveness to structural elements

Table 5.3 - Environmental Exposition Class

Aggressive elements	XA1	XA2	XA3
SO_4^-	200 – 600	600 – 3000	3000 – 6000
CO^2	15 – 40	40 – 100	> 100
PH	6.5 – 5.5	5.5 - 4.5	4.5 - 4.0
NH_4^+	15 – 30	30 – 60	60 – 100
Mg^{++}	300 – 1000	1000 – 3000	> 3000

From laboratory tests results it could be concluded that local water in Sines refinery is included in environmental exposition class XA1 mostly because pH value. The sample obtained form borehole S12 is included on environmental exposition class XA3 because the CO_2 aggressiveness, that is 75mg/dm^3.

Regarding the future road pavements, and in the presence of landfill soils, a replacement should be promoted (over excavation), mostly to remove the top layer of organic soils (even in the landfills), and the top layers that are very loose, for sure, and without any bearing capacity. This replacement shouldn't be less than 0.60m. If some excavation works are predicted, namely for the Nest Data Center internal roads, it should be verified if the referred thickness is removed. To the top layers, more demanding, (pavement structure), that will support the future pavements should be applied soils with the following characteristics:

- Fine soils percentage (<0.074mm) <25%
- Particle maximum dimensions 50 mm
- Plasticity Index NP
- CBR Index > 20%

These types of soils should be of granular nature, with an extensive sieving, equivalent to the S4 class (CE_IEP, 1998). All eventual earthworks should be properly compacted and controlled with dedicated equipment's and technicians.

Bobadela, October 2021

Geocontrole, Geotecnia e Estruturas de Fundação, S.A.

TECHNICAL DEPARTMENT:

CONSULTING AND GEOTECHNICAL PROSPECTION SECTOR

Assinado por : **LUÍS FILIPE FREIRE DE SOUSA**
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Data: 2021.11.03 09:29:39+00'00'

CHAVE MÓVEL

Luís Sousa
(Geological Eng.)

António Flor
(Civil Eng. – Technical Director)

Joaquim Beiró
(Management)

ANNEX I - GEOTECHNICAL PROSPECTION

Geotechnical Boreholes: S1 to S16;
Cone Penetration Tests: CPTu1 to CPTu8;
Trial Pits: PC1 to PC8;
Electric Resistivity Profiles: PR1 to PR8;

Geocontrole

GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

BOREHOLE **S1**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)
9/9/2021	Geo-004 Mobile Drill B47 HD	9.07

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
10/9/2021	Dry	90°	PT-TM06 (ETRS89)	M= -59989.807	P= -192168.740	Z= 17.99	Vasco	Luis Sousa

DEPTH (m)	DRILLING Ø	CORE RUN	STRATIGRAPHY	SYMBOLOGY	MATERIAL DESCRIPTION	WEATHERING (ISRM) W5 W4 W3 W2	FRACTURING (ISRM) F5 F4 F3 F2	% RECOVERY / % R.Q.D. 20 40 60 80	S.P.T. nº Blows (Nspt) 10 20 30 40 50	TESTS	DEPTH (m)
0			OS		Brown, ORGANIC sandy soils with vegetables remains.						0
1											1
2	200mm Auger		PQ		Medium dense, brown, somewhat orangish, fine to medium grain size silty SAND.				3 12 (30 cm)		2
3									5 27 (30 cm)		3
4											4
5					Hard, grey, foliated silty clay residual soils. Completely weathered SCHIST. Remaining rock fragments occurs.				9 30 (30 cm)		5
6			HMI						10 60 (26 cm)		6
7											7
8					As above, stiff.				16 60 (19 cm)		8
9						W5			60 (7 cm)		9
10					9.07m- End of Borehole						10

Remarks : **It was installed open circuit hidraulic piezometer (Ø=50mm), with 9.0m lenght.**

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

BOREHOLE **S2**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)
13/9/2021	Geo-004 Mobile Drill B47 HD	9.08

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
13/9/2021	7.50m	90°	PT-TM06 (ETRS89)	M= -59874.213	P= -192214.813	Z= 18.99	Vasco	Luis Sousa

DEPTH (m)	DRILLING Ø	CORE RUN	STRATIGRAPHY	SYMBOLOGY	MATERIAL DESCRIPTION	WEATHERING (ISRM) W5 W4 W3 W2	FRACTURING (ISRM) F5 F4 F3 F2	% RECOVERY / % R.Q.D. 20 40 60 80	S.P.T. n° Blows (Nspt) 1st Phase (15cm) 2nd Phase (30cm) 10 20 30 40 50	TESTS	DEPTH (m)
1	200mm Auger		RECENT		Loose, yellowish silty sand LANDFILLS. On the top occurs with organic component.				4 9 (30 cm)		1
2											2
3			PQ		Dense, reddish, fine to medium grain size silty SAND.				4 39 (30 cm)		3
4											4
5			HMI		Stiff, brownish grey, foliated silty clay residual soils. Completely weathered SCHIST. Remaining rock fragments occurs.				38 60 (10 cm)		5
6									45 60 (7 cm)		6
7											7
8									60 (9 cm)		8
9						W5			60 (8 cm)		9
10					9.08m- End of Borehole						10

Remarks :

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

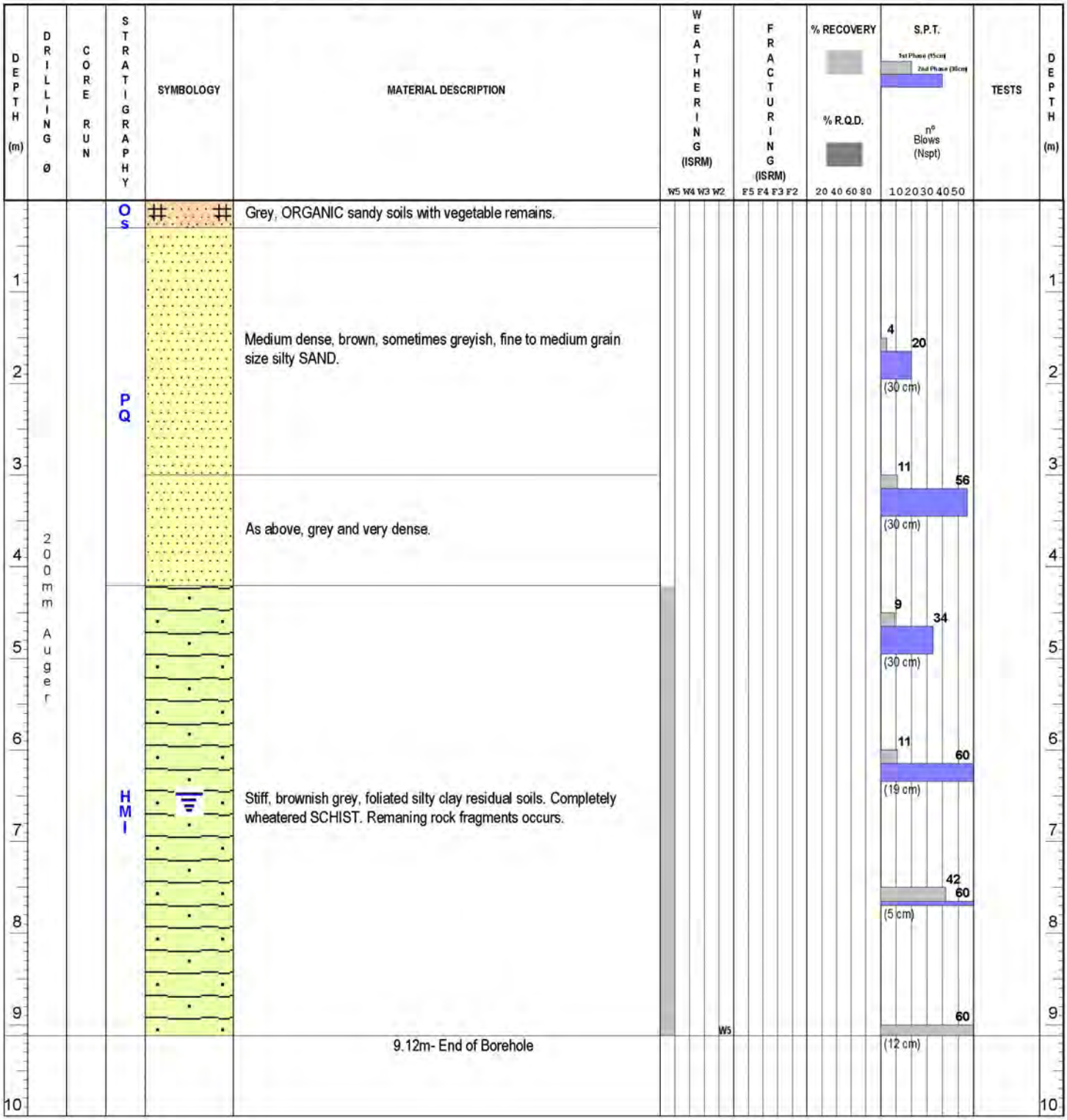
BOREHOLE **S3**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)
14/9/2021	Geo-004 Mobile Drill B47 HD	9.12

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
14/9/2021	6.40m	90°	PT-TM06 (ETRS89)	M= -59821.252	P= -192213.031	Z= 21.06	Vasco	Luis Sousa



Remarks : **It was installed open circuit hidraulic piezometer (Ø=50mm), with 9.0m lenght.**

Rua D. Nuno Alvares Pereira, nº 4, Parque Oriente Bloco 4 2699-501 Bobadela LRS Portugal Tel.: (+351) 219958000 Fax: (+351) 219958001 Móvel: (+351) 963035577 E-mail: mail@geocontrole.pt

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

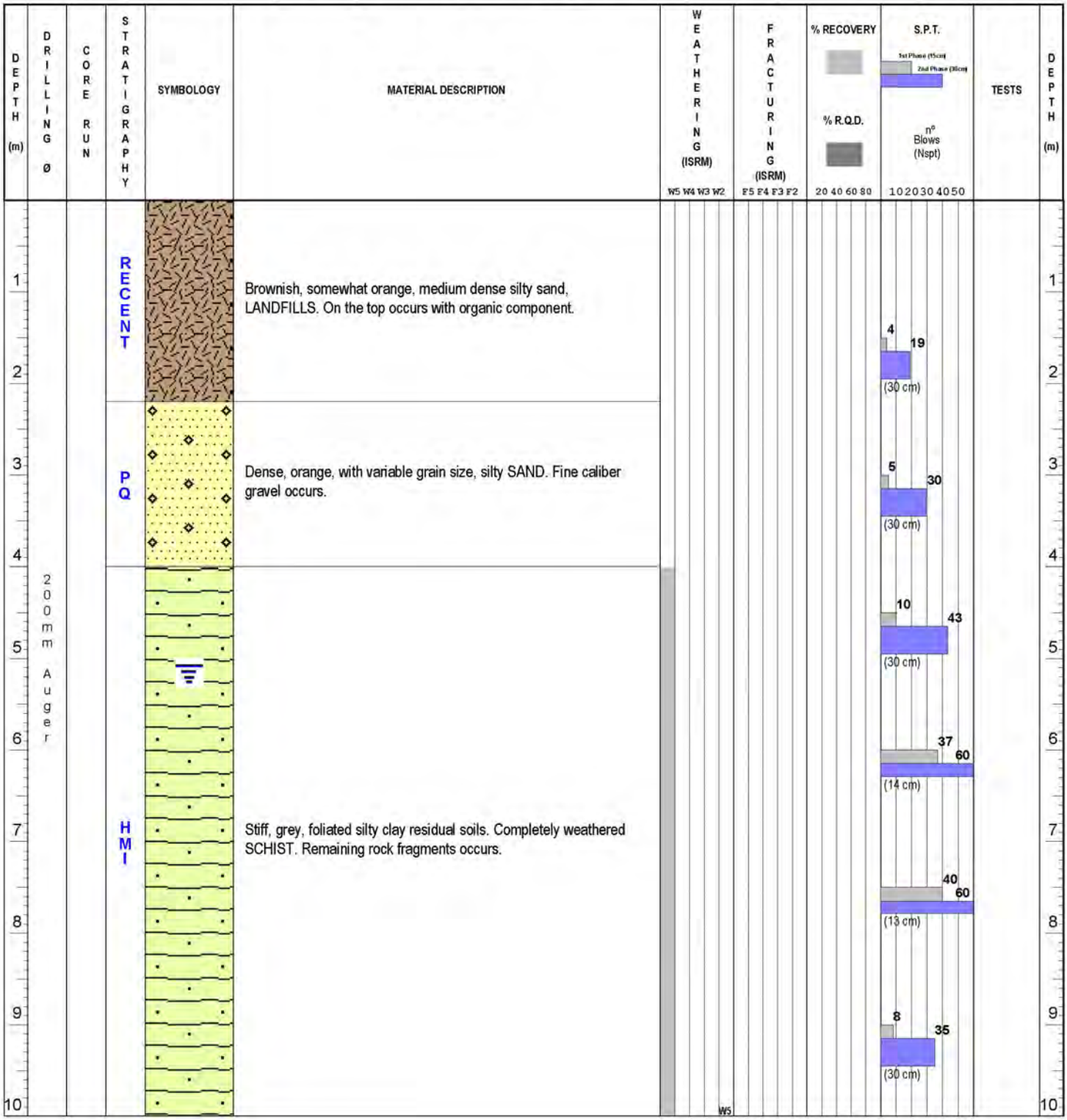
BOREHOLE **S4**

Job Number **37321**

Page **1 of 2**

Initial Date	Drill Rig	Final Depth (m)
21/9/2021	Geo-004 Mobile Drill B47 HD	13.75

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
21/9/2021	5.00m	90°	PT-TM06 (ETRS89)	M= -59764.970	P= -192246.920	Z= 19.30	Vasco	Luis Sousa



Remarks :

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

BOREHOLE **S4**

Job Number **37321**

Page **2 of 2**

Initial Date	Drill Rig	Final Depth (m)
21/9/2021	Geo-004 Mobile Drill B47 HD	13.75

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
21/9/2021	5.00m	90°	PT-TM06 (ETRS89)	M= -59764.970	P= -192246.920	Z= 19.30	Vasco	Luis Sousa

DEPTH (m)	DRILLING Ø	CORE RUN	STRATIGRAPHY	SYMBOLOGY	MATERIAL DESCRIPTION	WEATHERING (ISRM) W5 W4 W3 W2	FRACTURING (ISRM) F5 F4 F3 F2	% RECOVERY / % R.Q.D. 20 40 60 80	S.P.T. n° Blows (Nspt) 10 20 30 40 50	TESTS	DEPTH (m)
11	200mm Auger		HMI		Stiff, grey, foliated silty clay residual soils. Completely weathered SCHIST. Remaining rock fragments occurs.				20 / 60 (14 cm)		11
12									34 / 60 (12 cm)		12
13						W5			37 / 60 (10 cm)		13
14					13.75m- End of Borehole						14
15											15
16											16
17											17
18											18
19											19
20											20

Remarks :

Rua D. Nuno Alvares Pereira, nº 4, Parque Oriente Bloco 4 2699-501 Bobadela LRS Portugal Tel.: (+351) 219958000 Fax: (+351) 219958001 Móvel: (+351) 963035577 E-mail: mail@geocontrole.pt

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

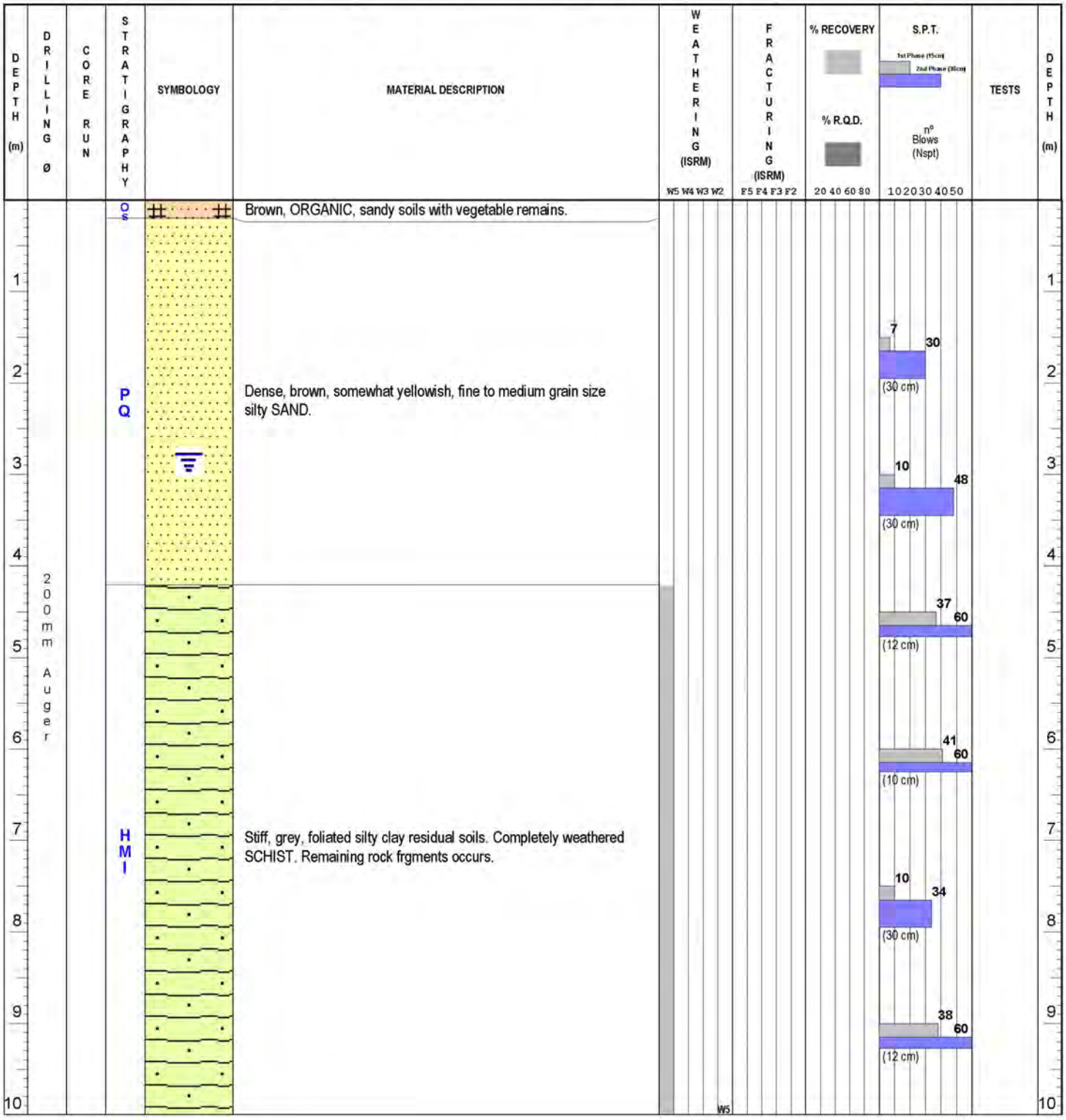
BOREHOLE **S5**

Job Number **37321**

Page **1 of 2**

Initial Date	Drill Rig	Final Depth (m)
20/9/2021	Geo-004 Mobile Drill B47 HD	12.08

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
20/9/2021	2.70m	90°	PT-TM06 (ETRS89)	M= -59703.590	P= -192285.130	Z= 20.25	Vasco	Luis Sousa



Remarks : **It was installed open circuit hidraulic piezometer (Ø=50mm), with 12.0m lenght.**

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

BOREHOLE **S5**

Job Number **37321**

Page **2 of 2**

Initial Date	Drill Rig	Final Depth (m)
20/9/2021	Geo-004 Mobile Drill B47 HD	12.08

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
20/9/2021	2.70m	90°	PT-TM06 (ETRS89)	M= -59703.590	P= -192285.130	Z= 20.25	Vasco	Luis Sousa

DEPTH (m)	DRILLING Ø	CORE RUN	STRATIGRAPHY	SYMBOLOGY	MATERIAL DESCRIPTION	WEATHERING (ISRM) W5 W4 W3 W2	FRACTURING (ISRM) F5 F4 F3 F2	% RECOVERY / % R.Q.D. 20 40 60 80	S.P.T. nº Blows (Nspt) 10 20 30 40 50	TESTS	DEPTH (m)
11	200mm Auger		HMI		Stiff, grey, foliated silty clay residual soils. Completely weathered SCHIST. Remaining rock frgments occurs.				60 (9 cm)		11
12						W5			60 (8 cm)		12
					12.08m- End of Borehole						
13											13
14											14
15											15
16											16
17											17
18											18
19											19
20											20

Remarks : **It was installed open circuit hidraulic piezometer (Ø=50mm), with 12.0m lenght.**

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

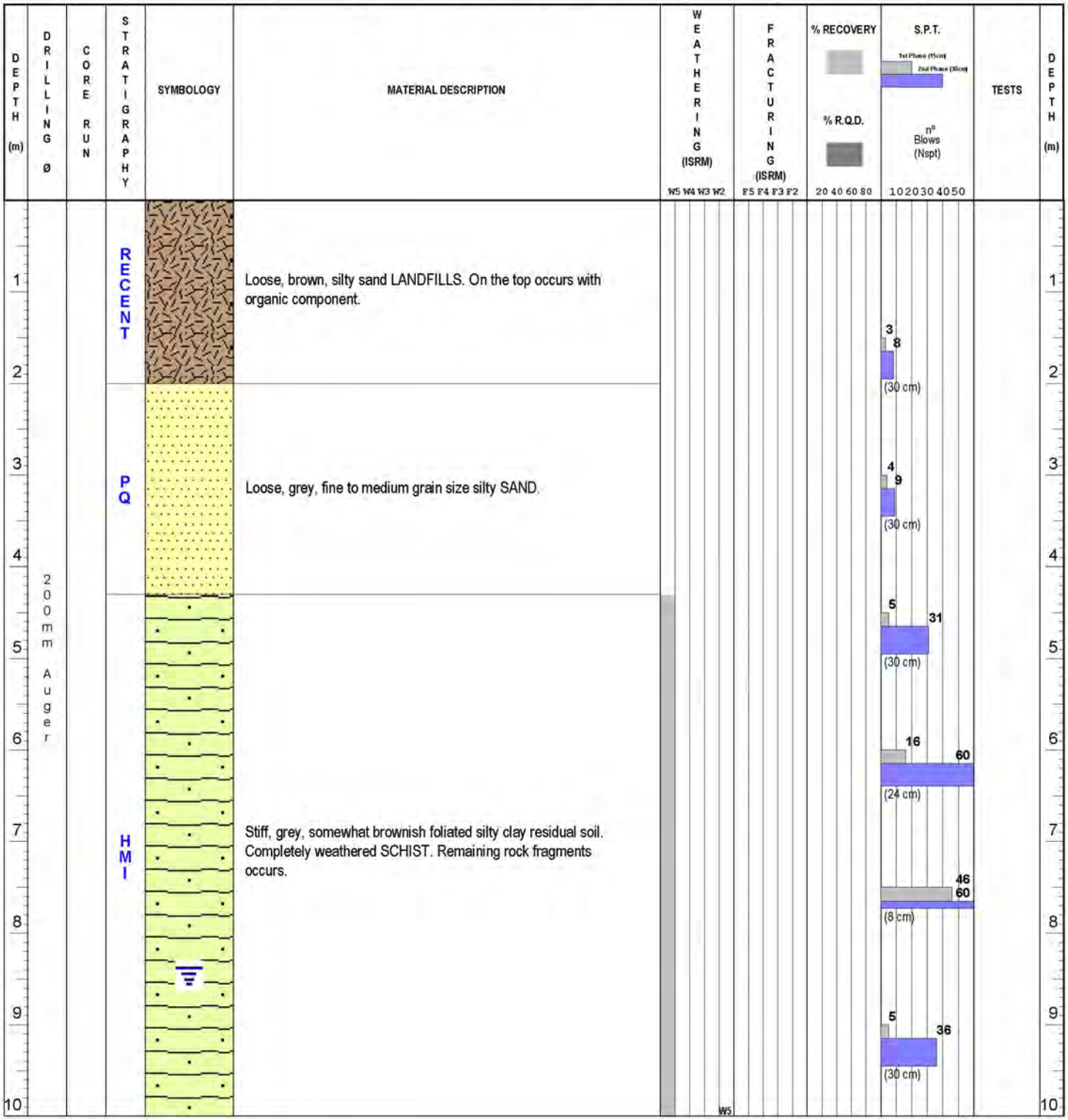
BOREHOLE **S6**

Job Number **37321**

Page **1 of 2**

Initial Date	Drill Rig	Final Depth (m)
10/9/2021	Geo-004 Mobile Drill B47 HD	13.61

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
10/9/2021	8.30m	90°	PT-TM06 (ETRS89)	M= -59900.360	P= -192144.126	Z= 19.23	Vasco	Luis Sousa



Remarks :

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

BOREHOLE **S6**

Job Number **37321**

Page **2 of 2**

Initial Date	Drill Rig	Final Depth (m)
10/9/2021	Geo-004 Mobile Drill B47 HD	13.61

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
10/9/2021	8.30m	90°	PT-TM06 (ETRS89)	M= -59900.360	P= -192144.126	Z= 19.23	Vasco	Luis Sousa

DEPTH (m)	DRILLING Ø	CORE RUN	STRATIGRAPHY	SYMBOLOGY	MATERIAL DESCRIPTION	WEATHERING (ISRM) W5 W4 W3 W2	FRACTURING (ISRM) F5 F4 F3 F2	% RECOVERY / % R.Q.D. 20 40 60 80	S.P.T. n° Blows (Nspt) 10 20 30 40 50	TESTS	DEPTH (m)
11	200mm Auger		HMI		Stiff, grey, somewhat brownish foliated silty clay residual soil. Completely weathered SCHIST. Remaining rock fragments occurs.				35 / 60 (9 cm)		11
12									60 (10 cm)		12
13						W5			60		13
14					13.61m- End of Borehole				(11 cm)		14
15											15
16											16
17											17
18											18
19											19
20											20

Remarks :

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

BOREHOLE **S7**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)	Final Date	Water Level	Dip	System	Coordinates	Elevation	Driller	Logged By
13/9/2021	Geo-004 Mobile Drill B47 HD	9.09	13/9/2021	Dry	90°	PT-TM06 (ETRS89)	M= -59790.308 P= -192166.127	Z= 21.73	Vasco	Luis Sousa

DEPTH (m)	DRILLING Ø	CORE RUN	STRATIGRAPHY	SYMBOLOGY	MATERIAL DESCRIPTION	WEATHERING (ISRM) W5 W4 W3 W2	FRACTURING (ISRM) F5 F4 F3 F2	% RECOVERY / % R.Q.D. 20 40 60 80	S.P.T. n° Blows (Nspt) 1st Phase (15cm) 2nd Phase (30cm) 10 20 30 40 50	TESTS	DEPTH (m)
1	200mm Auger		RECENT		Medium dense, greyish brown, sandy LANDFILLS. On the top occurs with organic component.				4 12 (30 cm)		1
2											2
3			PQ		Dense, greyish orange, fine to medium grain size silty SAND.				4 36 (30 cm)		3
4											4
5			HMI		Stiff, grey, foliated silty clay residual soils. Completely weathered SCHIST. Remaining rock fragments occurs.				14 53 (30 cm)		5
6									51 60 (5 cm)		6
7											7
8									60 0 (12 cm)		8
9						W5			60 (9 cm)		9
10					9.09m- End of Borehole						10

Remarks :

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

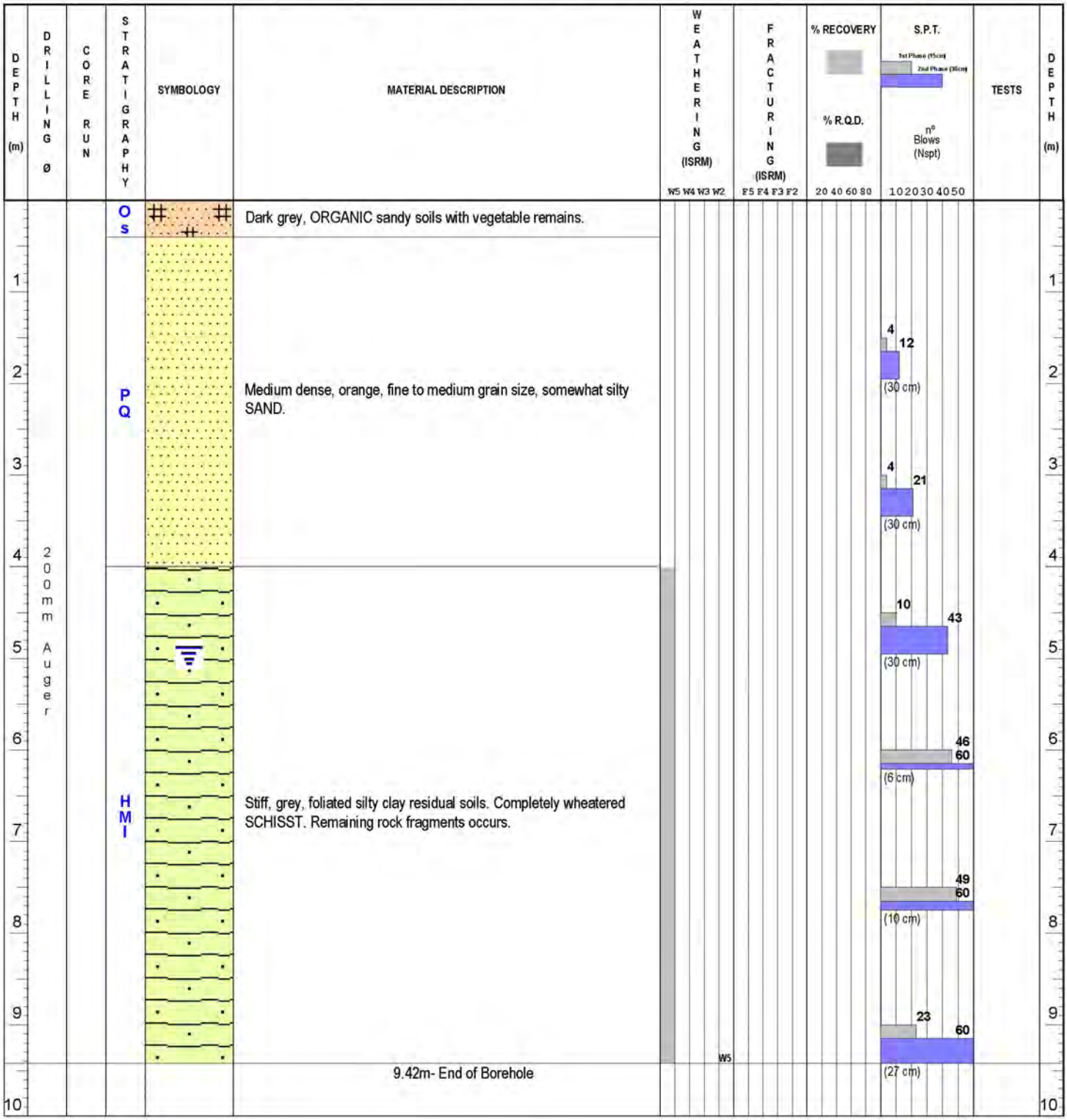
BOREHOLE **S8**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)
14/9/2021	Geo-004 Mobile Drill B47 HD	9.42

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
14/9/2021	4.80m	90°	PT-TM06 (ETRS89)	M= -59737.580	P= -192198.329	Z= 21.90	Vasco	Luis Sousa



Remarks :

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

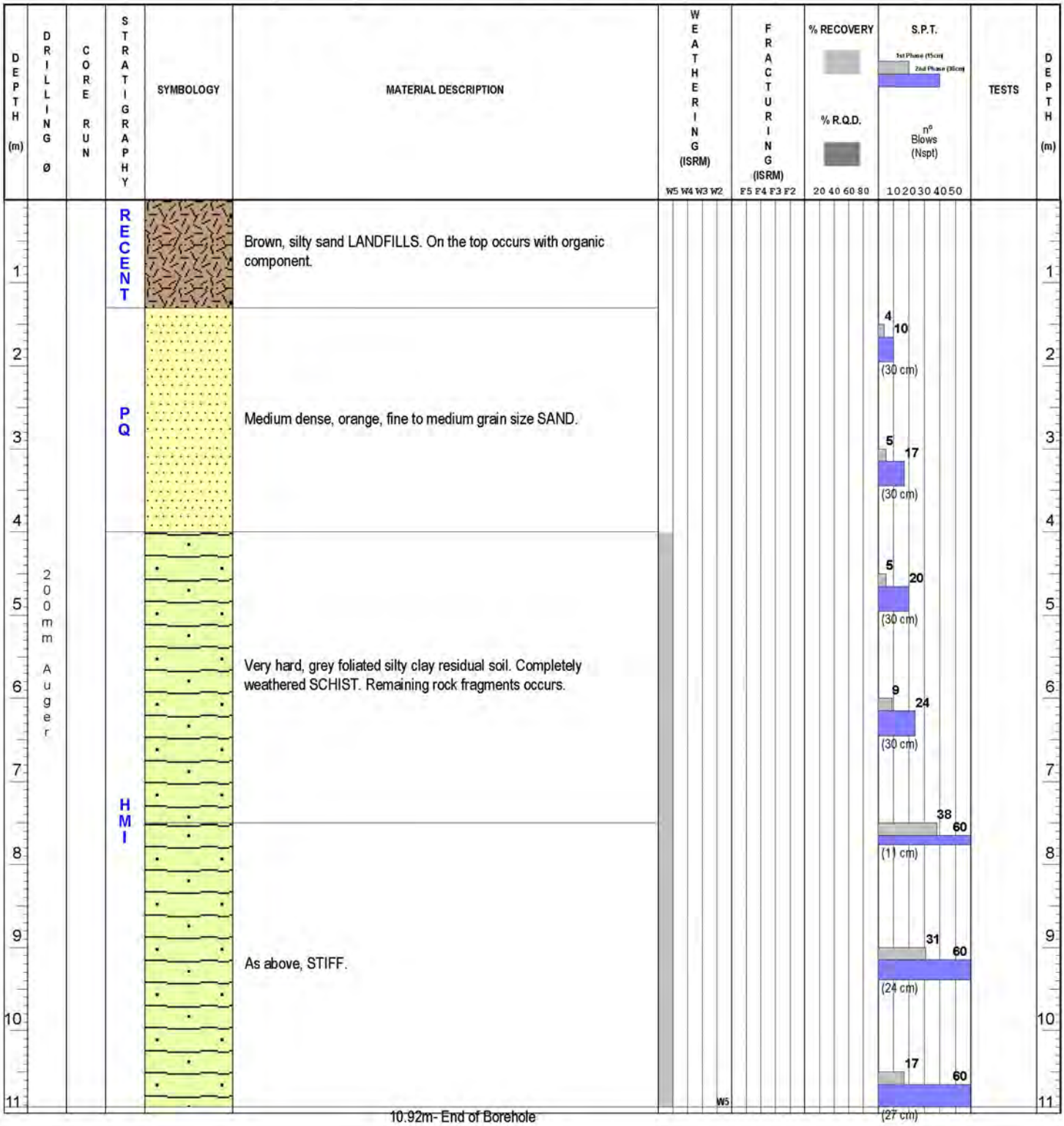
BOREHOLE **S9**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)
14/9/2021	Geo-004 Mobile Drill B47 HD	10.92

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
15/9/2021		90°	PT-TM06 (ETRS89)	M= -59673.389	P= -192235.369	Z= 22.69	Vasco	Luis Sousa



Remarks :

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Client : **Start Campus**

Job : **Nest Data Center Sines**

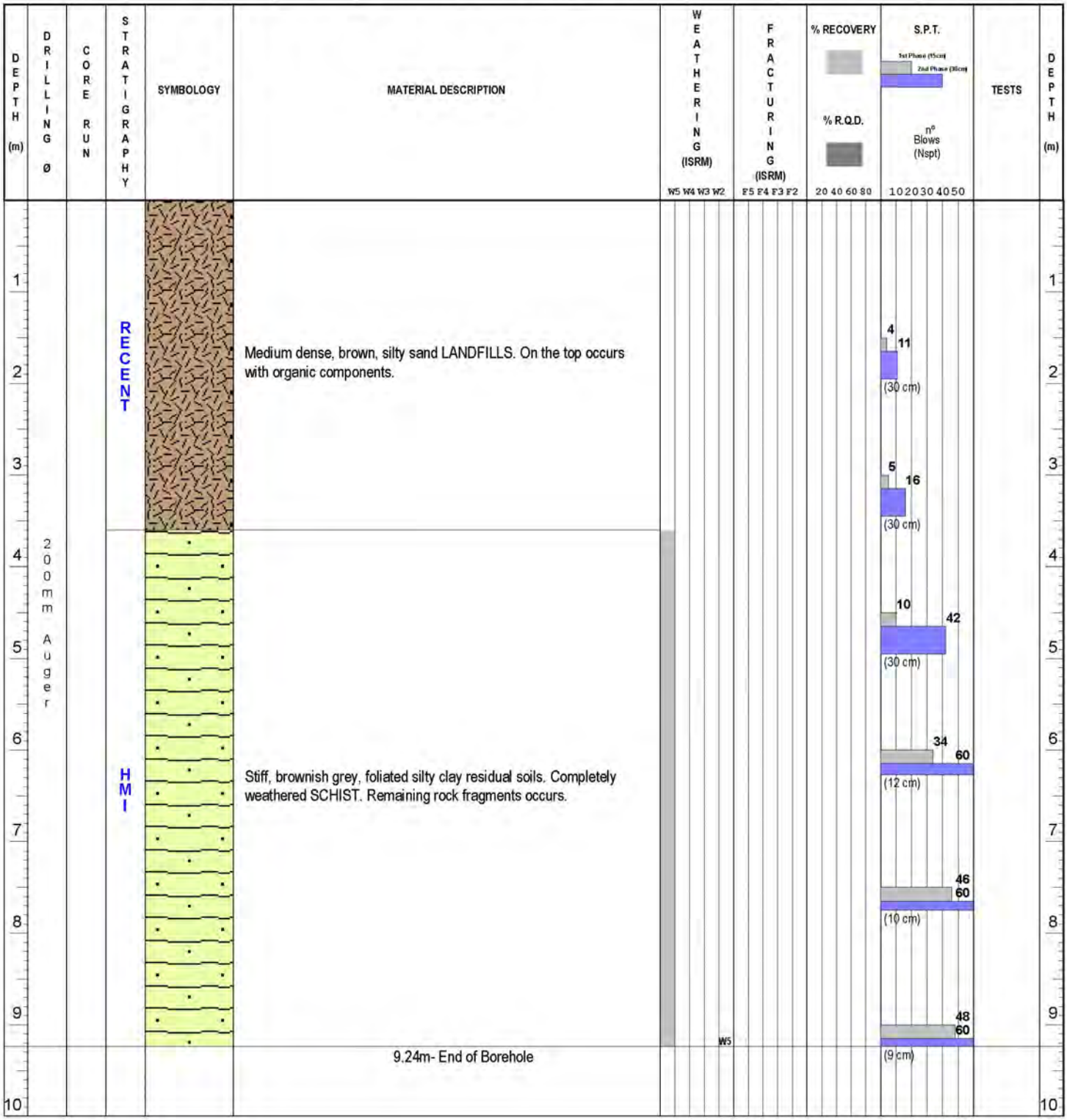
BOREHOLE **S10**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)
17/9/2021	Geo-004 Mobile Drill B47 HD	9.24

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
17/9/2021	Dry	90°	PT-TM06 (ETRS89)	M= -59748.963	P= -192112.044	Z= 22.93	Vasco	Luis Sousa



Remarks : **It was installed open circuit hidraulic piezometer (Ø=50mm), with 9.0m lenght.**

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

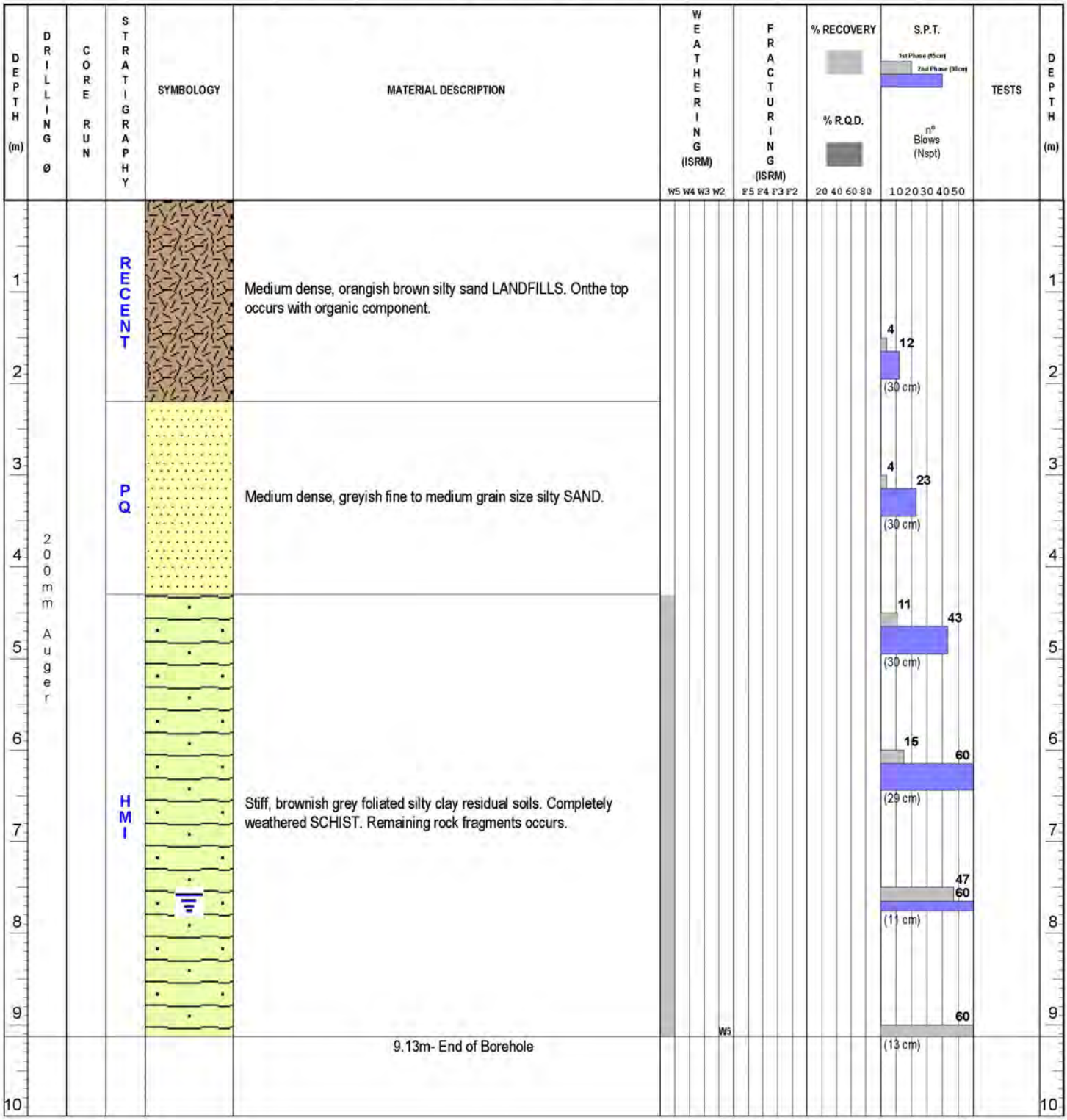
BOREHOLE **S11**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)
17/9/2021	Geo-004 Mobile Drill B47 HD	9.13

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
17/9/2021	7.50m	90°	PT-TM06 (ETRS89)	M= -59709.438	P= -192162.452	Z= 23.59	Vasco	Luis Sousa



Remarks :

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Job : **Nest Data Center Sines**

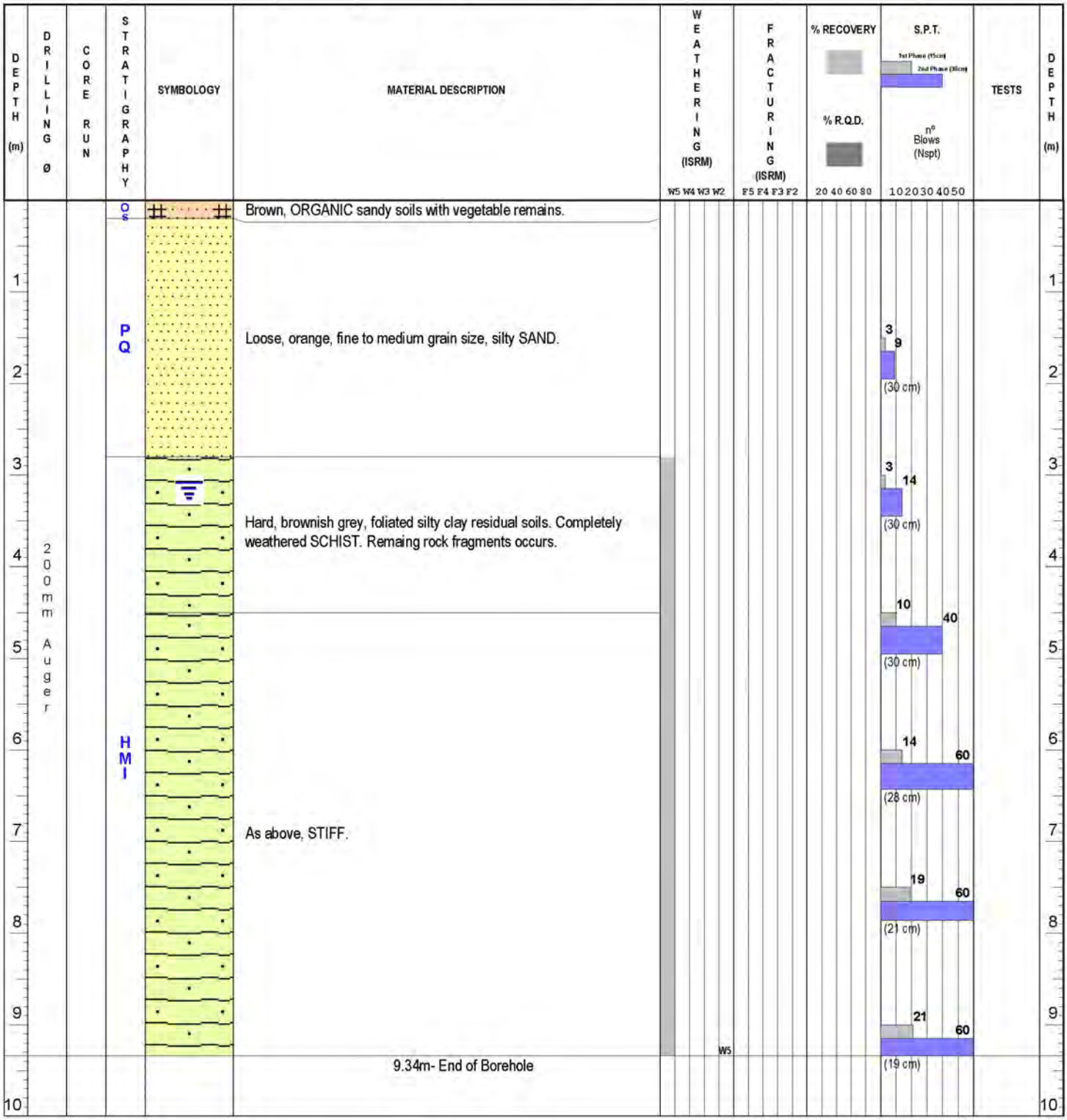
BOREHOLE **S12**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)
15/9/2021	Geo-004 Mobile Drill B47 HD	9.34

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
15/9/2021	3.00m	90°	PT-TM06 (ETRS89)	M= -59666.423	P= -192187.846	Z= 22.22	Vasco	Luis Sousa



Remarks : **It was installed open circuit hidraulic piezometer (Ø=50mm), with 9.0m lenght.**

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

BOREHOLE **S13**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)	Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
16/9/2021	Geo-004 Mobile Drill B47 HD	9.22	17/9/2021	2.50m	90°	PT-TM06 (ETRS89)	M= -59689.380	P= -192129.774	Z= 22.69	Vasco	Luis Sousa

DEPTH (m)	DRILLING Ø	CORE RUN	STRATIGRAPHY	SYMBOLOGY	MATERIAL DESCRIPTION	WEATHERING (ISRM) W5 W4 W3 W2	FRACTURING (ISRM) F5 F4 F3 F2	% RECOVERY / % R.Q.D. 20 40 60 80	S.P.T. nº Blows (Nspt) 1st Phase (15cm) 2nd Phase (30cm) 10 20 30 40 50	TESTS	DEPTH (m)
1–2	200mm Auger		RECENT		Medium dense, brownish silty sand LANDFILLS. Onthe top occurs with organic component.				3 10 (30 cm)		1–2
3–4			PQ		Loose, grey, with variable grain size, somewhat silty SAND.				2 9 (30 cm)		3–4
5–6			HMI		Very hard, brownish grey silty clay residual soils. Completely weathered SCHIST.				7 22 (30 cm)		5–6
6–7									31 60 (22 cm)		6–7
7–8					Stiff, grey, foliated silty clay residual soils. Completely weathered SCHIST. Remaining rock fragments occurs.				46 60 (11 cm)		7–8
8–9						W5			50 60 (7 cm)		8–9
9–10					9.22m- End of Borehole						9–10

Remarks :

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

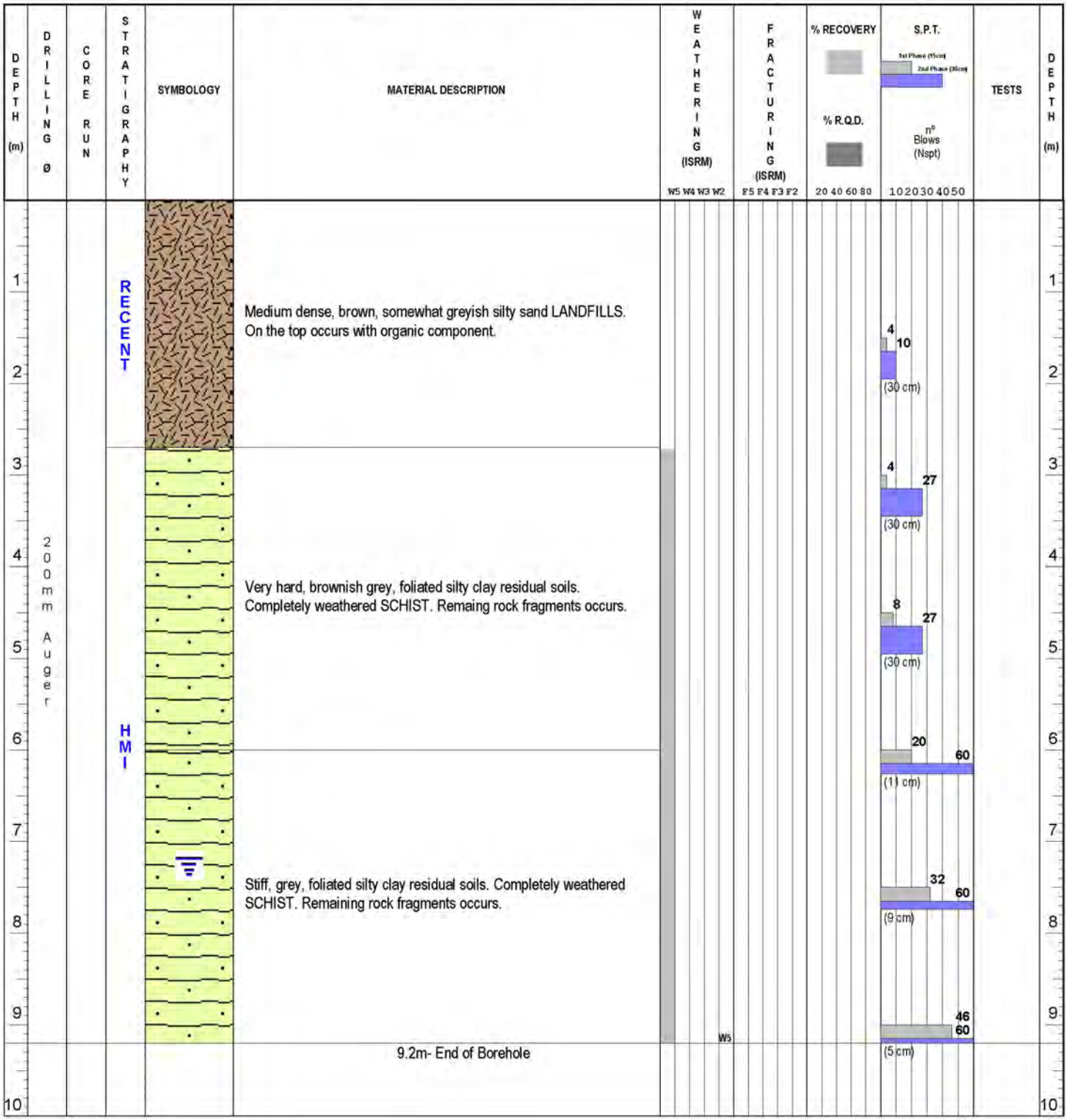
BOREHOLE **S14**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)
15/9/2021	Geo-004 Mobile Drill B47 HD	9.2

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
15/9/2021	7.10m	90°	PT-TM06 (ETRS89)	M= -59648.285	P= -192155.001	Z= 22.09	Vasco	Luis Sousa



Remarks :

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GEOTECHNICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

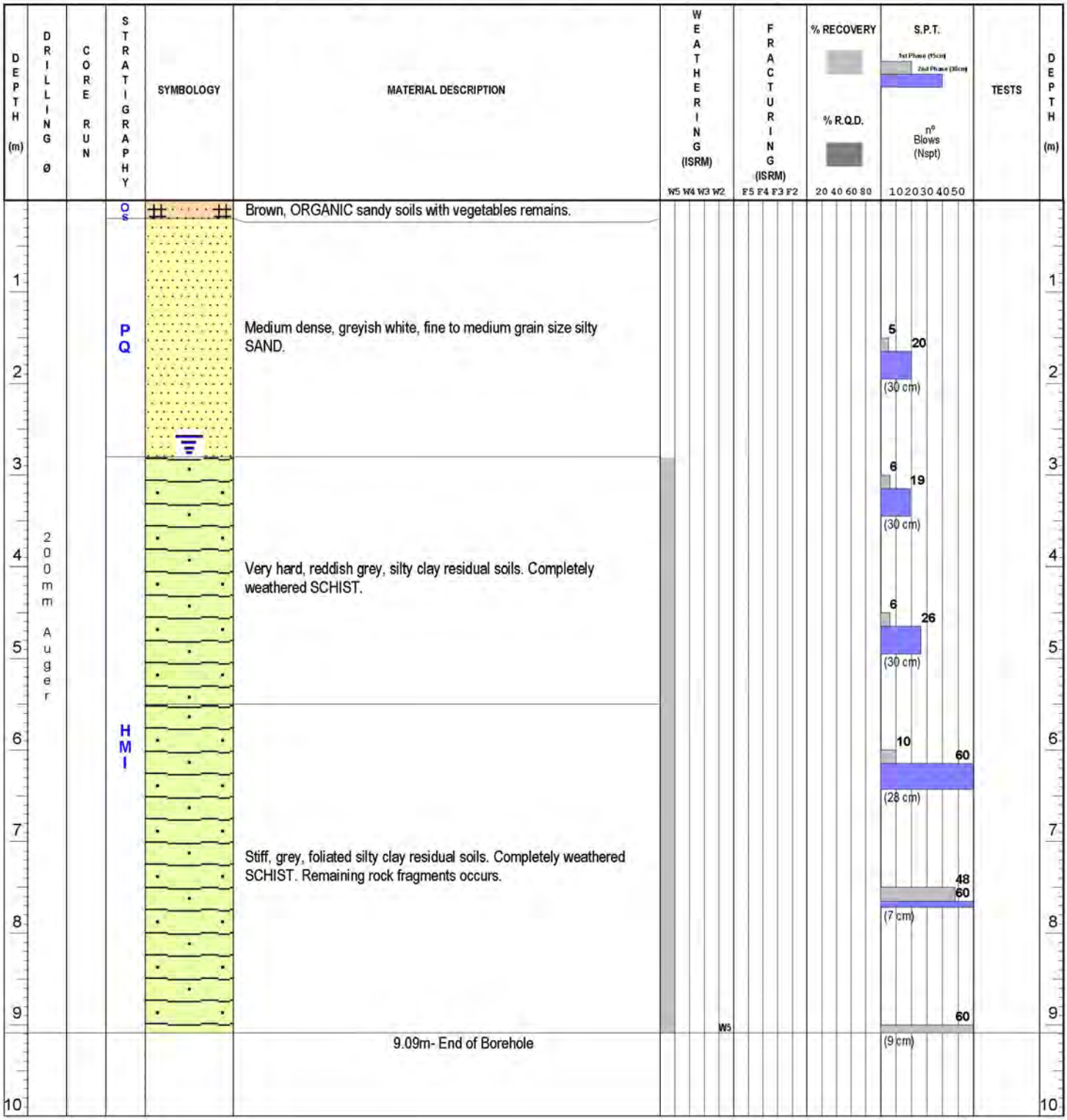
BOREHOLE **S15**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)
16/9/2021	Geo-004 Mobile Drill B47 HD	9.09

Final Date	Water Level	Dip	System	Coordinates		Elevation	Driller	Logged By
16/9/2021	2.50m	90°	PT-TM06 (ETRS89)	M= -59685.064	P= -192089.032	Z= 23.10	Vasco	Luis Sousa



Remarks :

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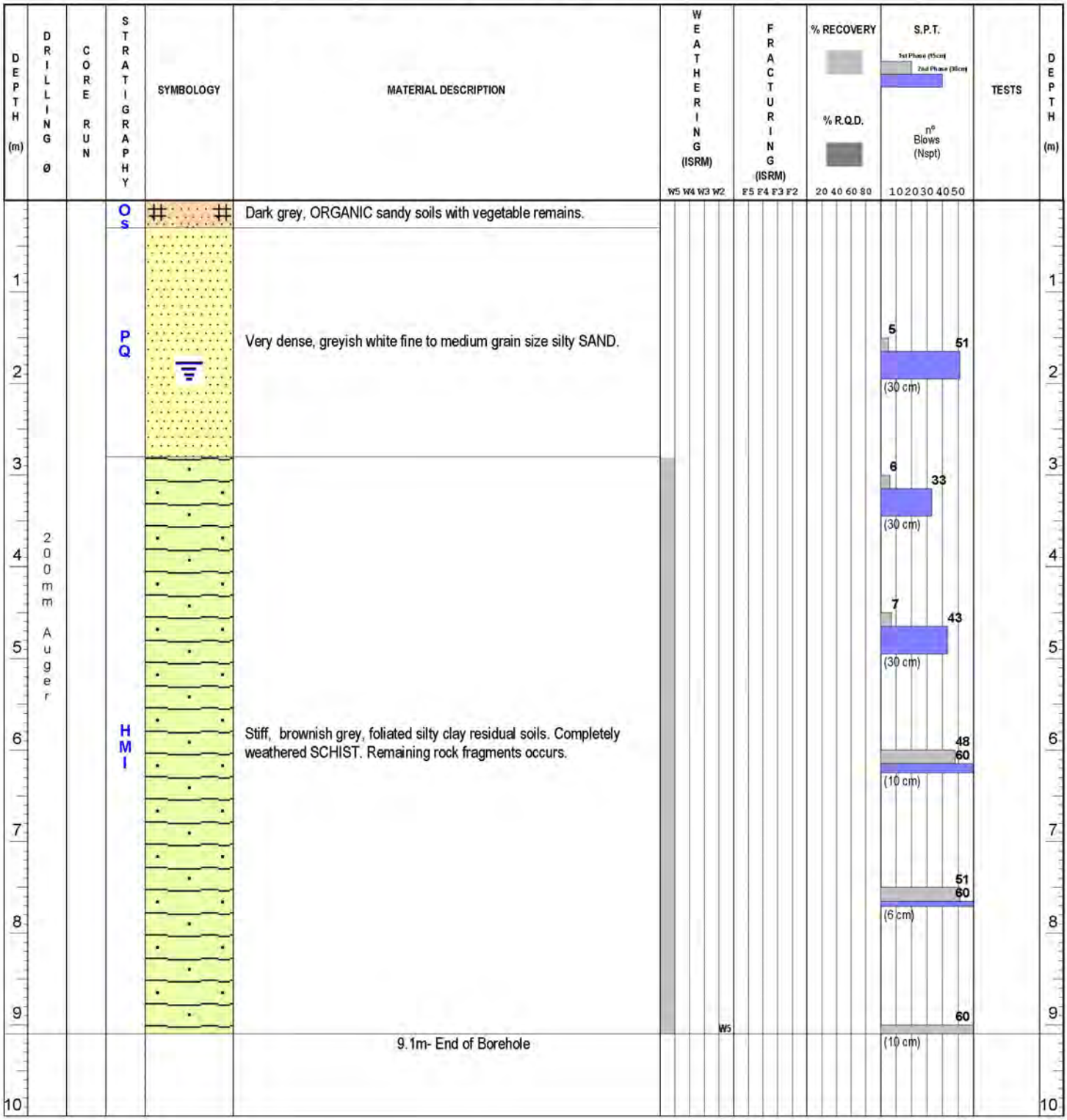
Job : **Nest Data Center Sines**

BOREHOLE **S16**

Job Number **37321**

Page **1 of 1**

Initial Date	Drill Rig	Final Depth (m)	Final Date	Water Level	Dip	System	Coordinates	Elevation	Driller	Logged By
16/9/2021	Geo-004 Mobile Drill B47 HD	9.1	16/9/2021	1.70m	90°	PT-TM06 (ETRS89)	M= -59639.026 P= -192113.060	Z= 22.49	Vasco	Luis Sousa



Remarks : **It was installed open circuit hidraulic piezometer (Ø=50mm), with 9.0m lenght.**

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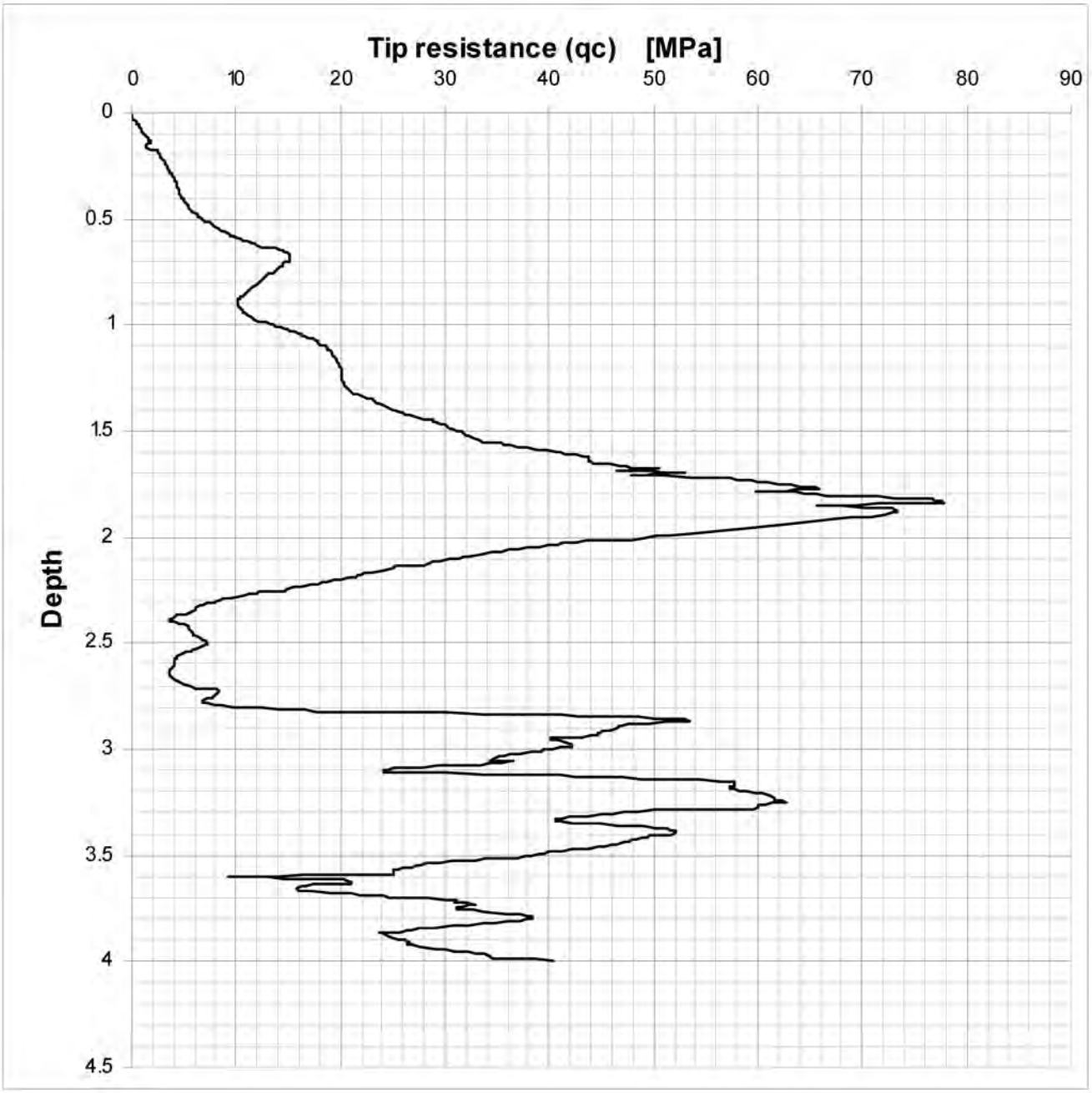
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Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portuga
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.p

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 1

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.98



Obs. :

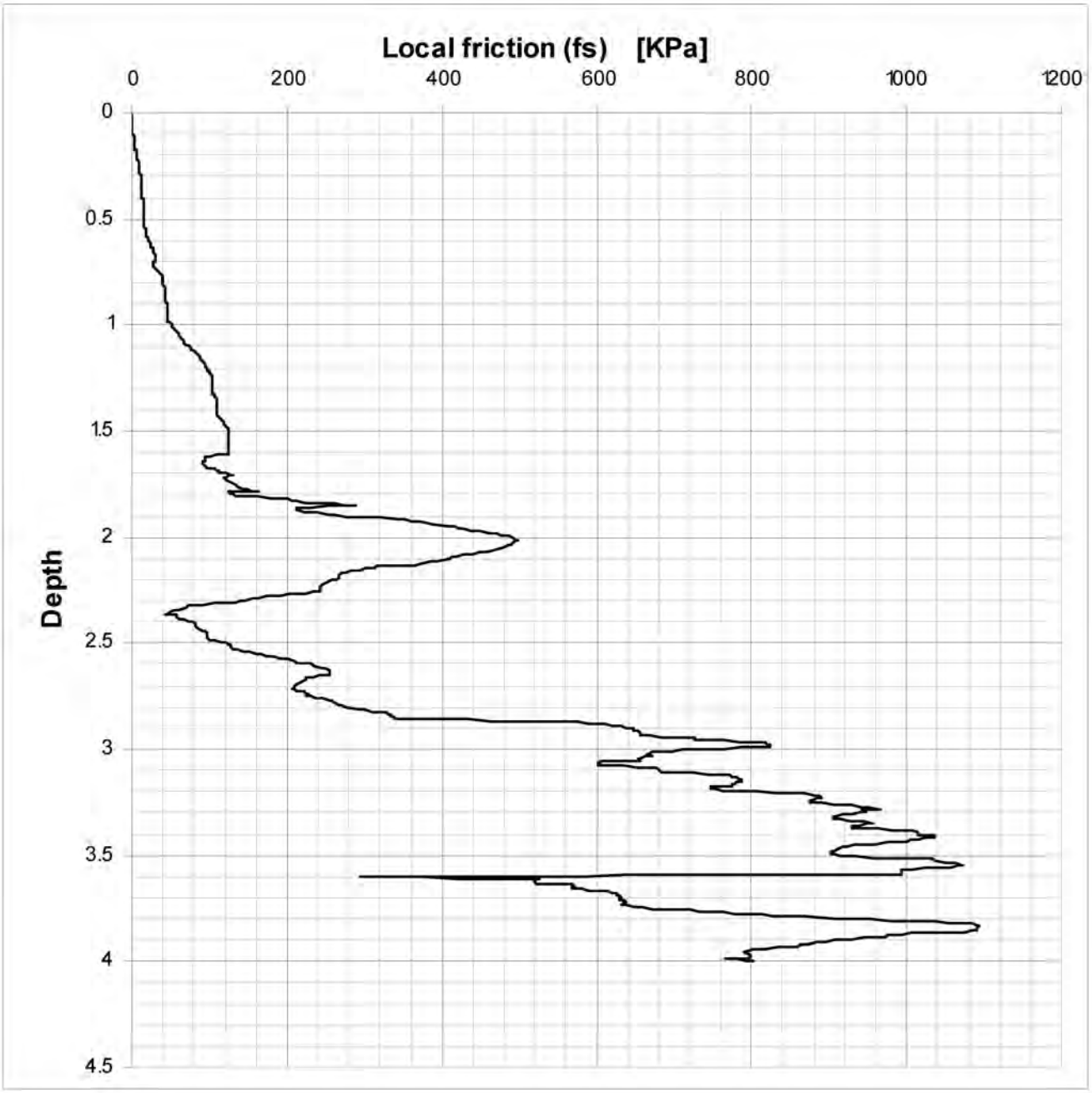
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 1

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.98



Obs. :

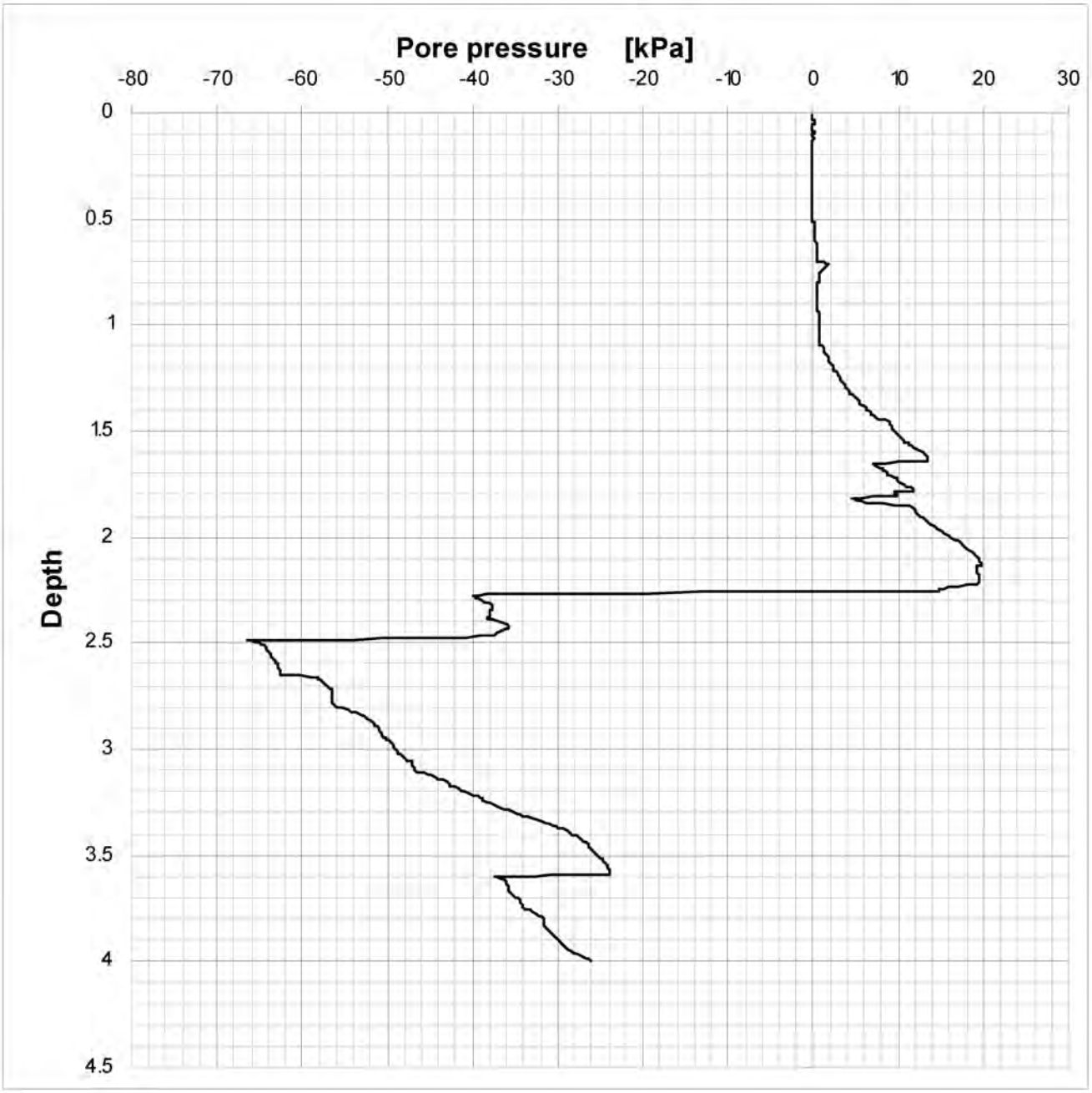
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 1

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.98



Obs. :

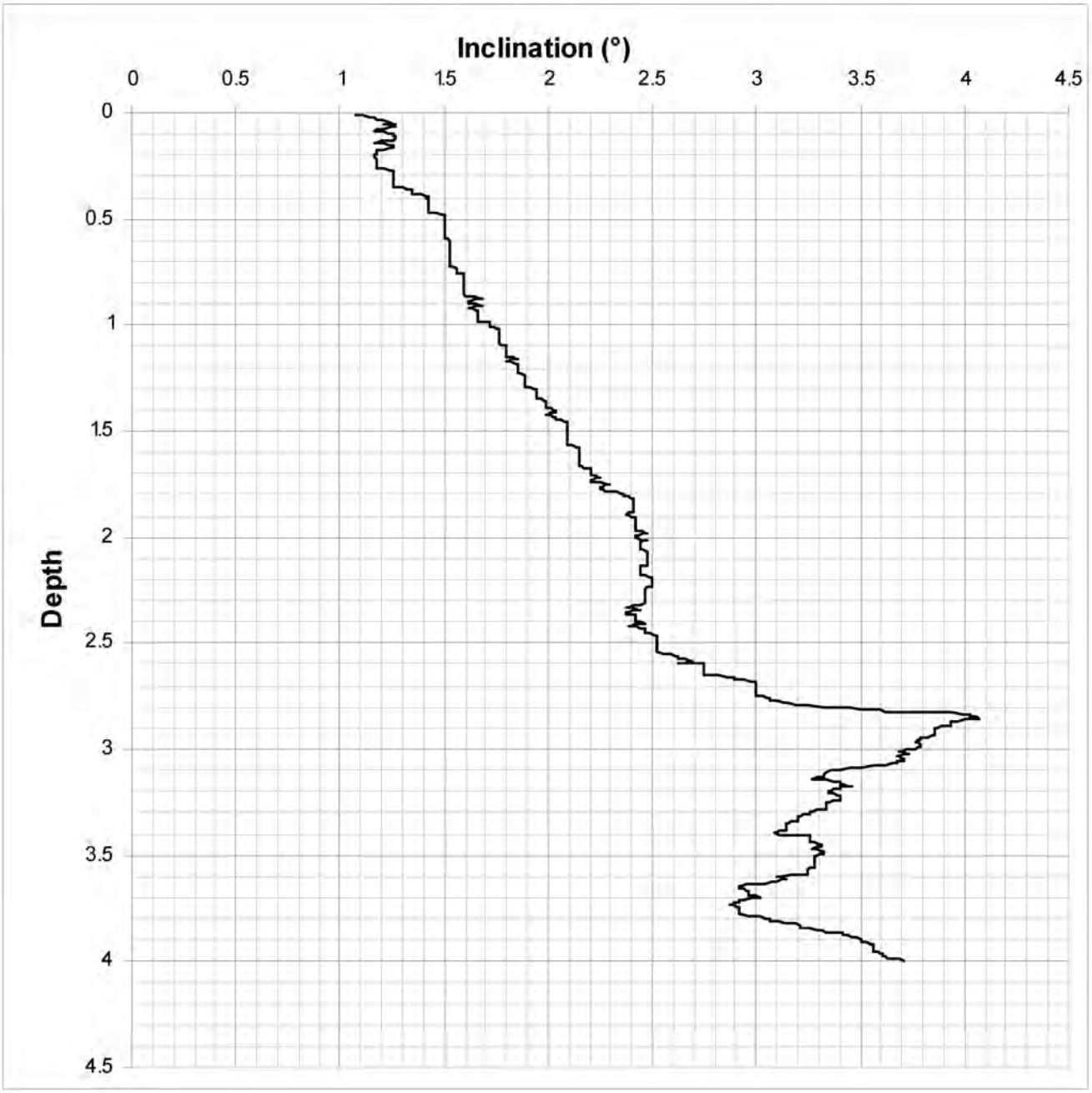
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 1

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.98



Obs. :

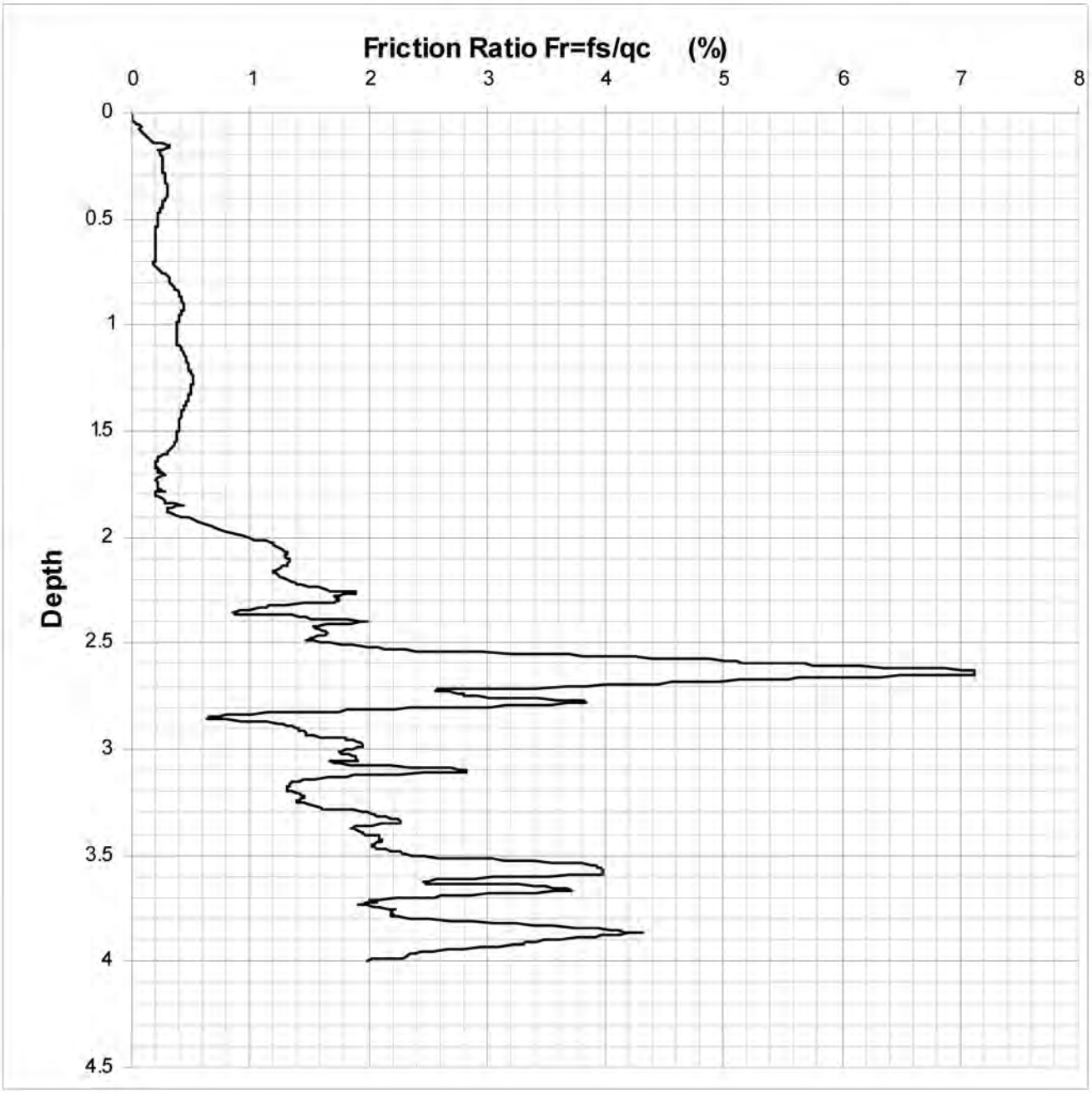
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 1

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.98



Obs. :

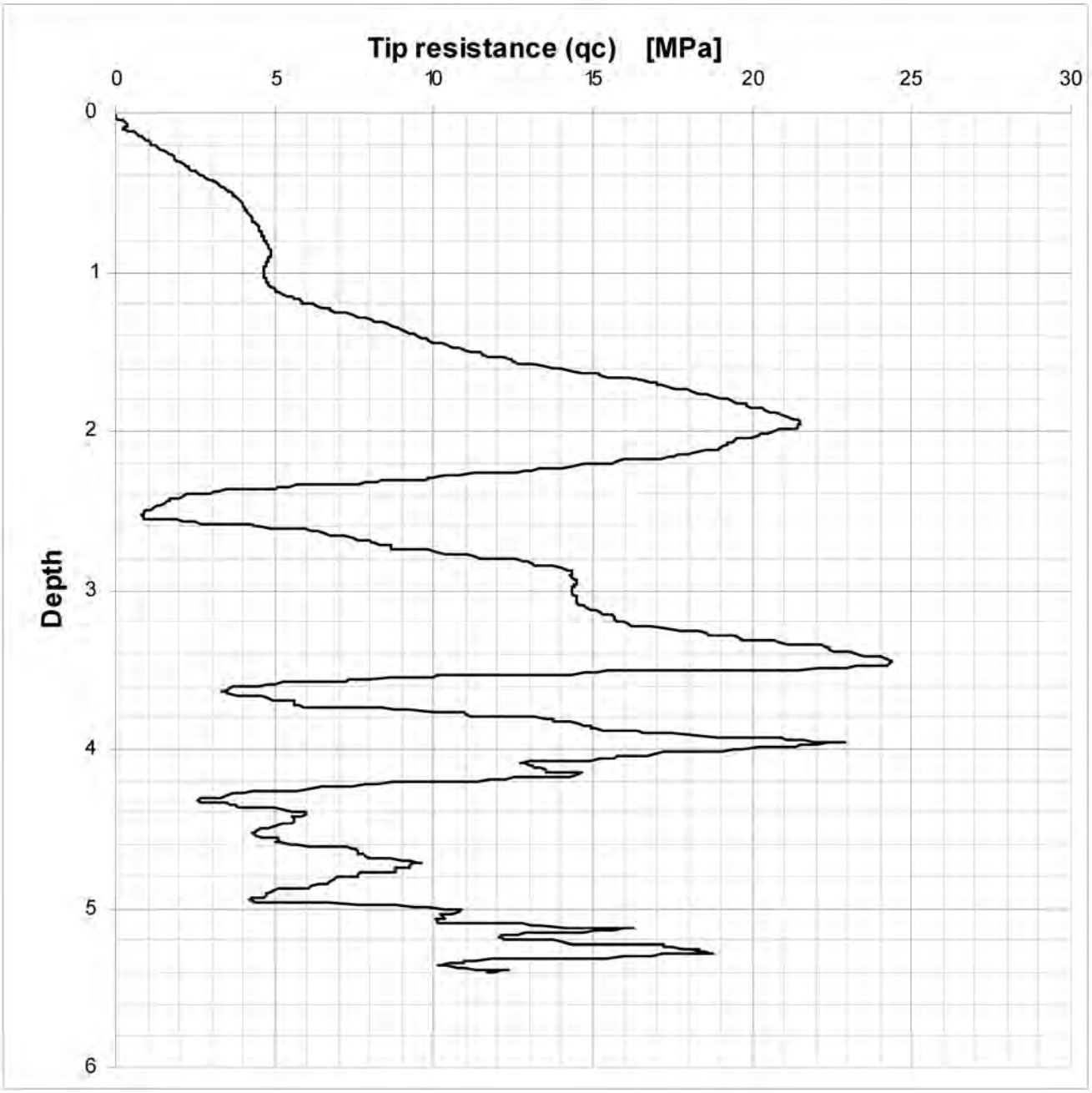
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portuga
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.p

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 2

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M e	P :	Z :	Water Level :	Depth 5.38



Obs. :

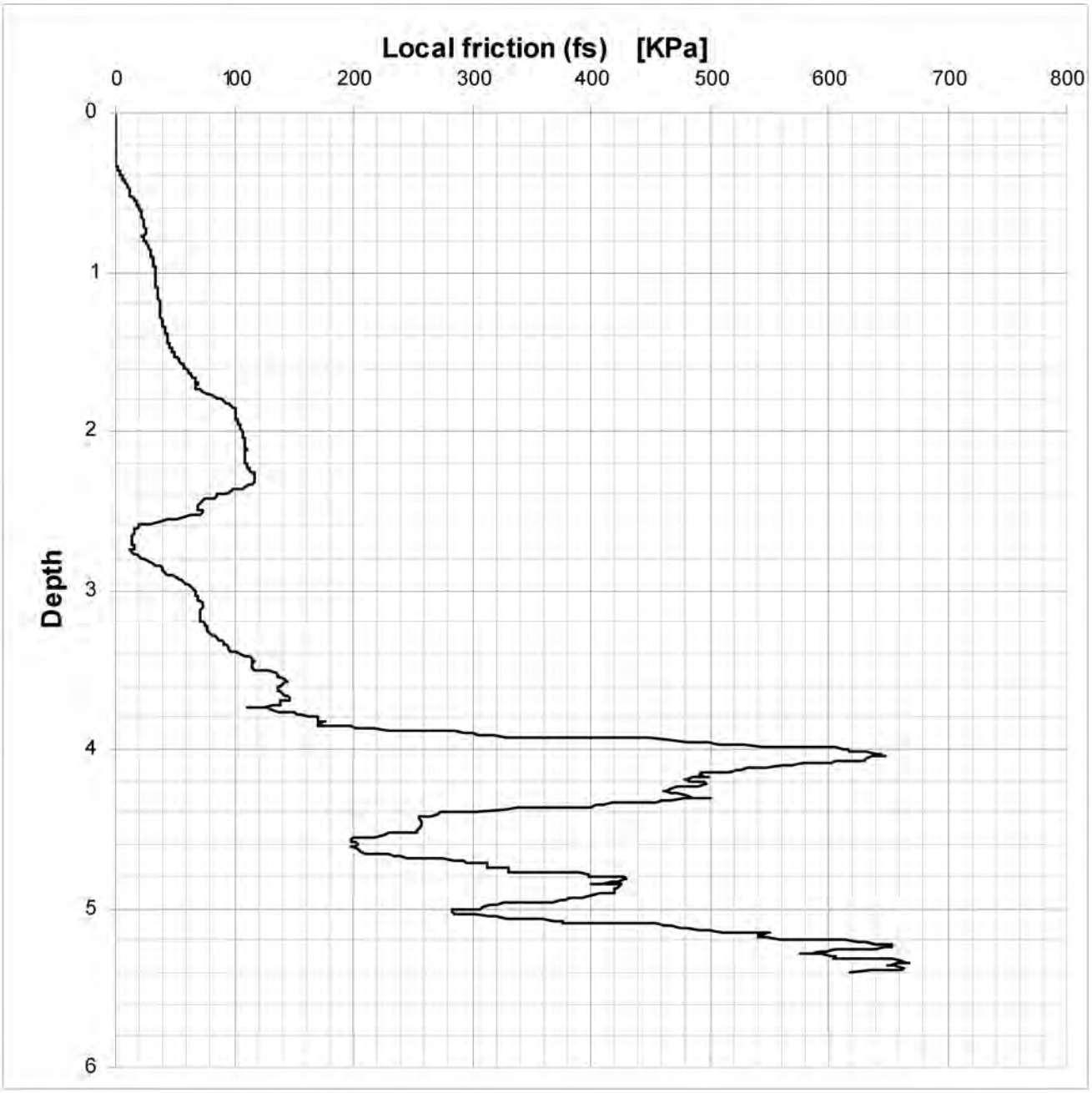
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 2

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M e	P :	Z :	Water Level :	Depth 5.38



Obs. :

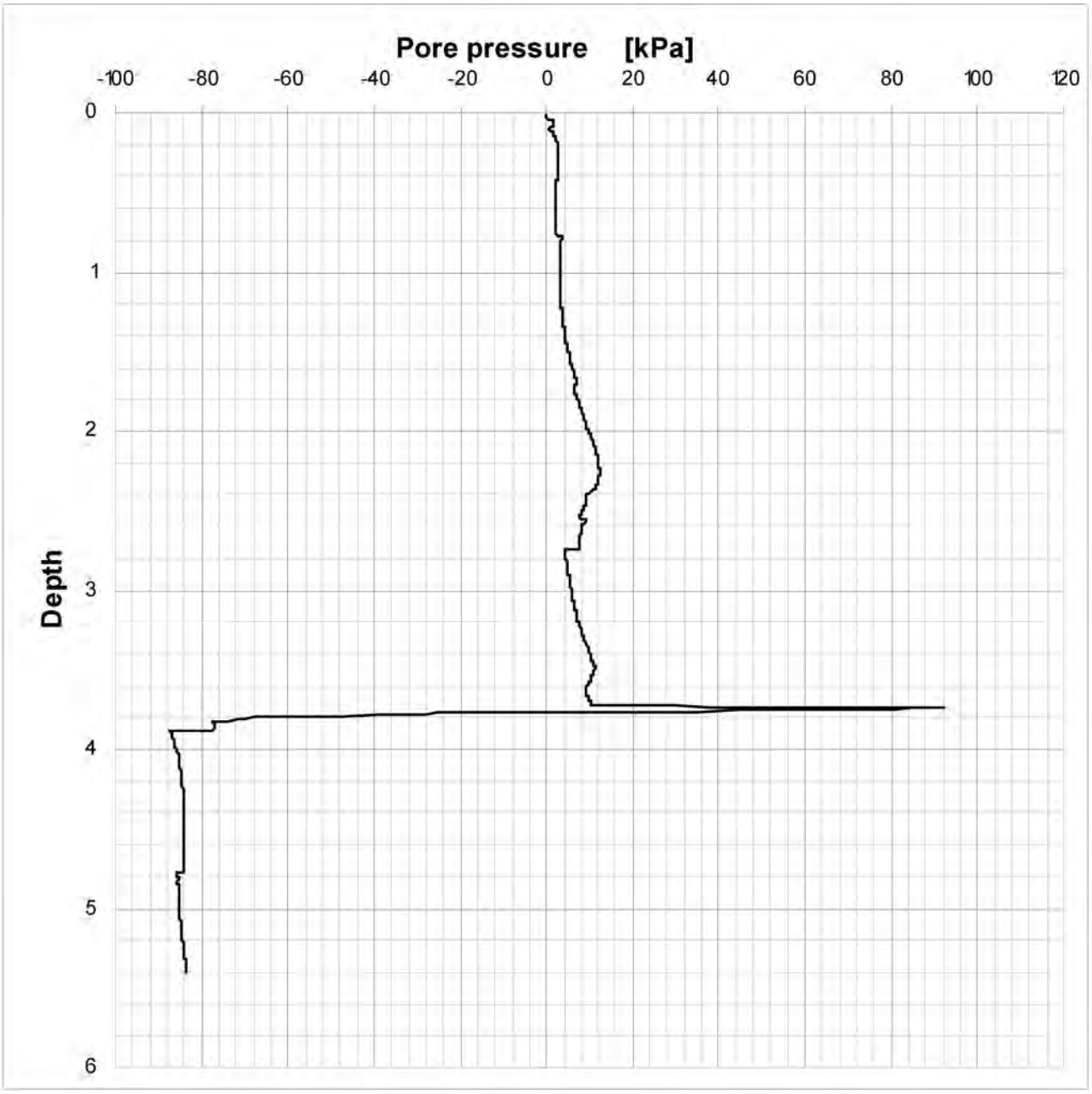
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 2

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M e	P :	Z :	Water Level :	Depth 5.38



Obs. :

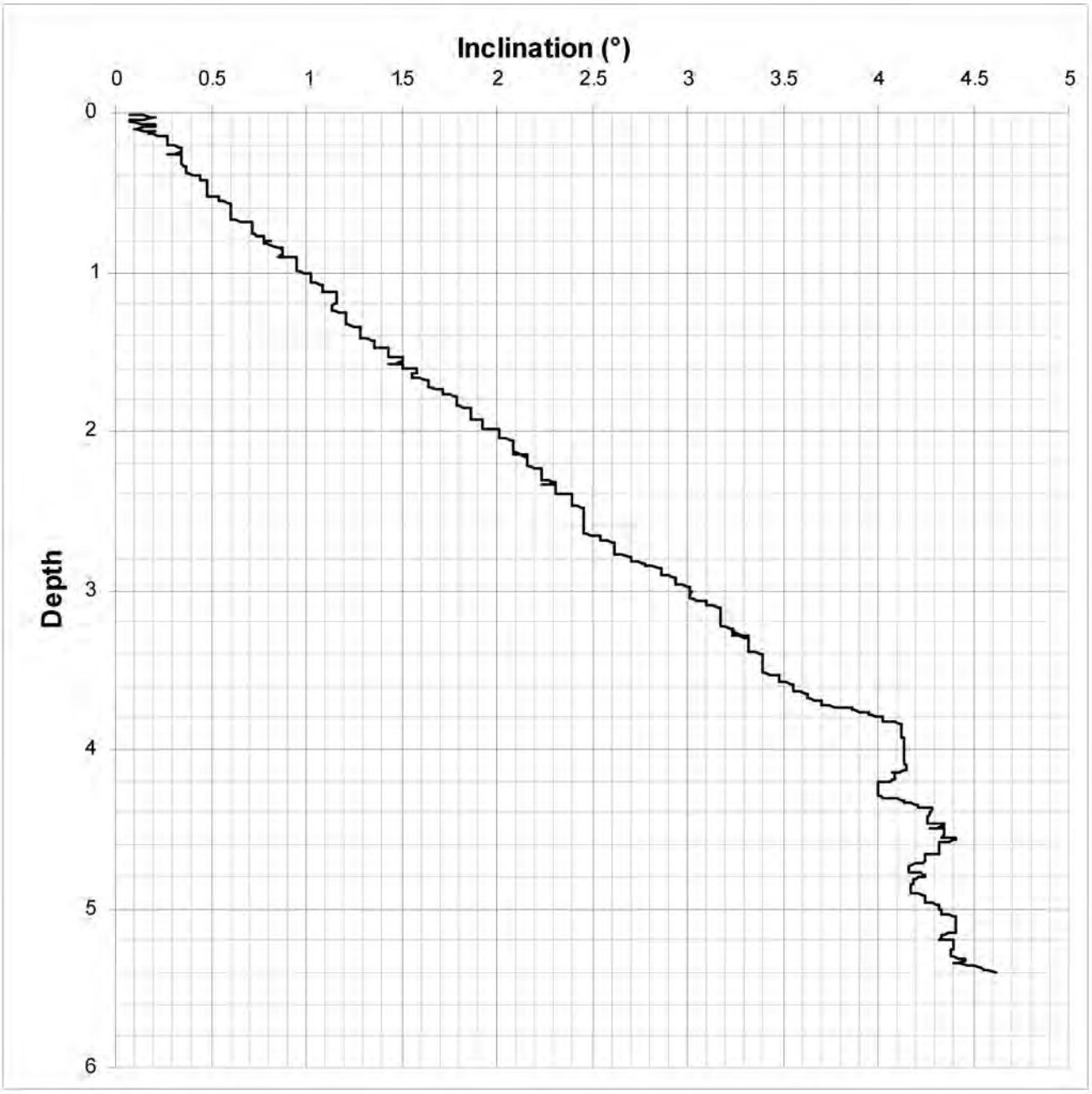
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 2

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M e	P :	Z :	Water Level :	Depth 5.38



Obs. :

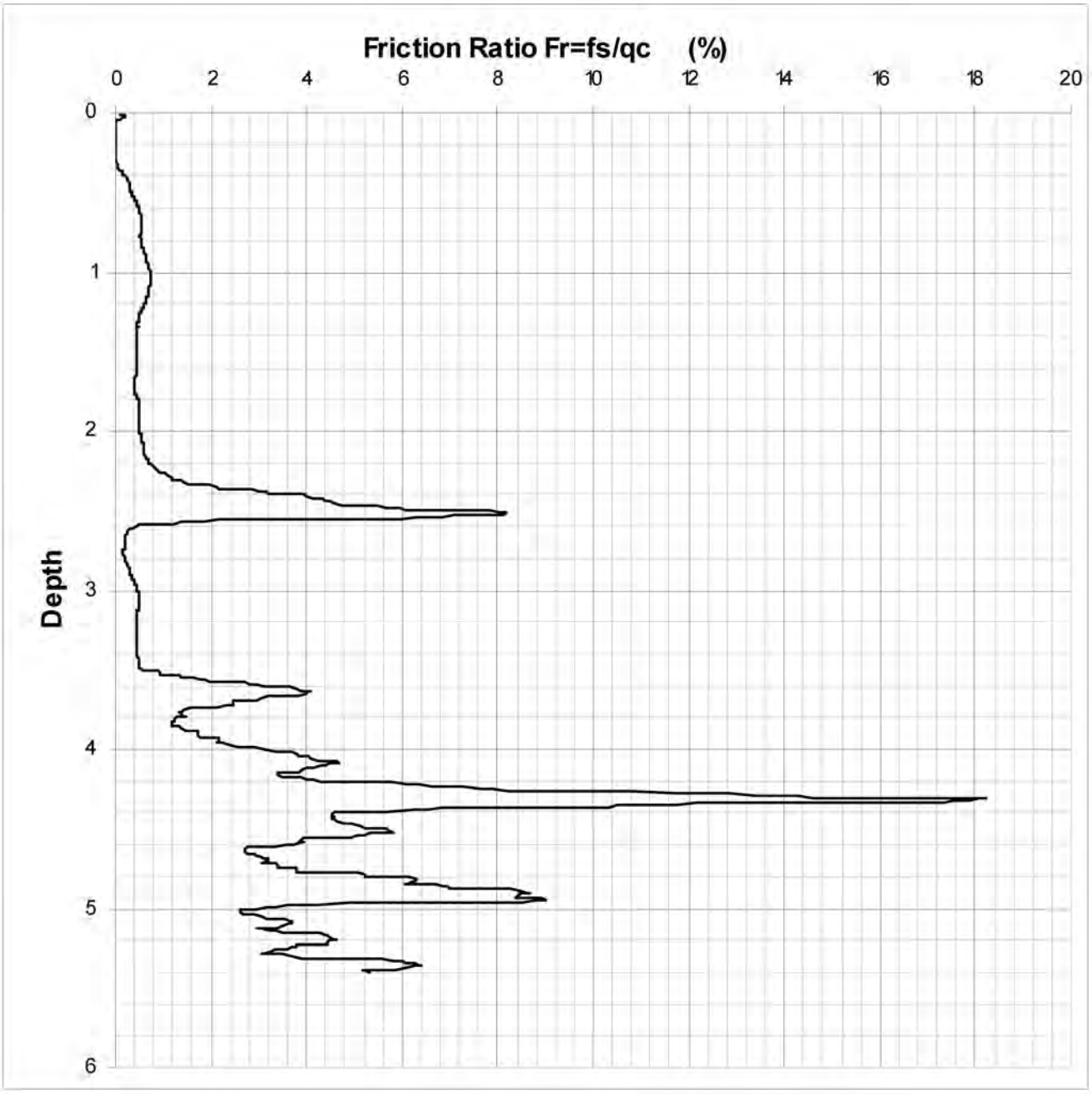
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 2

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M e	P :	Z :	Water Level :	Depth 5.38



Obs. :

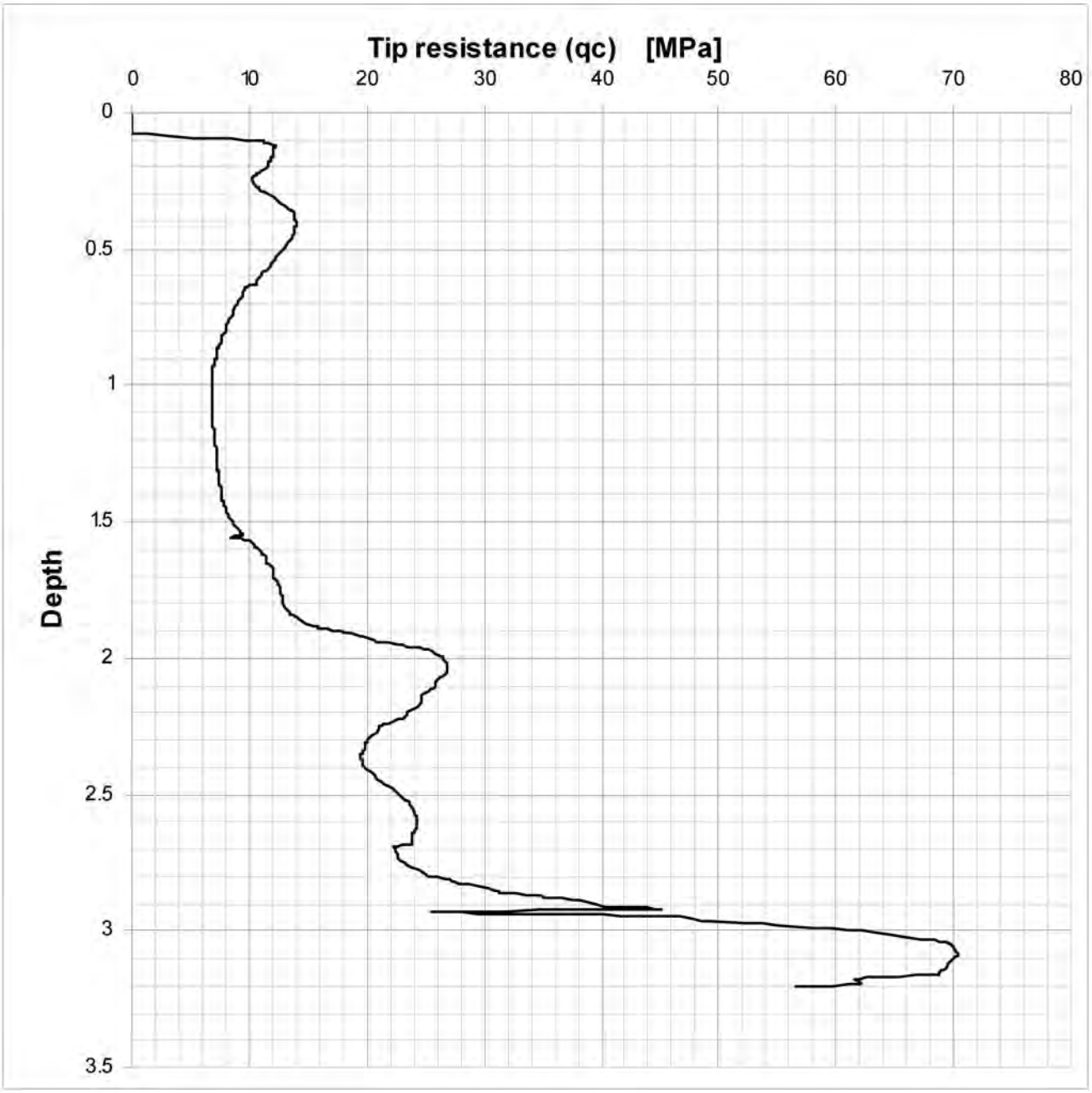
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portuga
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.p

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 3

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.18



Obs. :

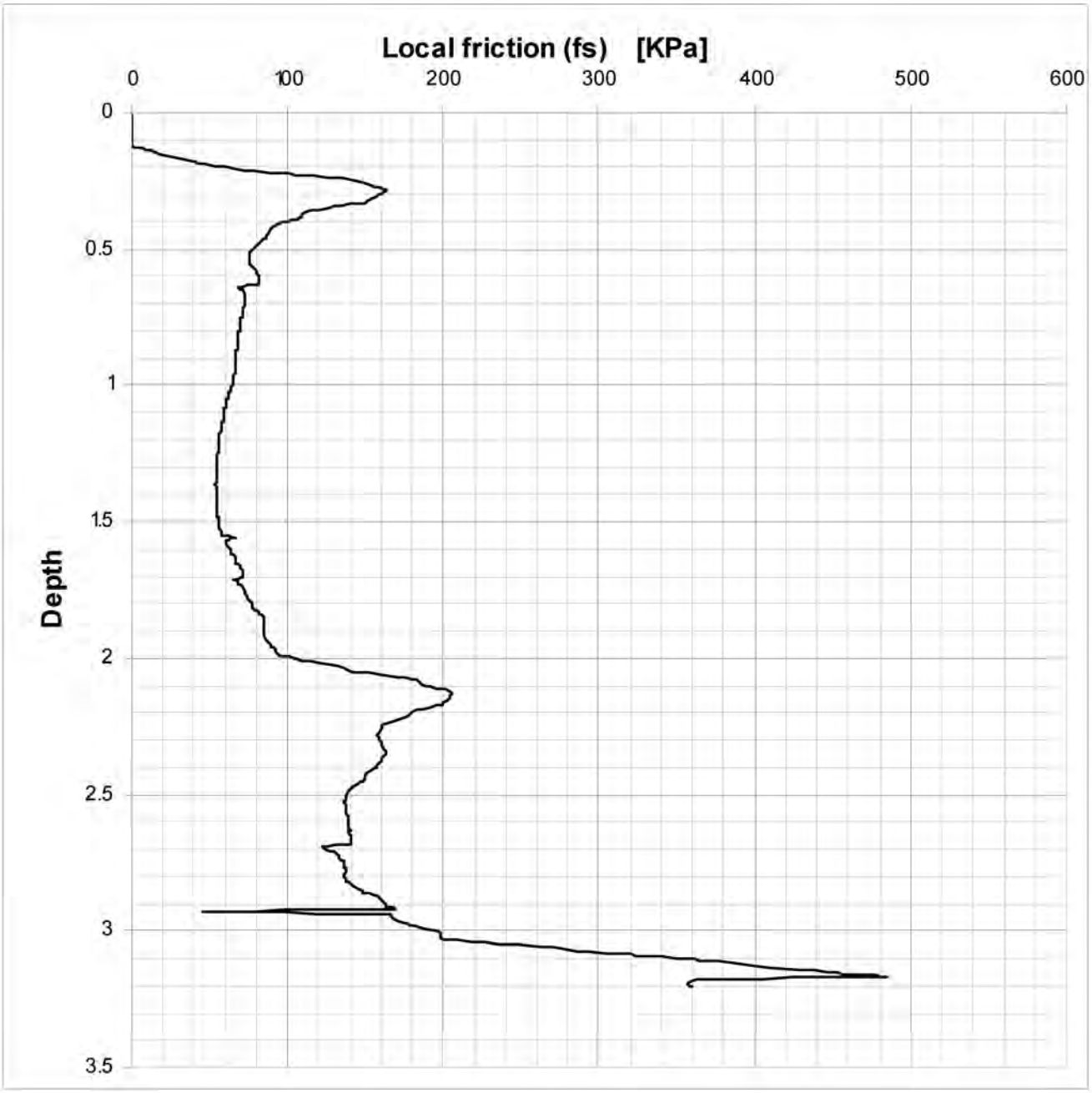
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 3

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.18



Obs. :

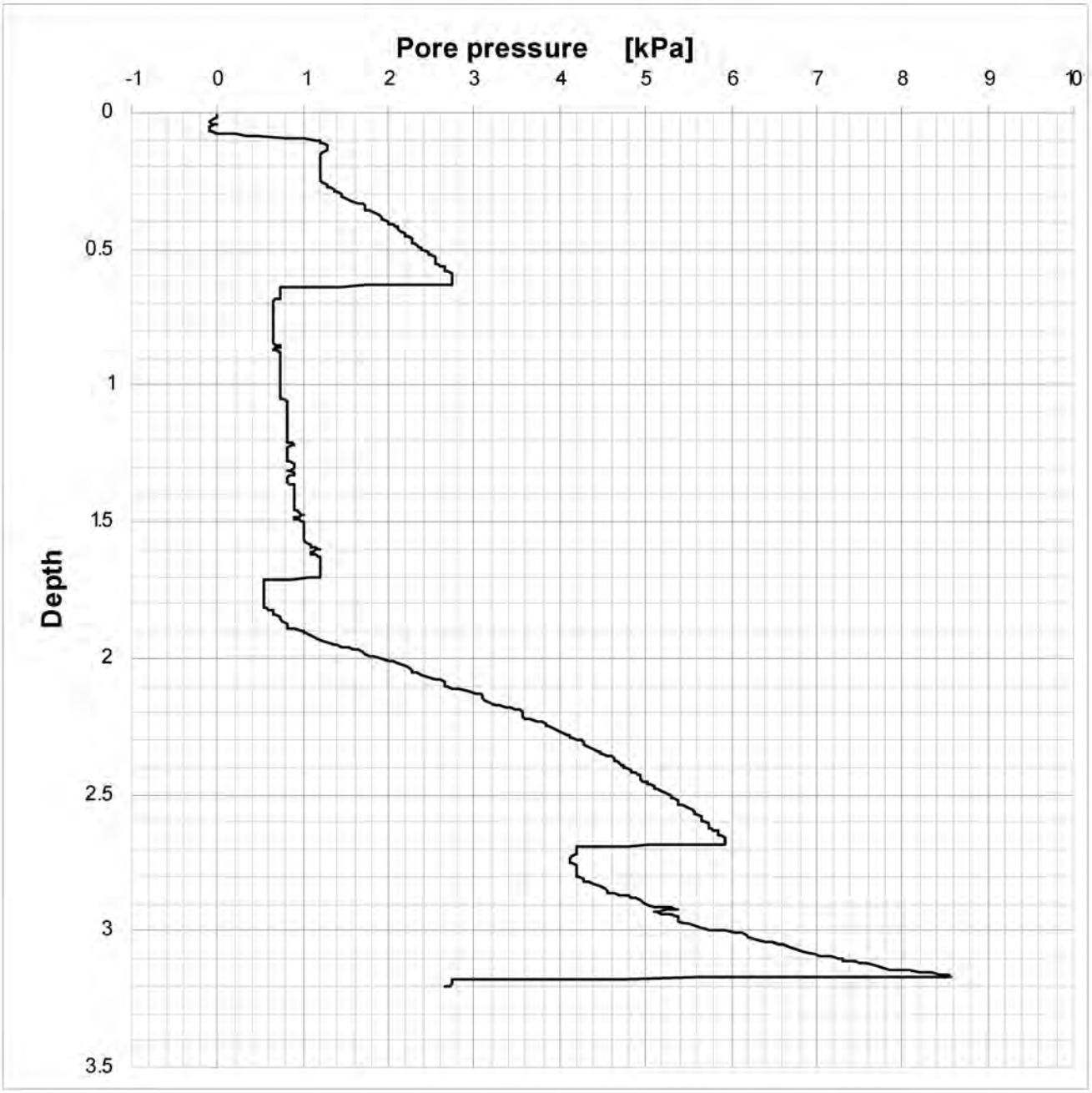
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 3

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.18



Obs. :

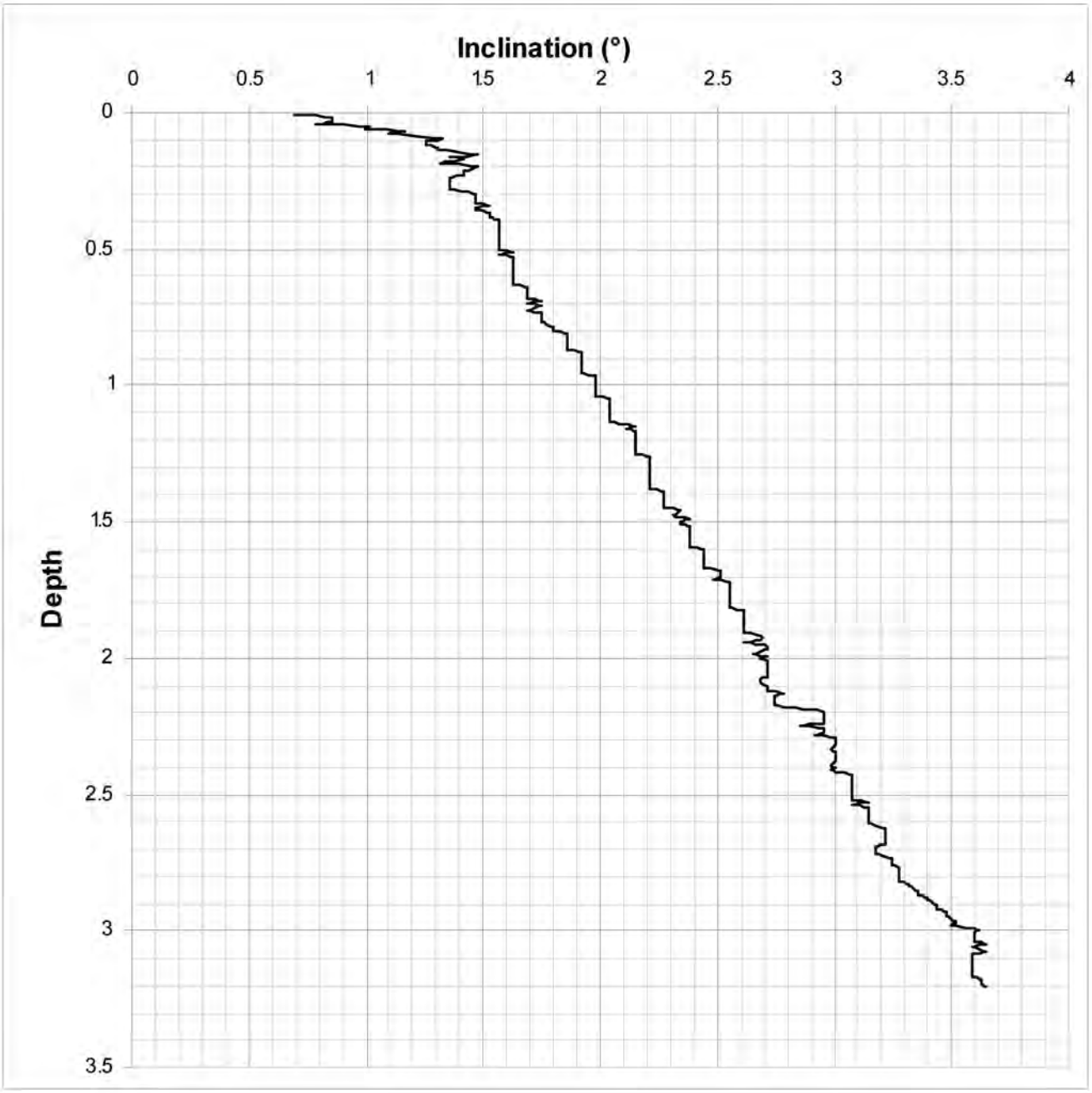
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 3

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.18



Obs. :

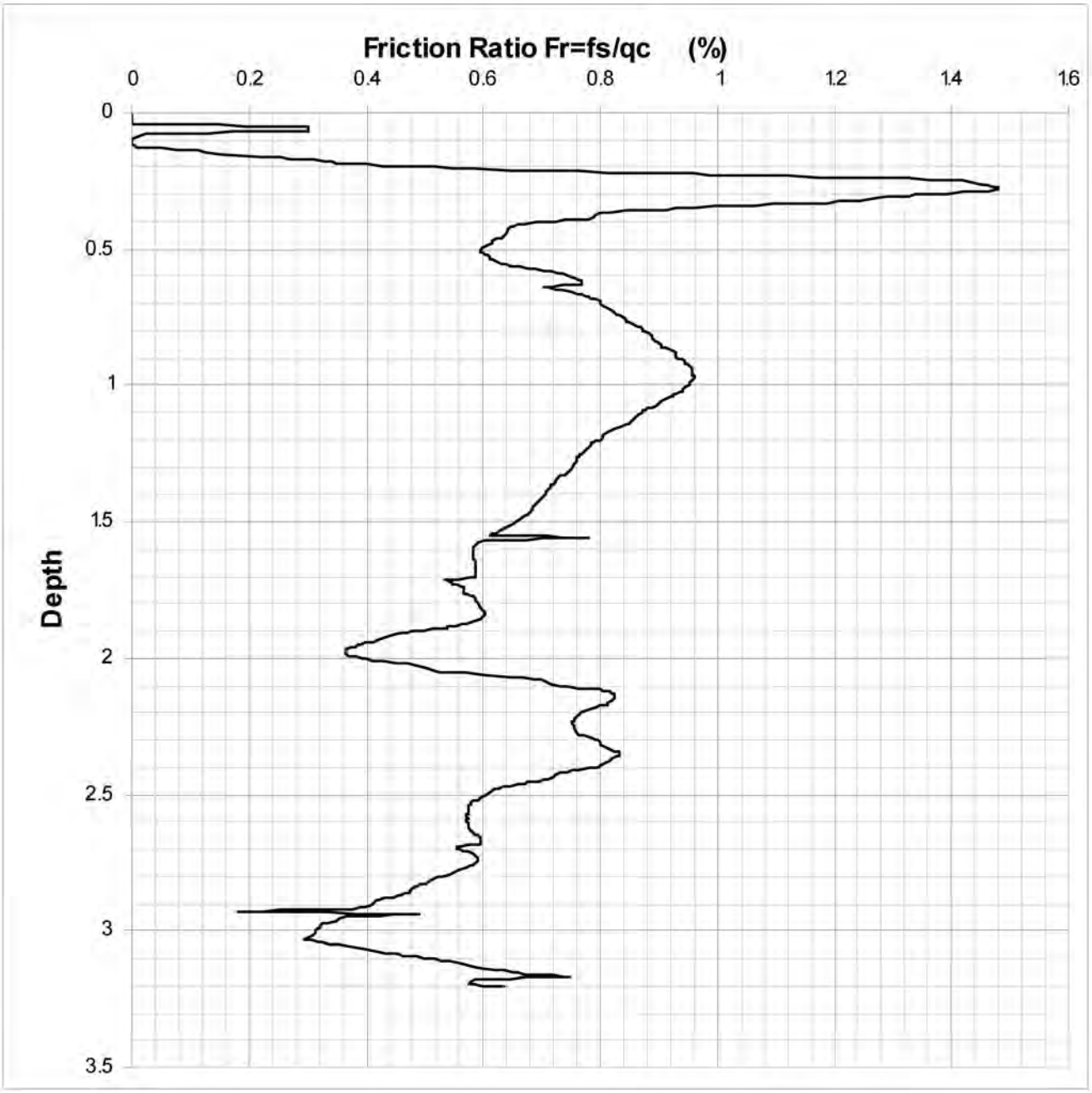
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 3

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.18



Obs. :

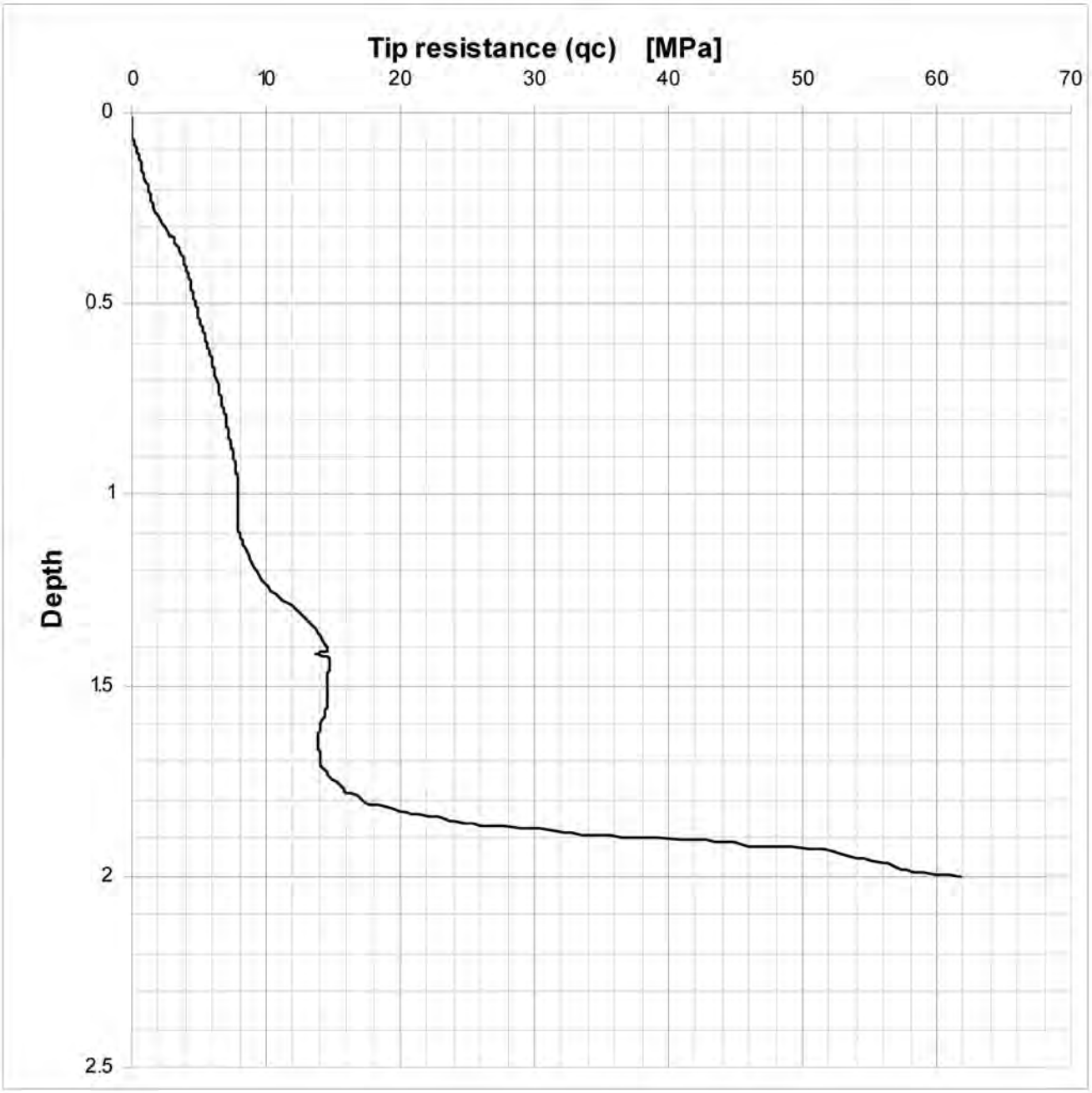
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portuga
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.p

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 4

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 1.98



Obs. :

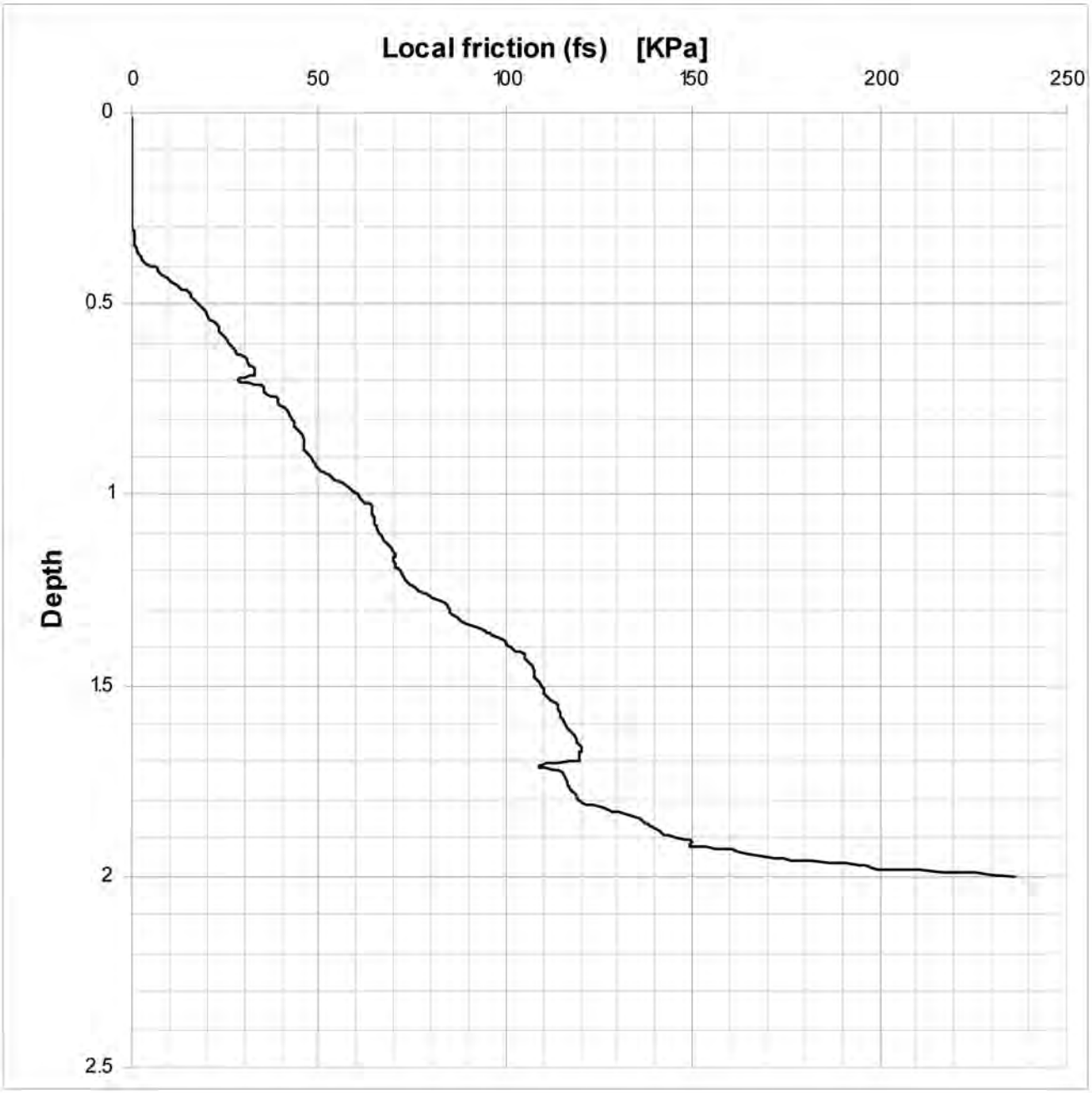
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 4

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 1.98



Obs. :

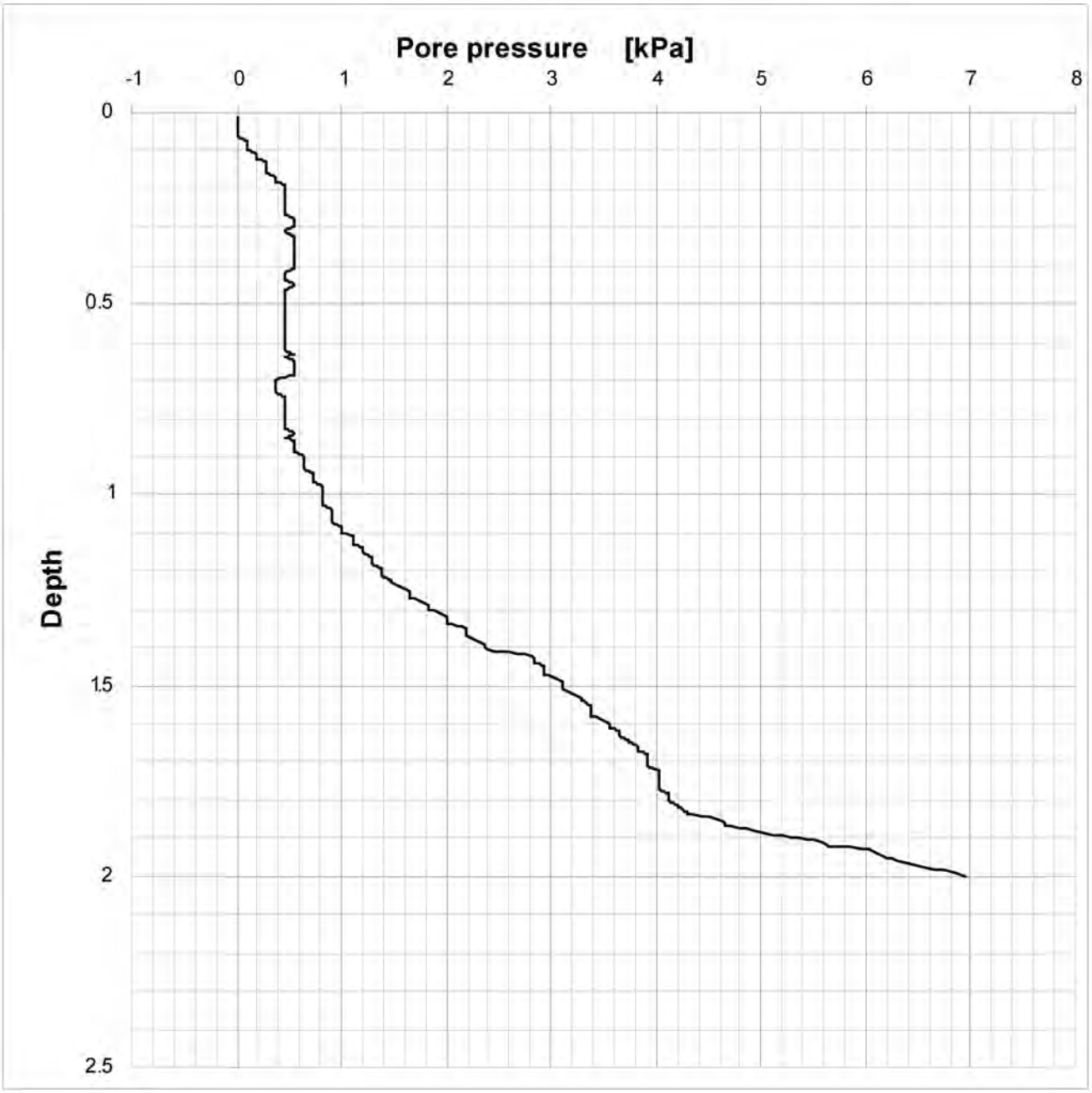
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 4

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 1.98



Obs. :

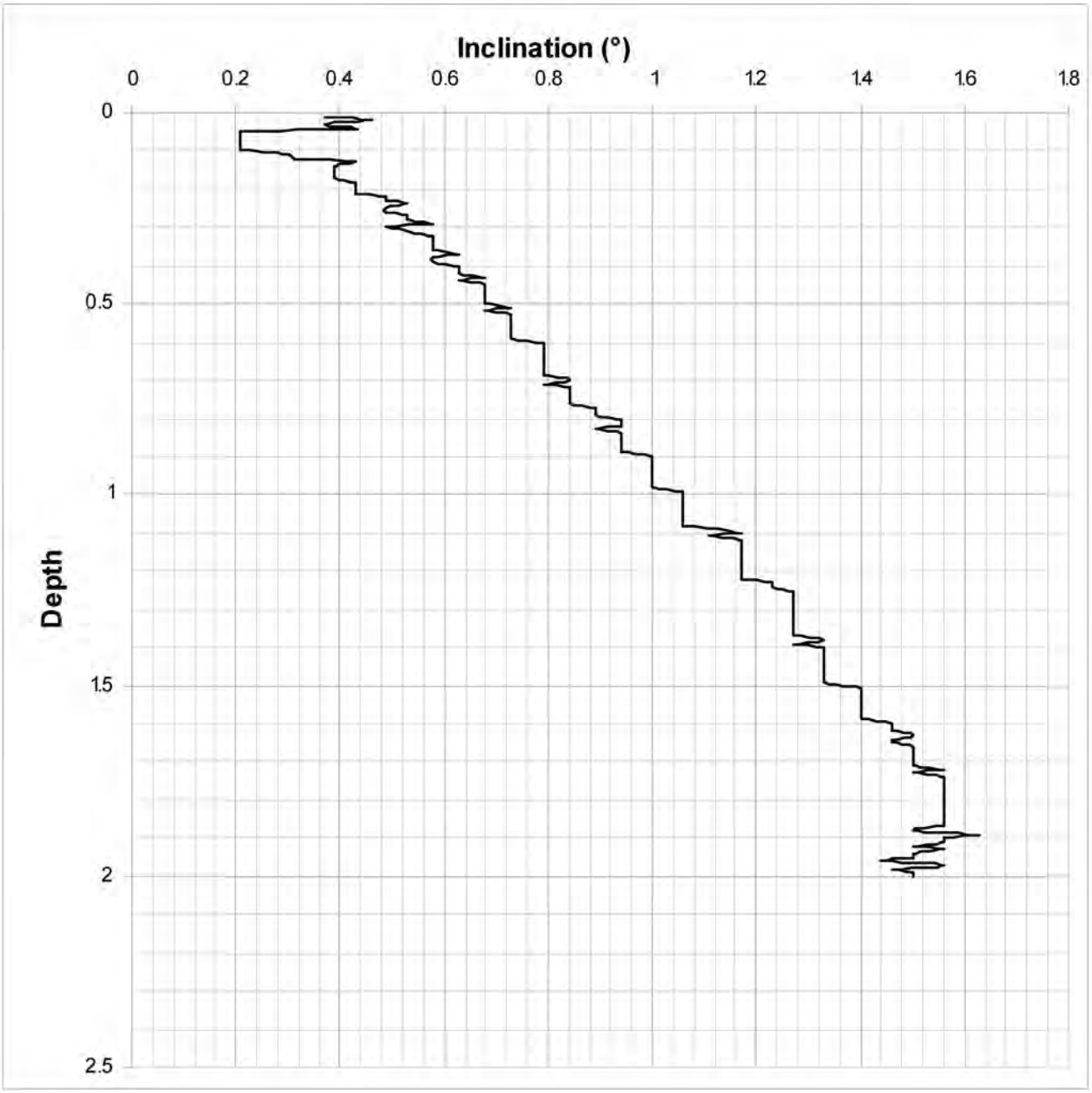
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 4

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 1.98



Obs. :

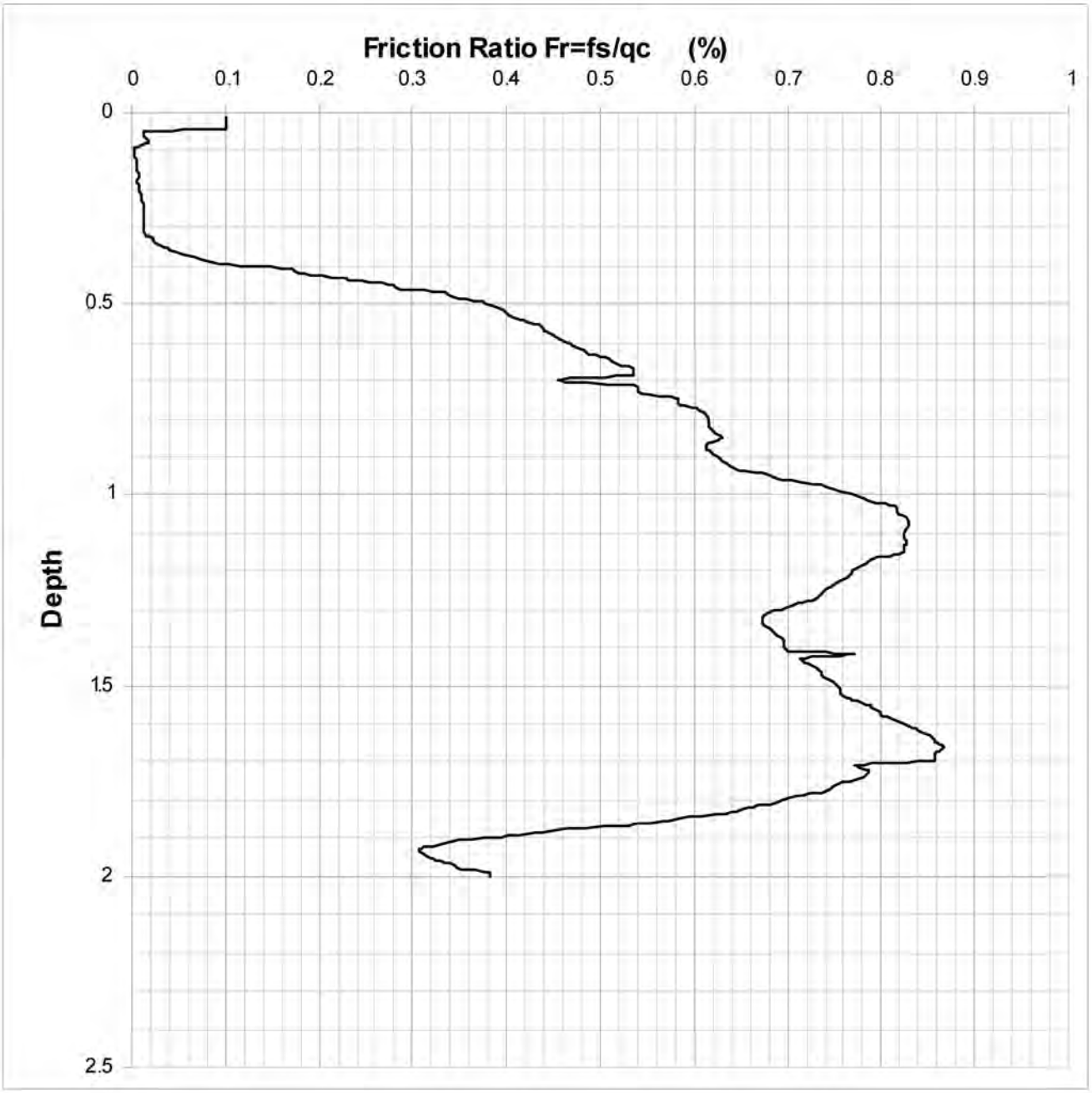
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 4

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 1.98



Obs. :

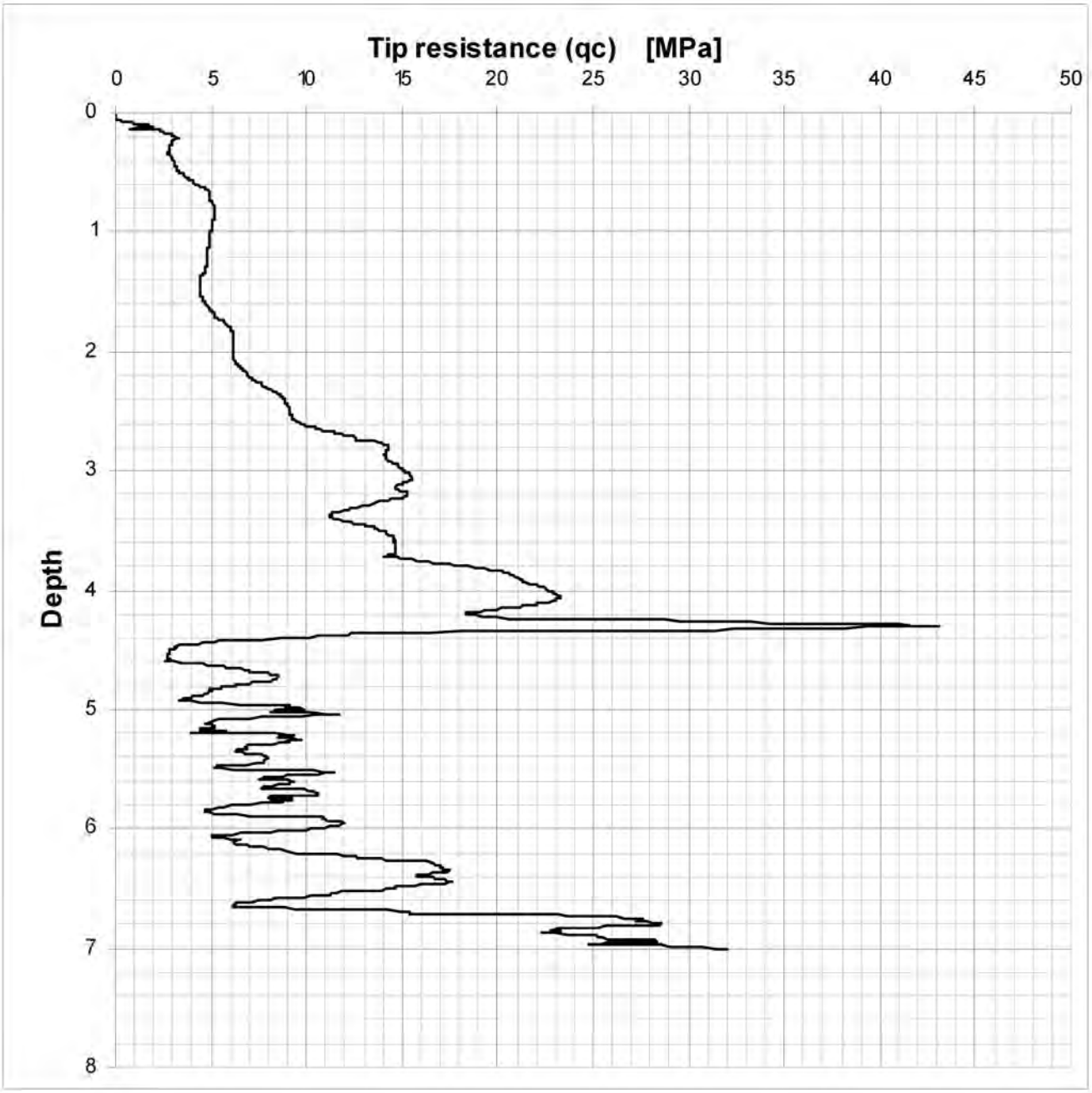
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portuga
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.p

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 5

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 6.98



Obs. :

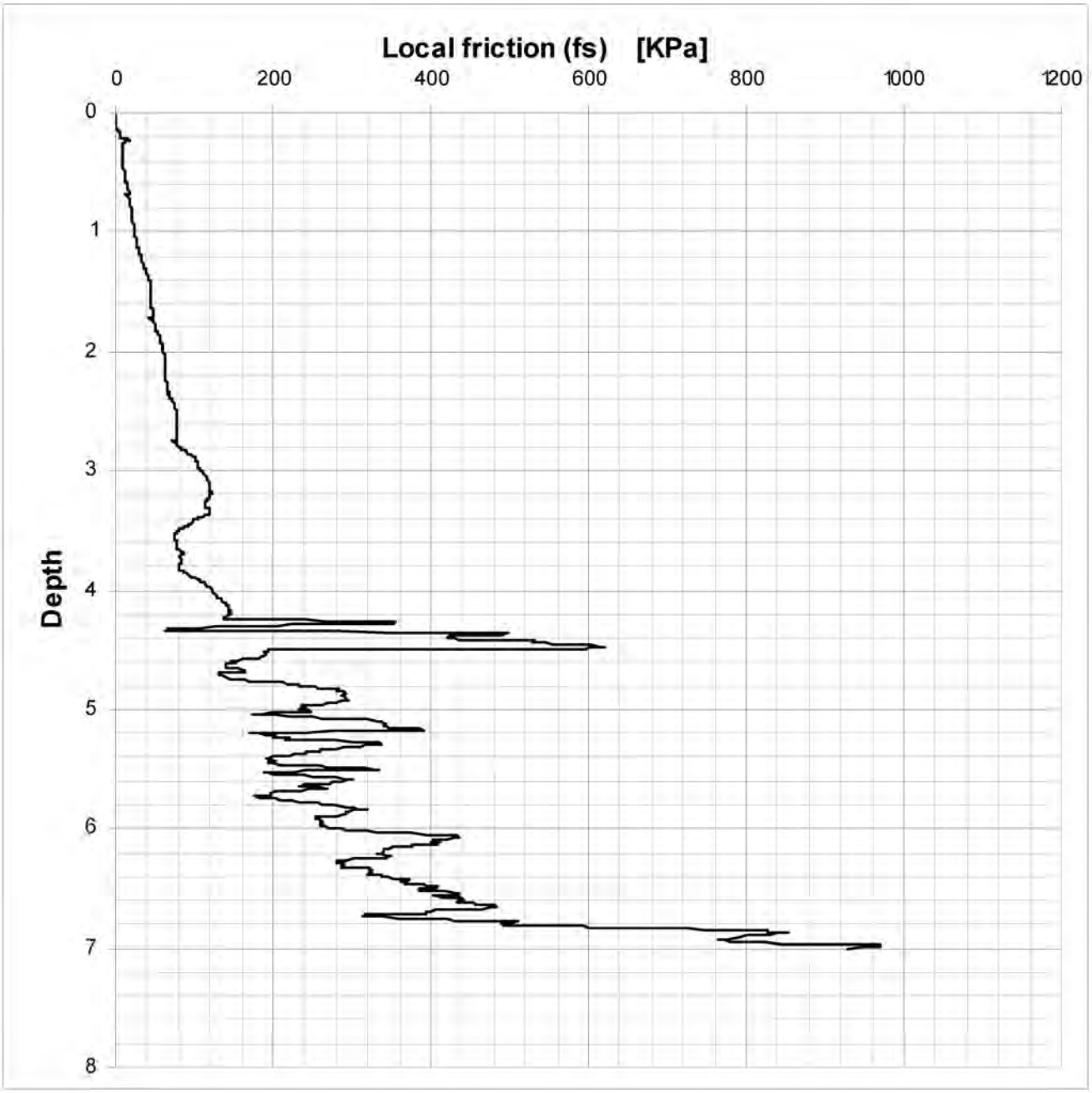
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 5

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 6.98



Obs. :

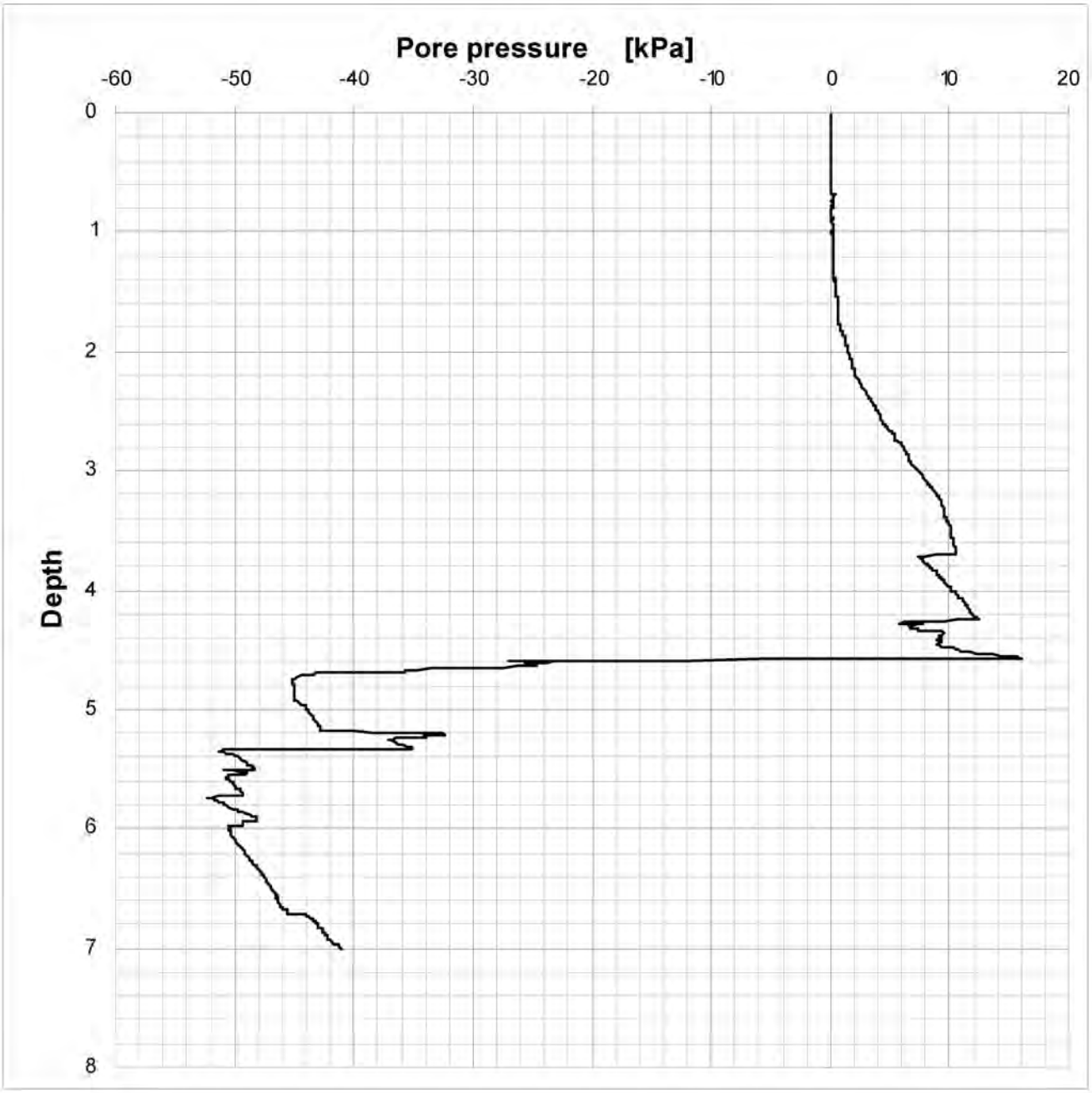
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº **5**

Date	Entity	Job Number
11/10/2021	**Start Campus**	**37321**
	Job: **Nest Data Center Sines**	

M	P :	Z :	Water Level :	Depth **6.98**



Obs. :

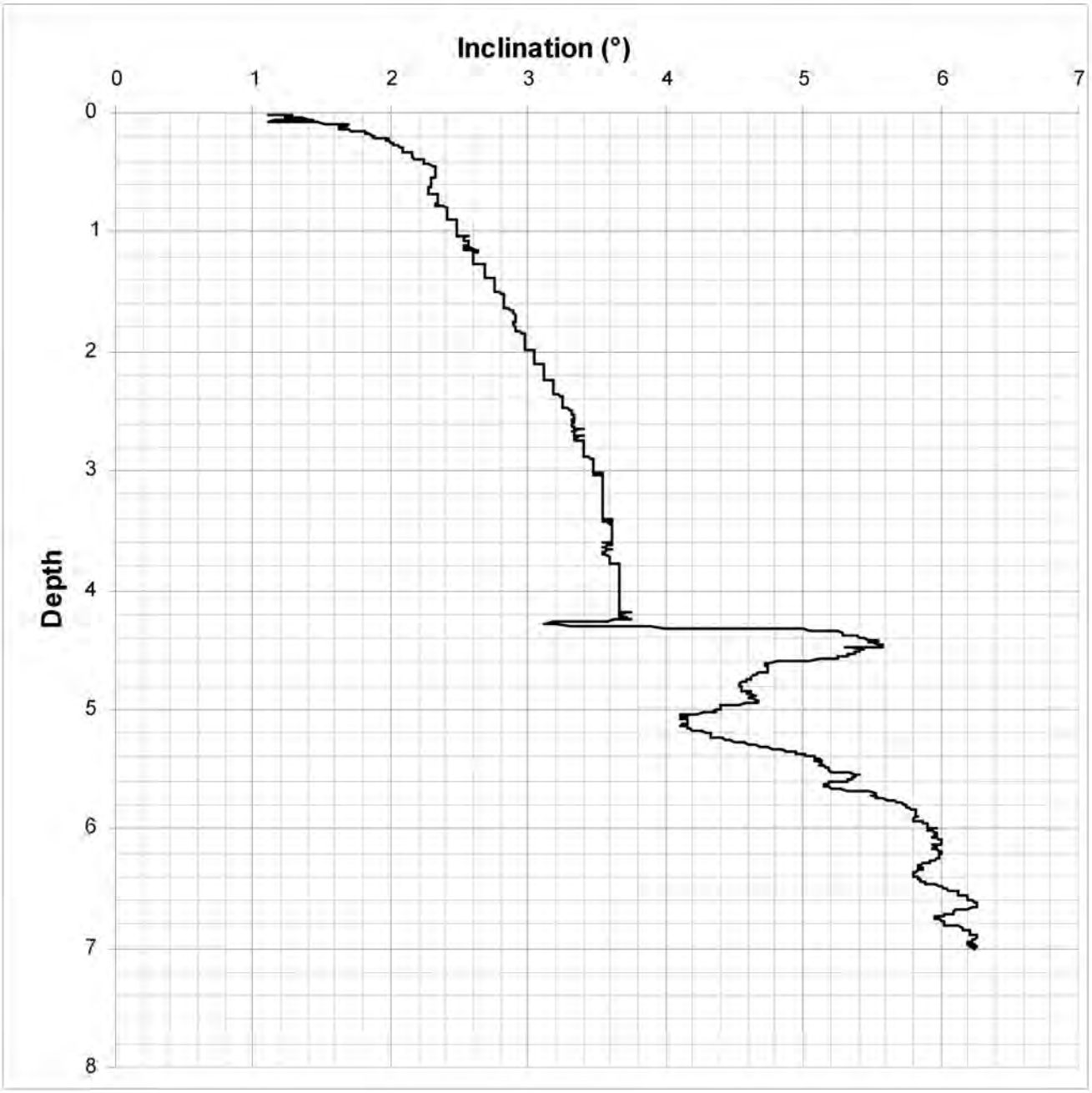
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº **5**

Date	Entity	Job Number
11/10/2021	**Start Campus**	**37321**
	Job: **Nest Data Center Sines**	

M	P :	Z :	Water Level :	Depth **6.98**



Obs. :

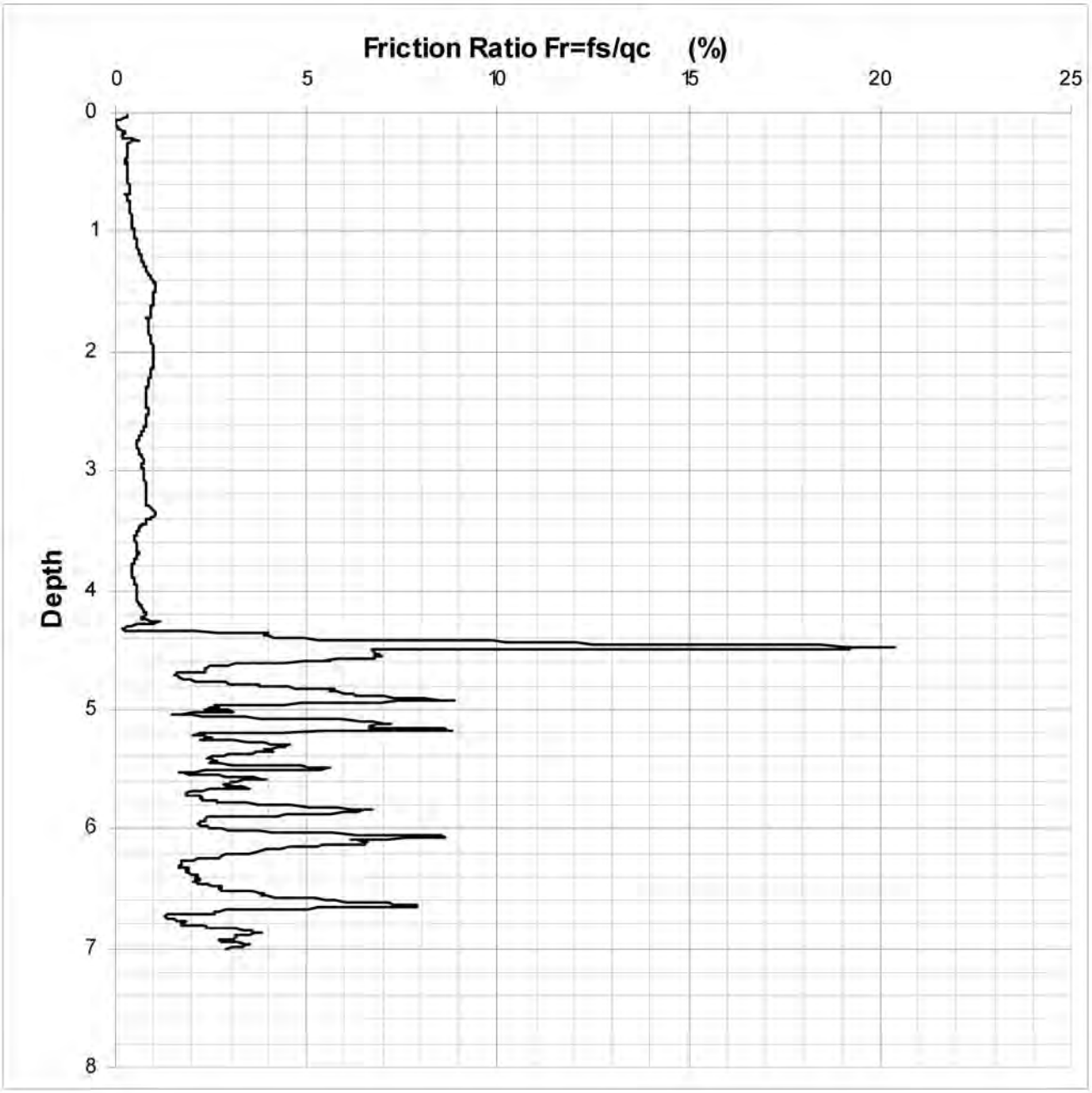
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 5

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 6.98



Obs. :

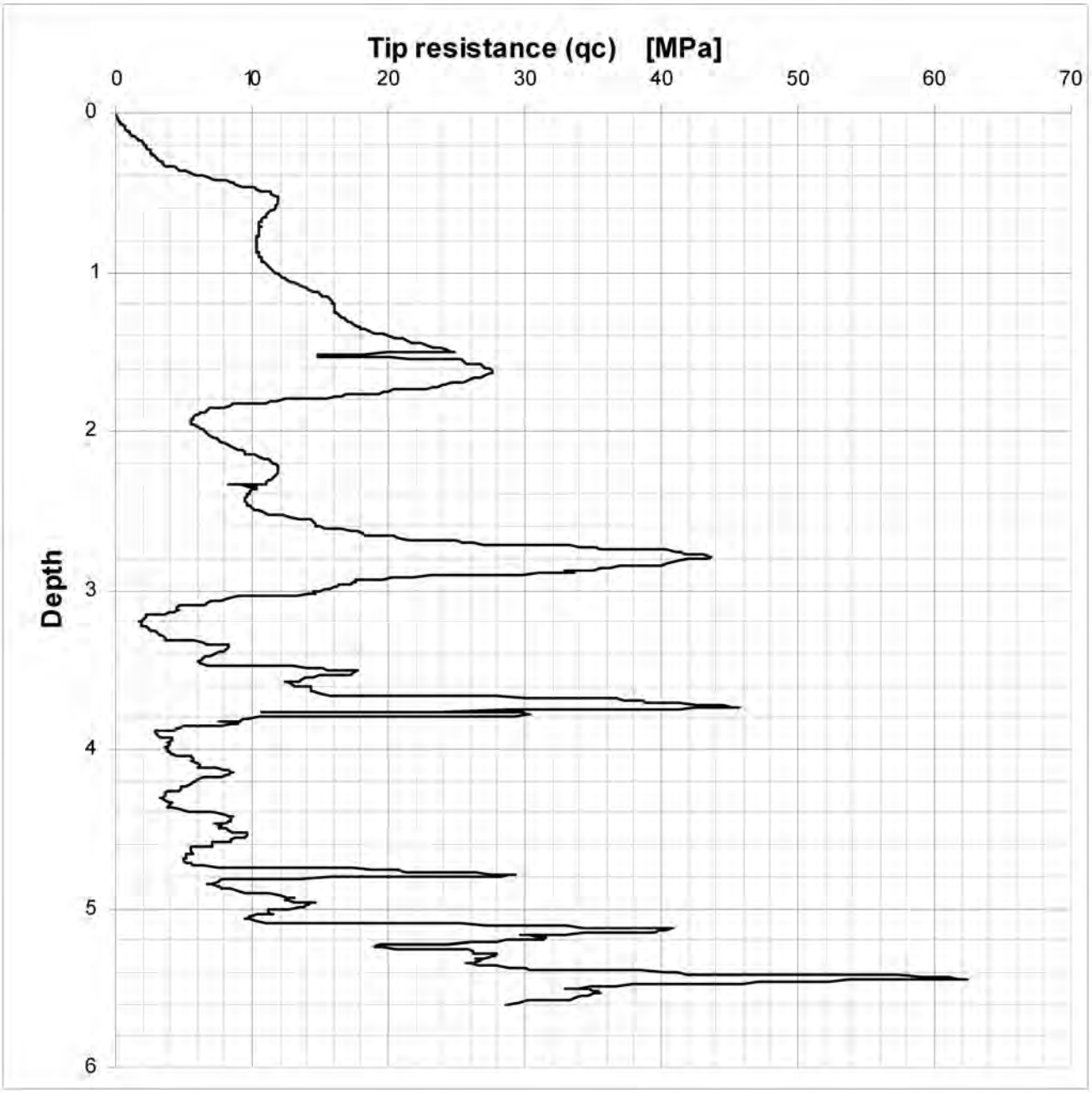
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portuga
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.p

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 6

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 5.58



Obs. :

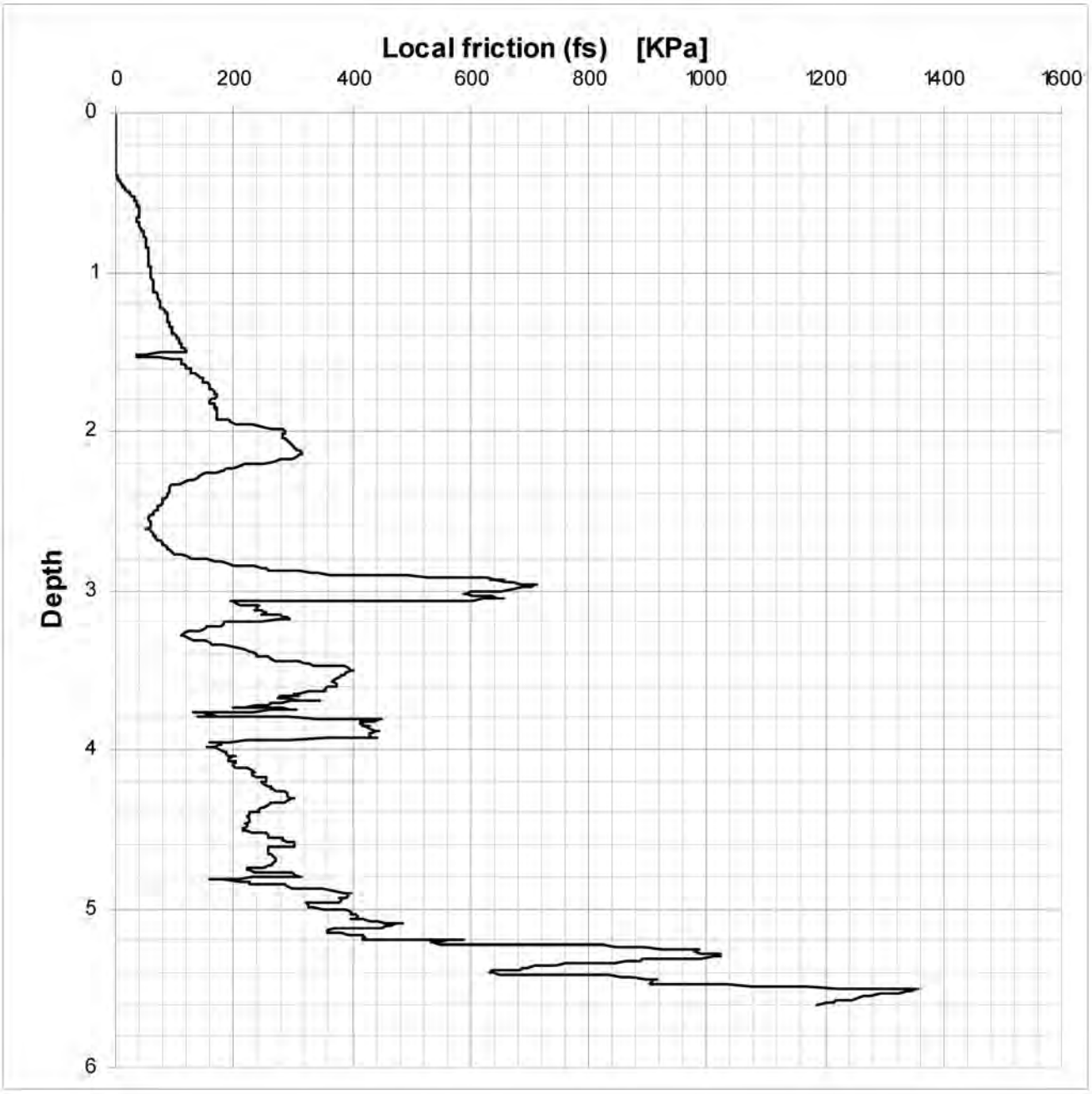
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 6

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 5.58



Obs. :

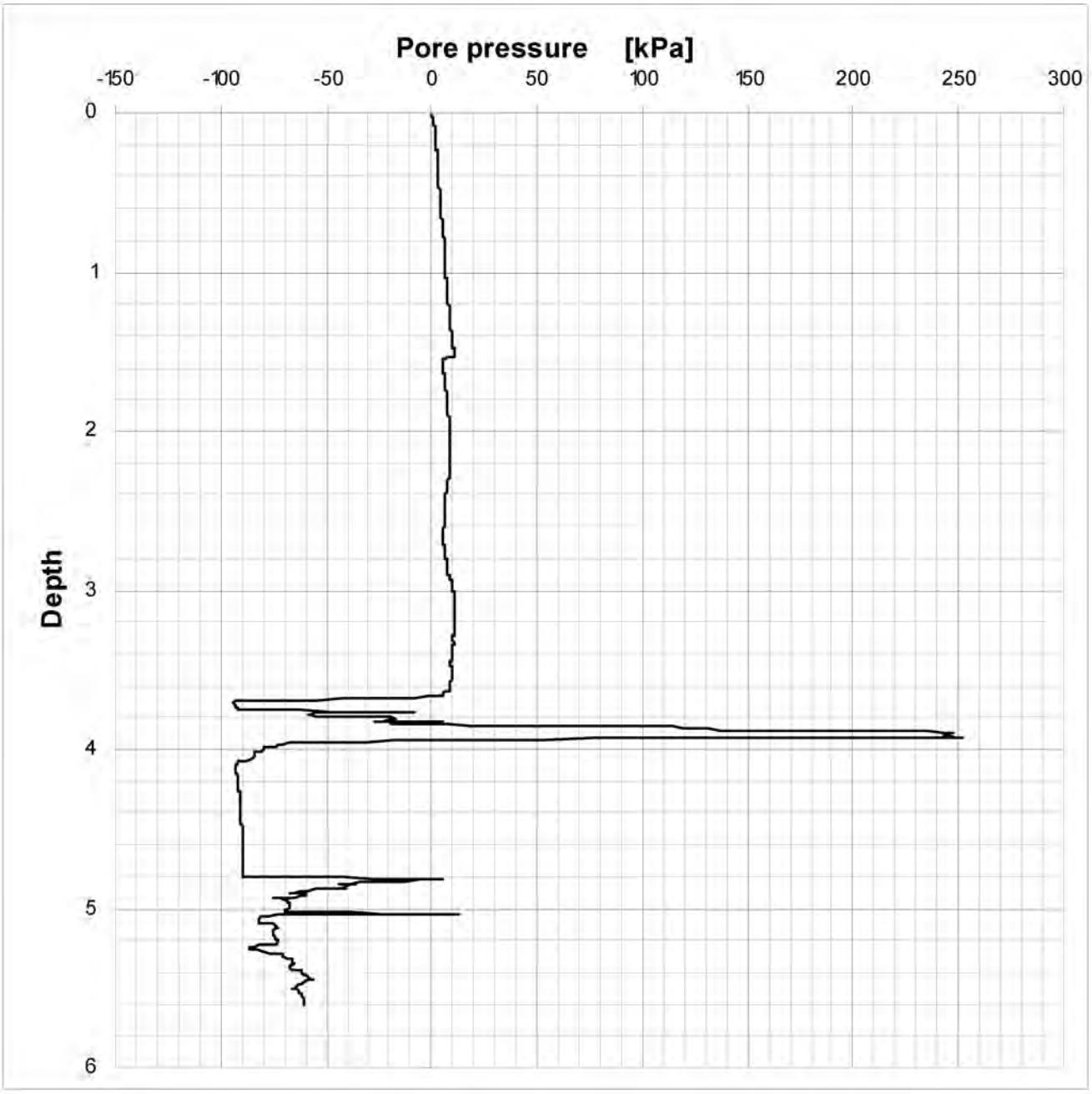
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 6

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 5.58



Obs. :

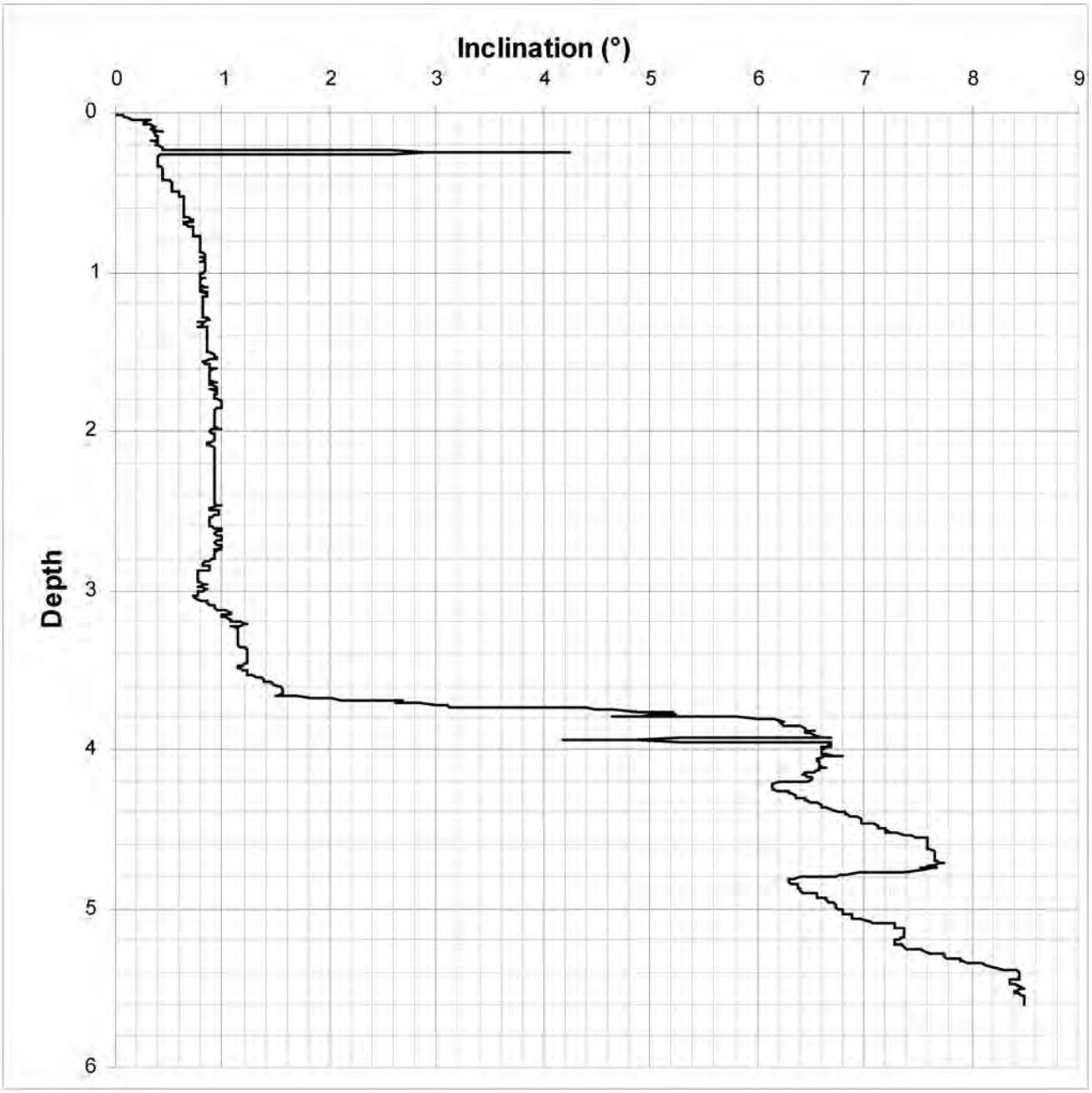
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 6

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 5.58



Obs. :

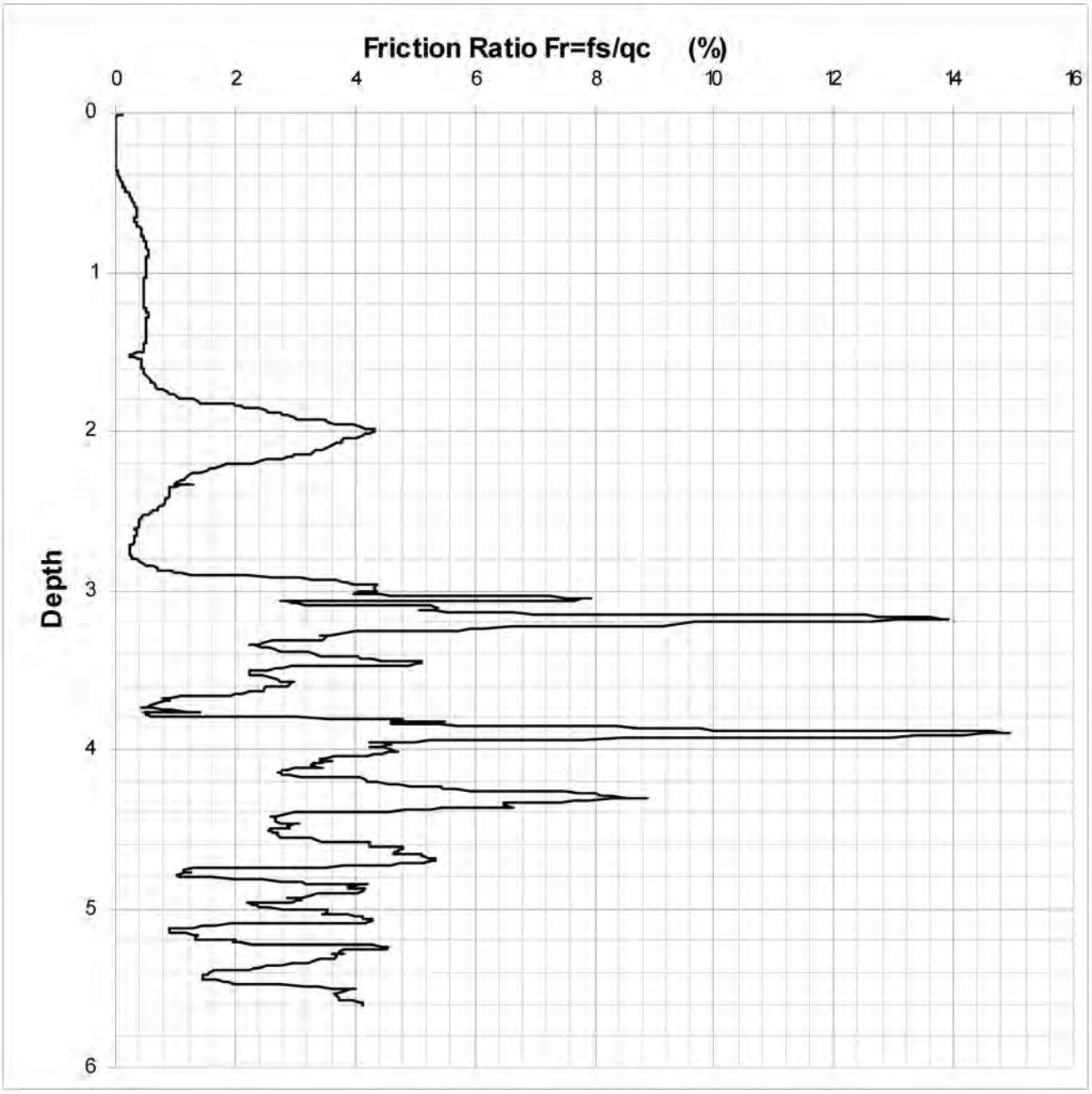
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 6

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 5.58



Obs. :

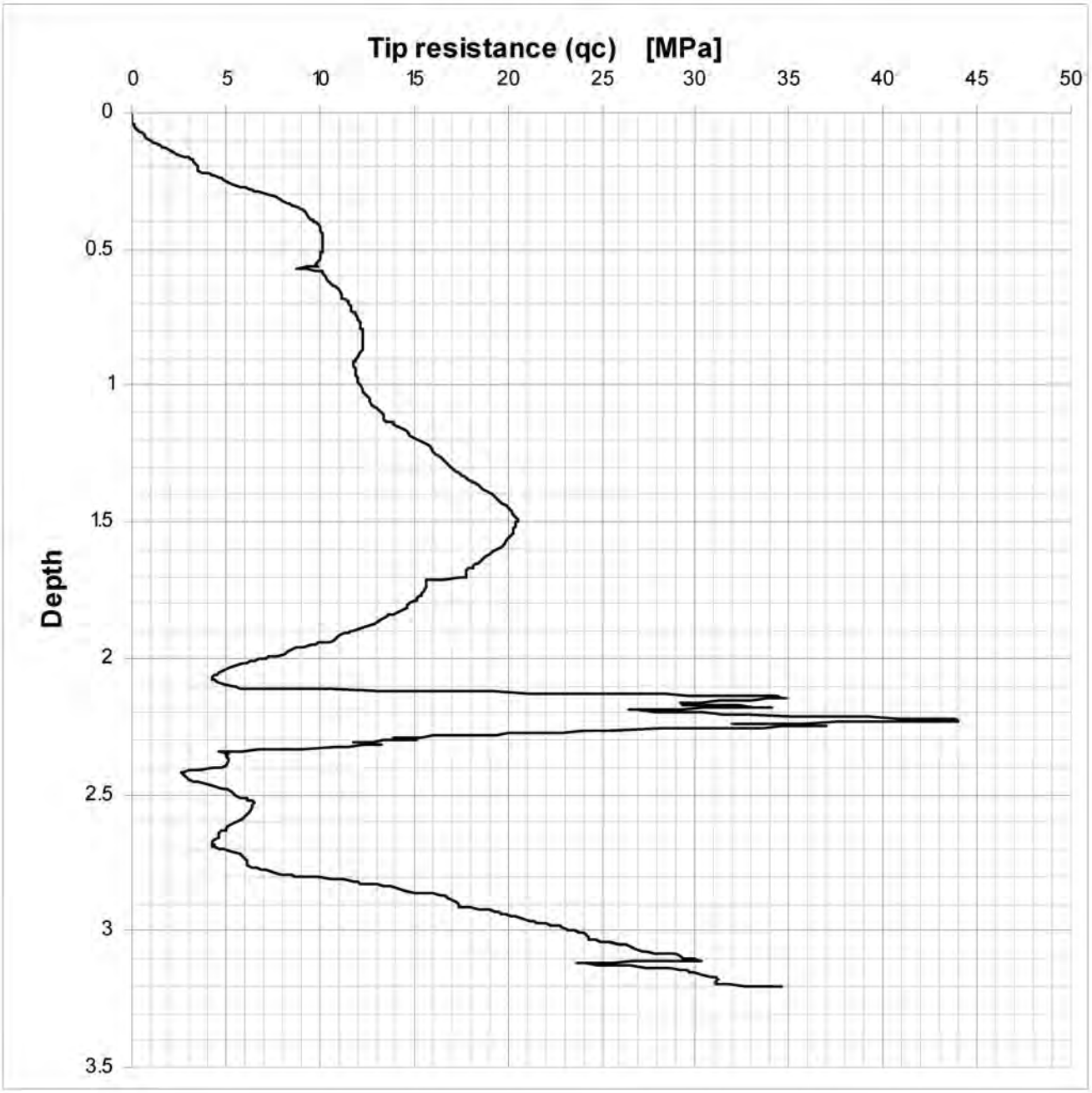
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portuga
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.p

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 7

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.18



Obs. :

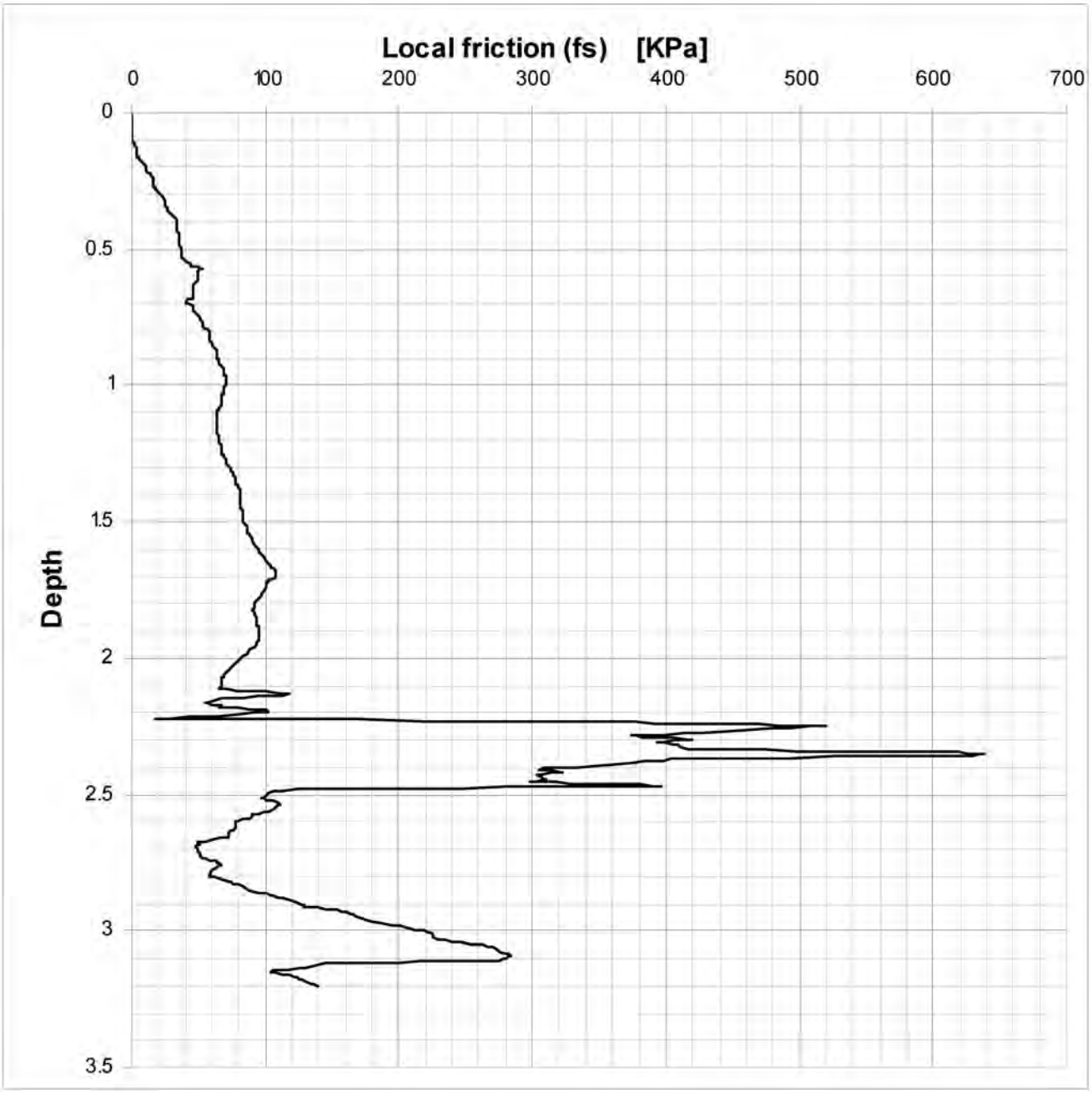
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 7

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.18



Obs. :

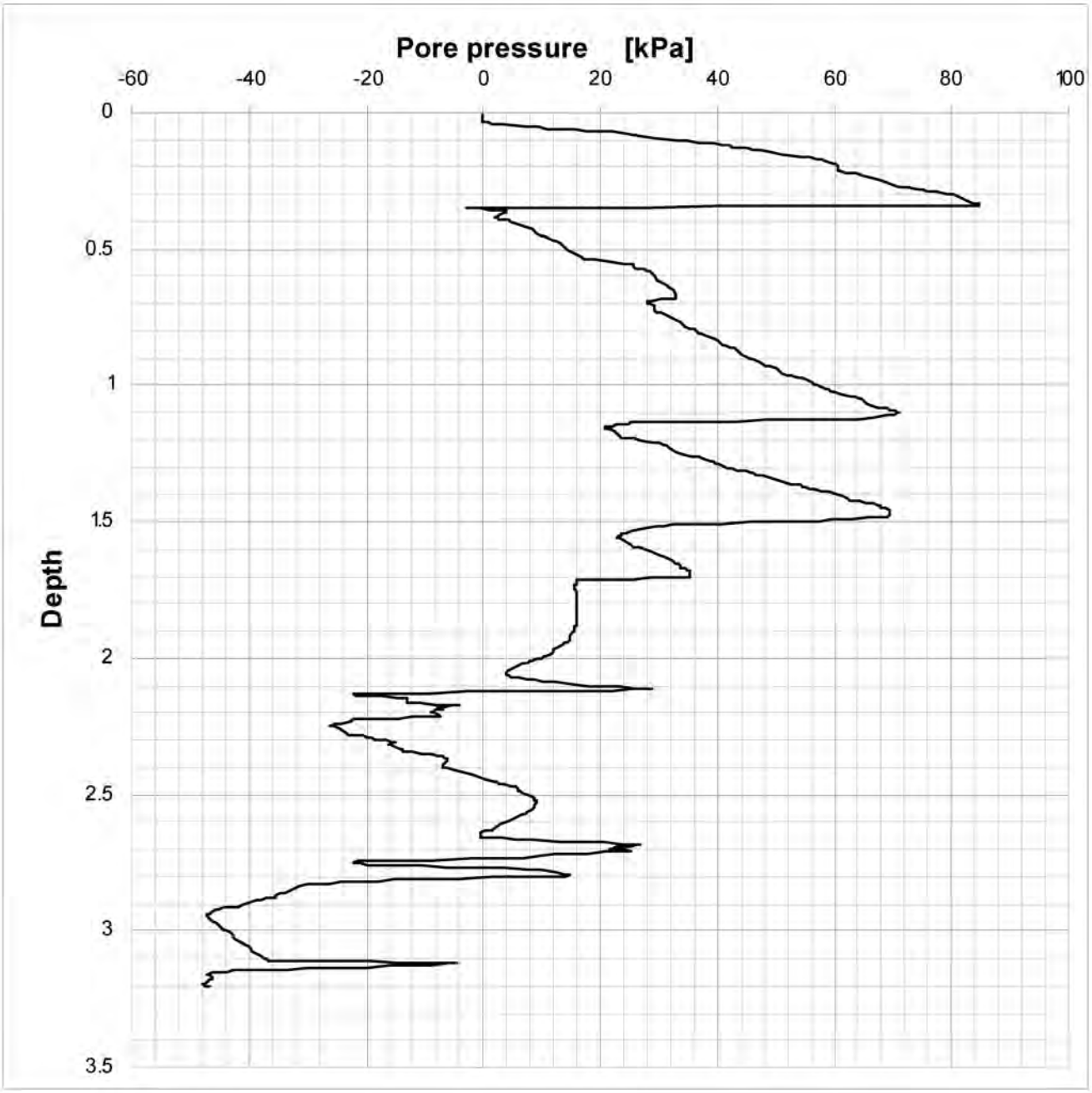
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 7

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.18



Obs. :

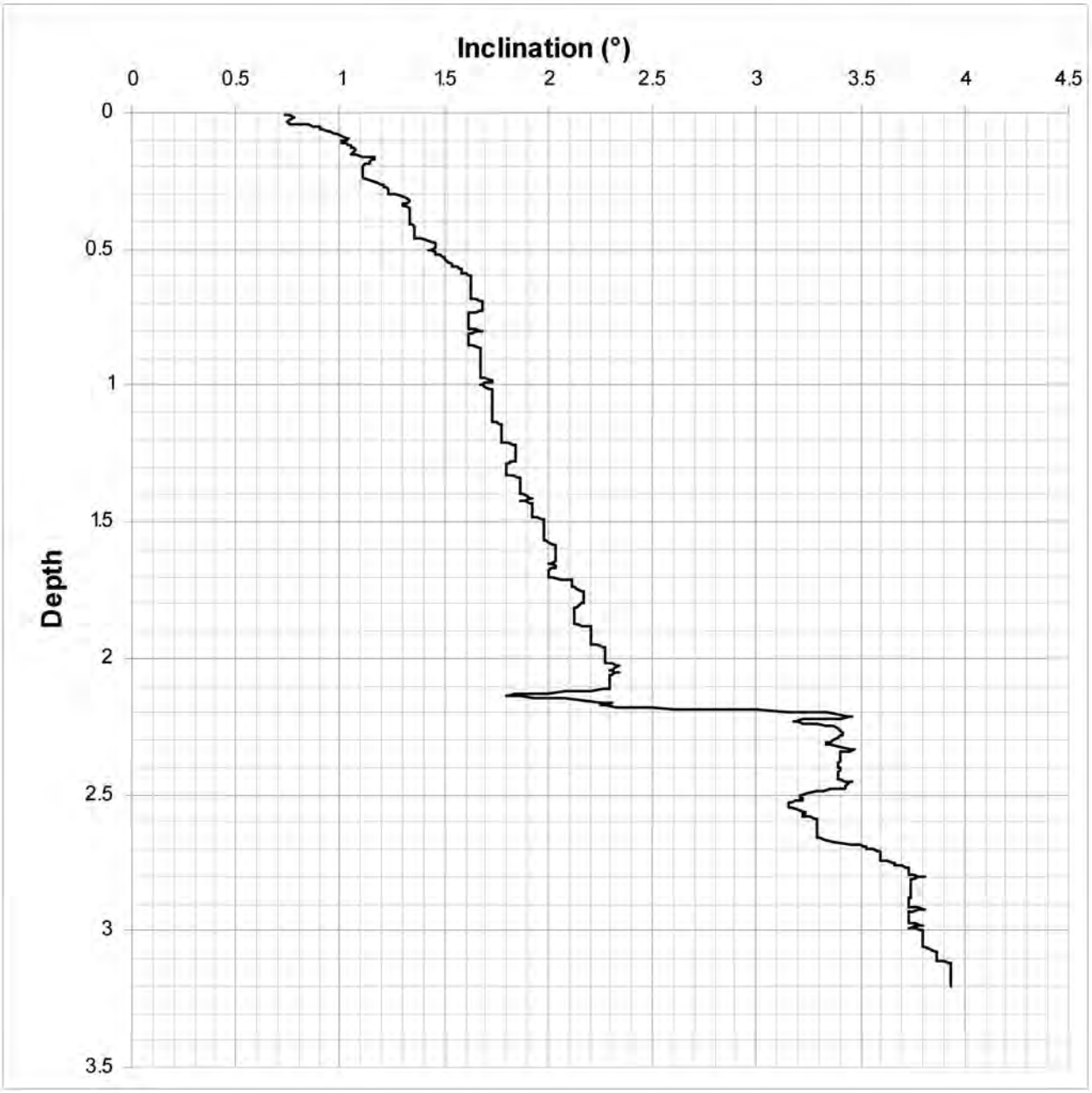
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 7

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.18



Obs. :

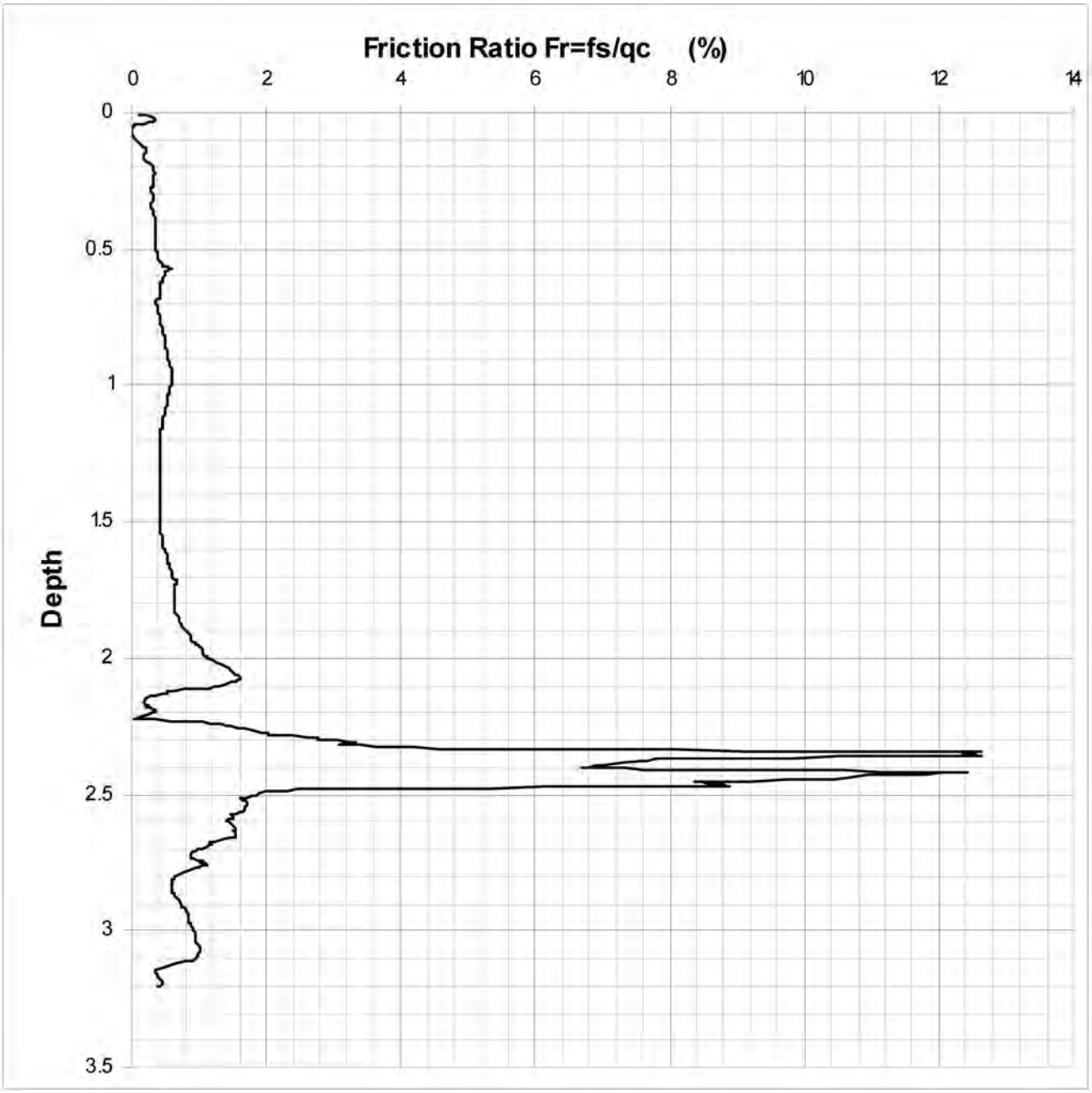
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 7

Date	Entity	Job Number
12/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.18



Obs. :

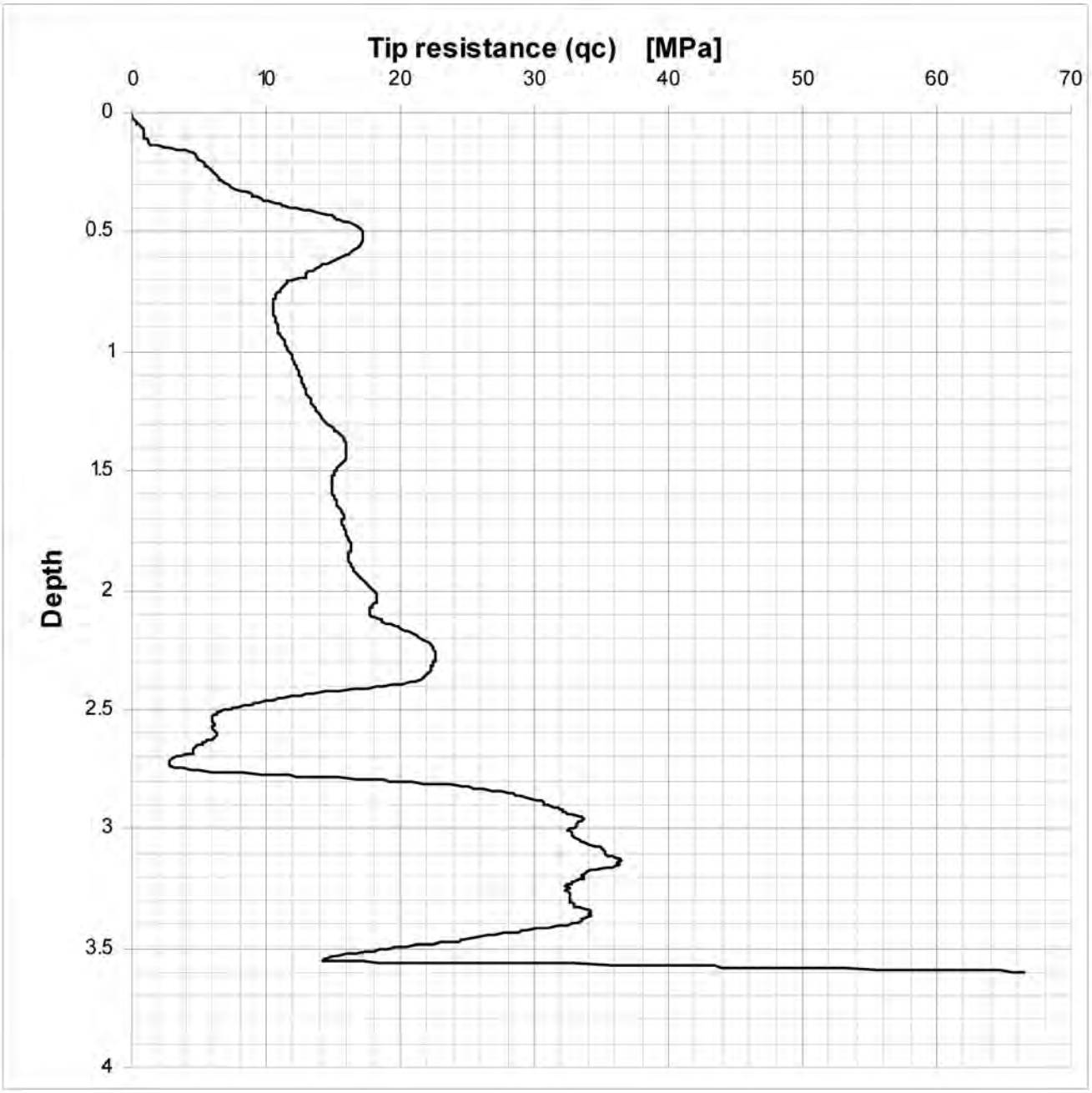
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portuga
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.p

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 8

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.58



Obs. :

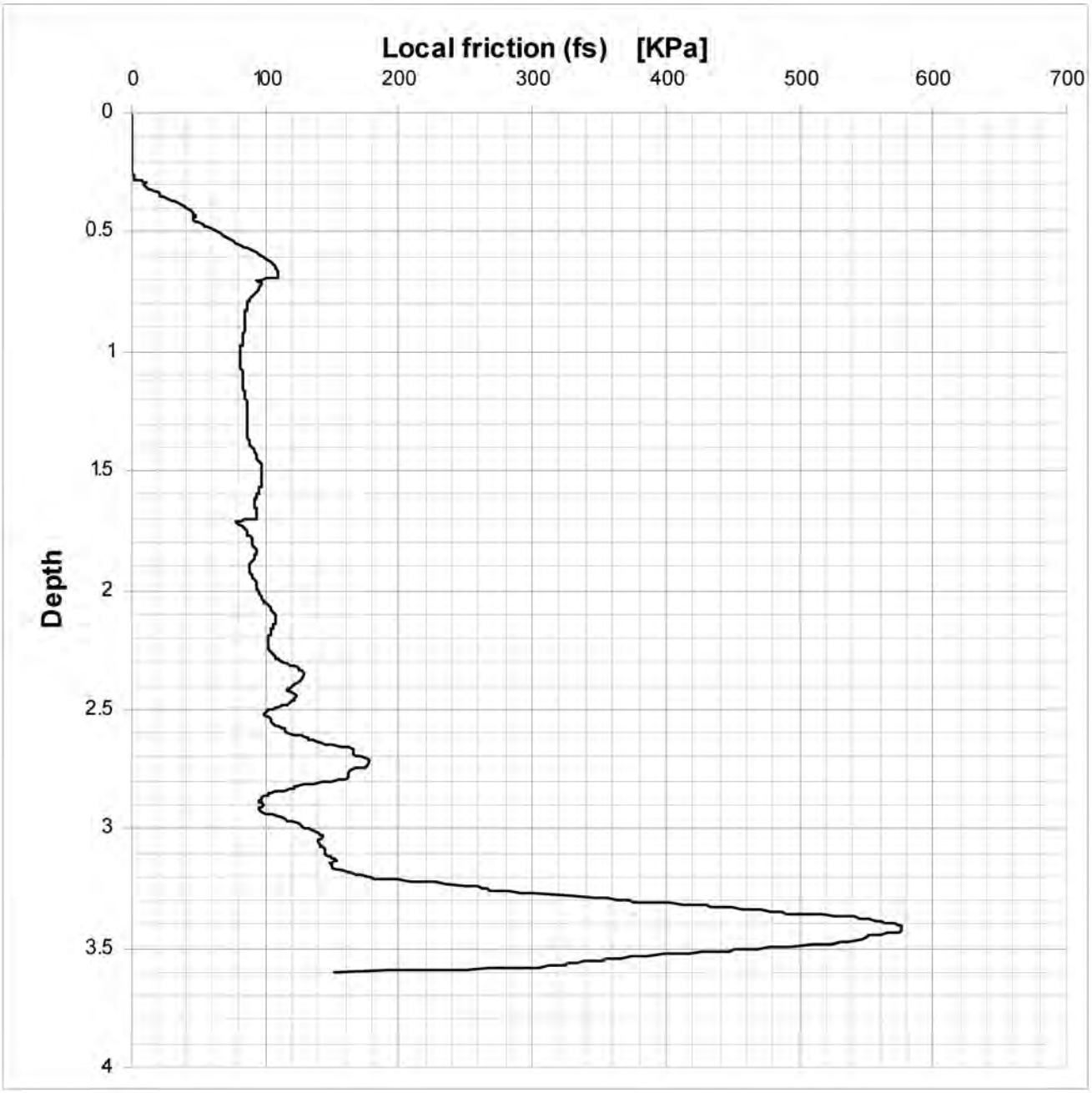
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 8

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.58



Obs. :

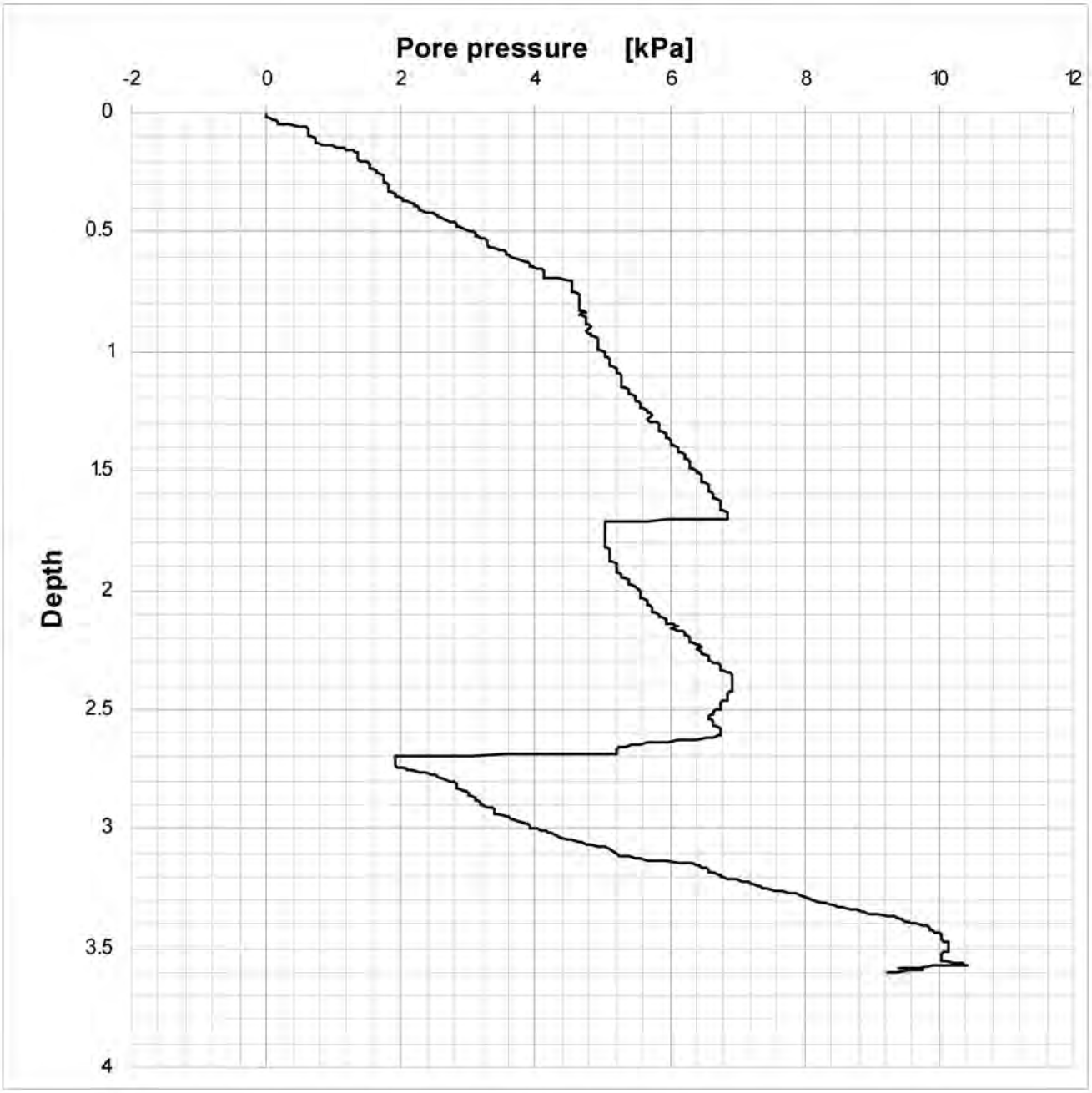
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 8

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.58



Obs. :

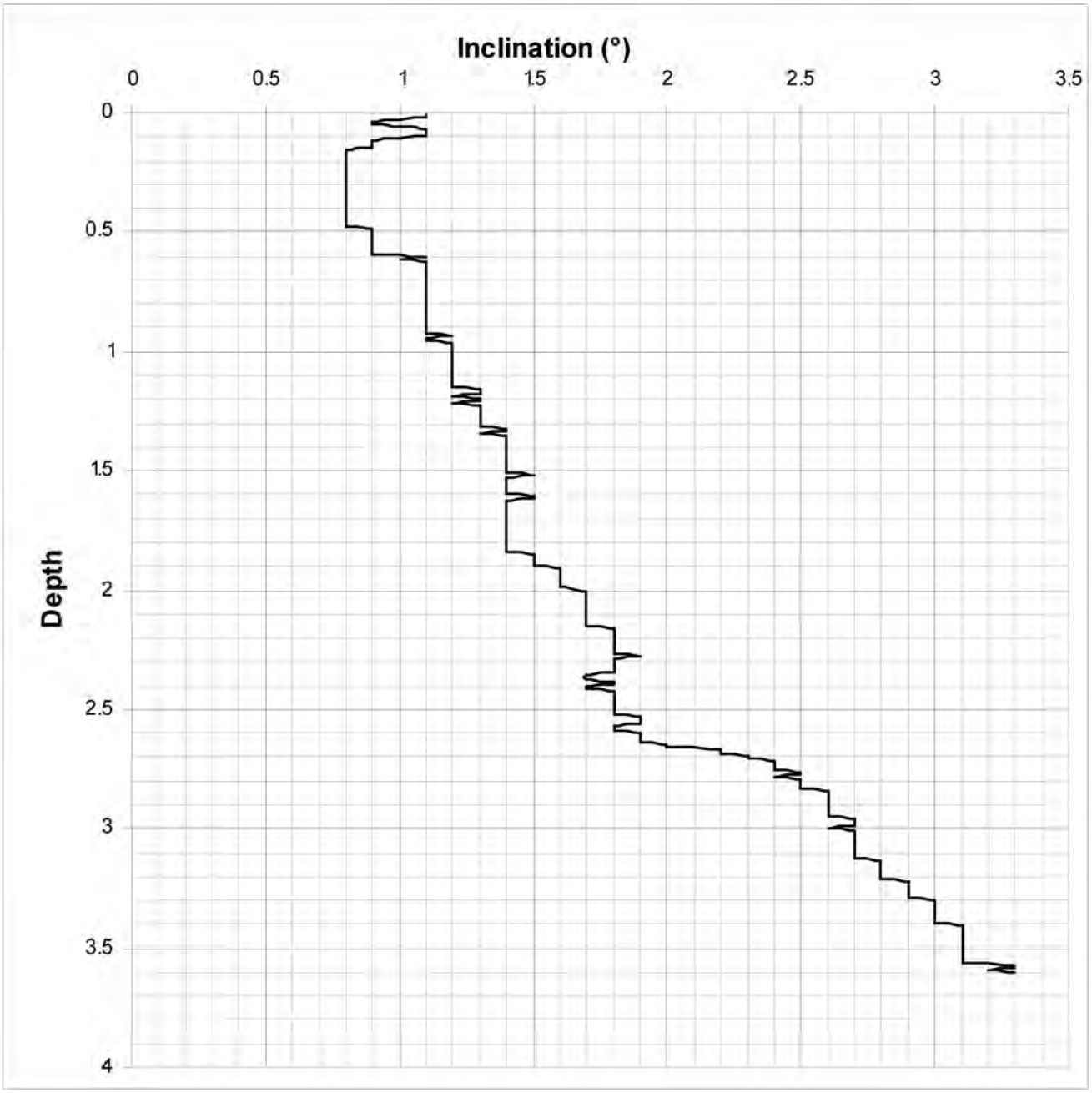
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 8

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.58



Obs. :

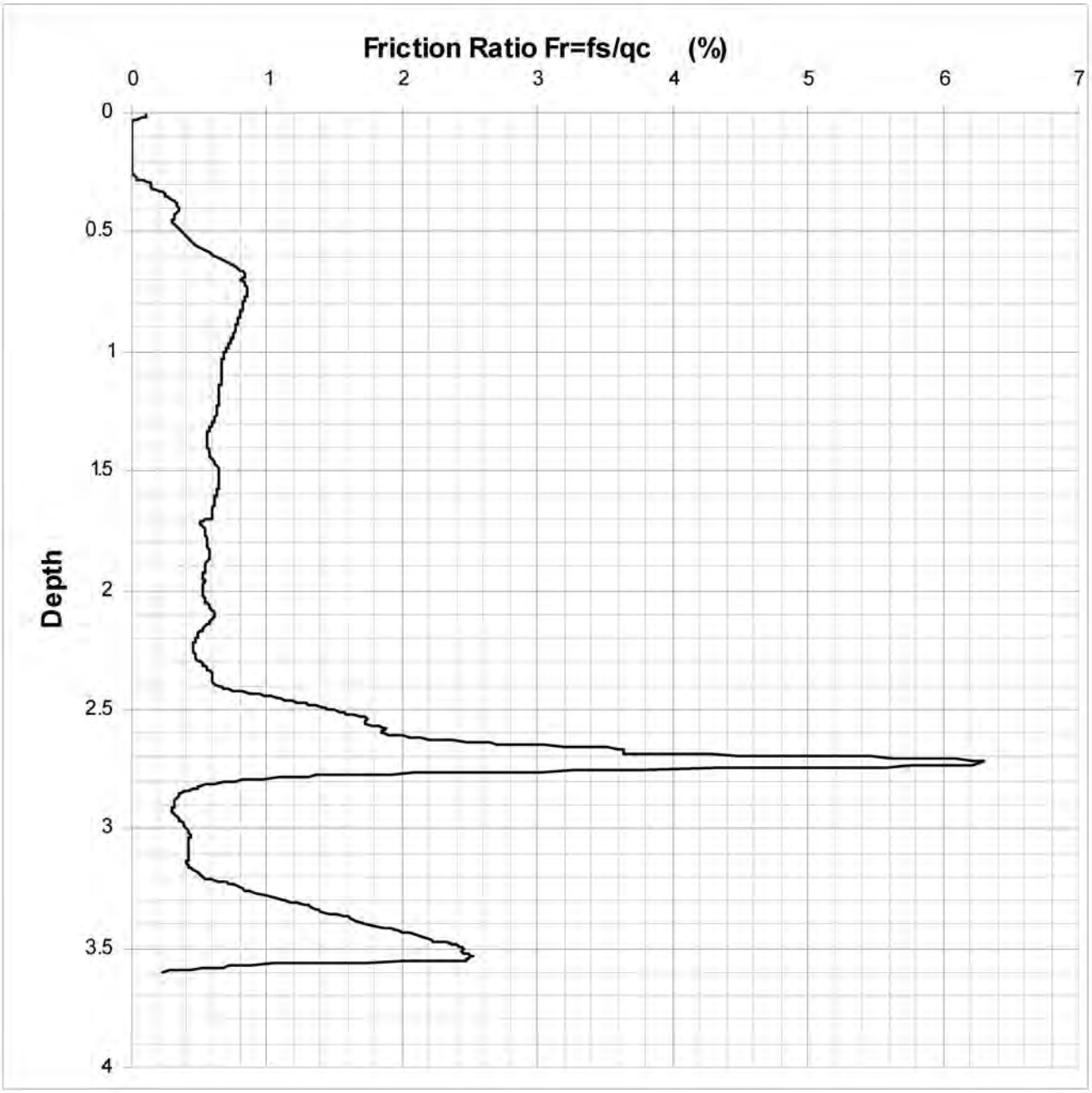
Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 Fax : 219958001 Mail : mail@geocontrole.pt

Cone Penetration Test
With Pore pressure Reading

CPTU Nº 8

Date	Entity	Job Number
11/10/2021	Start Campus	37321
	Job: Nest Data Center Sines	

M	P :	Z :	Water Level :	Depth 3.58



Obs. :

Geocontrole

GEOTECNHICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

TRIAL PIT **PC1**

Job Number **37321**

Page **1 of 1**

Initial date	Water Level
20/9/2021	
Final Date	**Dry**
20/9/2021	

System	Coordinates		Elevation	Done by
PT-TM06 (ETRS89)	M= -59944.562	P= -192191.821	Z= 17.75	Luis Sousa

DEPTH (m)	STRATIGRAPHY	SYMBOL	DESCRIPTION OF MATERIAL	SAMPLE	CLASSIFICATION UNIF. / GTR / RODOV.	CBR (95%)	Wopt (%) γ_{dm} (g/cm³)	W (%) γ_d (g/cm³)	LL LP IP (%)	% < 0.074mm	DEPTH (m)
	OS		Brown, ORGANIC, sandy soils with vegetables remains.								
				(2)							
1	PQ		Greyish, medium grain size, somewhat silty SAND.	66771	(SP-SM) A-3(0)		11.9 1.75	0.6		8	1
			Whitish, somewhat yellow, grey, fine to medium grain size, somewhat silty SAND.								
2			1.8m- END OF TRIAL PIT								2

Remarks : **- The excavation equipment capacity was achieved.**

Legend : **(2) - DISTURBED SAMPLE**

Rua D. Nuno Alvares Pereira, nº 4, Parque Oriente Bloco 4 2699-501 Bobadela LRS Portugal Tel.: (+351) 219958000 Fax: (+351) 219958001 Móvel: (+351) 963035577 E-mail: mail@geocontrole.pt

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TRIAL PIT PC1

Geocontrole

GEOTECNHICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

TRIAL PIT **PC2**

Job Number **37321**

Page **1** of **1**

Initial date	Water Level
20/9/2021	
Final Date	**Dry**
20/9/2021	

System	Coordinates		Elevation	Done by
PT-TM06 (ETRS89)	M= -59844.714	P= -192255.537	Z= 18.45	Luis Sousa

DEPTH (m)	STRATIGRAPHY	SYMBOL	DESCRIPTION OF MATERIAL	SAMPLE	CLASSIFICATION UNIF. / GTR / RODOV.	CBR (95%)	Wopt (%) γ_{dm} (g/cm³)	W (%) γ_d (g/cm³)	LL LP IP (%)	% < 0.074mm	DEPTH (m)
1	RECENT		Brown, silty sand LANDFILLS. On the top occurs with organic component.								1
	PQ		Light brown, with medium grain size, silty SAND.	(2) 66772	(SP-SM) A-2-4(0)		13.1 1.75	2.4		12	
			1.6m- END OF TRIAL PIT								
2											2

Remarks : **- The excavation equipment capacity was achieved.**

Legend : **(2) - DISTURBED SAMPLE**

Rua D. Nuno Alvares Pereira, nº 4, Parque Oriente Bloco 4 2699-501 Bobadela LRS Portugal Tel.: (+351) 219958000 Fax: (+351) 219958001 Móvel: (+351) 963035577 E-mail: mail@geocontrole.pt

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TRIAL PIT PC2

Geocontrole

GEOTECNHICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

TRIAL PIT **PC3**

Job Number **37321**

Page **1 of 1**

Initial date	Water Level
20/9/2021	
Final Date	**Dry**
20/9/2021	

System	Coordinates		Elevation	Done by
PT-TM06 (ETRS89)	M= -59717.380	P= -192336.708	Z= 18.75	Luis Sousa

DEPTH (m)	STRATIGRAPHY	SYMBOL	DESCRIPTION OF MATERIAL	SAMPLE	CLASSIFICATION UNIF. / GTR / RODOV.	CBR (95%)	Wopt (%) γ_{dm} (g/cm³)	W (%) γ_d (g/cm³)	LL LP IP (%)	% < 0.074mm	DEPTH (m)
1	RECENT		Brown, somewhat silty sandy LANDFILLS. Onthe top occurs with organic component.								1
2	PQ		Greyish brown, medium grain size silty SAND.	(2) 66773	(SP-SM) A-2-4(0)		13.9 1.73	2.0		11	2
3			2.55m- END OF TRIAL PIT								3

Remarks : **- The excavation equipment capacity was achieved.**

Legend : **(2) - DISTURBED SAMPLE**

Rua D. Nuno Alvares Pereira, nº 4, Parque Oriente Bloco 4 2699-501 Bobadela LRS Portugal Tel.: (+351) 219958000 Fax: (+351) 219958001 Móvel: (+351) 963035577 E-mail: mail@geocontrole.pt

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TRIAL PIT PC3

Geocontrole

GEOTECNHICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

TRIAL PIT **PC4**

Job Number **37321**

Page **1 of 1**

Initial date	Water Level
20/9/2021	
Final Date	**Dry**
20/9/2021	

System	Coordinates		Elevation	Done by
PT-TM06 (ETRS89)	M= -59854.394	P= -192152.622	Z= 20.43	Luis Sousa

DEPTH (m)	STRATIGRAPHY	SYMBOL	DESCRIPTION OF MATERIAL	SAMPLE	CLASSIFICATION UNIF. / GTR / RODOV.	CBR (95%)	Wopt (%) γ_{dm} (g/cm³)	W (%) γ_d (g/cm³)	LL LP IP (%)	% < 0.074mm	DEPTH (m)
	OS		Brown, ORGANIC, sandy soils with vegetables remains.								
1	PQ		Grey, medium size silty, SAND.	(2) 66774	(SP-SM) A-2-4(0)			3.6		12	1
2			Whitish yellow, fine to medium grain size, somewhat silty SAND.								2
3			3m- END OF TRIAL PIT								3

Remarks : **- The excavation equipment capacity was achieved.**

Legend : **(2) - DISTURBED SAMPLE**

Rua D. Nuno Alvares Pereira, nº 4, Parque Oriente Bloco 4 2699-501 Bobadela LRS Portugal Tel.: (+351) 219958000 Fax: (+351) 219958001 Móvel: (+351) 963035577 E-mail: mail@geocontrole.pt

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TRIAL PIT PC4

Geocontrole

GEOTECNHICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

TRIAL PIT **PC5**

Job Number **37321**

Page **1 of 1**

Initial date	Water Level
20/9/2021	
Final Date	**Dry**
20/9/2021	

System	Coordinates		Elevation	Done by
PT-TM06 (ETRS89)	M= -59621.912	P= -192262.349	Z= 21.47	Luis Sousa

DEPTH (m)	STRATIGRAPHY	SYMBOL	DESCRIPTION OF MATERIAL	SAMPLE	CLASSIFICATION UNIF. / GTR / RODOV.	CBR (95%)	Wopt (%) γ_{dm} (g/cm³)	W (%) γ_d (g/cm³)	LL LP IP (%)	% < 0.074mm	DEPTH (m)
	OS		Brown, ORGANIC, sandy soils with vegetables remains.								
1	PQ		Light brown, medium grain size, somewhat silty SAND.	(2) 66775	(SP-SM) A-3(0)		12.6 1.76	2.2		9	1
2											2
3			3m- END OF TRIAL PIT								3

Remarks : **- The excavation equipment capacity was achieved.**

Legend : **(2) - DISTURBED SAMPLE**

Rua D. Nuno Alvares Pereira, nº 4, Parque Oriente Bloco 4 2699-501 Bobadela LRS Portugal Tel.: (+351) 219958000 Fax: (+351) 219958001 Móvel: (+351) 963035577 E-mail: mail@geocontrole.pt

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TRIAL PIT PC5

Geocontrole

GEOTECNHICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

TRIAL PIT **PC6**

Job Number **37321**

Page **1 of 1**

Initial date	Water Level
20/9/2021	
Final Date	**Dry**
20/9/2021	

System	Coordinates		Elevation	Done by
PT-TM06 (ETRS89)	M= -59788.650	P= -192082.210	Z= 22.59	Luis Sousa

DEPTH (m)	STRATIGRAPHY	SYMBOL	DESCRIPTION OF MATERIAL	SAMPLE	CLASSIFICATION UNIF. / GTR / RODOV.	CBR (95%)	Wopt (%) γ_{dm} (g/cm³)	W (%) γ_d (g/cm³)	LL LP IP (%)	% < 0.074mm	DEPTH (m)
	OS		Brown, ORGANIC, sandy soils with vegetables remains.								
1	PQ		Yellowih white, fine to medium grain size, somewhat silty SAND.								1
2				(2) 66776	(SP-SM) A-3(0)		13.3 1.77	2.1		7	2
3			Light brown, medium grain size, somewhat silty SAND.								3
			3m- END OF TRIAL PIT								

Remarks : **- The excavation equipment capacity was achieved.**

Legend : **(2) - DISTURBED SAMPLE**

Rua D. Nuno Alvares Pereira, nº 4, Parque Oriente Bloco 4 2699-501 Bobadela LRS Portugal Tel.: (+351) 219958000 Fax: (+351) 219958001 Móvel: (+351) 963035577 E-mail: mail@geocontrole.pt

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TRIAL PIT PC6

Geocontrole

GEOTECNHICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

TRIAL PIT **PC7**

Job Number **37321**

Page **1 of 1**

Initial date	Water Level
20/9/2021	
Final Date	**Dry**
20/9/2021	

System	Coordinates		Elevation	Done by
PT-TM06 (ETRS89)	M= -59607.960	P= -192184.820	Z= 21.78	Luis Sousa

DEPTH (m)	STRATIGRAPHY	SYMBOL	DESCRIPTION OF MATERIAL	SAMPLE	CLASSIFICATION UNIF. / GTR / RODOV.	CBR (95%)	Wopt (%) γ_{dm} (g/cm³)	W (%) γ_d (g/cm³)	LL LP IP (%)	% < 0.074mm	DEPTH (m)
	RECENT		Brown, somewhat silty sandy LANDFILLS. Onthe top occurs with organic component.								
1	PQ		Light brown, medium grain size, somewhat silty SAND.	(2) 66777	(SP-SM) A-2-4(0)		12.8 1.76	1.7		11	1
2			As above, somewhat clayey.								2
			2.4m- END OF TRIAL PIT								

Remarks : **- The excavation equipment capacity was achieved.**

Legend : **(2) - DISTURBED SAMPLE**

Rua D. Nuno Alvares Pereira, nº 4, Parque Oriente Bloco 4 2699-501 Bobadela LRS Portugal Tel.: (+351) 219958000 Fax: (+351) 219958001 Móvel: (+351) 963035577 E-mail: mail@geocontrole.pt

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TRIAL PIT PC7

Geocontrole

GEOTECNHICAL SURVEY

Client : **Start Campus**

Job : **Nest Data Center Sines**

TRIAL PIT **PC8**

Job Number **37321**

Page **1** of **1**

Initial date	Water Level
20/9/2021	
Final Date	**Dry**
20/9/2021	

System	Coordinates		Elevation	Done by
PT-TM06 (ETRS89)	M= -59687.960	P= -192042.270	Z= 23.87	Luis Sousa

DEPTH (m)	STRATIGRAPHY	SYMBOL	DESCRIPTION OF MATERIAL	SAMPLE	CLASSIFICATION UNIF. / GTR / RODOV.	CBR (95%)	Wopt (%) γ_{dm} (g/cm³)	W (%) γ_d (g/cm³)	LL LP IP (%)	% < 0.074mm	DEPTH (m)
1	RECENT		Brown, somewhat silty sandy LANDFILLS. Onthe top occurs with organic component.								1
2	PQ		Light brown, medium grain size, somewhat silty SAND.	(2) 66778	(SP-SM) A-3(0)		13 1.75	2.6		10	2

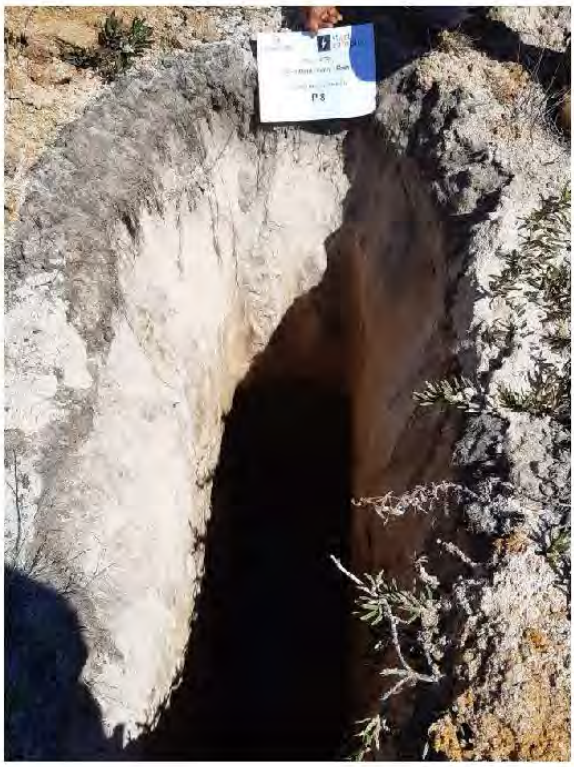
2.5m- END OF TRIAL PIT

Remarks : **- The excavation equipment capacity was achieved.**

Legend : **(2) - DISTURBED SAMPLE**

Rua D. Nuno Alvares Pereira, nº 4, Parque Oriente Bloco 4 2699-501 Bobadela LRS Portugal Tel.: (+351) 219958000 Fax: (+351) 219958001 Móvel: (+351) 963035577 E-mail: mail@geocontrole.pt

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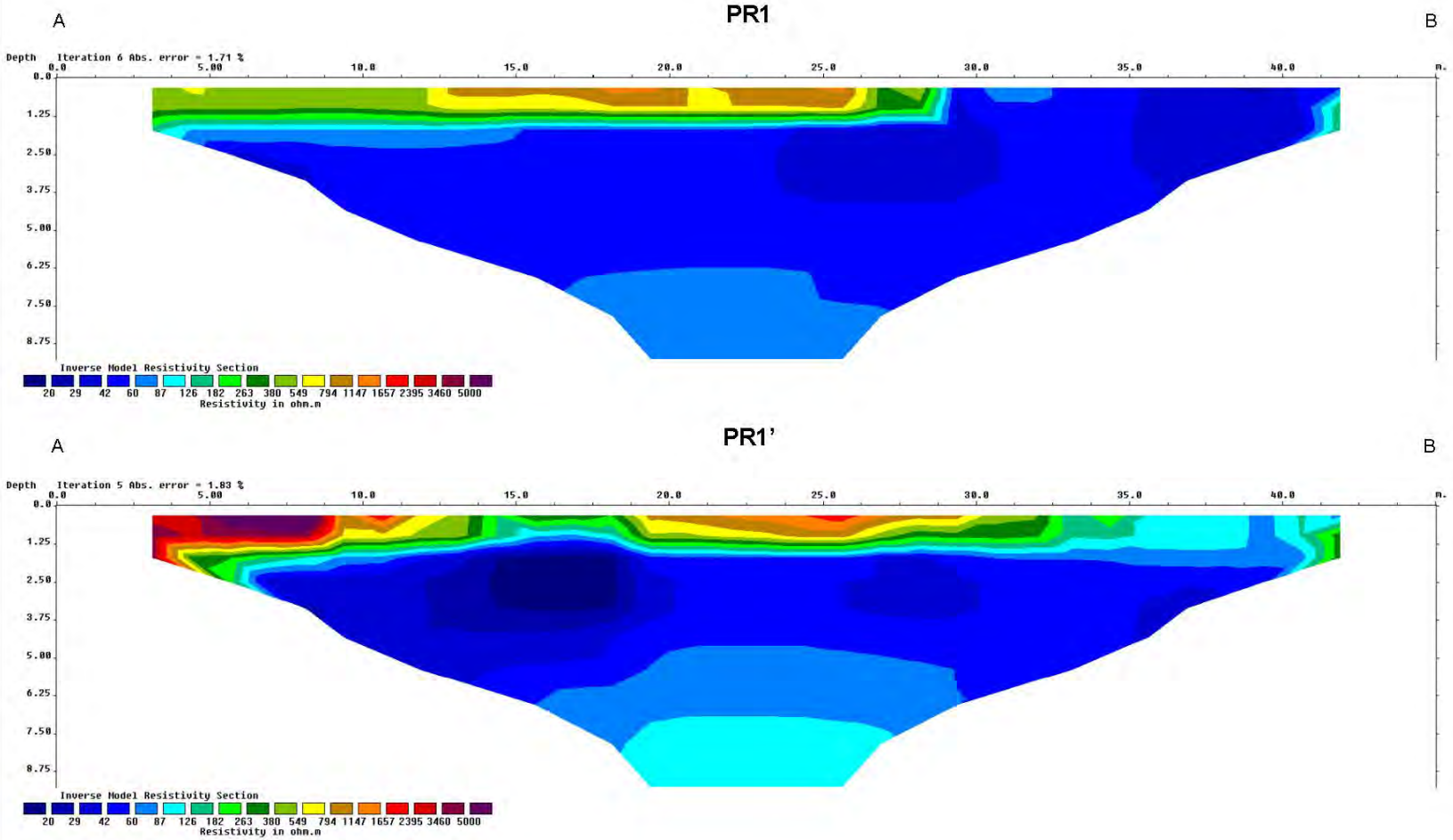


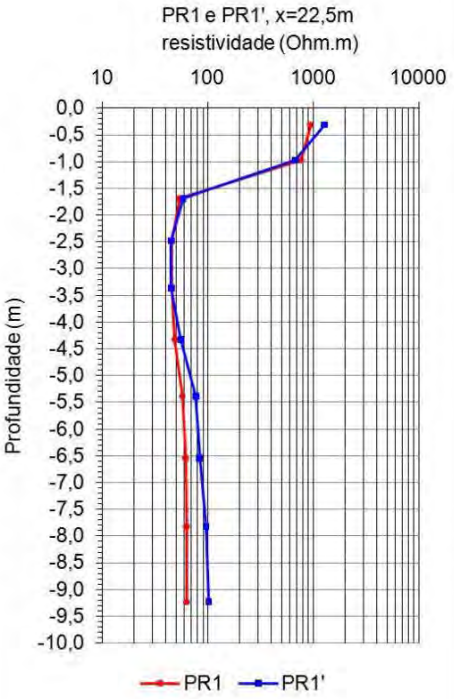




TRIAL PIT PC8

GEOPHYSICAL SURVEY USING THE ELECTRICAL RESISTIVITY METHOD		PR1		PR1'		Geocontrole
WORK:	Sines Nest Data Center	A	M= 140341 P= 107925	A	M= 140310 P= 107917	
CLIENT: Start Campus		B	M= 140318 P= 107886	B	M= 140349 P= 107894	September 2021





ELECTRICAL ARRAY	ELECTRODE SPACING	PROFILE LENGTH	PROCESSING SOFTWARE	TOMOGRAPHY SCALE	PERFORMED BY:
- Wenner -	2,5m	45m	Res2DInv	Axis graphical scale to be regarded	

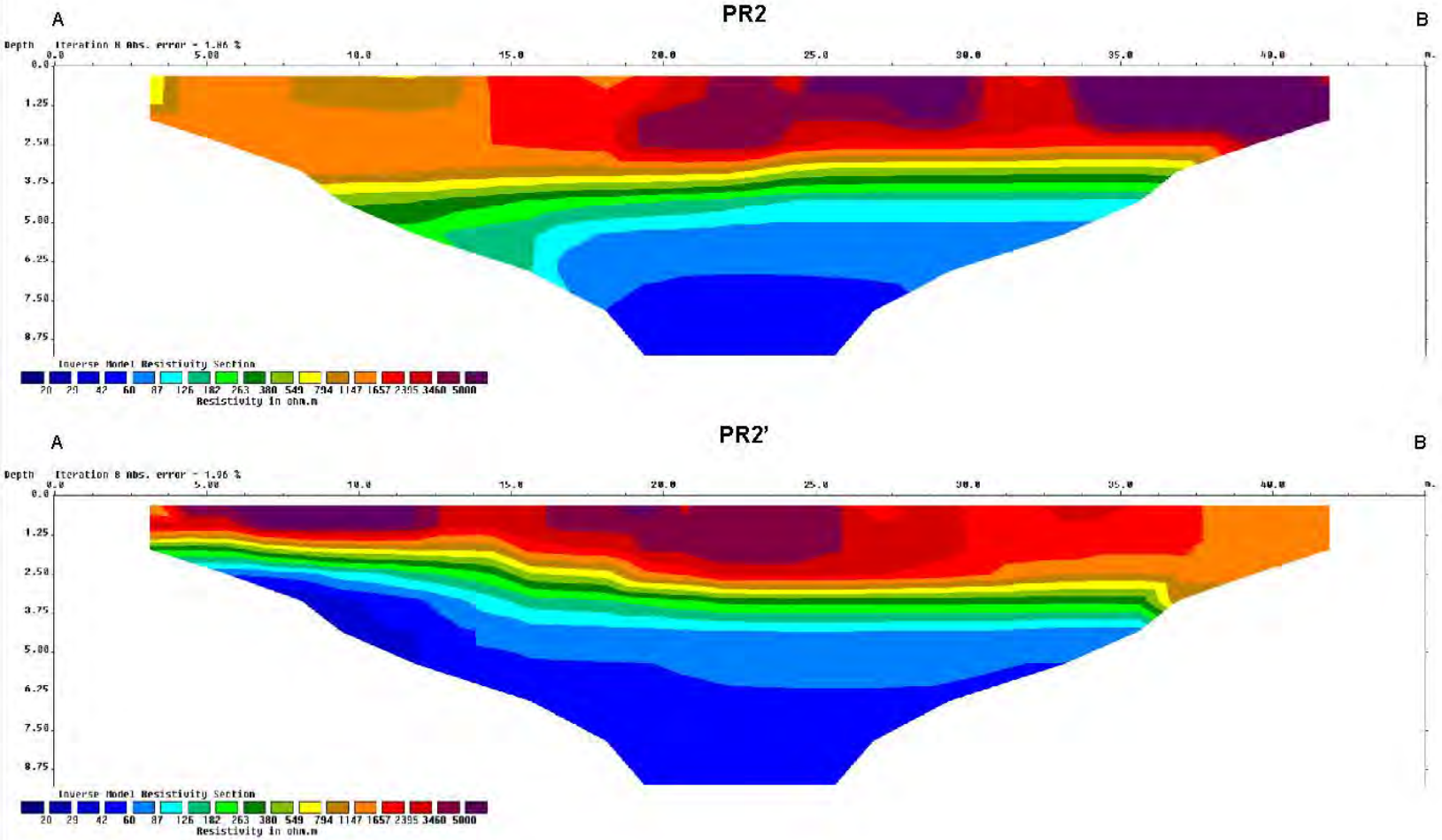
GEOPHYSICAL SURVEY USING THE ELECTRICAL RESISTIVITY METHOD

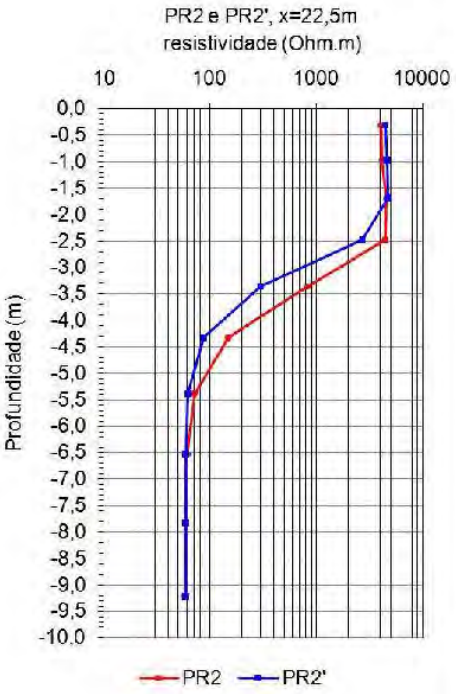
WORK:	Sines Nest Data Center
CLIENT: Start Campus	

PR2		PR2'	
A	M= 140261 P= 107874	A	M= 140230 P= 107866
B	M= 140238 P= 107835	B	M= 140269 P= 107844

Geocontrole

September 2021

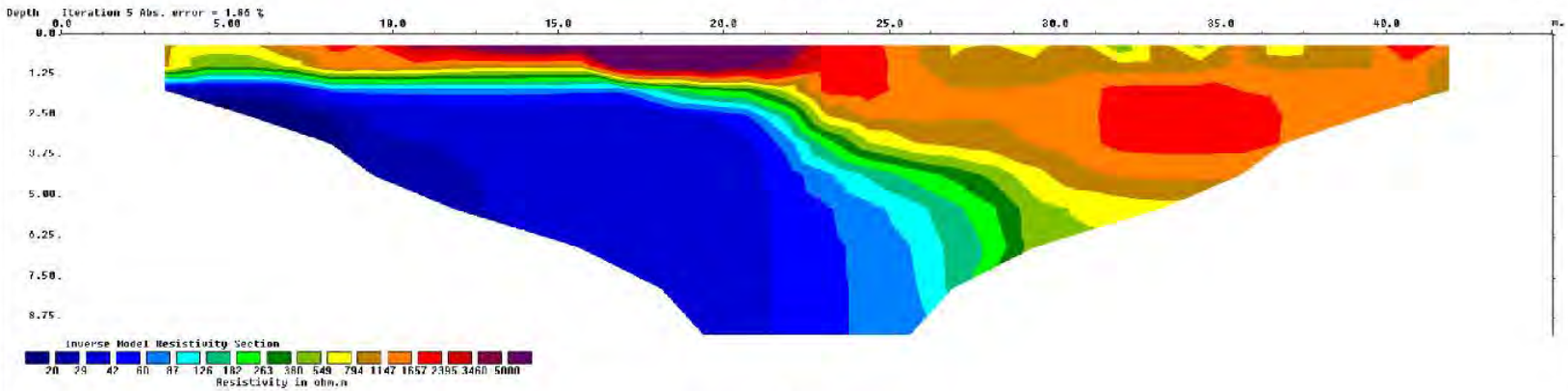




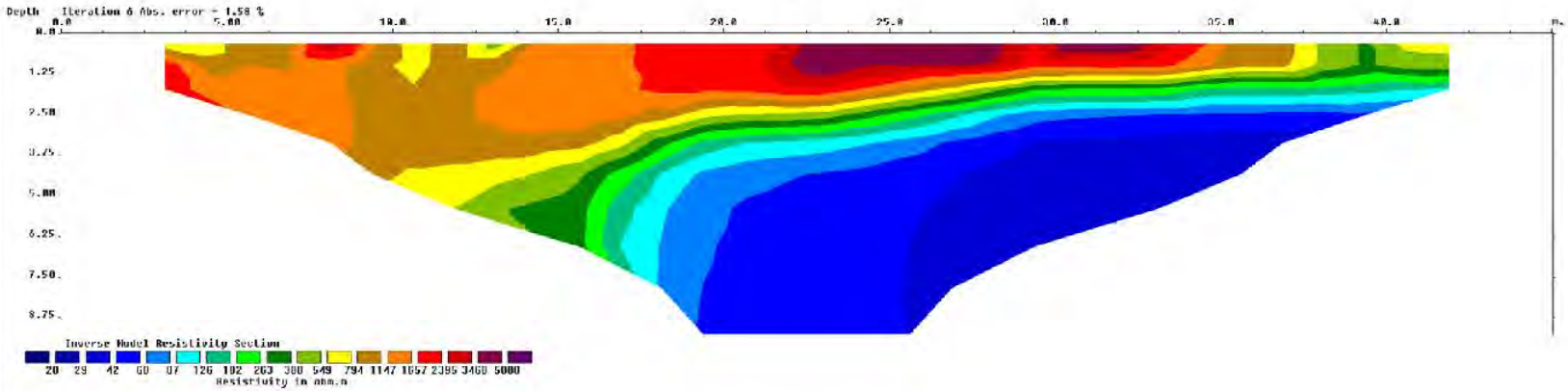
ELECTRICAL ARRAY	ELECTRODE SPACING	PROFILE LENGTH	PROCESSING SOFTWARE	TOMOGRAPHY SCALE	PERFORMED BY:
- Wenner -	2,5m	45m	Res2DInv	Axis graphical scale to be regarded	

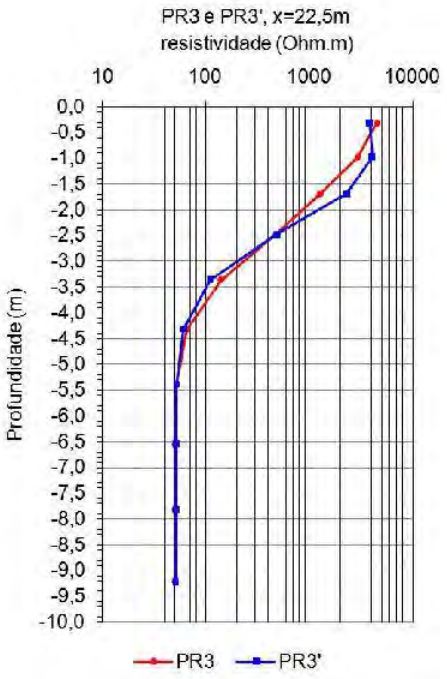
GEOPHYSICAL SURVEY USING THE ELECTRICAL RESISTIVITY METHOD		PR3		PR3'		Geocontrole
WORK:	Sines Nest Data Center	A	M= 140344 P=107834	A	M= 140313 P= 107826	
CLIENT: Start Campus		B	M= 140321 P= 107795	B	M= 140352 P= 107803	September 2021

PR3



PR3'





ELECTRICAL ARRAY	ELECTRODE SPACING	PROFILE LENGTH	PROCESSING SOFTWARE	TOMOGRAPHY SCALE	PERFORMED BY:
- Wenner -	2,5m	45m	Res2DInv	Axis graphical scale to be regarded	

GEOPHYSICAL SURVEY USING THE ELECTRICAL RESISTIVITY METHOD

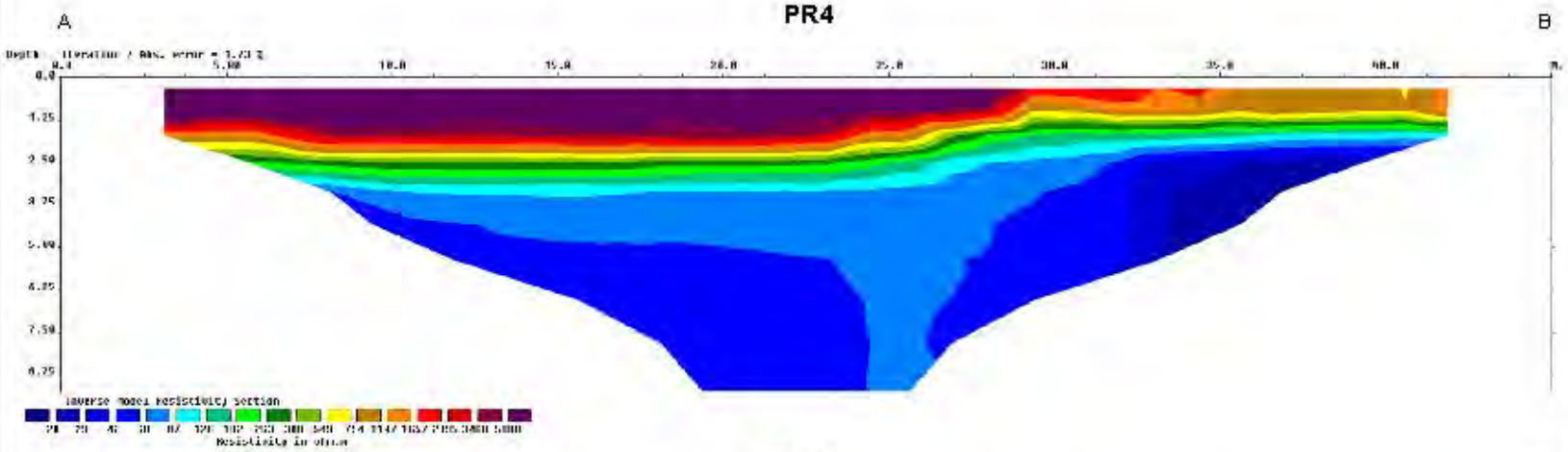
WORK:	Sines Nest Data Center

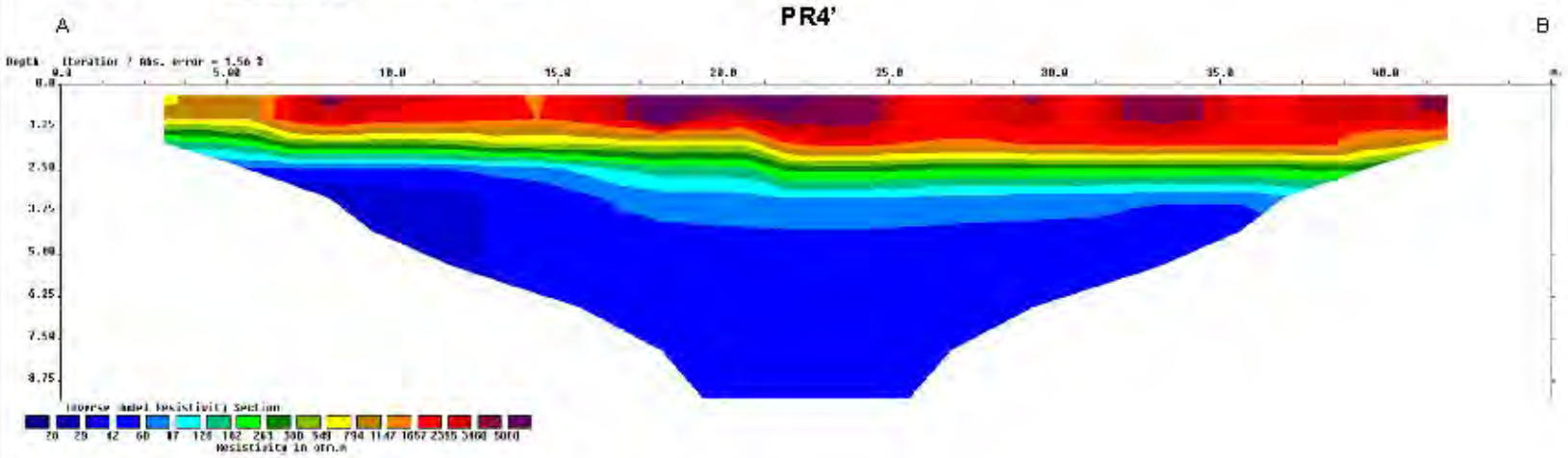
CLIENT: Start Campus

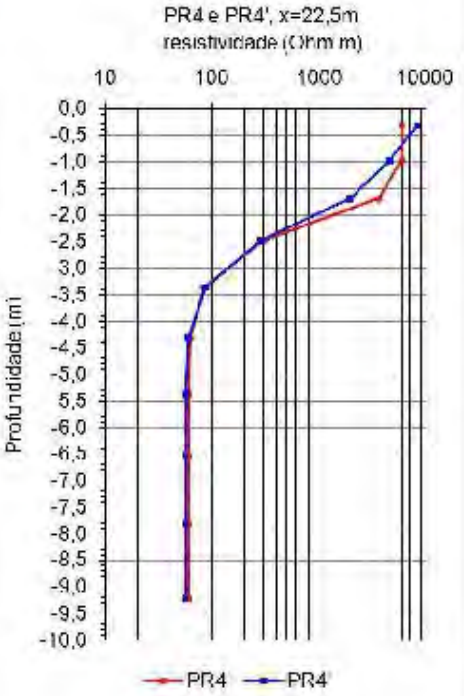
PR4		PR4'	
A	M= 140216 P= 107813	A	M= 140186 P= 107805
B	M= 140194 P= 107775	B	M= 140224 P= 107783

Geocontrole

September 2021





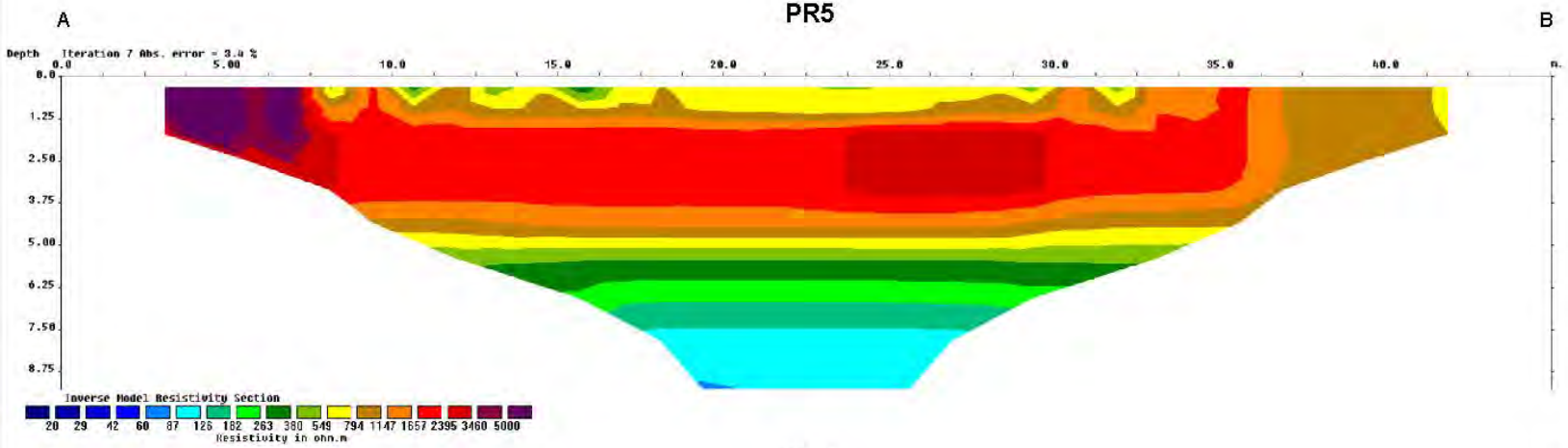


ELECTRICAL ARRAY	ELECTRODE SPACING	PROFILE LENGTH	PROCESSING SOFTWARE	TOMOGRAPHY SCALE	PERFORMED BY:
- Wenner -	2,5m	45m	Res2DInv	Axis graphical scale to be regarded	

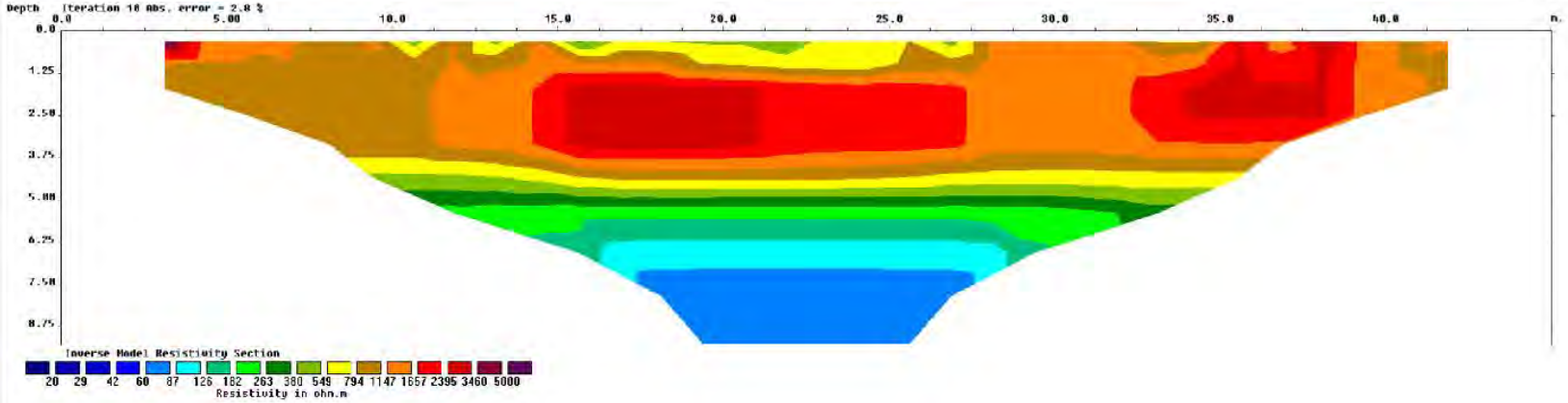
GEOPHYSICAL SURVEY USING THE ELECTRICAL RESISTIVITY METHOD		PR5		PR5'	
WORK:	Sines Nest Data Center	A	M= 140285 P= 107793	A	M= 140254 P= 107785
		B	M= 140263 P= 107754	B	M= 140293 P= 107762
CLIENT: Start Campus					September 2021

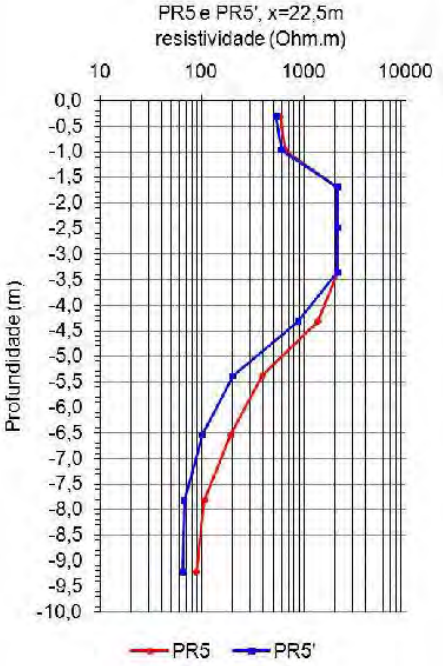
Geocontrole

PR5



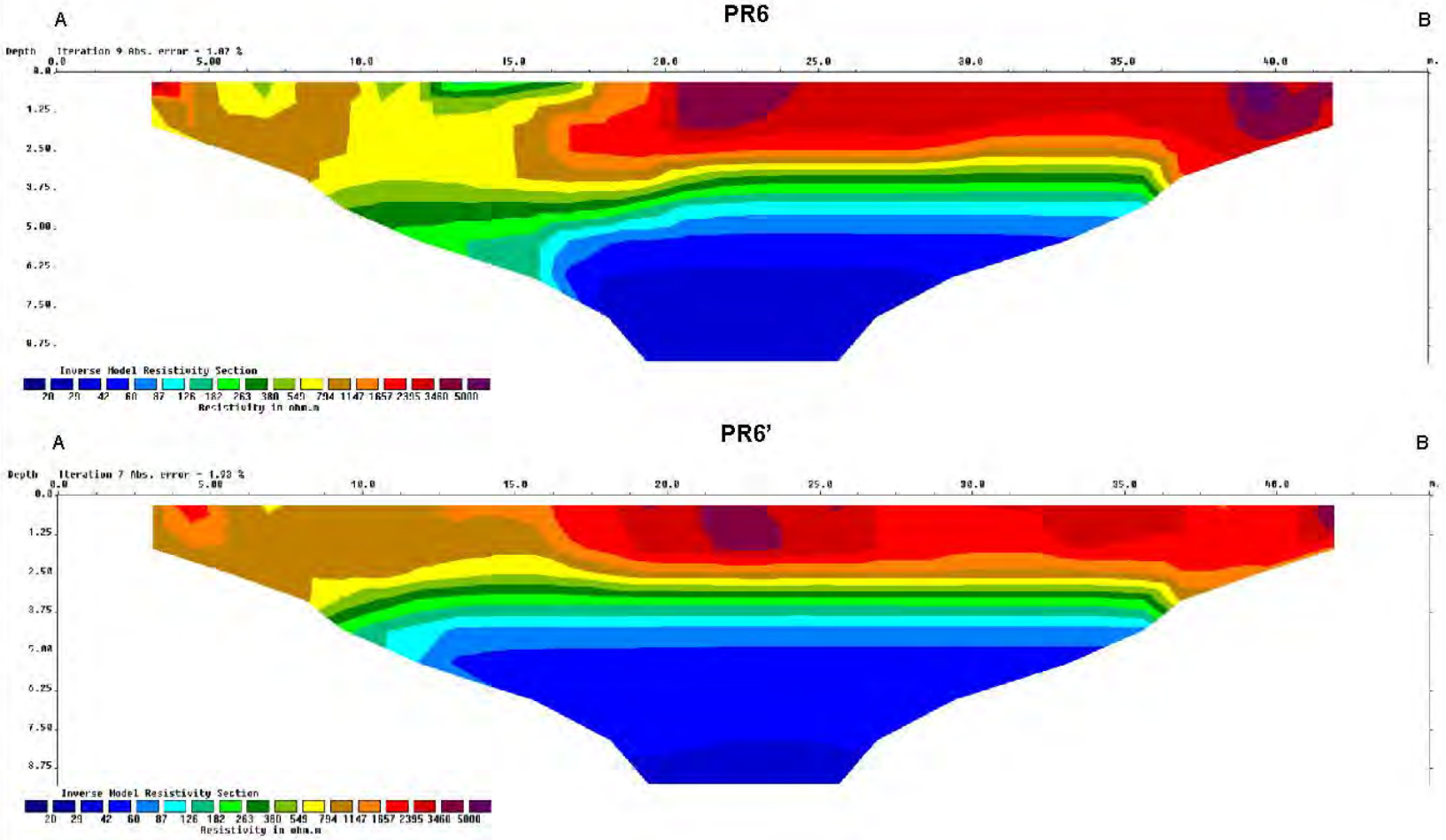
PR5'

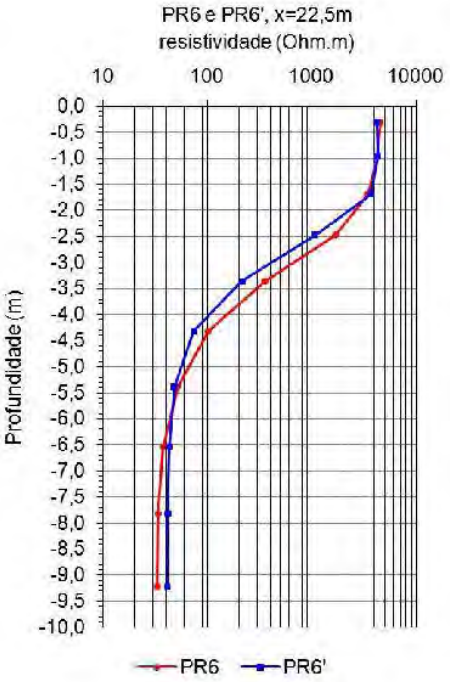




ELECTRICAL ARRAY	ELECTRODE SPACING	PROFILE LENGTH	PROCESSING SOFTWARE	TOMOGRAPHY SCALE	PERFORMED BY:
- Wenner -	2,5m	45m	Res2DInv	Axis graphical scale to be regarded	

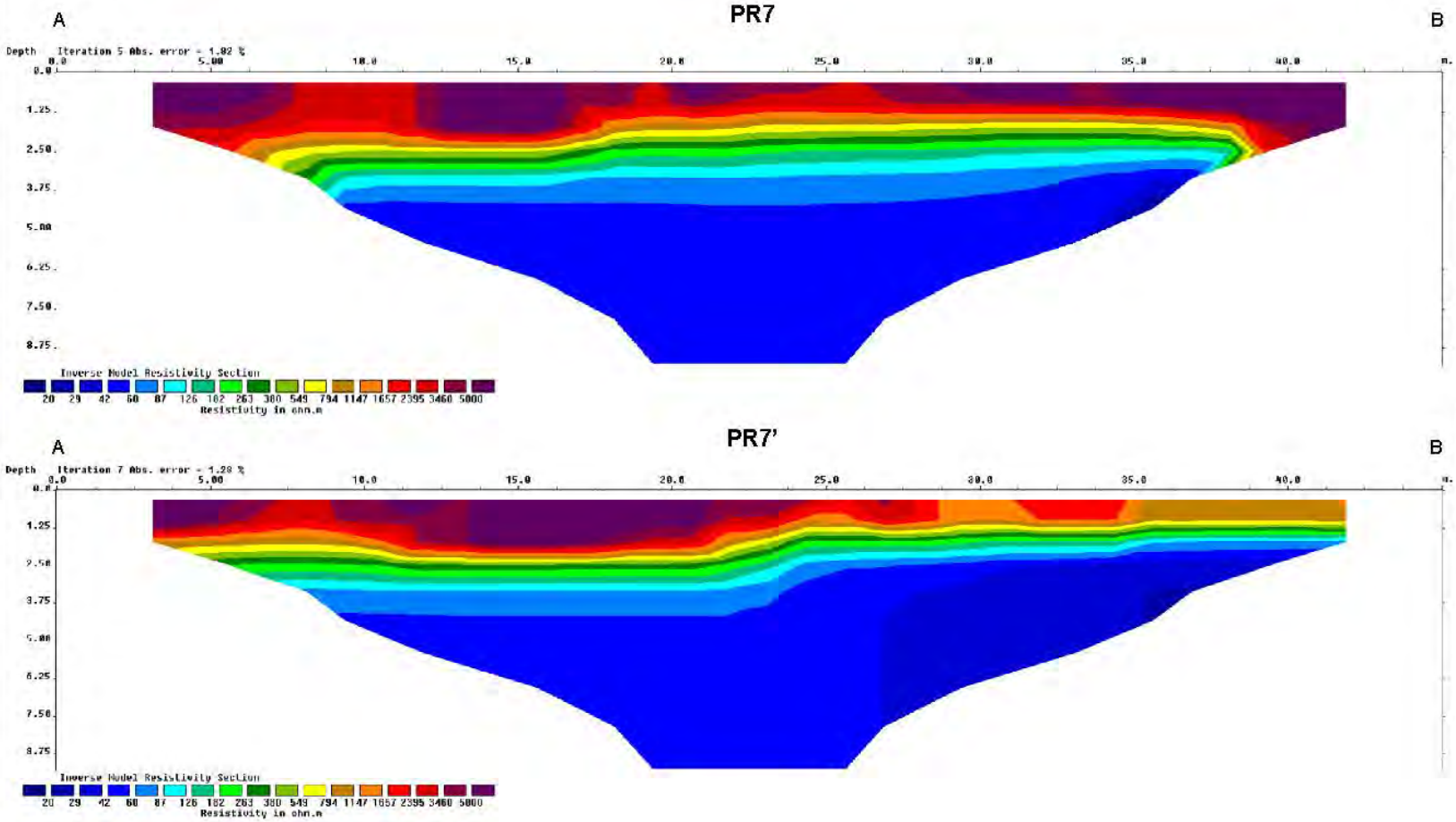
GEOPHYSICAL SURVEY USING THE ELECTRICAL RESISTIVITY METHOD		PR6		PR6'		Geocontrole
WORK:	Sines Nest Data Center	A	M = 140009 P = 107847	A	M = 139990 P = 107821	
CLIENT: Start Campus		B	M = 140015 P = 107802	B	M = 140034 P = 107827	September 2021

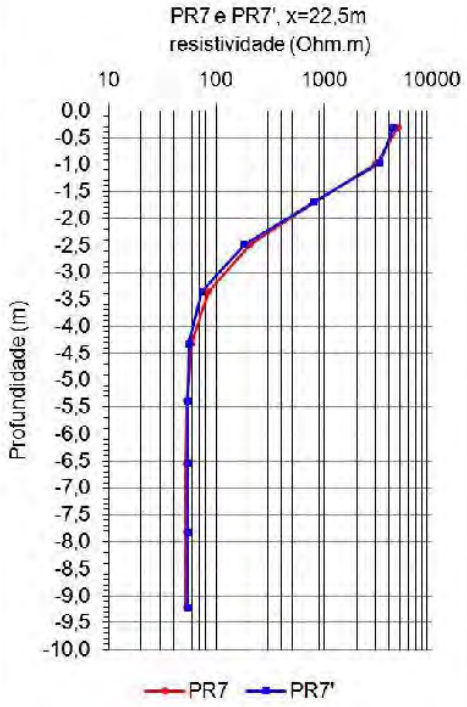




ELECTRICAL ARRAY	ELECTRODE SPACING	PROFILE LENGTH	PROCESSING SOFTWARE	TOMOGRAPHY SCALE	PERFORMED BY:
- Wenner -	2,5m	45m	Res2DInv	Axis graphical scale to be regarded	

GEOPHYSICAL SURVEY USING THE ELECTRICAL RESISTIVITY METHOD		PR7		PR7'		Geocontrole
WORK:	Sines Nest Data Center	A	M= 140162 P= 107793	A	M= 140131 P= 107785	
CLIENT: Start Campus		B	M= 140139 P= 107755	B	M= 140170 P= 107763	September 2021





ELECTRICAL ARRAY	ELECTRODE SPACING	PROFILE LENGTH	PROCESSING SOFTWARE	TOMOGRAPHY SCALE	PERFORMED BY:
- Wenner -	2,5m	45m	Res2DInv	Axis graphical scale to be regarded	

GEOPHYSICAL SURVEY USING THE ELECTRICAL RESISTIVITY METHOD

WORK:	Sines Nest Data Center

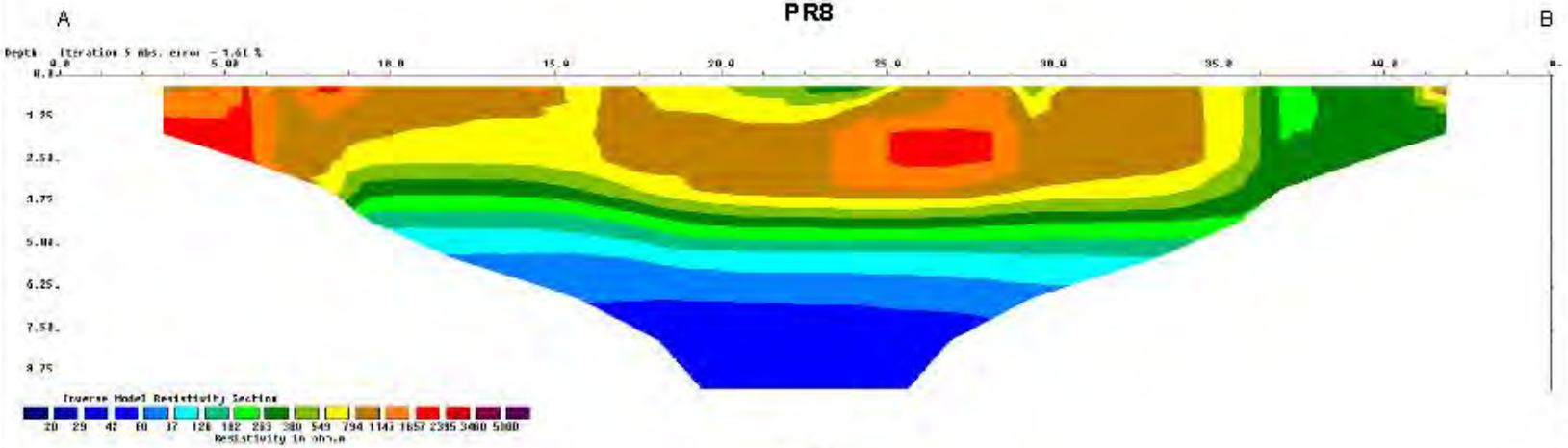
CLIENT: Start Campus

PR8		PR8'	
A	M= 140318 P= 107742	A	M= 140287 P= 107734
B	M= 140295 P= 107703	B	M= 140326 P= 107711

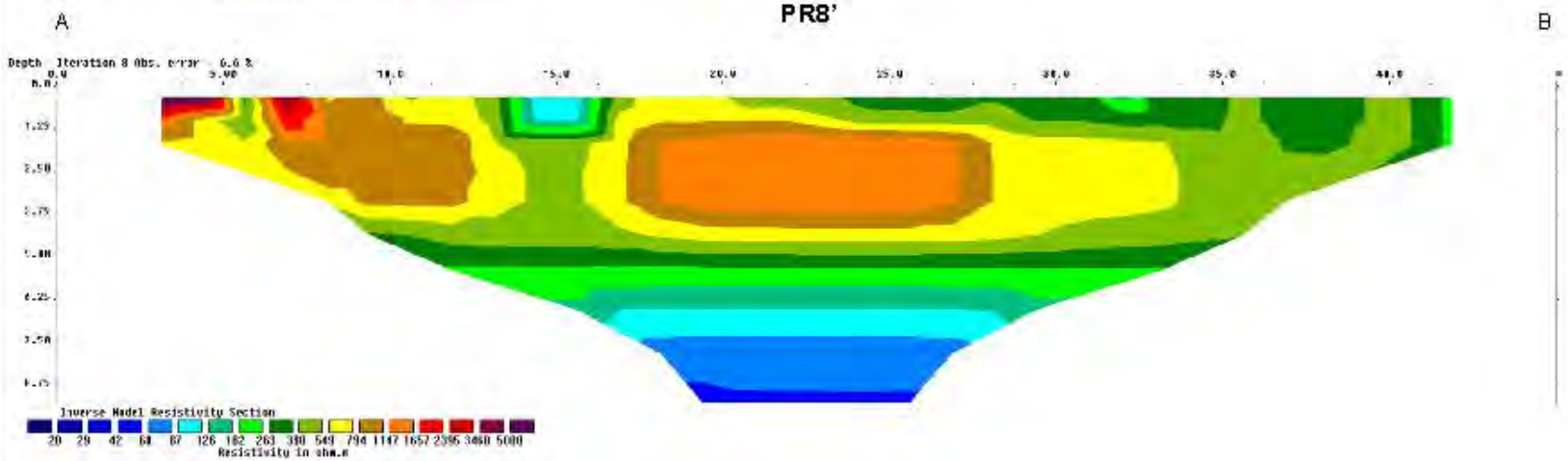
Geocontrole

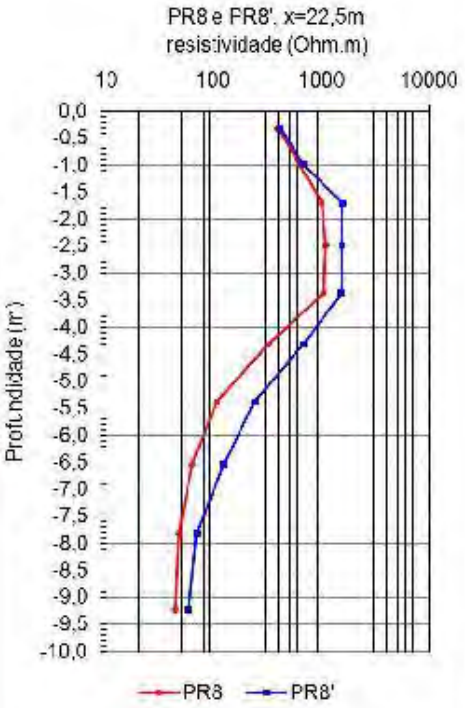
September 2021

PR8



PR8'





ELECTRICAL ARRAY	ELECTRODE SPACING	PROFILE LENGTH	PROCESSING SOFTWARE	TOMOGRAPHY SCALE	PERFORMED BY:
- Wenner -	2,5m	45m	Res2Dinv	Axis graphyical scale to be regarded	

ANNEX II – LABORATORY RESULTS

Disturbed Soil Samples: 66771 to 66778;

Water Samples: 66787 to 66790;

Geocontrole
Parque Oriente Bloco 4, EN 10, 2699-501 Bobadela LRS Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Client: Start Campus
Job: Nest Data Center Sines
Process: 37321

Sample Type : Disturbed

Laboratory Test Results

Borehole (Nº)	Sample (Nº)	Depth (m)	Description	Lit. - str.	Classif. Unified / RTR / AASHTO	W Sr SE (%)	ρ ρd (g/cm³) Dens. Part. G	L_L I_P S_L (%)	VB (g/100g) OM (%) pH	Particle size Characteristics <2.0 mm <0.42 mm (%)	<0.074 mm <0.002 mm (%)	dim. bigger part. Max. Min. (mm)	Comp. Wopt (%) γ dmax (kN/m³) Standard / Modified	CBR CR (%)	CBR Desv. Wopt (%)	CBR	CBR Expansibility (%)	CBR at 95% Penet.	Consolidation Cc eo	Cv (cm²/s) K (cm/s)	Shear Strength qu E (kPa)	σ3 σ1 (kPa)	C C' (kPa)	ϕ ϕ' (º)	Permeability Gradient I (kg/cm³) K (cm/s)
P1	66771	0.15 1.00	Greyish, slightly silty, medium grain size sand.		(SP-SM) A-3(0)	0.6		NP		100 69	8 3		11.9 1.75												
P2	66772	1.00 1.60	Light brown, silty, medium grain size sand.		(SP-SM) A-2-4(0)	2.4		NP		99 75	12 6		13.1 1.75												
P3	66773	1.60 2.55	Greyish brown, silty, medium grain size sand.		(SP-SM) A-2-4(0)	2.0		NP		98 75	11 6		13.9 1.73												
P4	66774	0.15 1.30	Greyish, silty, medium grain size sand.		(SP-SM) A-2-4(0)	3.6		NP		100 75	12 4														
P5	66775	0.30 3.00	Light brown, slightly silty, medium grain size sand.		(SP-SM) A-3(0)	2.2		NP		99 73	9 6		12.6 1.76												
P6	66776	2.20 3.00	Light brown, sligtly silty, medium grain size sand.		(SP-SM) A-3(0)	2.1		NP		98 75	7 6		13.3 1.77												
P7	66777	0.60 2.00	Light brown, slightly silty, medium grain size sand.		(SP-SM) A-2-4(0)	1.7		NP		98 70	11 6		12.8 1.76												
P8	66778	1.00 2.50	Light brown, slightly silty, medium grain size sand.		(SP-SM) A-3(0)	2.6		NP		99 75	10 6		13.0 1.75												

Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Sample Report

Process **37321** Lot **1**

Sample **66771**

Client's data

Boring **P1**

Depth **0.15 - 1.00**

Sample register date **30/09/2021**

Sample conclusion date **20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source	Site Sampling	Application

Results

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Sampling Procedure (*) (*) Efectuado Depart. Prospecção da Geocontrole **Sample Type** **DISTURBED**

Description(*) **Greyish, slightly silty, medium grain size sand.**

Classification(*) Unified (SP-SM) GTR : Highway (E 240) **A-3(0)**
ASTM (D2487-00) ASTM (D3282-97)

Ponderal feature Water content w = **0.6** % Particle Density G = ρ = g/cm³
(*) Organic matter content % (*) Ph= (*) ρ_d = g/cm³

Consistency limits Way of preparation ☒ Dry ☐ Wet LL= **NP** % PL **0** % (*) SL % (*) IP= **0**

Methylene Blue Stain test Expressed in grams of methylene blue for 100g of dry soil

Particle Size Analysis Way of preparation ☒ Dry ☐ Wet
%< 2,00 mm = **100**
%<0,420 mm = **69**
%<0,074 mm = **8**
%<0,002 mm = **3**
(*) Cu = D60/D10 = **3** (*) Cc = **1**
EA =

Expansibility (*) % Sample sujected to a load of g

Compaction (Proctor)

Mould	Test Type	γ dmax (g/cm³)	Wopt (%)
6"	**STANDARD EFFORT**	**1.75**	**11.9**

CBR

Moulding conditions						
	Cr =					%
	Deviation					%
	CBR =					%
	Expansibility					%

Coefficient (*) Fragmentability Degradability

Compressibility (*) Cc = σ_a = kN/m² e_o = Cv = m²/s K = m/s

Strenght (*) Unconfined compression test qu = kPa Ei = kPa

Direct shear test UU CU CD C = kPa θ = ° C' = kPa θ' = °

Triaxial compression UU CU CD σ_3 = kN/m² σ_1 = kN/m² C = kN/m² θ = °
Ei = kN/m² C' = kN/m² θ' = °

Permeability (*) K = m/s

(*) - The tests indicated are not included in the scope of accreditation

Comments :

The expanded uncertainty, when presented, is expressed by the standard uncertainty multiplied by the expansion factor k, corresponding to a probability of 95%.
Uncertainties are calculated according to document EA-4/02

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Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66771**

Client's data

Boring **P1**

Depth **0.15 - 1.00**

Sample register date **30/09/2021**

Test execution dates **30/09/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Water Moisture Content

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Standard : NP-84(1965)

Container	n°	**390**	**694**	**658**	
Wet sample mass + Container	m_2 g	**300.11**	**309.93**	**275.04**	
Dry sample mass + Container	m_4 g	**298.49**	**308.66**	**274.04**	
Container mass	m_1 g	**76.46**	**79.12**	**90.37**	
Water mass	m_a g	**1.62**	**1.27**	**1.00**	
Dry sample mass	m_s g	**222.03**	**229.54**	**183.67**	
Water moisture content $w = \frac{m_a}{m_s} \times 100$	%	**0.7**	**0.6**	**0.5**	

Water content average(w): 0.6 %

Table of uncertainty in each specimen

Expanded uncertainty	%	0.27	0.27	0.27	
Expansion factor k		2.00	2.00	2.00	

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66771**

Client's data

Boring **P1**

Depth **0.15 - 1.00**

Sample register date **30/09/2021**

Test execution dates **04/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Consistency limits

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

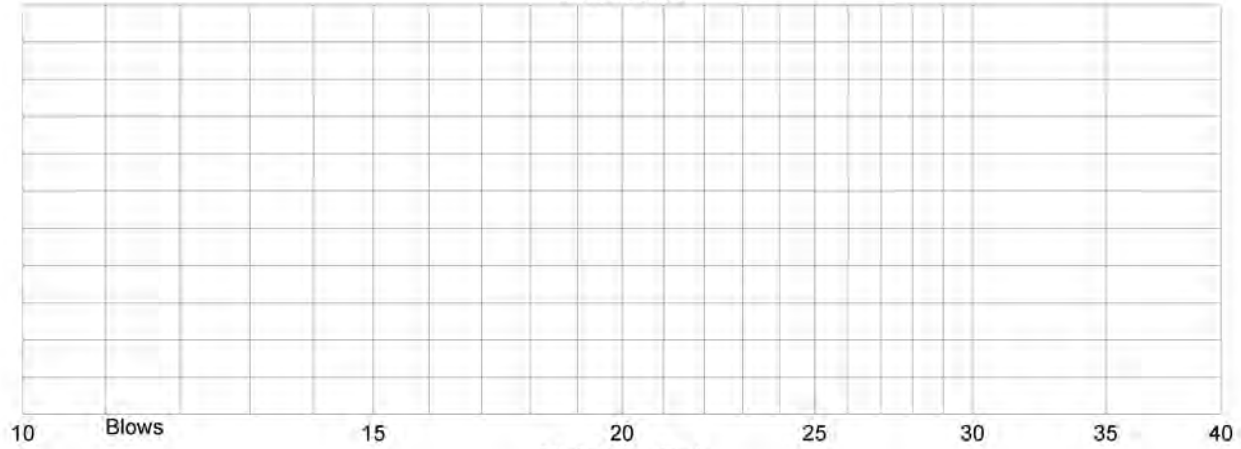
Standard : NP-143(1969)

		Liquidity limit	Plasticity limit
Container	nº		
Wet sample mass + container	g		
Dry sample mass + container	g		
Container mass	g		
Water mass	g		
Dry sample mass	g		
Water content	%		
Nr of blows			PL (Average) = %

N/P

W (%)

DIAGRAM



Shrinkage limit
(Non accredited method)

Container	**nº**					**Container volume V**	**cm^3**		
Wet sample + Container	**g**					**Quicksilver weight (1)**	**g**		
Dry sample + Container	**g**					**Dry soil volume (1)/13.55 (v)**			
Container mass	**g**					**V-v**			
Water mass	**g**					**A = V - v / Ps X 100**			
Dry sample Ps	**g**					**Shrinkage limit W-A**			
Water content W	**%**					**Shrinkage ratio Ps / v**			

LL = % **PL** % **(*) IP =**

(*) SL %

Limite de Liquidez	**Incerteza Expandida**	
	Fator de Expansão k	
Limite de Plasticidade	**Incerteza Expandida**	
	Fator de Expansão k	

(*) - Non accredited parameter

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66771**

Client's data

Boring **P1**

Depth **0.15 - 1.00**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Analysis

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196(1966) and E239(1970)

1) SIEVE ANALYSIS

Dry sample total weight : **655.70** g

COARSE ELEMENTS

Sieve designation		3 "	2 "	½ "	1"	3/4 "	3/8 "	4	10
Square shaped mesh	mm	76.1	50.8	38.1	25.4	19.0	9.51	4.76	2.00
Retained material mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.69**
Accumulated mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.69**
% Acumulados		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.11**
Complemento para 100%		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Fator de Expansão k									2.00
Incerteza Expandida									1.8

FINE ELEMENTS

Total fine elements weight used : **70.89** g

Sieve designation		20	40	60	140	200
Square shaped mesh	mm	0.841	0.420	0.250	0.105	0.074
Retained material mass	g	**1.31**	**20.44**	**25.08**	**17.41**	**1.17**
Accumulated mass	g	**1.31**	**21.75**	**46.83**	**64.24**	**65.41**
% Accumulated		**1.85**	**30.68**	**66.06**	**90.62**	**92.27**
Complement to 100%		**98.15**	**69.32**	**33.94**	**9.38**	**7.73**
% Refered to total mass		**98**	**69**	**34**	**9**	**8**
Fator de Expansão k		2.00	2.00	2.00	2.00	2.00
Incerteza Expandida		1.2	1.4	2.7	1.8	1.3

2) HYDROMETER ANALYSIS

Container nº **4**

Hydrometer nº **35**

Dispersing Agent **100** cm^3

Dry sample weight Ps **70.89** g

Particules density G= **2.64**

Corrections : Meniscus = **0.0002**

Antifloc. = **0.0002**

$$\% \text{ of particles} = \frac{G}{G-1} \times \frac{100}{Ps} \times (Lc-1) \times 10^3$$

Minutes (t)	Temperature (°C)	Densimeter value	Correction	Corrected reading (Lc)	Z (cm)	D= Z/t x K	Expanded uncertainty	Expansion factor k	% of particles	% Refer. to Total
1	**23**	**1.0019**	**0.0006**	**1.0025**	**14.11**	**0.0478**	**2.4**	**2.00**	**5.68**	**6**
2	**23**	**1.0013**	**0.0006**	**1.0019**	**14.34**	**0.0341**	**2.4**	**2.00**	**4.31**	**4**
5	**23**	**1.0013**	**0.0006**	**1.0019**	**14.34**	**0.0216**	**2.4**	**2.00**	**4.31**	**4**
15	**23**	**1.0013**	**0.0006**	**1.0019**	**14.34**	**0.0124**	**2.4**	**2.00**	**4.31**	**4**
30	**23**	**1.0013**	**0.0006**	**1.0019**	**14.34**	**0.0088**	**2.4**	**2.00**	**4.31**	**4**
60	**23**	**1.0013**	**0.0006**	**1.0019**	**14.34**	**0.0062**	**2.4**	**2.00**	**4.31**	**4**
250	**23**	**1.0011**	**0.0006**	**1.0017**	**14.42**	**0.0031**	**2.4**	**2.00**	**3.86**	**4**
1440	**23**	**1.0011**	**0.0006**	**1.0017**	**14.42**	**0.0013**	**2.4**	**2.00**	**3.86**	**4**
2880										

Comments :

Laboratory Management

Issue date: **21/10/2021**

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Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66771**

Client's data

Boring **P1**

Depth **0.15 - 1.00**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

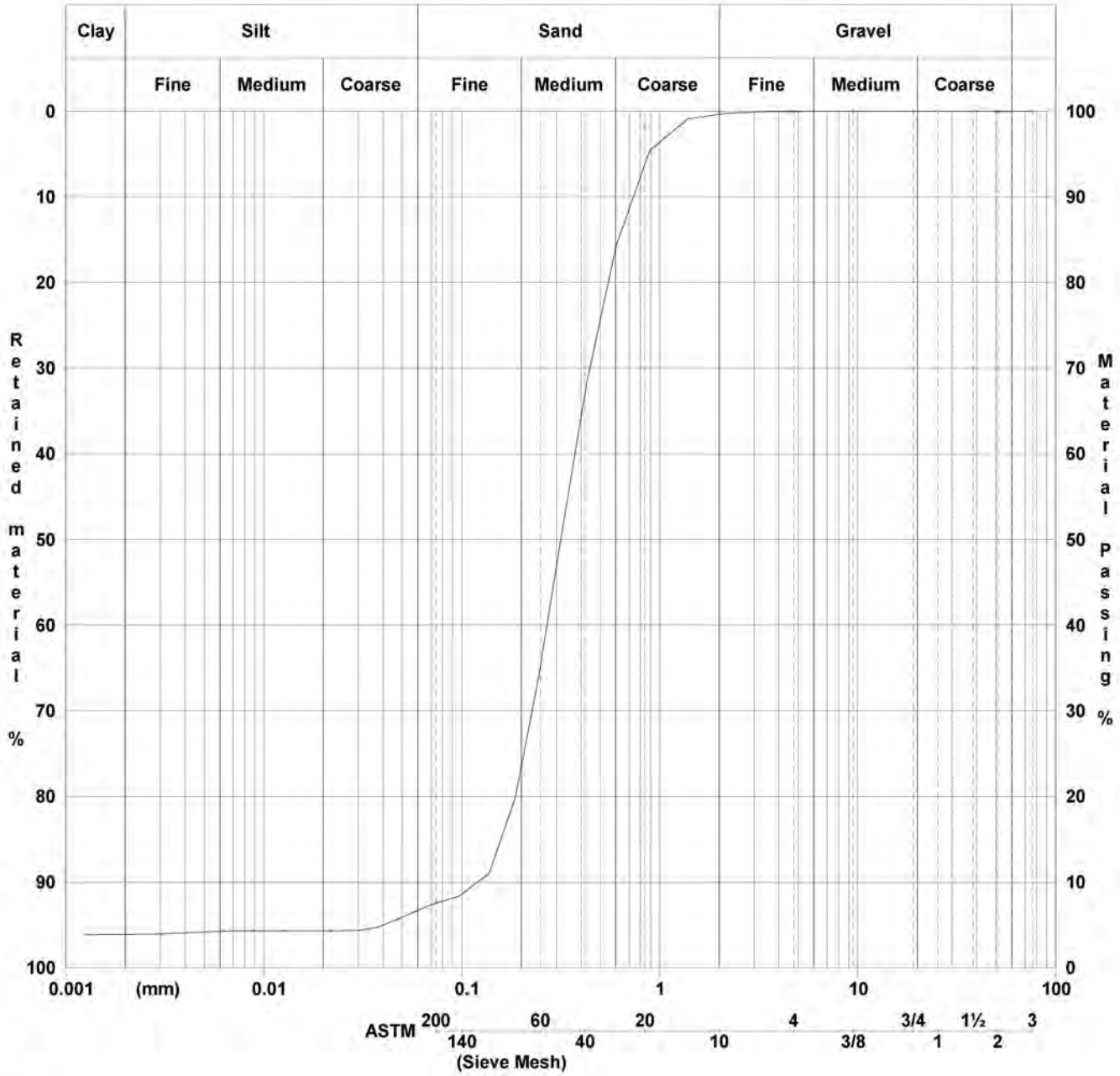
Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Distribution

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196



Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Geocontrole
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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66771**

Client's data

Boring **P1**

Depth **0.15 - 1.00**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Proctor compacting test

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type : ☐ Standard effort ☐ Modified effort

Mould : ☐ 4" ☒ 6"

Grains size less than ____ mm

Mould	(nº)	50		50		50		50		50	
Mould + wet soil	(g)	6489		6521		6565		6351		6207	
Wet soil	(g)	4026		4058		4102		3888		3744	
Wet density	($g.cm^{-3}$)	1.964		1.980		2.001		1.897		1.826	
Container	(nº)	738	298	351	727	828	818	677	678	725	668
Wet sample + container	(g)	280.33	315.22	308.65	268.63	298.30	323.32	296.20	291.78	262.14	246.65
Dry sample + container	(g)	258.37	290.93	282.15	245.49	270.27	290.60	276.76	272.41	248.63	235.39
Container mass	(g)	74.81	88.22	90.54	78.87	90.92	89.34	78.40	77.60	77.13	79.71
Water mass	(g)	21.96	24.29	26.50	23.14	28.03	32.72	19.44	19.37	13.51	11.26
Dry sample mass	(g)	183.56	202.71	191.61	166.62	179.35	201.26	198.36	194.81	171.50	155.68
Water moisture content	(%)	12.0	12.0	13.8	13.9	15.6	16.3	9.8	9.9	7.9	7.2

Water moisture content average	(%)	12.0	13.9	16.0	9.9	7.6
Dry density	($g.cm^{-3}$)	1.754	1.738	1.725	1.726	1.697

Table of uncertainty in each mould

Expanded uncertainty	%	0.015	0.015	0.015	0.015	0.015
Expansion factor k		2.00	2.00	2.00	2.00	2.00

(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Comments :

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Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66771**

Client's data

Boring **P1**

Depth **0.15 - 1.00**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source	Site Sampling	Application

Compacting curve

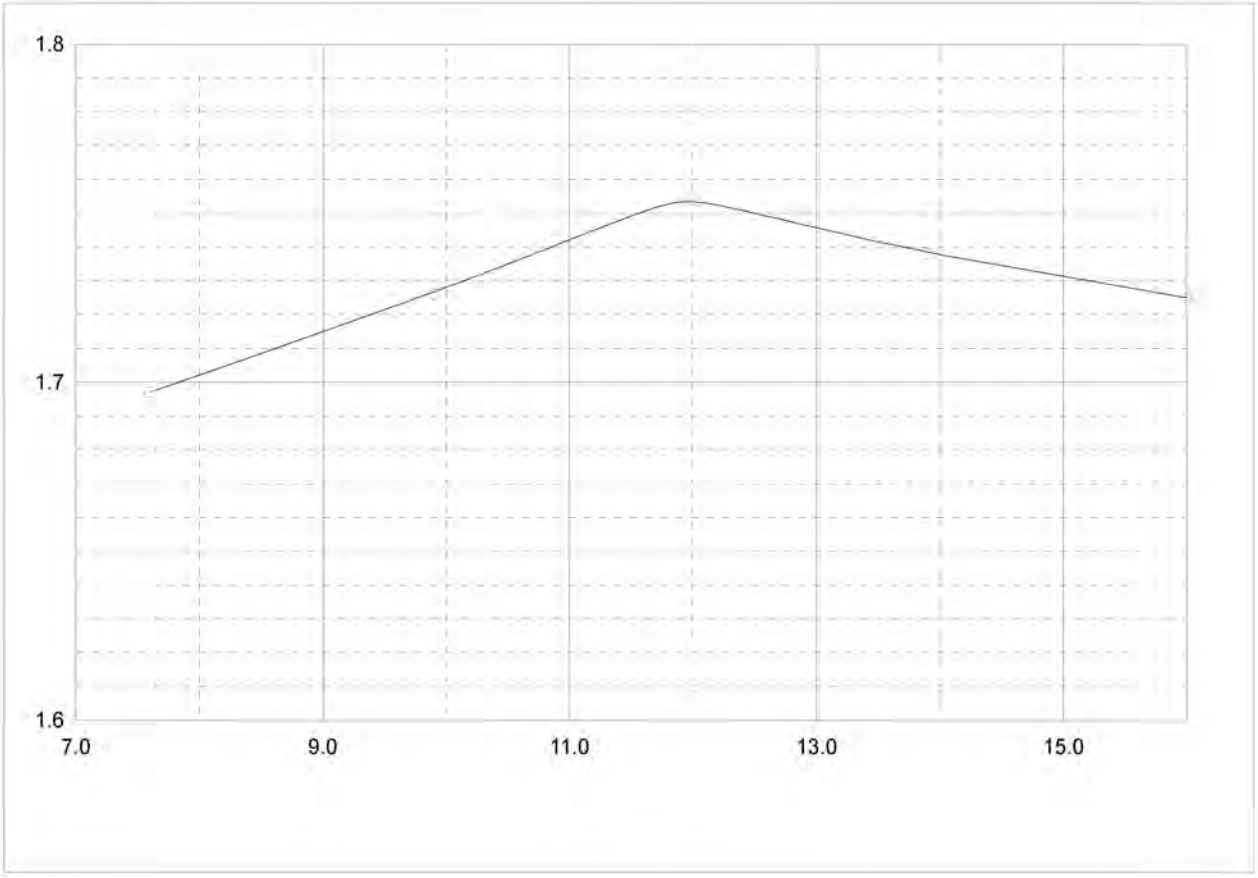
IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type ☒ Standard effort ☐ Modified effort

Mould ☐ 4" ☒ 6"

Grains size less than ____ mm



(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Table of uncertainty	Expansion factor k	Expanded uncertainty %
Optimum water moisture content	**2.00**	**0.28**
Maximum dry density	**2.00**	**0.026**

Optimum water moisture content Wopt = **11.9** %

Maximum dry density γ dmax = **1.75** g.cm^{-3}

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Geocontrole

Ensaio de Condutividade Térmica

Projecto:	Sines Nest Data Center	
Cliente:	STAR T CAMPUS	Data do ensaio: 15-10-2021

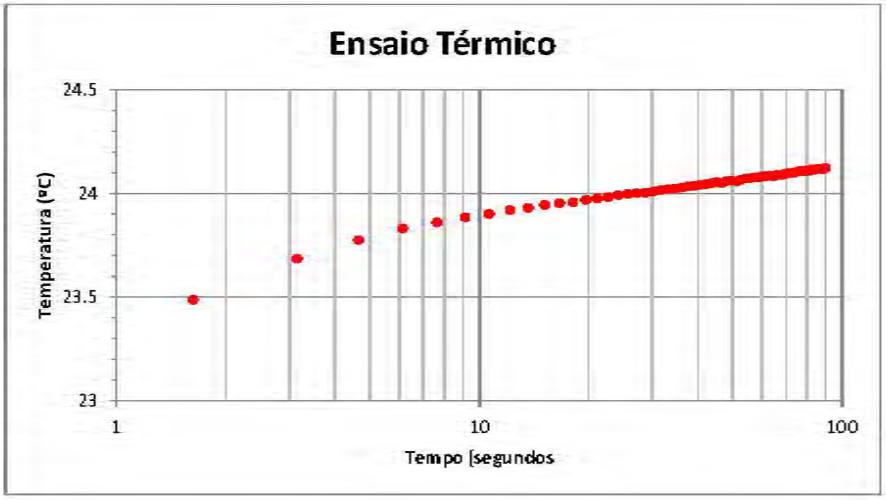
Equipmento:	Thermtest - TLS-100 Portatable Meter*				Coordenadas(ETRS89):
TLS sonda:	[x]	100 mm	[ ]	50 mm	M:
Tipo Amostra	[ ]	Não deformada	[x]	Moldada	P:
Método cravação	[x]	Pressão manual	[ ]	Pré-furo	*Calibrado de fabrica de acordo com a norma ISO22007-2:2015 TPS Measurements

Descrição da Amostra: areia média a fina quartzosa, de tons amarelados a acinzentados

TLS-100 Medições

Poço Ref.	P1
Amostra Ref.	66771
Ensaio Térmico Ref.	Amostra 7
Profundidade amostra [m]	0.15 - 1.00
Heating Power [W/m]	3.919
Temperatura da amostra [ºC]	23.105
k [W/m.K]	9.138
R [m.K/W]	0.109

Temperatura versus tempo - gráfico semi-log da amostra



* Procedimento realizado de acordo com a norma ASTM D5334 & IEEE 442-1981

Registo fotográfico da realização do ensaio



Observações:	Amostras em molde compactado a 95% do Proctor, no teor de humidade óptimo.			
Data: 18/10/2021	Local:	Lisboa	Realizado por:	Figueiredo. H

Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Sample Report

Process **37321** Lot **1**

Sample **66772**

Client's data

Boring **P2**

Depth **1.00 - 1.60**

Sample register date **30/09/2021**

Sample conclusion date **20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source	Site Sampling	Application

Results

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Sampling Procedure (*) (*) Efectuado Depart. Prospecção da Geocontrole **Sample Type** **DISTURBED**

Description(*) **Light brown, silty, medium grain size sand.**

Classification(*) Unified **(SP-SM)** GTR : Highway (E 240) **A-2-4(0)**
ASTM (D2487-00) ASTM (D3282-97)

Ponderal feature Water content w = **2.4** % Particle Density G = ρ = g/cm³
(*) Organic matter content % (*) Ph= (*) ρ_d = g/cm³

Consistency limits Way of preparation ☒ Dry ☐ Wet LL= **NP** % PL **0** % (*) SL % (*) IP= **0**

Methylene Blue Stain test Expressed in grams of methylene blue for 100g of dry soil

Particle Size Analysis Way of preparation ☒ Dry ☐ Wet
%< 2,00 mm = **99**
%<0,420 mm = **75**
%<0,074 mm = **12**
%<0,002 mm = **6**
(*) Cu = D60/D10 = **6** (*) Cc = **2**
EA =

Expansibility (*) % Sample sujected to a load of g

Compaction (Proctor)

Mould	Test Type	γ dmax (g/cm³)	Wopt (%)
6"	**STANDARD EFFORT**	**1.75**	**13.1**

CBR

Moulding conditions						
	Cr =					%
	Deviation					%
	CBR =					%
	Expansibility					%

Coefficient (*) Fragmentability Degradability

Compressibility (*) Cc = σ_a = kN/m² e_o = Cv = m²/s K = m/s

Strenght (*) Unconfined compression test qu = kPa Ei = kPa

Direct shear test UU CU CD C = kPa θ = ° C' = kPa θ' = °

Triaxial compression UU CU CD
σ_3 = kN/m² C = kN/m² θ = °
σ_1 = kN/m²
Ei = kN/m² C' = kN/m² θ' = °

Permeability (*) K = m/s

(*) - The tests indicated are not included in the scope of accreditation

Comments :

The expanded uncertainty, when presented, is expressed by the standard uncertainty multiplied by the expansion factor k, corresponding to a probability of 95%.
Uncertainties are calculated according to document EA-4/02

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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66772**

Client's data

Boring **P2**

Depth **1.00 - 1.60**

Sample register date **30/09/2021**

Test execution dates **30/09/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Water Moisture Content

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Standard : NP-84(1965)

Container	n°	**667**	**649**	**311**	
Wet sample mass + Container	m_2 g	**274.45**	**246.87**	**255.22**	
Dry sample mass + Container	m_4 g	**270.07**	**242.96**	**251.09**	
Container mass	m_1 g	**89.70**	**77.54**	**78.27**	
Water mass	m_a g	**4.38**	**3.91**	**4.13**	
Dry sample mass	m_s g	**180.37**	**165.42**	**172.82**	
Water moisture content $w = \frac{m_a}{m_s} \times 100$	%	**2.4**	**2.4**	**2.4**	

Water content average(w): 2.4 %

Table of uncertainty in each specimen

Expanded uncertainty	%	0.27	0.27	0.27	
Expansion factor k		2.00	2.00	2.00	

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

This test report can only be reproduced totally or partially with Geocontrole express authorization. The results are referring to the tested sample.

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Test Report

Process **37321** Lot **1**

Sample **66772**

Client's data

Boring **P2**

Depth **1.00 - 1.60**

Sample register date **30/09/2021**

Test execution dates **04/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Consistency limits

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

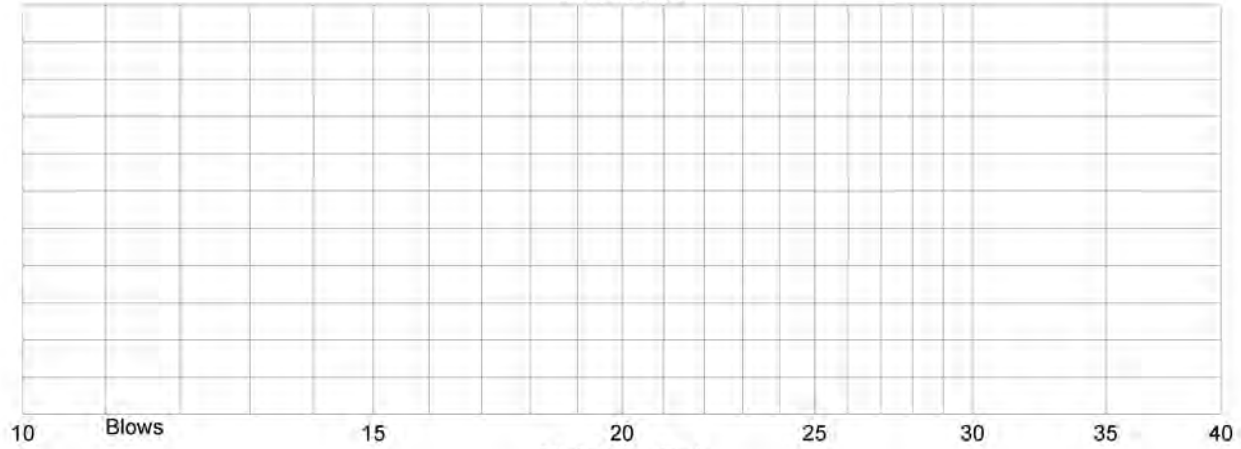
Standard : NP-143(1969)

		Liquidity limit	Plasticity limit
Container	nº		
Wet sample mass + container	g		
Dry sample mass + container	g		
Container mass	g		
Water mass	g		
Dry sample mass	g		
Water content	%		
Nr of blows			PL (Average) = %

N/P

W (%)

DIAGRAM



Shrinkage limit
(Non accredited method)

Container	**nº**					**Container volume V**	**cm^3**				
Wet sample + Container	**g**					**Quicksilver weight (1)**	**g**				
Dry sample + Container	**g**					**Dry soil volume (1)/13.55 (v)**					
Container mass	**g**					**V-v**					
Water mass	**g**					**A = V - v / Ps X 100**					
Dry sample Ps	**g**					**Shrinkage limit W-A**					
Water content W	**%**					**Shrinkage ratio Ps / v**					

LL = % **PL** % **(*) IP =**

(*) SL %

Limite de Liquidez	**Incerteza Expandida**	
	Fator de Expansão k	
Limite de Plasticidade	**Incerteza Expandida**	
	Fator de Expansão k	

(*) - Non accredited parameter

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66772**

Client's data

Boring **P2**

Depth **1.00 - 1.60**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Analysis

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196(1966) and E239(1970)

1) SIEVE ANALYSIS

Dry sample total weight : **968.00** g

COARSE ELEMENTS

Sieve designation		3 "	2 "	½ "	1"	3/4 "	3/8 "	4	10
Square shaped mesh	mm	76.1	50.8	38.1	25.4	19.0	9.51	4.76	2.00
Retained material mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.05**	**6.08**
Accumulated mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.05**	**7.13**
% Acumulados		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.11**	**0.74**
Complemento para 100%		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**99**
Fator de Expansão k								2.00	2.00
Incerteza Expandida								2.6	1.8

FINE ELEMENTS

Total fine elements weight used : **71.20** g

Sieve designation		20	40	60	140	200
Square shaped mesh	mm	0.841	0.420	0.250	0.105	0.074
Retained material mass	g	**4.33**	**13.22**	**20.98**	**22.69**	**1.59**
Accumulated mass	g	**4.33**	**17.55**	**38.53**	**61.22**	**62.81**
% Accumulated		**6.08**	**24.65**	**54.12**	**85.98**	**88.22**
Complement to 100%		**93.92**	**75.35**	**45.88**	**14.02**	**11.78**
% Refered to total mass		**93**	**75**	**46**	**14**	**12**
Fator de Expansão k		2.00	2.00	2.00	2.00	2.00
Incerteza Expandida		1.2	1.4	2.7	1.8	1.3

2) HYDROMETER ANALYSIS

Container nº **12**

Hydrometer nº **35**

Dispersing Agent **100** cm^3

Dry sample weight Ps **71.20** g

Particules density G= **2.64**

Corrections : Meniscus = **0.0002**

Antifloc. = **0.0002**

$$\% \text{ of particles} = \frac{G}{G-1} \times \frac{100}{Ps} \times (Lc-1) \times 10^3$$

Minutes (t)	Temperature (°C)	Densimeter value	Correction	Corrected reading (Lc)	Z (cm)	D= Z/t x K	Expanded uncertainty	Expansion factor k	% of particles	% Refer. to Total
1	**23**	**1.0034**	**0.0006**	**1.0040**	**13.52**	**0.0468**	**2.4**	**2.00**	**9.04**	**9**
2	**23**	**1.0030**	**0.0006**	**1.0036**	**13.68**	**0.0333**	**2.4**	**2.00**	**8.14**	**8**
5	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0211**	**2.4**	**2.00**	**7.69**	**8**
15	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0122**	**2.4**	**2.00**	**7.69**	**8**
30	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0086**	**2.4**	**2.00**	**7.69**	**8**
60	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0061**	**2.4**	**2.00**	**7.69**	**8**
250	**23**	**1.0024**	**0.0006**	**1.0030**	**13.91**	**0.0030**	**2.4**	**2.00**	**6.78**	**7**
1440	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0013**	**2.4**	**2.00**	**6.10**	**6**
2880										

Comments :

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Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66772**

Client's data

Boring **P2**

Depth **1.00 - 1.60**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

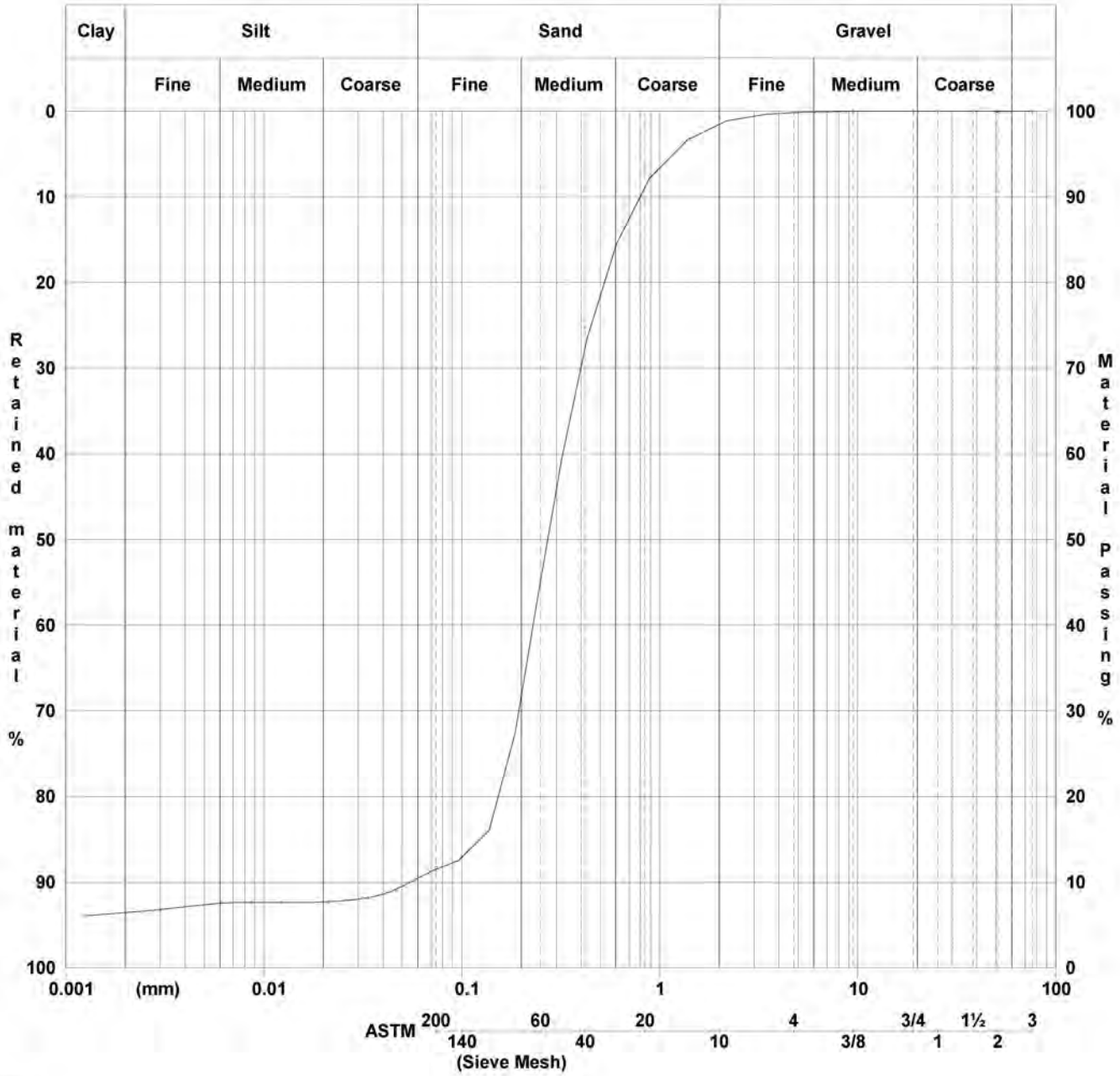
Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Distribution

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196



Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66772**

Client's data

Boring **P2**

Depth **1.00 - 1.60**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Proctor compacting test

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type : ☐ Standard effort ☐ Modified effort

Mould : ☐ 4" ☒ 6"

Grains size less than ____ mm

Mould	(nº)	50		50		50		50		50	
Mould + wet soil	(g)	6336		6425		6523		6567		6581	
Wet soil	(g)	3873		3962		4060		4104		4118	
Wet density	($g.cm^{-3}$)	1.889		1.933		1.980		2.002		2.009	
Container	(nº)	714	292	746	708	797	826	740	285	723	281
Wet sample + container	(g)	270.91	300.70	286.84	256.49	276.45	262.46	264.52	311.31	293.43	287.48
Dry sample + container	(g)	255.18	283.65	266.34	238.89	254.27	241.71	240.79	282.37	261.63	257.56
Container mass	(g)	80.69	90.81	80.18	74.84	88.86	79.90	80.25	89.51	75.25	78.60
Water mass	(g)	15.73	17.05	20.50	17.60	22.18	20.75	23.73	28.94	31.80	29.92
Dry sample mass	(g)	174.49	192.84	186.16	164.05	165.41	161.81	160.54	192.86	186.38	178.96
Water moisture content	(%)	9.0	8.8	11.0	10.7	13.4	12.8	14.8	15.0	17.1	16.7

Water moisture content average	(%)	8.9	10.9	13.1	14.9	16.9
Dry density	($g.cm^{-3}$)	1.735	1.743	1.751	1.742	1.718

Table of uncertainty in each mould

Expanded uncertainty	%	0.015	0.015	0.015	0.015	0.015
Expansion factor k		2.00	2.00	2.00	2.00	2.00

(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Comments :

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Geocontrole
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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66772**

Client's data

Boring **P2**

Depth **1.00 - 1.60**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Compacting curve

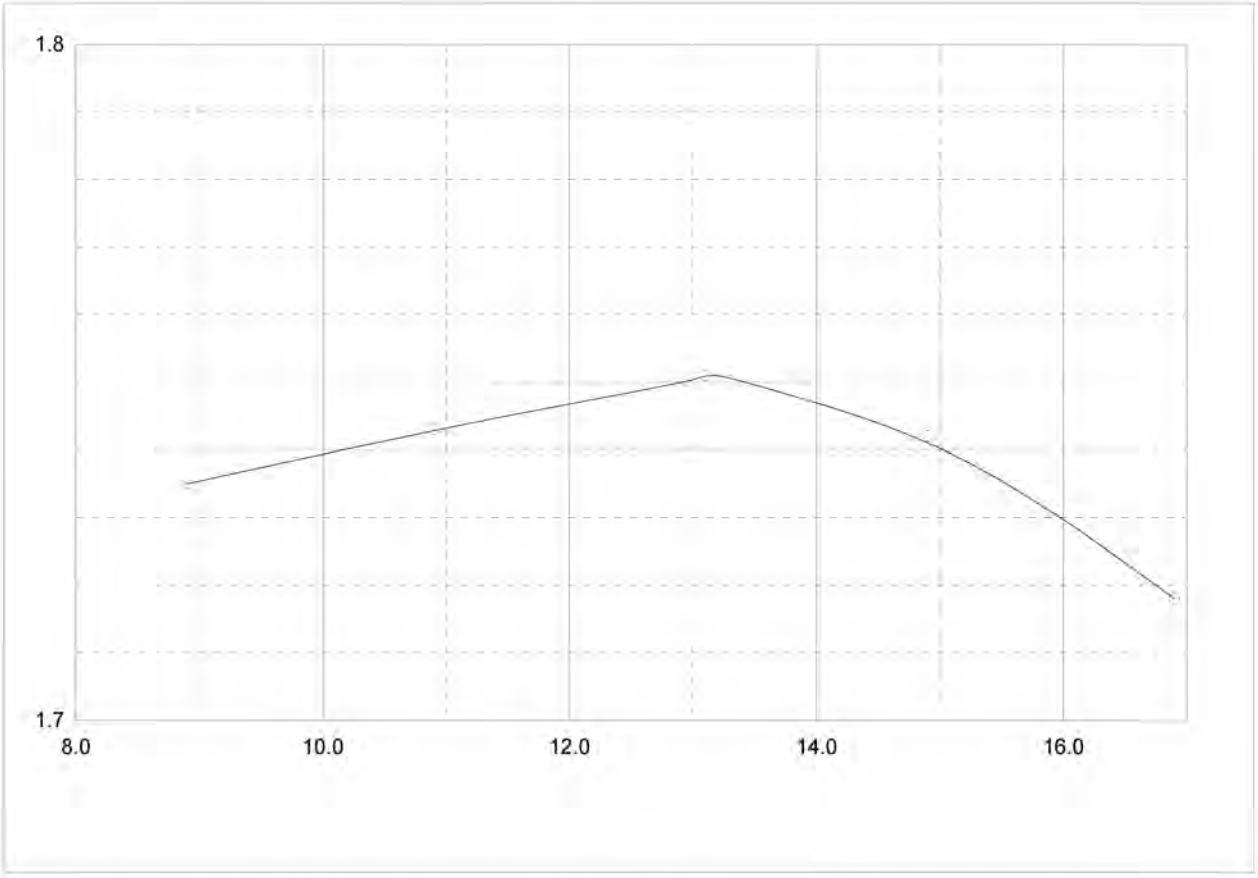
IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type ☒ Standard effort ☐ Modified effort

Mould ☐ 4" ☒ 6"

Grains size less than ____ mm



(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Table of uncertainty	Expansion factor k	Expanded uncertainty %
Optimum water moisture content	**2.00**	**0.28**
Maximum dry density	**2.00**	**0.026**

Optimum water moisture content Wopt = **13.1** %

Maximum dry density γ dmax = **1.75** g.cm^{-3}

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

This test report can only be reproduced totally or partially with Geocontrole express authorization. The results are referring to the tested sample.

Ensaio de Condutividade Térmica

Projecto:	**Sines Nest Data Center**	
Cliente:	START CAMPUS	**Data do ensaio:** 15-10-2021

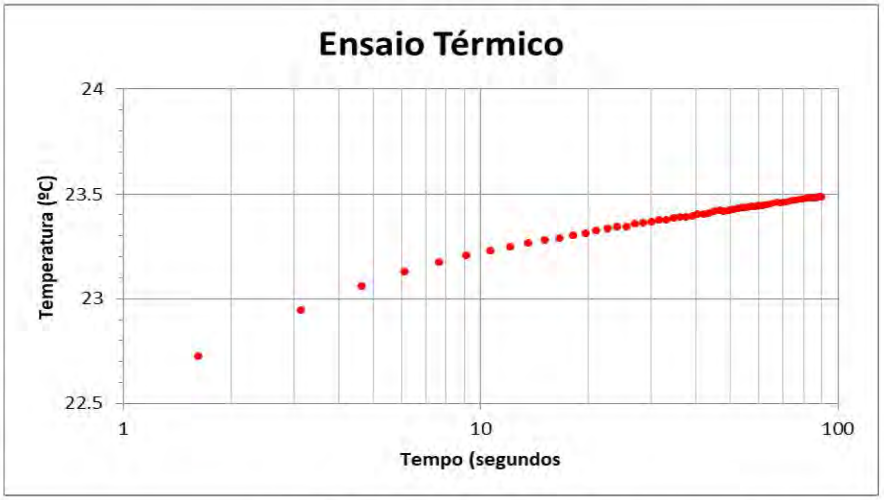
Equipmento:	Thermtest - TLS-100 Portatable Meter*				**Coordenadas(ETRS89):**
TLS sonda:	[x]	100 mm	[ ]	50 mm	M:
Tipo Amostra	[ ]	Não deformada	[x]	Moldada	P:
Método cravação	[x]	Pressão manual	[ ]	Pré-furo	*Calibrado de fabrica de acordo com a norma ISO22007-2:2015 TPS Measurements

Descrição da Amostra: areia média a fina quartzosa, de tons amarelados a acinzentados

TLS-100 Medições

Poço Ref.	**P2**
Amostra Ref.	66772
Ensaio Térmico Ref.	Amostra 4
Profundidade amostra (m)	1.00 - 1.60
Heating Power (W/m)	3.919
Temperatura da amostra (ºC)	22.325
k (W/m.K)	**7.655**
R (m.K/W)	**0.130**

Temperatura versus tempo - gráfico semi-log da amostra



* Procedimento realizado de acordo com a norma ASTM D5334 &IEEE 442-1981

Registo fotográfico da realização do ensaio



Observações:	Amostras em molde compactado a 95% do Proctor, no teor de húmidade óptimo.				
Data: 18/10/2021	Local:	Lisboa	Realizado por:	Figueiredo. H	

Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Sample Report

Process **37321** Lot **1**

Sample **66773**

Client's data

Boring **P3**

Depth **1.60 - 2.55**

Sample register date **30/09/2021**

Sample conclusion date **20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Results

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Sampling Procedure (*) (*) Efectuado Depart. Prospecção da Geocontrole **Sample Type** **DISTURBED**

Description(*) **Greyish brown, silty, medium grain size sand.**

Classification(*) Unified **(SP-SM)** GTR : Highway (E 240) **A-2-4(0)**
ASTM (D2487-00) ASTM (D3282-97)

Ponderal feature Water content w = **2.0** % Particle Density G = ρ = g/cm³
(*) Organic matter content % (*) Ph= (*) ρ_d = g/cm³

Consistency limits Way of preparation ☒ Dry ☐ Wet LL= **NP** % PL **0** % (*) SL % (*) IP= **0**

Methylene Blue Stain test Expressed in grams of methylene blue for 100g of dry soil

Particle Size Analysis Way of preparation ☒ Dry ☐ Wet
%< 2,00 mm = **98**
%<0,420 mm = **75**
%<0,074 mm = **11**
%<0,002 mm = **6**
(*) Cu = D60/D10 = **6** (*) Cc = **2**
EA =

Expansibility (*) % Sample sujected to a load of g

Compaction (Proctor)

Mould	Test Type	γ dmax (g/cm³)	Wopt (%)
6"	**STANDARD EFFORT**	**1.73**	**13.9**

CBR

Moulding conditions						
	Cr =					%
	Deviation					%
	CBR =					%
	Expansibility					%

Coefficient (*) Fragmentability Degradability

Compressibility (*) Cc = σ_a = kN/m² e_o = Cv = m²/s K = m/s

Strenght (*) Unconfined compression test qu = kPa Ei = kPa

Direct shear test UU CU CD C = kPa θ = ° C' = kPa θ' = °

Triaxial compression UU CU CD
σ_3 = kN/m² C = kN/m² θ = °
σ_1 = kN/m²
Ei = kN/m² C' = kN/m² θ' = °

Permeability (*) K = m/s

(*) - The tests indicated are not included in the scope of accreditation

Comments :

The expanded uncertainty, when presented, is expressed by the standard uncertainty multiplied by the expansion factor k, corresponding to a probability of 95%.
Uncertainties are calculated according to document EA-4/02

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Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66773**

Client's data

Boring **P3**

Depth **1.60 - 2.55**

Sample register date **30/09/2021**

Test execution dates **30/09/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Water Moisture Content

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Standard : NP-84(1965)

Container	n°	**298**	**678**	**281**	
Wet sample mass + Container	m_2 g	**317.47**	**282.36**	**254.09**	
Dry sample mass + Container	m_4 g	**312.74**	**278.55**	**250.51**	
Container mass	m_1 g	**88.22**	**77.60**	**78.60**	
Water mass	m_a g	**4.73**	**3.81**	**3.58**	
Dry sample mass	m_s g	**224.52**	**200.95**	**171.91**	
Water moisture content $w = \frac{m_a}{m_s} \times 100$	%	**2.1**	**1.9**	**2.1**	

Water content average(w): 2.0 %

Table of uncertainty in each specimen

Expanded uncertainty	%	0.27	0.27	0.27	
Expansion factor k		2.00	2.00	2.00	

Comments :

Laboratory Management

Issue date: **21/10/2021**

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Test Report

Process **37321** Lot **1**

Sample **66773**

Client's data

Boring **P3**

Depth **1.60 - 2.55**

Sample register date **30/09/2021**

Test execution dates **04/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Consistency limits

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

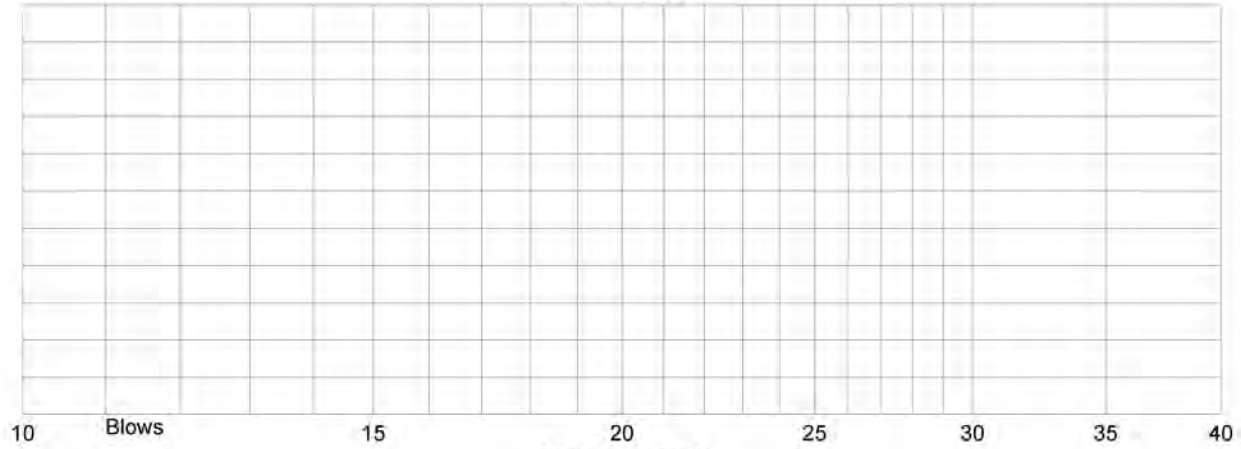
Standard : NP-143(1969)

		Liquidity limit	Plasticity limit
Container	nº		
Wet sample mass + container	g		
Dry sample mass + container	g		
Container mass	g		
Water mass	g		
Dry sample mass	g		
Water content	%		
Nr of blows			PL (Average) = %

N/P

W (%)

DIAGRAM



Shrinkage limit
(Non accredited method)

Container	**nº**					**Container volume V**	**cm^3**			
Wet sample + Container	**g**					**Quicksilver weight (1)**	**g**			
Dry sample + Container	**g**					**Dry soil volume (1)/13.55 (v)**				
Container mass	**g**					**V-v**				
Water mass	**g**					**A = V - v / Ps X 100**				
Dry sample Ps	**g**					**Shrinkage limit W-A**				
Water content W	**%**					**Shrinkage ratio Ps / v**				

LL = % **PL** % **(*) IP =**

(*) SL %

Limite de Liquidez	**Incerteza Expandida**	
	Fator de Expansão k	
Limite de Plasticidade	**Incerteza Expandida**	
	Fator de Expansão k	

(*) - Non accredited parameter

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Test Report

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Client's data

Boring **P3**

Depth **1.60 - 2.55**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Analysis

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196(1966) and E239(1970)

1) SIEVE ANALYSIS

Dry sample total weight : **1832.80** g

COARSE ELEMENTS

Sieve designation		3 "	2 "	½ "	1"	3/4 "	3/8 "	4	10
Square shaped mesh	mm	76.1	50.8	38.1	25.4	19.0	9.51	4.76	2.00
Retained material mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**5.34**	**7.26**	**17.34**
Accumulated mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**5.34**	**12.60**	**29.94**
% Acumulados		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.29**	**0.69**	**1.63**
Complemento para 100%		**100**	**100**	**100**	**100**	**100**	**100**	**99**	**98**
Fator de Expansão k							2.00	2.00	2.00
Incerteza Expandida							1.0	2.6	1.8

FINE ELEMENTS

Total fine elements weight used : **70.70** g

Sieve designation		20	40	60	140	200
Square shaped mesh	mm	0.841	0.420	0.250	0.105	0.074
Retained material mass	g	**1.17**	**15.30**	**26.51**	**18.76**	**0.96**
Accumulated mass	g	**1.17**	**16.47**	**42.98**	**61.74**	**62.70**
% Accumulated		**1.65**	**23.30**	**60.79**	**87.33**	**88.68**
Complement to 100%		**98.35**	**76.70**	**39.21**	**12.67**	**11.32**
% Refered to total mass		**97**	**75**	**39**	**12**	**11**
Fator de Expansão k		2.00	2.00	2.00	2.00	2.00
Incerteza Expandida		1.2	1.4	2.7	1.8	1.3

2) HYDROMETER ANALYSIS

Container nº **2**

Hydrometer nº **35**

Dispersing Agent **100** cm^3

Dry sample weight Ps **70.70** g

Particules density G= **2.63**

Corrections : Meniscus = **0.0002**

Antifloc. = **0.0002**

$$\% \text{ of particles} = \frac{G}{G-1} \times \frac{100}{Ps} \times (Lc-1) \times 10^3$$

Minutes (t)	Temperature (°C)	Densimeter value	Correction	Corrected reading (Lc)	Z (cm)	D= Z/t x K	Expanded uncertainty	Expansion factor k	% of particles	% Refer. to Total
1	**23**	**1.0036**	**0.0006**	**1.0042**	**13.44**	**0.0465**	**2.4**	**2.00**	**9.59**	**9**
2	**23**	**1.0031**	**0.0006**	**1.0037**	**13.64**	**0.0331**	**2.4**	**2.00**	**8.44**	**8**
5	**23**	**1.0031**	**0.0006**	**1.0037**	**13.64**	**0.0210**	**2.4**	**2.00**	**8.44**	**8**
15	**23**	**1.0031**	**0.0006**	**1.0037**	**13.64**	**0.0121**	**2.4**	**2.00**	**8.44**	**8**
30	**23**	**1.0030**	**0.0006**	**1.0036**	**13.68**	**0.0086**	**2.4**	**2.00**	**8.22**	**8**
60	**23**	**1.0029**	**0.0006**	**1.0035**	**13.72**	**0.0061**	**2.4**	**2.00**	**7.99**	**8**
250	**23**	**1.0024**	**0.0006**	**1.0030**	**13.91**	**0.0030**	**2.4**	**2.00**	**6.85**	**7**
1440	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0013**	**2.4**	**2.00**	**6.16**	**6**
2880										

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Test Report

Process **37321** Lot **1**

Sample **66773**

Client's data

Boring **P3**

Depth **1.60 - 2.55**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

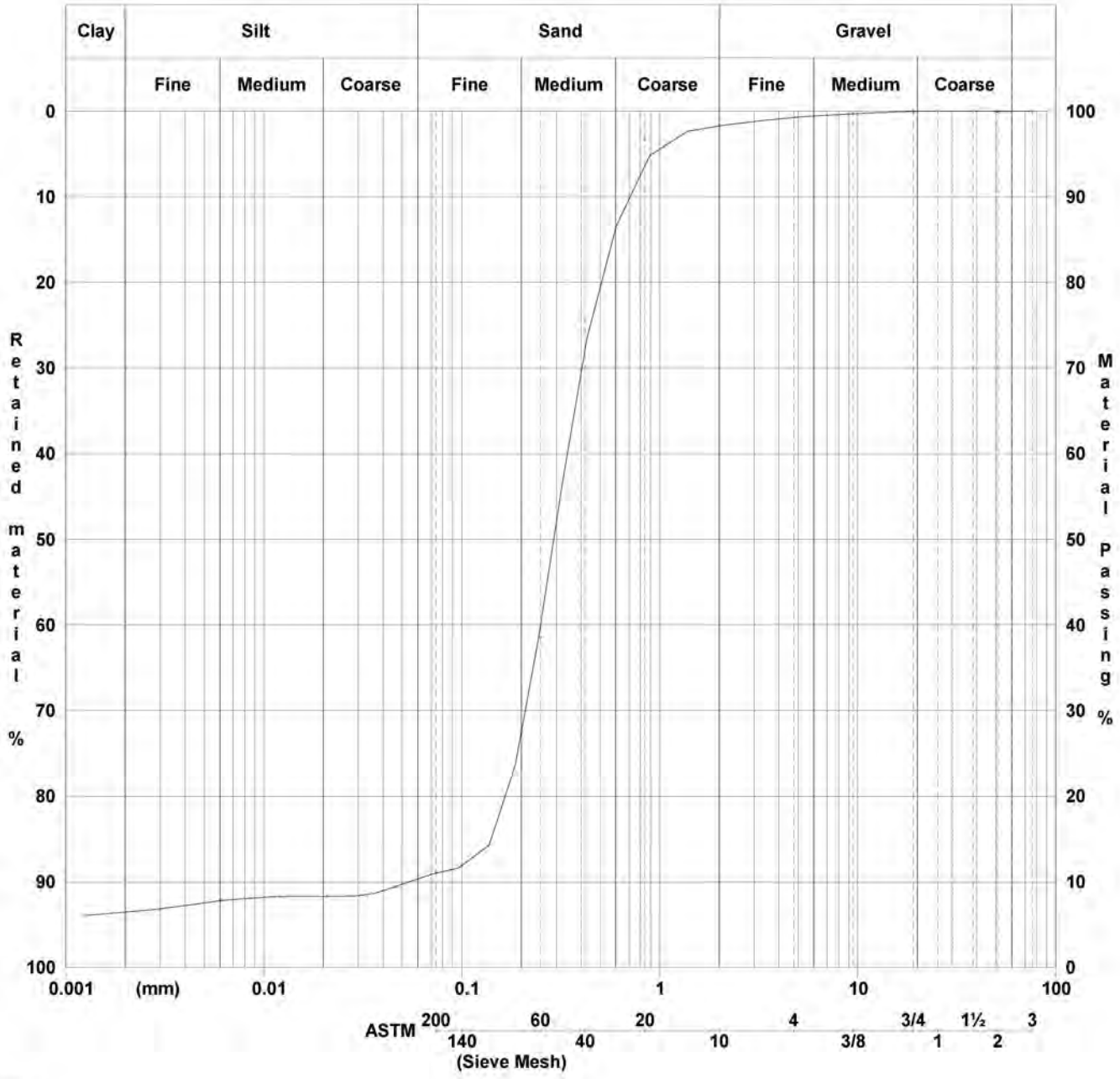
Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Distribution

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196



Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Test Report

Process **37321** Lot **1**

Sample **66773**

Client's data

Boring **P3**

Depth **1.60 - 2.55**

Sample register date **30/09/2021**

Test execution dates **11/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Proctor compacting test

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type : ☐ Standard effort ☐ Modified effort

Mould : ☐ 4" ☒ 6"

Grains size less than _____ mm

Mould	(nº)	50		50		50		50		50	
Mould + wet soil	(g)	6213		6334		6431		6518		6538	
Wet soil	(g)	3750		3871		3968		4055		4075	
Wet density	($g.cm^{-3}$)	1.829		1.888		1.936		1.978		1.988	
Container	(nº)	666	673	679	702	745	678	816	658	351	292
Wet sample + container	(g)	267.71	270.96	303.12	286.53	316.76	316.35	341.65	318.69	296.68	268.82
Dry sample + container	(g)	254.08	256.06	281.34	265.85	290.14	290.04	308.35	290.34	267.24	244.01
Container mass	(g)	90.61	90.51	79.75	74.69	78.73	77.60	79.04	90.37	90.54	90.81
Water mass	(g)	13.63	14.90	21.78	20.68	26.62	26.31	33.30	28.35	29.44	24.81
Dry sample mass	(g)	163.47	165.55	201.59	191.16	211.41	212.44	229.31	199.97	176.70	153.20
Water moisture content	(%)	8.3	9.0	10.8	10.8	12.6	12.4	14.5	14.2	16.7	16.2

Water moisture content average	(%)	8.7	10.8	12.5	14.4	16.5
Dry density	($g.cm^{-3}$)	1.683	1.704	1.721	1.729	1.706

Table of uncertainty in each mould

Expanded uncertainty	%	0.015	0.015	0.015	0.015	0.015
Expansion factor k		2.00	2.00	2.00	2.00	2.00

(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Comments :

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Test Report

Process **37321** Lot **1**

Sample **66773**

Client's data

Boring **P3**

Depth **1.60 - 2.55**

Sample register date **30/09/2021**

Test execution dates **11/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source	Site Sampling	Application

Compacting curve

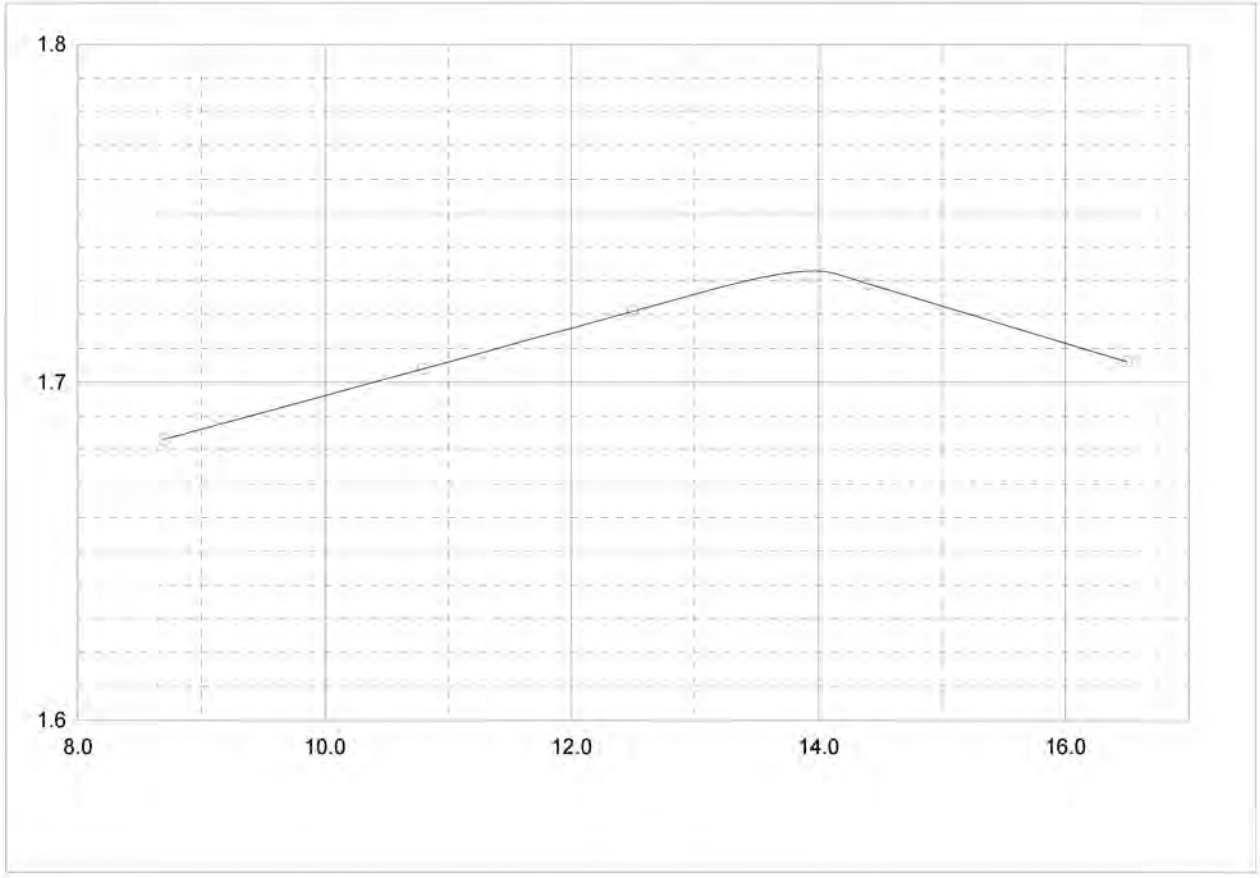
Procedure : PL.09/2(2018) (*)

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Test type ☒ Standard effort ☐ Modified effort

Mould ☐ 4" ☒ 6"

Grains size less than ____ mm



(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Table of uncertainty	Expansion factor k	Expanded uncertainty %
Optimum water moisture content	**2.00**	**0.28**
Maximum dry density	**2.00**	**0.026**

Optimum water moisture content Wopt = **13.9** %

Maximum dry density γ dmax = **1.73** g.cm^{-3}

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Ensaio de Condutividade Térmica

Projecto:	Sines Nest Data Center	
Cliente:	START CAMPUS	Data do ensaio: 15-10-2021

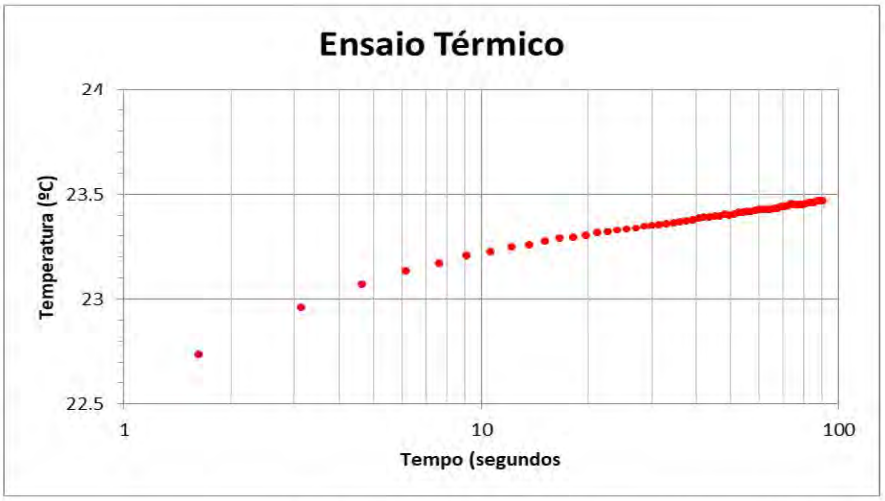
Equipmento:	Thermtest - TLS-100 Portatable Meter*			**Coordenadas(ETRS89):**	
TLS sonda:	[x]	100 mm	[ ]	50 mm	M:
Tipo Amostra	[ ]	Não deformada	[x]	Moldada	P:
Método cravação	[x]	Pressão manual	[ ]	Pré-furo	*Calibrado de fabrica de acordo com a norma ISO22007-2:2015 TPS Measurements

Descrição da Amostra: areia média a fina quartzosa, de tons amarelados a acinzentados

TLS-100 Medições

Poço Ref.	P3
Amostra Ref.	66773
Ensaio Térmico Ref.	Amostra 2
Profundidade amostra (m)	1.6 - 2.55
Heating Power (W/m)	3.919
Temperatura da amostra (ºC)	22.331
k (W/m.K)	7.913
R (m.K/W)	0.126

Temperatura versus tempo - gráfico semi-log da amostra



* Procedimento realizado de acordo com a norma ASTM D5334 &IEEE 442-1981

Registo fotográfico da realização do ensaio



Observações:	Amostras em molde compactado a 95% do Proctor, no teor de húmidade óptimo.				
Data: 18/10/2021	Local:	Lisboa	Realizado por:	Figueiredo. H	

Geocontrole
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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Sample Report

Process **37321** Lot **1**

Sample **66774**

Client's data

Boring **P4**

Depth **0.15 - 1.30**

Sample register date **30/09/2021**

Sample conclusion date **20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Results

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Sampling Procedure (*) (*) Efectuado Depart. Prospecção da Geocontrole **Sample Type** **DISTURBED**

Description(*) **Greyish, silty, medium grain size sand.**

Classification(*) Unified **(SP-SM)** GTR : Highway (E 240) **A-2-4(0)**
ASTM (D2487-00) ASTM (D3282-97)

Ponderal feature Water content w = **3.6** % Particle Density G = ρ = g/cm³
(*) Organic matter content % (*) Ph= (*) ρ_d = g/cm³

Consistency limits Way of preparation ☒ Dry ☐ Wet LL= **NP** % PL **0** % (*) SL % (*) IP= **0**

Methylene Blue Stain test Expressed in grams of methylene blue for 100g of dry soil

Particle Size Analysis Way of preparation ☒ Dry ☐ Wet
%< 2,00 mm = **100**
%<0,420 mm = **75**
%<0,074 mm = **12**
%<0,002 mm = **4**
(*) Cu = D60/D10 = **6** (*) Cc = **1**
EA =

Expansibility (*) % Sample sujected to a load of g

Compaction (Proctor)

Mould	Test Type	γ dmax (g/cm³)	Wopt (%)

CBR

Moulding conditions						
	Cr =					%
	Deviation					%
	CBR =					%
	Expansibility					%

Coefficient (*) Fragmentability Degradability

Compressibility (*) Cc = σ_a = kN/m² e_o = Cv = m²/s K = m/s

Strenght (*) Unconfined compression test qu = kPa Ei = kPa

Direct shear test UU CU CD C = kPa θ = ° C' = kPa θ' = °

Triaxial compression UU CU CD
σ_3 = kN/m² C = kN/m² θ = °
σ_1 = kN/m²
Ei = kN/m² C' = kN/m² θ' = °

Permeability (*) K = m/s

(*) - The tests indicated are not included in the scope of accreditation

Comments :

The expanded uncertainty, when presented, is expressed by the standard uncertainty multiplied by the expansion factor k, corresponding to a probability of 95%.
Uncertainties are calculated according to document EA-4/02

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Test Report

Process **37321** Lot **1**

Sample **66774**

Client's data

Boring **P4**

Depth **0.15 - 1.30**

Sample register date **30/09/2021**

Test execution dates **30/09/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Water Moisture Content

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Standard : NP-84(1965)

Container	n°	**638**	**297**	**466**	
Wet sample mass + Container	m_2 g	**266.07**	**224.63**	**236.09**	
Dry sample mass + Container	m_4 g	**259.65**	**220.07**	**231.04**	
Container mass	m_1 g	**89.49**	**89.50**	**88.90**	
Water mass	m_a g	**6.42**	**4.56**	**5.05**	
Dry sample mass	m_s g	**170.16**	**130.57**	**142.14**	
Water moisture content $w = \frac{m_a}{m_s} \times 100$	%	**3.8**	**3.5**	**3.6**	

Water content average(w): 3.6 %

Table of uncertainty in each specimen

Expanded uncertainty	%	0.27	0.27	0.27	
Expansion factor k		2.00	2.00	2.00	

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Test Report

Process **37321** Lot **1**

Sample **66774**

Client's data

Boring **P4**

Depth **0.15 - 1.30**

Sample register date **30/09/2021**

Test execution dates **04/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Consistency limits

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

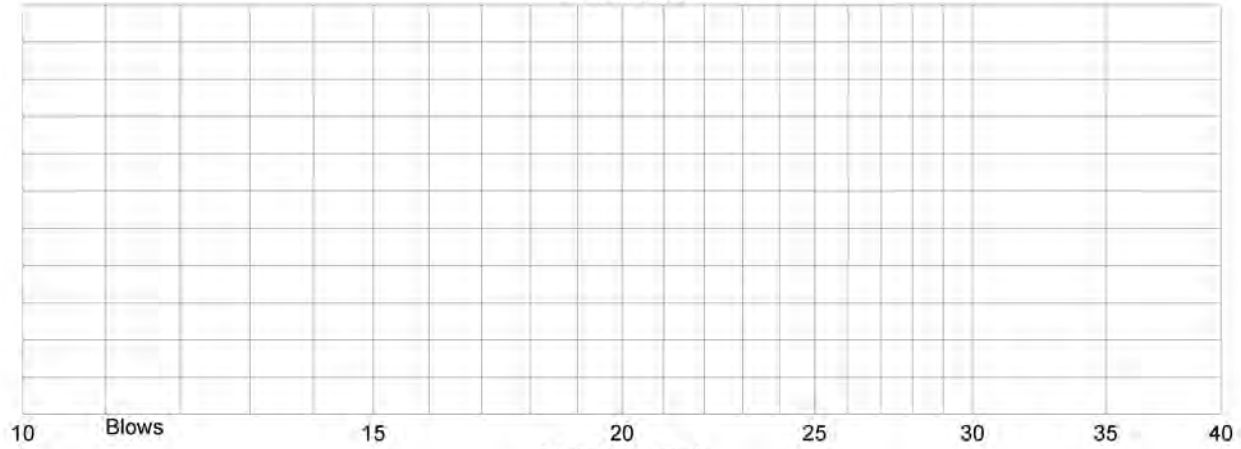
Standard : NP-143(1969)

		Liquidity limit	Plasticity limit
Container	nº		
Wet sample mass + container	g		
Dry sample mass + container	g		
Container mass	g		
Water mass	g		
Dry sample mass	g		
Water content	%		
Nr of blows			PL (Average) = %

N/P

W (%)

DIAGRAM



Shrinkage limit
(Non accredited method)

Container	**nº**					**Container volume V**	**cm^3**				
Wet sample + Container	**g**					**Quicksilver weight (1)**	**g**				
Dry sample + Container	**g**					**Dry soil volume (1)/13.55 (v)**					
Container mass	**g**					**V-v**					
Water mass	**g**					**A = V - v / Ps X 100**					
Dry sample Ps	**g**					**Shrinkage limit W-A**					
Water content W	**%**					**Shrinkage ratio Ps / v**					

LL = % **PL** % **(*) IP =**

(*) SL %

Limite de Liquidez	**Incerteza Expandida**	
	Fator de Expansão k	
Limite de Plasticidade	**Incerteza Expandida**	
	Fator de Expansão k	

(*) - Non accredited parameter

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66774**

Client's data

Boring **P4**

Depth **0.15 - 1.30**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Analysis

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196(1966) and E239(1970)

1) SIEVE ANALYSIS

Dry sample total weight : **800.10** g

COARSE ELEMENTS

Sieve designation		3 "	2 "	½ "	1"	3/4 "	3/8 "	4	10
Square shaped mesh	mm	76.1	50.8	38.1	25.4	19.0	9.51	4.76	2.00
Retained material mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Accumulated mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
% Acumulados		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Complemento para 100%		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Fator de Expansão k									
Incerteza Expandida									

FINE ELEMENTS

Total fine elements weight used : **71.34** g

Sieve designation		20	40	60	140	200
Square shaped mesh	mm	0.841	0.420	0.250	0.105	0.074
Retained material mass	g	**1.56**	**16.49**	**24.34**	**18.69**	**1.80**
Accumulated mass	g	**1.56**	**18.05**	**42.39**	**61.08**	**62.88**
% Accumulated		**2.19**	**25.30**	**59.42**	**85.62**	**88.14**
Complement to 100%		**97.81**	**74.70**	**40.58**	**14.38**	**11.86**
% Refered to total mass		**98**	**75**	**41**	**14**	**12**
Fator de Expansão k		**2.00**	**2.00**	**2.00**	**2.00**	**2.00**
Incerteza Expandida		**1.2**	**1.4**	**2.7**	**1.8**	**1.3**

2) HYDROMETER ANALYSIS

Container nº **17**

Hydrometer nº **35**

Dispersing Agent **100** cm^3

Dry sample weight Ps **71.34** g

Particules density G= **2.64**

Corrections : Meniscus = **0.0002**

Antifloc. = **0.0002**

$$\% \text{ of particles} = \frac{G}{G-1} \times \frac{100}{Ps} \times (Lc-1) \times 10^3$$

Minutes (t)	Temperature (°C)	Densimeter value	Correction	Corrected reading (Lc)	Z (cm)	D= Z/t x K	Expanded uncertainty	Expansion factor k	% of particles	% Refer. to Total
1	**23**	**1.0029**	**0.0006**	**1.0035**	**13.72**	**0.0471**	**2.4**	**2.00**	**7.90**	**8**
2	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0337**	**2.4**	**2.00**	**6.09**	**6**
5	**23**	**1.0020**	**0.0006**	**1.0026**	**14.07**	**0.0214**	**2.4**	**2.00**	**5.87**	**6**
15	**23**	**1.0019**	**0.0006**	**1.0025**	**14.11**	**0.0123**	**2.4**	**2.00**	**5.64**	**6**
30	**23**	**1.0018**	**0.0006**	**1.0024**	**14.14**	**0.0087**	**2.4**	**2.00**	**5.42**	**5**
60	**23**	**1.0015**	**0.0006**	**1.0021**	**14.26**	**0.0062**	**2.4**	**2.00**	**4.74**	**5**
250	**23**	**1.0012**	**0.0006**	**1.0018**	**14.38**	**0.0031**	**2.4**	**2.00**	**4.06**	**4**
1440	**23**	**1.0012**	**0.0006**	**1.0018**	**14.38**	**0.0013**	**2.4**	**2.00**	**4.06**	**4**
2880										

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
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Test Report

Process **37321** Lot **1**

Sample **66774**

Client's data

Boring **P4**

Depth **0.15 - 1.30**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

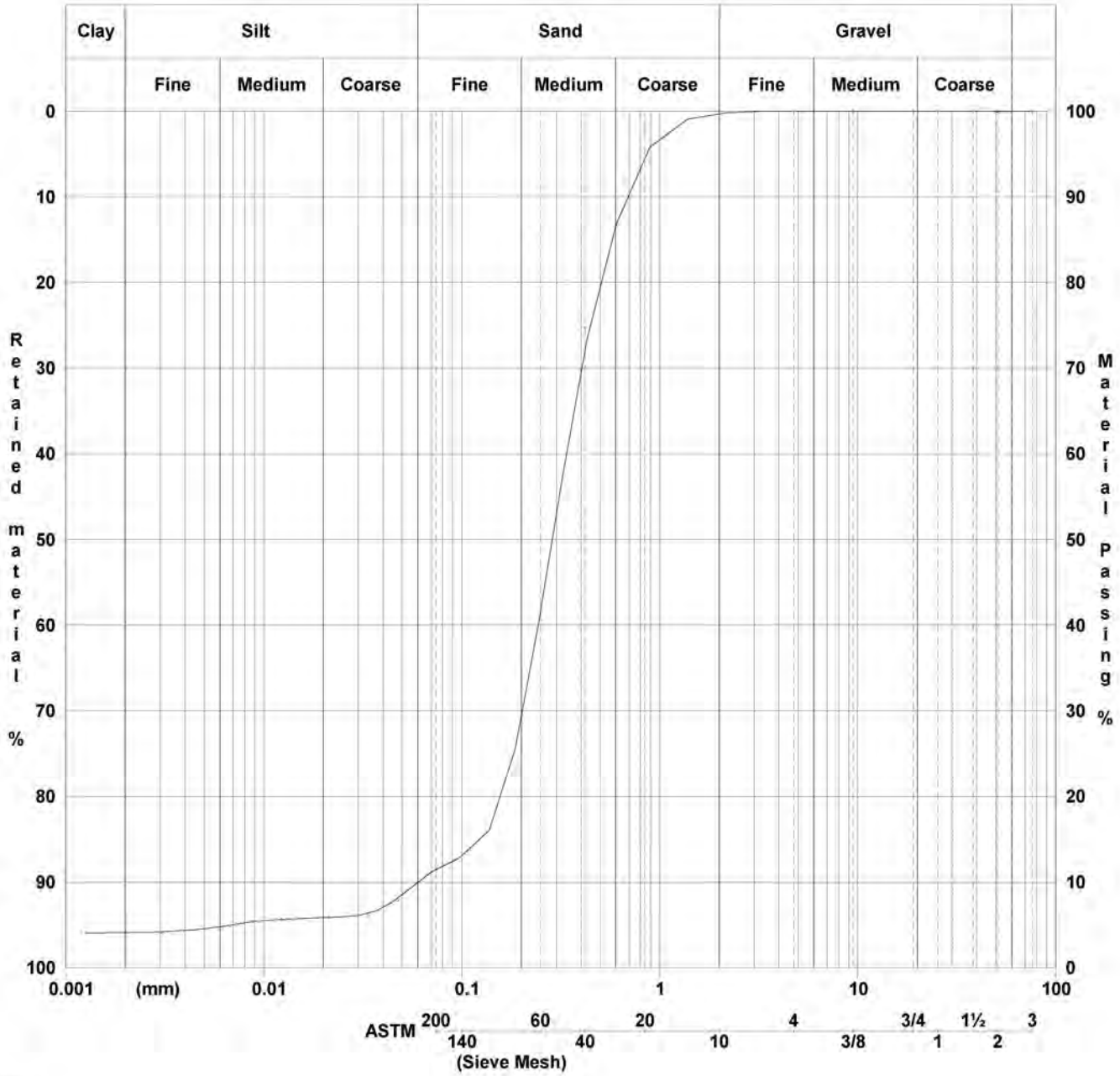
Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Distribution

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196



Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Geocontrole
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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Sample Report

Process **37321** Lot **1**

Sample **66775**

Client's data

Boring **P5**

Depth **0.30 - 3.00**

Sample register date **30/09/2021**

Sample conclusion date **20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source	Site Sampling	Application

Results

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Sampling Procedure (*) (*) Efectuado Depart. Prospecção da Geocontrole **Sample Type** **DISTURBED**

Description(*) **Light brown, slightly silty, medium grain size sand**

Classification(*) Unified ASTM (D2487-00) **(SP-SM)** GTR : Highway (E 240) **A-3(0)** ASTM (D3282-97)

Ponderal feature Water content w = **2.2** % Particle Density G = ρ = g/cm³

(*) Organic matter content % (*) Ph= (*) ρ_d = g/cm³

Consistency limits Way of preparation ☒ Dry ☐ Wet LL= **NP** % PL **0** % (*) SL % (*) IP= **0**

Methylene Blue Stain test Expressed in grams of methylene blue for 100g of dry soil

Particle Size Analysis Way of preparation ☒ Dry ☐ Wet

%< 2,00 mm = **99**
%<0,420 mm = **73**
%<0,074 mm = **9**
%<0,002 mm = **6**

(*) Cu = $\frac{D60}{D10}$ = **4** (*) Cc = **1**

EA =

Expansibility (*) % Sample sujected to a load of g

Compaction (Proctor)

Mould	Test Type	γ dmax (g/cm³)	Wopt (%)
6"	**STANDARD EFFORT**	**1.76**	**12.6**

CBR

Moulding conditions						
	Cr =					%
	Deviation					%
	CBR =					%
	Expansibility					%

Coefficient (*) Fragmentability Degradability

Compressibility (*) Cc = σ_a = kN/m² e_o = Cv = m²/s K = m/s

Strenght (*) Unconfined compression test qu = kPa Ei = kPa

Direct shear test UU CU CD C = kPa θ = ° C' = kPa θ' = °

Triaxial compression UU CU CD σ_3 = kN/m² σ_1 = kN/m² Ei = kN/m² C = kN/m² θ = ° C' = kN/m² θ' = °

Permeability (*) K = m/s

(*) - The tests indicated are not included in the scope of accreditation

Comments :

The expanded uncertainty, when presented, is expressed by the standard uncertainty multiplied by the expansion factor k, corresponding to a probability of 95%.
Uncertainties are calculated according to document EA-4/02

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Test Report

Process **37321** Lot **1**

Sample **66775**

Client's data

Boring **P5**

Depth **0.30 - 3.00**

Sample register date **30/09/2021**

Test execution dates **30/09/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Water Moisture Content

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Standard : NP-84(1965)

Container	nº	**351**	**666**	**316**	
Wet sample mass + Container	m_2 g	**273.59**	**185.19**	**179.94**	
Dry sample mass + Container	m_4 g	**269.21**	**182.72**	**177.29**	
Container mass	m_1 g	**90.54**	**90.61**	**7.90**	
Water mass	m_a g	**4.38**	**2.47**	**2.65**	
Dry sample mass	m_s g	**178.67**	**92.11**	**169.39**	
Water moisture content $w = \frac{m_a}{m_s} \times 100$	%	**2.5**	**2.7**	**1.6**	

Water content average(w): 2.2 %

Table of uncertainty in each specimen

Expanded uncertainty	%	0.27	0.27	0.27	
Expansion factor k		2.00	2.00	2.00	

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Test Report

Process **37321** Lot **1**

Sample **66775**

Client's data

Boring **P5**

Depth **0.30 - 3.00**

Sample register date **30/09/2021**

Test execution dates **04/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Consistency limits

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

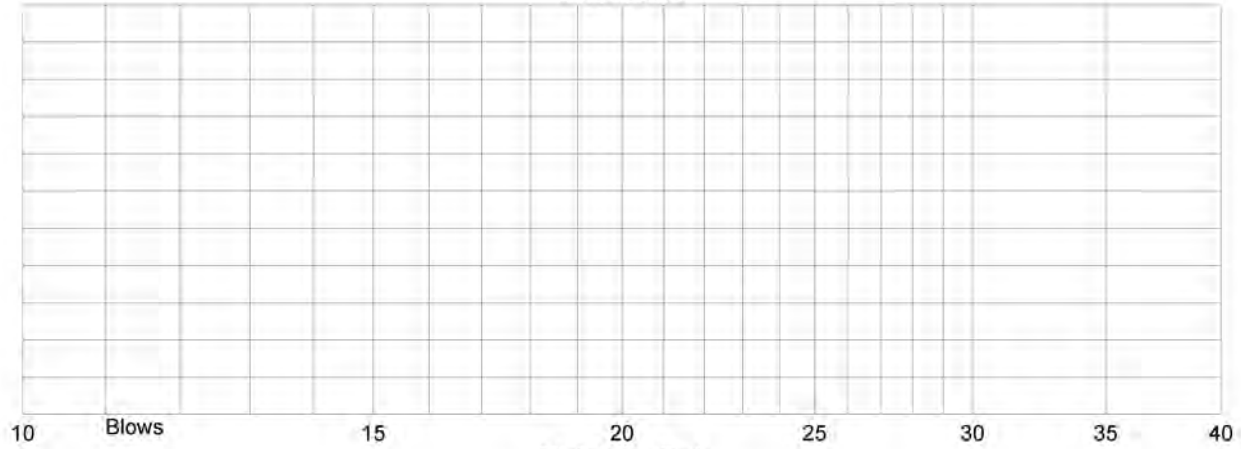
Standard : NP-143(1969)

		Liquidity limit	Plasticity limit
Container	nº		
Wet sample mass + container	g		
Dry sample mass + container	g		
Container mass	g		
Water mass	g		
Dry sample mass	g		
Water content	%		
Nr of blows			PL (Average) = %

N/P

W (%)

DIAGRAM



Shrinkage limit
(Non accredited method)

Container	**nº**					**Container volume V**	**cm^3**				
Wet sample + Container	**g**					**Quicksilver weight (1)**	**g**				
Dry sample + Container	**g**					**Dry soil volume (1)/13.55 (v)**					
Container mass	**g**					**V-v**					
Water mass	**g**					**A = V - v / Ps X 100**					
Dry sample Ps	**g**					**Shrinkage limit W-A**					
Water content W	**%**					**Shrinkage ratio Ps / v**					

LL = % **PL** % **(*) IP =**

(*) SL %

Limite de Liquidez	**Incerteza Expandida**	
	Fator de Expansão k	
Limite de Plasticidade	**Incerteza Expandida**	
	Fator de Expansão k	

(*) - Non accredited parameter

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Test Report

Process **37321** Lot **1**

Sample **66775**

Client's data

Boring **P5**

Depth **0.30 - 3.00**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Analysis

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196(1966) and E239(1970)

1) SIEVE ANALYSIS

Dry sample total weight : **1483.90** g

COARSE ELEMENTS

Sieve designation		3 "	2 "	½ "	1"	3/4 "	3/8 "	4	10
Square shaped mesh	mm	76.1	50.8	38.1	25.4	19.0	9.51	4.76	2.00
Retained material mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**7.77**	**5.20**	**7.05**
Accumulated mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**7.77**	**12.97**	**20.02**
% Acumulados		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.52**	**0.87**	**1.35**
Complemento para 100%		**100**	**100**	**100**	**100**	**100**	**99**	**99**	**99**
Fator de Expansão k							2.00	2.00	2.00
Incerteza Expandida							1.0	2.6	1.8

FINE ELEMENTS

Total fine elements weight used : **71.23** g

Sieve designation		20	40	60	140	200
Square shaped mesh	mm	0.841	0.420	0.250	0.105	0.074
Retained material mass	g	**4.91**	**13.78**	**21.19**	**23.27**	**1.28**
Accumulated mass	g	**4.91**	**18.69**	**39.88**	**63.15**	**64.43**
% Accumulated		**6.89**	**26.24**	**55.99**	**88.66**	**90.45**
Complement to 100%		**93.11**	**73.76**	**44.01**	**11.34**	**9.55**
% Refered to total mass		**92**	**73**	**43**	**11**	**9**
Fator de Expansão k		2.00	2.00	2.00	2.00	2.00
Incerteza Expandida		1.2	1.4	2.7	1.8	1.3

2) HYDROMETER ANALYSIS

Container nº **13**

Hydrometer nº **35**

Dispersing Agent **100** cm^3

Dry sample weight Ps **71.23** g

Particules density G= **2.63**

Corrections : Meniscus = **0.0002**

Antifloc. = **0.0002**

$$\% \text{ of particles} = \frac{G}{G-1} \times \frac{100}{Ps} \times (Lc-1) \times 10^3$$

Minutes (t)	Temperature (°C)	Densimeter value	Correction	Corrected reading (Lc)	Z (cm)	D= Z/t x K	Expanded uncertainty	Expansion factor k	% of particles	% Refer. to Total
1	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0471**	**2.4**	**2.00**	**7.70**	**8**
2	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0333**	**2.4**	**2.00**	**7.70**	**8**
5	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0210**	**2.4**	**2.00**	**7.70**	**8**
15	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0122**	**2.4**	**2.00**	**7.70**	**8**
30	**23**	**1.0026**	**0.0006**	**1.0032**	**13.83**	**0.0086**	**2.4**	**2.00**	**7.25**	**7**
60	**23**	**1.0022**	**0.0006**	**1.0028**	**13.99**	**0.0061**	**2.4**	**2.00**	**6.34**	**6**
250	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0030**	**2.4**	**2.00**	**6.12**	**6**
1440	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0013**	**2.4**	**2.00**	**6.12**	**6**
2880										

Comments :

Laboratory Management

Issue date: **21/10/2021**

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Test Report

Process **37321** Lot **1**

Sample **66775**

Client's data

Boring **P5**

Depth **0.30 - 3.00**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

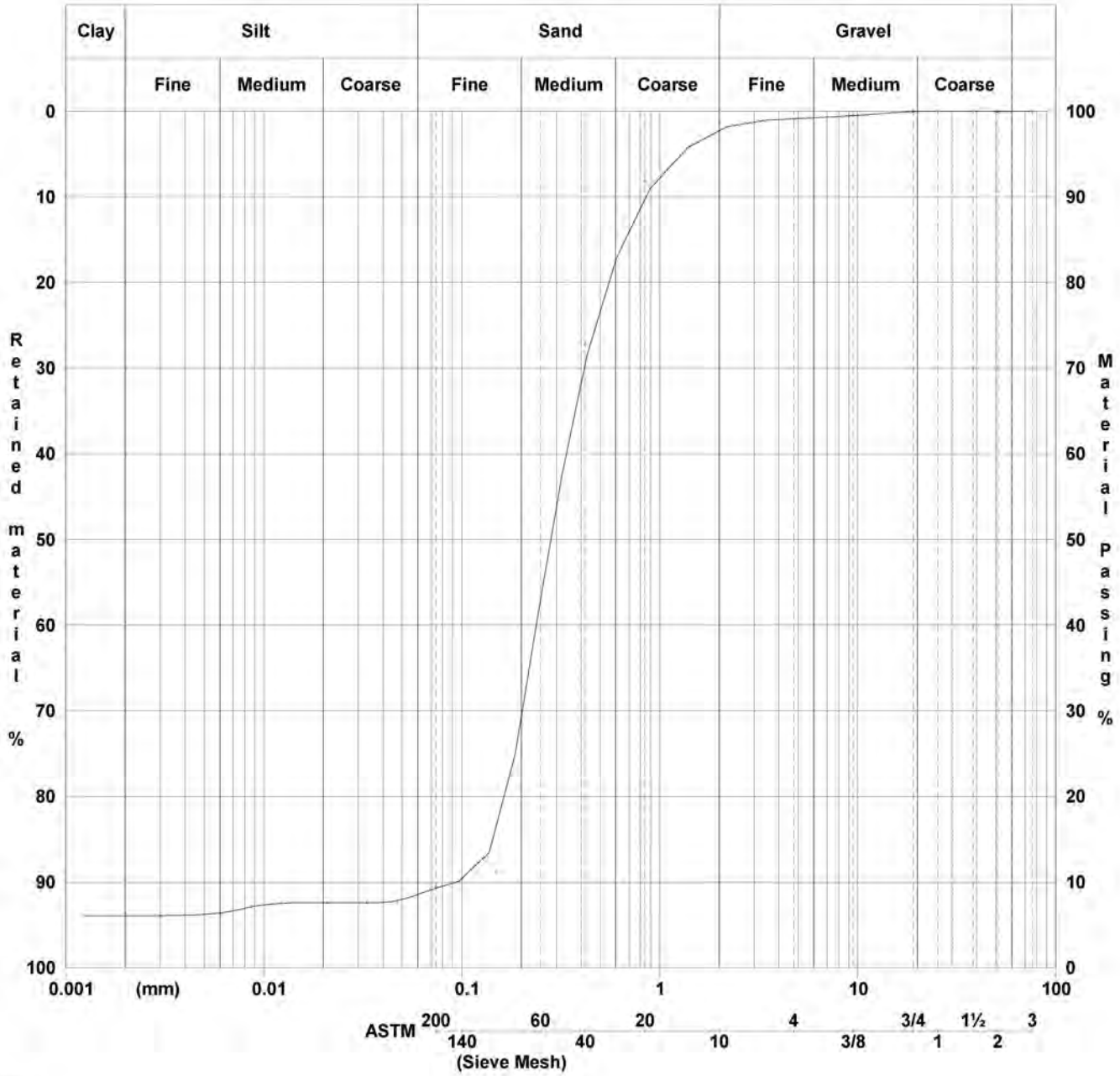
Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Distribution

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196



Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Test Report

Process **37321** Lot **1**

Sample **66775**

Client's data

Boring **P5**

Depth **0.30 - 3.00**

Sample register date **30/09/2021**

Test execution dates **11/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Proctor compacting test

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type : ☐ Standard effort ☐ Modified effort

Mould : ☐ 4" ☒ 6"

Grains size less than _____ mm

Mould	(nº)	50		50		50		50		50	
Mould + wet soil	(g)	6207		6386		6519		6512		6502	
Wet soil	(g)	3744		3923		4056		4049		4039	
Wet density	($g.cm^{-3}$)	1.826		1.914		1.979		1.975		1.970	
Container	(nº)	390	298	383	287	721	740	743	731	823	300
Wet sample + container	(g)	251.19	272.15	264.57	309.16	270.44	240.63	287.74	281.98	335.04	287.24
Dry sample + container	(g)	238.40	257.54	246.76	286.67	248.53	222.93	261.37	256.11	299.32	256.41
Container mass	(g)	76.46	88.22	79.60	77.64	77.65	80.25	76.94	79.37	90.63	76.89
Water mass	(g)	12.79	14.61	17.81	22.49	21.91	17.70	26.37	25.87	35.72	30.83
Dry sample mass	(g)	161.94	169.32	167.16	209.03	170.88	142.68	184.43	176.74	208.69	179.52
Water moisture content	(%)	7.9	8.6	10.7	10.8	12.8	12.4	14.3	14.6	17.1	17.2

Water moisture content average	(%)	8.3	10.8	12.6	14.5	17.2
Dry density	($g.cm^{-3}$)	1.686	1.727	1.757	1.725	1.681

Table of uncertainty in each mould

Expanded uncertainty	%	0.015	0.015	0.015	0.015	0.015
Expansion factor k		2.00	2.00	2.00	2.00	2.00

(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Comments :

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Test Report

Process **37321** Lot **1**

Sample **66775**

Client's data

Boring **P5**

Depth **0.30 - 3.00**

Sample register date **30/09/2021**

Test execution dates **11/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source	Site Sampling	Application

Compacting curve

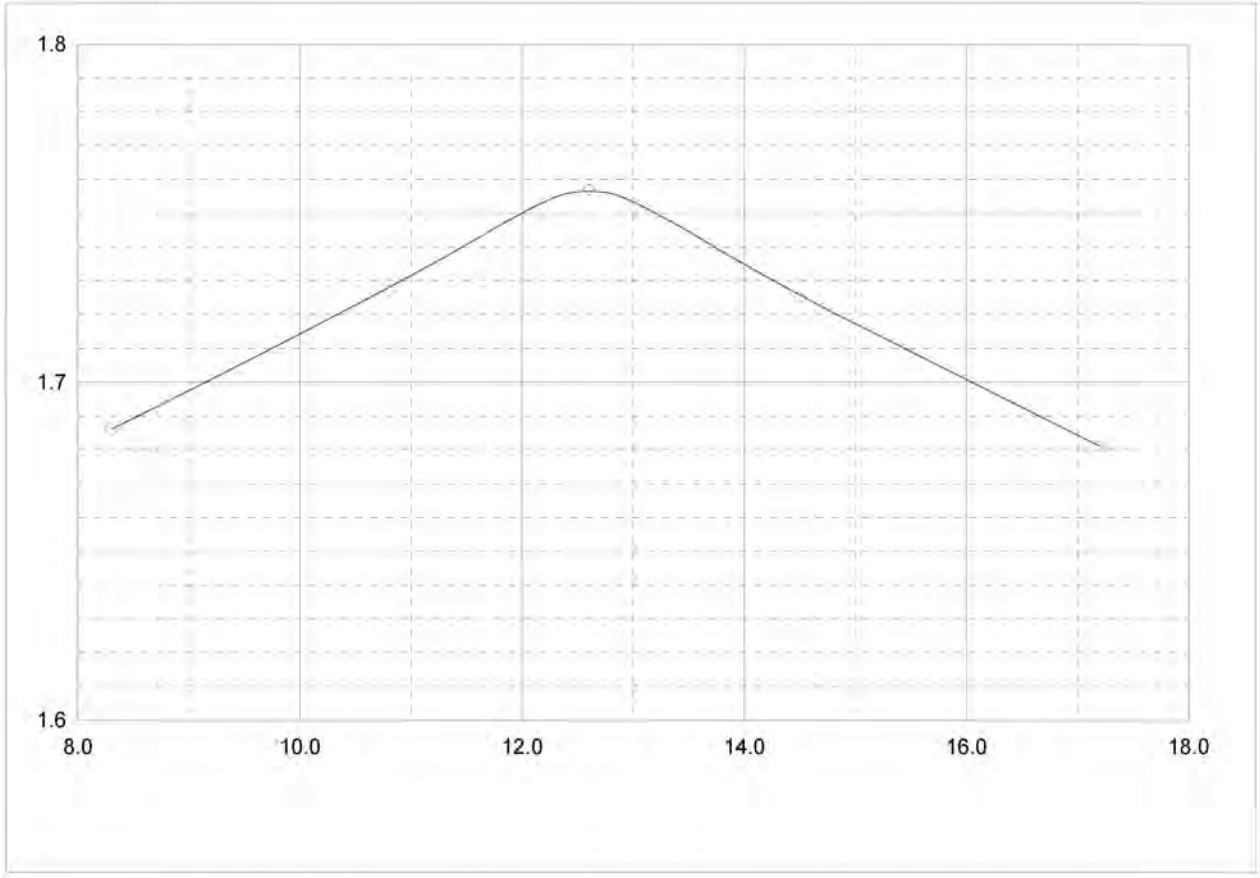
IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type ☒ Standard effort ☐ Modified effort

Mould ☐ 4" ☒ 6"

Grains size less than _____ mm



(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Table of uncertainty	Expansion factor k	Expanded uncertainty %
Optimum water moisture content	**2.00**	**0.28**
Maximum dry density	**2.00**	**0.026**

Optimum water moisture content Wopt = **12.6** %

Maximum dry density γ dmax = **1.76** g.cm^{-3}

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Ensaio de Condutividade Térmica

Projecto:	**Sines Nest Data Center**	
Cliente:	START CAMPUS	**Data do ensaio:** 15-10-2021

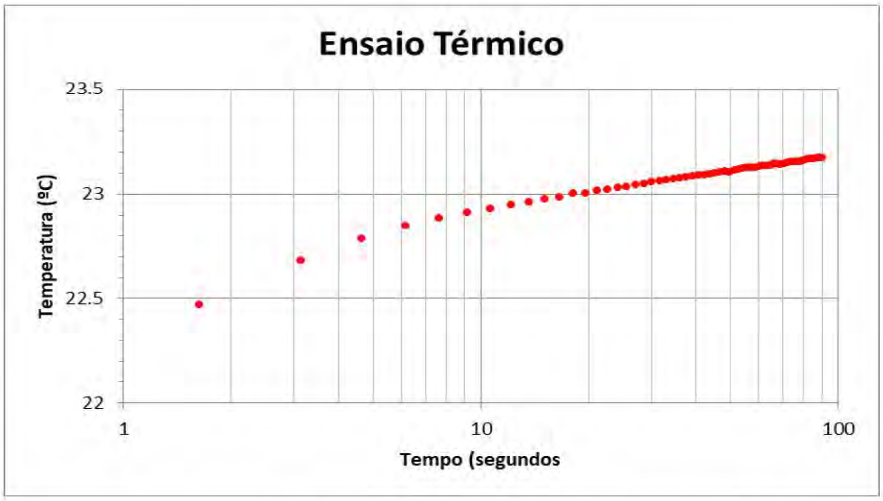
Equipmento:	Thermtest - TLS-100 Portatable Meter*				**Coordenadas(ETRS89):**
TLS sonda:	[x]	100 mm	[ ]	50 mm	M:
Tipo Amostra	[ ]	Não deformada	[x]	Moldada	P:
Método cravação	[x]	Pressão manual	[ ]	Pré-furo	*Calibrado de fabrica de acordo com a norma ISO22007-2:2015 TPS Measurements

Descrição da Amostra: areia média a fina quartzosa, de tons amarelados a acinzentados

TLS-100 Medições

Poço Ref.	**P5**
Amostra Ref.	66775
Ensaio Térmico Ref.	Amostra 1
Profundidade amostra (m)	0.3 - 3.0
Heating Power (W/m)	3.919
Temperatura da amostra (ºC)	22.090
k (W/m.K)	**7.942**
R (m.K/W)	**0.125**

Temperatura versus tempo - gráfico semi-log da amostra



* Procedimento realizado de acordo com a norma ASTM D5334 &IEEE 442-1981

Registo fotográfico da realização do ensaio



Observações:	Amostras em molde compactado a 95% do Proctor, no teor de húmidade óptimo.				
Data: 18/10/2021	Local:	Lisboa	Realizado por:	Figueiredo. H	

Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Sample Report

Process **37321** Lot **1**

Sample **66776**

Client's data

Boring **P6**

Depth **2.20 - 3.00**

Sample register date **30/09/2021**

Sample conclusion date **20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Results

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Sampling Procedure (*) (*) Efectuado Depart. Prospecção da Geocontrole **Sample Type** **DISTURBED**

Description(*) **Light brown, sligtly silty, medium grain size sand.**

Classification(*) Unified **(SP-SM)** GTR : Highway (E 240) **A-3(0)**
ASTM (D2487-00) ASTM (D3282-97)

Ponderal feature Water content w = **2.1** % Particle Density G = ρ = g/cm³
(*) Organic matter content % (*) Ph= (*) ρ_d = g/cm³

Consistency limits Way of preparation ☒ Dry ☐ Wet LL= **NP** % PL **0** % (*) SL % (*) IP= **0**

Methylene Blue Stain test Expressed in grams of methylene blue for 100g of dry soil

Particle Size Analysis Way of preparation ☒ Dry ☐ Wet
%< 2,00 mm = **98**
%<0,420 mm = **75**
%<0,074 mm = **7**
%<0,002 mm = **6**
(*) Cu = D60/D10 = **3** (*) Cc = **1**
EA =

Expansibility (*) % Sample sujected to a load of g

Compaction (Proctor)

Mould	Test Type	γ dmax (g/cm³)	Wopt (%)
6"	**STANDARD EFFORT**	**1.77**	**13.3**

CBR

Moulding conditions						
	Cr =					%
	Deviation					%
	CBR =					%
	Expansibility					%

Coefficient (*) Fragmentability Degradability

Compressibility (*) Cc = σ_a = kN/m² e_0 = Cv = m²/s K = m/s

Strenght (*) Unconfined compression test qu = kPa Ei = kPa

Direct shear test UU CU CD C = kPa θ = ° C' = kPa θ' = °

Triaxial compression UU CU CD
σ_3 = kN/m²
σ_1 = kN/m²
Ei = kN/m² C = kN/m² θ = °
C' = kN/m² θ' = °

Permeability (*) K = m/s

(*) - The tests indicated are not included in the scope of accreditation

Comments :

The expanded uncertainty, when presented, is expressed by the standard uncertainty multiplied by the expansion factor k, corresponding to a probability of 95%.
Uncertainties are calculated according to document EA-4/02

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Test Report

Process **37321** Lot **1**

Sample **66776**

Client's data

Boring **P6**

Depth **2.20 - 3.00**

Sample register date **30/09/2021**

Test execution dates **30/09/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Water Moisture Content

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Standard : NP-84(1965)

Container	n°	**632**	**668**	**659**	
Wet sample mass + Container	m_2 g	**301.90**	**321.64**	**300.04**	
Dry sample mass + Container	m_4 g	**297.63**	**316.22**	**295.91**	
Container mass	m_1 g	**80.02**	**79.71**	**90.01**	
Water mass	m_a g	**4.27**	**5.42**	**4.13**	
Dry sample mass	m_s g	**217.61**	**236.51**	**205.90**	
Water moisture content $w = \frac{m_a}{m_s} \times 100$	%	**2.0**	**2.3**	**2.0**	

Water content average(w): 2.1 %

Table of uncertainty in each specimen

Expanded uncertainty	%	0.27	0.27	0.27	
Expansion factor k		2.00	2.00	2.00	

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

This test report can only be reproduced totally or partially with Geocontrole express authorization. The results are referring to the tested sample.

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Test Report

Process **37321** Lot **1**

Sample **66776**

Client's data

Boring **P6**

Depth **2.20 - 3.00**

Sample register date **30/09/2021**

Test execution dates **04/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Consistency limits

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

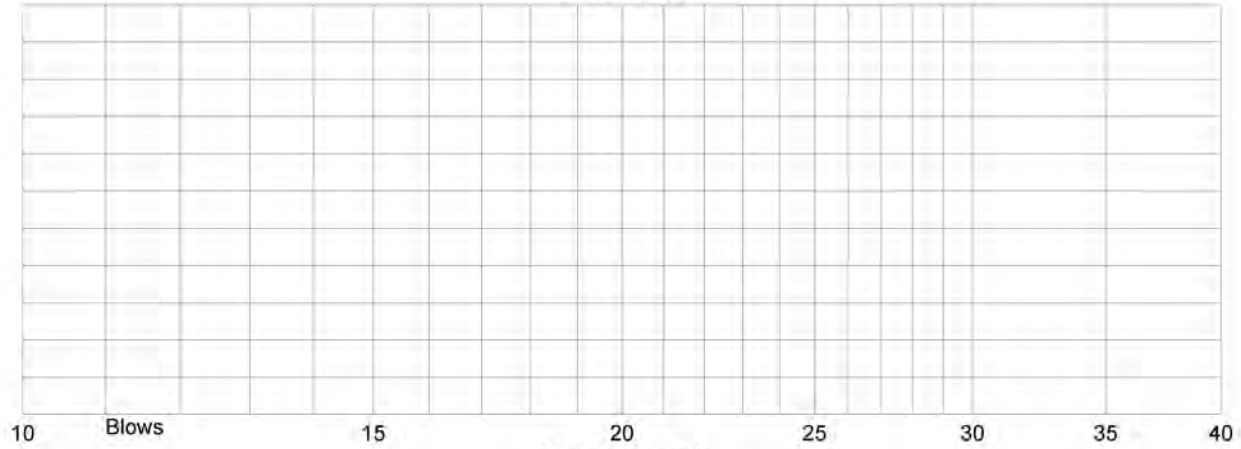
Standard : NP-143(1969)

		Liquidity limit	Plasticity limit
Container	nº		
Wet sample mass + container	g		
Dry sample mass + container	g		
Container mass	g		
Water mass	g		
Dry sample mass	g		
Water content	%		
Nr of blows			PL (Average) = %

N/P

W (%)

DIAGRAM



Shrinkage limit
(Non accredited method)

Container	**nº**					**Container volume V**	**cm^3**			
Wet sample + Container	**g**					**Quicksilver weight (1)**	**g**			
Dry sample + Container	**g**					**Dry soil volume (1)/13.55 (v)**				
Container mass	**g**					**V-v**				
Water mass	**g**					**A = V - v / Ps X 100**				
Dry sample Ps	**g**					**Shrinkage limit W-A**				
Water content W	**%**					**Shrinkage ratio Ps / v**				

LL = % **PL** % **(*) IP =**

(*) SL %

Limite de Liquidez	**Incerteza Expandida**	
	Fator de Expansão k	
Limite de Plasticidade	**Incerteza Expandida**	
	Fator de Expansão k	

(*) - Non accredited parameter

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Test Report

Process **37321** Lot **1**

Sample **66776**

Client's data

Boring **P6**

Depth **2.20 - 3.00**

Sample register date **30/09/2021**

Test execution dates **14/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Analysis

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196(1966) and E239(1970)

1) SIEVE ANALYSIS

Dry sample total weight : **1921.50** g

COARSE ELEMENTS

Sieve designation		3 "	2 "	1½ "	1"	3/4 "	3/8 "	4	10
Square shaped mesh	mm	76.1	50.8	38.1	25.4	19.0	9.51	4.76	2.00
Retained material mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**16.92**	**3.04**	**5.47**	**10.80**
Accumulated mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**16.92**	**19.96**	**25.43**	**36.23**
% Acumulados		**0.00**	**0.00**	**0.00**	**0.00**	**0.88**	**1.04**	**1.32**	**1.89**
Complemento para 100%		**100**	**100**	**100**	**100**	**99**	**99**	**99**	**98**
Fator de Expansão k						2.00	2.00	2.00	2.00
Incerteza Expandida						1.1	1.0	2.6	1.8

FINE ELEMENTS

Total fine elements weight used : **70.63** g

Sieve designation		20	40	60	140	200
Square shaped mesh	mm	0.841	0.420	0.250	0.105	0.074
Retained material mass	g	**5.18**	**11.73**	**22.35**	**24.78**	**1.43**
Accumulated mass	g	**5.18**	**16.91**	**39.26**	**64.04**	**65.47**
% Accumulated		**7.33**	**23.94**	**55.59**	**90.67**	**92.69**
Complement to 100%		**92.67**	**76.06**	**44.41**	**9.33**	**7.31**
% Refered to total mass		**91**	**75**	**44**	**9**	**7**
Fator de Expansão k		2.00	2.00	2.00	2.00	2.00
Incerteza Expandida		1.2	1.4	2.7	1.8	1.3

2) HYDROMETER ANALYSIS

Container nº **18**

Hydrometer nº **35**

Dispersing Agent **100** cm^3

Dry sample weight Ps **70.63** g

Particules density G= **2.64**

Corrections : Meniscus = **0.0002**

Antifloc. = **0.0002**

$$\% \text{ of particles} = \frac{G}{G-1} \times \frac{100}{Ps} \times (Lc-1) \times 10^3$$

Minutes (t)	Temperature (°C)	Densimeter value	Correction	Corrected reading (Lc)	Z (cm)	D= Z/t x K	Expanded uncertainty	Expansion factor k	% of particles	% Refer. to Total
1	**23**	**1.0022**	**0.0006**	**1.0028**	**13.99**	**0.0476**	**2.4**	**2.00**	**6.38**	**6**
2	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0337**	**2.4**	**2.00**	**6.15**	**6**
5	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0213**	**2.4**	**2.00**	**6.15**	**6**
15	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0123**	**2.4**	**2.00**	**6.15**	**6**
30	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0087**	**2.4**	**2.00**	**6.15**	**6**
60	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0062**	**2.4**	**2.00**	**6.15**	**6**
250	**23**	**1.0019**	**0.0006**	**1.0025**	**14.11**	**0.0030**	**2.4**	**2.00**	**5.70**	**6**
1440	**23**	**1.0019**	**0.0006**	**1.0025**	**14.11**	**0.0013**	**2.4**	**2.00**	**5.70**	**6**
2880										

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Test Report

Process **37321** Lot **1**

Sample **66776**

Client's data

Boring **P6**

Depth **2.20 - 3.00**

Sample register date **30/09/2021**

Test execution dates **14/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

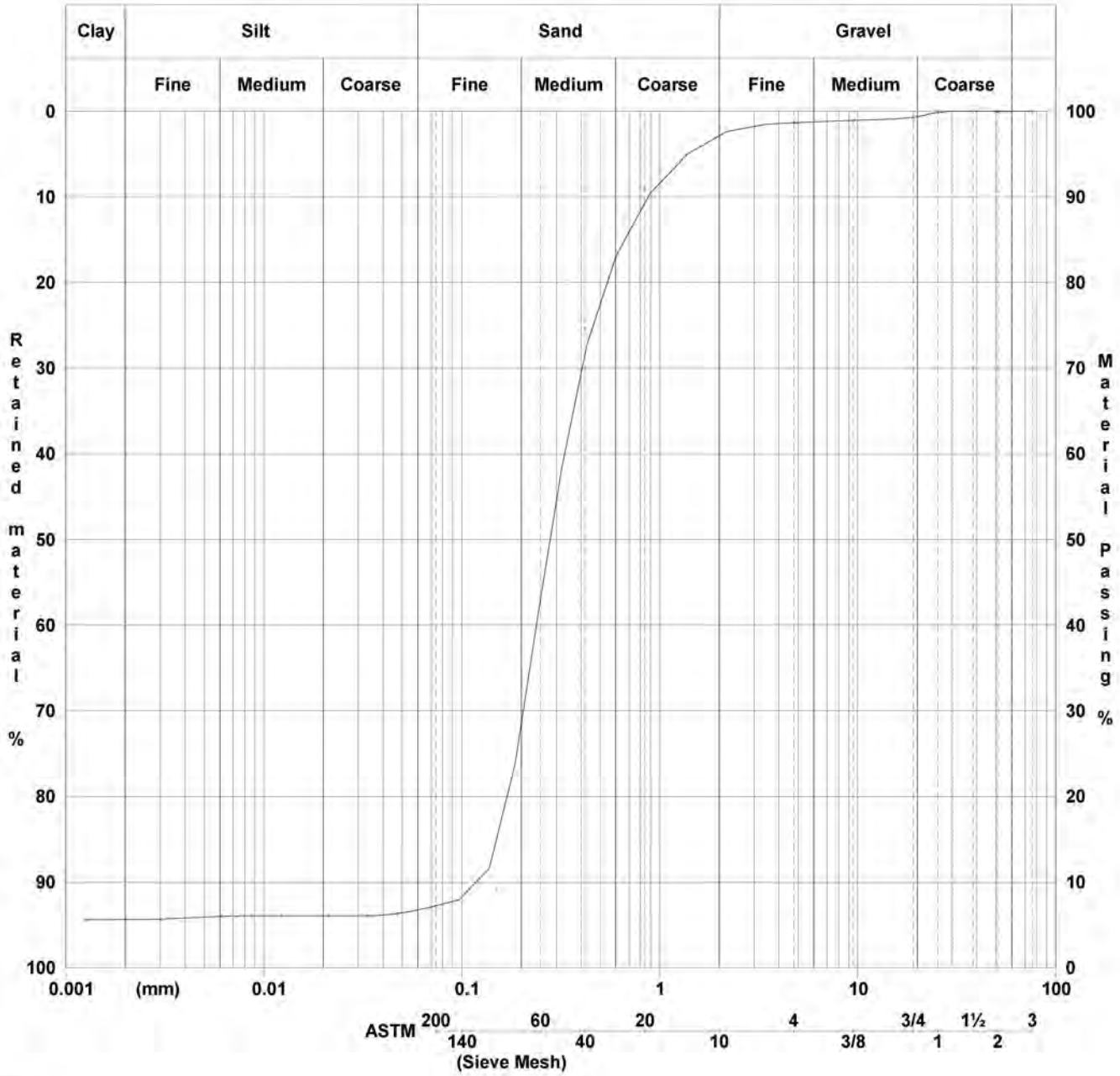
Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Distribution

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196



Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Test Report

Process **37321** Lot **1**

Sample **66776**

Client's data

Boring **P6**

Depth **2.20 - 3.00**

Sample register date **30/09/2021**

Test execution dates **06/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Proctor compacting test

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type : ☐ Standard effort ☐ Modified effort

Mould : ☐ 4" ☒ 6"

Grains size less than ____ mm

Mould	(nº)	11		11		11		11		11	
Mould + wet soil	(g)	6279		6381		6507		6598		6584	
Wet soil	(g)	3781		3883		4009		4100		4086	
Wet density	($g.cm^{-3}$)	1.848		1.898		1.959		2.004		1.997	
Container	(nº)	323	673	816	300	311	717	810	667	640	337
Wet sample + container	(g)	253.98	242.14	296.01	292.81	292.66	305.99	326.65	289.68	345.37	292.69
Dry sample + container	(g)	242.39	232.00	277.53	274.00	270.17	282.04	298.54	265.97	309.09	264.18
Container mass	(g)	79.64	90.51	79.04	76.89	78.27	79.57	90.02	89.70	78.77	77.11
Water mass	(g)	11.59	10.14	18.48	18.81	22.49	23.95	28.11	23.71	36.28	28.51
Dry sample mass	(g)	162.75	141.49	198.49	197.11	191.90	202.47	208.52	176.27	230.32	187.07
Water moisture content	(%)	7.1	7.2	9.3	9.5	11.7	11.8	13.5	13.5	15.8	15.2

Water moisture content average	(%)	7.2	9.4	11.8	13.5	15.5
Dry density	($g.cm^{-3}$)	1.724	1.735	1.753	1.766	1.729

Table of uncertainty in each mould

Expanded uncertainty	%	0.015	0.015	0.015	0.015	0.015
Expansion factor k		2.00	2.00	2.00	2.00	2.00

(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Comments :

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Test Report

Process **37321** Lot **1**

Sample **66776**

Client's data

Boring **P6**

Depth **2.20 - 3.00**

Sample register date **30/09/2021**

Test execution dates **06/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Proctor compacting test

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type : ☐ Standard effort ☐ Modified effort

Mould : ☐ 4" ☒ 6"

Grains size less than ____ mm

Mould	(nº)	11									
Mould + wet soil	(g)	6567									
Wet soil	(g)	4069									
Wet density	($g.cm^{-3}$)	1.989									
Container	(nº)	711	659								
Wet sample + container	(g)	308.46	290.20								
Dry sample + container	(g)	272.49	260.03								
Container mass	(g)	75.70	90.01								
Water mass	(g)	35.97	30.17								
Dry sample mass	(g)	196.79	170.02								
Water moisture content	(%)	18.3	17.7								

Water moisture content average	(%)	18.0				
Dry density	($g.cm^{-3}$)	1.685				

Table of uncertainty in each mould

Expanded uncertainty	%					
Expansion factor k						

(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Comments :

Laboratory Management

Issue date: **21/10/2021**

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Test Report

Process **37321** Lot **1**

Sample **66776**

Client's data

Boring **P6**

Depth **2.20 - 3.00**

Sample register date **30/09/2021**

Test execution dates **06/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Compacting curve

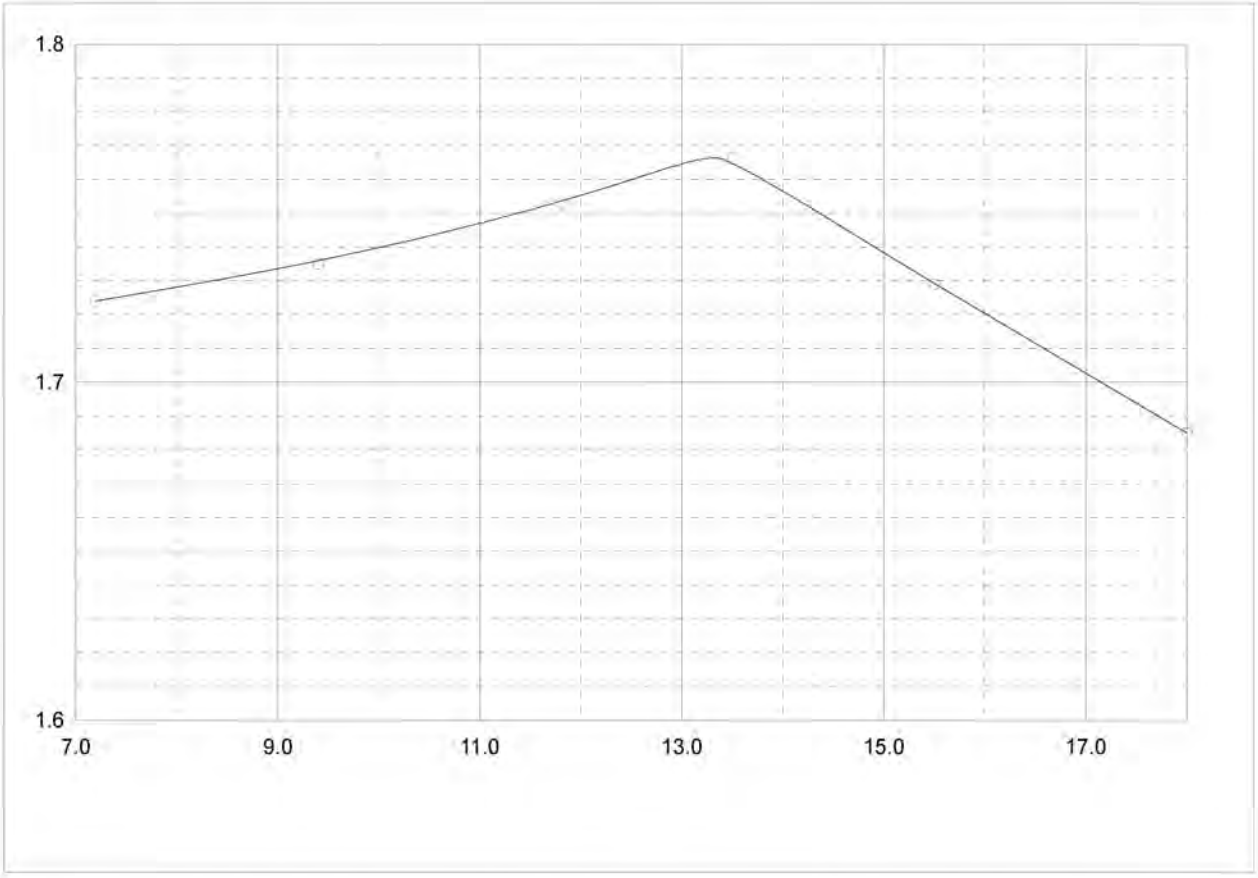
IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type: ☒ Standard effort ☐ Modified effort

Mould: ☐ 4" ☒ 6"

Grains size less than ____ mm



(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Table of uncertainty	Expansion factor k	Expanded uncertainty %
Optimum water moisture content	**2.00**	**0.28**
Maximum dry density	**2.00**	**0.026**

Optimum water moisture content Wopt = **13.3** %

Maximum dry density γ dmax = **1.77** g.cm^{-3}

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Ensaio de Condutividade Térmica

Projecto:	**Sines Nest Data Center**	
Cliente:	START CAMPUS	**Data do ensaio:** 15-10-2021

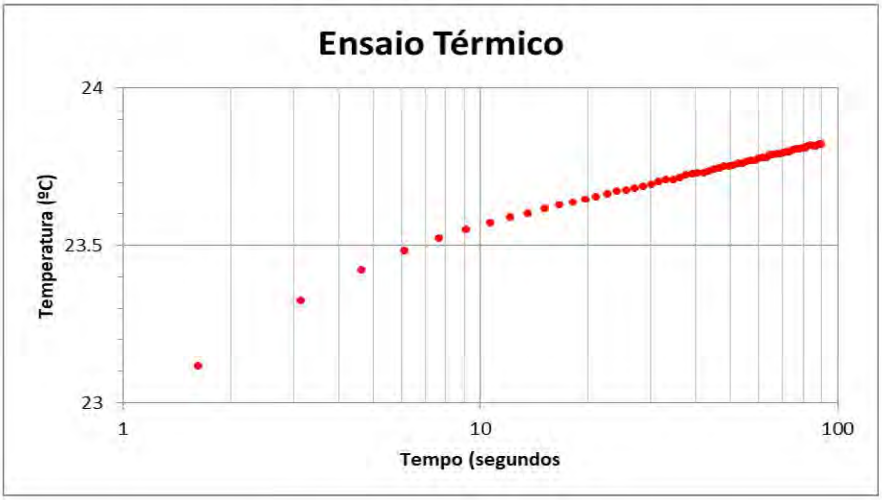
Equipmento:	Thermtest - TLS-100 Portatable Meter*			**Coordenadas(ETRS89):**	
TLS sonda:	[x]	100 mm	[ ]	50 mm	M:
Tipo Amostra	[ ]	Não deformada	[x]	Moldada	P:
Método cravação	[x]	Pressão manual	[ ]	Pré-furo	*Calibrado de fabrica de acordo com a norma ISO22007-2:2015 TPS Measurements

Descrição da Amostra: areia média a fina quartzosa, de tons amarelados a acinzentados

TLS-100 Medições

Poço Ref.	**P6**
Amostra Ref.	66776
Ensaio Térmico Ref.	Amostra 6
Profundidade amostra (m)	2.2 - 3.0
Heating Power (W/m)	3.918
Temperatura da amostra (ºC)	22.735
k (W/m.K)	**7.308**
R (m.K/W)	**0.136**

Temperatura versus tempo gráfico - semi-log da amostra



* Procedimento realizado de acordo com a norma ASTM D5334 &IEEE 442-1981

Registo fotográfico da realização do ensaio



Observações:	Amostras em molde compactado a 95% do Proctor, no teor de húmidade óptimo.				
Data: 18/10/2021	Local:	Lisboa	Realizado por:	Figueiredo. H	

Geocontrole
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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Sample Report

Process **37321** Lot **1**

Sample **66777**

Client's data

Boring **P7**

Depth **0.60 - 2.00**

Sample register date **30/09/2021**

Sample conclusion date **20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source	Site Sampling	Application

Results

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Sampling Procedure (*) (*) Efectuado Depart. Prospecção da Geocontrole **Sample Type** **DISTURBED**

Description(*) **Light brown, slightly silty, medium grain size sand.**

Classification(*) Unified **(SP-SM)** GTR : Highway (E 240) **A-2-4(0)**
ASTM (D2487-00) ASTM (D3282-97)

Ponderal feature Water content w = **1.7** % Particle Density G = ρ = g/cm³
(*) Organic matter content % (*) Ph= (*) ρ_d = g/cm³

Consistency limits Way of preparation ☒ Dry ☐ Wet LL= **NP** % PL **0** % (*) SL % (*) IP= **0**

Methylene Blue Stain test Expressed in grams of methylene blue for 100g of dry soil

Particle Size Analysis Way of preparation ☒ Dry ☐ Wet
%< 2,00 mm = **98**
%<0,420 mm = **70**
%<0,074 mm = **11**
%<0,002 mm = **6**
(*) Cu = D60/D10 = **5** (*) Cc = **1**
EA =

Expansibility (*) % Sample sujected to a load of g

Compaction (Proctor)

Mould	Test Type	γ dmax (g/cm³)	Wopt (%)
6"	**STANDARD EFFORT**	**1.76**	**12.8**

CBR

Moulding conditions						
	Cr =					%
	Deviation					%
	CBR =					%
	Expansibility					%

Coefficient (*) Fragmentability Degradability

Compressibility (*) Cc = σa = kN/m² e_0 = Cv = m²/s K = m/s

Strenght (*) Unconfined compression test qu = kPa Ei = kPa

Direct shear test UU CU CD C = kPa θ = ° C' = kPa θ' = °

Triaxial compression UU CU CD
σ_3 = kN/m²
σ_1 = kN/m²
Ei = kN/m² C = kN/m² θ = °
C' = kN/m² θ' = °

Permeability (*) K = m/s

(*) - The tests indicated are not included in the scope of accreditation

Comments :

The expanded uncertainty, when presented, is expressed by the standard uncertainty multiplied by the expansion factor k, corresponding to a probability of 95%.
Uncertainties are calculated according to document EA-4/02

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Test Report

Process **37321** Lot **1**

Sample **66777**

Client's data

Boring **P7**

Depth **0.60 - 2.00**

Sample register date **30/09/2021**

Test execution dates **30/09/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Water Moisture Content

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Standard : NP-84(1965)

Container	n°	**674**	**679**	**639**	
Wet sample mass + Container	m_2 g	**314.01**	**279.51**	**306.07**	
Dry sample mass + Container	m_4 g	**309.49**	**276.89**	**302.50**	
Container mass	m_1 g	**90.29**	**79.75**	**89.28**	
Water mass	m_a g	**4.52**	**2.62**	**3.57**	
Dry sample mass	m_s g	**219.20**	**197.14**	**213.22**	
Water moisture content $w = \frac{m_a}{m_s} \times 100$	%	**2.1**	**1.3**	**1.7**	

Water content average(w): 1.7 %

Table of uncertainty in each specimen

Expanded uncertainty	%	0.27	0.27	0.27	
Expansion factor k		2.00	2.00	2.00	

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Geocontrole
Rua D. Nuno Álvares Pereira, N.º4-Bloco 4, 2699-501 Bobadela Portugal
Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66777**

Client's data

Boring **P7**

Depth **0.60 - 2.00**

Sample register date **30/09/2021**

Test execution dates **04/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Consistency limits

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

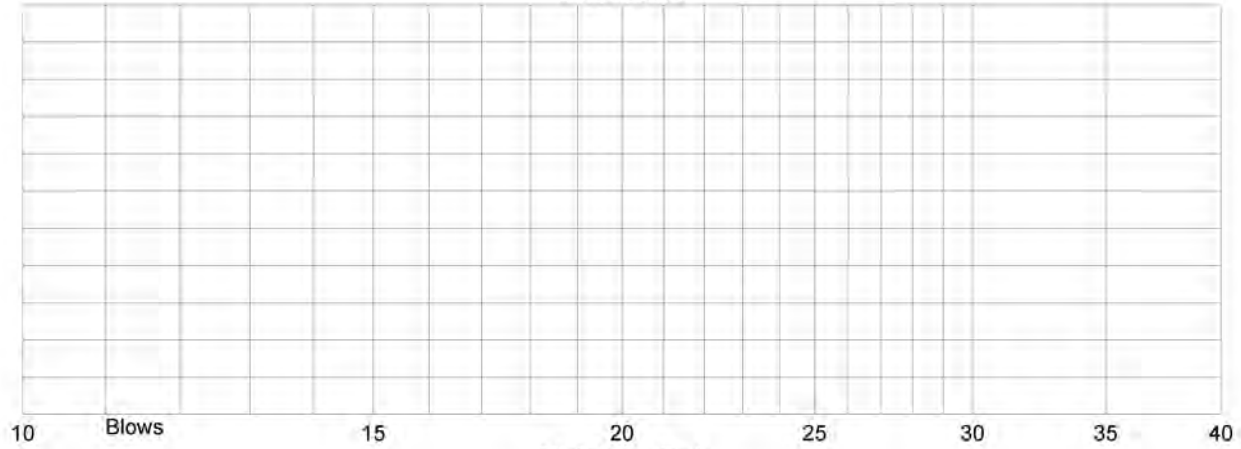
Standard : NP-143(1969)

		Liquidity limit	Plasticity limit
Container	nº		
Wet sample mass + container	g		
Dry sample mass + container	g		
Container mass	g		
Water mass	g		
Dry sample mass	g		
Water content	%		
Nr of blows			PL (Average) = %

N/P

W (%)

DIAGRAM



Shrinkage limit
(Non accredited method)

Container	**nº**					**Container volume V**	**cm^3**				
Wet sample + Container	**g**					**Quicksilver weight (1)**	**g**				
Dry sample + Container	**g**					**Dry soil volume (1)/13.55 (v)**					
Container mass	**g**					**V-v**					
Water mass	**g**					**A = V - v / Ps X 100**					
Dry sample Ps	**g**					**Shrinkage limit W-A**					
Water content W	**%**					**Shrinkage ratio Ps / v**					

LL = % **PL** % **(*) IP =**

(*) SL %

Limite de Liquidez	**Incerteza Expandida**	
	Fator de Expansão k	
Limite de Plasticidade	**Incerteza Expandida**	
	Fator de Expansão k	

(*) - Non accredited parameter

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Test Report

Process **37321** Lot **1**

Sample **66777**

Client's data

Boring **P7**

Depth **0.60 - 2.00**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Analysis

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196(1966) and E239(1970)

1) SIEVE ANALYSIS

Dry sample total weight : **1570.00** g

COARSE ELEMENTS

Sieve designation		3 "	2 "	½ "	1"	3/4 "	3/8 "	4	10
Square shaped mesh	mm	76.1	50.8	38.1	25.4	19.0	9.51	4.76	2.00
Retained material mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2.54**	**15.29**	**14.53**
Accumulated mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2.54**	**17.83**	**32.36**
% Acumulados		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.16**	**1.14**	**2.06**
Complemento para 100%		**100**	**100**	**100**	**100**	**100**	**100**	**99**	**98**
Fator de Expansão k							2.00	2.00	2.00
Incerteza Expandida							1.0	2.6	1.8

FINE ELEMENTS

Total fine elements weight used : **70.67** g

Sieve designation		20	40	60	140	200
Square shaped mesh	mm	0.841	0.420	0.250	0.105	0.074
Retained material mass	g	**6.34**	**14.01**	**19.59**	**21.83**	**1.31**
Accumulated mass	g	**6.34**	**20.35**	**39.94**	**61.77**	**63.08**
% Accumulated		**8.97**	**28.80**	**56.52**	**87.41**	**89.26**
Complement to 100%		**91.03**	**71.20**	**43.48**	**12.59**	**10.74**
% Refered to total mass		**89**	**70**	**43**	**12**	**11**
Fator de Expansão k		2.00	2.00	2.00	2.00	2.00
Incerteza Expandida		1.2	1.4	2.7	1.8	1.3

2) HYDROMETER ANALYSIS

Container nº **1**

Hydrometer nº **35**

Dispersing Agent **100** cm^3

Dry sample weight Ps **70.67** g

Particules density G= **2.62**

Corrections : Meniscus = **0.0002**

Antifloc. = **0.0002**

$$\% \text{ of particles} = \frac{G}{G-1} \times \frac{100}{Ps} \times (Lc-1) \times 10^3$$

Minutes (t)	Temperature (°C)	Densimeter value	Correction	Corrected reading (Lc)	Z (cm)	D= Z/t x K	Expanded uncertainty	Expansion factor k	% of particles	% Refer. to Total
1	**23**	**1.0030**	**0.0006**	**1.0036**	**13.68**	**0.0468**	**2.4**	**2.00**	**8.24**	**8**
2	**23**	**1.0027**	**0.0006**	**1.0033**	**13.79**	**0.0332**	**2.4**	**2.00**	**7.55**	**7**
5	**23**	**1.0022**	**0.0006**	**1.0028**	**13.99**	**0.0212**	**2.4**	**2.00**	**6.41**	**6**
15	**23**	**1.0022**	**0.0006**	**1.0028**	**13.99**	**0.0122**	**2.4**	**2.00**	**6.41**	**6**
30	**23**	**1.0022**	**0.0006**	**1.0028**	**13.99**	**0.0086**	**2.4**	**2.00**	**6.41**	**6**
60	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0061**	**2.4**	**2.00**	**6.18**	**6**
250	**23**	**1.0020**	**0.0006**	**1.0026**	**14.07**	**0.0030**	**2.4**	**2.00**	**5.95**	**6**
1440	**23**	**1.0019**	**0.0006**	**1.0025**	**14.11**	**0.0013**	**2.4**	**2.00**	**5.72**	**6**
2880										

Comments :

Laboratory Management

Issue date: **21/10/2021**

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Test Report

Process **37321** Lot **1**

Sample **66777**

Client's data

Boring **P7**

Depth **0.60 - 2.00**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

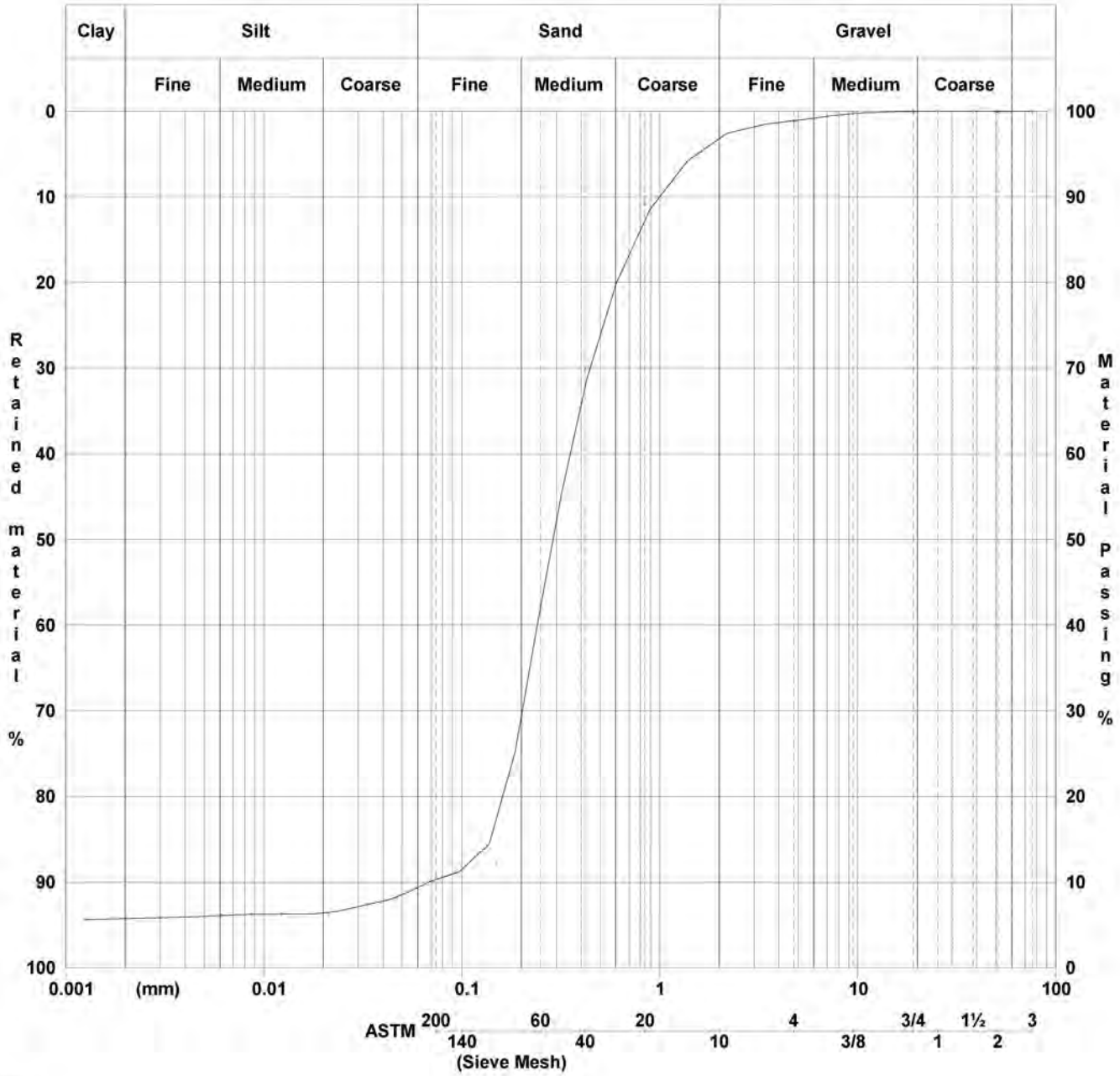
Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Distribution

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196



Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Test Report

Process **37321** Lot **1**

Sample **66777**

Client's data

Boring **P7**

Depth **0.60 - 2.00**

Sample register date **30/09/2021**

Test execution dates **11/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Proctor compacting test

Procedure : PL.09/2(2018) (*)

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Test type : ☐ Standard effort ☐ Modified effort

Mould : ☐ 4" ☒ 6"

Grains size less than _____ mm

Mould	(nº)	50		50		50		50		50	
Mould + wet soil	(g)	6323		6450		6542		6545		6550	
Wet soil	(g)	3860		3987		4079		4082		4087	
Wet density	($g.cm^{-3}$)	1.883		1.945		1.990		1.991		1.994	
Container	(nº)	810	466	669	296	688	674	639	748	694	732
Wet sample + container	(g)	281.86	264.98	306.11	324.88	330.33	338.21	318.76	368.67	323.18	326.98
Dry sample + container	(g)	266.39	252.17	283.43	301.97	301.20	310.06	288.80	329.30	287.97	290.41
Container mass	(g)	90.02	88.90	78.80	90.16	78.87	90.29	89.28	80.35	79.12	79.77
Water mass	(g)	15.47	12.81	22.68	22.91	29.13	28.15	29.96	39.37	35.21	36.57
Dry sample mass	(g)	176.37	163.27	204.63	211.81	222.33	219.77	199.52	248.95	208.85	210.64
Water moisture content	(%)	8.8	7.8	11.1	10.8	13.1	12.8	15.0	15.8	16.9	17.4

Water moisture content average	(%)	8.3	11.0	13.0	15.4	17.2
Dry density	($g.cm^{-3}$)	1.739	1.752	1.761	1.726	1.701

Table of uncertainty in each mould

Expanded uncertainty	%	0.015	0.015	0.015	0.015	0.015
Expansion factor k		2.00	2.00	2.00	2.00	2.00

(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Comments :

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Test Report

Process **37321** Lot **1**

Sample **66777**

Client's data

Boring **P7**

Depth **0.60 - 2.00**

Sample register date **30/09/2021**

Test execution dates **11/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Compacting curve

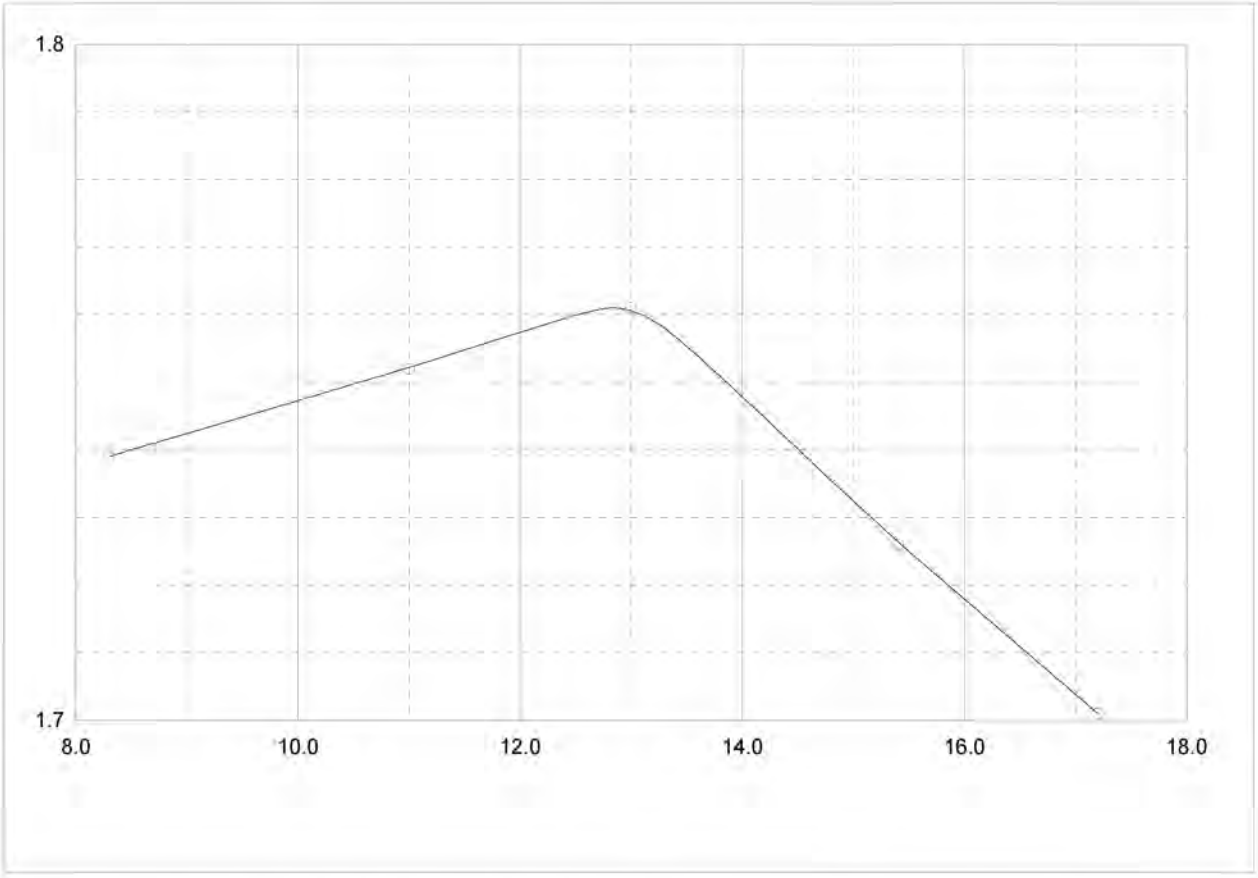
IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type: ☒ Standard effort ☐ Modified effort

Mould: ☐ 4" ☒ 6"

Grains size less than ____ mm



(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Table of uncertainty	Expansion factor k	Expanded uncertainty %
Optimum water moisture content	**2.00**	**0.28**
Maximum dry density	**2.00**	**0.026**

Optimum water moisture content Wopt = **12.8** %

Maximum dry density γ dmax = **1.76** g.cm^{-3}

Comments :

Laboratory Management

Issue date: **21/10/2021**

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Ensaio de Condutividade Térmica

Projecto:	**Sines Nest Data Center**	
Cliente:	START CAMPUS	**Data do ensaio:** 15-10-2021

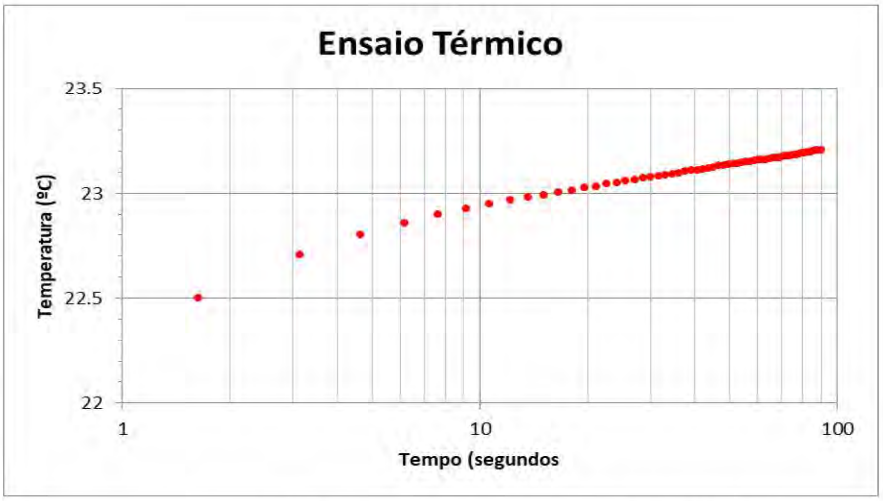
Equipmento:	Thermtest - TLS-100 Portatable Meter*				**Coordenadas(ETRS89):**
TLS sonda:	[x]	100 mm	[ ]	50 mm	M:
Tipo Amostra	[ ]	Não deformada	[x]	Moldada	P:
Método cravação	[x]	Pressão manual	[ ]	Pré-furo	*Calibrado de fabrica de acordo com a norma ISO22007-2:2015 TPS Measurements

Descrição da Amostra: areia média a fina quartzosa, de tons amarelados a acinzentados

TLS-100 Medições

Poço Ref.	**P7**
Amostra Ref.	66777
Ensaio Térmico Ref.	Amostra 5
Profundidade amostra (m)	0.6 - 2.0
Heating Power (W/m)	3.918
Temperatura da amostra (ºC)	22.128
k (W/m.K)	**7.874**
R (m.K/W)	**0.126**

Temperatura versus tempo gráfico - semi-log da amostra



* Procedimento realizado de acordo com a norma ASTM D5334 &IEEE 442-1981

Registo fotográfico da realização do ensaio



Observações:	Amostras em molde compactado a 95% do Proctor, no teor de húmidade óptimo.				
Data: 18/10/2021	Local:	Lisboa	Realizado por:	Figueiredo. H	

Geocontrole
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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Sample Report

Process **37321** Lot **1**

Sample **66778**

Client's data

Boring **P8**

Depth **1.00 - 2.50**

Sample register date **30/09/2021**

Sample conclusion date **20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source	Site Sampling	Application

Results

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Sampling Procedure (*) (*) Efectuado Depart. Prospecção da Geocontrole **Sample Type** **DISTURBED**

Description(*) **Light brown, slightly silty, medium grain size sand.**

Classification(*) Unified **(SP-SM)** GTR : Highway (E 240) **A-3(0)**
ASTM (D2487-00) ASTM (D3282-97)

Ponderal feature Water content w = **2.6** % Particle Density G = ρ = g/cm³
(*) Organic matter content % (*) Ph= (*) ρ_d = g/cm³

Consistency limits Way of preparation [X] Dry [ ] Wet LL= **NP** % PL **0** % (*) SL % (*) IP= **0**

Methylene Blue Stain test Expressed in grams of methylene blue for 100g of dry soil

Particle Size Analysis Way of preparation [X] Dry [ ] Wet
%< 2,00 mm = **99**
%<0,420 mm = **75**
%<0,074 mm = **10**
%<0,002 mm = **6**
(*) Cu = D60/D10 = **4** (*) Cc = **1**
EA =

Expansibility (*) % Sample sujected to a load of g

Compaction (Proctor)

Mould	Test Type	γ dmax (g/cm³)	Wopt (%)
6"	**STANDARD EFFORT**	**1.75**	**13.0**

CBR

Moulding conditions						
	Cr =					%
	Deviation					%
	CBR =					%
	Expansibility					%

Coefficient (*) Fragmentability Degradability

Compressibility (*) Cc = σ_a = kN/m² e_o = Cv = m²/s K = m/s

Strenght (*) Unconfined compression test qu = kPa Ei = kPa

Direct shear test UU CU CD C = kPa θ = ° C' = kPa θ' = °

Triaxial compression UU CU CD σ_3 = kN/m² σ_1 = kN/m² C = kN/m² θ = °
Ei = kN/m² C' = kN/m² θ' = °

Permeability (*) K = m/s

(*) - The tests indicated are not included in the scope of accreditation

Comments :

The expanded uncertainty, when presented, is expressed by the standard uncertainty multiplied by the expansion factor k, corresponding to a probability of 95%.
Uncertainties are calculated according to document EA-4/02

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Test Report

Process **37321** Lot **1**

Sample **66778**

Client's data

Boring **P8**

Depth **1.00 - 2.50**

Sample register date **30/09/2021**

Test execution dates **30/09/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Water Moisture Content

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Standard : NP-84(1965)

Container	n°	**810**	**669**	**745**	
Wet sample mass + Container	m_2 g	**305.49**	**337.99**	**315.41**	
Dry sample mass + Container	m_4 g	**299.64**	**331.43**	**309.73**	
Container mass	m_1 g	**90.02**	**78.80**	**78.73**	
Water mass	m_a g	**5.85**	**6.56**	**5.68**	
Dry sample mass	m_s g	**209.62**	**252.63**	**231.00**	
Water moisture content $w = \frac{m_a}{m_s} \times 100$	%	**2.8**	**2.6**	**2.5**	

Water content average(w): 2.6 %

Table of uncertainty in each specimen

Expanded uncertainty	%	0.27	0.27	0.27	
Expansion factor k		2.00	2.00	2.00	

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Test Report

Process **37321** Lot **1**

Sample **66778**

Client's data

Boring **P8**

Depth **1.00 - 2.50**

Sample register date **30/09/2021**

Test execution dates **04/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Consistency limits

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

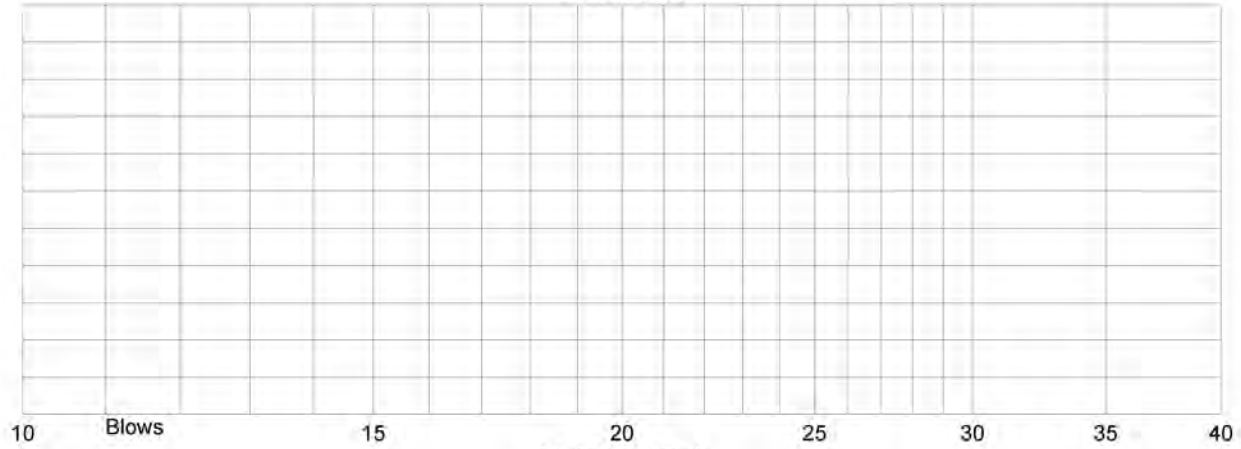
Standard : NP-143(1969)

		Liquidity limit	Plasticity limit
Container	nº		
Wet sample mass + container	g		
Dry sample mass + container	g		
Container mass	g		
Water mass	g		
Dry sample mass	g		
Water content	%		
Nr of blows			PL (Average) = %

N/P

W (%)

DIAGRAM



Shrinkage limit
(Non accredited method)

Container	**nº**					**Container volume V**	**cm^3**			
Wet sample + Container	**g**					**Quicksilver weight (1)**	**g**			
Dry sample + Container	**g**					**Dry soil volume (1)/13.55 (v)**				
Container mass	**g**					**V-v**				
Water mass	**g**					**A = V - v / Ps X 100**				
Dry sample Ps	**g**					**Shrinkage limit W-A**				
Water content W	**%**					**Shrinkage ratio Ps / v**				

LL = % **PL** % **(*) IP =**

(*) SL %

Limite de Liquidez	**Incerteza Expandida**	
	Fator de Expansão k	
Limite de Plasticidade	**Incerteza Expandida**	
	Fator de Expansão k	

(*) - Non accredited parameter

Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Test Report

Process **37321** Lot **1**

Sample **66778**

Client's data

Boring **P8**

Depth **1.00 - 2.50**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Analysis

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196(1966) and E239(1970)

1) SIEVE ANALYSIS

Dry sample total weight : **777.37** g

COARSE ELEMENTS

Sieve designation		3 "	2 "	½ "	1"	3/4 "	3/8 "	4	10
Square shaped mesh	mm	76.1	50.8	38.1	25.4	19.0	9.51	4.76	2.00
Retained material mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.17**	**4.30**
Accumulated mass	g	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.17**	**5.47**
% Acumulados		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.15**	**0.70**
Complemento para 100%		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**99**
Fator de Expansão k								2.00	2.00
Incerteza Expandida								2.6	1.8

FINE ELEMENTS

Total fine elements weight used : **70.61** g

Sieve designation		20	40	60	140	200
Square shaped mesh	mm	0.841	0.420	0.250	0.105	0.074
Retained material mass	g	**4.60**	**12.58**	**22.05**	**23.09**	**1.51**
Accumulated mass	g	**4.60**	**17.18**	**39.23**	**62.32**	**63.83**
% Accumulated		**6.51**	**24.33**	**55.56**	**88.26**	**90.40**
Complement to 100%		**93.49**	**75.67**	**44.44**	**11.74**	**9.60**
% Refered to total mass		**93**	**75**	**44**	**12**	**10**
Fator de Expansão k		2.00	2.00	2.00	2.00	2.00
Incerteza Expandida		1.2	1.4	2.7	1.8	1.3

2) HYDROMETER ANALYSIS

Container nº **3**

Hydrometer nº **35**

Dispersing Agent **100** cm^3

Dry sample weight Ps **70.61** g

Particules density G= **2.63**

Corrections : Meniscus = **0.0002**

Antifloc. = **0.0002**

$$\% \text{ of particles} = \frac{G}{G-1} \times \frac{100}{Ps} \times (Lc-1) \times 10^3$$

Minutes (t)	Temperature (°C)	Densimeter value	Correction	Corrected reading (Lc)	Z (cm)	D= Z/t x K	Expanded uncertainty	Expansion factor k	% of particles	% Refer. to Total
1	**23**	**1.0033**	**0.0006**	**1.0039**	**13.56**	**0.0467**	**2.4**	**2.00**	**8.91**	**9**
2	**23**	**1.0029**	**0.0006**	**1.0035**	**13.72**	**0.0332**	**2.4**	**2.00**	**8.00**	**8**
5	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0210**	**2.4**	**2.00**	**7.77**	**8**
15	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0122**	**2.4**	**2.00**	**7.77**	**8**
30	**23**	**1.0028**	**0.0006**	**1.0034**	**13.75**	**0.0086**	**2.4**	**2.00**	**7.77**	**8**
60	**23**	**1.0025**	**0.0006**	**1.0031**	**13.87**	**0.0061**	**2.4**	**2.00**	**7.08**	**7**
250	**23**	**1.0023**	**0.0006**	**1.0029**	**13.95**	**0.0030**	**2.4**	**2.00**	**6.63**	**7**
1440	**23**	**1.0021**	**0.0006**	**1.0027**	**14.03**	**0.0013**	**2.4**	**2.00**	**6.17**	**6**
2880										

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66778**

Client's data

Boring **P8**

Depth **1.00 - 2.50**

Sample register date **30/09/2021**

Test execution dates **07/10/2021 - 20/10/2021**

Entity : **Start Campus**

Address :

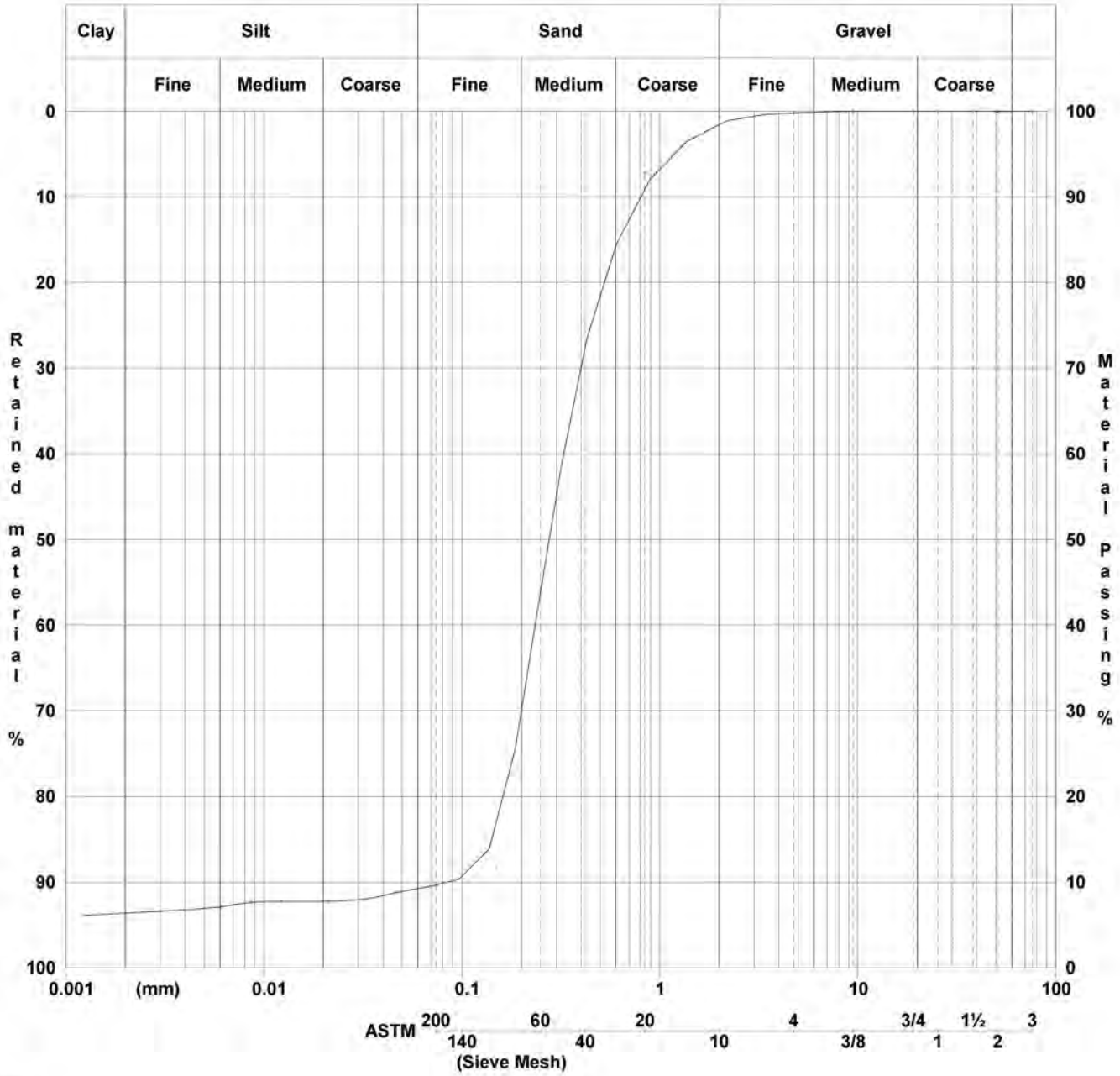
Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Particle-Size Distribution

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Specification - LNEC:E196



Comments :

Laboratory Management | Issue date: **21/10/2021** | Page : of

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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66778**

Client's data

Boring **P8**

Depth **1.00 - 2.50**

Sample register date **30/09/2021**

Test execution dates **08/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Proctor compacting test

Procedure : PL.09/2(2018) (*)

IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Test type : ☐ Standard effort ☐ Modified effort

Mould : ☐ 4" ☒ 6"

Grains size less than ____ mm

Mould	(nº)	50		50		50		50		50	
Mould + wet soil	(g)	6285		6411		6507		6546		6570	
Wet soil	(g)	3822		3948		4044		4083		4107	
Wet density	($g.cm^{-3}$)	1.864		1.926		1.973		1.992		2.003	
Container	(nº)	311	691	640	667	668	746	738	725	649	797
Wet sample + container	(g)	239.59	245.08	310.33	311.98	292.76	295.92	316.99	308.57	352.96	321.12
Dry sample + container	(g)	227.41	232.98	285.95	290.73	268.46	271.29	285.53	279.14	313.43	287.30
Container mass	(g)	78.27	90.41	78.77	89.70	79.71	80.18	74.81	77.13	77.54	88.86
Water mass	(g)	12.18	12.10	24.38	21.25	24.30	24.63	31.46	29.43	39.53	33.82
Dry sample mass	(g)	149.14	142.57	207.18	201.03	188.75	191.11	210.72	202.01	235.89	198.44
Water moisture content	(%)	8.2	8.5	11.8	10.6	12.9	12.9	14.9	14.6	16.8	17.0

Water moisture content average	(%)	8.4	11.2	12.9	14.8	16.9
Dry density	($g.cm^{-3}$)	1.720	1.732	1.747	1.735	1.714

Table of uncertainty in each mould

Expanded uncertainty	%	0.015	0.015	0.015	0.015	0.015
Expansion factor k		2.00	2.00	2.00	2.00	2.00

(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Comments :

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Tel.: 219958000 fax: 219958001 e-mail: mail@geocontrole.pt

Test Report

Process **37321** Lot **1**

Sample **66778**

Client's data

Boring **P8**

Depth **1.00 - 2.50**

Sample register date **30/09/2021**

Test execution dates **08/10/2021 - 14/10/2021**

Entity : **Start Campus**

Address :

Work: **Nest Data Center Sines**

Source | Site Sampling | Application

Compacting curve

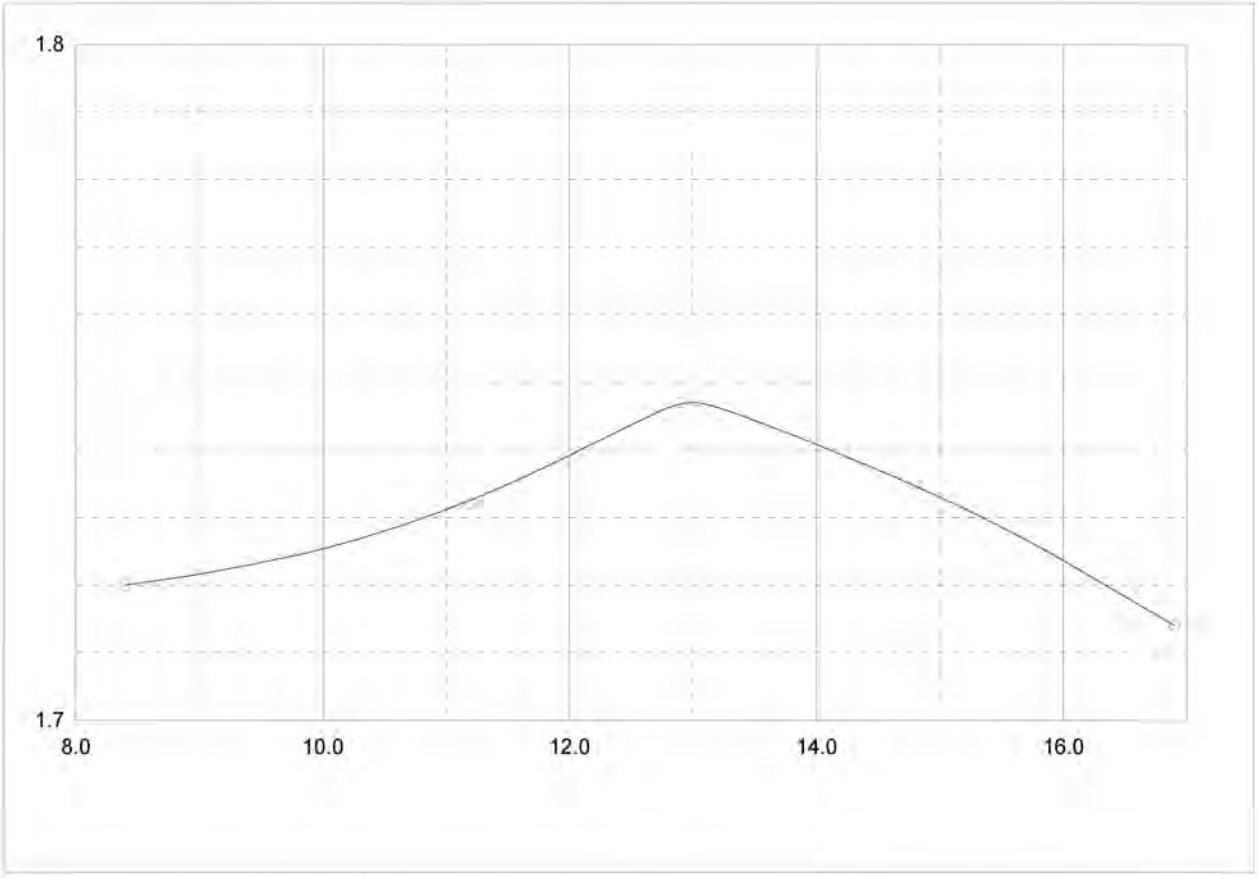
IPAC acreditação L0265 ISO/IEC 17025 Ensaios

Procedure : PL.09/2(2018) (*)

Test type ☒ Standard effort ☐ Modified effort

Mould ☐ 4" ☒ 6"

Grains size less than ____ mm



(*)The PL.09 procedure differs from the LNEC E197 specification by accepting the test run with 5 test pieces and a mechanical compactor being used.

Table of uncertainty	Expansion factor k	Expanded uncertainty %
Optimum water moisture content	**2.00**	**0.28**
Maximum dry density	**2.00**	**0.026**

Optimum water moisture content Wopt = **13.0** %

Maximum dry density γ dmax = **1.75** g.cm^{-3}

Comments :

Laboratory Management

Issue date: **21/10/2021**

Page : of

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Ensaio de Condutividade Térmica

Projecto:	Sines Nest Data Center	
Cliente:	START CAMPUS	Data do ensaio: 15-10-2021

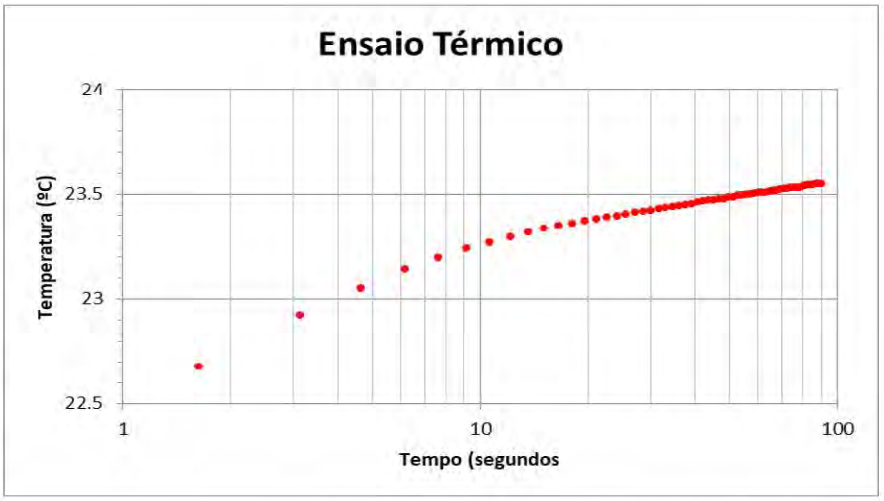
Equipmento:	Thermtest - TLS-100 Portatable Meter*			**Coordenadas(ETRS89):**	
TLS sonda:	[x]	100 mm	[ ]	50 mm	M:
Tipo Amostra	[ ]	Não deformada	[x]	Moldada	P:
Método cravação	[x]	Pressão manual	[ ]	Pré-furo	*Calibrado de fabrica de acordo com a norma ISO22007-2:2015 TPS Measurements

Descrição da Amostra: areia média a fina quartzosa, de tons amarelados a acinzentados

TLS-100 Medições

Poço Ref.	P8
Amostra Ref.	66778
Ensaio Térmico Ref.	Amostra 3
Profundidade amostra (m)	1.0 - 2.5
Heating Power (W/m)	3.918
Temperatura da amostra (ºC)	22.259
k (W/m.K)	7.076
R (m.K/W)	0.141

Temperatura versus tempo gráfico - semi-log da amostra



* Procedimento realizado de acordo com a norma ASTM D5334 &IEEE 442-1981

Registo fotográfico da realização do ensaio

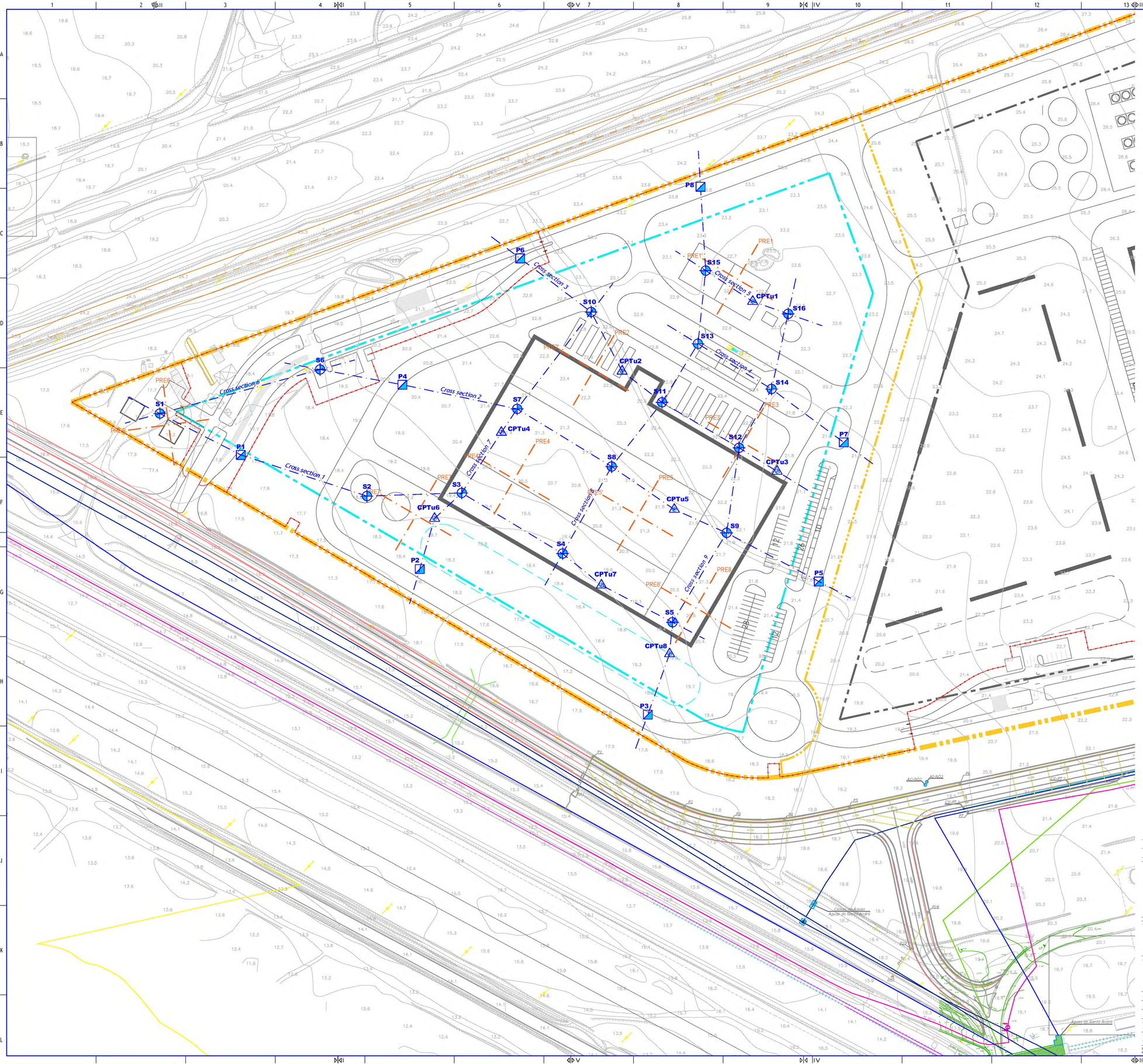


Observações:	Amostras em molde compactado a 95% do Proctor, no teor de húmidade óptimo.				
Data: 18/10/2021	Local:	Lisboa	Realizado por:	Figueiredo. H	

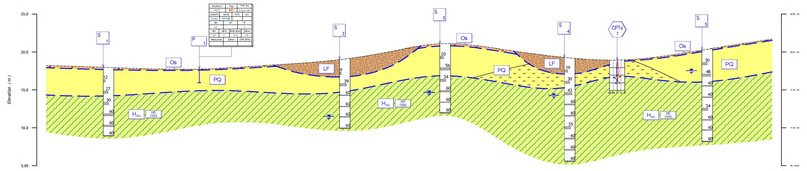
ANNEX III - DRAWINGS

Drawing No. CPG-001 - Location plan;

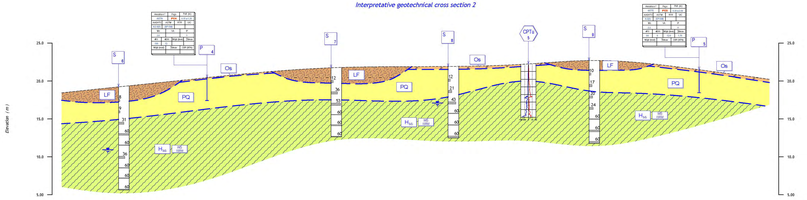
Drawing No. CPG-002 - Interpretive Geological and Geotechnical Profiles;


S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
P1
P2
P3
P4
P5
P6
P7
P8
CPTu1
CPTu2
CPTu3
CPTu4
CPTu5
CPTu6
CPTu7
CPTu8
PRE1
PRE2
PRE3
PRE4
PRE5
PRE6
PRE7
PRE8
Cross section 1
Cross section 2
Cross section 3
Cross section 4
Cross section 5
Cross section 6
Cross section 7
Cross section 8
Cross section 9
Cross section 10
Cross section 11
Cross section 12
Cross section 13
Cross section

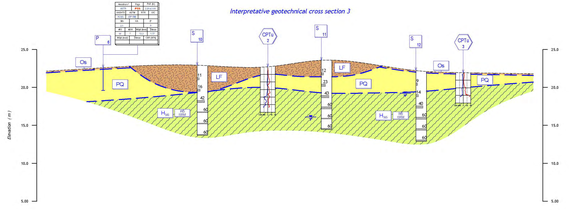
Interpretative geotechnical cross section 1



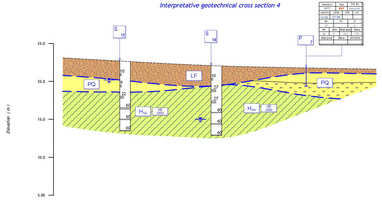
Interpretative geotechnical cross section 2



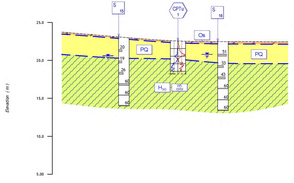
Interpretative geotechnical cross section 3



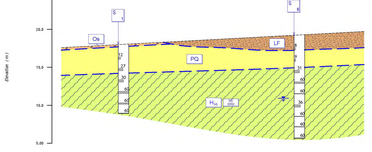
Interpretative geotechnical cross section 4



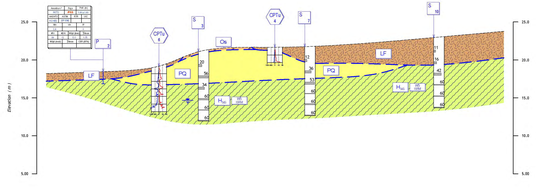
Interpretative geotechnical cross section 5



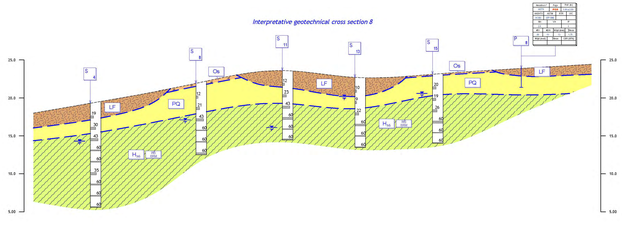
Interpretative geotechnical cross section 6



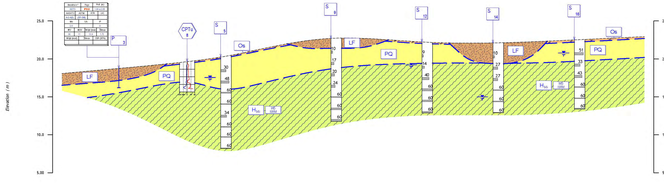
Interpretative geotechnical cross section 7



Interpretative geotechnical cross section 8



Interpretative geotechnical cross section 9



GEOTECHNICAL LEGEND

LITHOSTRATIGRAFY

HOLOCENE

Ok — *Organic soils*

Brown organic sandy soils with vegetable remains

LF — *Landfill Deposits*

Brown to grey, fine to coarse grain size silty, sandy gravels.

PLEISTOCENE

PQ — *Areias com seixo de Praínha Litoral*

Brown consistent strength, cohesive rubbish and/or grey, fine to medium grain size silty sands. Sometimes round cobbles clayey

Orange, with variable grain size (fine to coarse), silty sands. Fine rubber gravel lenses

CARBONIC

H_{PQ} — *Formação de Aliru*

Grey sometimes brownish grey, foliated silty CLAY (CL/CH) and/or clayey SILT (ML/MH) and/or CLAYEY SILT (CL-ML). Fracturing and fragments rocks

CONVENTIONAL SIGNS

Geological boundary

Lithological boundary

Water level

Boreholes — Trial pit — Water level (piezometer type)

Aquifers: Unconfined aquifer; Confined aquifer; Aquifer

REVIEW	DATE	DESCRIPTION	TECHNICIAN

Geocontrole

start campus

Rua Victor Hugo, Edifício Alfa, Bloco A, Piso 4, 4430-189 Vila Nova de Gaia, Portugal, Telefone (+351) 210 308 100 - Telefax (+351) 210 308 101 - e-mail: info@geocontrole.pt - Website: www.geocontrole.pt

JOB: START CAMPUS

NEST DATA

CENTER DINES

SOIL INVESTIGATION- GEOTECHNICAL STUDY

DESCRIPTION:	INTERPRETATIVE GEOTECHNICAL CROSS SECTION	SCALE:	H1:40 | V1:40
DESCRIPTION:	TECHNICAL	FILE:	start-dines-solo-investigation-geotechnical_gt-01-03-00.dwg
			1 / 1
	MM/	SIGNATURE	
DAT. DESIGNER	Luís Pereira	PROJ.	37121
DAT. DRAWING	Luís Pereira	DRAWING Nº	
DAT. CHECKING	Luís Sousa	DATE	21-abril-2021

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Sines 4.0

Geological and Geotechnical Study

Geoárea

Consultores de Geotecnia e Ambiente







www.geoarea.pt

Information about document and authors

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Type of Document	Geological and Geotechnical Study
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External Contributions	-
Project Manager	Eurico Teixeira
Date	February 2021

Revised by	Fernando Ferreira
Validated	Eurico Teixeira

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- Drawing 00421.21DVDE003 - Geotechnical Model. Plan Views at Depths of 2.0m and 3.0m
- Drawing 00421.21DVDE004 - Geotechnical Model. Plan Views at Depths of 4.0m and 5.0m
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- Data Report of DPSH tests

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1. Introduction

This document comprises the geological and geotechnical study undertaken by GEOAREA as part of the development plan for an area located at zone 9 of Sines Industrial Zone, regarding an investment licensing under candidacy to a national interest programme.

Within this study scope ground investigation works were carried out by GEOAREA comprising super heavy dynamic probing tests (DPSH). A geological detailed map was also elaborated following field reconnaissance works.

This report is structured in 5 main chapters, including this one, as indicated in the following brief description.

- **Introduction**
- **General Ground Settings,** where geographical, geomorphological, geological and seismicity local settings are described.
- **Fieldworks,** where fieldwork methodology is addressed regarding both ground investigation works and geological mapping and obtained data is presented.
- **Geotechnical Considerations,** where ground conditions are evaluated.
- **Final Remarks**

Ground investigation works were carried out between the 27th and 29th of January with fulfilment of a previously established ground survey programme. Field reconnaissance works for detailed geological mapping were undertaken on the 8th of February, after the updated topography map was made available.

Data reports of the DPSH tests and several drawings concerning the detailed geological map, ground investigation works location plan and the geotechnical interpretative model at various depths may be consulted appended to this document.

2. General Ground Settings

2.1 Geography and Geomorphology

Study area is located within the municipality of Sines, belonging to the parish council with the same name and placed at the industrial zone assigned to this council, approximately 5km southeast of town.

Direct accessibility to the site requires taking stretch of road EN120-1 that ensures road linking between Sines and national road EN120 and diversion to municipal road EM1144 that borders the south of the area.

Figure 1 displays an extract of military maps 515A, 516 e 526 published on a scale of 1:25K by the Army Services. To be noted that study site falls exclusively on map 526. A detailed aerial view made available by Google is also exhibited with an outline of the area.

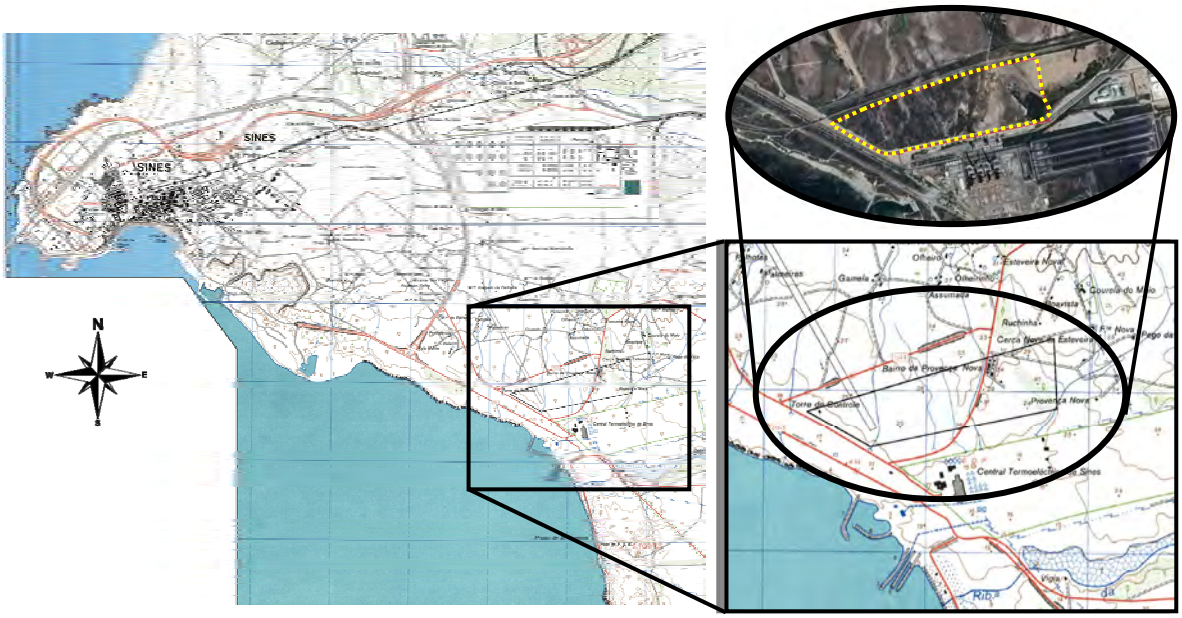


Figure 1 – Study area overlapped in military maps. Aerial view from Google Earth

This region is part of a littoral plain with smooth ground morphology featuring elevations that vary between 20-50m that decrease into the coastline. Local geodesic land marks Esteveira (65m), in the northeast, and São Torpes (35m) in the south, stand out as higher ground. Norwest of the study site a residual landform integrating an eruptive rock mass (Chãos – 105m) also stands out as the most elevated ground in the surroundings.

This extensive coastal area dominantly comprises plio-quaternary terrains but is carved into the Palaeozoic bedrock, forming a marine abrasion platform of Pleistocene-Calabrian age that, south of Sines, ends abruptly in active cliffs. This coastline is highly irregular either by mechanical marine erosion or dissection from several waterlines that flow to the coast.

Study area exhibits an overall flat ground model with ground elevations ranging between 18 and 29m. These generally decrease south, in the direction of the recently deactivated thermoelectric power station of Sines that occupies the lower terrains nearby the alluvial plain of the Junqueira stream. Locally, ground elevations are associated with residual landforms related to the Palaeozoic bedrock

Superficial water drainage is expected to follow the topographical model with a dendritic pattern in Pleistocene terrains as no structural conditionings are anticipated.

Figure 2 exhibits a few photographic general views.

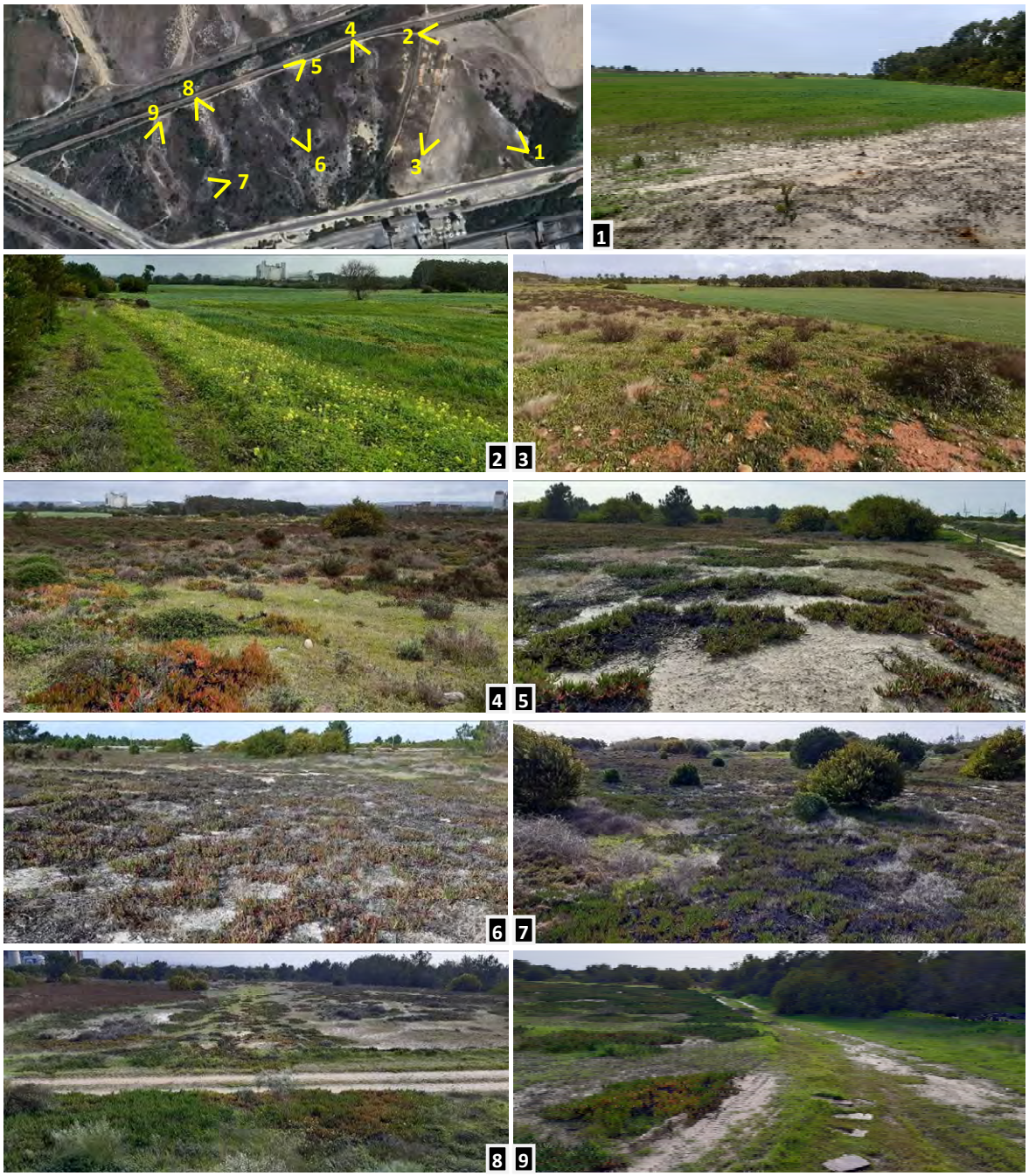


Figure 2 – General views of the study area

2.2 Geology

2.2.1 Lithostratigraphy

The geological settings of the studied area are mapped on sheet 42C of the Geological Map of Portugal published on a scale of 1:50K by the national geological services (Serviços Geológicos de Portugal) in 1986, and referred on present date as LNEG, Laboratório Nacional de Energia e Geologia. An extract is exhibited below, in Figure 3.

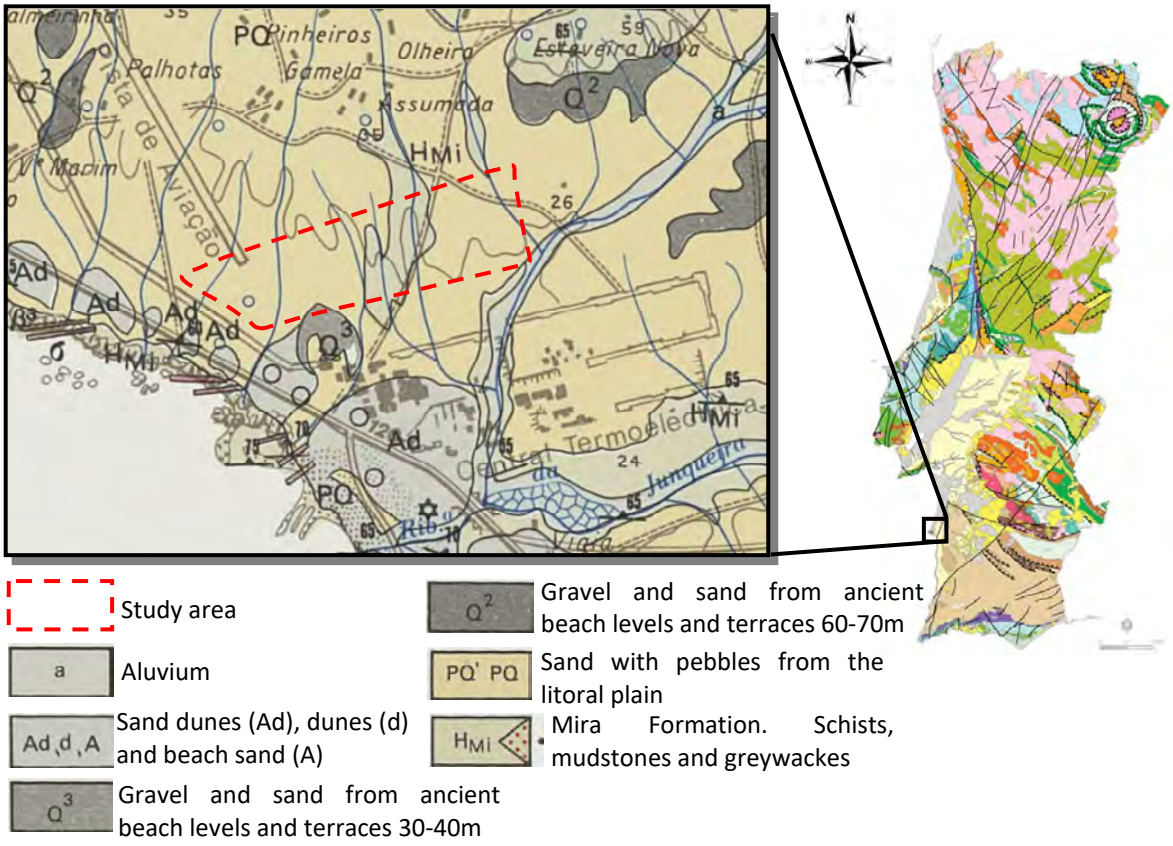


Figure 3 – Extract of sheet 42C of the Geological Map of Portugal (1:50K)

The analysis of the available geological elements verifies that this site coincides with prevalent soils from the Plio-Pleistocene formation (PQ) incorporated in the littoral plain. The underlying metasedimentary Mira Formation (H_{Mi}) from the Baixo Alentejo Flysh Group is also exposed in the area.

Under the scope of this study both geological units are described in the following paragraphs taking as reference the explanatory notebook of sheet 42C (Inverno, C. et al, 1993).

The Plio-Pleistocene materials that occur are associated with marine and continental deposits, both without fossil content in the region. These soils comprise, in general, orange to reddish sands with small quartz cobbles and pebbles, schist slivers and Triassic sandstone fragments. Occasionally, levels with rounded and significant sized quartz and quartzitic gravels and cobbles

occur. Locally, mudstone interbeds, carbonate concretions and abundant ferruginous pisoliths may also be observed.

The disposition of these deposits reflect the covering of the ancient abrasive platform carved in the metasedimentary Mira Formation, revealing a detrital build up prevalence after the erosion of that geomorphological landform. These materials are also covered by remains of sand dunes and ancient beach levels and terraces.

The Mira Formation is a turbidite unit of the flysh type comprising rhythmically disposed schist, greywacke and mudstone thin beds of greyish and greenish colouration. Also present are carbonaceous schists that when weathered exhibit a whitish and reddish colouration. This turbidite sequence matches the (Bouma) divisions B and C and, therefore, medium to fine grained sand and fine grained sand to silt, that alternates with the E division (clay). Greywackes comprised on this formation contain less rock fragments and albite but more quartz than the stratigraphically preceding Mertola Formation.

Also worth mentioning is the dense dyke network associated with Sines eruptive massif. Due to the Plio-Pleistocene soil covering, these are only observed on the coastline where Palaeozoic rock formations are exposed, particularly between Lagoa beach, north of Sines, and S. Torpes beach, southeast of town.

These dykes mainly occur vertically with predominance of directions N-S and E-W. By observations throughout the coastline these intrusions are essentially basaltic, traquibasaltic and sienitic.

2.2.2 Tectonic

In what concerns structural geology, the Plio-Pleistocene soil cover that prevails in the area overlays the bedrock occurring underneath where morpho-structural features are expected to be materialized. Therefore, its assessment mainly relies on indirect study methodologies supported by geophysics and extrapolations from regional observations and nearby rock outcrops.

As tectonic is presumed with little relevance on this study context, this subject will be approached on general terms and in regards to regional settings that are considered applicable to metasedimentary rock occurrences in the area.

Regional tectonics were affected by both Hercynian and Meso-Cenozoic aged movements

Hercynian orogeny is the result of 4 deformation phases F1, F2, F3 and F4. The first one generated cylindrical folds with near horizontal axis orientated NW-SE, revealing schistosity cleavage S1 of axial plane that dips northeast. The second one affected deeper structural levels and resulted on the formation of homoaxial folding regarding the F1 ones. Simultaneously, a crenulation cleavage S2 was developed, orientated NNW-SSE with accentuated inclination ENE up to vertical. The

following two phases, F3 and F4, are late-Hercynian and are the result of $\sigma 3$ orientated N-S and E-W, respectively. Such compression forces originated kink folds with S3 and S4 near vertical planes, orientated E-W and N-S, respectively, with near vertical or near horizontal axis.

Regarding fracturing systems related to the Hercynian orogeny, the main fault systems were established during phases F3 and F4 with near vertical planes. Some, however, were reactivated during the Meso-Cenozoic orogeny. During phase F3, with maximum compression N-S, left strike slip movements NNE-SSW to ENE-WSE and right strike slip movements NNW-SSE to NW-SE were developed. During phase F4, with maximum compression E-W, right strike slip movements NE-SW and combined left strike slip movements WNW-ESSE to NW-SE were developed.

The Meso-Cenozoic orogeny is characterized by distensible phases that resulted on the reactivation of Hercynian faults that induced tilting from Palaeozoic basement blocks which originated an inner-kratonic basin.

Within this subject, 4 main structures dominated the morpho-structural evolution of this region. They are the Santo André Fault, the Santa Cruz Fault, the Grândola Fault and the structural alignment Portimão-Sintra. Out of all of these the Santo André Fault stands out due to the continuous subsidence of its west block that allowed for the vast sedimentation that occurred in this region and where the study area is included.

Out of the consecutive Meso-Cenozoic distensible phases the one occurred in late Cretaceous should be highlighted, as it favours the igneous intrusion of the Sines volcanic complex with the already mentioned local dyke apophysis.

In terms of active tectonic structures and accordingly to the Map of the Quaternary Active Faults of Iberia, published in 2012 by the Spanish Geological Services and available through the QAFI database, there are no known active faults within the vicinities of the study area.

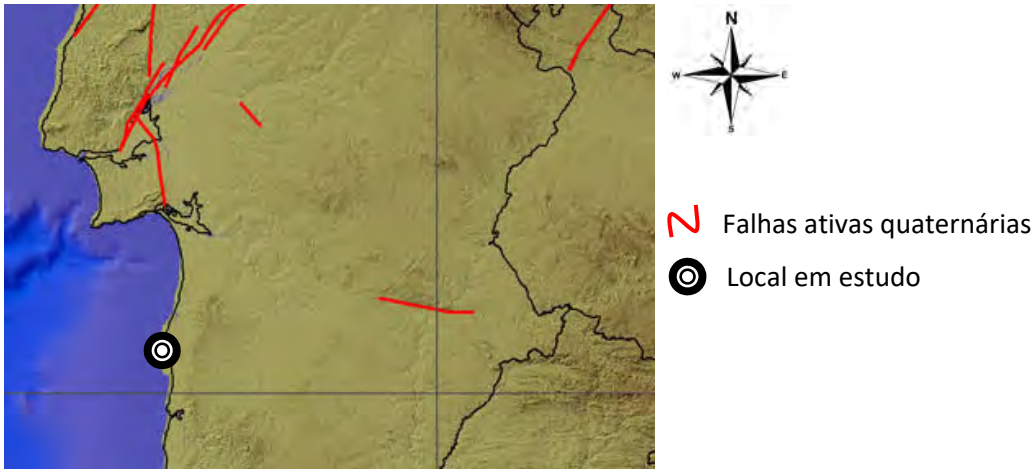


Figure 4 – Extract of the map of Quaternary active faults of Iberia

2.2.3 Hidrogeology

On the subject of local hydrogeological settings, these are presumed to be mainly conditioned by the upper sedimentary deposit features that prevail in the area, and its relevance is anticipated to increase with thickness and permeability of such materials.

The hydrogeological aptitude of these deposits are highly dependent on ground morphology, usually establishing a hydraulic connection to the hydrological network both directly, when the aquifer is intersected, as indirectly, through alluvial deposits.

Moderate to low production levels are, however, expected. Aquifer recharge occurs directly by precipitation and drainage from local water courses. Concerning the latter the hydrological network functions, in distinctive times and depending on the season, as effluent and influent.

To be noted that this aquifer relevance goes beyond the establishment of small phreatic tables, as these deposits may actively take part on the recharge of the underlying aquifer system associated with the metasedimentary Mira Formation.

On such aquifer systems the occurrence of important groundwater levels are dominantly conditioned by well-developed rock mass discontinuities and its main physical features. In this geological scenario a fissured aquifer system takes place. On such conditions the most productive groundwater flows are expected to be associated with structural alignments, comprising complex and unpredictable aquifer hydrodynamics due to the wide discontinuity spectrum through which groundwater circulates.

2.3 Seismicity

The seismicity considerations established on this chapter are in consonance with the norm Eurocode 8, NP EN 1998-1:2010 (Design of structures for earthquake resistance); Part 1, General rules, seismic actions and rules for buildings; Portuguese National Annex.

On the tectonic plate global scenario, Portugal coincides with the Eurasian plate and relatively close to the Azores-Gibraltar fracture that constitutes the border with the African plate. More precisely Portugal is inserted on the Iberian subplate, separated of the European continent by the Pyrenean chain.

By situating in a transition position between the African and Iberian plate borders and the inner stable continental regions of the European northwest, Portugal is affected by 2 major seismic activity zones:

- Interplate seismicity, associated with the Eurasian and African plate borders, generated at the fracture zone Azores-Gibraltar. May result on high magnitude earthquakes

- Intraplate seismicity, associated with displacements along resonance structures in the interior of the Eurasian plate. It's the result of cumulated tension and deformation and may result on earthquakes of moderated magnitudes.

Consequently, when evaluating seismic actions in Portugal, there are 2 scenarios that should be taken into consideration:

- Type 1 seismic action: related to earthquakes with epicentre within the Atlantic region.
- Type 2 seismic action: related to earthquakes with epicentre within the continental territory

The following figure displays the seismic zoning to be considered in continental Portugal as proposed by the national Annex of Eurocode 8, taking into account both seismic action types.

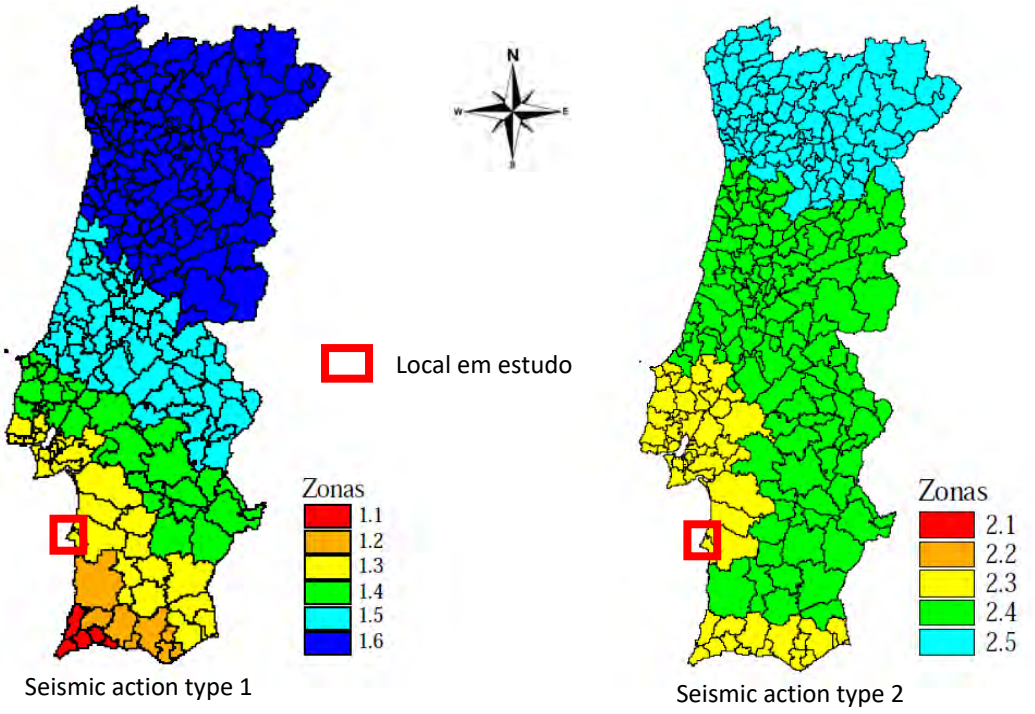


Figure 5 – Seismic zoning for seism action type 1 and 2

The values for the reference peak ground acceleration (agR) in different zones of the country and for both seismic action types are indicated in the following table.

Table 1 – Reference peak ground acceleration values (agR)

Seismic action type 1		Seismic action type 2	
Seismic zone	**a_{gR} (m/s^2)**	**Seismic zone**	**a_{gR} (m/s^2)**
1,1	2,5	2,1	2,5
1,2	2,0	2,2	2,0
1,3	1,5	2,3	1,7
1,4	1,0	2,4	1,1
1,5	0,6	2,5	0,8
1,6	0,35	-	-

Eurocode 8 establishes several ground types (A, B, C, D, E, S1 e S2) related to different stratigraphic profiles and parameters that are to be taken into consideration to account for the influence of local ground conditions on the seismic action.

Taking as reference the described geological settings of the study area, a ground type "E" was considered appropriate for the occurring soil profile. This terrain type is described in the EC8 standard as a "soil profile consisting of a surface alluvium layer with v_s values of 180-360 m/s and N_{SPT} 15-50 and thickness varying between about 5m and 20m, underlain by stiffer material with v_s > 800 m/s"(therefore a bedrock).

Erro! A origem da referência não foi encontrada. includes the parameters that define the elastic response spectrum in both seismic actions

Table 2 – Parameters that define the elastic response spectrum

Tipo de Terreno	Ação sísmica Tipo 1				Ação sísmica Tipo 2			
	S_{max}	T_B	T_C	T_D	S_{max}	T_B	T_C	T_D
A	1,0	0,1	0,6	2,0	1,0	0,1	0,25	2,0
B	1,35	0,1	0,6	2,0	1,35	0,1	0,25	2,0
C	1,6	0,1	0,6	2,0	1,6	0,1	0,25	2,0
D	2,0	0,1	0,8	2,0	2,0	0,1	0,30	2,0
E	1,8	0,1	0,6	2,0	1,8	0,1	0,25	2,0

Taking into consideration the importance factor (γI) indicated in the following table, directly related to the building importance class and mean return period, a design ground acceleration a_g may be estimated for both seismic action types. Given the unkown type of buildings or structures to be considered for the area an importance classe of II was assigned to the site (ordinary buildings).

Table 3 – Importance factor and mean return period

Importance Class	Return period (years)	Importance factor (γI) for seismic action type 1	Importance factor (γI) for seismic action type 2
I	243	0,65	0,75
II	475	1,00	1,00
III	821	1,45	1,25
IV	1303	1,95	1,50

The design ground displacement d_g corresponding to the design ground acceleration a_g may be estimated by the following expression:

$$dg = 0{,}025.a_g.T_C.T_D$$

The analysis of these elements allows for the establishment of several seismic parameters that should be taken into account on subsequent structural design works, taking as reference the worst case scenario.

Table 4 – Seismicity parameters of the study area

Ground type	Seismic action	Seismic zone	a_{gR} (m/s²)	S_{max} / S	a_g (1) (m/s²)	α (2)	d_g (cm)
Type E	Type 1	1.3	1.5	1.8 / 1,67	2,5	0,25	7,5
	Type 2	2.3	1.7	1.8 / 1,61	2,7	0,27	3,4

(1) Reference acceleration considering ground type and importance class, obtained by $a_{gR}.S.\gamma_I$
(2) Ratio between reference acceleration and gravity acceleration

The values to be taken in consideration on pseudo-static analysis for the seismic inertia forces, represented by permanent horizontal and vertical loads related to the peak ground acceleration(agR), shall consider the following coefficients:

$$kh = 0{,}5.\alpha.S = \mathbf{0{,}21} \;/\; kv = 0{,}5.kh = \mathbf{0{,}11}$$

3. Fieldworks

3.1 General Remarks

Superficial reconnaissance works carried out in the area aimed at mapping the occurring geological units or readjusting the outlined limits displayed on geological map 42C, originally published on a 1:50K scale.

These works had the support of the most recent topographical data that was surveyed by Geóide under the scope of this project.

Additionally, it was also intended to identify and describe relevant geological and geotechnical ground features through *in situ* observations and thus particularize the characterization of the site of investigation.

A ground survey works campaign was also carried out comprising 10 Dynamic Penetrometer Super-Heavy tests (DPSH). These survey works aimed for the characterization of subsoil features, particularly in regards to soil strength parameters in-depth and thus contributing on the establishment of a geotechnical zoning across the study area.

Prior to the execution of these works a ground survey programme was made available and submitted for approval. This included a plan location for these tests.

It's worth mentioning, however, that throughout the ground works campaign it became clear that a few of the proposed test locations would have to be relocated due to difficult terrain conditions. Indeed, due to the rainy season, ground conditions were often too saturated for equipment positioning. On this issue DPSH8 and DPSH10 tests were the most affected ones.

Work methodology and results will be included on the following subchapters. Data field reports for the DPSH tests may be consulted on the appended documents.

Figure 6 displays the elaborated geological map and the final ground investigation works location plan. Also included are the observation point locations that will be mentioned on the subchapter related to the field reconnaissance works.

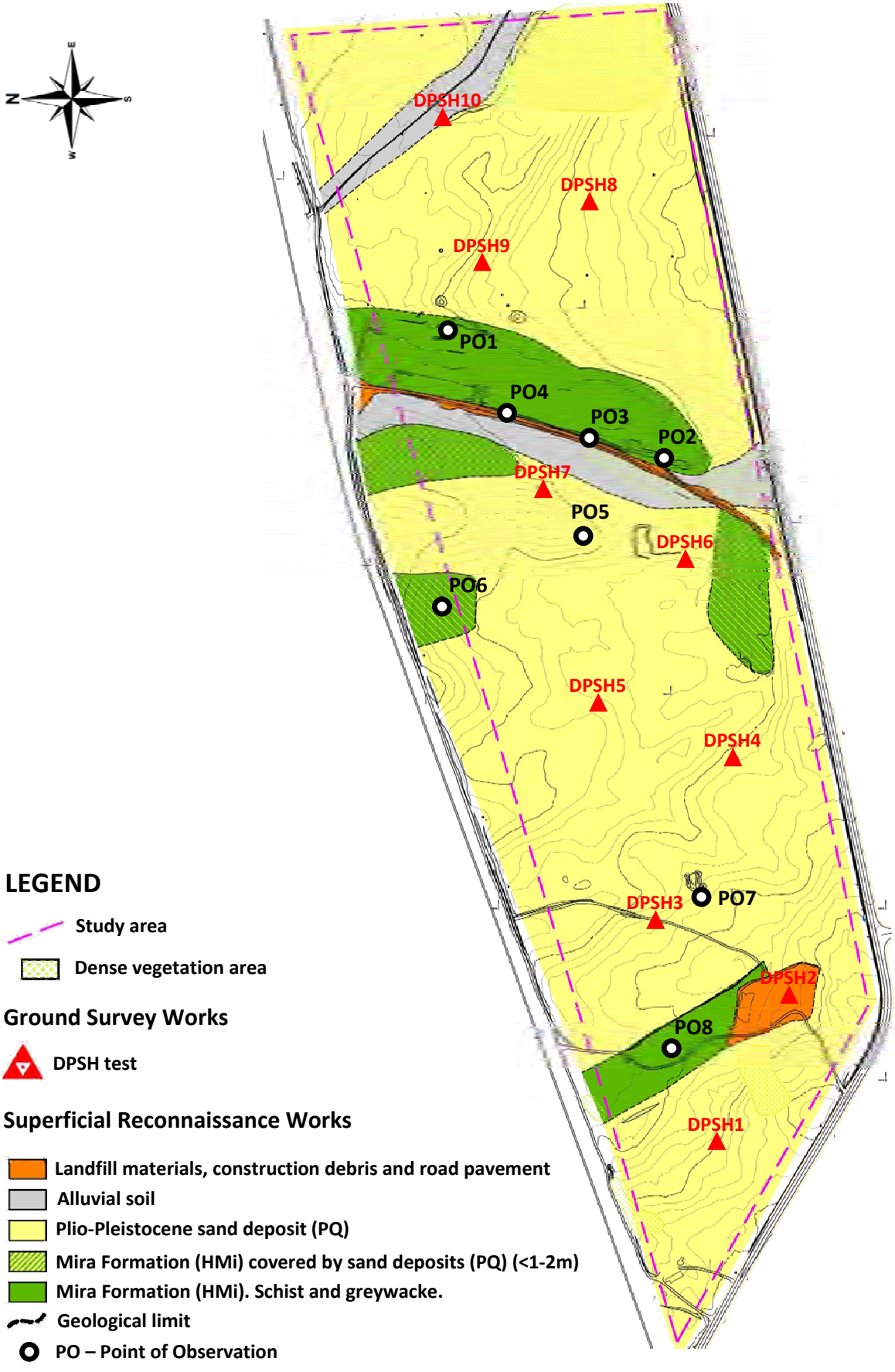


Figure 6 – Geological map and fieldworks location plan

3.2 Superficial Reconnaissance

Even though field reconnaissance works were focused on mapping the geological limits occurring in the area and consubstantiated in the geological map exhibited on Figure 6 and drawing 00421.21DVDE001, other observed aspects were considered relevant and will be here addressed, namely lithology features and groundwater levels.

3.2.1 Observed lithologies

Observed lithologies include metasedimentary rocks from the Mira Formation and sandy deposits associated not only with the Plio-Pleistocene soils, prevalent in the area, but also alluvial soils and local landfill materials, the latter expectantly a lot more heterogeneous.

Metasedimentary rocks were observed at observation points PO1, PO2, PO3 and PO4. On these locations rock mass is exposed on small cut slopes, revealing schist predominance over greywacke lithology that occurs interbedded with thin layers. The most relevant of these small excavations are associated with the old layout of municipal road EM1144 that crosses the area. Areas where these metasedimentary materials prevail are usually associated with a thin residual soil cover.

These points of observation are illustrated in Figure 7. Overall, exposed rock mass exhibits a highly weathered grading (W4) with alternating decomposed interbeds (W5). Greywackes, though secondary, may be associated with the occurring harder rock layers when present. Rock mass compartmentalization discloses a densely fractured (F5) rock massif with very close spaced discontinuities. Bedding planes (S0) are set with an orientation of N60-90ºE, dipping 80-84ºNW.

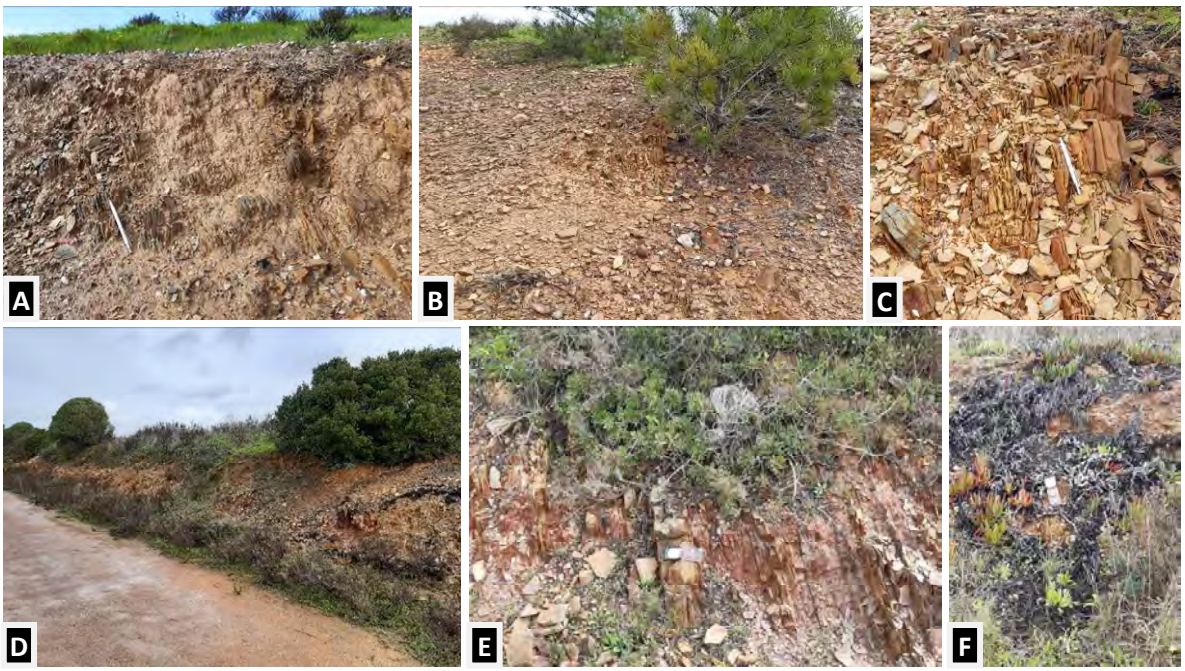


Figure 7 – Ilustration of metasedimentary rock outcrops. A - PO1. B and C - PO2. D and E - PO3. F - PO4.

In addition to these outlined areas of rock mass prevalence there are, however, some zones where Plio-Pleistocene sandy deposits cover the underlying metasedimentary bedrock with a thickness that expectantly doesn't go beyond the metre reference and, therefore, should be distinguished from all others with sand prevalence.

The criteria for its contour delineation fell upon the existence of frequently occurring schist gravel and cobbles on the ground surface where sandy soil prevails.

A clear example of this situation was observed in the area where PO6 was marked. In this location, an excavation for a small pool exposed the underlying metasedimentary rock mass where, at the surface, sand deposits prevail (PQ). And even though rock mass isn't observable because of the pool water, rock debris is clearly identifiable in the excavation debris.



Figure 8 – PO6 illustration and rock debris from local ground excavation

To be noted that the criteria based on the occurrence of schist fragments is very limited as dense vegetation spread out across some areas may hide such evidences. Therefore, a few more areas where this situation occurs may have not been identified on the elaborated geological map.

Still in regards to the metasedimentary areas, point of observation PO8 is to be highlighted as it comprises the old airfield track of Sines where earthworks apparently removed the occurring PQ sandy soil cover and exposed a predominately metasedimentary ground. Even though no rock outcrops are available in this area, there is an abundant quantity of schist fragments and ground stiffness that contrast with both lateral sandy grounds. Also a side note for the sandy debris on the terminal section of the track that suggests that earthworks were carried out in this site.



Figure 9 – PO8 illustration and contrast between metasedimentary ground and sandy deposit

Other occurring lithology is the already mentioned Plio-Pleistocene sands that cover the metasedimentary bedrock with variable thickness. These sands prevail across the study area and comprise a sedimentary deposit body that accumulated over the Mira Formation.

These soils are characterized by medium grained sized sands of quartzose nature with frequently occurring schist lithoclasts. They usually exhibit light tones comprising yellowish or brownish colours. Darker colours may be observed when enriched with organic matter which sometimes occurs on the upper soil horizon.

Figure 10 displays a few illustrations of these sandy deposits such as observed on PO5 and PO7.

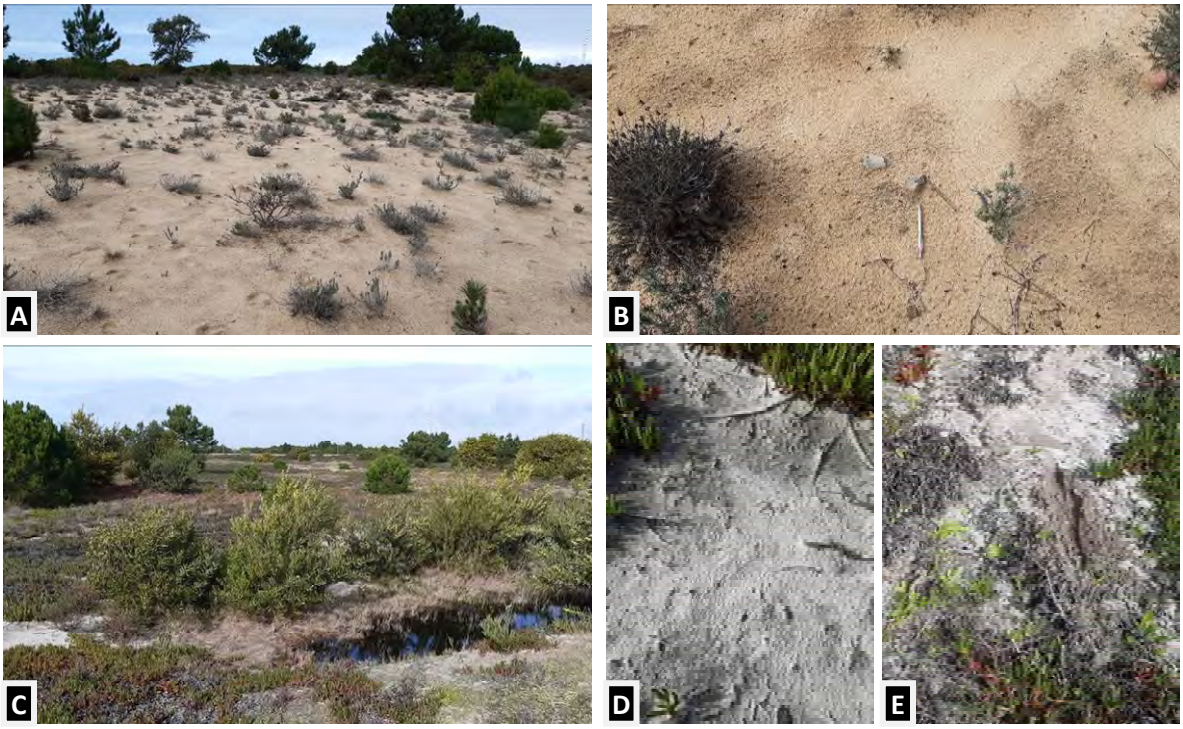


Figure 10 – Ilustration of the Plio-Pleistocene sand deposits. A and B – PO5. C to E – PO7

Another occurring geological unit is the alluvial soils associated with the 2 main waterlines. In truth, these deposits are composed of materials from the Plio-Pleistocene sands that were remobilized by water during strong hydrodynamic periods. They usually include a strong organic enrichment that affects its geomechanical behaviour.

Finally, the existence of land fill material spread out across the area is also worth mentioning. The main observable ones are related to the old EM1144 road and the old airfield track, where earthworks are evident. Notwithstanding, several others may exist in the area although dissimulated by dense vegetation.

3.2.2 Groundwater levels

Several water puddles may be observed in the area, accumulated on topographical depressions and low grounds, particularly across the sector starting from the metasedimentary prevalent ground alignment, nearby PO6, up to the east border.

This observation suggests a big influence of the metasedimentary bedrock on ground permeability even if covered by sand deposits. Expectantly, these deposits quickly saturate during rainy seasons, particularly when exhibiting small thicknesses. This, combined with the generally flat ground morphology that reduces soil drainage, favours the observed ground saturation.

On the west sector, these water puddles were not observed. This raises the hypothesis of thicker sand deposits above the impervious metasedimentary ground which leads to a higher reservoir capacity.

Five excavated small pools of water and two water wells may also be found on site comprising local groundwater abstraction infrastructures. The former exhibit a water level close to the natural ground level, so at a depth of about -0.5m to 0m. The latter exhibit a water level around -2m and 0m. Three piezometers were also observed around the eastern waterline, lined with a PVC tube and sealed with a screw cap. They were presumably installed after drill works at the area. Water levels on these piezometers were not accurately measures but were estimated at around -2.5m to -3m.

Figure 11 displays a few illustrations of these water abstraction infrastructures.



Figure 11 – Water abstraction infrastructures in the study area

3.3 DPSH tests

Dynamic probing tests were performed under the requirements of the normative document EN 22476-2. According to the referred document this test results are especially suited for the qualitative determination of a soil profile. They may also be used for the determination of the strength and deformation properties of soils through appropriate correlations.

Dynamic probing tests were carried out using its super heavy array. The constant energy for this heavyweight dynamic cone penetrometer is a 63.5 kg weight that is raised to a height of 760mm and then dropped, driving the cone into the soil.

The obtained penetration resistance is defined as the number of blows required to drive the penetrometer over 20 cm intervals, providing a continuous record throughout the surveyed depth. No samples are recovered.

Although a maximum limit of 100 blows/20cm (test refusal) is usually considered for the test depth range, within this study scope an investigation depth limit of 8m was also established. This means that all dynamic probing tests reached a depth of 8m unless test refusal was accomplished first.

A few general views of DPSH performance are exhibited in Figure 12.



Figure 12 – General views of performed DPSH tests

Unit point resistance (rd) and dynamic point resistance (qd) was determined using the following formulae:

$$r_d = \frac{m.g.h}{A.e} \qquad q_d = \frac{m}{m+m'} r_d$$

Where:

m is the mass of the hammer

g is the acceleration due to gravity

h is the height of fall of the hammer

A is the base at the area of the cone

e is the average penetration per blow (0.1/N20)

m' is the total mass of the extension rods

Table 5 summarizes the obtained DPSH test data including its geographical references. Additional data may be consulted on the test data reports appended to this document.

Table 5 – DPSH test results

Ref.	Coordinateds ETRS89 (m)		Fina depth (m)	Depth of blow count N_{20} (m)				Depth of cone resistance Qd (m)		
	M	P		≤10	10-20	20-50	≥50	≤8 MPa	8-15 MPa	15-35MPa
DPSH1	-59826	-192207	3,97	0,0-2,0	2,0-3,6	-	3,6-3,97	0,0-2,0	2,0-3,6	3,6-3,97
DPSH2	-59653	-192288	8,00	0,0-2,2 2,8-4,6	2,2-2,8 4,6-5,0 6,0-6,6	5,2-6,0 6,6-8,00	-	0,0-2,2 2,8-4,6	2,2-2,8 4,6-5,0 6,0-6,6	5,2-6,0 6,6-8,00
DPSH3	-59567	-192134	6,58	0,0-3,0	3,0-3,6	3,6-5,0	5,0-6,58	0,0-3,0	3,0-3,6	3,6-6,58
DPSH4	-59374	-192224	8,00	0,0-2,0	2,0-4,2	4,2-5,4 6,2-8,00	5,4-6,2	0,0-2,0	2,0-4,2	4,2-8,00
DPSH5	-59313	-192065	8,00	0,0-3,2	3,2-4,2 5,6-6,4	4,2-5,6	6,4-8,00	0,0-3,2	3,2-4,2 5,6-6,4	4,2-5,6 6,4-8,0
DPSH6	-59145	-192168	4,38	0,0-0,8	0,8-4,0	-	4,0-4,38	0,0-0,8	0,8-4,0	4,0-4,38
DPSH7	-59061	-191998	4,57	0,0-2,6	2,6-3,8	3,8-4,2	4,2-4,57	0,0-2,6	2,6-3,8	3,8-4,57
DPSH8	-58728	-192056	8,00	0,0-1,4	4,6-8,0	1,4-4,6	-	0,0-1,4	4,6-8,0	1,4-4,6
DPSH9	-58800	-191929	6,16	0,0-1,8	1,8-2,8 3,6-4,2 5,2-6,0	2,8-3,6 4,2-5,2	6,0-6,16	0,0-1,8	1,8-2,8 3,6-4,2 5,2-6,0	2,8-3,6 4,2-5,2 6,0-6,16
DPSH10	-58633	-191883	8,00	0,0-2,2	2,4-5,2	-	5,2-8,00	0,0-2,2	2,4-5,2	5,2-8,00

Note: level transitions of less than 40cm were disregarded

Figure 13 displays the DPSH test blow and cone resistance graphical evolution in depth.

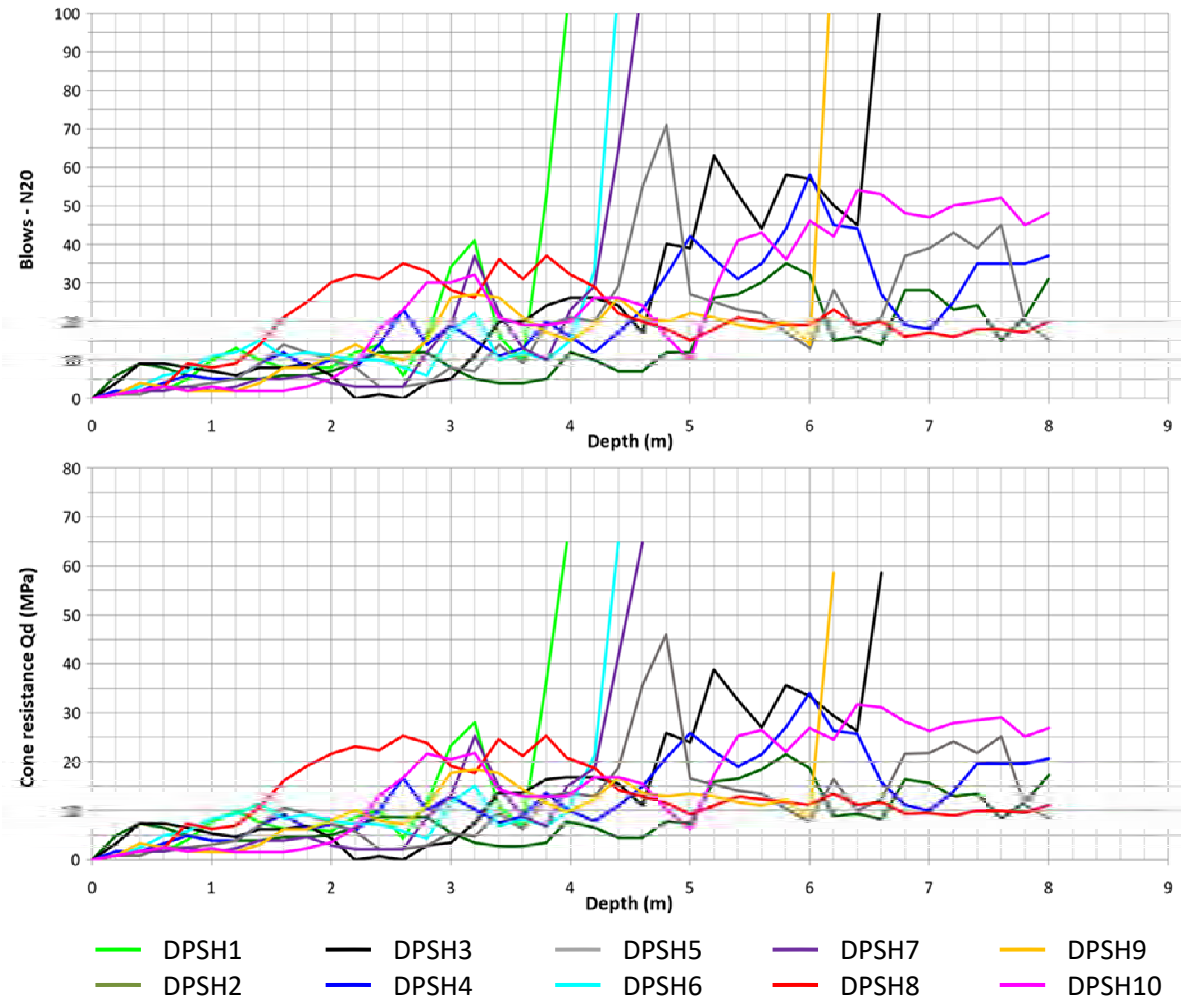


Figure 13 – Graphical compilation of N_{20} and Qd

The following remarks may be highlighted from the analysis of DPSH test data performed across the studied area:

- Test refusal was obtained in DPSH1, DPSH3, DPSH6, DPSH7 and DPSH9. Out of these tests, DPSH1, DPSH6 and DPSH7 didn't reach the 5m depth mark. The remaining ones, DPSH3 and DPSH9, achieved depths of 6 and 7m, respectively.
- All other DPSH tests (DPSH2, DPSH4, DPSH5, DPSH8 e DPSH10) were concluded accordingly to the maximum established survey depth (8m) and, thus, not complying with the test refusal criteria of N20 > 100.
- In general, performed DPSH tests display similar results that reveal a low strength upper horizon that tends to increase within depth. On DPSH1 to DPSH7 ground strength increases from a depth of 4 to 5m. On DPSH 8 to DPS10 ground strength increase starts from 1.5 to 3m deep.
- A few ground strength variations may be observed in depth with increases and decreases of blow count and cone resistance values. These may be associated with lithological particularities such as fine particle content, grain size variations and intersection of coarser materials such as gravel or cobble.

4. Geotechnical Considerations

4.1 General Remarks

On the following subchapter a geotechnical ground model for the study area is proposed. In addition, soil strength parameters are estimated for each geotechnical zone through correlations based on the DPSH test results.

The submitted geotechnical model intends to establish ground horizons with different mechanical features and, thus, typify geotechnical ground behaviours and solutions. At this phase, elaborated model must be presumed preliminary and part of an evolving system that may be adjusted if complementary data is made available.

4.2 Geotechnical Zoning

Proposed geotechnical model includes the following horizons, distinguished by DPSH test results and presumed valid up to a depth of 8m:

- **Geotechnical Zone GZ4:** DPSH test results (N_{20}) below 12 blows, determining a cone resistance inferior to 8 MPa. This horizon was associated with loose to very loose sand covering deposits or residual metasedimentary soil.
- **Geotechnical Zone GZ3:** DPSH test results (N_{20}) between 13 and 25 blows, determining a cone resistance ranging between 8 and 15 MPa. This horizon was associated with medium dense sand deposits or decomposed metasedimentary rock mass.
- **Geotechnical Zone GZ2:** DPSH test results (N_{20}) between 26 and 40 blows, determining a cone resistance ranging between 15 and 30 MPa. This horizon was associated with dense sand deposits or decomposed metasedimentary rock mass.
- **Geotechnical Zone GZ1:** DPSH test results (N_{20}) above 40 blows, determining a cone resistance superior to 30 MPa. This horizon was associated with highly weathered metasedimentary rock mass.

The analysis of the available data reveals a geotechnical model with horizons that fail to be ever-increasing in-depth in what concerns its strength parameters. This means that geotechnical zones are not sequentially laid out and frequently stronger horizons alternate with weaker ones.

Given this scenario, established geotechnical model will be displayed using several plan views considering depths of 0.5m, 1.0m, 2.0m, 3.0m, 4.0m, 5.0m, 6.0m and 7.0m. These maps should, however, be regarded with caution in what concerns its outlined areas as they were solely based on available ground investigation points and geological mapping. This means it required interpolation procedures that may locally compromise its contour assertiveness.

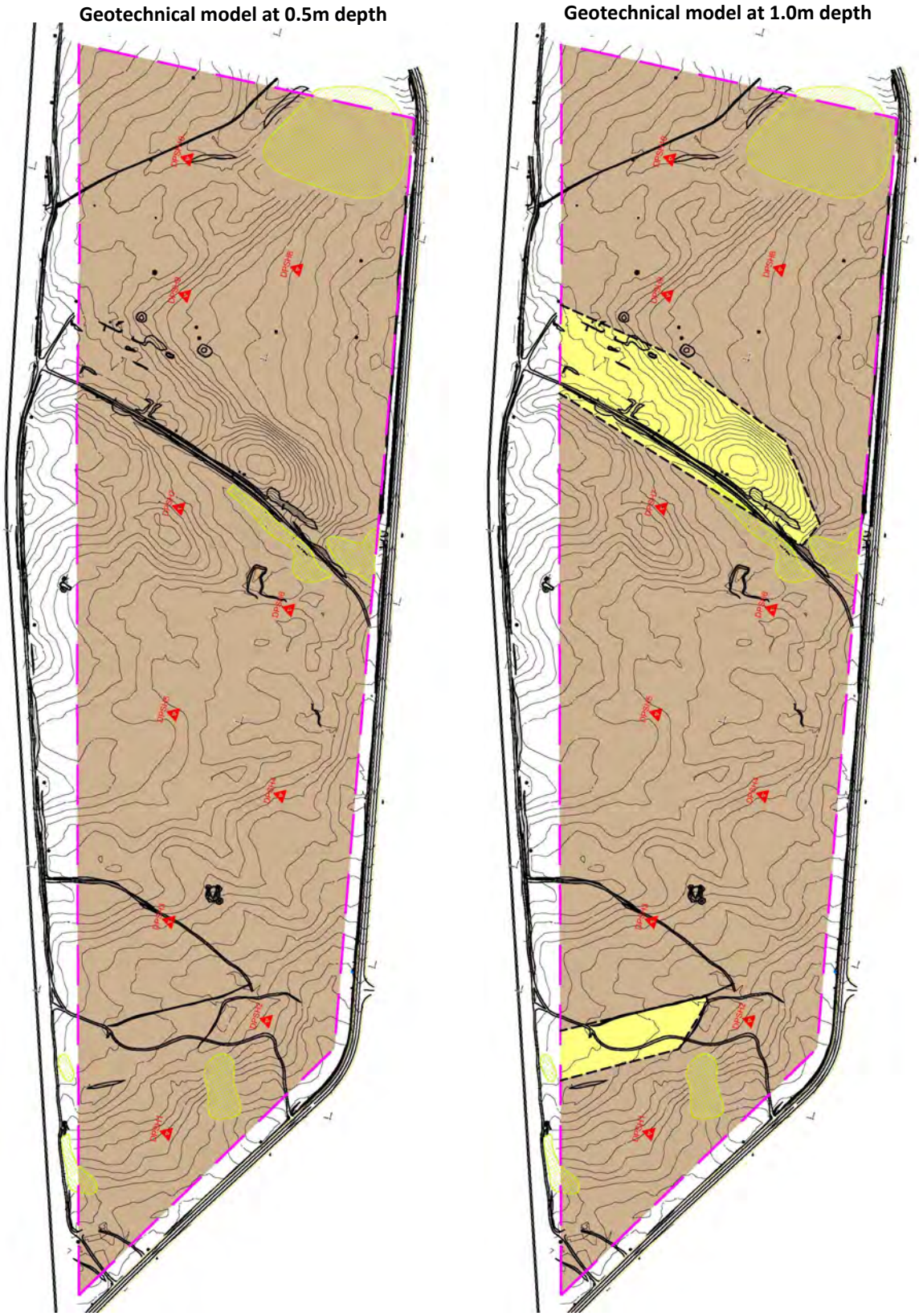
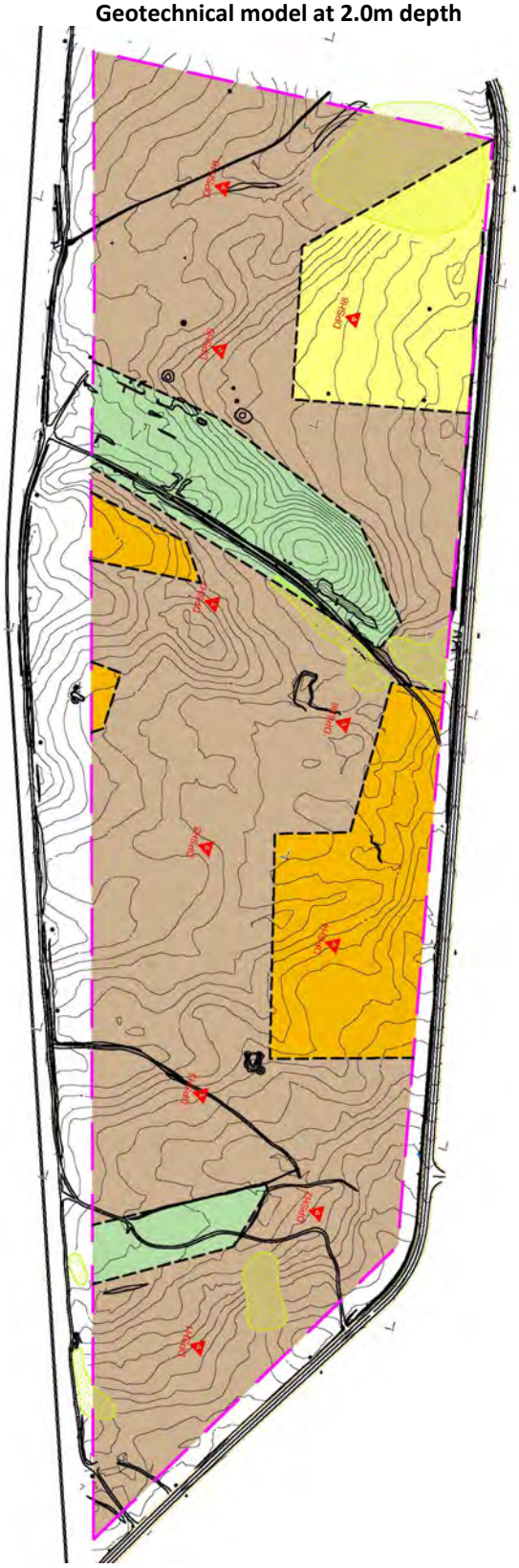
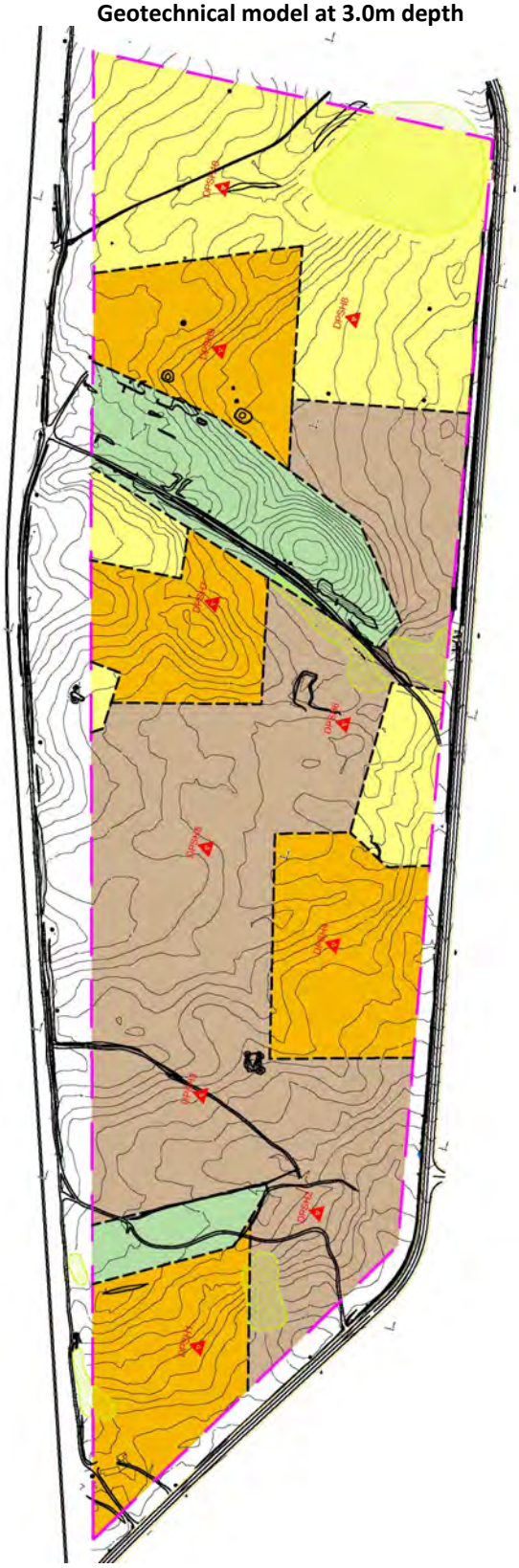


Figure 14 – Plan views of geotechnical model at depths of 0.5m (left) and 1.0m (right)

Geotechnical model at 2.0m depth



Geotechnical model at 3.0m depth



GZ4 – DPSH test results < 12 blows. Loose to very loose sand deposits or residual schistose soil
GZ3 – DPSH test results between 13-25 blows. Medium dense sand or decomposed schist
GZ2 – DPSH test results between 26-40 blows. Dense sand or highly weathered to decomposed schist
GZ1 – DPSH test results > 40 blows. Highly weathered schist

Figure 15 – Plan views of geotechnical model at depths of 2.0m (left) and 3.0m (right)

Geotechnical model at 4.0m depth

Geotechnical model at 5.0m depth

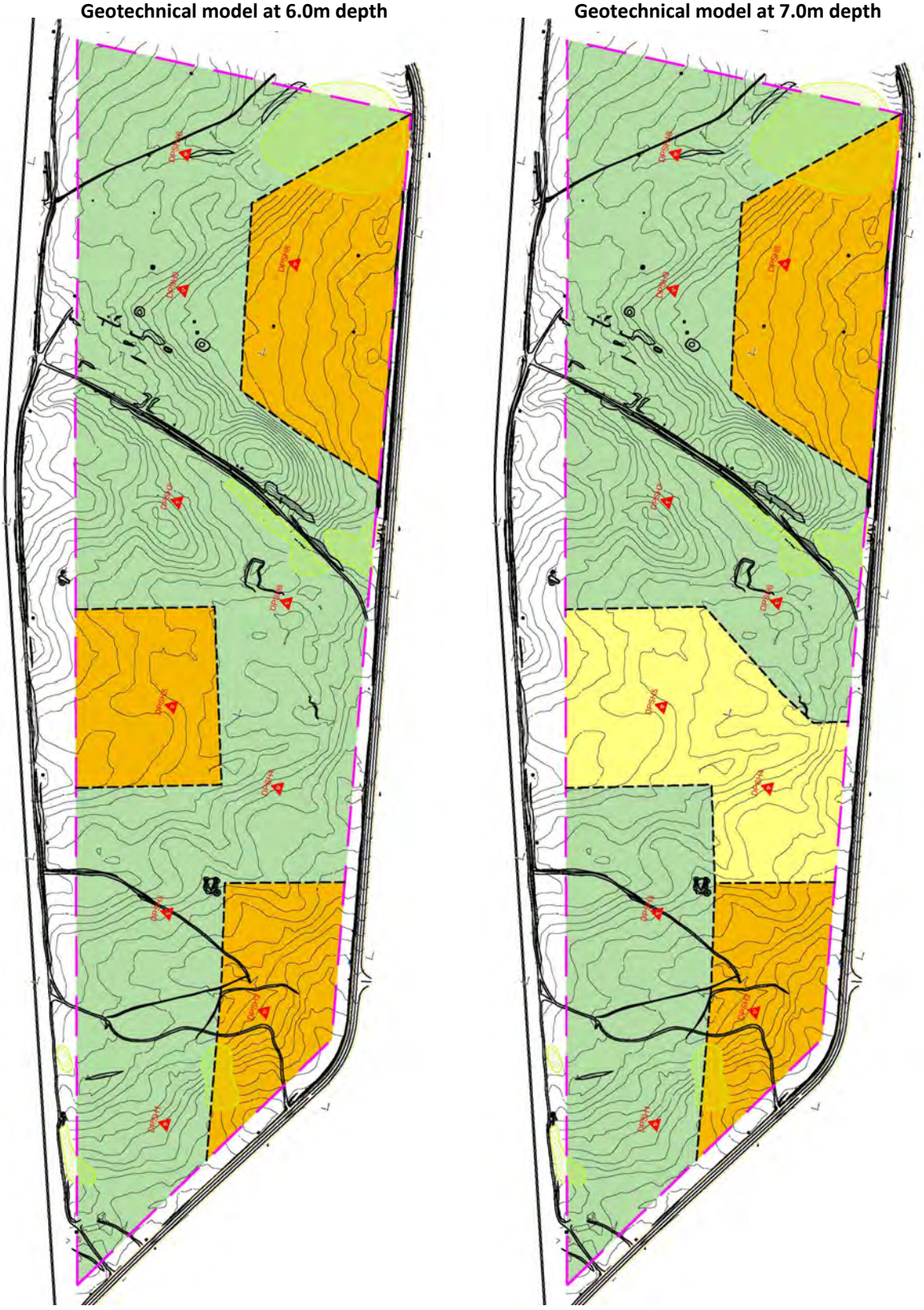


GZ4 – DPSH test results < 12 blows. Loose to very loose sand deposits or residual schistose soil
GZ3 – DPSH test results between 13-25 blows. Medium dense sand or decomposed schist
GZ2 – DPSH test results between 26-40 blows. Dense sand or highly weathered to decomposed schist
GZ1 – DPSH test results > 40 blows. Highly weathered schist

Figure 16 – Plan views of geotechnical model at depths of 4.0m (left) and 5.0m (right)

Geotechnical model at 6.0m depth

Geotechnical model at 7.0m depth



GZ4 – DPSH test results < 12 blows. Loose to very loose sand deposits or residual schistose soil
GZ3 – DPSH test results between 13-25 blows. Medium dense sand or decomposed schist
GZ2 – DPSH test results between 26-40 blows. Dense sand or highly weathered to decomposed schist
GZ1 – DPSH test results > 40 blows. Highly weathered schist

Figure 17 – Plan views of geotechnical model at depths of 6.0m (left) and 7.0m (right)

4.3 Geotechnical Parameters

Geomechanical parameters concerning the geotechnical horizons described in the previous subchapter are exhibited in Table 6.

To this effect and taking into consideration the occurring sandy soil prevalence in the area, all geotechnical zones were analysed regarding drained soil mechanic premises.

The occurring metasedimentary rock mass was also analysed within soil mechanics given its highly weathering grading and close fracture spacing. Notwithstanding, this evaluation may be redefined once detailed studies featuring drill works intersecting this schistose rock mass are carried out.

In order to compute soil strength parameters a conversion of DPSH N_{20} to N_{SPT} values was performed following a linear correlation proposed by Muromashi and Kobayashi in 1982 and resumed by the ratio N_{20}/N_{SPT}= 0.76 or N_{SPT}= 1.32N_{20}.

Once N_{SPT} was determined the most common formulations were applied in order to compute corresponding soil strength parameters as indicated below. Other parameters were estimated based on knowledge from similar ground conditions.

$$\phi = 27 + 15.Dr \quad D_r = \sqrt{\frac{N_{SPT}}{60}} \quad q_c = x(=3{,}5).\rho_a.N_{SPT} \quad E = 2{,}5\,.q_c \text{ e } E = 500.(N_{SPT} + 15)$$

Table 6 – Geomechanical parameter of the geotechnical model

Zone	N_{20}	q_d (MPa)	N_{20} (design values)	N_{SPT}	Dr (%)	q_c (MPa)	γ_h (kN/m³)	Strength parameters		E (MPa)
								c' (KPa)	Φ' (º)	
GZ4	<12	≤8	3-8	4-10	25-40	1,5-3,5	14 (*)	0 (*)	30-33	4-7
GZ3	13 – 25	8-15	13-23	17-30	50-70	6-10	15-16 (*)	0 (*)	35-38	15-20
GZ2	26 - 40	15-30	26-40	35-52	75-90	12-18	17-19 (*)	0 (*)	38-40	30-40
GZ1	≥ 40	≥30	40-60	52-60	>90	18-21	19-22 (*)	1-5 (*)	40-42	45-50

(*) Conservative estimated parameters based on knowledge from similar ground conditions

4.4 Foundation Settings

All established considerations relating to foundation settings of the study area should be regarded as general and susceptible to adjustments once detailed geotechnical studies are carried out, focused on accurate locations of infrastructures and with additional ground data.

With this in mind and taking as reference the previously established geotechnical model and its geomechanical parameters, the following remarks should be considered:

- Horizon GZ4 should not be regarded as foundation ground given its weak properties and inadequate bearing resistance.
- Further to the previous point and given this horizon prevalence up to depths of at least 2m and significant area representativeness where it occurs up to depths of 3m, embedment foundation settings should acknowledge a minimum depth of 3m.
- Exception to the previous point may be assigned to the outlined metasedimentary areas where ground foundation may consider depths starting from 1m.
- The analysis of the above explained points highlights the metasedimentary ground areas as sectors where precedence should be given when planning infrastructure placement.
- Deep foundations, if considered, should take into account a minimum pile length of 6m. Pile point embedment should preferably intersect the metasedimentary bedrock.

The determination of soil bearing resistance in drained conditions for shallow spread footings may be calculated using the following expression, as proposed by standard NP EN1997-1:2010 (eurocode 7):

- $q_r = c'.N_c.b_c.s_c.i_c + q'.N_q.b_q.s_q.i_q + 0,5.\gamma'.B'.N_\gamma.b_\gamma.s_\gamma.i$. In this equation c' e $\emptyset$' represent soil strength parameters reduced by 1,25; N_c, N_q e N_γ are dimensionless bearing resistance factors; b_c, b_q e b_γ are dimensionless foundation base inclination factors; s_c, s_q e s_γ are dimensionless foundation shape factors; i_c, i_q e i_γ are dimensionless load inclination factors; q' is the effective overburden pressure at the level of the foundation and B' is the effective foundation width.

Table 7 summarizes the estimated bearing resistance for each geotechnical zone taking as reference soil parameters as indicated on Table 6. A hypothetical scenario of B'=1m was considered. Also, ground conditions were presumed saturated.

Table 7 – Foundation bearing resistance for B=1m

Zone	B' (m)	q_r (kPa)
GZ4	1	70 - 100
GZ3		300 - 450
GZ2		600 - 700
GZ1		800 - 900

Given the assessed features of the studied subsoil, settlement displacements caused by soil consolidation are not anticipated. Therefore, foundation loading is expected to affect ground settlement in accordance with the elasticity theory.

Under these circumstances, immediate settlements derived from foundation loadings (see Table 7) were verified following the premises of the equation below. They were revealed in compliance with the expression and, therefore, settlements aren't expected to surpass the 20mm imposed reference.

$$\frac{q.B}{E}(1-\upsilon^2).I_f \leq 0.02$$

This implies the validation of the determined ground bearing resistances as allowable bearing resistances to be considered for each geotechnical horizons. As a result, $q_r = q_{allow}$.

If design loads are anticipated to surpass the estimated allowable bearing resistances for shallow footing design, then deep foundations should be considered and piles or micro-piles are to be designed by specific studies using the available ground data and other complementary survey elements.

A final remark should be addressed to possible foundation constrains in the area. Indeed, given the already highlighted ground particularities, attention should be drawn to the following:

- High groundwater levels and saturated ground occurrences: structural design should account for these situations that were revealed across the area, particularly on the north-eastern sector.

- Geomechanical dissimilarities on foundation grounds: this is especially relevant in a scenario where infrastructure foundation bases are set on different ground types such as metasedimentary rock mass and sand deposits. In these cases, a deepening of the weaker ground should be considered so that the support horizon remains homogenous and, therefore, differential settlements are minimized.

4.5 Excavation Conditions

Excavation works across the area are anticipated to be easily accomplished using common hydraulic mechanical excavators.

However, intersection of metasedimentary rock mass may demand higher performance mechanical equipments. In such scenario and particularly when hard rock levels are encountered, such as greywacke layers, hydraulic rock mass breaking may be required.

If excavation works are carried out during rainy seasons special attention should be given to groundwater levels and superficial water run-offs. Adequate drainage conditions should, therefore, be ensured.

Resulting cut slopes should also be assessed concerning slope containment interventions so that earthworks are carried through without significant incidents.

In this regard, cut slopes up to 3m high are recommended to assume the following vertical to horizontal geometries, if provisional (V:H):

- 2V:1H if metasedimentary rock mass is intersected
- 1V:1.5H if sand deposits are intersected

If definitive, cut slopes up to 3m high are recommended to assume the following vertical to horizontal geometries (V:H):

- 1V:1H if metasedimentary rock mass is intersected
- 1V:2H if sand deposits are intersected

Throughout excavation works a careful assessment of slope stability conditions is recommended to be carried through, taking into consideration the encountered geological and geotechnical conditions. If necessary the above indicated geometries should adjusted to more conservative relations.

If deeper excavations are considered, further geotechnical evaluations are required.

5. Final Remarks

This document comprises the Geological and Geotechnical Study for an area included in Sines industrial zone.

Within this framework, fieldworks were carried out including performance of 10 DPSH tests and superficial reconnaissance works that allowed for the elaboration of a detailed geological map. The resulting analysis and conclusions are based on conditions as they existed at the time of performance of these fieldworks.

All discussed geotechnical considerations should be understood within a generalized context regarding the study area. Any future development projects must include detailed assessment studies on geological and geotechnical local settings.

This study experience reveals that groundwater monitoring and ground profile sampling with detailed descriptions are inevitable when aiming for assertiveness of ground geotechnical models. For this reason, further ground investigation works should take into account the required design specifications and be preceded by a deliberated survey programme.

Alfragide, 11 of February 2021

Author



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Eurico Teixeira,

(Geologist)

ANNEXES

Drawing 00421.21DVDE001

Geological Map and Ground Investigation Works Location Plan



Coordinates of DPSH tests

Ref.	Coordinates ETRS89		Final depth
	M	P	
DPSH1	-59826	-192207	3.97
DPSH2	-59653	-192288	8.00
DPSH3	-59567	-192134	6.58
DPSH4	-59374	-192224	8.00
DPSH5	-59313	-192065	8.00
DPSH6	-59145	-192168	4.38
DPSH7	-59061	-191998	4.57
DPSH8	-58728	-192056	8.00
DPSH9	-58800	-191929	6.16
DPSH10	-58633	-191883	8.00

LEGEND

Study area limit

Dense vegetation

Ground Survey Works

DPSH test

Superficial Reconnaissance Works

- Landfill deposits, construction debris and road pavement
- Alluvial soil
- Plio-Pleistocene sand deposit (PQ)
- Mira Formation (HMi) covered by sand deposits (PQ) (<1-2m)
- Mira Formation (HMi): schist and greywacke
- Geological Limit

Revision	Description	Date	Drafter	Rev./ Coord.

Revised by: F. Ferreira | Studied by: E. Teixeira | Coordinator: E. Teixeira | Drafter: E. Teixeira | Date: February 2021

Scale: 1:2000 (A1) | Replaces drawing: | Replaced by drawing: | Drawing nº 00421.21DVDE001 00 | Reference 00421 _ 21 | Sheet 01/01

Project: SINES 4.0
GEOLOGICAL AND GEOTECHNICAL STUDY
GEOLOGICAL MAP AND GROUND INVESTIGATION WORKS LOCATION PLAN

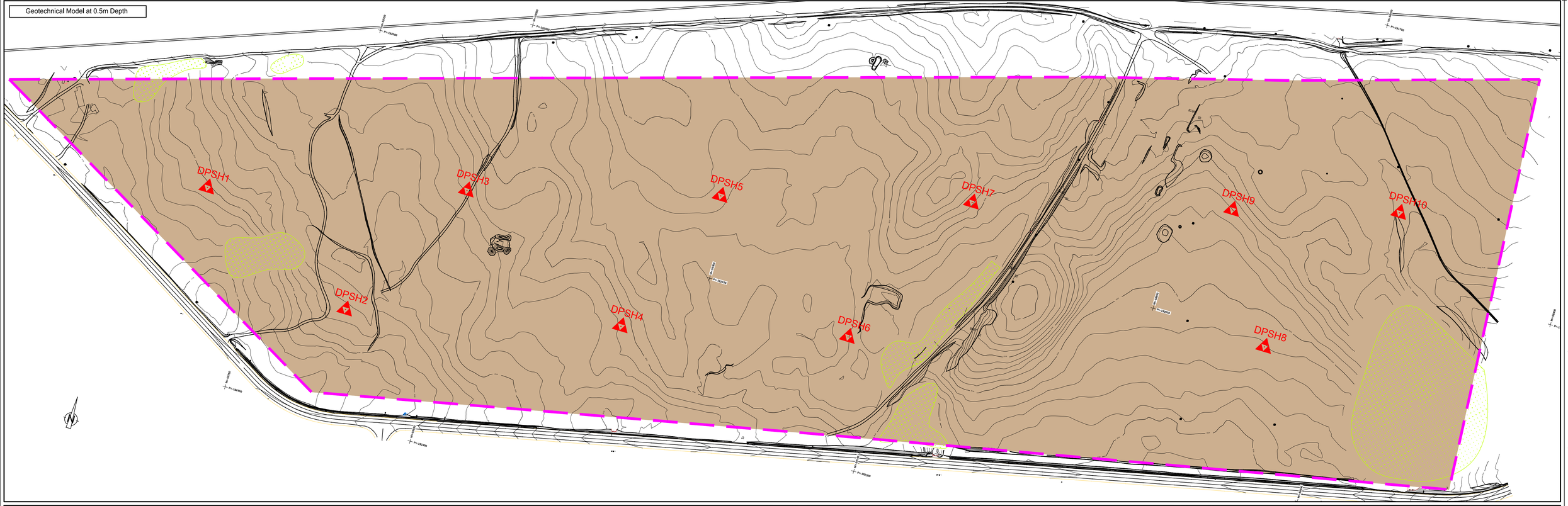
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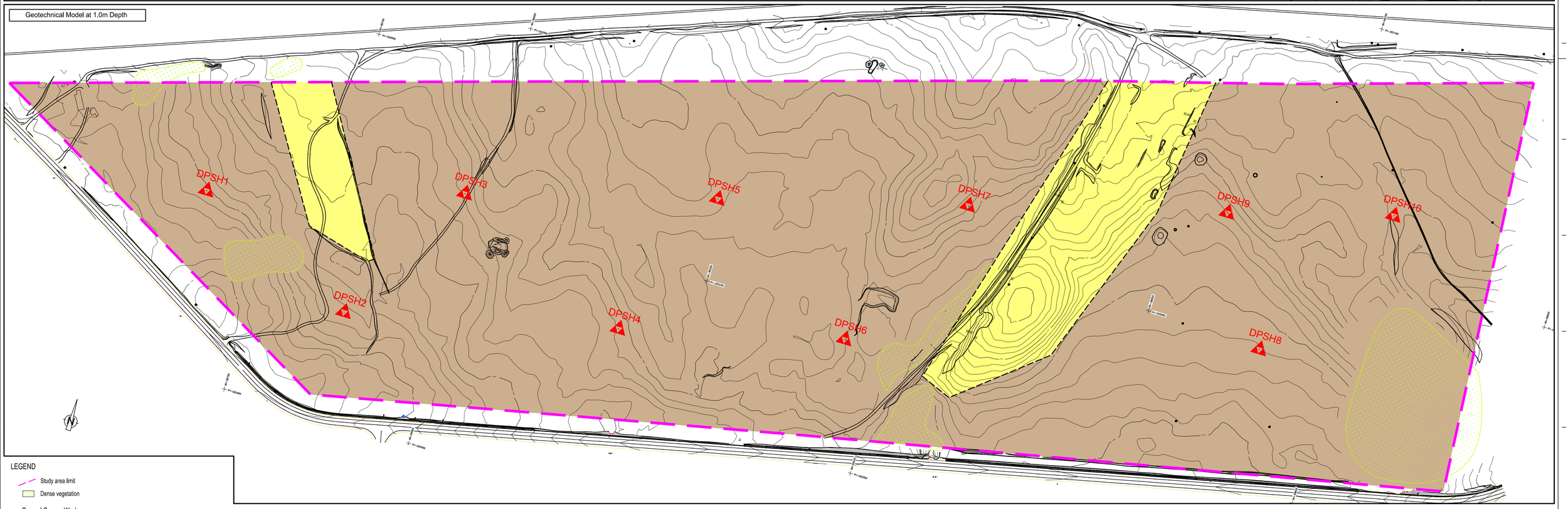
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Geotechnical Model. Plans Views at Depths of 0.5m and 1.0m

Geotechnical Model at 0.5m Depth



Geotechnical Model at 1.0m Depth



LEGEND

- Study area limit
- Dense vegetation

Ground Survey Works

- DPSH test

Geotechnical Zoning

- GZ4 - DPSH test results < 12 blows. Loose to very loose sand deposits or residual schistose soil
- GZ3 - DPSH test results between 13 and 25 blows. Medium dense sand or decomposed schistose rock mass
- GZ2 - DPSH test results between 26 and 40 blows. Dense sand or highly weathered to decomposed schistose rock mass
- GZ1 - DPSH test redults >40 blows. Highly weathered schistose rock mass
- Geotechnical limit

Revised by: F. Ferreira	Studied by: E. Teixeira	Date: February 2021	Scale: 1:2000 (A1)	Drawing nº: 00421.21DVDE001 00	Project: SINES 4.0 GEOLOGICAL AND GEOTECHNICAL STUDY
Coordinator: E. Teixeira	Drafter: E. Teixeira		Replaces drawing:	Reference: 00421 _ 21 / Sheet: 01/01	Geotechnical Model. Plan views at Depths of 0.5m and 1.0m
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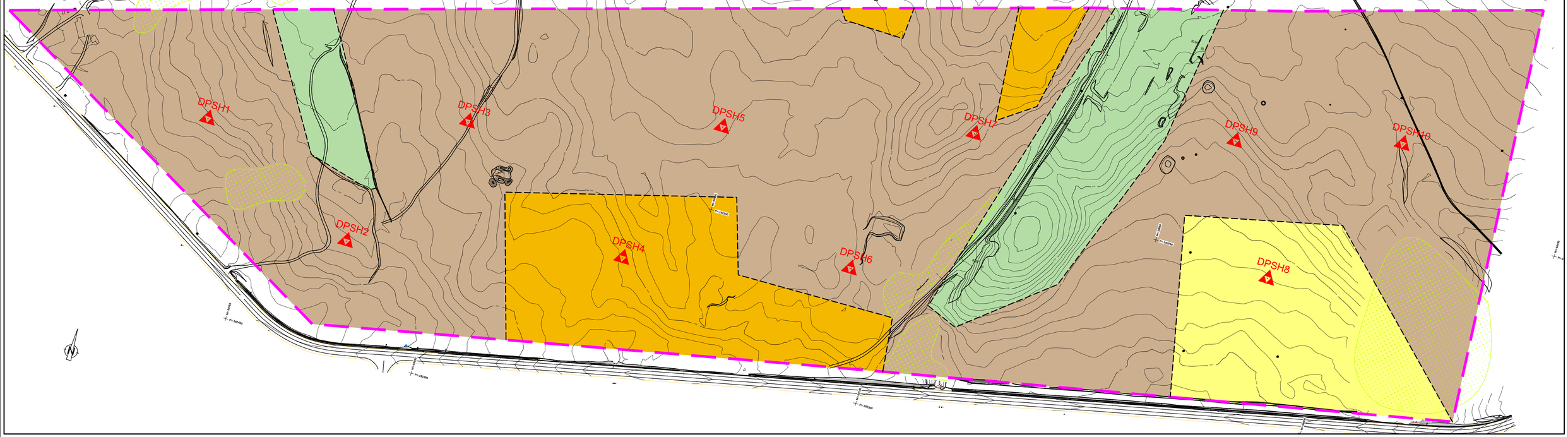
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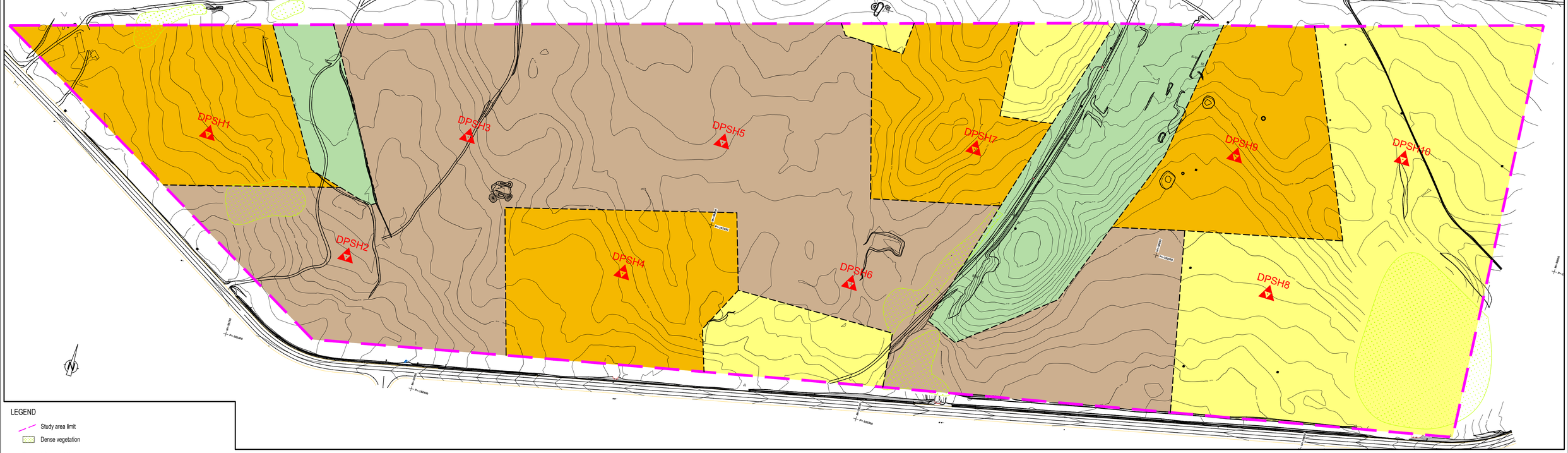
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Geotechnical Model. Plans Views at Depths of 2.0m and 3.0m

Geotechnical Model at 2.0m Depth



Geotechnical Model at 3.0m Depth



LEGEND

- Study area limit
- Dense vegetation

Ground Survey Works

- DPSH test

Geotechnical Zoning

- GZ4 - DPSH test results < 12 blows. Loose to very loose sand deposits or residual schistose soil
- GZ3 - DPSH test results between 13 and 25 blows. Medium dense sand or decomposed schistose rock mass
- GZ2 - DPSH test results between 26 and 40 blows. Dense sand or highly weathered to decomposed schistose rock mass
- GZ1 - DPSH test redults >40 blows. Highly weathered schistose rock mass
- Geotechnical limit

Revised by:	Studied by:	Date:
F. Ferreira	E. Teixeira	February 2021
Coordinator:	Drafter:	
E. Teixeira	E. Teixeira	

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Reference: 00421 _ 21
Sheet: 01/01

Project:
SINES 4.0
GEOLOGICAL AND GEOTECHNICAL STUDY

Geotechnical Model. Plan views at Depths of 2.0m and 3.0m

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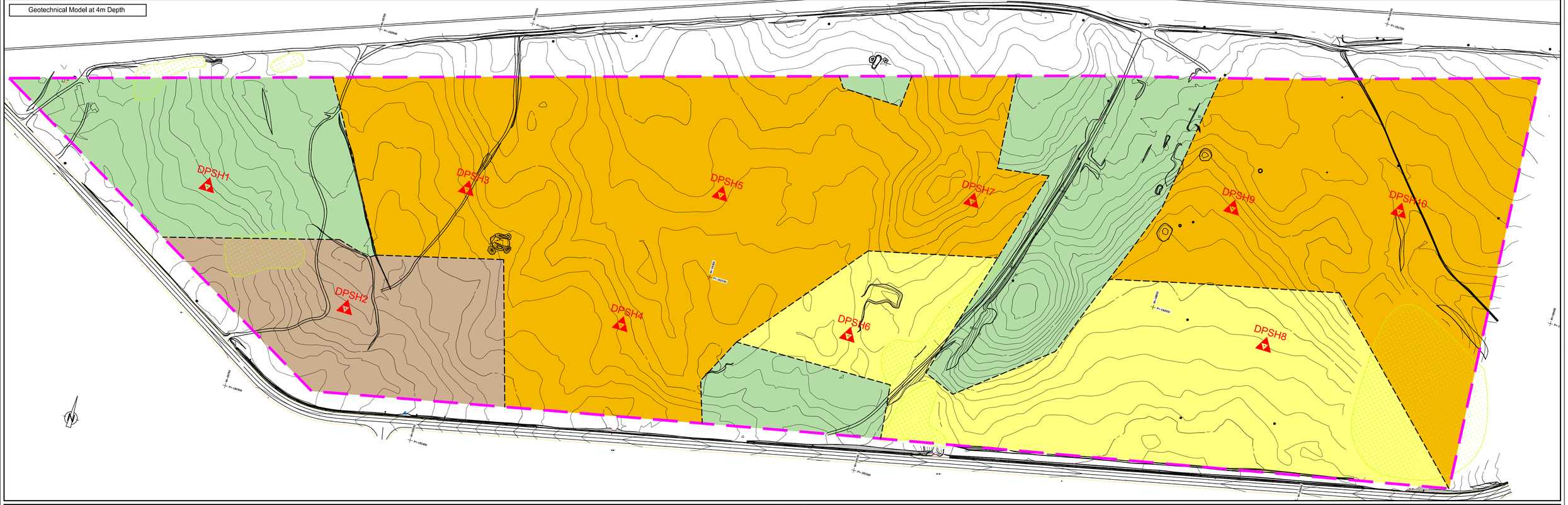
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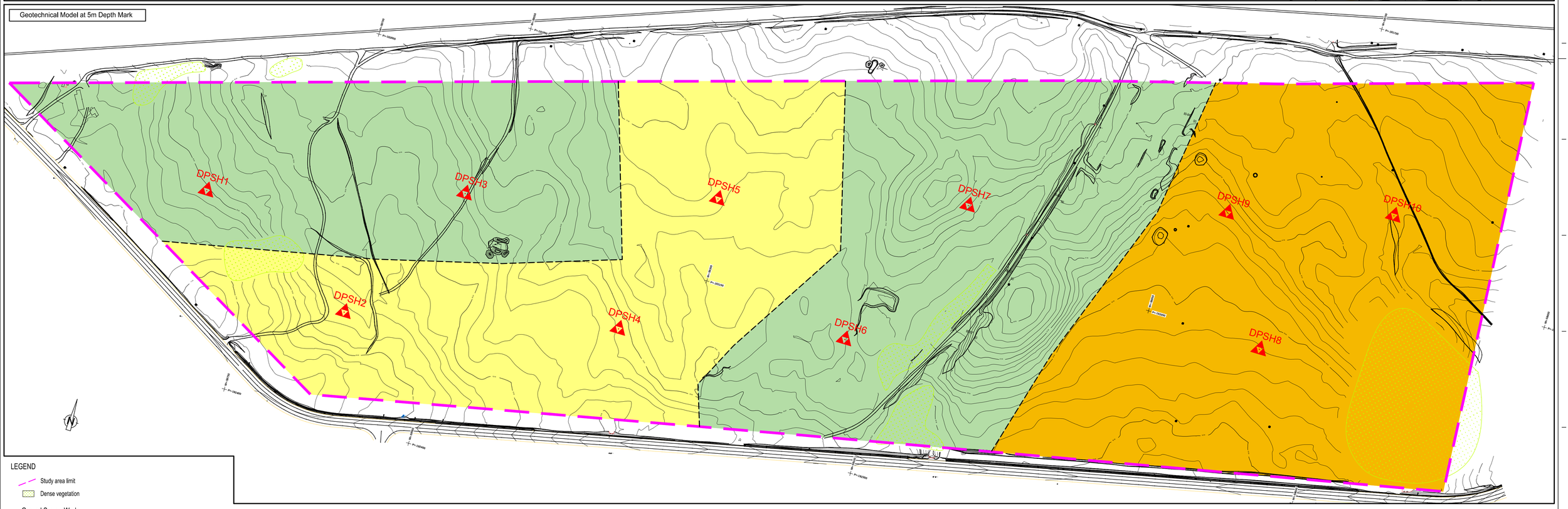
Drawing 00421.21DVDE004

Geotechnical Model. Plans Views at Depths of 4.0m and 5.0m

Geotechnical Model at 4m Depth



Geotechnical Model at 5m Depth Mark



LEGEND

- Study area limit
- Dense vegetation

Ground Survey Works

- DPSH test

Geotechnical Zoning

- GZ4 - DPSH test results < 12 blows. Loose to very loose sand deposits or residual schistose soil
- GZ3 - DPSH test results between 13 and 25 blows. Medium dense sand or decomposed schistose rock mass
- GZ2 - DPSH test results between 26 and 40 blows. Dense sand or highly weathered to decomposed schistose rock mass
- GZ1 - DPSH test redults >40 blows. Highly weathered schistose rock mass
- Geotechnical limit

Revised by:	Studied by:	Date:
F. Ferreira	E. Teixeira	February 2021
Coordinator:	Drafter:	
E. Teixeira	E. Teixeira	

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Reference: 00421 _ 21
Sheet: 01/01

Project: SINES 4.0
GEOLOGICAL AND GEOTECHNICAL STUDY

Geotechnical Model. Plan views at Depths of 4.0m and 5.0m

Revision	Description	Date	Drafter	Rev./ Coord.

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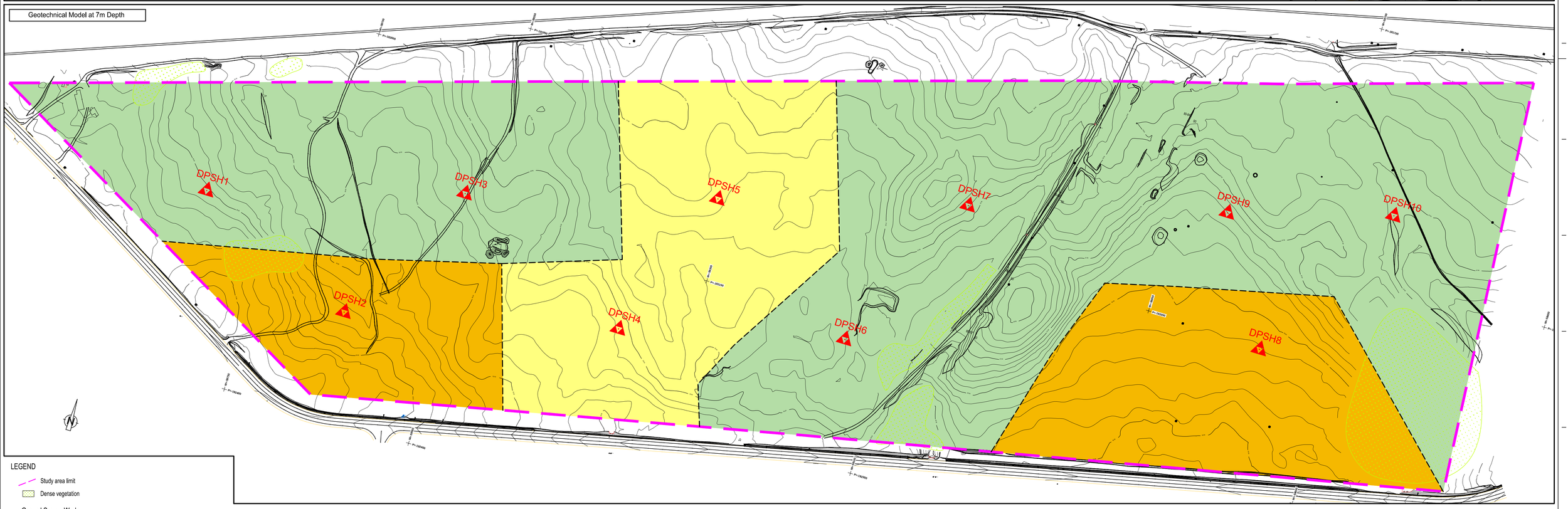
Drawing 00421.21DVDE005

Geotechnical Model. Plans Views at Depths of 6.0m and 7.0m

Geotechnical Model at 6m Depth



Geotechnical Model at 7m Depth



LEGEND

- Study area limit
- Dense vegetation

Ground Survey Works

- DPSH test

Geotechnical Zoning

- GZ4 - DPSH test results < 12 blows. Loose to very loose sand deposits or residual schistose soil
- GZ3 - DPSH test results between 13 and 25 blows. Medium dense sand or decomposed schistose rock mass
- GZ2 - DPSH test results between 26 and 40 blows. Dense sand or highly weathered to decomposed schistose rock mass
- GZ1 - DPSH test redults >40 blows. Highly weathered schistose rock mass
- Geotechnical limit

Revised by: F. Ferreira	Studied by: E. Teixeira	Date: February 2021	Scale: 1:2000 (A1)
Coordinator: E. Teixeira	Drafter: E. Teixeira		Replaces drawing:
			Replaced by drawing:

Drawing nº: 00421.21DVDE004 00

Reference: 00421 _ 21 | Sheet: 01/01

Project: SINES 4.0
GEOLOGICAL AND GEOTECHNICAL STUDY

Geotechnical Model. Plan views at Depths of 6.0m and 7.0m

Revision	Description	Date	Drafter	Rev./ Coord.

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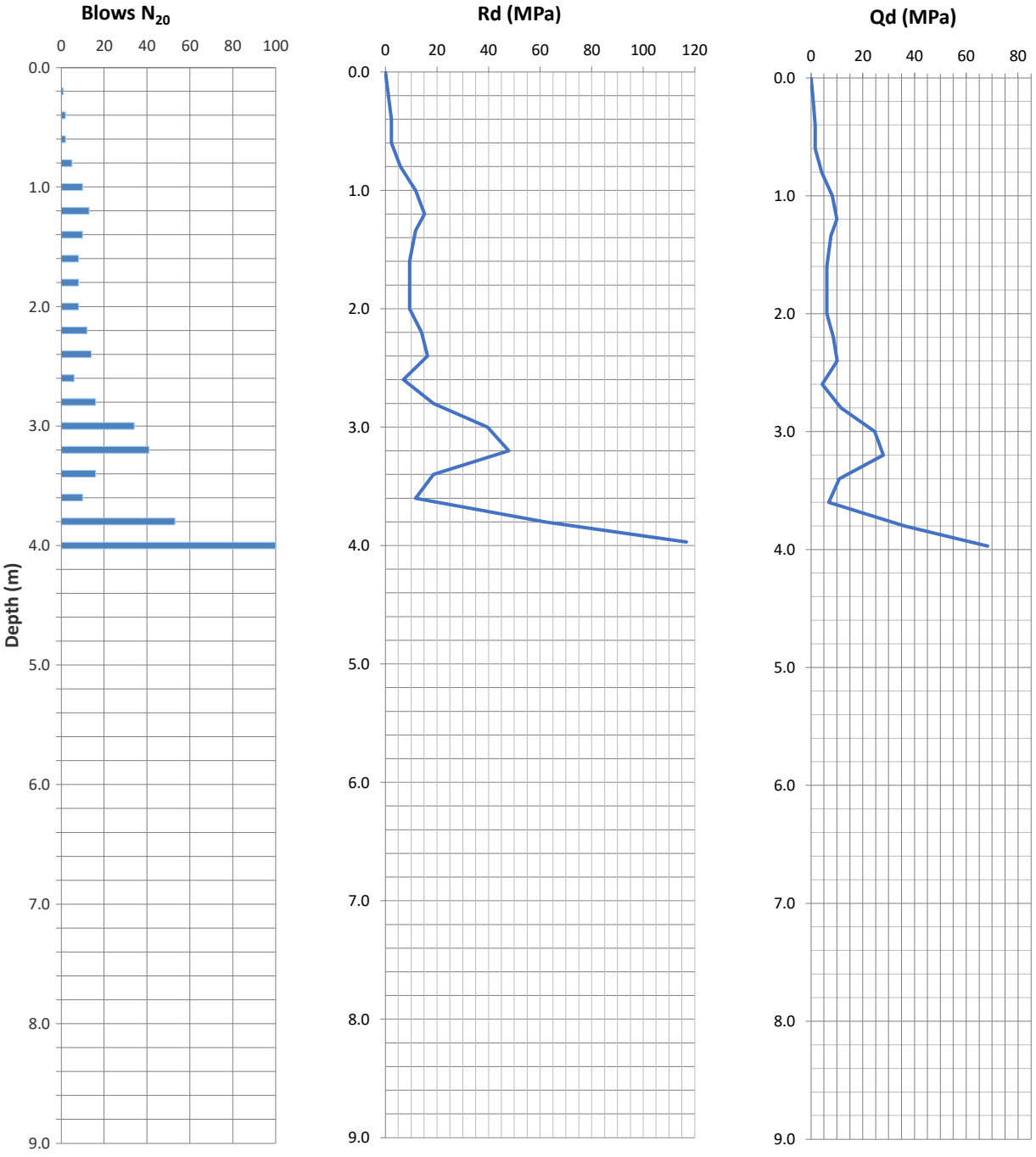
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Data Report of DPSH tests

Geoárea PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59826m P= -192207m Z= 20m	**DPSH 01** **Date:** 27/01/2021
Location: SINES		**Page:** 1 / 2

Hammer mass =	63.5 kg	Rod length=	1.0 m	**Depth:** 3.97 m
Height of fall =	0.75 m	Anvil mass (guide rod included)=	21.0 kg	
Rod mass =	6.0 kg	Blow count interval=	0.2 m	



Observations: The last adavance was 17cm.

Technician: Henrique Rézio
Verified by: Frederico Ribeiro

Geoárea / PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59826m P= -192207m Z= 20m	**DPSH 01** Date: 27/01/2021
Location: SINES		**Page:** 2 / 2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)
0			
0.2	1	1.2	0.8
0.4	2	2.3	1.6
0.6	2	2.3	1.6
0.8	5	5.8	4.1
1.0	10	11.7	8.2
1.2	13	15.2	10.0
1.3	10	11.7	7.7
1.6	8	9.3	6.1
1.8	8	9.3	6.1
2.0	8	9.3	6.1
2.2	12	14.0	8.7
2.4	14	16.3	10.1
2.6	6	7.0	4.3
2.8	16	18.7	11.6
3.0	34	39.7	24.6
3.2	41	47.8	28.0
3.4	16	18.7	10.9
3.6	10	11.7	6.8
3.8	53	61.8	36.2
3.97	100	116.7	68.3

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)



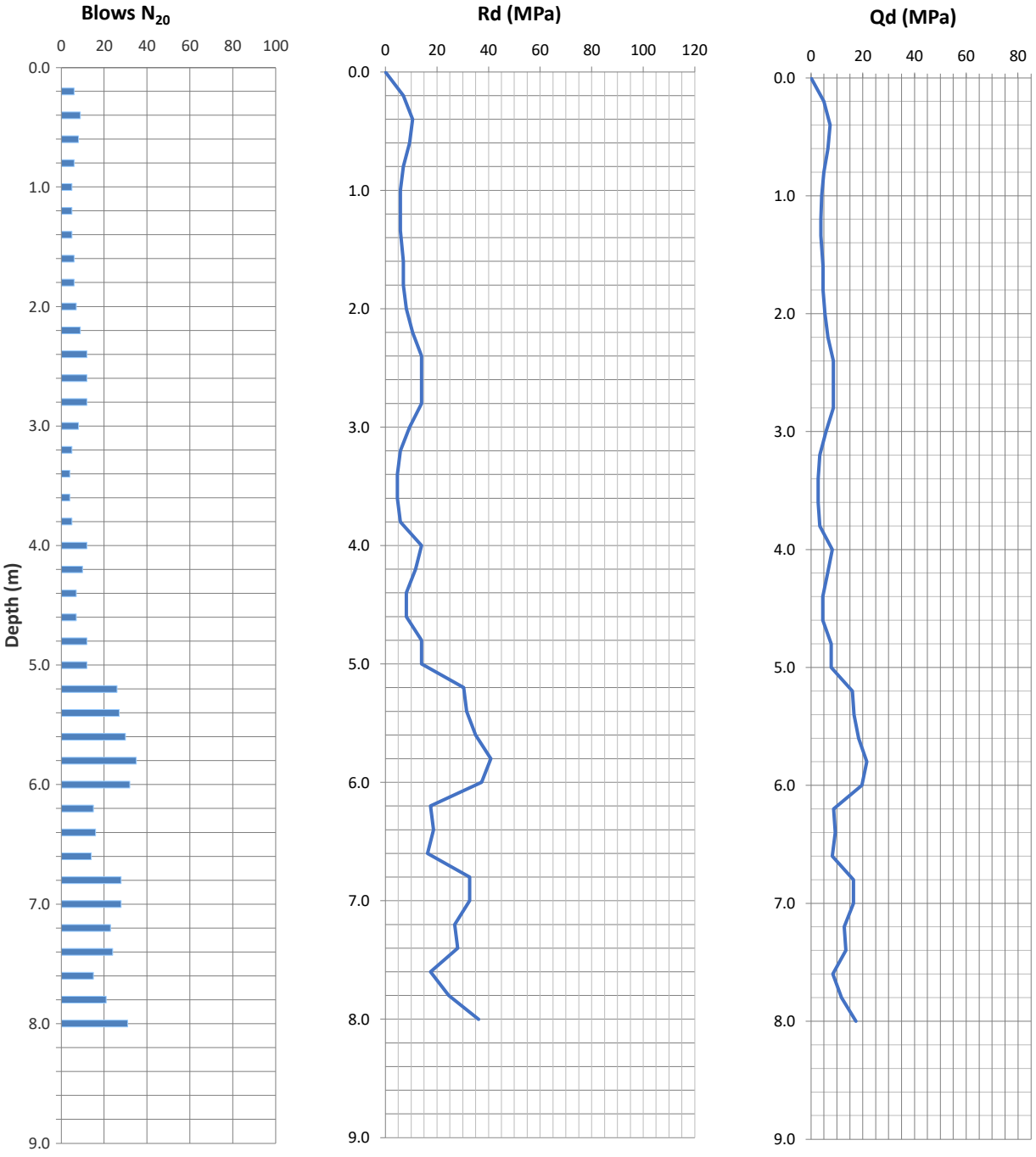
DPSH 01

Observations: The last adavance was 17cm.	**Technician:** Henrique Rézio
	Verified by: Frederico Ribeiro

Geoárea PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59653m P= -192288m Z= 21,5m	**DPSH 02** **Date:** 27/01/2021
Location: SINES		**Page:** 1 / 2

Hammer mass =	63.5 kg	Rod length=	1.0 m	**Depth:** 8.0 m
Height of fall =	0.75 m	Anvil mass (guide rod included)=	21.0 kg	
Rod mass =	6.0 kg	Blow count interval=	0.2 m	



Observations: Humidity observed from 2.4m	**Technician:** Henrique Rézio **Verified by:** Frederico Ribeiro

GeoÁrea / PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59653m P= -192288m Z= 21,5m	**DPSH 02** Date: 27/01/2021
Location: SINES		**Page:** 2 / 2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)
0			
0.2	6	7.0	4.9
0.4	9	10.5	7.4
0.6	8	9.3	6.5
0.8	6	7.0	4.9
1.0	5	5.8	4.1
1.2	5	5.8	3.8
1.3	5	5.8	3.8
1.6	6	7.0	4.6
1.8	6	7.0	4.6
2.0	7	8.2	5.4
2.2	9	10.5	6.5
2.4	12	14.0	8.7
2.6	12	14.0	8.7
2.8	12	14.0	8.7
3.0	8	9.3	5.8
3.2	5	5.8	3.4
3.4	4	4.7	2.7
3.6	4	4.7	2.7
3.8	5	5.8	3.4
4.0	12	14.0	8.2
4.2	10	11.7	6.5
4.4	7	8.2	4.5
4.6	7	8.2	4.5
4.8	12	14.0	7.8
5.0	12	14.0	7.8
5.2	26	30.3	16.0
5.4	27	31.5	16.6
5.6	30	35.0	18.4
5.8	35	40.8	21.5
6.0	32	37.3	19.7
6.2	15	17.5	8.8
6.4	16	18.7	9.4
6.6	14	16.3	8.2
6.8	28	32.7	16.4
7.0	28	32.7	16.4
7.2	23	26.8	12.9
7.4	24	28.0	13.4
7.6	15	17.5	8.4
7.8	21	24.5	11.7
8.0	31	36.2	17.3

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)



DPSH 02

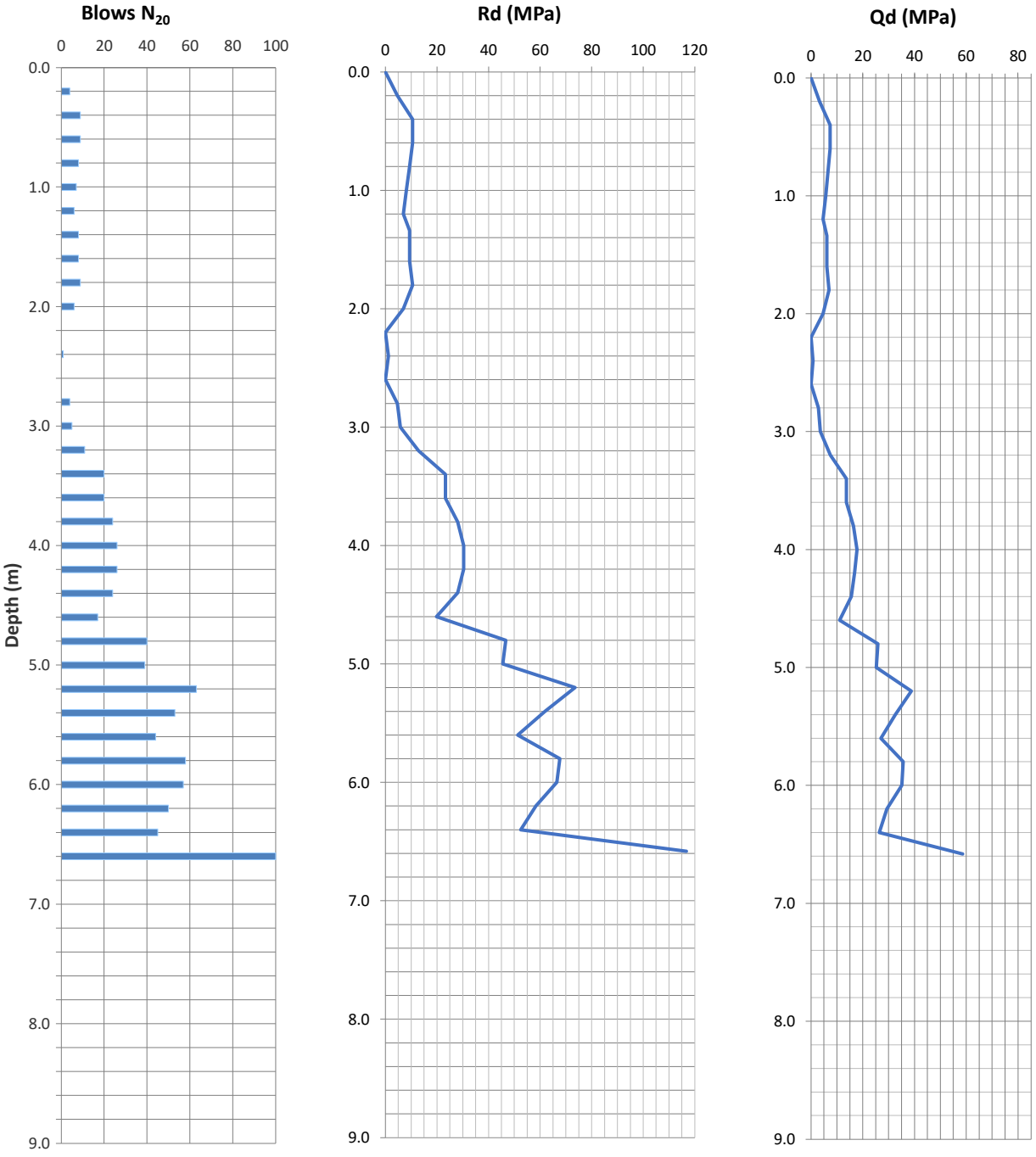
Observations: Humidity observed from 2.4m

Technician: Henrique Rézio

Verified by: Frederico Ribeiro

Geoárea PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus
SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59567m P= -192134m Z= 23,5m	**DPSH 03** **Date:** 27/01/2021
Location: SINES		**Page:** 1 / 2

Hammer mass =	63.5 kg	Rod length=	1.0 m	**Depth:** 6.58 m
Height of fall =	0.75 m	Anvil mass (guide rod included)=	21.0 kg	
Rod mass =	6.0 kg	Blow count interval=	0.2 m	



Observations: Humidity observed from 2.5m. Last advance was 18cm.

Technician: Henrique Rézio
Verified by: Frederico Ribeiro

GeoÁrea / PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59567m P= -192134m Z= 23,5m	**DPSH 03** Date: 27/01/2021
Location: SINES		**Page:** 2 / 2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)
0			
0.2	4	4.7	3.3
0.4	9	10.5	7.4
0.6	9	10.5	7.4
0.8	8	9.3	6.5
1.0	7	8.2	5.7
1.2	6	7.0	4.6
1.3	8	9.3	6.1
1.6	8	9.3	6.1
1.8	9	10.5	6.9
2.0	6	7.0	4.6
2.2	0	0.0	0.0
2.4	1	1.2	0.7
2.6	0	0.0	0.0
2.8	4	4.7	2.9
3.0	5	5.8	3.6
3.2	11	12.8	7.5
3.4	20	23.3	13.7
3.6	20	23.3	13.7
3.8	24	28.0	16.4
4.0	26	30.3	17.8
4.2	26	30.3	16.8
4.4	24	28.0	15.5
4.6	17	19.8	11.0
4.8	40	46.7	25.9
5.0	39	45.5	25.2
5.2	63	73.5	38.7
5.4	53	61.8	32.6
5.6	44	51.3	27.1
5.8	58	67.7	35.7
6.0	57	66.5	35.0
6.2	50	58.3	29.3
6.4	45	52.5	26.4
6.58	100	116.7	58.6

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)

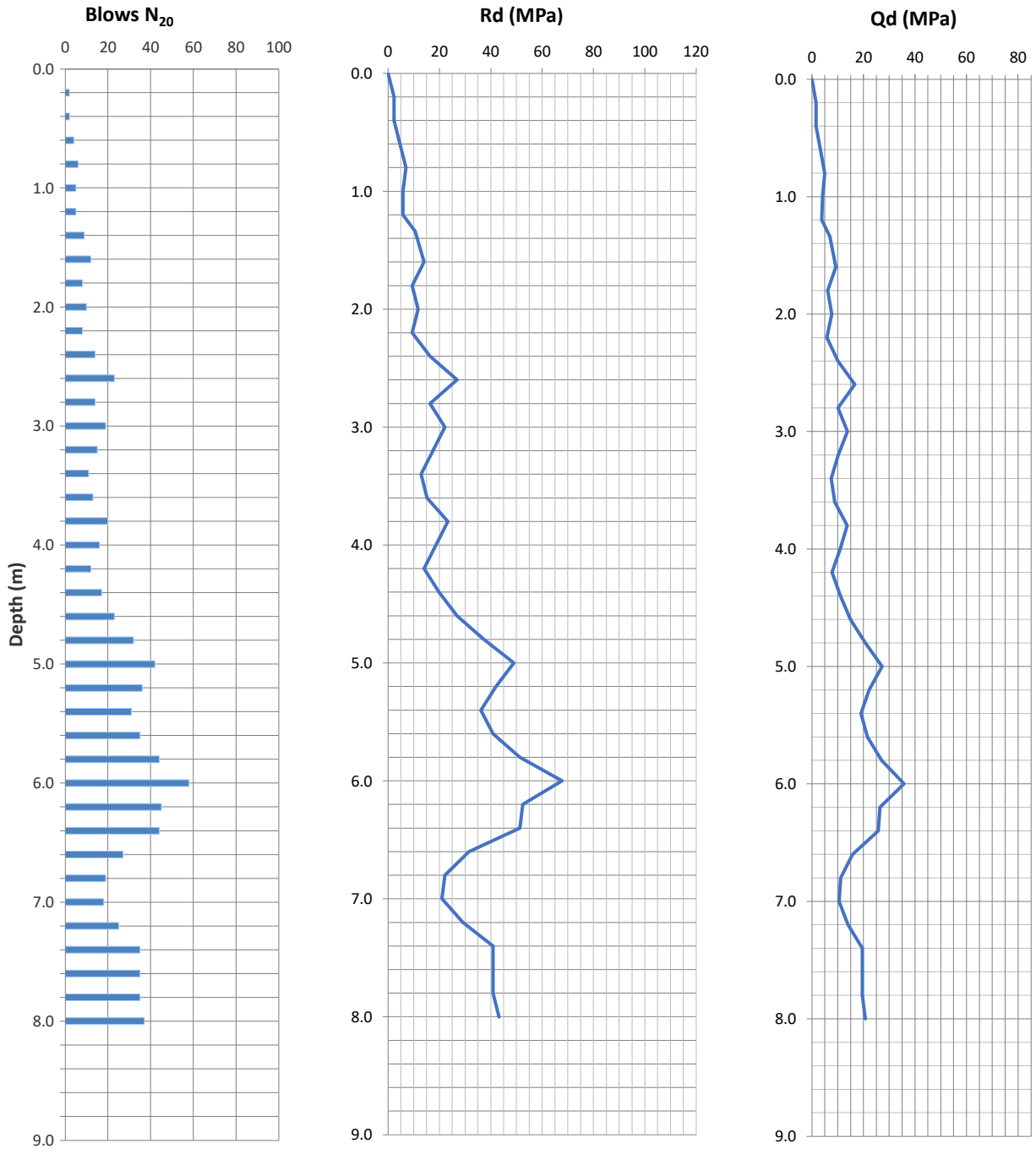


DPSH 03

Observations: Humidity observed from 2.5m. Last advance was 18cm.	**Technician:** Henrique Rézio **Verified by:** Frederico Ribeiro

Geoárea PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus
SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59374m P= -192224m Z= 24,5m	**DPSH 04** **Date:** 27/01/2021
Location: SINES		**Page:** 1 / 2

Hammer mass =	63.5 kg	Rod length=	1.0 m	**Depth:** 8.0 m
Height of fall =	0.75 m	Anvil mass (guide rod included)=	21.0 kg	
Rod mass =	6.0 kg	Blow count interval=	0.2 m	



Observations: Humidity observed from 2.0m	**Technician:** Henrique Rézio **Verified by:** Frederico Ribeiro

Geoárea / PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus
SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59374m P= -192224m Z= 24,5m	**DPSH 04** Date: 27/01/2021
Location: SINES		**Page:** 2 / 2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)
0			
0.2	2	2.3	1.6
0.4	2	2.3	1.6
0.6	4	4.7	3.3
0.8	6	7.0	4.9
1.0	5	5.8	4.1
1.2	5	5.8	3.8
1.3	9	10.5	6.9
1.6	12	14.0	9.2
1.8	8	9.3	6.1
2.0	10	11.7	7.7
2.2	8	9.3	5.8
2.4	14	16.3	10.1
2.6	23	26.8	16.6
2.8	14	16.3	10.1
3.0	19	22.2	13.7
3.2	15	17.5	10.2
3.4	11	12.8	7.5
3.6	13	15.2	8.9
3.8	20	23.3	13.7
4.0	16	18.7	10.9
4.2	12	14.0	7.8
4.4	17	19.8	11.0
4.6	23	26.8	14.9
4.8	32	37.3	20.7
5.0	42	49.0	27.2
5.2	36	42.0	22.1
5.4	31	36.2	19.1
5.6	35	40.8	21.5
5.8	44	51.3	27.1
6.0	58	67.7	35.7
6.2	45	52.5	26.4
6.4	44	51.3	25.8
6.6	27	31.5	15.8
6.8	19	22.2	11.1
7.0	18	21.0	10.5
7.2	25	29.2	14.0
7.4	35	40.8	19.6
7.6	35	40.8	19.6
7.8	35	40.8	19.6
8.0	37	43.2	20.7

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)

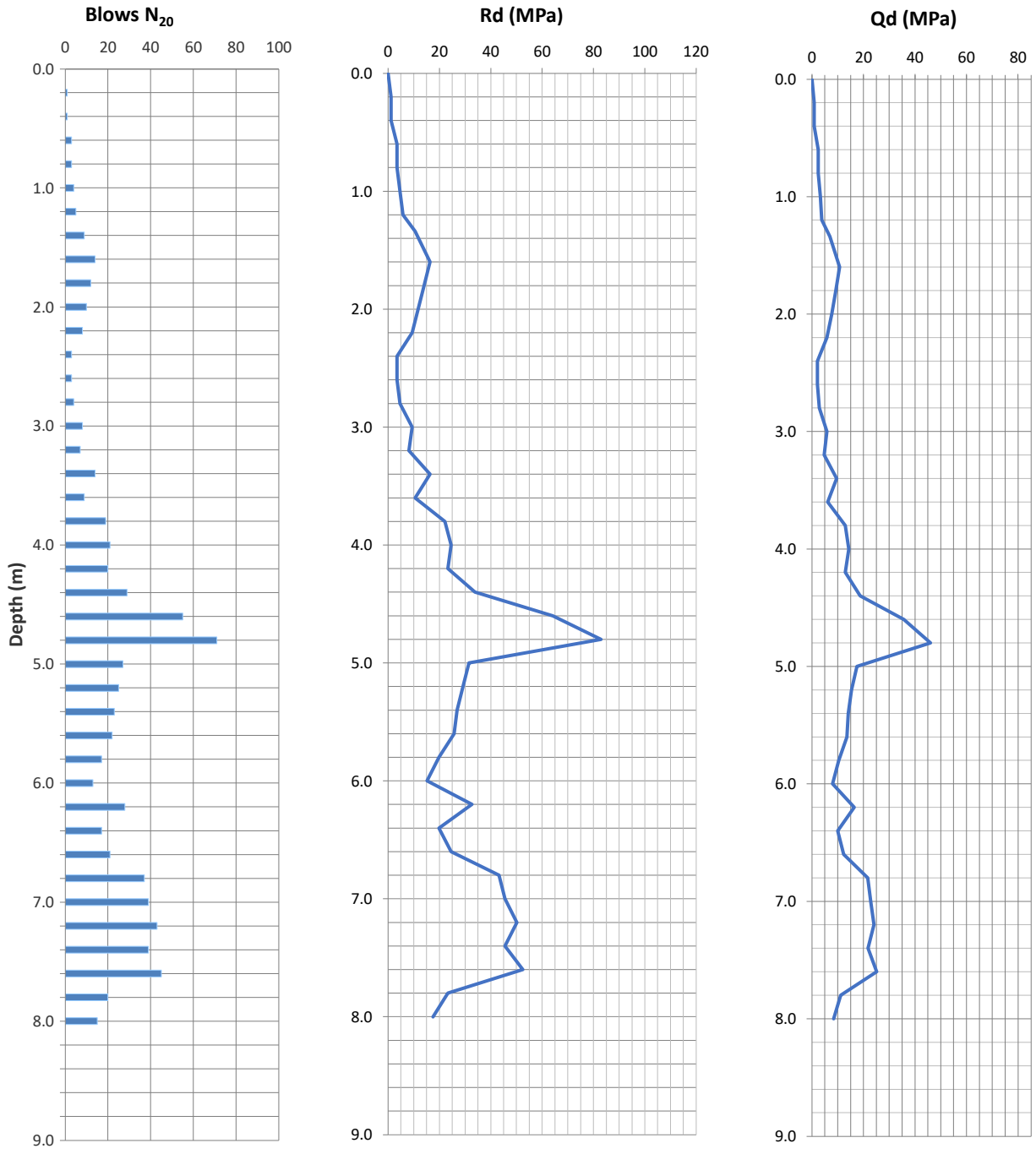


DPSH 04

Observations: Humidity observed from 2.0m	**Technician:** Henrique Rézio **Verified by:** Frederico Ribeiro

Geoárea PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus
SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59313m P= -192065m Z= 26,5m	**DPSH 05** **Date:** 28/01/2021
Location: SINES		**Page:** 1 / 2

Hammer mass =	63.5 kg	Rod length=	1.0 m	**Depth:** 8.0 m
Height of fall =	0.75 m	Anvil mass (guide rod included)=	21.0 kg	
Rod mass =	6.0 kg	Blow count interval=	0.2 m	



Observations: Humidity observed from 2.5m

Technician: Henrique Rézio
Verified by: Frederico Ribeiro

GeoÁrea / PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59313m P= -192065m Z= 26,5m	**DPSH 05** Date: 28/01/2021
Location: SINES		**Page:** 2 / 2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)
0			
0.2	1	1.2	0.8
0.4	1	1.2	0.8
0.6	3	3.5	2.5
0.8	3	3.5	2.5
1.0	4	4.7	3.3
1.2	5	5.8	3.8
1.3	9	10.5	6.9
1.6	14	16.3	10.7
1.8	12	14.0	9.2
2.0	10	11.7	7.7
2.2	8	9.3	5.8
2.4	3	3.5	2.2
2.6	3	3.5	2.2
2.8	4	4.7	2.9
3.0	8	9.3	5.8
3.2	7	8.2	4.8
3.4	14	16.3	9.6
3.6	9	10.5	6.1
3.8	19	22.2	13.0
4.0	21	24.5	14.3
4.2	20	23.3	12.9
4.4	29	33.8	18.8
4.6	55	64.2	35.6
4.8	71	82.8	45.9
5.0	27	31.5	17.5
5.2	25	29.2	15.4
5.4	23	26.8	14.1
5.6	22	25.7	13.5
5.8	17	19.8	10.5
6.0	13	15.2	8.0
6.2	28	32.7	16.4
6.4	17	19.8	10.0
6.6	21	24.5	12.3
6.8	37	43.2	21.7
7.0	39	45.5	22.8
7.2	43	50.2	24.0
7.4	39	45.5	21.8
7.6	45	52.5	25.2
7.8	20	23.3	11.2
8.0	15	17.5	8.4

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)



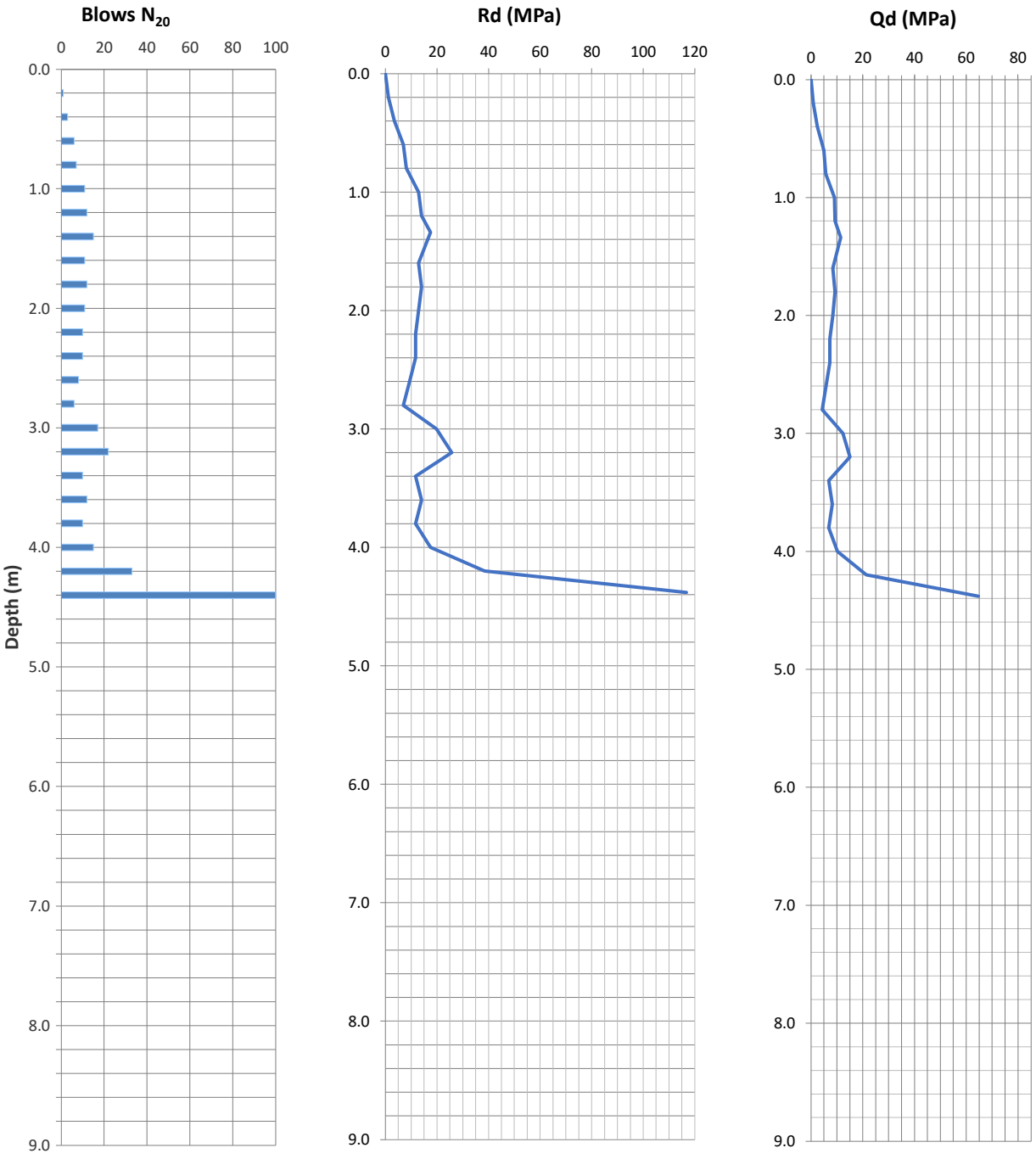
DPSH 05

Observations: Humidity observed from 2.5m	**Technician:** Henrique Rézio
	Verified by: Frederico Ribeiro

Geoárea PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -591452m P= -192168m Z= 26m	**DPSH 06** **Date:** 28/01/2021
Location: SINES		**Page:** 1 / 2

Hammer mass =	63.5 kg	Rod length=	1.0 m	**Depth:** 4.38 m
Height of fall =	0.75 m	Anvil mass (guide rod included)=	21.0 kg	
Rod mass =	6.0 kg	Blow count interval=	0.2 m	



Observations: Humidity observed from 3.0m. The last advance was 18cm.

Technician: Henrique Rézio
Verified by: Frederico Ribeiro

Geoárea / PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59145m P= -192168m Z= 26m	**DPSH 06** Date: 28/01/2021
Location: SINES		**Page:** 2 / 2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)
0			
0.2	1	1.2	0.8
0.4	3	3.5	2.5
0.6	6	7.0	4.9
0.8	7	8.2	5.7
1.0	11	12.8	9.0
1.2	12	14.0	9.2
1.3	15	17.5	11.5
1.6	11	12.8	8.4
1.8	12	14.0	9.2
2.0	11	12.8	8.4
2.2	10	11.7	7.2
2.4	10	11.7	7.2
2.6	8	9.3	5.8
2.8	6	7.0	4.3
3.0	17	19.8	12.3
3.2	22	25.7	15.0
3.4	10	11.7	6.8
3.6	12	14.0	8.2
3.8	10	11.7	6.8
4.0	15	17.5	10.2
4.2	33	38.5	21.4
4.38	100	116.7	64.7

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)



DPSH 06

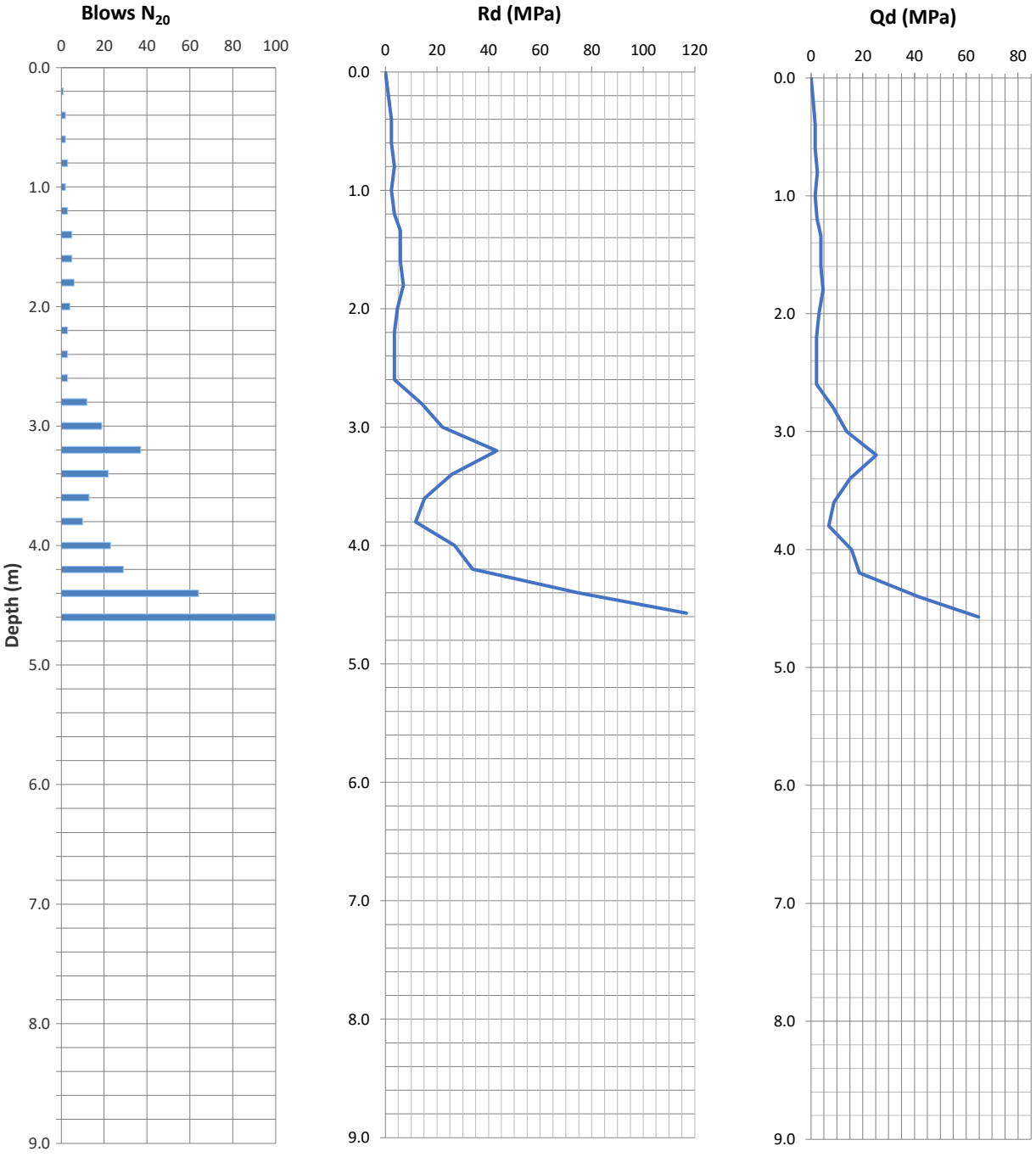
Observations: Humidity observed from 3.0m. The last advance was 18cm.

Technician: Henrique Rézio

Verified by: Frederico Ribeiro

Geoárea PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus
SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59061m P= -191998m Z= 27,5m	**DPSH 07** **Date:** 28/01/2021
Location: SINES		**Page:** 1 / 2

Hammer mass =	63.5 kg	Rod length=	1.0 m	**Depth:** 4.57 m
Height of fall =	0.75 m	Anvil mass (guide rod included)=	21.0 kg	
Rod mass =	6.0 kg	Blow count interval=	0.2 m	



Observations: Humidity observed from 2.4m. The last advance was 17cm.

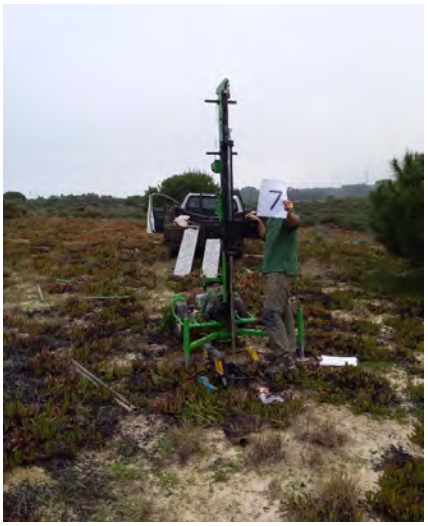
Technician: Henrique Rézio
Verified by: Frederico Ribeiro

GeoÁrea / PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -59061m P= -191998m Z= 27,5m	**DPSH 07** Date: 28/01/2021
Location: SINES		**Page:** 2 / 2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)
0			
0.2	1	1.2	0.8
0.4	2	2.3	1.6
0.6	2	2.3	1.6
0.8	3	3.5	2.5
1.0	2	2.3	1.6
1.2	3	3.5	2.3
1.3	5	5.8	3.8
1.6	5	5.8	3.8
1.8	6	7.0	4.6
2.0	4	4.7	3.1
2.2	3	3.5	2.2
2.4	3	3.5	2.2
2.6	3	3.5	2.2
2.8	12	14.0	8.7
3.0	19	22.2	13.7
3.2	37	43.2	25.3
3.4	22	25.7	15.0
3.6	13	15.2	8.9
3.8	10	11.7	6.8
4.0	23	26.8	15.7
4.2	29	33.8	18.8
4.4	64	74.7	41.4
4.57	100	116.7	64.7

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)



DPSH 07

Observations: Humidity observed from 2.4m. The last advance was 17cm.

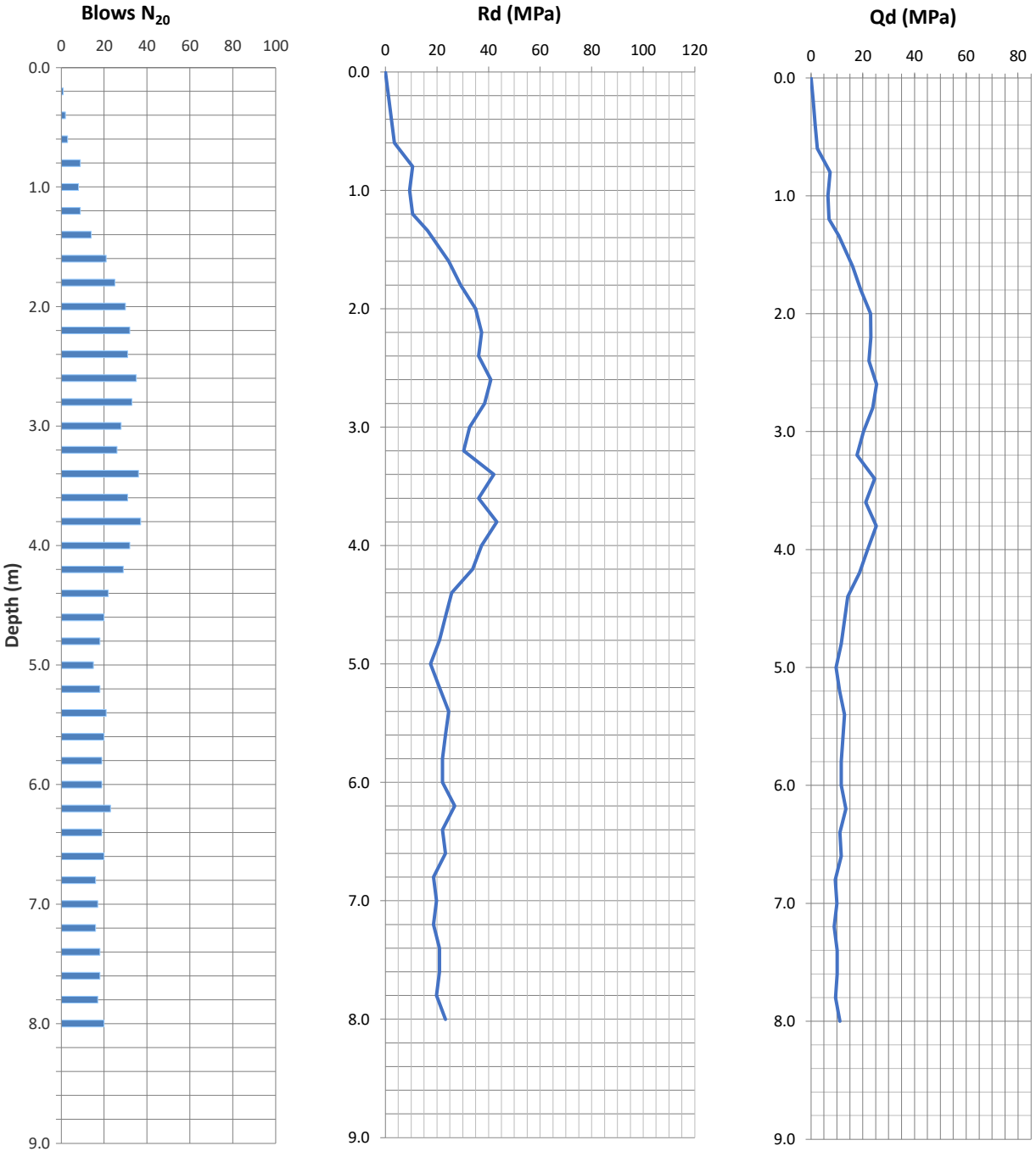
Technician: Henrique Rézio

Verified by: Frederico Ribeiro

Geoárea PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -58728m P= -192056m Z= 24,5m	**DPSH 08** **Date:** 29/01/2021
Location: SINES		**Page:** 1 / 2

Hammer mass =	63.5 kg	Rod length=	1.0 m	**Depth:** 8.0 m
Height of fall =	0.75 m	Anvil mass (guide rod included)=	21.0 kg	
Rod mass =	6.0 kg	Blow count interval=	0.2 m	



Observations: Humidity observed from 0.2m.	**Technician:** Henrique Rézio **Verified by:** Frederico Ribeiro

Geoárea / PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -58728m P= -192056m Z= 24,5m	**DPSH 08** Date: 29/01/2021
Location: SINES		**Page:** 2 / 2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)
0			
0.2	1	1.2	0.8
0.4	2	2.3	1.6
0.6	3	3.5	2.5
0.8	9	10.5	7.4
1.0	8	9.3	6.5
1.2	9	10.5	6.9
1.3	14	16.3	10.7
1.6	21	24.5	16.1
1.8	25	29.2	19.2
2.0	30	35.0	23.0
2.2	32	37.3	23.1
2.4	31	36.2	22.4
2.6	35	40.8	25.3
2.8	33	38.5	23.9
3.0	28	32.7	20.2
3.2	26	30.3	17.8
3.4	36	42.0	24.6
3.6	31	36.2	21.2
3.8	37	43.2	25.3
4.0	32	37.3	21.9
4.2	29	33.8	18.8
4.4	22	25.7	14.2
4.6	20	23.3	12.9
4.8	18	21.0	11.6
5.0	15	17.5	9.7
5.2	18	21.0	11.1
5.4	21	24.5	12.9
5.6	20	23.3	12.3
5.8	19	22.2	11.7
6.0	19	22.2	11.7
6.2	23	26.8	13.5
6.4	19	22.2	11.1
6.6	20	23.3	11.7
6.8	16	18.7	9.4
7.0	17	19.8	10.0
7.2	16	18.7	8.9
7.4	18	21.0	10.1
7.6	18	21.0	10.1
7.8	17	19.8	9.5
8.0	20	23.3	11.2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)

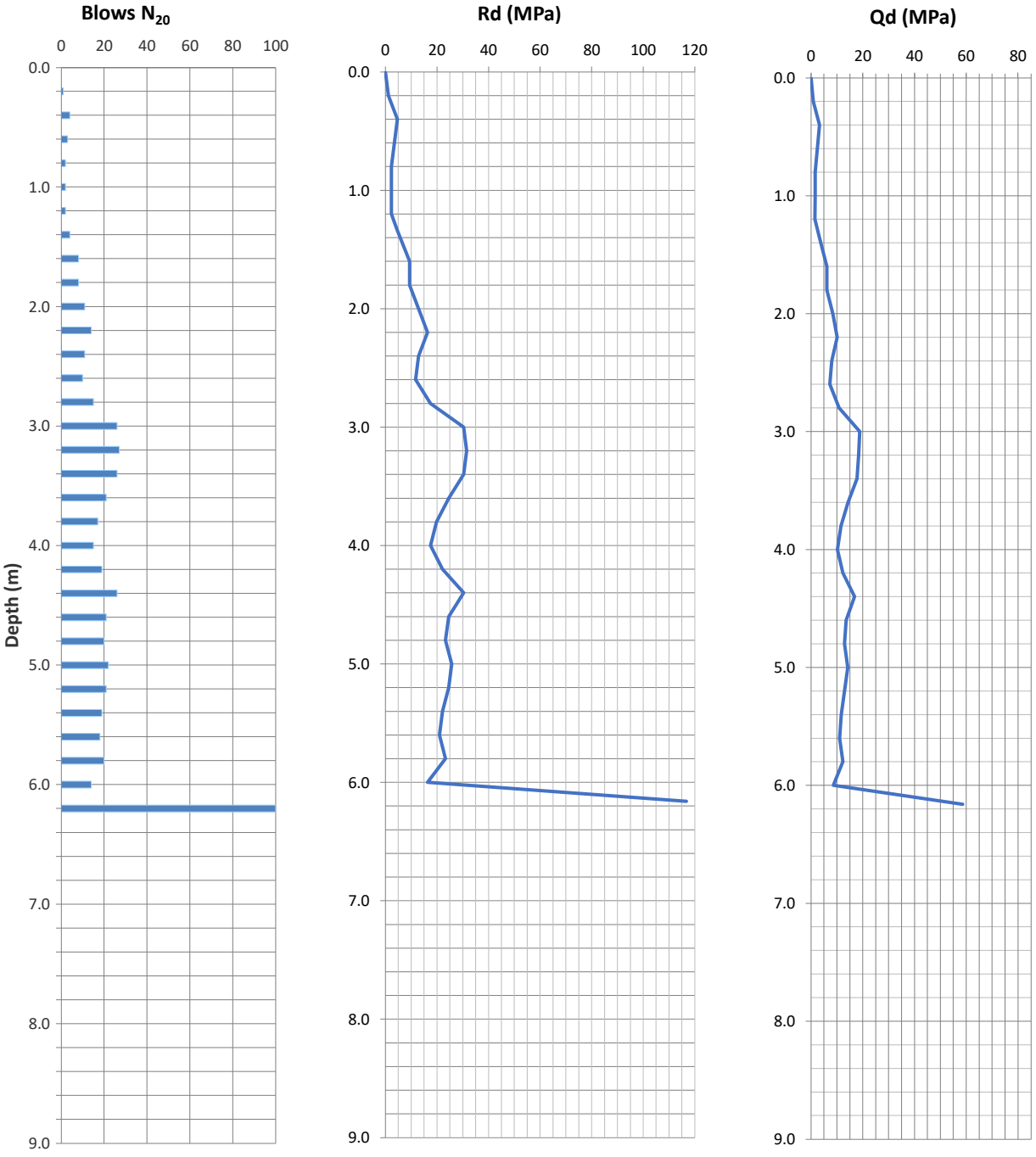


DPSH 08

Observations: Humidity observed from 0.2m.	**Technician:** Henrique Rézio **Verified by:** Frederico Ribeiro

Geoárea PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus
SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -58800m P= -191929m Z= 26,5m	**DPSH 09** **Date:** 29/01/2021
Location: SINES		**Page:** 1 / 2

Hammer mass =	63.5 kg	Rod length=	1.0 m	**Depth:** 6.16 m
Height of fall =	0.75 m	Anvil mass (guide rod included)=	21.0 kg	
Rod mass =	6.0 kg	Blow count interval=	0.2 m	



Observations: Humidity observed from 0.2m. The last advance was 16cm.

Technician: Henrique Rézio
Verified by: Frederico Ribeiro

Geoárea / PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -58800m P= -191929m Z= 26,5m	**DPSH 09** Date: 29/01/2021
Location: SINES		**Page:** 2 / 2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)
0			
0.2	1	1.2	0.8
0.4	4	4.7	3.3
0.6	3	3.5	2.5
0.8	2	2.3	1.6
1.0	2	2.3	1.6
1.2	2	2.3	1.5
1.3	4	4.7	3.1
1.6	8	9.3	6.1
1.8	8	9.3	6.1
2.0	11	12.8	8.4
2.2	14	16.3	10.1
2.4	11	12.8	8.0
2.6	10	11.7	7.2
2.8	15	17.5	10.8
3.0	26	30.3	18.8
3.2	27	31.5	18.4
3.4	26	30.3	17.8
3.6	21	24.5	14.3
3.8	17	19.8	11.6
4.0	15	17.5	10.2
4.2	19	22.2	12.3
4.4	26	30.3	16.8
4.6	21	24.5	13.6
4.8	20	23.3	12.9
5.0	22	25.7	14.2
5.2	21	24.5	12.9
5.4	19	22.2	11.7
5.6	18	21.0	11.1
5.8	20	23.3	12.3
6.0	14	16.3	8.6
6.16	100	116.7	58.6

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)



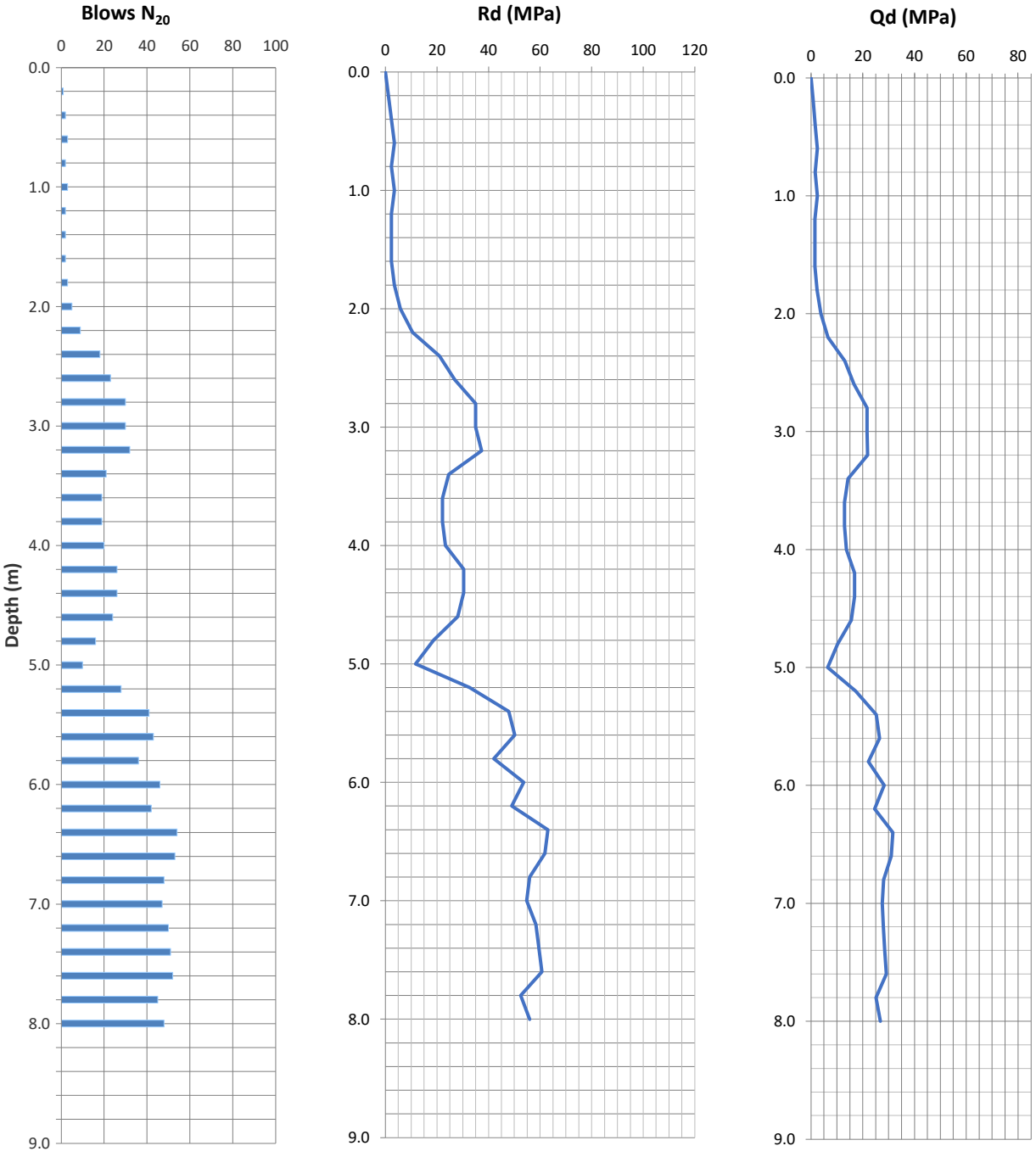
DPSH 09

Observations: Humidity observed from 0.2m. The last advance was 16cm.	**Technician:** Henrique Rézio **Verified by:** Frederico Ribeiro

Geoárea PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -58633m P= -191883m Z= 28m	**DPSH 10** **Date:** 29/01/2021
Location: SINES		**Page:** 1 / 2

Hammer mass =	63.5 kg	Rod length=	1.0 m	**Depth:** 8.0 m
Height of fall =	0.75 m	Anvil mass (guide rod included)=	21.0 kg	
Rod mass =	6.0 kg	Blow count interval=	0.2 m	



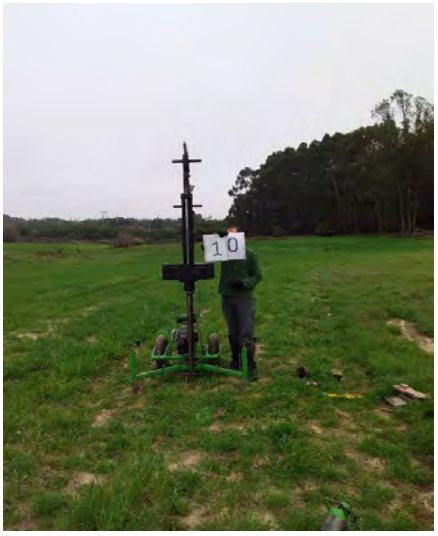
Observations: Humidity observed from 1.0 m.	**Technician:** Henrique Rézio **Verified by:** Frederico Ribeiro

GeoÁrea / PROFICO ENGINEERING SOLUTIONS	**Dynamic Probing Super Heavy**	start campus

SINES 4.0 **Geological-Geotechnical Study**	**Coordinates: ETRS89** M= -58633m P= -191883m Z= 28m	**DPSH 10** Date: 29/01/2021
Location: SINES		**Page:** 2 / 2

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)
0			
0.2	1	1.2	0.8
0.4	2	2.3	1.6
0.6	3	3.5	2.5
0.8	2	2.3	1.6
1.0	3	3.5	2.5
1.2	2	2.3	1.5
1.3	2	2.3	1.5
1.6	2	2.3	1.5
1.8	3	3.5	2.3
2.0	5	5.8	3.8
2.2	9	10.5	6.5
2.4	18	21.0	13.0
2.6	23	26.8	16.6
2.8	30	35.0	21.7
3.0	30	35.0	21.7
3.2	32	37.3	21.9
3.4	21	24.5	14.3
3.6	19	22.2	13.0
3.8	19	22.2	13.0
4.0	20	23.3	13.7
4.2	26	30.3	16.8
4.4	26	30.3	16.8
4.6	24	28.0	15.5
4.8	16	18.7	10.4
5.0	10	11.7	6.5
5.2	28	32.7	17.2
5.4	41	47.8	25.2
5.6	43	50.2	26.4
5.8	36	42.0	22.1
6.0	46	53.7	28.3
6.2	42	49.0	24.6
6.4	54	63.0	31.6
6.6	53	61.8	31.0
6.8	48	56.0	28.1
7.0	47	54.8	27.5
7.2	50	58.3	28.0
7.4	51	59.5	28.5
7.6	52	60.7	29.1
7.8	45	52.5	25.2
8.0	48	56.0	26.8

Depth (m)	$N_{(20)}$	Rd (Mpa)	Qd (Mpa)



DPSH 10

Observations: Humidity observed from 1.0 m.	**Technician:** Henrique Rézio **Verified by:** Frederico Ribeiro

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Appendix C. Structural

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Sines 4.0© START Campus Phase N Seismic Design Criteria

9 March 2023

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1. Summary



Summary

The purpose of this study is to establish and define the seismic and associated tsunami criteria by which the Phase N will be designed. The seismic and tsunami design criteria recommendations being proposed herein will apply to the Phase N Buildings and all Nonstructural Components that will reside within it.

The sources used in determining the proposed seismic design criteria are as follows:

- ANSI/TIA-942-B; American National Standards Institute / Telecommunications Infrastructure Standard for Data Centers. 2017
- BS EN 50600-2-1; The British Standards Institute / Information technology. Data centre facilities and infrastructures - Building construction. 2021
- Client seismic and tsunami hazard assessment studies

Based on our evaluations, the recommended proposed seismic design criteria for the Phase N includes:

- Building Design:
  - Importance Class III – 45% increase in design acceleration (based on type 1 action)
    - Operational Status – 10% in 50-year event (475-year return period)
    - Life Safety Status – 821-year return period
  - Lateral force resisting systems
    - For 1-storey plant building provide concrete shear wall or steel braced frame.
    - Phase N DC: For multi-storey provide a damped system such as Buckling Restrained Braces.
  - Tsunami Design:
    - Inundation TBD
    - Detailed design criteria TBD
- Nonstructural Components:
  - Importance Factor =1.5 for all systems
  - Deflection limits on electrical equipment
  - Equipment shall meet or exceed lateral component accelerations

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2. Building Design



Building Design

ANSI/TIA-942: Tier Classifications & their related Structural Requirements

A summary of the tiered classification of data centers.

Tier	Title	General	Availability	Downtime
I	Basic	susceptible to disruptions from both planned and unplanned activity	99.671%	28.8 hr/yr
II	Redundant Components	slightly less susceptible to disruptions from both planned and unplanned activity than a basic data center	99.741%	22.0 hr/yr
III	Concurrently Maintainable	allows for any planned site infrastructure activity without disrupting the computer hardware operation in any way	99.982%	1.6 hr/yr
IV	Fault Tolerant	provides site infrastructure capacity and capability to permit any planned activity without disruption to the critical load	99.995%	0.4 hr/yr

Recommended Tier Classification for Structural system

Overall Target = Tier III+ (3+)

A summary of the structural design philosophy of the tiers.

Tier	Structural Requirements
I	No requirements for protection against physical events, intentional or accidental, natural or man-made, which could cause the data center to fail.
II	Tier I requirements and includes minimal protections against some physical events, intentional or accidental, natural or man-made, which could cause the data center to fail.
III	Tier II requirements and has protection against most physical events, intentional or accidental, natural or manmade, which could cause the data center to fail.
IV	Tier III requirements and considers all potential physical events that could cause the data center to fail. Provides specific and in some cases redundant protections against such events. Considers the potential problems with natural disasters such as seismic events, floods, fire, hurricanes, and storms, as well as potential problems with terrorism and disgruntled employees. Has control over all aspects of their facility.

Recommended Tier Classification for structural requirements

Overall Target = Tier III+ (3+)

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Building Design

ANSI/TIA-942: Structural Requirements of Tiers

Recommended Tier Classification
For structural requirements

Overall Target = Tier 3+

	TIER 1	TIER 2	TIER 3	TIER 4
Structural				
Seismic zone -any zone acceptable although it may dictate more costly support mechanisms	no restriction	no restriction	no restriction	no restriction
Facility designed to seismic zone requirements	no restriction	no restriction	no restriction	In Seismic Zone 0, 1, 2 to Zone 3 requirements. In Seismic Zone 3 & 4 to Zone 4 requirements
Site Specific Response Spectra - Degree of local Seismic accelerations	no	no	with Operation Status after 10% in 50 year event	with Operation Status after 5% in 100 year event
Importance factor - assists to ensure greater than code design	I=1	I=1.5	I=1.5	I=1.5
Telecommunications equipment racks/cabinets anchored to base or supported at top and base	no	Base only	Fully braced	Fully braced
Deflection limitation on telecommunications equipment within limits acceptable by the electrical attachments	no	no	yes	yes
Bracing of electrical conduits runs and cable trays	per code	per code w/Importance	per code w/Importance	per code w/Importance
Bracing of mechanical system major duct runs	per code	per code w/Importance	per code w/Importance	per code w/Importance
Floor loading capacity superimposed live load	7.2 kPa (150 lbf/sq ft).	8.4 kPa (175 lbf/sq ft)	12 kPa (250 lbf/sq ft)	12 kPa (250 lbf/sq ft)
Floor hanging capacity for ancillary loads suspended from below	1.2 kPa (25 lbf/sq ft)	1.2 kPa (25 lbf/sq ft)	2.4 kPa (50 lbf/sq ft)	2.4 kPa (50 lbf/sq ft)

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Building Design

ANSI/TIA-942: Structural Requirements of Tiers (cont.)

Recommended Tier Classification For structural requirements

Overall Target = Tier 3+

	TIER 1	TIER 2	TIER 3	TIER 4
Structural				
Concrete Slab Thickness at ground	127 mm (5 in)	127 mm (5 in)	127 mm (5 in)	127 mm (5 in)
Concrete topping over flutes for elevated floors affects size of anchor which can be installed	102 mm (4 in)	102mm (4in)	102 mm (4 in)	102 mm (4 in)
Building LFRS (Shearwall/Braced Frame/Moment Frame) indicates displacement of structure	Steel/Conc MF	Conc. Shearwall/ Steel BF	Conc. Shearwall/ Steel BF	Conc. Shearwall/ Steel BF
Building Energy Dissipation - Passive Dampers/Base Isolation (energy absorption)	none	none	Passive Dampers	Passive Dampers/Base Isolation
Battery/UPS floor vs. building composition. Concrete floors more difficult to upgrade for intense loads. Steel framing with metal deck and fill much more easily upgraded.	PT concrete	CIP Mild Concrete	Steel Deck & Fill	Steel Deck & Fill
Steel Deck & Fill/ PT concrete/ CIP Mild - PT slabs much more difficult to install anchors	PT concrete	CIP Mild Concrete	Steel Deck & Fill	Steel Deck & Fill

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Seismic Design Criteria – START Campus Project Site

Importance Factor: III

Seismic Action:
- Type 1 = Zone 1.3
- Type 2 = Zone 2.3

Design Ground Acceleration (Ag):
- Type 1 = 2.175 m/s²
- Type 2 = 2.125 m/s²

Soil Type:
- Type E

Design Spectral Acceleration (Ag x S):
- Type 1 = 3.24 m/s²
- Type 2 = 3.18 m/s²

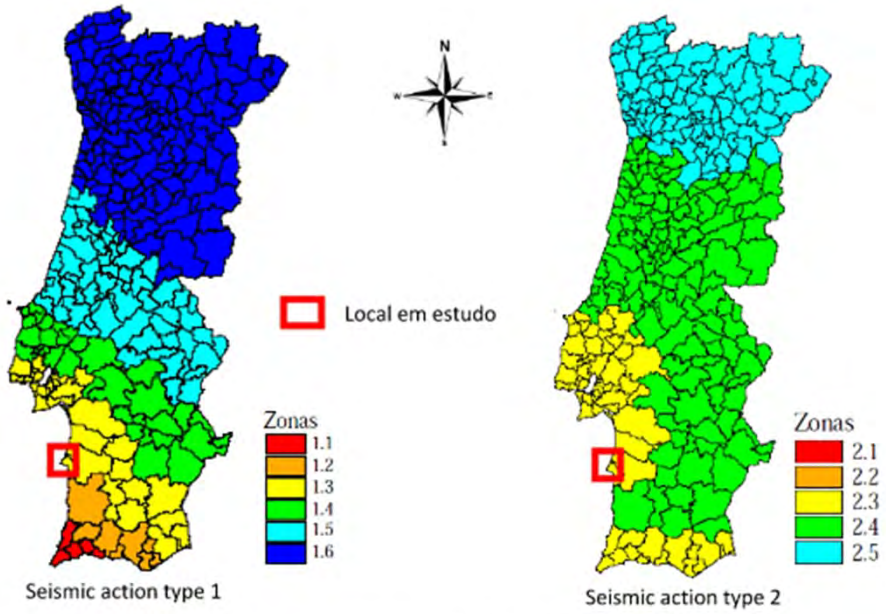
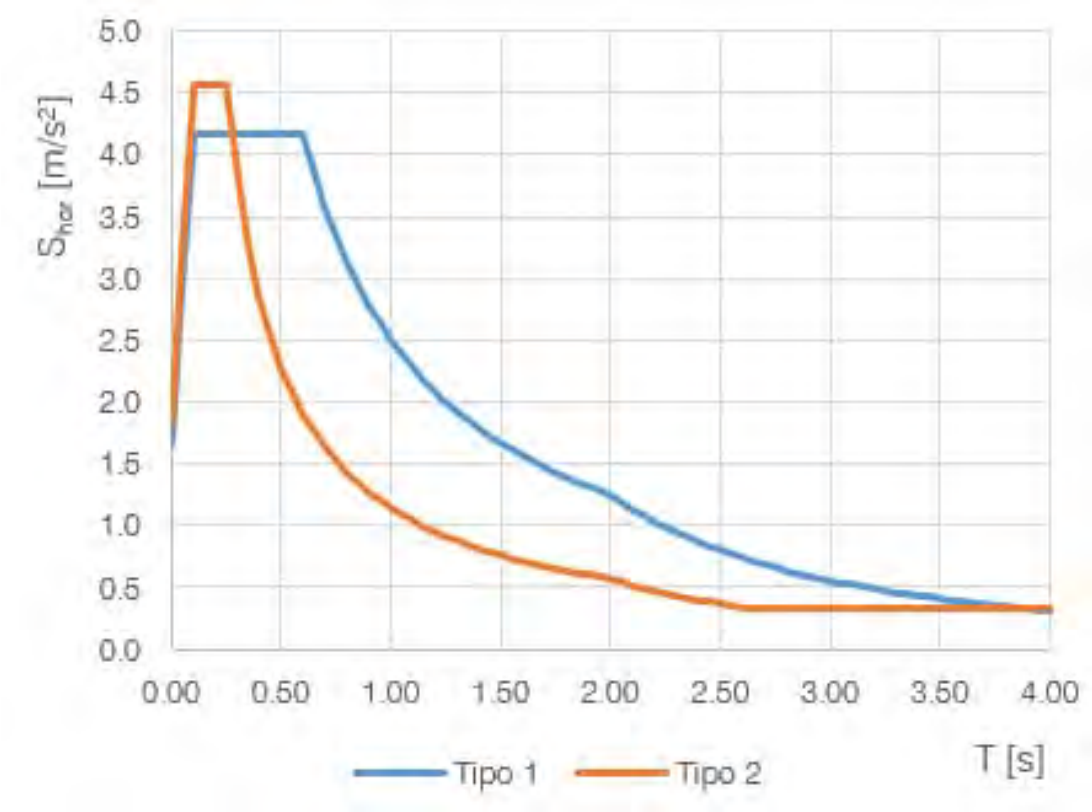


Figure 5 – Seismic zoning for seism action type 1 and 2

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Building Design

Design Response Spectra Envelope (Type 1 and 2), Importance Class II

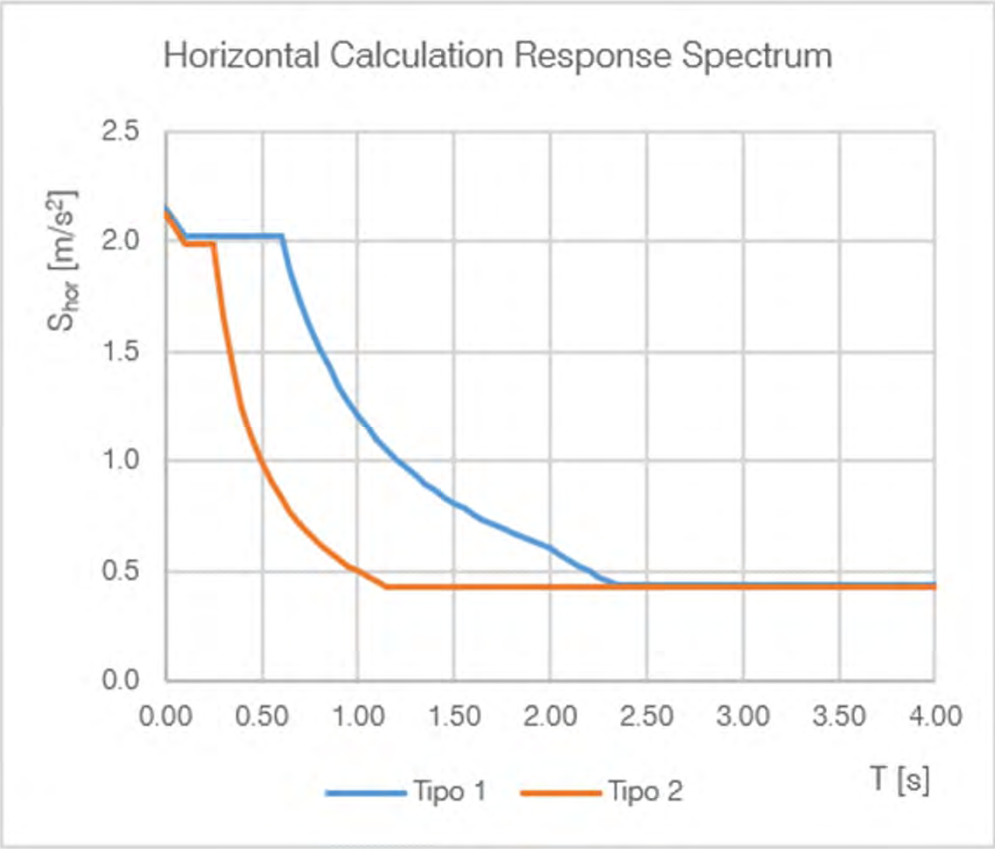


- Importance Class II – Office or Standard Building
- Controlled by higher magnitudes earthquakes at longer distances.
- Importance Coefficient of 1.0
  - Return Period of 475 years
- Behavior Factor (q) = 1.5
- S(T) max = 4.57 m/s² ~ 0.46g
- One Story Building fundamental period likely to be within S(T) max.

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Design Response Spectra Envelope (Type 1 and 2), Importance Class III (proposed)

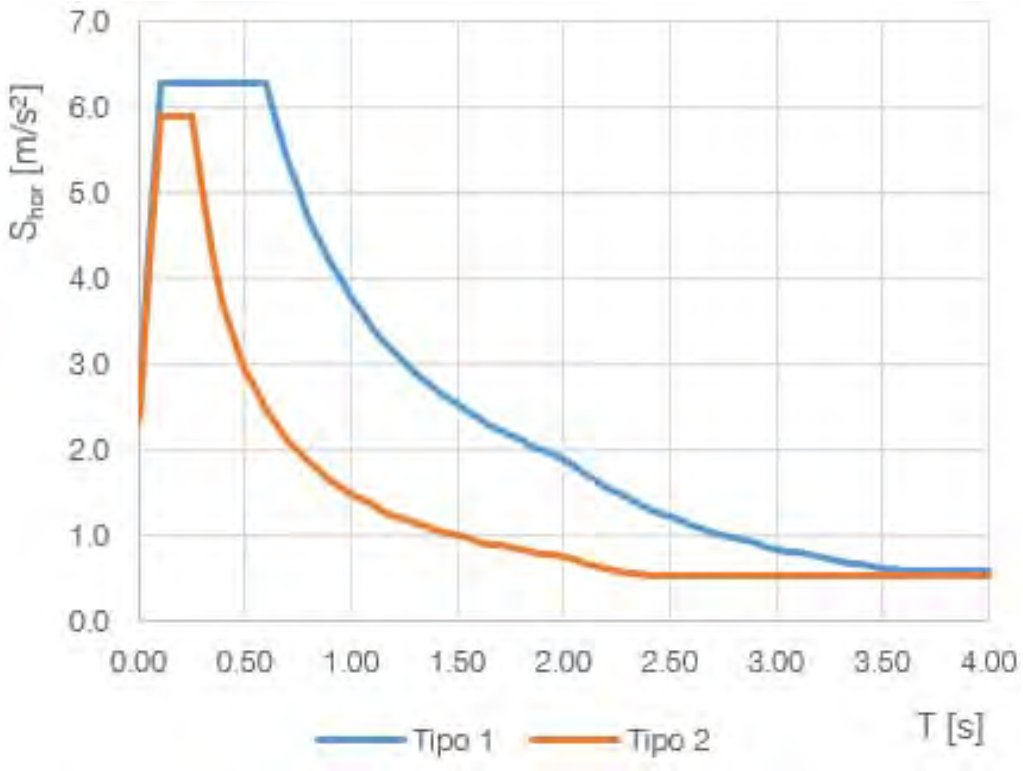


- Importance Class III – Critical Buildings (e.g. Data Centres)
- Controlled by moderate magnitude earthquakes at close distance.
- Importance Factor:
  - Type 1 =1.45
  - Type 2 = 1.25
  - (Portugal National Annex) Return Period of 821 years.
- Behavior Factor (q) = 4.0
- S(T) max = 1.23 m/s² ~ 0.125g
- Multi-story approximate building period = 1.0 sec.

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Building Design

Design Response Spectra Envelope (Type 1 and 2), Importance Class IV

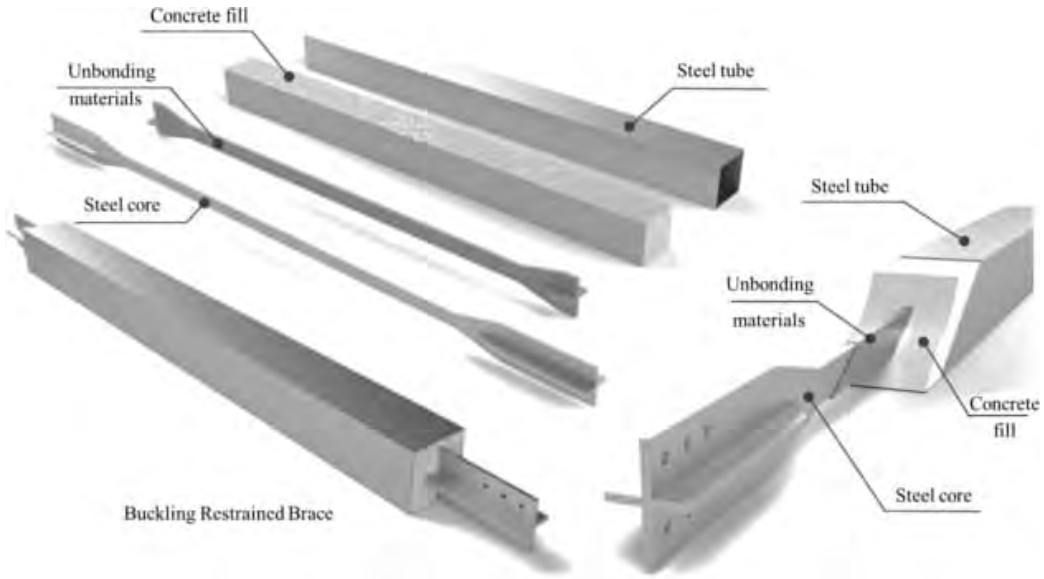


- Importance Class IV – Essential Buildings (e.g. hospitals and fire stations)
- Controlled by moderate magnitude earthquakes at close distance.
- Importance Factor:
  - Type 1 = 1.95
  - Type 2 = 1.50
  - (Portugal National Annex) Return Period of 1303 years.
- Behavior Factor (q) = 1.5
- S(T) max = 6.27 m/s² ~ 0.64g
- One Story Building fundamental period likely to be within S(T) max.

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Lateral Bracing Systems - Buckling Restrained Braced Frames as Damping System





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Design Ground Acceleration and Risk Assessment (BS EN 50600-10 6.2)

Table 1 — PGA and Seismic Intensity Scales

PGA ms^2	0,25 to 0,80		0,80 to 1,40	1,40 to 2,50	2,50 to 3,15	3,15 to 4,00	> 4 m/s^2
Mercalli SIS	V to VII		V to VIII	VI to IX	VIII to X	IX to X	X to XII
Japanese SIS shindo	4		5		6		7
			5 lower	5 upper	6 lower	6 upper	
	3,5 to 3,9	4,0 to 4,4	4,5 to 4,9	5,0 to 5,4	5,5 to 5,9	6,0 to 6,4	> 6,5

- Code Reference Design Spectral Acceleration for category III structures on the START Campus site is between 3.18 m/s^2 and 3.24 m/s^2
- Client Seismic Hazard Assessment – Recommending elevated PGA of 4 to 6 m/s^2. Final Design recommendation TBD. Substantial increase over code possible.

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Design Ground Acceleration and Risk Assessment (BS EN 50600-10 6.2)

Table 2 — PGA and typical damage

PGA range	Impact on buildings	Impact on outside spaces	Impact on utilities
2,50 to 3,15	Normal buildings receive heavy damage and can be destroyed. Earthquake-resistant buildings can suffer large cracks in walls and will be moderately damaged. In some buildings, wall tiles and windowpanes are damaged and fall.	Small to medium cracks appear in the ground, and larger landslides take place.	Primary power supply can be interrupted. Gas pipes and water mains are damaged and there can be widespread interruption of supply.

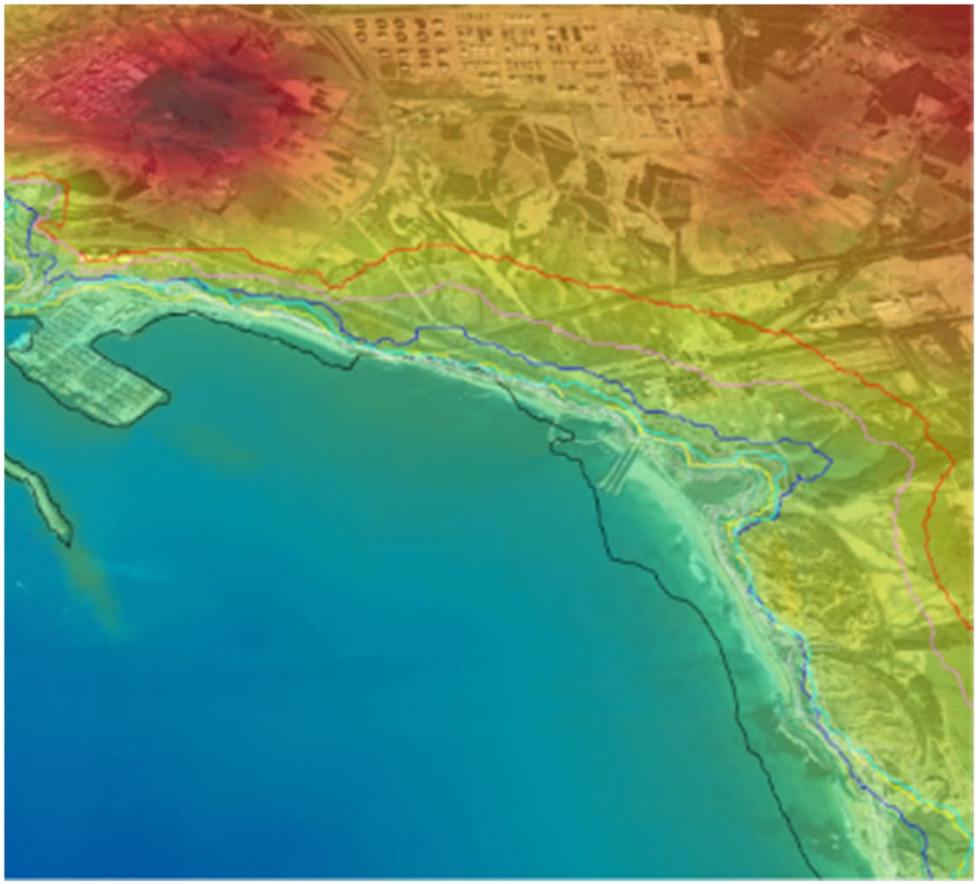
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Building Design

Tsunami Design Criteria – START Campus Project Site

Tsunami Action:

- Magenta line selected by Start and IST for further characterization
- Inundation level and design criteria TBD (not full site)
- Ensure structural impacts of design seismic event do not compromise tsunami resistance.



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Building Design

Importance Class Recommendations and Comparison for Building Design

- Importance Class III recommended for building design.
- Difference in Design Accelerations between Importance Class II and III (with low ductility) is ~45%.
  - This upgrade is while substantial, it doubles return period, and does not drive major design change in viable seismic force resisting systems.
- Base shear can be reduced providing ductility to the building structural system (q).
  - Reduced Base Shear will likely reduce costs associated to the foundation system but adds some complexity to detailing.
  - Ductility should be incorporated in accordance with EN 1998-1 (2004) Eurocode 8: Design of structures for earthquake resistance, Table 6.2.

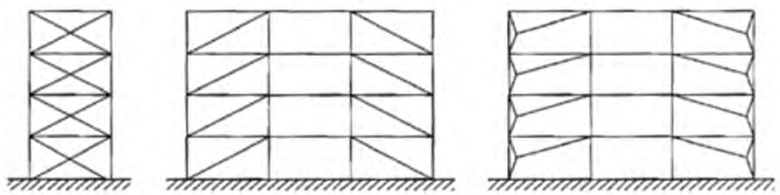


Figure 6.2: Frames with concentric diagonal bracings (dissipative zones in tension diagonals only).

Table 6.2: Upper limit of reference values of behaviour factors for systems regular in elevation

STRUCTURAL TYPE	Ductility Class	
	DCM	DCH
a) Moment resisting frames	4	$5\alpha_u/\alpha_1$
b) Frame with concentric bracings		
Diagonal bracings	4	4
V-bracings	2	2,5
c) Frame with eccentric bracings	4	$5\alpha_u/\alpha_1$
d) Inverted pendulum	2	$2\alpha_u/\alpha_1$
e) Structures with concrete cores or concrete walls	See section 5	
f) Moment resisting frame with concentric bracing	4	$4\alpha_u/\alpha_1$
g) Moment resisting frames with infills		
Unconnected concrete or masonry infills, in contact with the frame	2	2
Connected reinforced concrete infills	See section 7	
Infills isolated from moment frame (see moment frames)	4	$5\alpha_u/\alpha_1$

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3 & 4 Story DC Category Comparison

3 Story DC Building

- Category III: Traditional braced frame superstructure lateral system
- Category III: Extensive deep foundation system required to resist lateral and uplift forces
- Category IV: Traditional braced frame superstructure lateral system
- Category IV: Braced frame expansion most likely required to distribute loads to foundations. Extensive deep foundation system required to resist lateral and uplift forces

4 Story DC Building

- Category III: Robust braced frame superstructure lateral system
- Category III: Extensive deep foundation system required to resist lateral and uplift forces
- Category IV: Alternate lateral system required. Systems such as BRBs incorporating additional ductility or base isolation are possible alternatives.
- Category IV: Braced frame expansion required to distribute loads to foundations. Extensive deep foundation system required to resist lateral and uplift forces.

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3. Nonstructural Components



Nonstructural Components

When Earthquake damage occurs:

- Nonstructural components are often overshadowed by the focus on building.
- Poor performance of nonstructural components is the greatest contributor to damage, losses, and business interruption for most facilities after an earthquake.
- Nonstructural components include Racks, Generators, Chillers, Compressors, Battery Racks, Suspended Ceilings, Light Fixtures, etc.



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Nonstructural Components

Estimated Floor Accelerations for Day N Campus

		Cat II	Cat III	Cat IV
Floor	Z (m)	Sa (g)	Sa (g)	Sa (g)
Ground	0	0.30	0.35	0.39
Second	8	0.41	0.48	0.53
Third	16	0.52	0.61	0.67
Fourth	24	0.63	0.73	0.81
Roof	32	0.74	0.89	0.96

(2) The effects of the seismic action may be determined by applying to the non-structural element a horizontal force F_a which is defined as follows:

$$F_a = (S_a \cdot W_a \cdot \gamma_a)/q_a \qquad (4.24)$$

where

F_a is the horizontal seismic force, acting at the centre of mass of the non-structural element in the most unfavourable direction;

W_a is the weight of the element;

S_a is the seismic coefficient applicable to non-structural elements, (see **(3)** of this subclause);

γ_a is the importance factor of the element, see **4.3.5.3**;

q_a is the behaviour factor of the element, see Table 4.4.

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Nonstructural Components

Design Ground Acceleration and Risk Mitigation (BSI 50600-10 7.1.3)

Considerations include:

- Provide seismic risk localized mitigation to nonstructural components to be installed within the building.
- Nonstructural components should be designed to site specific seismic parameters including an importance factor of 1.5.
- Vendors usually provide shake table tests to comply with site specific seismic demands.
- The Design Ground Acceleration for this project is not high or uncommon. Most Vendors should be able to comply with equipment capable to continue operation after a seismic event.

Nonstructural Component Design Constraints:

- Anchoring of equipment to slabs required.
- Impose deflection limits on electrical equipment to ensure operational status. This is critical for the multi-story DC builds where equipment will experience higher accelerations on upper floors.

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End

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Sines 4.0© START Campus Generator Platform Evaluation Studies

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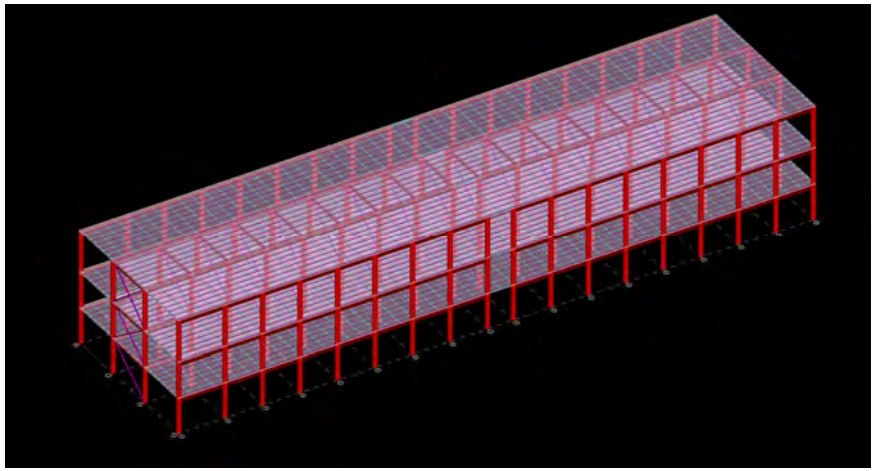
Generator Platform Studies

- Various generator platform studies were reviewed to assess the lateral system of the structure and the impacts of Category III vs Category IV designations.
- The studies presented reviewed 3 story generator platforms with braced frames (BF) in the short direction and either moment frames (MF) in the longitudinal or a combination of braced frames and moment frames in the longitudinal.
- The MF systems for both Category III & IV are challenged to control drifts within code requirements making some framing configurations less practical from a Constuction perspective but not impossible.
- A combination of BF and MF systems in the longitudinal direction provide drift control and flexibility of access to the generators. This system is recommended as it provides improved drift control over the MF only system and is more easily scaled to category IV.
- Next steps include evaluation of ground level steel framing vs. concrete slab and it impacts on providing fixity at base.

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Gen 3 Story Importance Class III (Braced Frame & Moment Frames)

- Braced Frames in the N-S direction
- Moment Frames in the E-W direction (all lines)
- ag = 2.18 m/s²
- v=0.4 (Importance class III or IV)
- Max Interstorey Drift = 0.4*dr < 0.75%
- Calculated T



LOAD CASE: E3

Seismic	EN1998-1:2004+A1:2013 Lateral Force Method
Ground Accel ag (m/s2):	2.18
Spectra Type:	National Annex
Ground Type:	E
Soil Factor:	1.30
TB:	0.10
TC:	0.60
TD:	2.00

Dir	Eccent	Period	Ac(m2)	Ct	T(s)
X	+ And -	Calculated	--	--	0.65
Y	+ And -	Calculated	--	--	0.83

Dir	Dist.Method	q	Beta	Sd(T)	Lambda
X	Mode Shape	4.00	0.20	0.168 g	0.85
Y	Mode Shape	4.00	0.20	0.130 g	0.85

Total Building Weight (kN) = 106542.32

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Gen 3 Story Importance Class III (Braced Frame & Moment Frames)

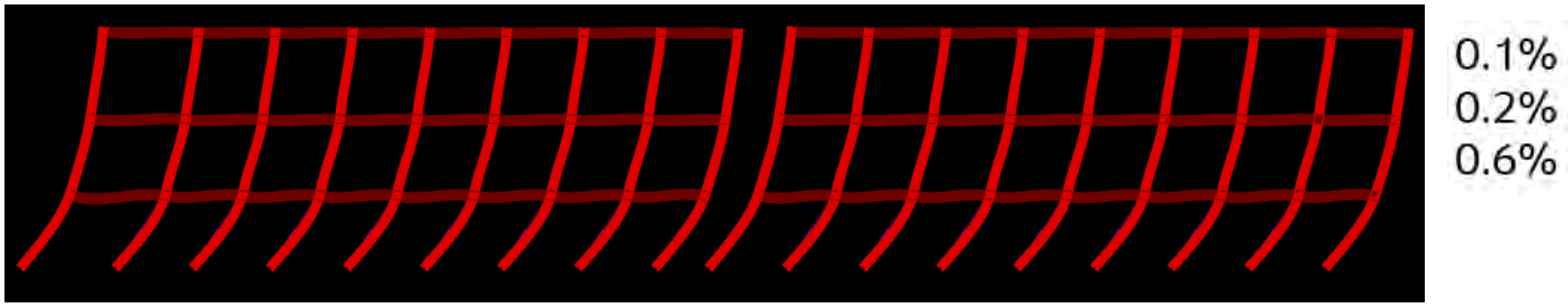
Story	LdC	Displacement		Story Drift		Drift Ratio	
		X	Y	X	Y	X	Y
		mm	mm	mm	mm		
ROOF	D	0.0218	-0.0055	0.0072	-0.0031	0.0000	0.0000
	Lp	-0.7320	-0.1459	-0.2606	-0.0779	0.0000	0.0000
	E1	48.3495	-1.3825	7.3250	-0.3490	0.0008	0.0000
Second	D	0.0146	-0.0024	0.0065	-0.0017	0.0000	0.0000
	Lp	-0.4713	-0.0680	-0.2390	-0.0493	0.0000	0.0000
	E1	41.0246	-1.0334	11.5664	-0.4582	0.0014	0.0001
First	D	0.0081	-0.0007	0.0081	-0.0007	0.0000	0.0000
	Lp	-0.2323	-0.0187	-0.2323	-0.0187	0.0000	0.0000
	E1	29.4581	-0.5752	29.4581	-0.5752	0.0037	0.0001

- Real (v*q*dr)
  - 0.4*4*0.0008 = 0.1% OK
  - 0.4*4*0.0014 = 0.2% OK
  - 0.4*4*0.0037 = 0.6% OK

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Gen 3 Story Importance Class III (Braced Frame & Moment Frames)

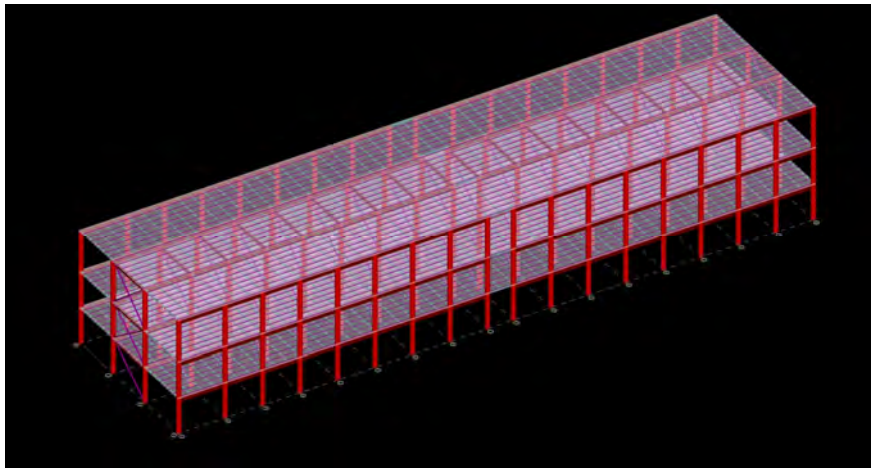
- HEB1000 column
- HEA1000 beams



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Gen 3 Story Importance Class IV (Braced Frame & Moment Frames)

- Braced Frames in the N-S direction
- Moment Frames in the E-W direction (all lines)
- ag = 2.93 m/s²
- v=0.4 (Importance class III or IV)
- Max Interstorey Drift = 0.4*dr < 0.75%
- Calculated T



LOAD CASE: Seismic

Seismic	EN1998-1:2004+A1:2013 Lateral Force Method
Ground Accel ag (m/s2):	2.93
Spectra Type:	National Annex
Ground Type:	E
Soil Factor:	1.30
TB:	0.10
TC:	0.60
TD:	2.00

Dir	Eccent	Period	Ac(m2)	Ct	T(s)
X	+ And -	Calculated	--	--	0.65
Y	+ And -	Calculated	--	--	0.83

Dir	Dist.Method	q	Beta	Sd(T)	Lambda
X	Mode Shape	4.00	0.20	0.225 g	0.85
Y	Mode Shape	4.00	0.20	0.175 g	0.85

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Gen 3 Story Importance Class IV (Braced Frame & Moment Frames)

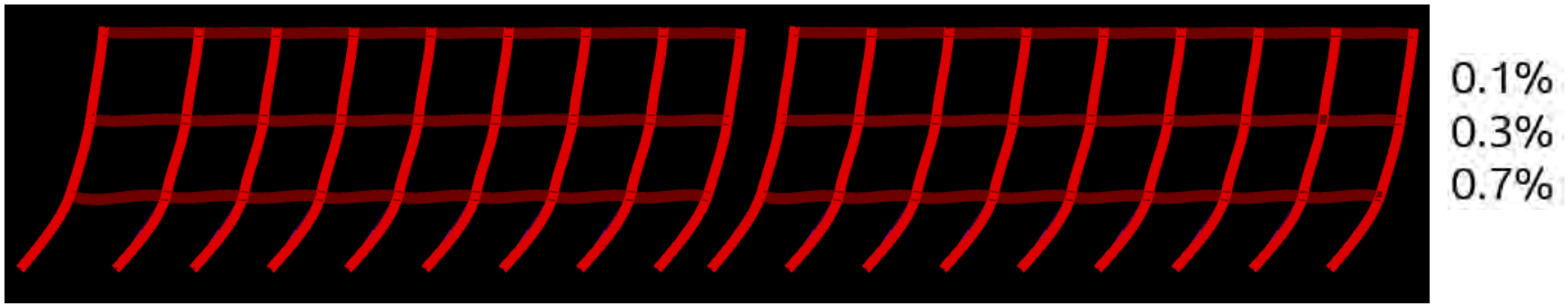
Story	LdC	Displacement		Story Drift		Drift Ratio	
		X	Y	X	Y	X	Y
		mm	mm	mm	mm		
ROOF	D	0.0218	-0.0055	0.0072	-0.0031	0.0000	0.0000
	Lp	-0.7321	-0.1459	-0.2607	-0.0779	0.0000	0.0000
	E1	55.8556	-1.5979	8.4590	-0.4034	0.0009	0.0000
Second	D	0.0147	-0.0024	0.0065	-0.0017	0.0000	0.0000
	Lp	-0.4714	-0.0680	-0.2390	-0.0493	0.0000	0.0000
	E1	47.3966	-1.1945	13.3592	-0.5297	0.0017	0.0001
First	D	0.0081	-0.0007	0.0081	-0.0007	0.0000	0.0000
	Lp	-0.2324	-0.0187	-0.2324	-0.0187	0.0000	0.0000
	E1	34.0374	-0.6648	34.0374	-0.6648	0.0043	0.0001

- Real (v*q*dr)
  - 0.4*4*0.0009 = 0.1% OK
  - 0.4*4*0.0017 = 0.3% OK
  - 0.4*4*0.0043 = 0.7% OK

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Gen 3 Story Importance Class IV (Braced Frame & Moment Frames)

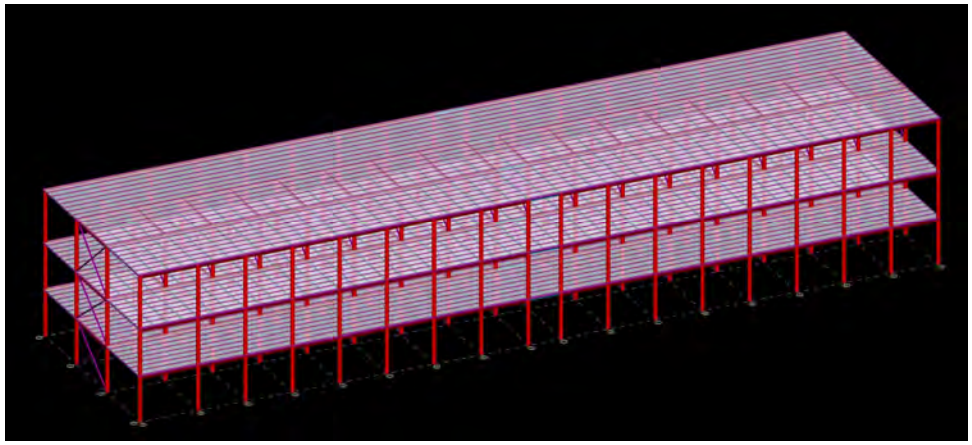
- HEB1000 column
- HEA1000 beams



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Gen 3 Story Importance Class IV (Fixed Base/Frames @Ground Floor)

- Braced Frames in the N-S direction
- MF fixed bases in the E-W direction (all lines)
- ag = 2.93 m/s²
- v=0.4 (Importance class III or IV)
- Max Interstorey Drift = 0.4*dr < 0.75%
- Calculated T



LOAD CASE: Seismic

Seismic	EN1998-1:2004+A1:2013 Lateral Force Method
Ground Accel ag (m/s2):	2.93
Spectra Type:	National Annex
Ground Type:	E
Soil Factor:	1.30
TB:	0.10
TC:	0.60
TD:	2.00

Dir	Eccent	Period	Ac(m2)	Ct	T(s)
X	+ And -	Calculated	--	--	0.65
Y	+ And -	Calculated	--	--	0.83

Dir	Dist.Method	q	Beta	Sd(T)	Lambda
X	Mode Shape	4.00	0.20	0.225 g	0.85
Y	Mode Shape	4.00	0.20	0.175 g	0.85

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Gen 3 Story Importance Class IV (Fixed Base/Frames @Ground Floor)

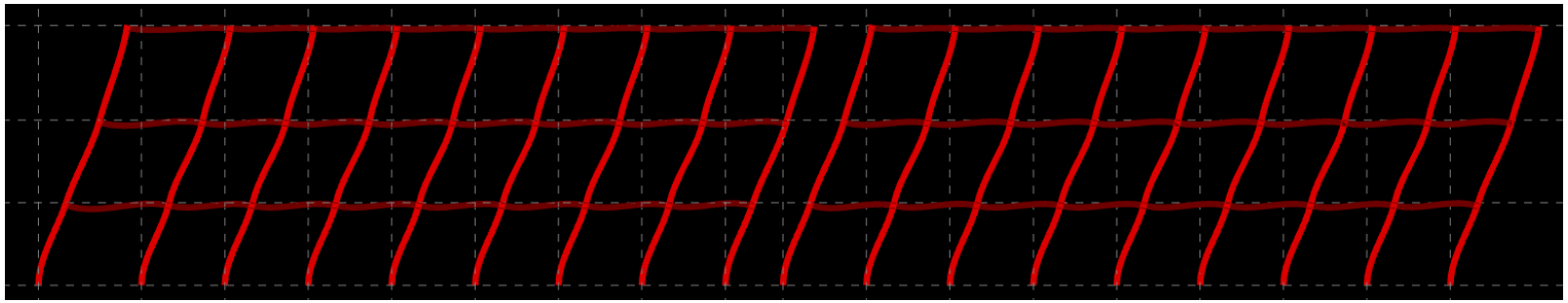
Story	LdC	Displacement		Story Drift		Drift Ratio	
		X	Y	X	Y	X	Y
		mm	mm	mm	mm		
ROOF	D	0.0881	-0.0081	0.0410	-0.0046	0.0000	0.0000
	Lp	-2.1359	-0.2184	-0.9337	-0.1167	0.0001	0.0000
	E1	86.8538	-1.5255	26.8928	-0.4572	0.0029	0.0000
Second	D	0.0471	-0.0035	0.0310	-0.0026	0.0000	0.0000
	Lp	-1.2022	-0.1017	-0.8208	-0.0736	0.0001	0.0000
	E1	59.9610	-1.0683	32.8713	-0.5320	0.0041	0.0001
First	D	0.0161	-0.0009	0.0161	-0.0009	0.0000	0.0000
	Lp	-0.3814	-0.0281	-0.3814	-0.0281	0.0000	0.0000
	E1	27.0896	-0.5363	27.0896	-0.5363	0.0034	0.0001

- Real (v*q*dr)
  - 0.4*4*0.0029 = 0.46% OK
  - 0.4*4*0.0041 = 0.65% OK
  - 0.4*4*0.0034 = 0.54% OK

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Gen 3 Story Importance Class IV (Fixed Base/Frames @Ground Floor)

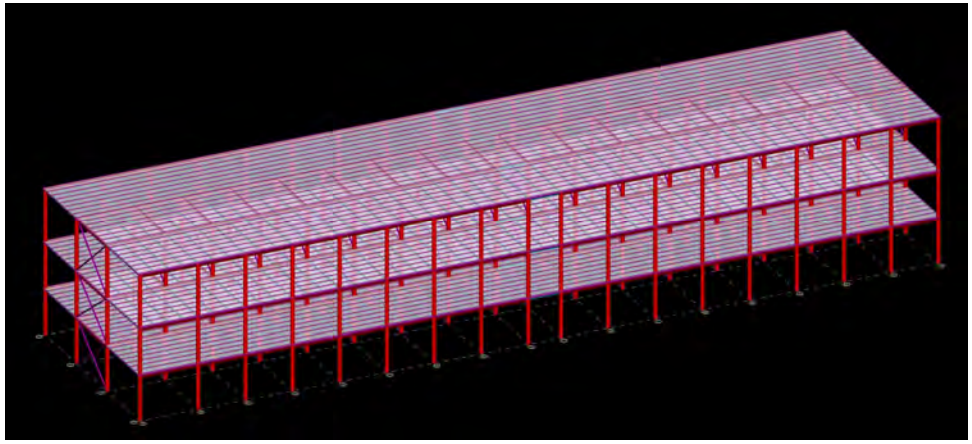
- HEB 600 column
- HEA 600 beams
- May need grade beams or a frame at ground floor.

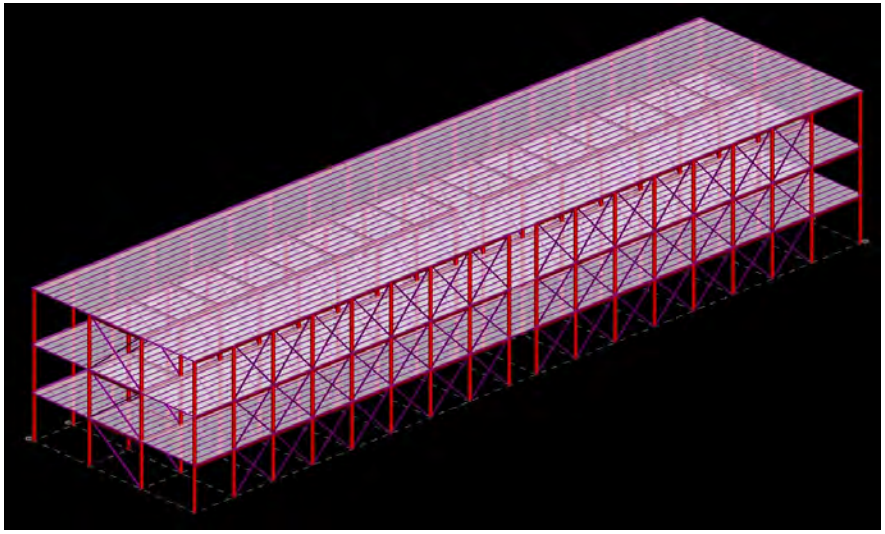


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Gen 3 Story Importance Class III (BF on N face & MF on SF)

- Braced Frames in the N-S direction
- MF pinned bases in the E-W direction (only south face)
- ag = 2.18 m/s²
- v=0.4 (Importance class III or IV)
- Max Interstorey Drift = 0.4*dr < 0.75%
- HEB 600 column
- HEA 600 beams





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Gen 3 Story Importance Class III (BF on N face & MF on SF)

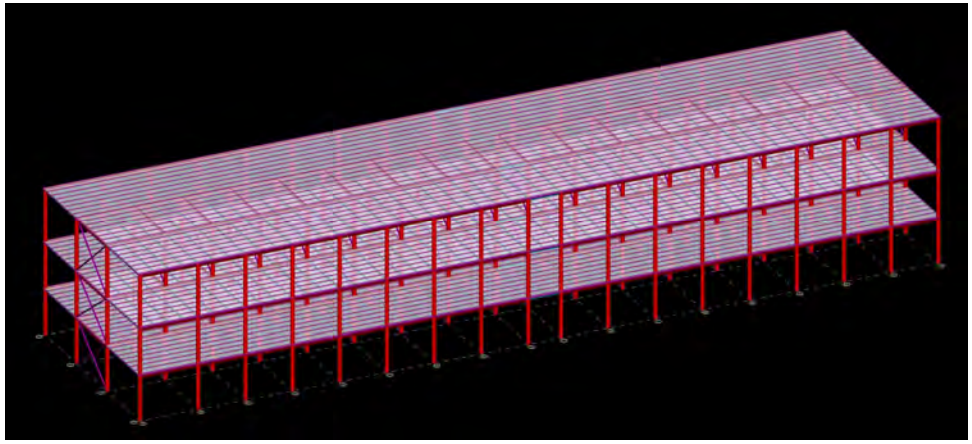
Story	LdC	Displacement		Story Drift		Drift Ratio	
		X	Y	X	Y	X	Y
		mm	mm	mm	mm		
ROOF	D	-0.0002	-0.0194	-0.0003	-0.0106	0.0000	0.0000
	Lp	-0.2056	-0.4426	-0.0955	-0.2201	0.0000	0.0000
	E1	44.5754	23.9354	11.8749	6.8999	0.0013	0.0008
Second	D	0.0000	-0.0088	-0.0000	-0.0064	0.0000	0.0000
	Lp	-0.1101	-0.2225	-0.0802	-0.1624	0.0000	0.0000
	E1	32.7006	17.0355	14.8354	7.9583	0.0019	0.0010
First	D	0.0001	-0.0023	0.0001	-0.0023	0.0000	0.0000
	Lp	-0.0299	-0.0602	-0.0299	-0.0602	0.0000	0.0000
	E1	17.8652	9.0772	17.8652	9.0772	0.0022	0.0011

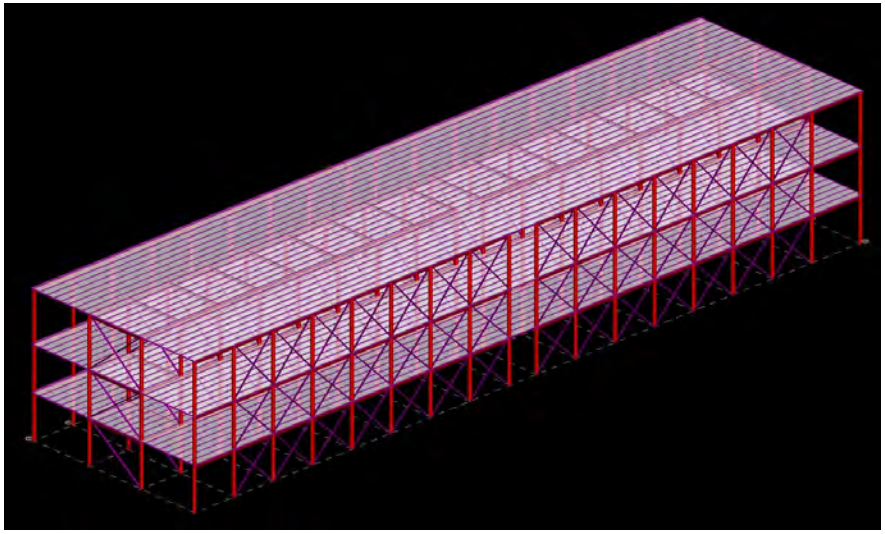
- Real (v*q*dr)
  - 0.4*4*0.0013 = 0.21% OK
  - 0.4*4*0.0019 = 0.30% OK
  - 0.4*4*0.0022 = 0.35% OK

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Gen 3 Story Importance Class IV (BF on N face & MF on SF)

- Braced Frames in the N-S direction
- MF pinned bases in the E-W direction (only south face)
- ag = 2.93 m/s²
- v=0.4 (Importance class III or IV)
- Max Interstorey Drift = 0.4*dr < 0.75%
- HEB 600 column
- HEA 600 beams





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Gen 3 Story Importance Class IV (BF on N face & MF on SF)

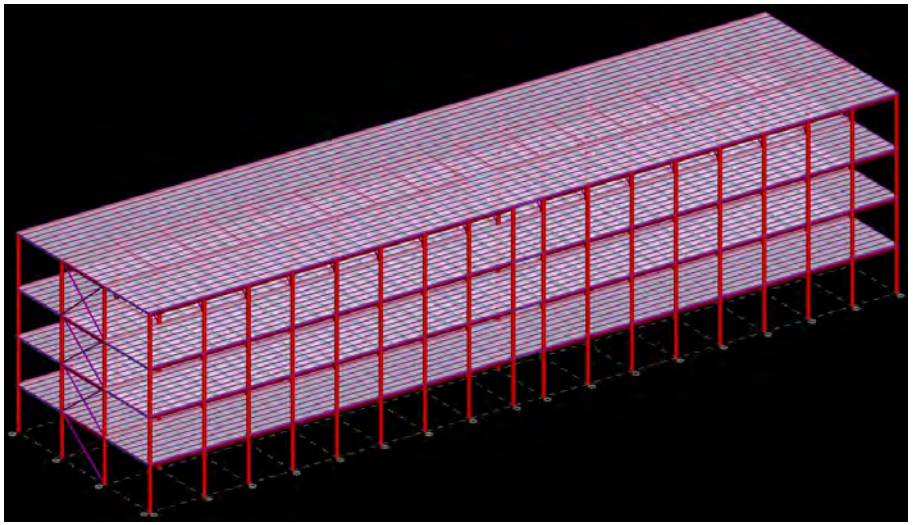
Story	LdC	Displacement		Story Drift		Drift Ratio	
		X	Y	X	Y	X	Y
		mm	mm	mm	mm		
ROOF	D	-0.0002	-0.0194	-0.0002	-0.0106	0.0000	0.0000
	Lp	-0.2062	-0.4429	-0.0958	-0.2202	0.0000	0.0000
	E1	51.9939	27.9161	13.8526	8.0474	0.0015	0.0009
	E2	55.4511	34.7425	14.8508	10.0384	0.0016	0.0011
Second	D	0.0000	-0.0088	-0.0000	-0.0064	0.0000	0.0000
	Lp	-0.1105	-0.2227	-0.0805	-0.1625	0.0000	0.0000
	E1	38.1413	19.8687	17.3043	9.2819	0.0022	0.0012
	E2	40.6003	24.7041	18.4716	11.6195	0.0023	0.0015
First	D	0.0001	-0.0023	0.0001	-0.0023	0.0000	0.0000
	Lp	-0.0300	-0.0602	-0.0300	-0.0602	0.0000	0.0000
	E1	20.8370	10.5869	20.8370	10.5869	0.0026	0.0013
	E2	22.1286	13.0846	22.1286	13.0846	0.0028	0.0016

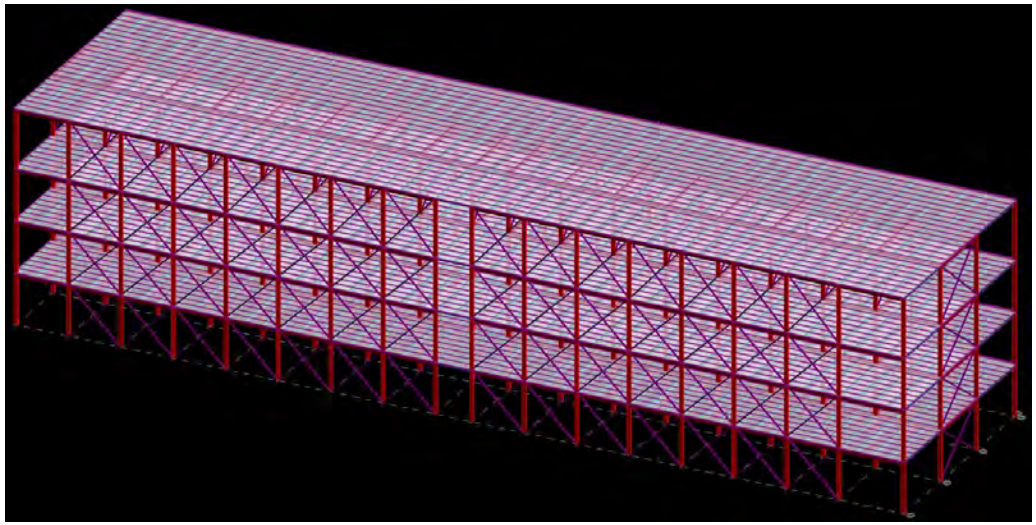
- Real (v*q*dr)
  - 0.4*4*0.0016 = 0.26% OK
  - 0.4*4*0.0023 = 0.37% OK
  - 0.4*4*0.0028 = 0.45% OK

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Gen 3 Story Importance Class IV (BF on N face & MF on SF)

- Braced Frames in the N-S direction
- MF pinned bases in the E-W direction (only south face)
- ag = 2.93 m/s²
- v=0.4 (Importance class III or IV)
- Max Interstorey Drift = 0.4*dr < 0.75%
- HEB 600 column
- HEA 600 beams





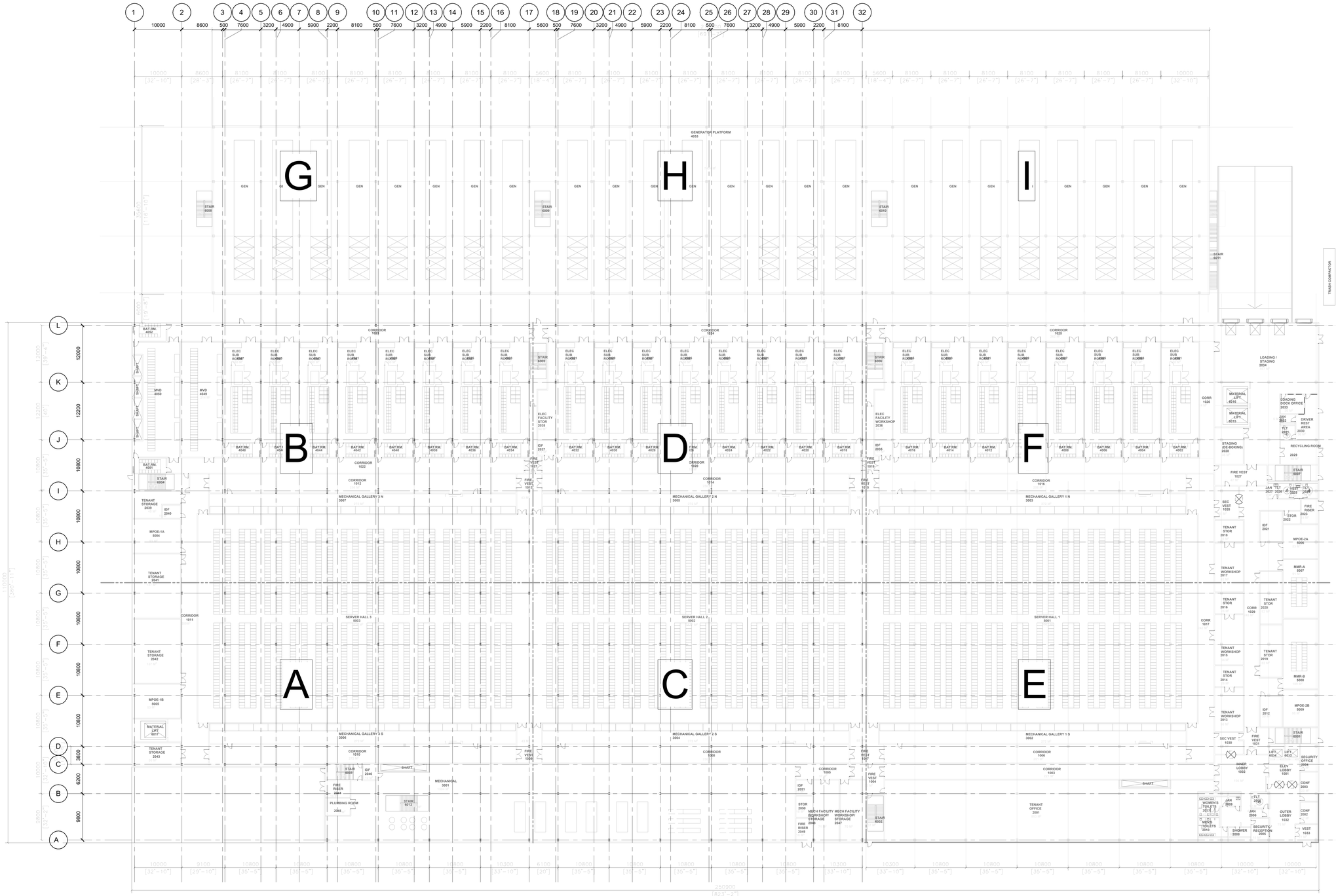
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Gen 4 Story Importance Class IV (BF on N face & MF on SF)

Story	LdC	Displacement		Story Drift		Drift Ratio	
		X	Y	X	Y	X	Y
		mm	mm	mm	mm		
ROOF	D	-0.0062	-0.0494	-0.0028	-0.0213	0.0000	0.0000
	Lp	-0.2874	-0.7487	-0.1049	-0.3076	0.0000	0.0000
	E1	75.8730	45.3625	20.3150	12.5053	0.0022	0.0014
	E2	81.4568	56.6313	21.8812	15.6810	0.0024	0.0017
Third	D	-0.0034	-0.0281	-0.0025	-0.0147	0.0000	0.0000
	Lp	-0.1828	-0.4407	-0.0722	-0.1865	0.0000	0.0000
	E1	55.6040	32.7884	17.4636	12.1915	0.0022	0.0015
	E2	59.6329	40.8646	18.9342	15.2322	0.0024	0.0019
Second	D	-0.0009	-0.0134	-0.0007	-0.0098	0.0000	0.0000
	Lp	-0.1106	-0.2542	-0.0798	-0.1852	0.0000	0.0000
	E1	38.1404	20.5968	18.5948	10.4664	0.0023	0.0013
	E2	40.6987	25.6324	19.9159	13.1114	0.0025	0.0016
First	D	-0.0003	-0.0036	-0.0003	-0.0036	0.0000	0.0000
	Lp	-0.0308	-0.0691	-0.0308	-0.0691	0.0000	0.0000
	E1	19.5455	10.1304	19.5455	10.1304	0.0024	0.0013
	E2	20.7828	12.5210	20.7828	12.5210	0.0026	0.0016

- Real (v*q*dr)
  - 0.4*4*0.0024 = 0.38% OK
  - 0.4*4*0.0024 = 0.38% OK
  - 0.4*4*0.0025 = 0.40% OK
  - 0.4*4*0.0026 = 0.42% OK

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lmsa Engenharia de Edifícios

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Key Plan TBD

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L7018103

TÍTULO DE DESENHO / DRAWING TITLE
GROUND FLOOR - OVERALL

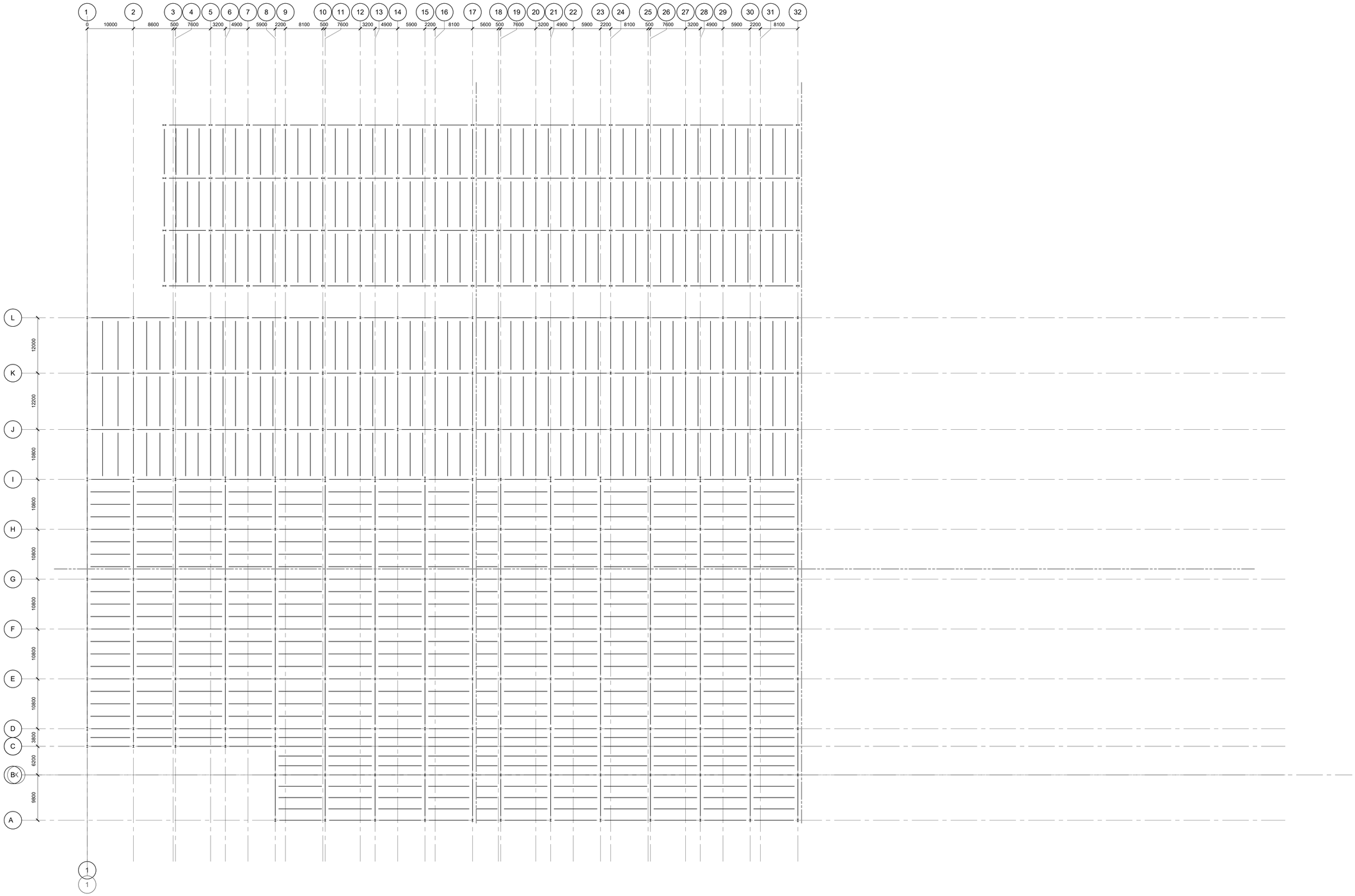
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ESTADO / STATUS
RIBA 2

DESENHADO / DRAWN	PROJETADO / DESIGNED
Author	**Designer**
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Checker	**Approver**
REVISÃO / REVISION	ADEQUAçãO / SUITABILITY
P01	**S0**

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Architectural - Reify

Mechanical, Electrical and Plumbing - LMSA

LMSA
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Structural - Gapres

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TÍTULO DE DESENHO / DRAWING TITLE
FIRST FLOOR - OVERALL

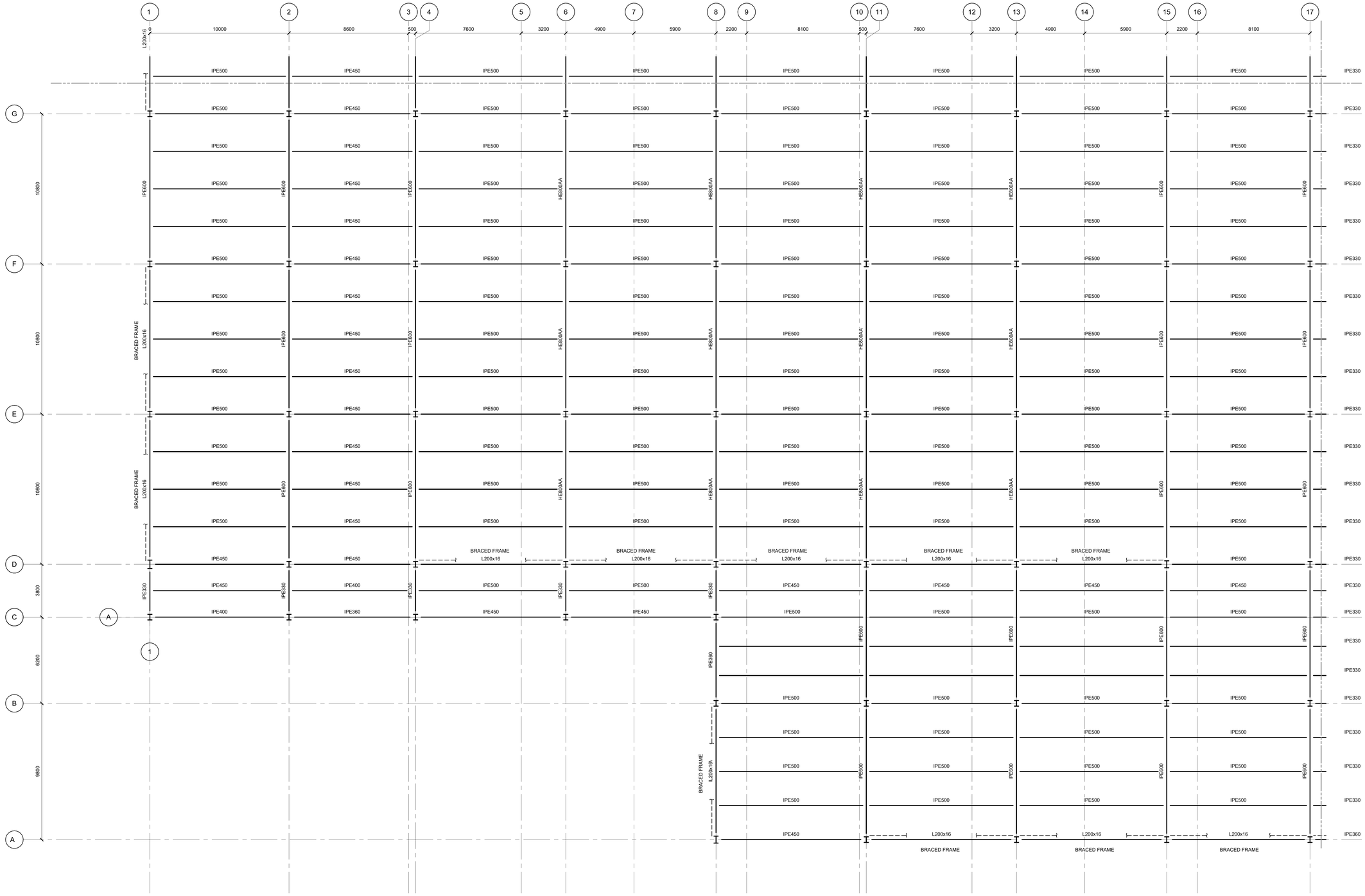
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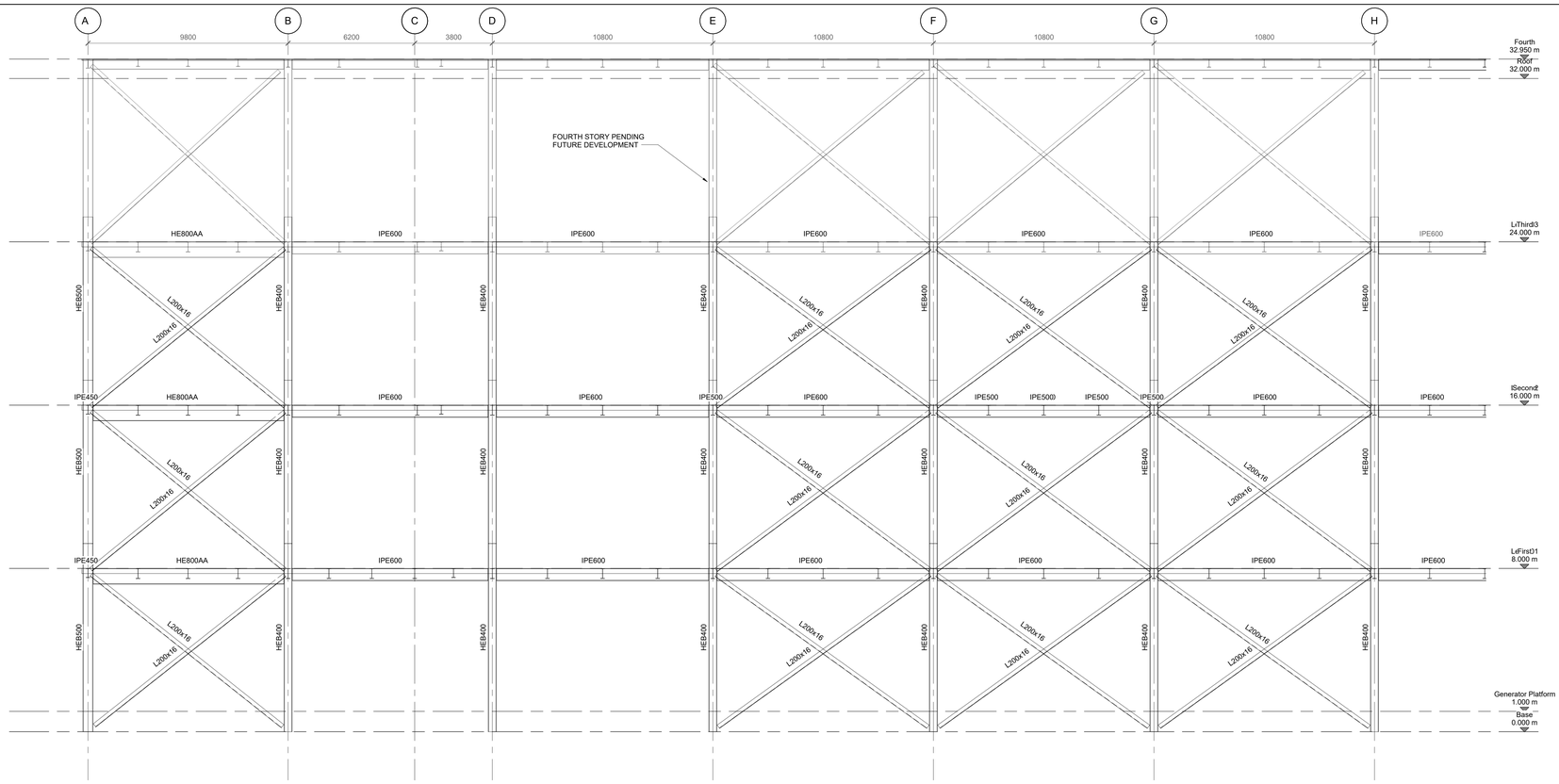
ESTADO / STATUS
RIBA 2

DESENHADO / DRAWN	PROJETADO / DESIGNED
Author	**Designer**
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Checker	**Approver**
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P01	**S0**

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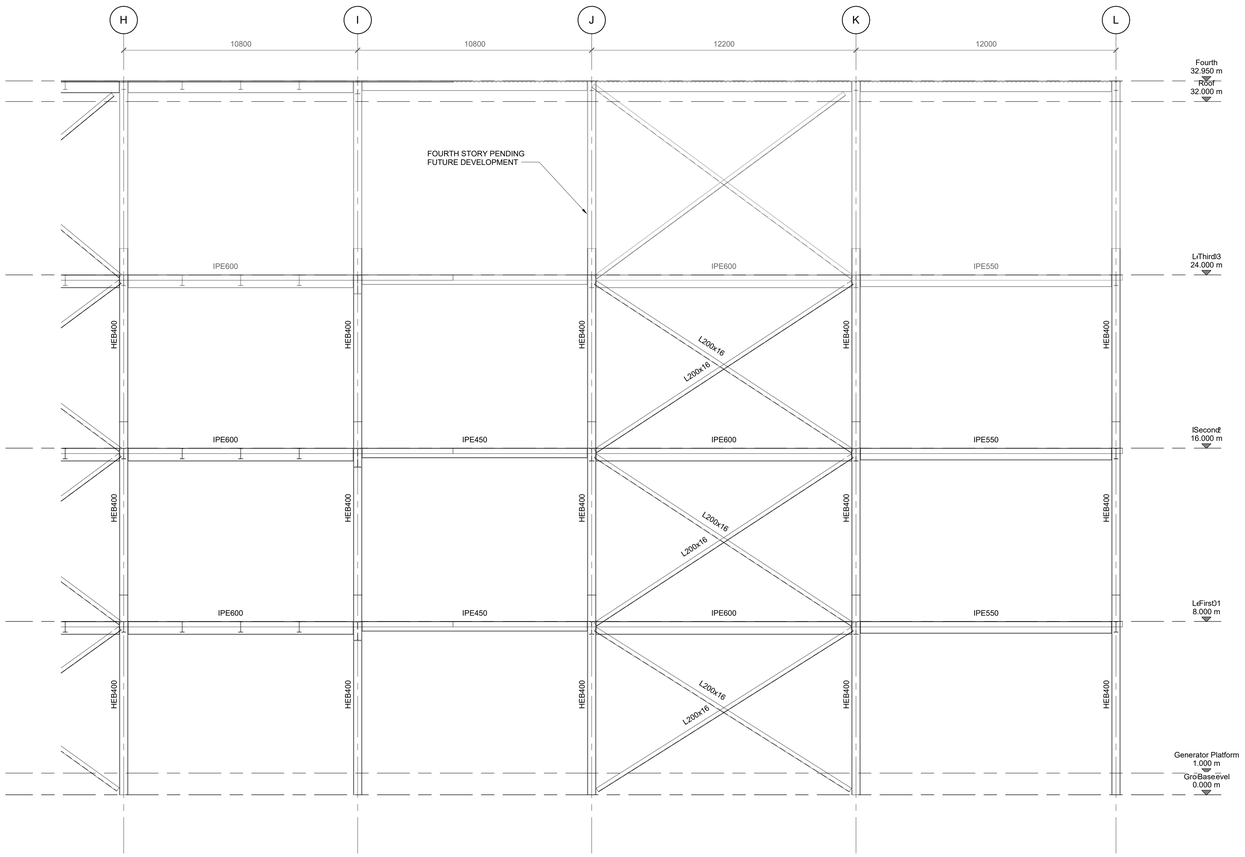
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BRACED FRAME L200x16
BRACED FRAME L200x16
BRACED FRAME L200x16



BUILDING ELEVATION - EAST PART 1

SCALE 1 : 100



BUILDING ELEVATION - EAST PART 2

SCALE 1 : 100

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BUILDING ELEVATIONS

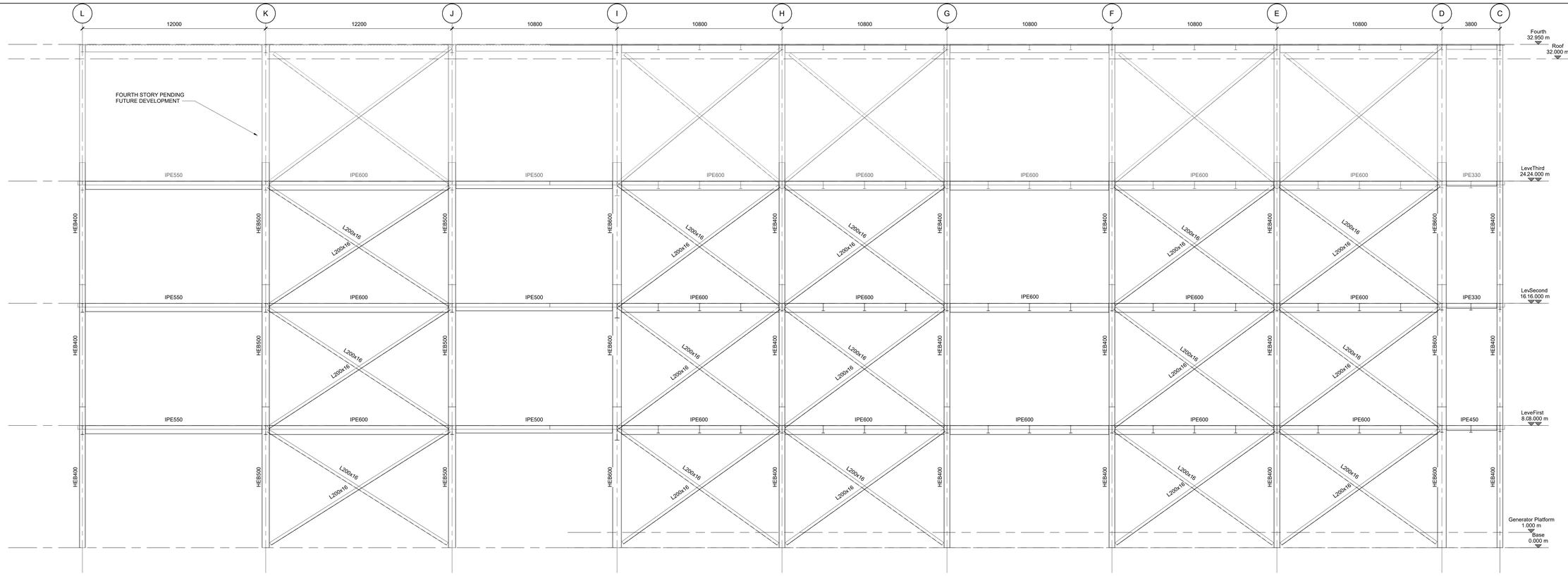
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Author	**Designer**
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Checker	**Approver**
REVISÃO / REVISION	ADEQUAçãO / SUITABILITY
P01	**S0**

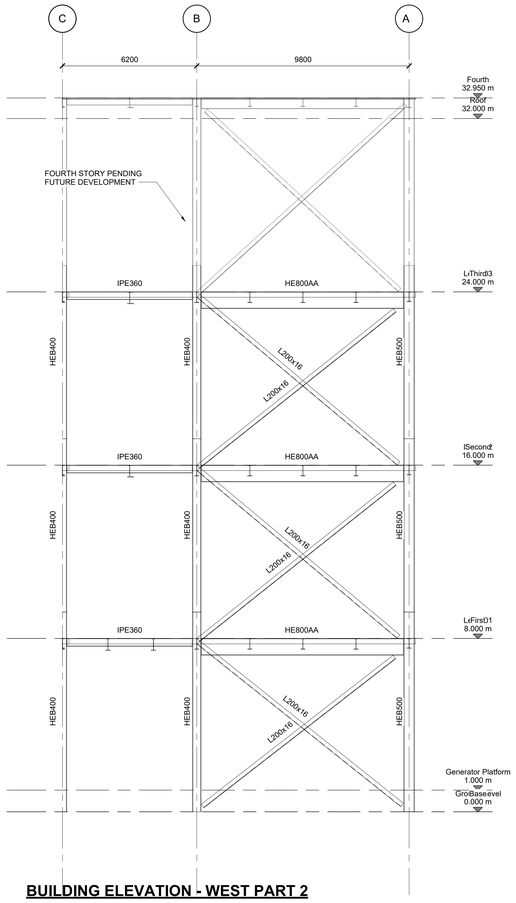
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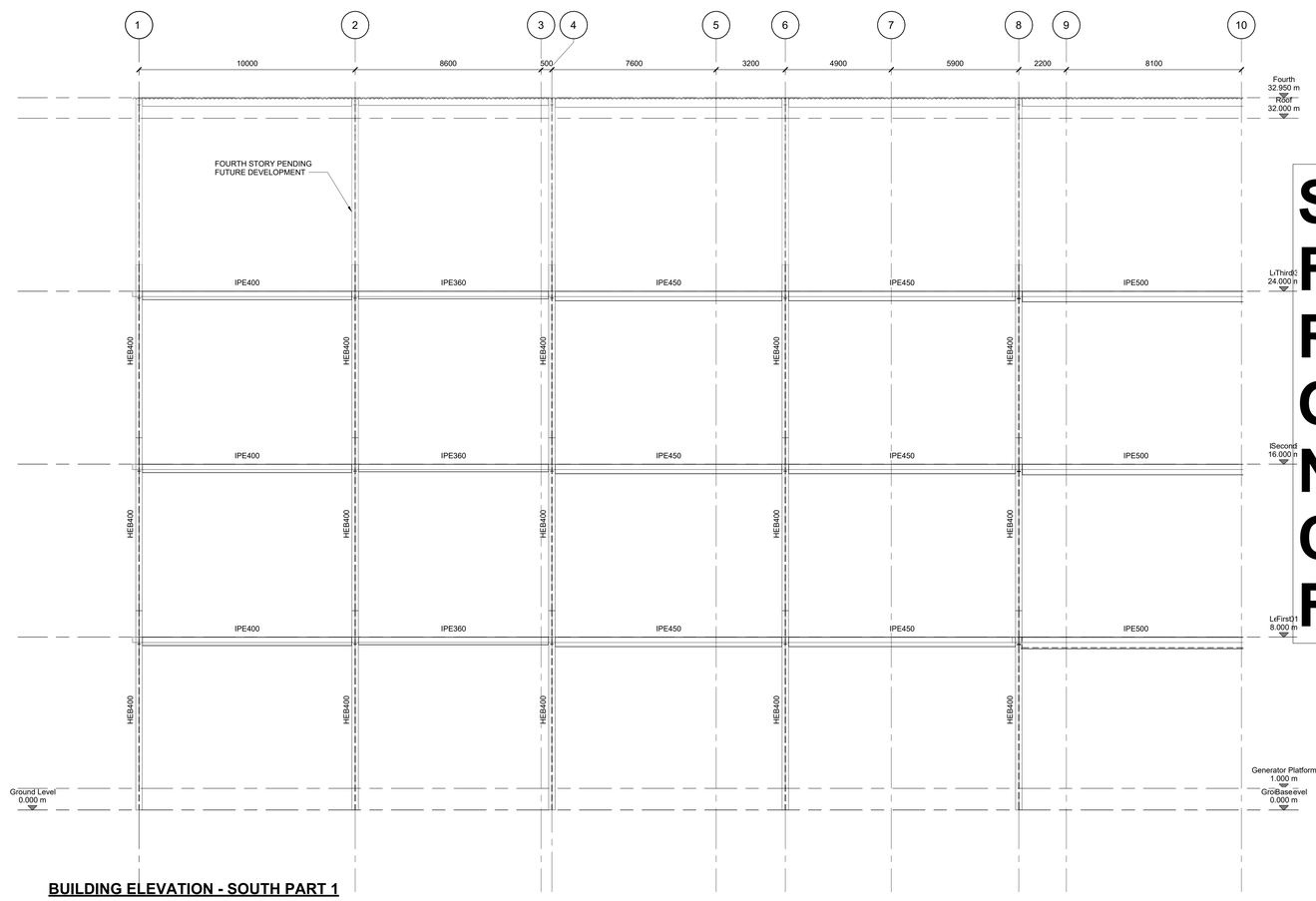
BUILDING ELEVATION - WEST PART 1

SCALE 1 : 100



BUILDING ELEVATION - WEST PART 2

SCALE 1 : 100



BUILDING ELEVATION - SOUTH PART 1

SCALE 1 : 100

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TÍTULO DE DESENHO / DRAWING TITLE
BUILDING ELEVATIONS

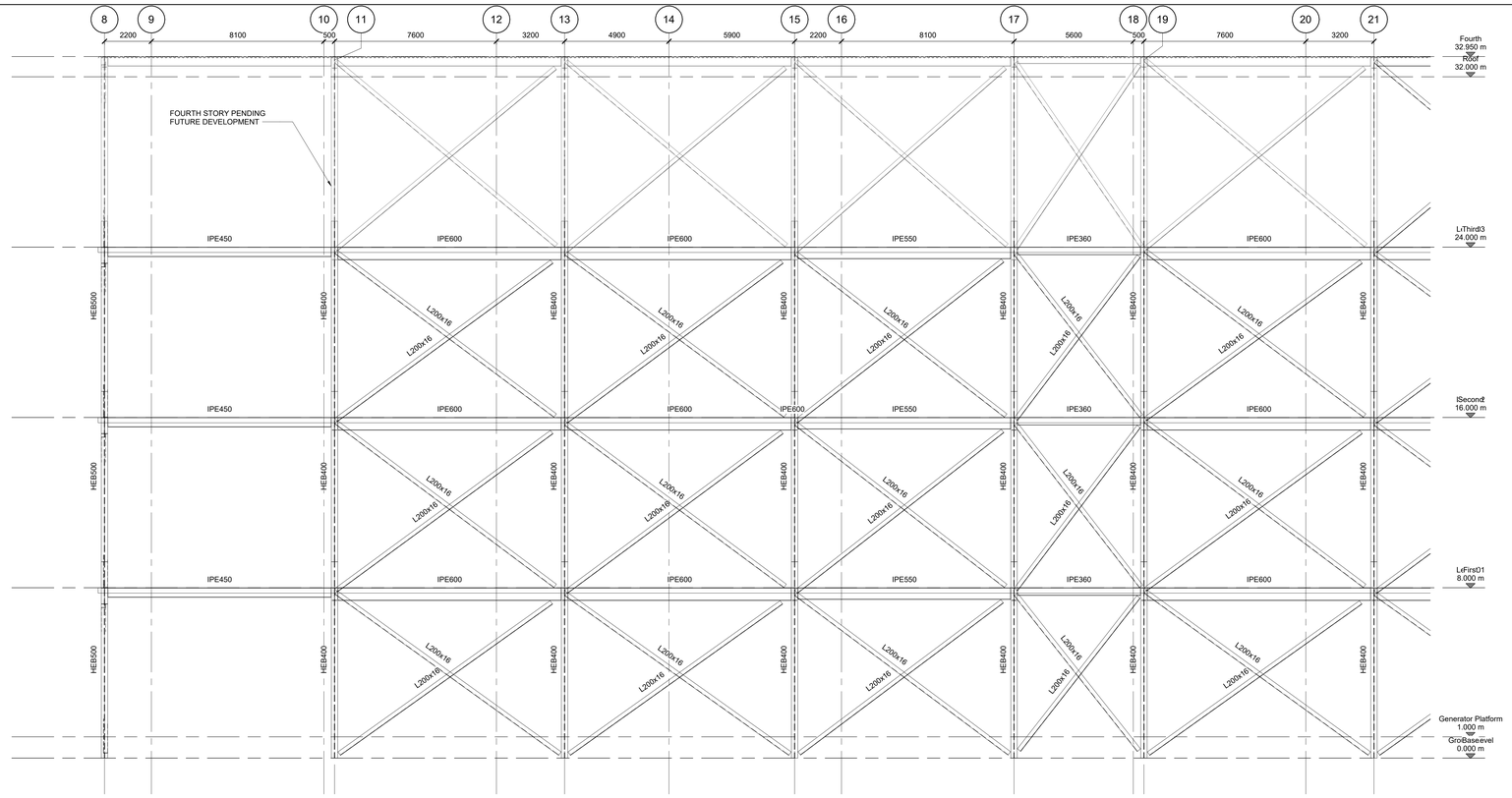
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01

ESTADO / STATUS
RIBA 2

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Author	**Designer**
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Checker	**Approver**
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P01	**S0**

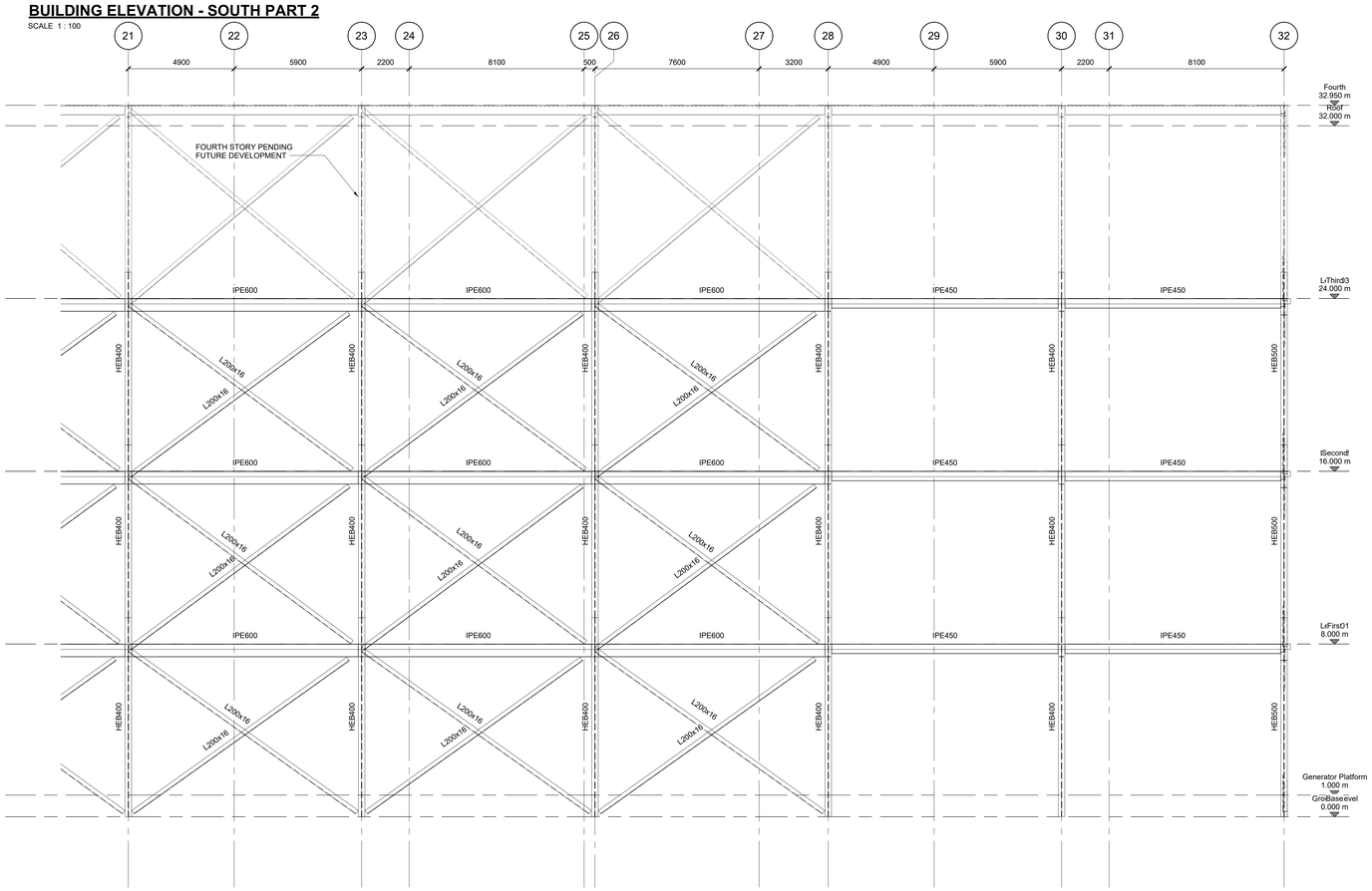
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BUILDING ELEVATION - SOUTH PART 2

SCALE 1 : 100



BUILDING ELEVATION - SOUTH PART 3

SCALE 1 : 100

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TÍTULO DE DESENHO / DRAWING TITLE
BUILDING ELEVATIONS

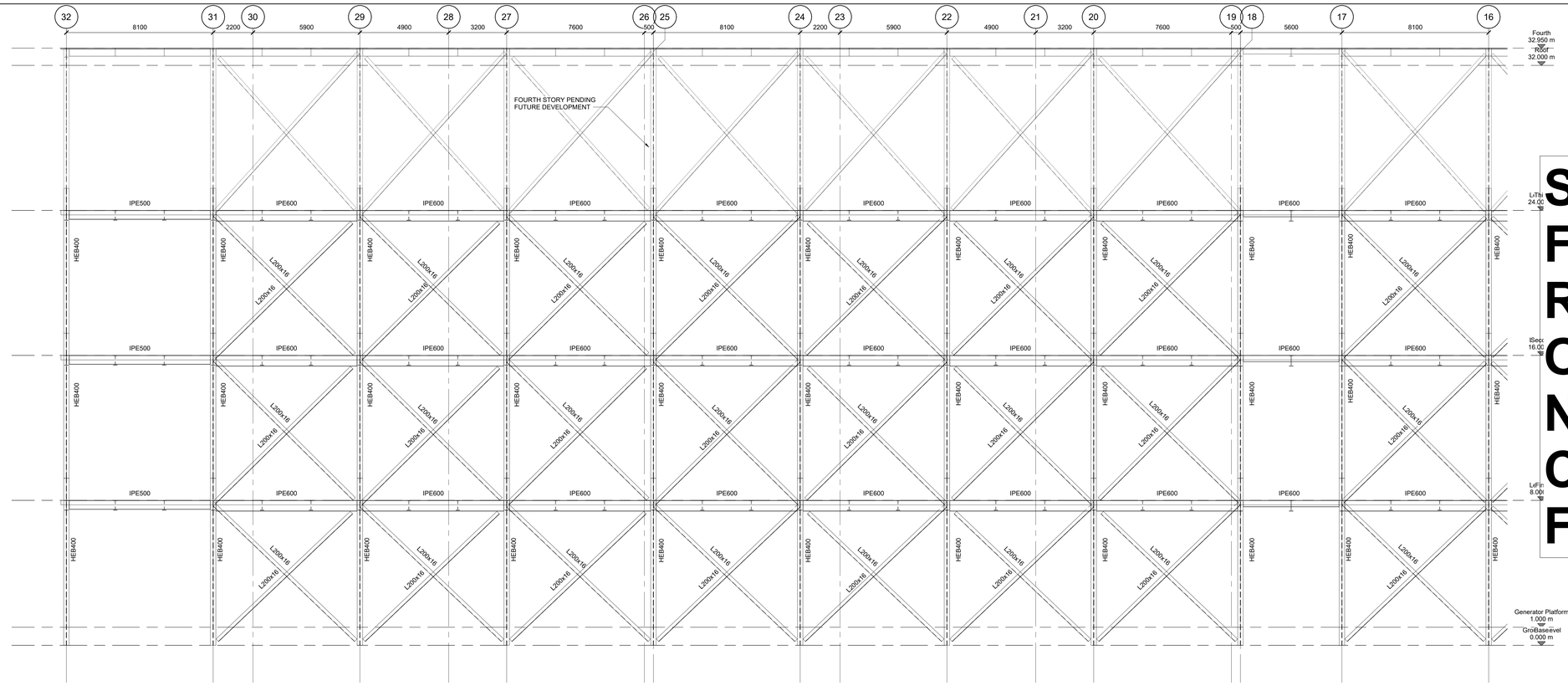
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ESTADO / STATUS
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Author	**Designer**
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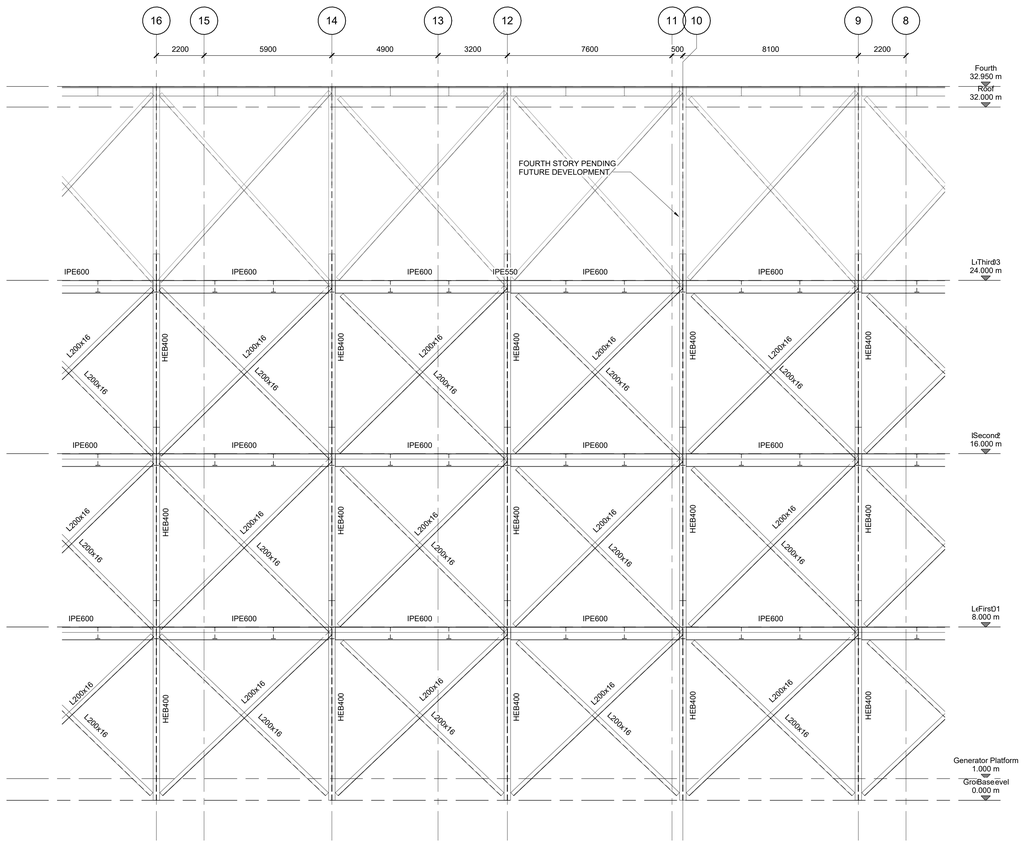
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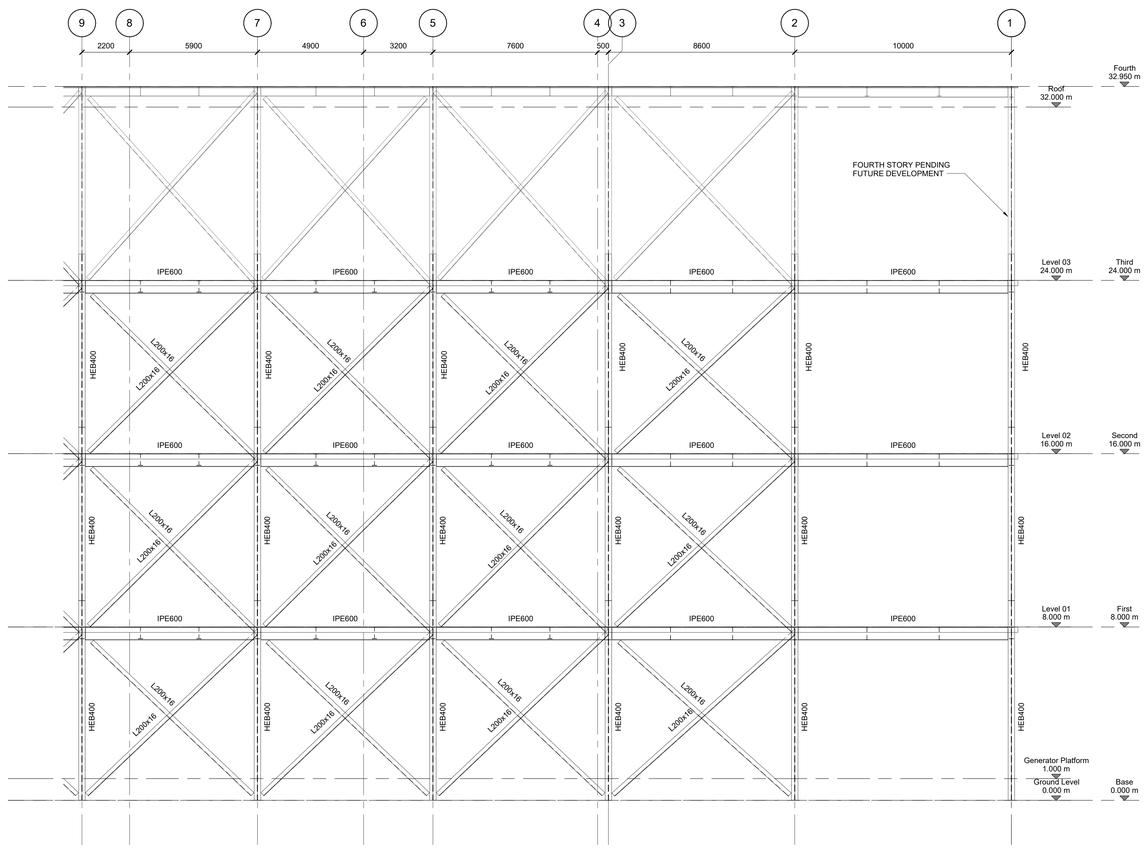
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BUILDING ELEVATION - NORTH PART 2

SCALE 1 : 100



BUILDING ELEVATION - NORTH PART 3

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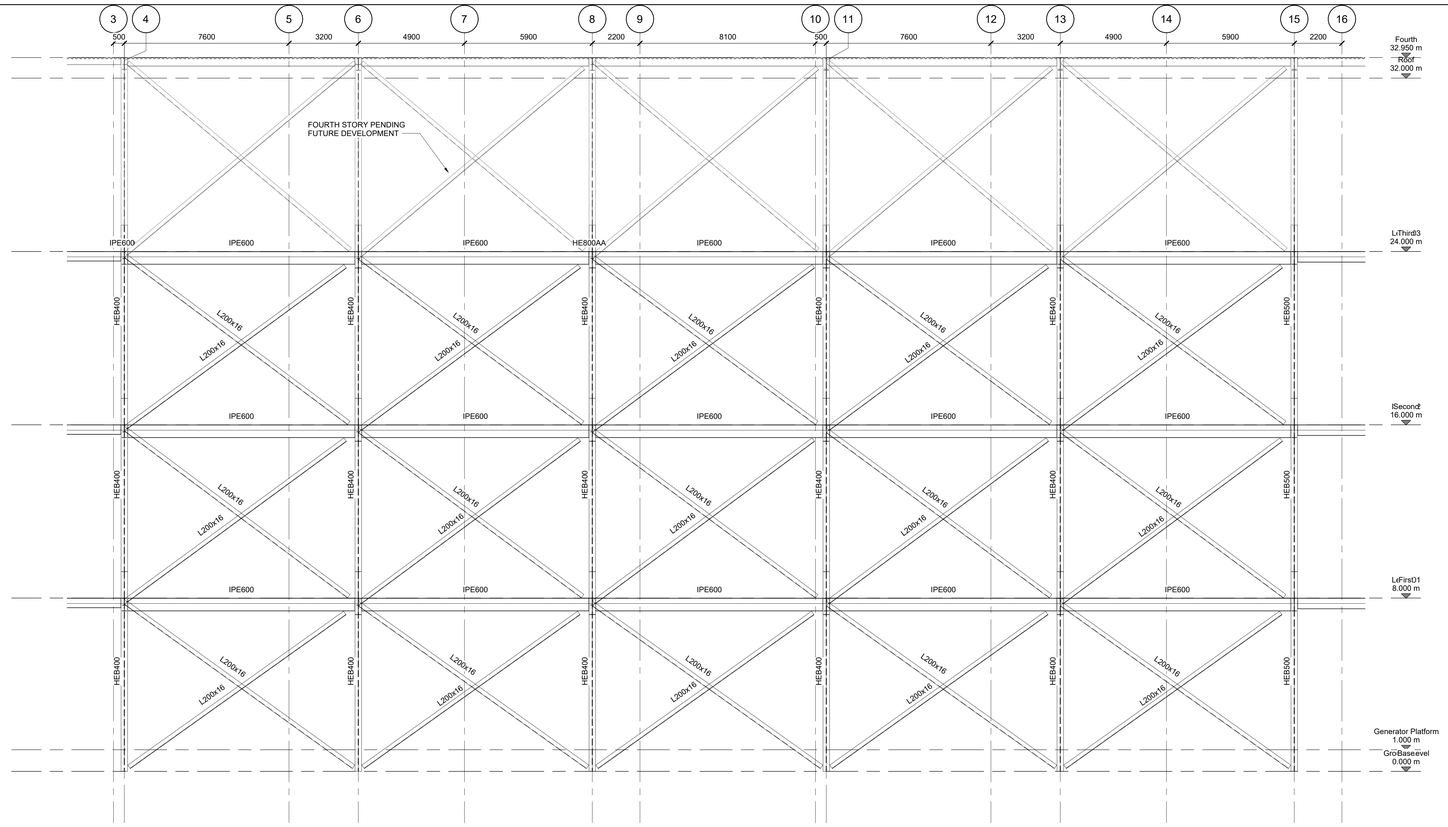
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ESTADO / STATUS
RIBA 2

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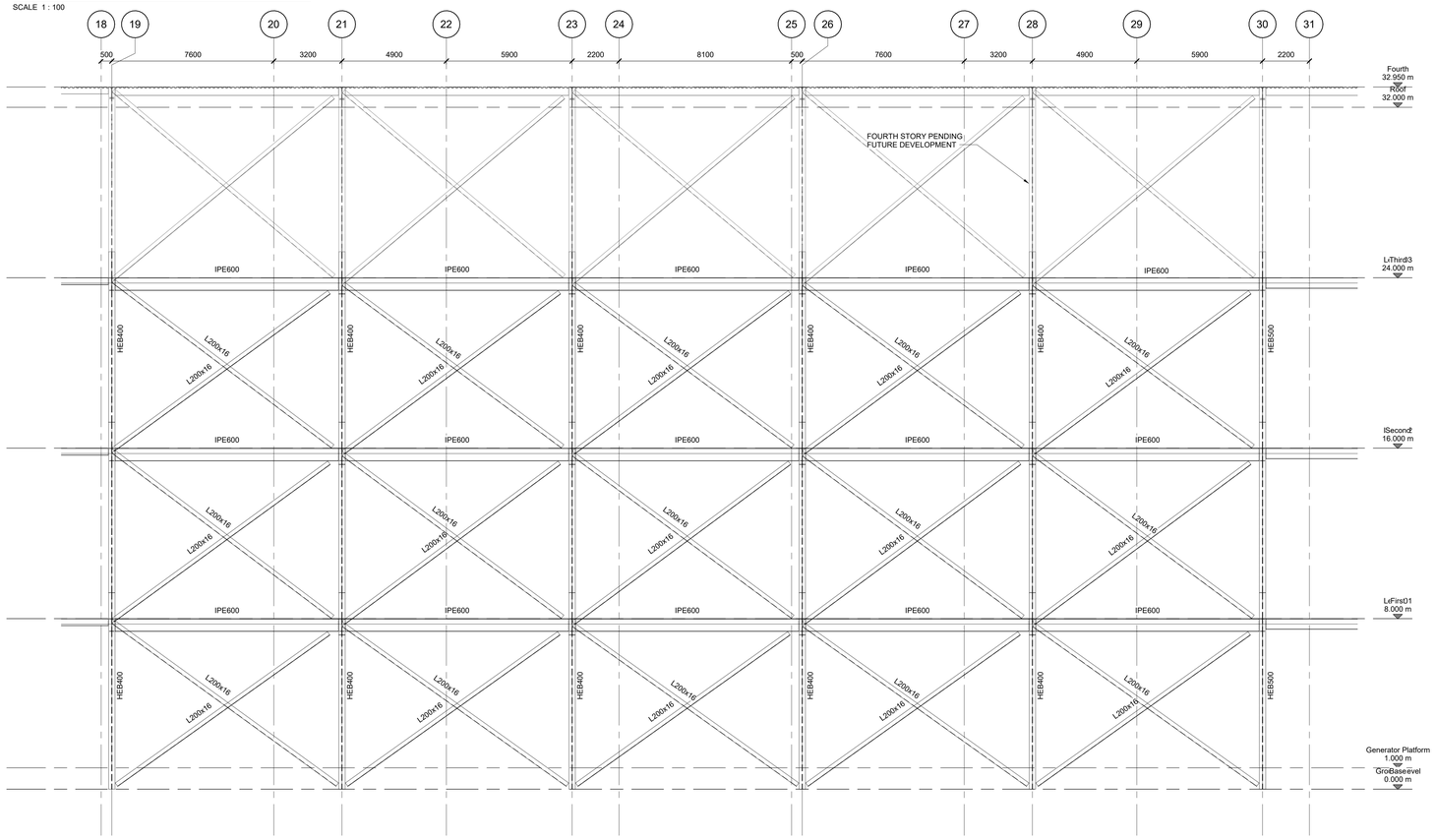
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BUILDING SECTION ALONG GRID D. 4-15

SCALE 1 : 100



BUILDING SECTION ALONG GRID D. 19-30

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TÍTULO DE DESENHO / DRAWING TITLE
BUILDING SECTIONS

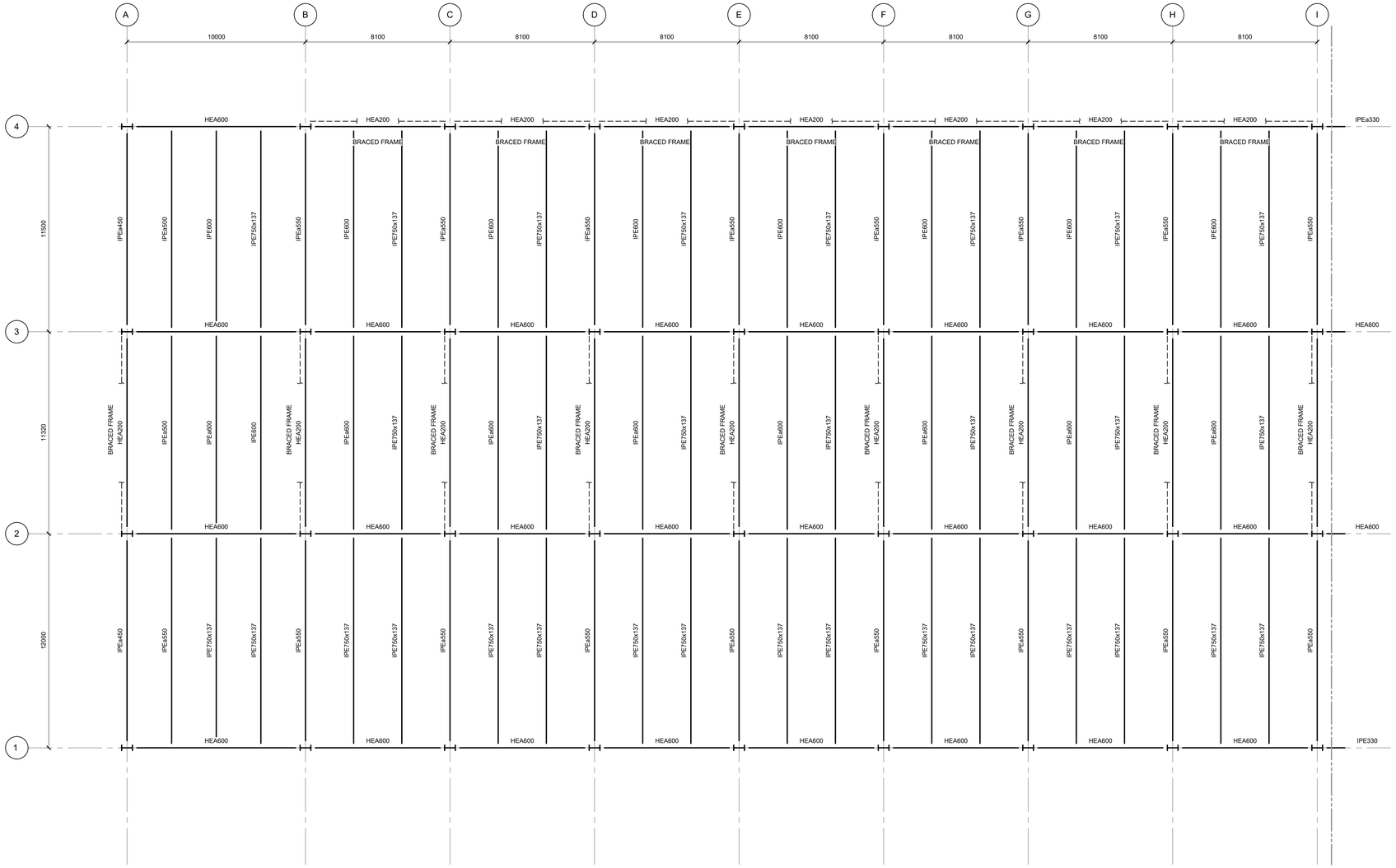
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TÍTULO DE DESENHO / DRAWING TITLE
FIRST FLOOR PLAN - AREA G

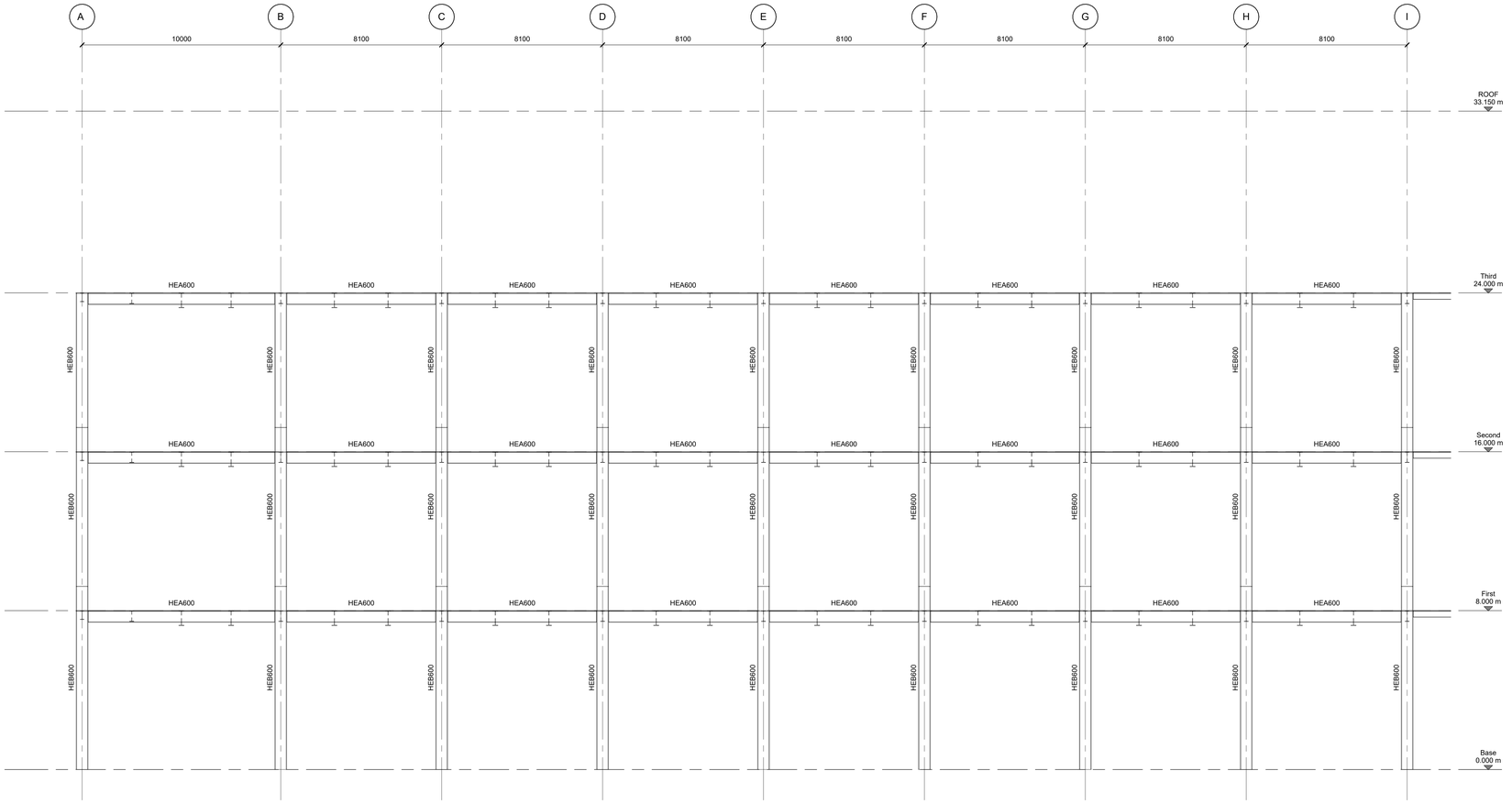
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RIBA 2

DESENHADO / DRAWN	PROJETADO / DESIGNED
Author	**Designer**
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Checker	**Approver**
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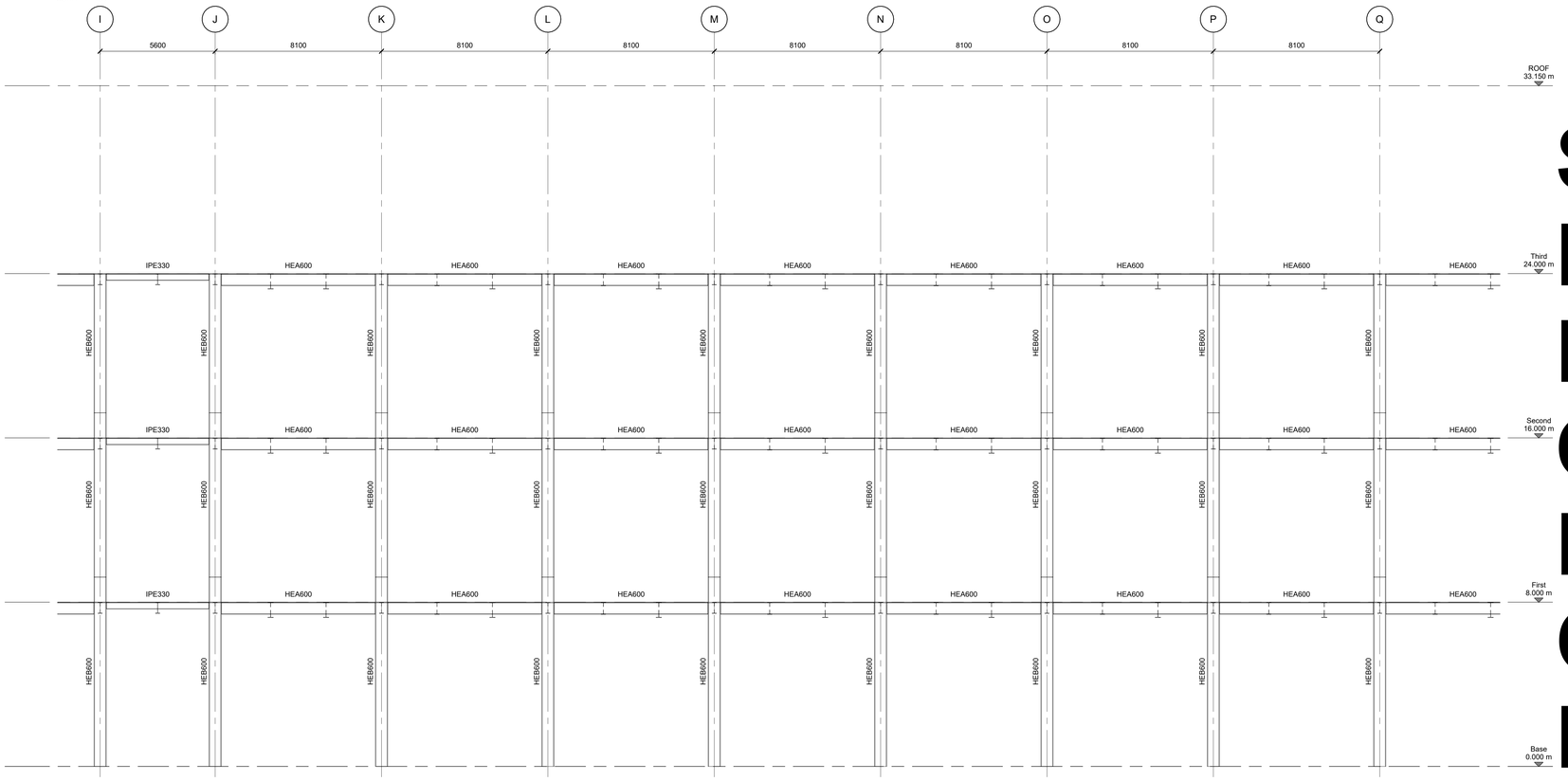
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BUILDING ELEVATION - SOUTH PART 1

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BUILDING ELEVATION - SOUTH PART 2

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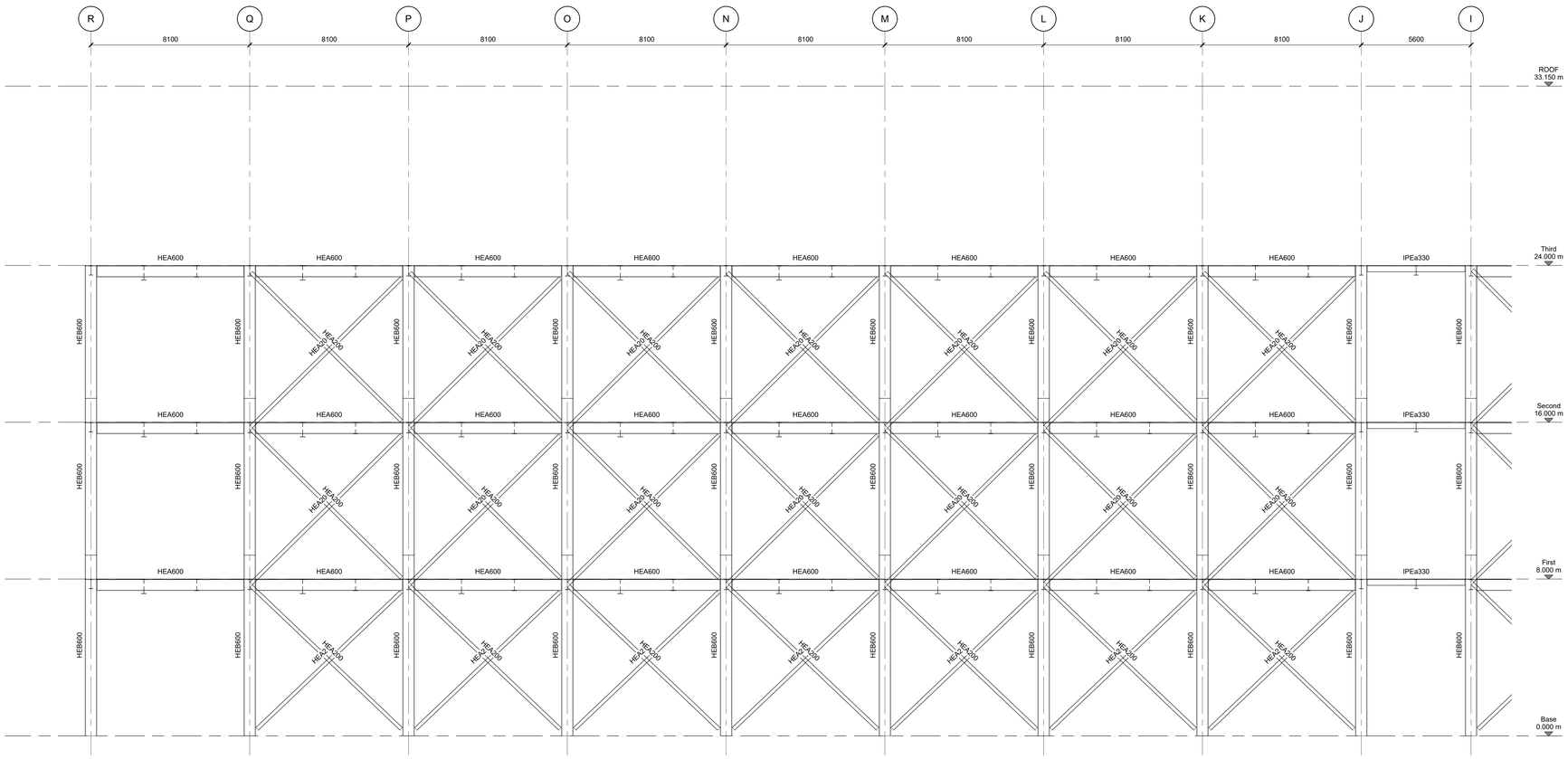
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ESTADO / STATUS
RIBA 2

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Checker	**Approver**
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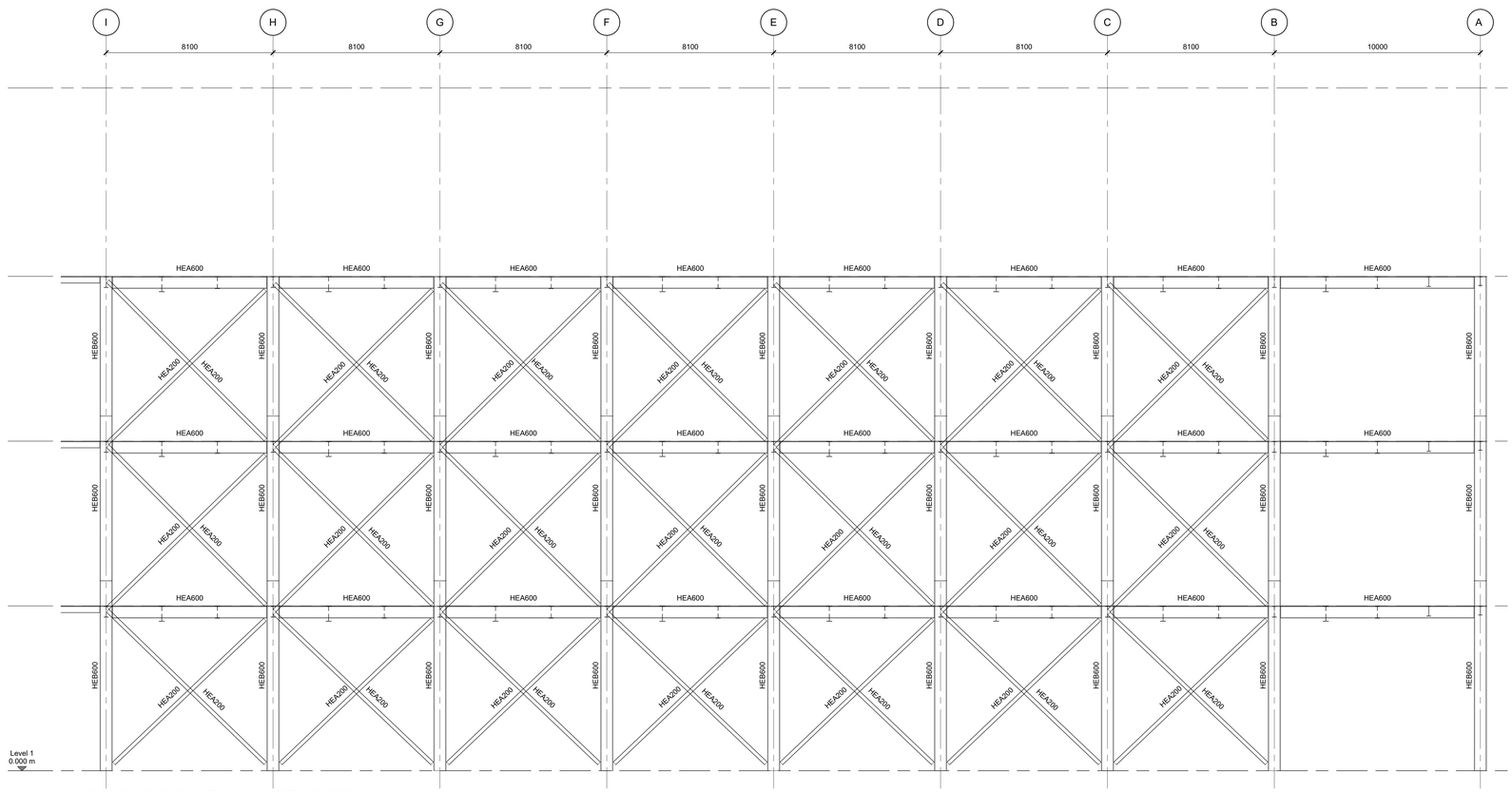
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BUILDING ELEVATION - NORTH PART 1

SCALE 1 : 100



BUILDING ELEVATION - NORTH PART 2

SCALE 1 : 100

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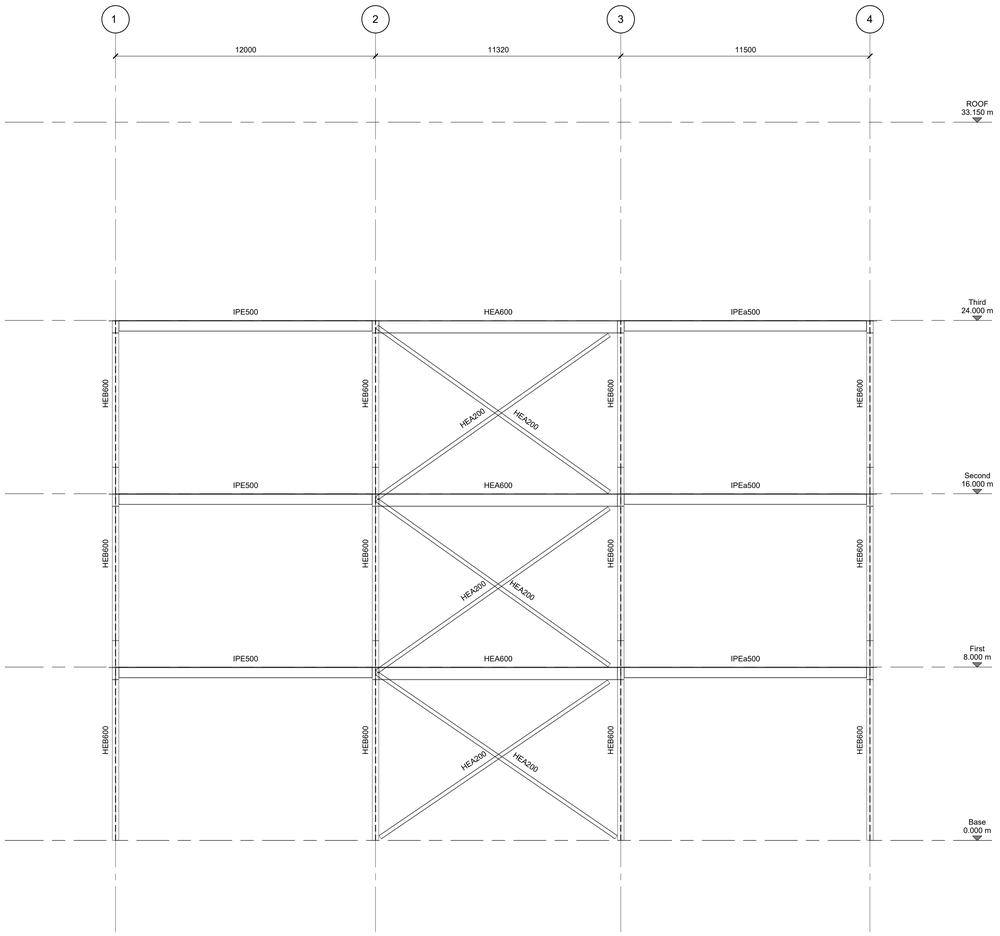
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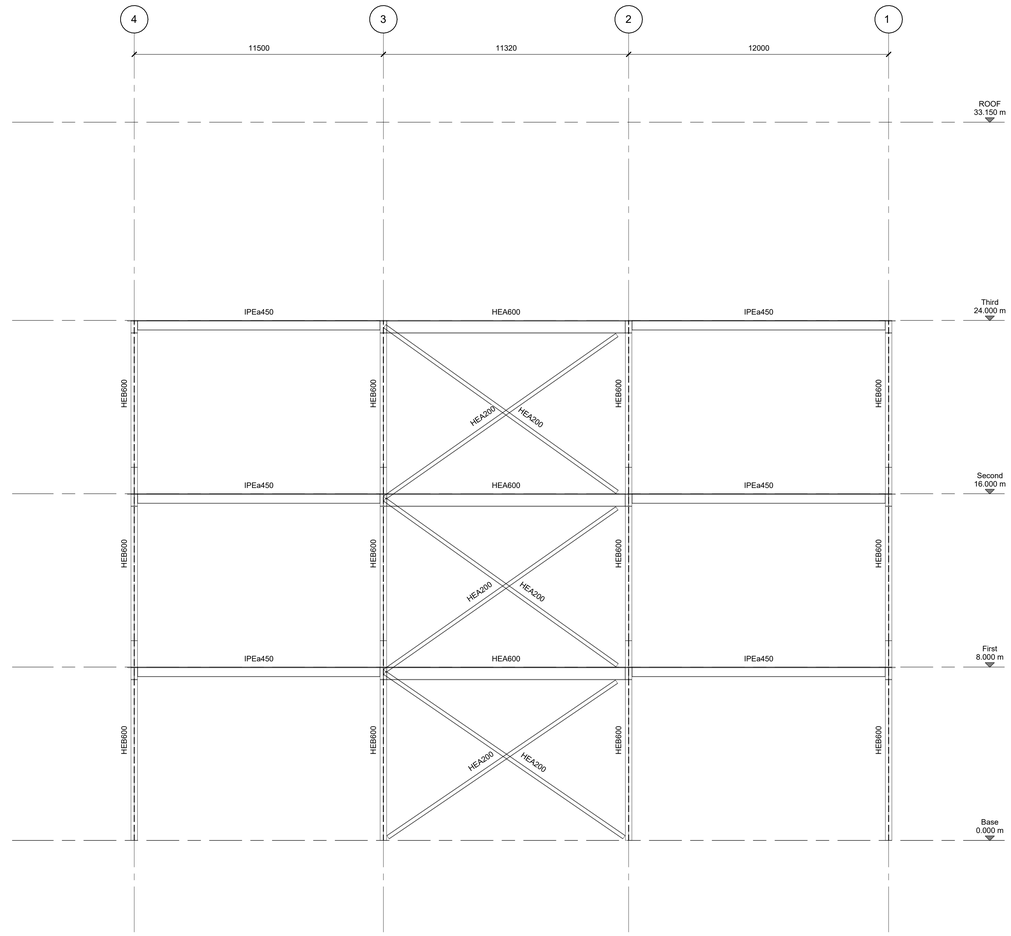
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BUILDING ELEVATION - EAST

SCALE 1 : 100



BUILDING ELEVATION - WEST

SCALE 1 : 100

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BIMMS BUILDING INFORMATION MODELING & MANAGEMENT SOLUTIONS

Civils and Hard Landscape - Prospectiva

prospectiva Projectos, Serviços, Estudos, SA

Quality Assurance - PGI

Architectural - Reify

Mechanical, Electrical and Plumbing - LMSA

lmsa Engenharia de Edifícios

Structural - Gapres

Project Management

General Contractor

PLANO-CHAVE / KEY PLAN

Key Plan TBD

N

ESCALAS / SCALE @ A0

1 : 100

CLIENTE / CLIENT

Start Campus

Jacobs

2001 Market Street
9th Floor, Suite 900
Philadelphia, PA 19103
United States
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PROJETO / PROJECT

SIN0201

Nº PROJETO / PROJECT NO.

L7018103

TÍTULO DE DESENHO / DRAWING TITLE

BUILDING ELEVATIONS

SUB ESPECIALIDADE / SUB DISCIPLINE

ESTADO / STATUS

RIBA 2

DESENHADO / DRAWN	PROJETADO / DESIGNED
Author	**Designer**

VERIFICADO / CHECKED	APROVADO / APPROVED
Checker	**Approver**

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Building Design

Seismic Design Criteria – START Campus Project Site

Importance Factor: III

Seismic Action:
- Type 1 = Zone 1.3
- Type 2 = Zone 2.3

Design Ground Acceleration (Ag):
- Type 1 = 2.175 m/s²
- Type 2 = 2.125 m/s²

Soil Type:
- Type E

Design Spectral Acceleration (Ag x S):
- Type 1 = 3.24 m/s²
- Type 2 = 3.18 m/s²

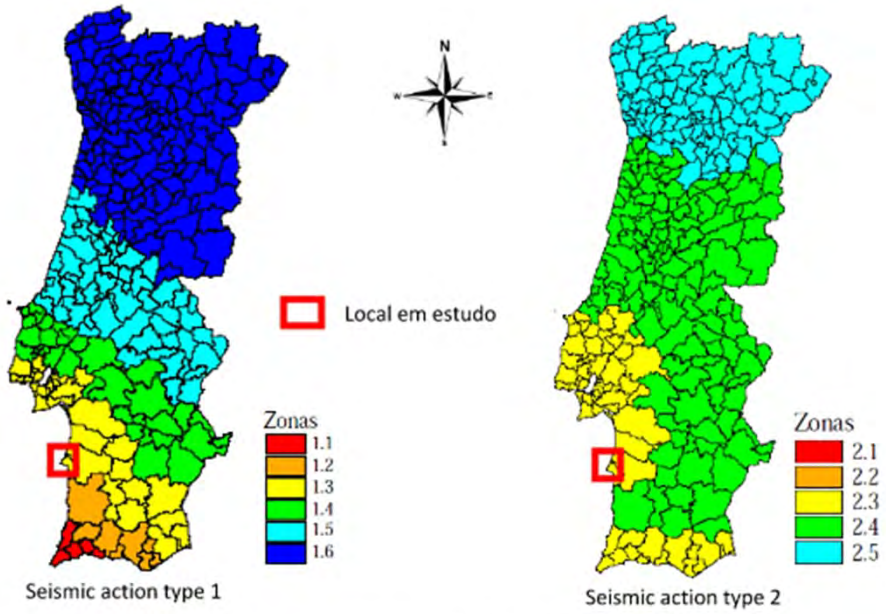
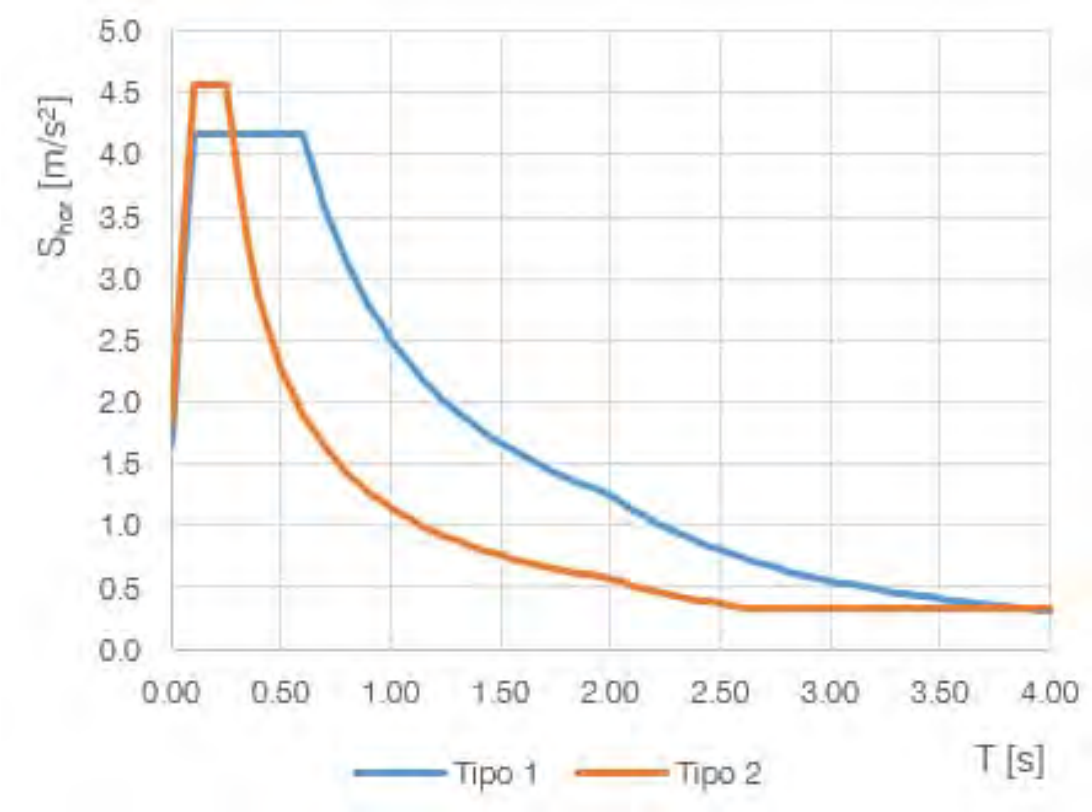


Figure 5 – Seismic zoning for seism action type 1 and 2

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Building Design

Design Response Spectra Envelope (Type 1 and 2), Importance Class II

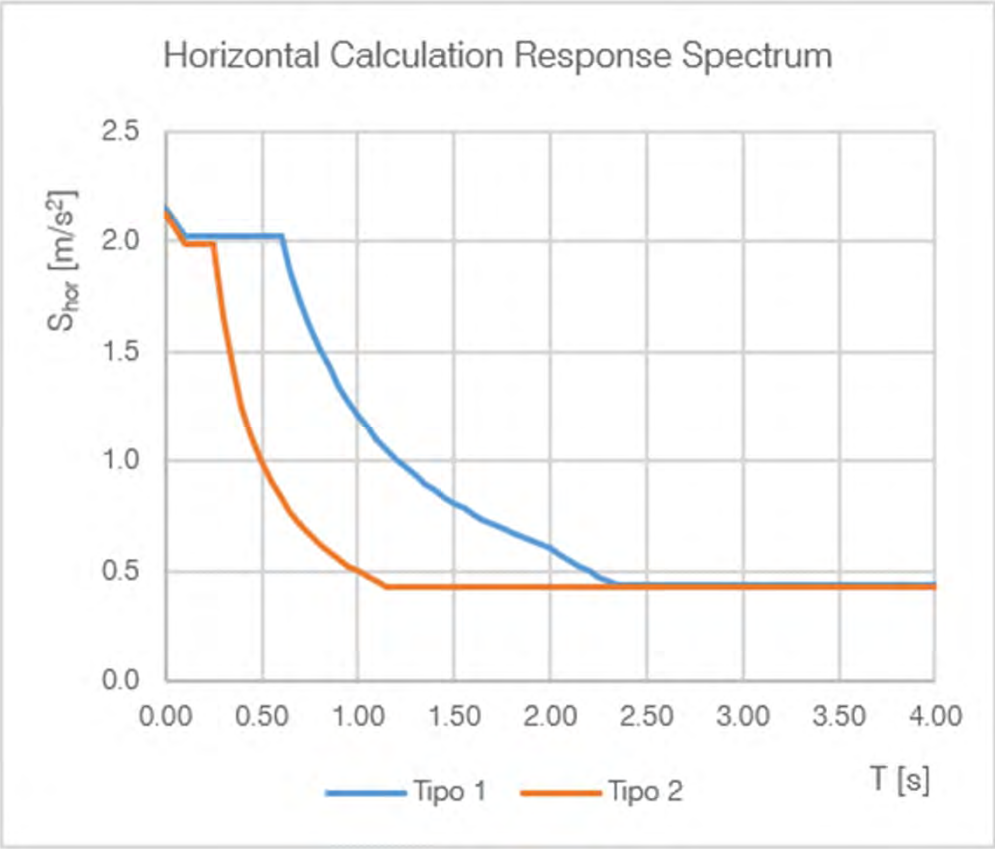


- Importance Class II – Office or Standard Building
- Controlled by higher magnitudes earthquakes at longer distances.
- Importance Coefficient of 1.0
  - Return Period of 475 years
- Behavior Factor (q) = 1.5
- S(T) max = 4.57 m/s² ~ 0.46g
- One Story Building fundamental period likely to be within S(T) max.

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Building Design

Design Response Spectra Envelope (Type 1 and 2), Importance Class III (proposed)

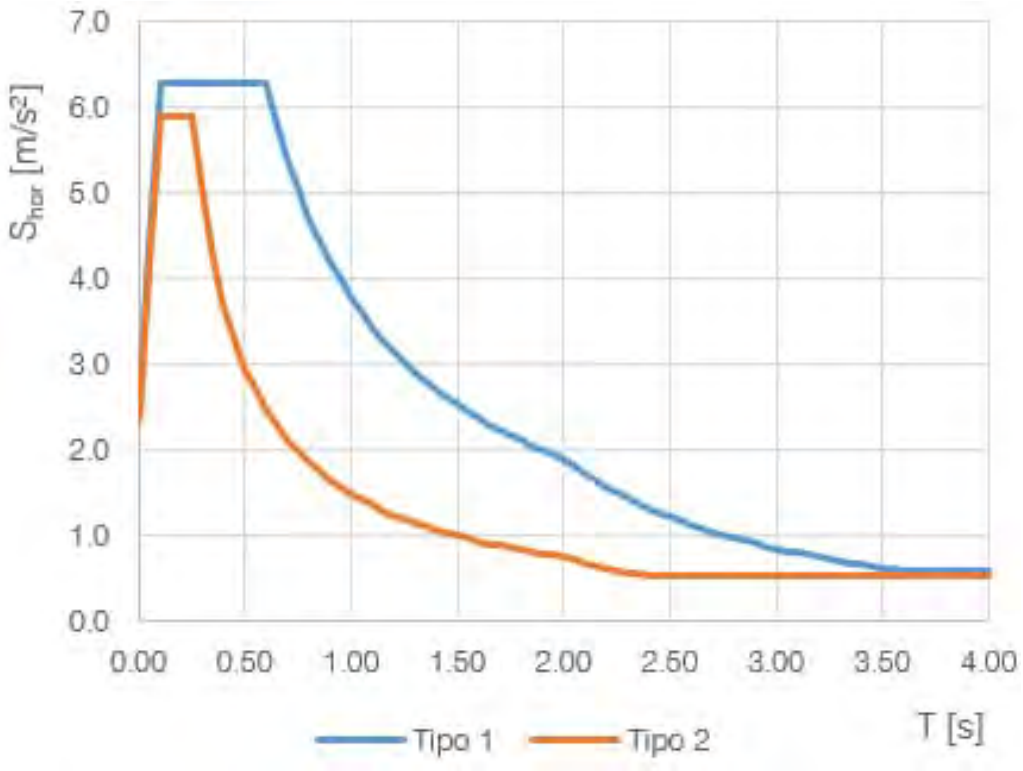


- Importance Class III – Critical Buildings (e.g. Data Centres)
- Controlled by moderate magnitude earthquakes at close distance.
- Importance Factor:
  - Type 1 =1.45
  - Type 2 = 1.25
  - (Portugal National Annex) Return Period of 821 years.
- Behavior Factor (q) = 4.0
- S(T) max = 1.23 m/s² ~ 0.125g
- Multi-story approximate building period = 1.0 sec.

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Building Design

Design Response Spectra Envelope (Type 1 and 2), Importance Class IV

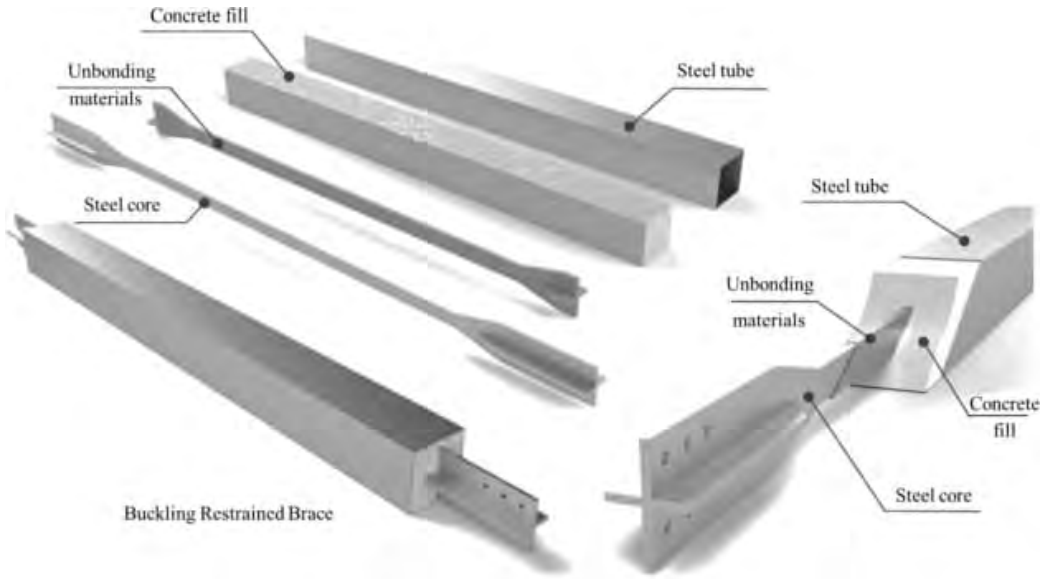


- Importance Class IV – Essential Buildings (e.g. hospitals and fire stations)
- Controlled by moderate magnitude earthquakes at close distance.
- Importance Factor:
  - Type 1 = 1.95
  - Type 2 = 1.50
  - (Portugal National Annex) Return Period of 1303 years.
- Behavior Factor (q) = 1.5
- S(T) max = 6.27 m/s² ~ 0.64g
- One Story Building fundamental period likely to be within S(T) max.

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Building Design

Lateral Bracing Systems - Buckling Restrained Braced Frames as Damping System





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Building Design

Design Ground Acceleration and Risk Assessment (BS EN 50600-10 6.2)

Table 1 — PGA and Seismic Intensity Scales

PGA ms^2	0,25 to 0,80		0,80 to 1,40	1,40 to 2,50	2,50 to 3,15	3,15 to 4,00	> 4 m/s^2
Mercalli SIS	V to VII		V to VIII	VI to IX	VIII to X	IX to X	X to XII
Japanese SIS shindo	4		5		6		7
			5 lower	5 upper	6 lower	6 upper	
	3,5 to 3,9	4,0 to 4,4	4,5 to 4,9	5,0 to 5,4	5,5 to 5,9	6,0 to 6,4	> 6,5

- Code Reference Design Spectral Acceleration for category III structures on the START Campus site is between 3.18 m/s^2 and 3.24 m/s^2
- Client Seismic Hazard Assessment – Recommending elevated PGA of 4 to 6 m/s^2. Final Design recommendation TBD. Substantial increase over code possible.

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Building Design

Design Ground Acceleration and Risk Assessment (BS EN 50600-10 6.2)

Table 2 — PGA and typical damage

PGA range	Impact on buildings	Impact on outside spaces	Impact on utilities
2,50 to 3,15	Normal buildings receive heavy damage and can be destroyed. Earthquake-resistant buildings can suffer large cracks in walls and will be moderately damaged. In some buildings, wall tiles and windowpanes are damaged and fall.	Small to medium cracks appear in the ground, and larger landslides take place.	Primary power supply can be interrupted. Gas pipes and water mains are damaged and there can be widespread interruption of supply.

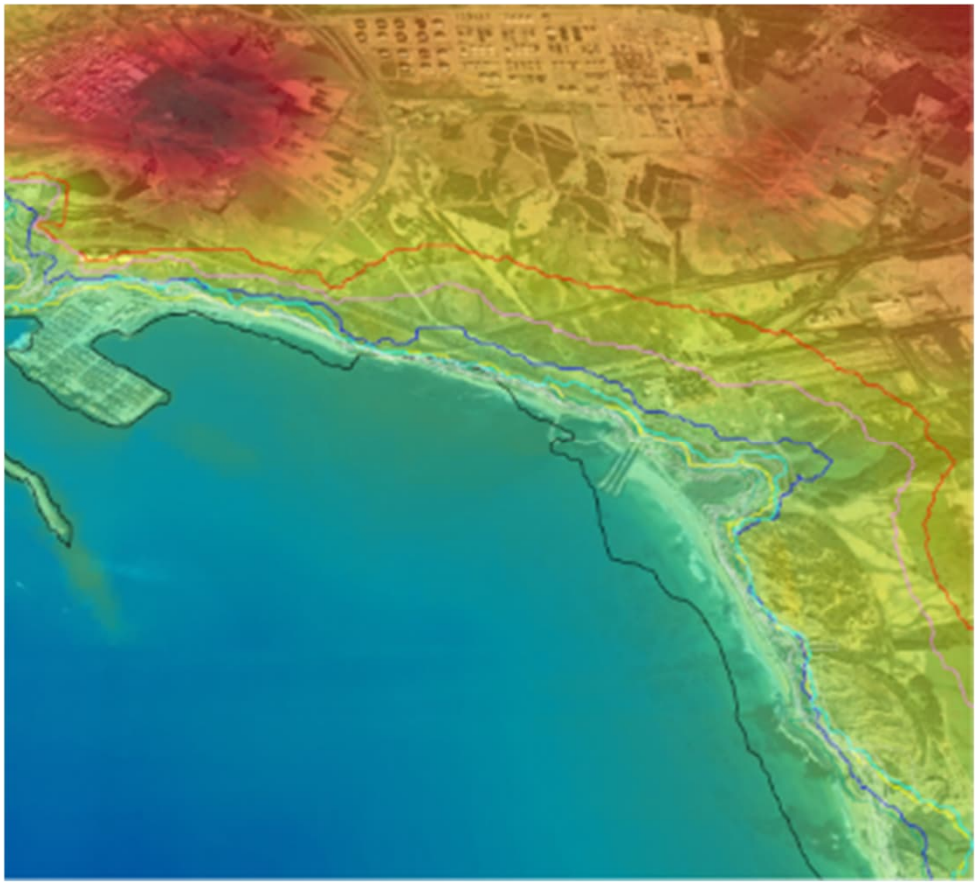
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Building Design

Tsunami Design Criteria – START Campus Project Site

Tsunami Action:

- Magenta line selected by Start and IST for further characterization
- Inundation level and design criteria TBD (not full site)
- Ensure structural impacts of design seismic event do not compromise tsunami resistance.



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Building Design

Importance Class Recommendations and Comparison for Building Design

- Importance Class III recommended for building design.
- Difference in Design Accelerations between Importance Class II and III (with low ductility) is ~45%.
  - This upgrade is while substantial, it doubles return period, and does not drive major design change in viable seismic force resisting systems.
- Base shear can be reduced providing ductility to the building structural system (q).
  - Reduced Base Shear will likely reduce costs associated to the foundation system but adds some complexity to detailing.
  - Ductility should be incorporated in accordance with EN 1998-1 (2004) Eurocode 8: Design of structures for earthquake resistance, Table 6.2.

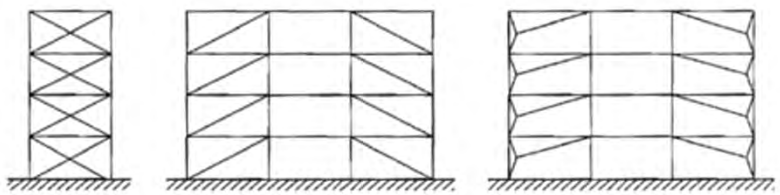


Figure 6.2: Frames with concentric diagonal bracings (dissipative zones in tension diagonals only).

Table 6.2: Upper limit of reference values of behaviour factors for systems regular in elevation

STRUCTURAL TYPE	Ductility Class	
	DCM	DCH
a) Moment resisting frames	4	$5\alpha_u/\alpha_1$
b) Frame with concentric bracings		
Diagonal bracings	4	4
V-bracings	2	2,5
c) Frame with eccentric bracings	4	$5\alpha_u/\alpha_1$
d) Inverted pendulum	2	$2\alpha_u/\alpha_1$
e) Structures with concrete cores or concrete walls	See section 5	
f) Moment resisting frame with concentric bracing	4	$4\alpha_u/\alpha_1$
g) Moment resisting frames with infills		
Unconnected concrete or masonry infills, in contact with the frame	2	2
Connected reinforced concrete infills	See section 7	
Infills isolated from moment frame (see moment frames)	4	$5\alpha_u/\alpha_1$

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3 & 4 Story DC Category Comparison

3 Story DC Building

- Category III: Traditional braced frame superstructure lateral system
- Category III: Extensive deep foundation system required to resist lateral and uplift forces
- Category IV: Traditional braced frame superstructure lateral system
- Category IV: Braced frame expansion most likely required to distribute loads to foundations. Extensive deep foundation system required to resist lateral and uplift forces

4 Story DC Building

- Category III: Robust braced frame superstructure lateral system
- Category III: Extensive deep foundation system required to resist lateral and uplift forces
- Category IV: Alternate lateral system required. Systems such as BRBs incorporating additional ductility or base isolation are possible alternatives.
- Category IV: Braced frame expansion required to distribute loads to foundations. Extensive deep foundation system required to resist lateral and uplift forces.

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3. Nonstructural Components



Nonstructural Components

When Earthquake damage occurs:

- Nonstructural components are often overshadowed by the focus on building.
- Poor performance of nonstructural components is the greatest contributor to damage, losses, and business interruption for most facilities after an earthquake.
- Nonstructural components include Racks, Generators, Chillers, Compressors, Battery Racks, Suspended Ceilings, Light Fixtures, etc.



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Nonstructural Components

Estimated Floor Accelerations for Day N Campus

		Cat II	Cat III	Cat IV
Floor	Z (m)	Sa (g)	Sa (g)	Sa (g)
Ground	0	0.30	0.35	0.39
Second	8	0.41	0.48	0.53
Third	16	0.52	0.61	0.67
Fourth	24	0.63	0.73	0.81
Roof	32	0.74	0.89	0.96

(2) The effects of the seismic action may be determined by applying to the non-structural element a horizontal force F_a which is defined as follows:

$$F_a = (S_a \cdot W_a \cdot \gamma_a)/q_a \qquad (4.24)$$

where

F_a is the horizontal seismic force, acting at the centre of mass of the non-structural element in the most unfavourable direction;

W_a is the weight of the element;

S_a is the seismic coefficient applicable to non-structural elements, (see **(3)** of this subclause);

γ_a is the importance factor of the element, see **4.3.5.3**;

q_a is the behaviour factor of the element, see Table 4.4.

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Nonstructural Components

Design Ground Acceleration and Risk Mitigation (BSI 50600-10 7.1.3)

Considerations include:

- Provide seismic risk localized mitigation to nonstructural components to be installed within the building.
- Nonstructural components should be designed to site specific seismic parameters including an importance factor of 1.5.
- Vendors usually provide shake table tests to comply with site specific seismic demands.
- The Design Ground Acceleration for this project is not high or uncommon. Most Vendors should be able to comply with equipment capable to continue operation after a seismic event.

Nonstructural Component Design Constraints:

- Anchoring of equipment to slabs required.
- Impose deflection limits on electrical equipment to ensure operational status. This is critical for the multi-story DC builds where equipment will experience higher accelerations on upper floors.

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Progress report I: Preliminary tsunami simulations

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Instituto Superior Técnico, Universidade de Lisboa, Portugal

22 September 2022

Abstract

The present document aims to summarize the main progress of the IST team from the aspects of tsunami numerical modeling. Section 1 introduces geophysical and numerical assumptions to model seismic-induced tsunami sources. Section 2 describes physical, modeling and numerical conditions adopted to perform tsunami simulations at a macro-scale level, from source to near-shore domain. Section 3 resumes tsunami numerical solutions at a macro-scale level. Section 4 lists future works regarding tsunami hazard on Sines region.

1 Tsunamigenesis potential

Despite the Sines moderate seismic activity, the location had experienced extreme earthquake and tsunami in the past. A complex network of thrust faults in the southwest Iberia margin (SWIM), Gulf of Cadiz region and slow convergence in the boundaries of the African and Eurasian plates (Moreira, 1985; Rosas et al., 2009; Cunha et al., 2010; Bezzeghoud et al., 2010; Duarte et al., 2013; Teves-Costa et al., 2019; Somoza et al., 2021; Martínez-Loriente et al., 2021; Serra et al., 2021) is responsible for regional and local tsunamigenesis potential. Distant sources were neglected due to previous work (Omira et al., 2016) demonstrating they pose less hazardous scenarios for Sines. Following literature based on geological and geophysical evidence, Fig. 1 depicts the main seismic sources located in SW Iberia with potential to generate tsunamis threatening the Sines coastal region (adopted from (Reis et al., 2022)).

The computation of tsunami initial condition assumed that the free-surface elevation at instant $t = 0\,s$ mimics the ocean floor displacements (Kajiura, 1970). The computation of the co-seismic displacements followed Okada's theory (Okada, 1985), implemented in

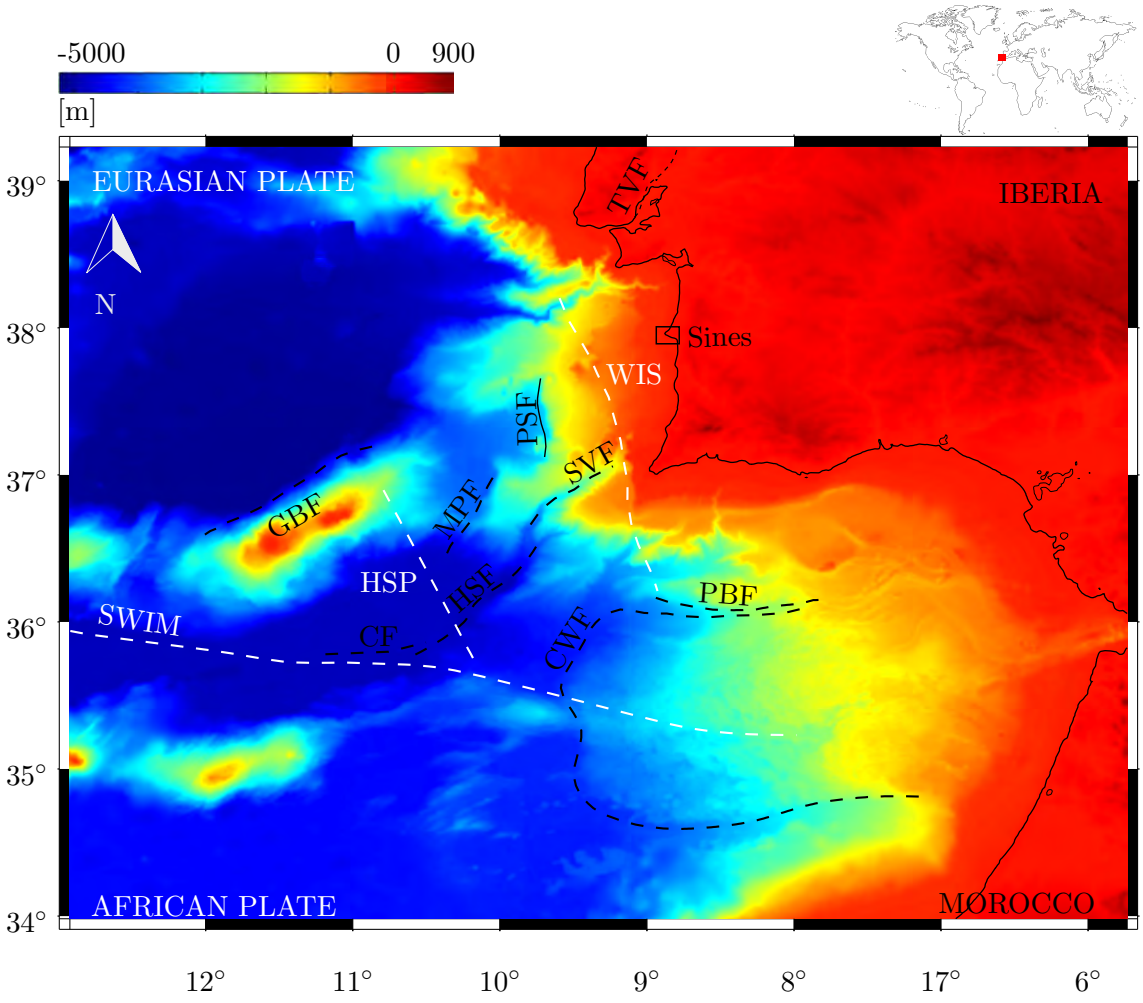


Figure 1: Topo-bathymetric map with identification of tsunamigenic sources in Gulf of Cadiz region. The solid black line represents a normal fault, while black dashed lines represent the predominant thrust faults of the tectonic complex. White dashed lines represent hypothetical fault ruptures. Acronyms of the tsunamigenic geological mechanisms: GBF - Gorringe Bank fault, MPF - Marquês de Pombal fault, CWF - Cadiz Wedge fault, HSF - Horseshoe fault, SVF - São Vicente fault, PBF - Portimão Bank fault, WIS - Western Iberian Shelf, PS - Pereira de Sousa, TV - Tagus Valley (onshore), CF - Corner fault, HSP - Horseshoe Plain, SWIM - Southwest Iberian Margin. Adopted from Reis et al. (2022).

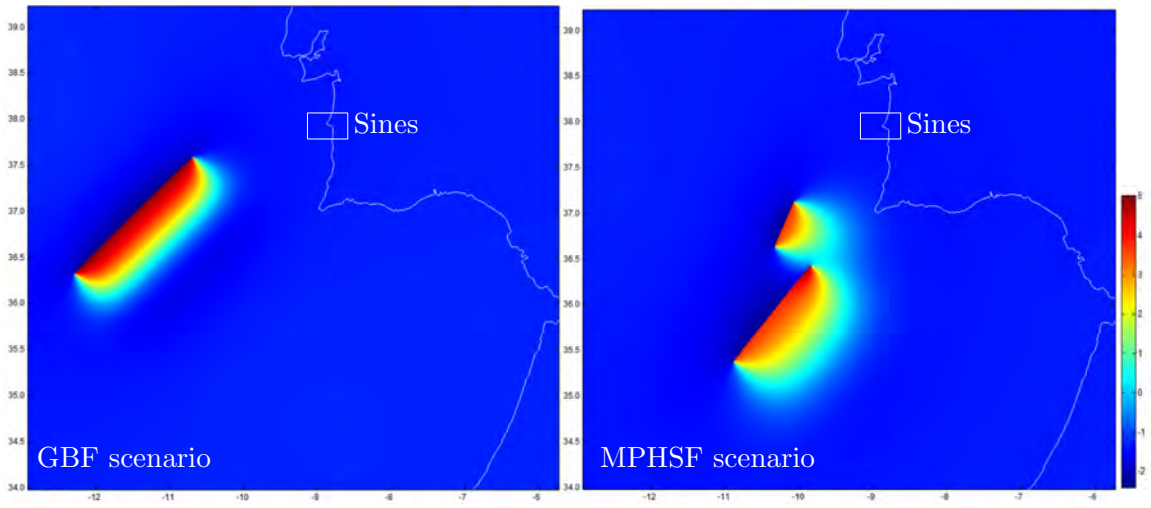


Figure 2: Representative scenarios of a single (left) and composed (right) rupture.

Mirone open-source software (Luis, 2007). The tsunami initial conditions were generated from fault parameters proposed in the literature considering single and composed sources. The initial conditions for the tsunami simulations were imposed in the form of grid overlapping the $15\,arc-sec$ resolution topo-bathymetric grid, which is available at the General Bathymetric Chart of the Oceans site (GEBCO, `gebco.net`, last accessed: 30 January 2022). Fig. 2 shows two representative scenarios of tsunami initial conditions: a single rupture scenario adopting GBF source with parameters proposed by Johnston (1996), and a composed rupture scenario adopting MPF and HSF sources with parameters proposed by Ribeiro et al. (2006).

2 Tsunami simulations

The tsunami simulations are based on physical, modeling and numerical conditions.

Physical and environmental assumptions:

The simulations adopted mean sea conditions to set the level reference (free surface elevation $\eta = 0\,m$). Environmental time-dependent effects, such as sea-level variations due to tides or climate changes, and geotechnical failure due to prior earthquake were out of numerical simulation carried out to characterize the tsunami propagation phase.

Modeling and simulation assumptions:

At the macro-scale level of tsunami propagation, the resolution of GEBCO grid is

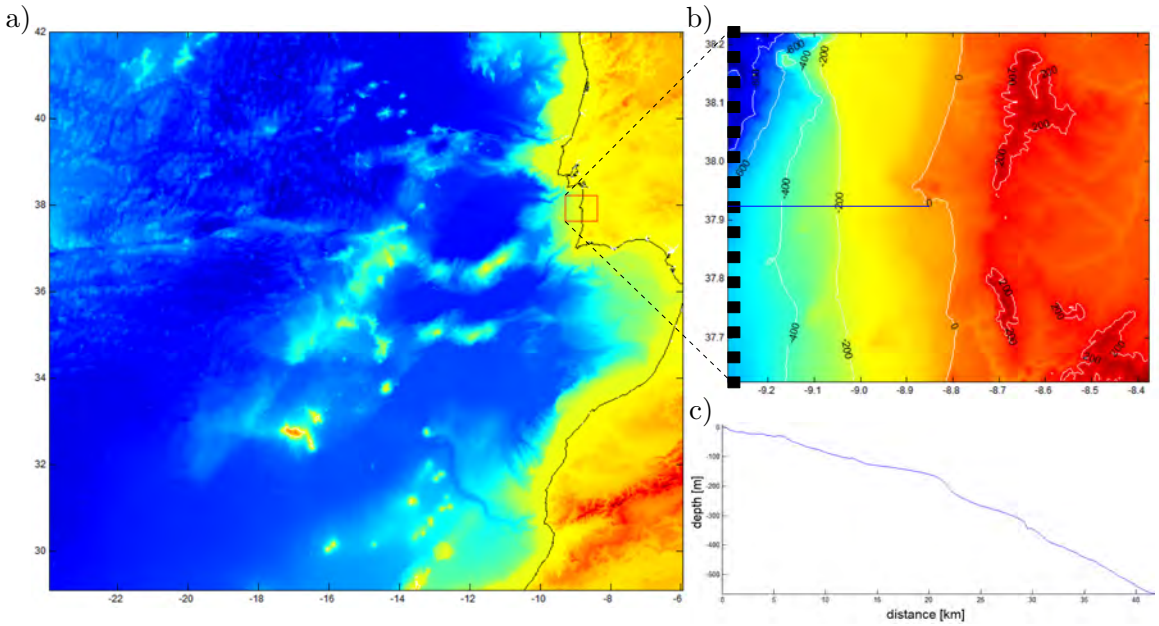


Figure 3: Tsunami simulation: a) numerical domain, b) location of VGs, represented as black squares, scattered along Sines coast, and blue line representing the location of altimetry profile, c) generic altimetry profile near Sines coast.

deemed necessary to obtain accurate numerical solutions.

The simulations of tsunami propagation simulations were performed using a well-balance numerical scheme using Finite Volume method to solve the non-linear system of Shallow-Water equations (Clain et al., 2016). Tsunami propagation model commonly accepts the Shallow-Water equations as governing equations. The numerical tool was exhaustively verified against a full battery of benchmarking data, including analytical formulations, recorded data from laboratory campaigns and real instrumental records from past tsunami (Reis, 2019).

The simulation time was set to $t_{sim} = 7200\,s$ to assure the characterization of (at least) three cycles of tsunami waves. The computation was performed to assess tsunami hydrostatic and hydrodynamic quantities, such as free-surface elevation, η, flow velocity, u and momentum flux, M_F in the vicinity of Sines coast. Virtual gauges, VG, were implemented $5\,km$-apart along Sines near-shore ($\approx 50\,km$ from shoreline), capturing tsunami quantities to be adopted as initial condition on future high-resolution simulations of tsunami inundation phase. Fig. 3 depicts the strategic location of the fifteen VG.

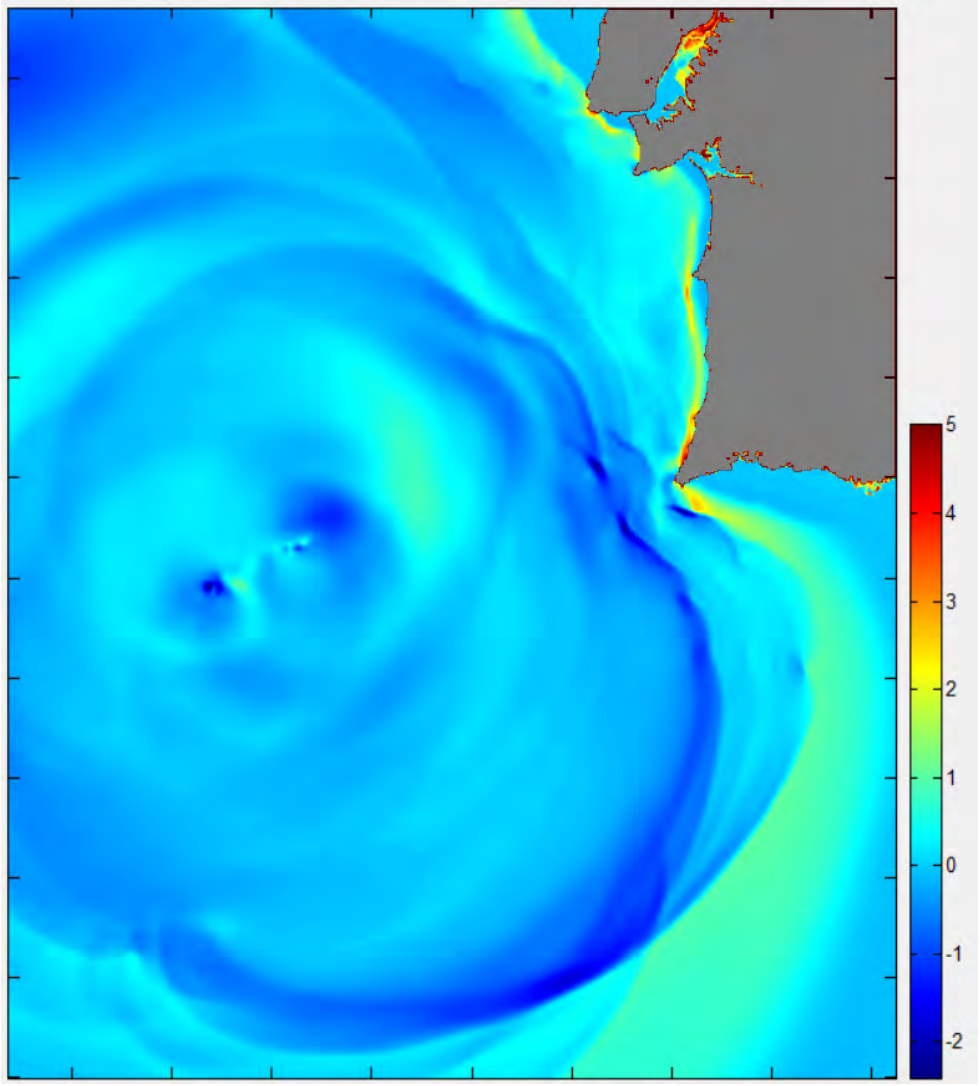


Figure 4: Arrival of the first tsunami wave at Sines site.

3 Numerical solutions

The numerical solutions of tsunami propagation were assessed for 10 scenarios (two sources at GBF, and one source at MPF and HSF, and SVF, MPPSF, MPHSF, MPPBF faults). Fig. 4 depicts a representative time-step of tsunami arrival at Sines, around $t_{sim} = 25\,m$ after the GBF triggering earthquake, while Figs. 5 and 6 show corresponding η and u quantities captured by some of the VG, respectively. All scenarios were identically processed, inferring η, u and M_F.

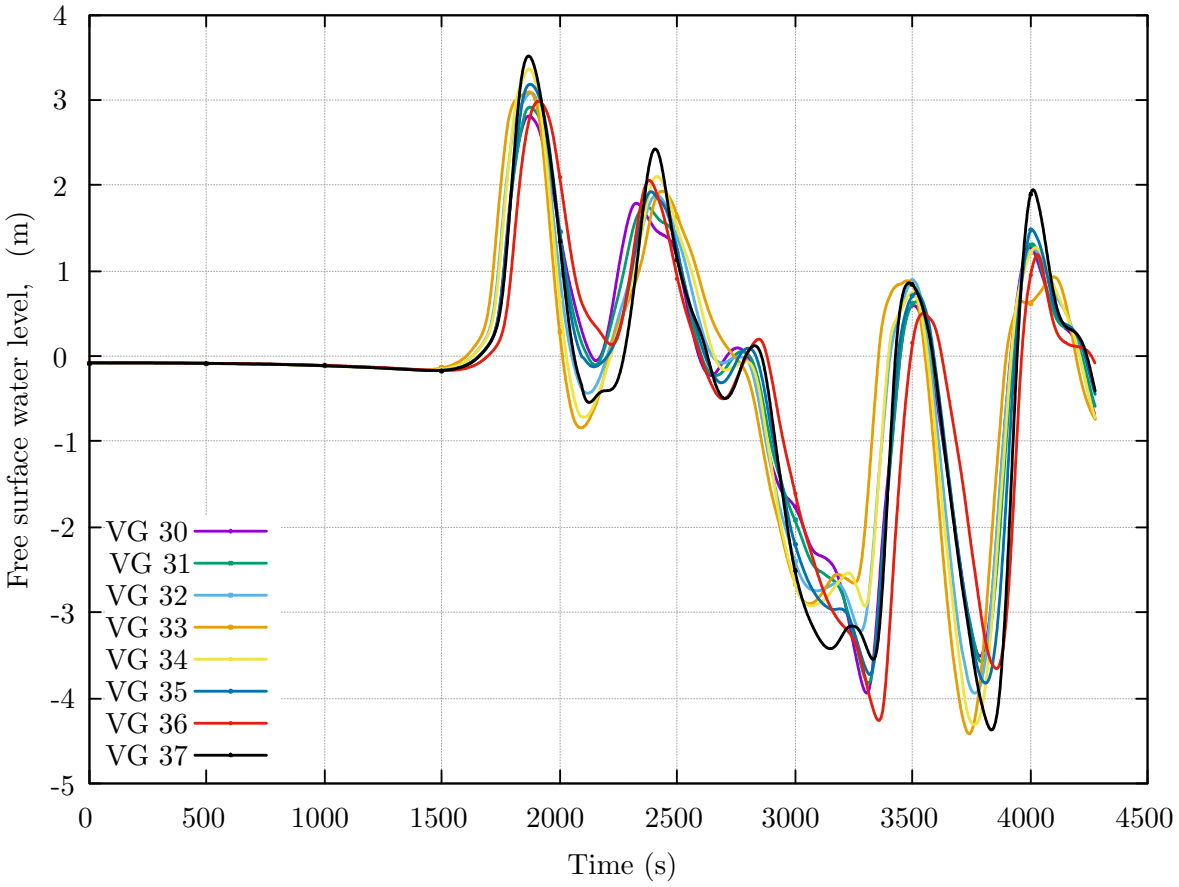


Figure 5: Time histories of free surface elevation captured by some of the VG.

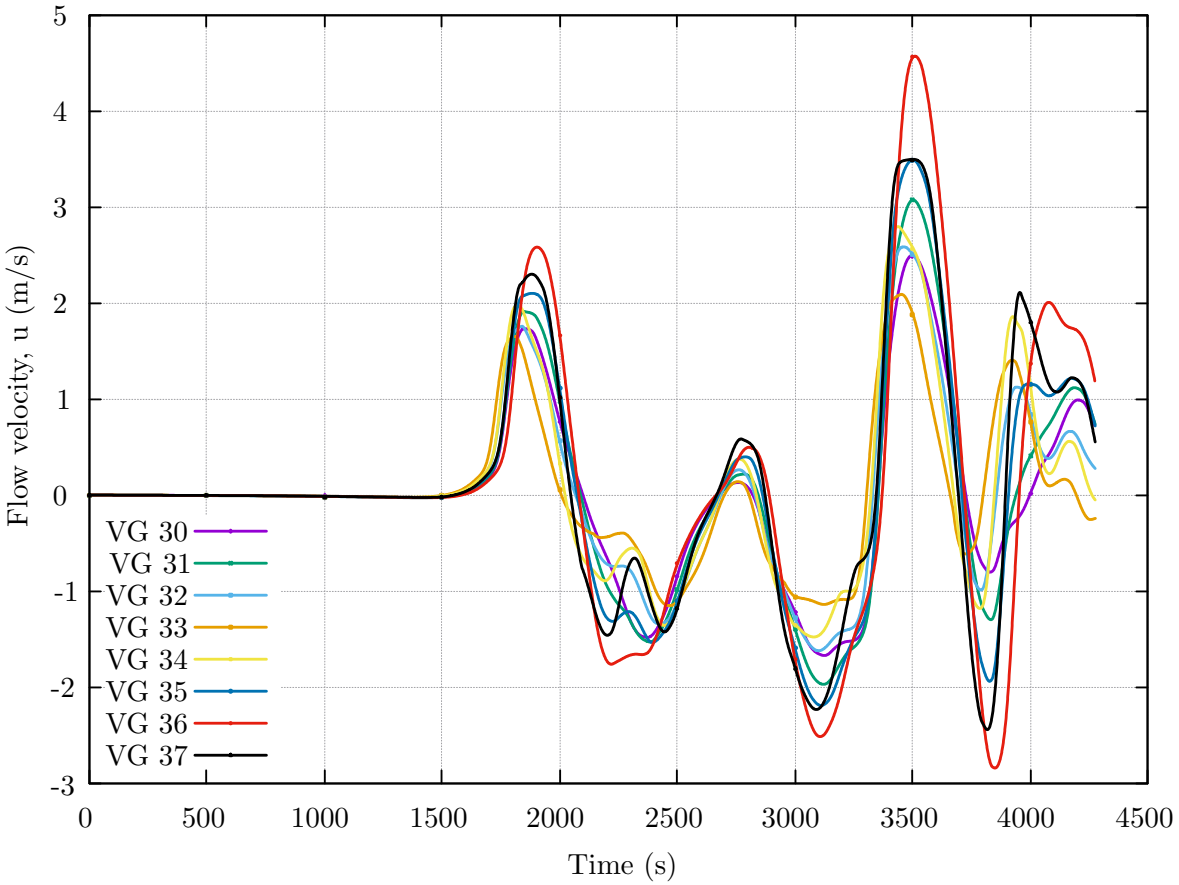


Figure 6: Time histories of flow velocities captured by some of the VG.

4 Future works

The next phase comprehends the simulation of the tsunami run-up in the Sines coast, with emphasis on the Start Campus area. The simulation of the inundation will take place over the high-resolution topo-bathymetric and surface data representing the buildings and critical structures of the Data Centre. Mean and high sea levels will be considered to reproduce the tidal effects.

The following phase entails simulating the run-up in the sea-level conditions of year 10, considering the sea level rise expressed in the anomaly maps of NOOA for 2032.

The composition of high-resolution grids to encompass natural terrain elevation and built environment constitutes one of the ongoing tasks. The numerical tool(s) to perform refined characterization of tsunami behavior are being calibrated to encompass consecutive spatial discretization, from near-shore Sines towards Start Campus site.

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Progress report II: PGA distribution

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15 October 2022

Abstract

The present document aims to summarize the main progress of the IST team from the aspects of seismic ground motion predictions. Section 1 introduces the ground motion prediction equations. Section 2 describes physical, modeling and numerical conditions adopted to predict the distribution of Peak Ground Acceleration at Sines site. Section 3 resumes the seismic numerical solutions for the various scenarios. Section 4 lists recommendations and future works.

1 Ground motion prediction

Ground motion prediction equations, GMPE, implemented in OpenQuake software library Pagani et al. (2014) (available at `https://www.globalquakemodel.org/`) were adopted to characterize the seismic acceleration targeting Sines region.

A GMPE model relates the ground-motion intensity measure to a set of variables describing the source, wave propagation path and site conditions Yenier and Atkinson (2015). Its generic functional form reads as Eq. 1:

$$lnY = F_E + F_z + F_\gamma + F_S + C, \tag{1}$$

where lnY is the logarithmic expression of a ground-motion intensity measure, peak ground acceleration, PGA, for the present study. The F_E, F_z, F_γ and F_S represent functions for earthquake source, attenuation along the path, and geometrical and anelastic site-effects, respectively.

2 Seismic modeling and simulations

Assuming the source parameters of the candidate scenarios adopted and identified in Report I (preliminary tsunami simulations), a twofold criterion was assumed to select geologic structures located less than $300\,km$ from Sines with capacity to generate earthquakes of moment magnitude $Mw8.0$ or greater.

The fault parameters of each of the tsunamigenic sources were then characterized by geometry (surface area, A, hypocentral depth, d), kinematics (strike, φ, dip, δ, slip, λ and rake, Θ) and soil rigidity, μ, to set the candidate scenarios for the subsequent analyses.

The simulations of each scenario are repeatedly carried out varying sources parameters of ten single and composed fault combined with about twenty attenuation laws to generate multiple ground motion fields concerning the distribution of the PGA at the site of interest. Due to the infrequent nature of large magnitude events in the region of the case-study, the GMPE models are assembled considering source and propagation uncertainties, while the site amplification and liquefaction potential are neglected due to site characteristic rocky soil.

3 Numerical solutions

The numerical results were processed using QGIS3 open-source tool. From the result, both source rupture and attenuation laws adopted to reproduce seismic waves propagation play an important influence on intensity measures quantification and distribution pattern. All scenarios were identically processed, inferring the distribution of PGA values on the SW Iberian region. The PGA solutions at Sines were evaluated between $0.27\,g$ and $0.52\,g$. Fig. 1 depicts a representative scenario of PGA distribution, considering the rupture of Horseshoe fault adopting source parameters proposed by Ribeiro et al. (2006), attenuation law proposed by Atkinson and Boore (1995) and negligible site amplification at Sines region. Note that the worst case scenario of composite fault rupture, proposed by Terrinha et al. (2003), adopting Campbell (2003) attenuation law triggered higher PGA value on Sines.

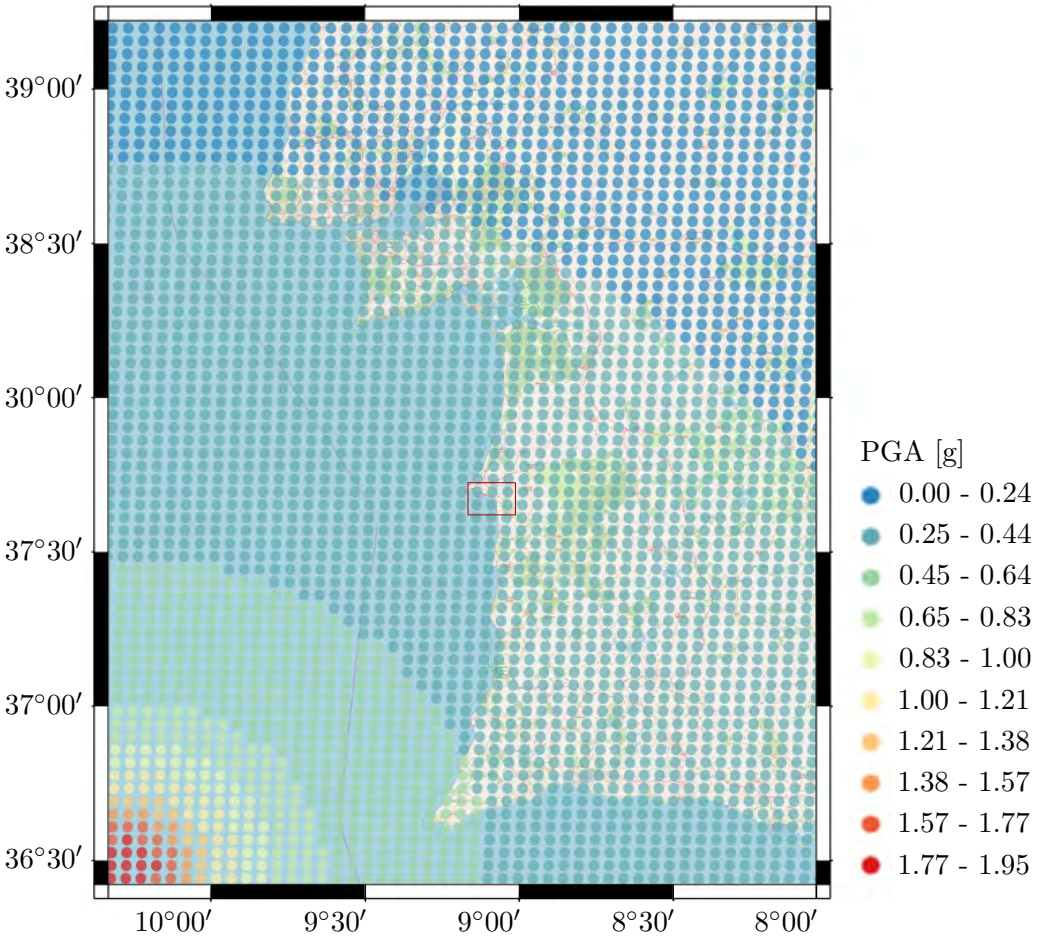


Figure 1: Representative PGA distribution of scenario considering Horseshoe fault source.

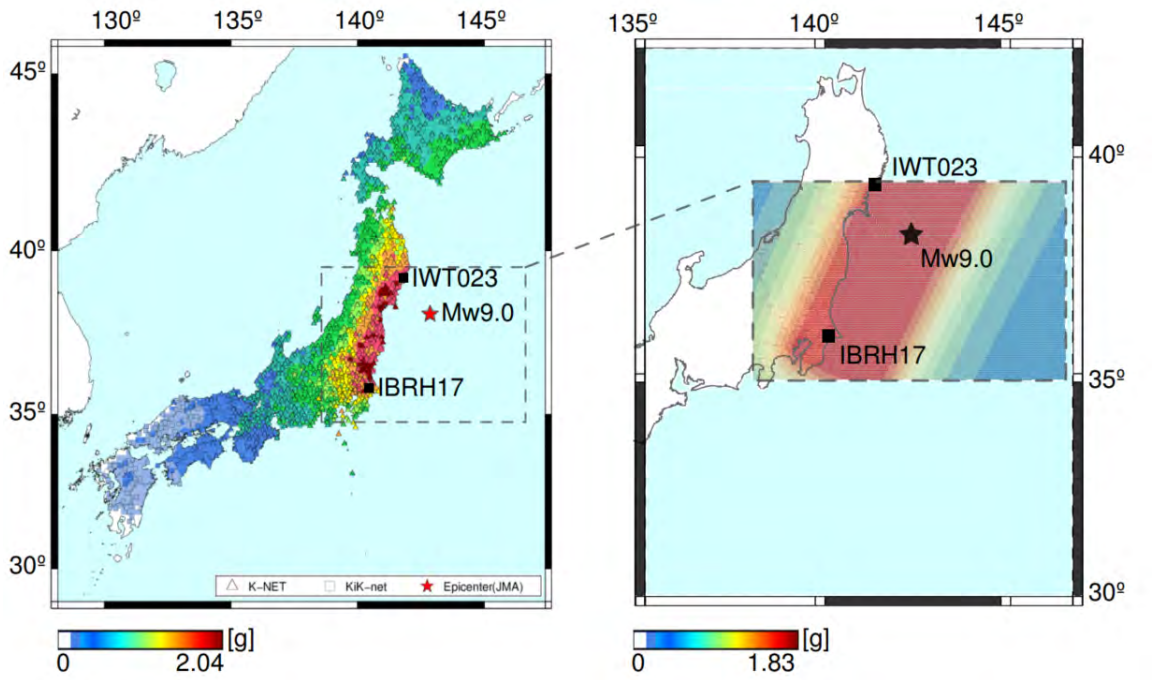


Figure 2: Map of PGA distribution during Japan 2011 earthquake. Location of Iwate and Kasumigaura seismic stations, which are part of the seismic networking that recorded the event.

4 Future works

Discrete PGA are time-independent while maps of PGA intrinsically have a generalist distribution. If Start Campus is interested in a time-dependent characterization of ground motion acceleration targeting the Start Campus hub, the IST team is capable to infer them from more sophisticated analysis. Fig. 2 shows the validation of a PGA distribution map using instrumentally-recorded data from the Japan, 2011 earthquake. The same methodology was used to perform the seismic analysis for Sines region. Fig. 3 shows the corresponding time-dependant characterization for two specific locations were seismic stations of the Japanese networking were implemented, at borehole and superficial levels. The same analysis can be developed for Start Campus hub, if required.

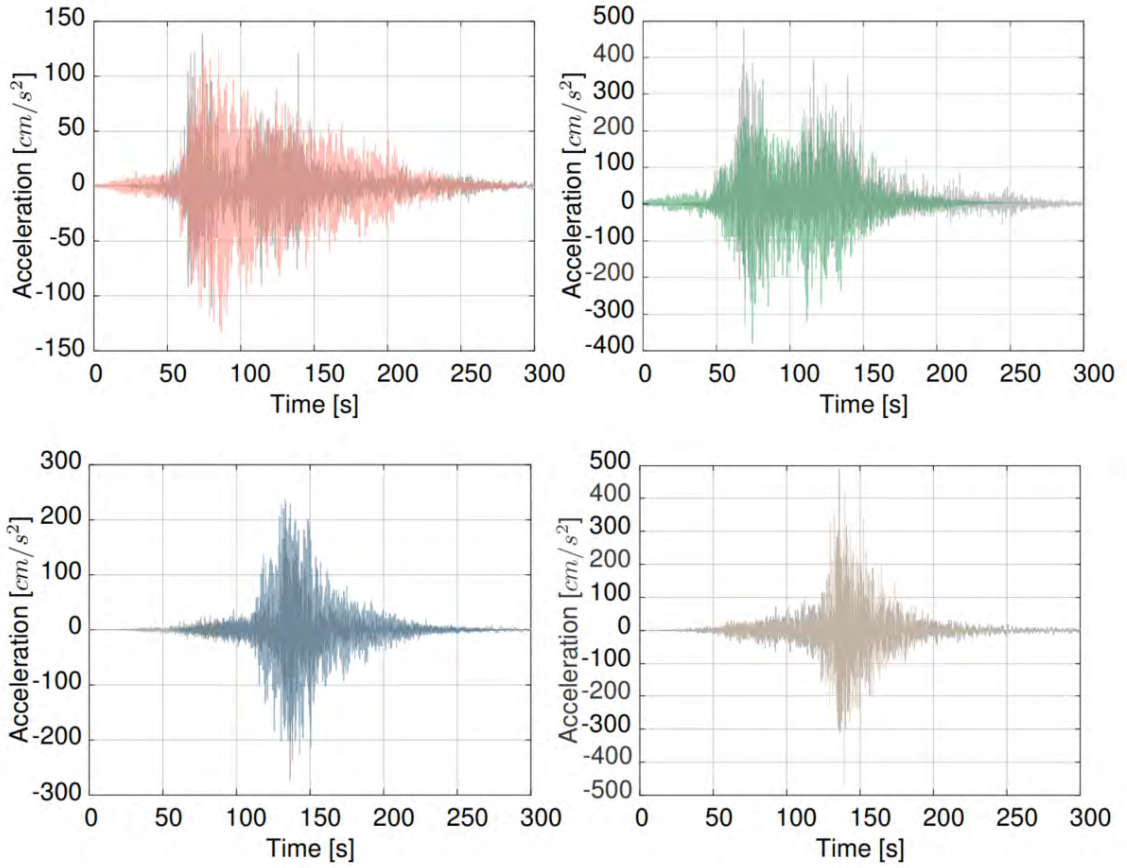


Figure 3: Corresponding time history of seismic accelerations for Iwate (top) and Kasumigaura (bottom) at borehole (left) and surface (right) levels due to Japan 2011 earthquake. Black line correspond to recorded data, colorful lines are numerically reproduced accelerations.

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Progress report III: Simulations of tsunami inundation

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02 December 2022

Abstract

The present document aims to summarize the main progress of the IST team from the aspects of tsunami inundation simulations. Section 1 describes the assembling process of the topo-bathymetric that was constructed to conduct the numerical simulations. Section 2 describes physical, modeling and numerical conditions adopted to perform the simulations of tsunami propagation and inundation stages. Section 3 resumes tsunami numerical solutions of tsunami inundated regions. Section 4 lists future works regarding tsunami interaction with Start-Campus delimited region.

1 Topo-bathy site conditions

The data proficiency included bathymetry data with $450\,m$ of spatial resolution acquired from the General Bathymetric Chart of the Oceans (GEBCO) and vector data of the Sines port area with contour interval of $5\,m$ provided by the Hydrographic Institute (IH). For topography data was used the European Digital Elevation Model (EU-DEM) with $30\,m$ of spatial resolution from the Copernicus Land Monitoring Service, which is part of the European program Copernicus for Monitoring the Earth.

The operations of assembling the bathymetric grids and Digital Elevation Models (DEM) were accomplished through raster data processing using math, image mosaicking, merging operations, among others. To support compatibility procedures were also developed intermediate raster surfaces. All the operations described bellow were carried out by the ArcGIS Pro software, licensed from the ESRI company.

Data from GEBCO and EU-DEM model were sectioned to define the study area of Sines port and then re-sampled to the same spatial resolution (in this first essay, a $30\,m$-resolution

was adopted) to assure compatibility on next operations. Similarly, the IH bathymetric vector data was also processed to complement the topo-bathymetric grid of the port area.

To add the terrain altimetry information, and considering the lack of relief information of the IH bathymetric grid, raster math calculations (plus and minus) were performed between IH grid and EU-DEM. Then the two surfaces were merged using a raster mosaicking tools while maintaining the same spatial resolution referred above.

For the final purpose of complementing the GEBCO grid via integration on the previous merged data, some additional operations were performed to overcome the differences between the two bathymetric references. First, it had been chosen and collected bathymetric information in the intersection areas (of around $400\,m$ width) of the two grids (GEBCO and IH). For those areas, a low pass filter (focal statistics) was applied to attenuate the bathymetric differences. The filter calculated a statistic (the mean) for all input cells contained within a specified neighborhood around it. The information was then converted into a grid of points, which were subjected to the Triangular Irregular Network algorithm (TIN). The interpolation technique conducted to a new raster surface of that intersection area. Finally, all data sources (GEBCO, EU-DEM, IH and the intersection generated raster surface previously described) were merged and converted into a resulting grid of points. A new interpolation accounting all grid points produced a new global TIN of the sectioned area of study. Then a new raster surface was generated to model the final topo-bathymetric raster grid for the further tsunami simulations. Fig. 1 depicts the final grid.

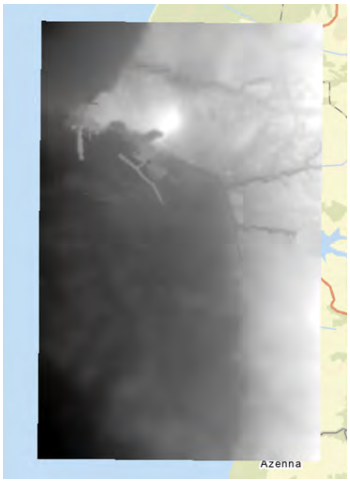


Figure 1: Merge of IH bathymetric data and EU-DEM elevation data on GEBCO.

2 Simulations of tsunami inundation

The simulations of tsunami propagation and inundation were performed using a well-balance numerical scheme using Finite Volume method to solve the non-linear system of Shallow-Water equations (Clain et al., 2016; Reis, 2019). The simulations adopted mean sea conditions to set the level reference (free surface elevation $\eta = 0\,m$). Environmental time-dependent effects, such as sea-level variations due to tides or climate changes, and geotechnical failure were neglected.

The simulation running over the compiled grid of topo-bathymetric data was set to reproduce a minimum of three tsunami inflow-outflow stages ($t_{sim} = 7200\,s$).

3 Numerical solutions

The numerical solutions of tsunami inundation at Sines were assessed for 10 scenarios (sources at GBF, MPF and HSF, and SVF, MPPSF, MPHSF, MPPBF, WIS). Fig. 2 depicts the results.

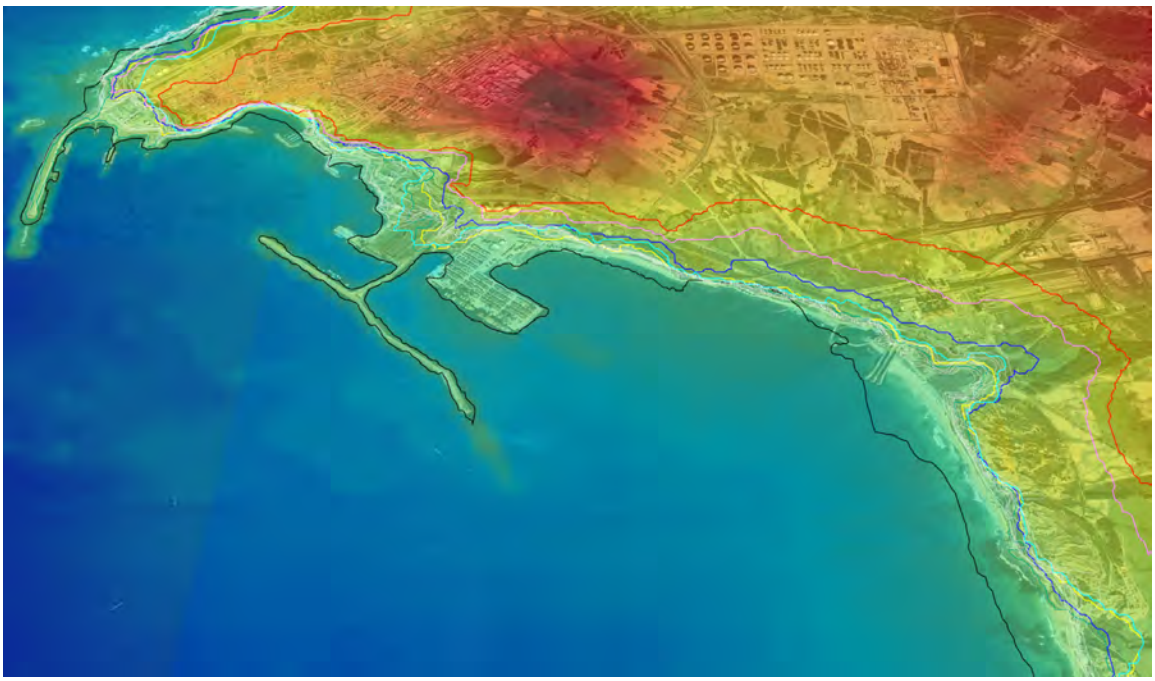


Figure 2: Scenarios of tsunami inundation at Sines site.

The simulations show most of scenarios inducing tsunami inundation along the entire

Sines coast. Three of the scenarios demonstrated inundation potential for StartCampus site due to the combination of tsunami behavior and natural conditions.

The solutions were presented during the 28^{th} november 2022 meeting between Start Campus and IST. After a discussion on reasonable tsunami design considerations, the scenario using initial conditions proposed by Wood et al. 2009 Wood and Mignan (2009) (composite rupture of the Marquês de Pombal and Portimão bank faults) represented by the magenta line was selected for further characterization.

4 Future works

Following the road-map defined over the last meeting (28nov), the next deliverable will comprehend the design loading pattern of cascading earthquake and tsunami actions referring to the 'magenta scenario' in terms of peak values.

To perform the tsunami simulation an upgraded high-resolution topo-bathymetric and surface data representing the buildings and critical structures of the Data Centre will be used.

Mean and high sea levels will be considered to reproduce the tidal effects. The following phase entails simulating the run-up in the sea-level conditions of year 10 considering the sea level rise expressed in the anomaly maps of NOOA for 2032, and bottom friction.

The computation will be performed to assess tsunami inundated areas and respective tsunami quantities, such as free-surface elevation, η, flow velocity, u and momentum flux, M_F, captured by virtual gauges, VG, implemented near shoreline and at StartCampus delimited area:

- along a $1.5\,Km + 1.5\,Km$ profile of Sines near shore and up to Start Campus property, respectively, and
- detailed over a dry-wet interface using VG with regular distribution spaced $5\,m$ apart.

The corresponding seismic acceleration will be verified (if accordance with recommendations already provided in Report II, 15oct) using GMPE approach.

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Progress report IV: Tsunami quantities

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28 December 2022

Abstract

The present document aims to summarize the main progress of the IST team from quantitative aspects of tsunami. Section 1 describes the assembling process of integrating the main structures into topo-bathymetric data used to conduct the numerical simulations. Section 2 describes the scenario-based simulation of tsunami. Section 3 resumes tsunami quantities acquired at strategic locations to characterize tsunami inundation. Section 4 introduces the US regulatory approach recommended to assess tsunami hydrodynamic loads. The strategy is applied to characterize the tsunami loads exerted on NEST building due to the selected scenario. Section 5 characterizes the seismic acceleration inherent to the selected scenario. Finally, Section 6 resumes the tasks completed in the framework of the previously defined Modules, enabling to identify the standing-point at the moment and discussion about possible future developments.

1 Topo-bathy site conditions

Following the data generation and assembling grids operations, previously described, the next stage had the purpose of integrating the Digital Terrain Model (DTM) and Digital Surface Models (DSM) representing the future NEST datacenter area, as well as, all the relevant and considered critical surrounding infrastructures, namely the buildings of the recently deactivated thermoelectric central of Sines. Therefore, this additional data will bring new and fundamental elements to the new simulations of tsunami inundation.

Thus, and regarding the production of the DTM of the NEST datacenter area, it has been used the topographic survey of the area, that was requested and provided by Start Campus. In an early stage, the topographic information had to be updated, on adding to all height elements featured, the respective altimetric information. Thereafter, the altimetric data collected was then interpolated using the Triangular Irregular Network

algorithm (TIN), and subsequently was produced the DTM of the interest area referred above. Alongside, and based on several information documents and drawings of the future NEST datacenter location, there were implemented (on planimetric and altimetric levels) the main buildings, as other critical infrastructures that will be operating in the campus. However, in this task the main sewerage and refrigeration circuit pipes, as the ditch coal were not yet taking into account. So, once more, a new TIN of this elements was generated and then produced a DSM of the campus area. Finally, the DTM and DSM previously produced were then merged, and converted into a new raster surface.

Concerning the data of all the other relevant surrounding infrastructures (including the deactivated thermoelectric central), it was collected using researched documentation on the internet and satellite images, through web environments like Google Earth and ESRI basemaps. Moreover, after the identification of the main buildings and other infrastructures, they were implemented both on planimetric and altimetric tiers respectively. In the same way, a TIN of these elements was then generated and produced another DSM of all the infrastructures and main buildings. Furthermore, this DSM was then merged with the European Digital Elevation Model (EU-DEM) and converted in another raster surface.

Alongside to the previous section, all the data sources (GEBCO, EU-DEM, IH, intersection raster surface between IH and GEBCO, NEST area surface and the surrounding buildings surface) were then merged and converted into grid points.

Similarly, it has been made a new interpolation through all the points producing a new global TIN. After the TIN creation, a new global raster surface was generated, providing the final raster grid, with all the DSM elements.

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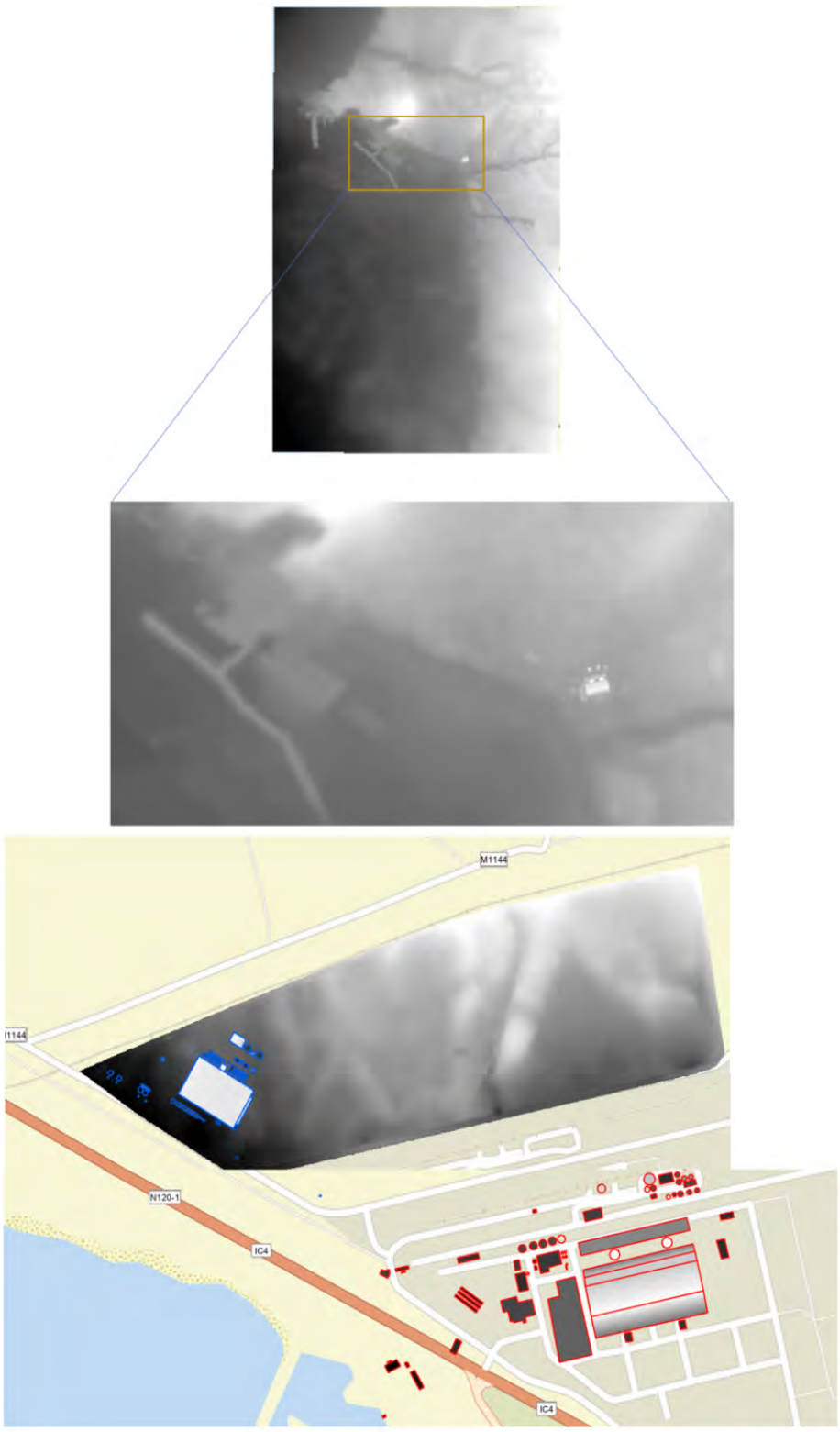


Figure 1: NEST area DTM and DSMs of the NEST, thermoelectric central and surrounding buildings.

2 Simulations of tsunami inundation

The simulations of tsunami propagation and inundation were performed using a well-balance numerical scheme using Finite Volume method to solve the non-linear system of Shallow-Water equations (Clain et al., 2016; Reis, 2019). The simulations adopted mean sea and high sea conditions. For the latter, a value of $2\,m$ was defined before carrying out the simulations. The simulation time was set to $t_{sim} = 7200\,s$ to capture inflow and outflow stages of tsunami.

Virtual gauges (VG) were strategically scattered near shoreline, in both offshore and inland directions, to capture hydrodynamic quantities of tsunami. For the sake of clarity, Fig. 2 depicts the configurations of the VG positions along profiles of topo-bathymetry. Yet, ten complementary VGs were implemented in the last cell before the frontal façade of NEST building.

3 Numerical solutions

The numerical solutions of tsunami inundation at Sines were assessed for the previously selected scenario (magenta line computed using previous version of topo-bathy data), considering the composed rupture of Marquês de Pombal and Portimão bank faults proposed by Wood and Mignan (2009) to generate the tsunami initial conditions. Fig. 3 depicts the numerical solutions of tsunami inundation, considering tidal mean- and high-sea levels.

The tsunami travel time was estimated in $1500\,s$, $25\,m$ after rupture of the faults. The MSL scenario induces values ranging from $1.25\,km$ to $1.75\,km$ of maximum run-up, while HSL presents $1.25\,km$ to $2.05\,km$ of maximum run-up (measured from mid-point of StartCampus front edge projected on shoreline).

The profiles of maximum inundation depth were then determined for profiles A, B and C identified in Fig. 2. Fig. 5 represents the maximum inundation depths along profiles A, B and C.

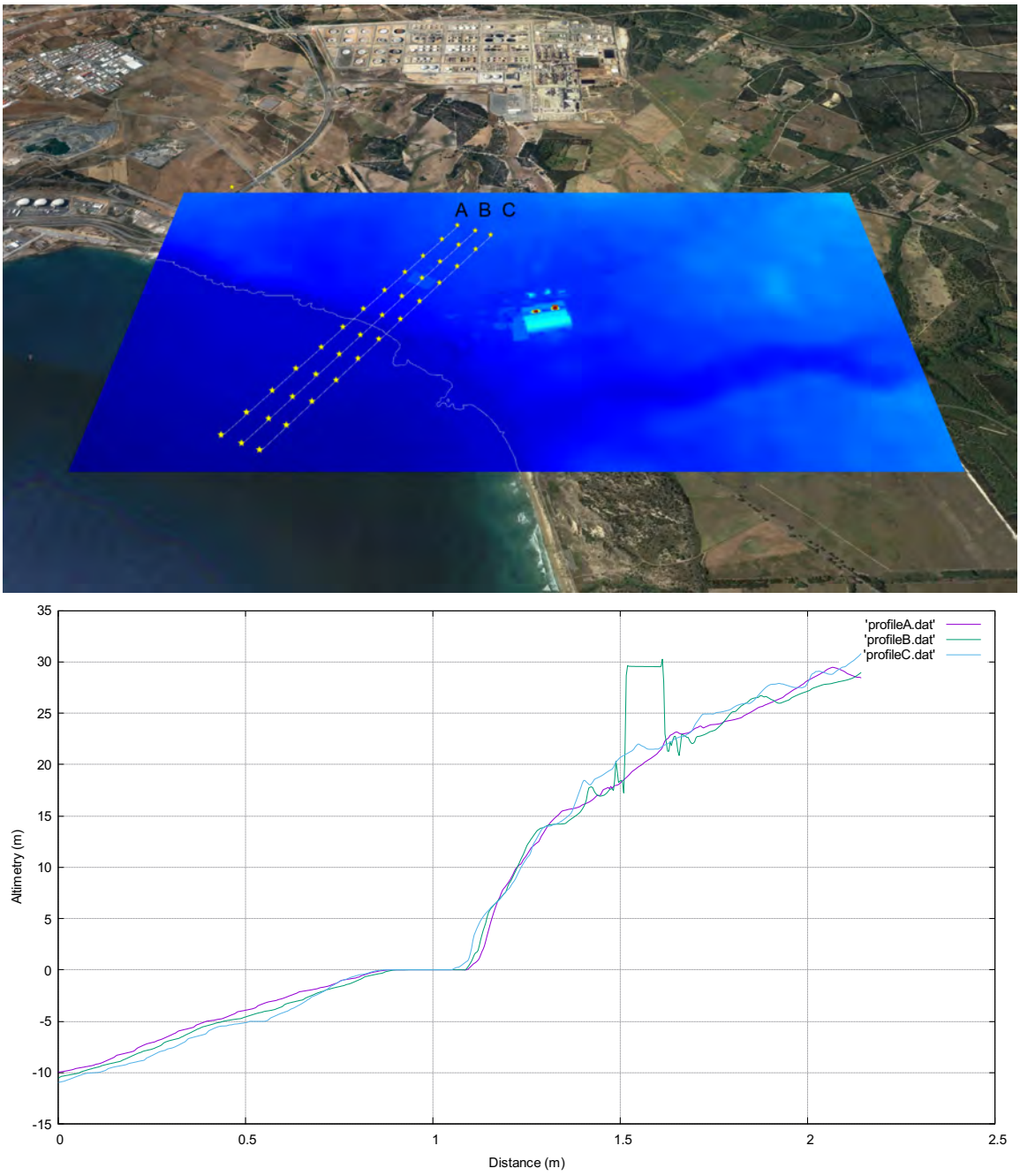


Figure 2: Locations of the VGs to capture tsunami quantities at Start Campus site (top) and topo-bathymetry of A, B and C profiles (bottom).

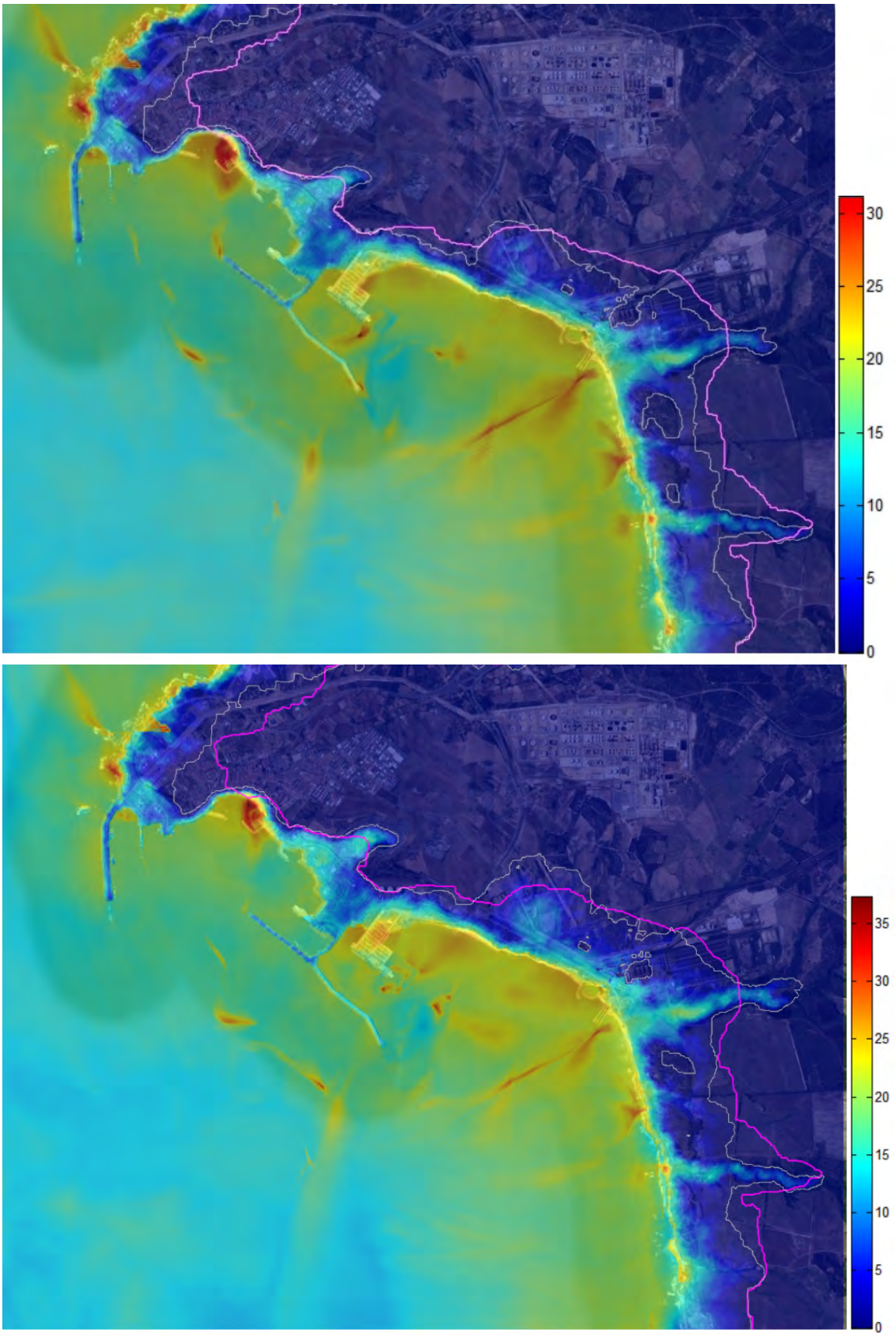
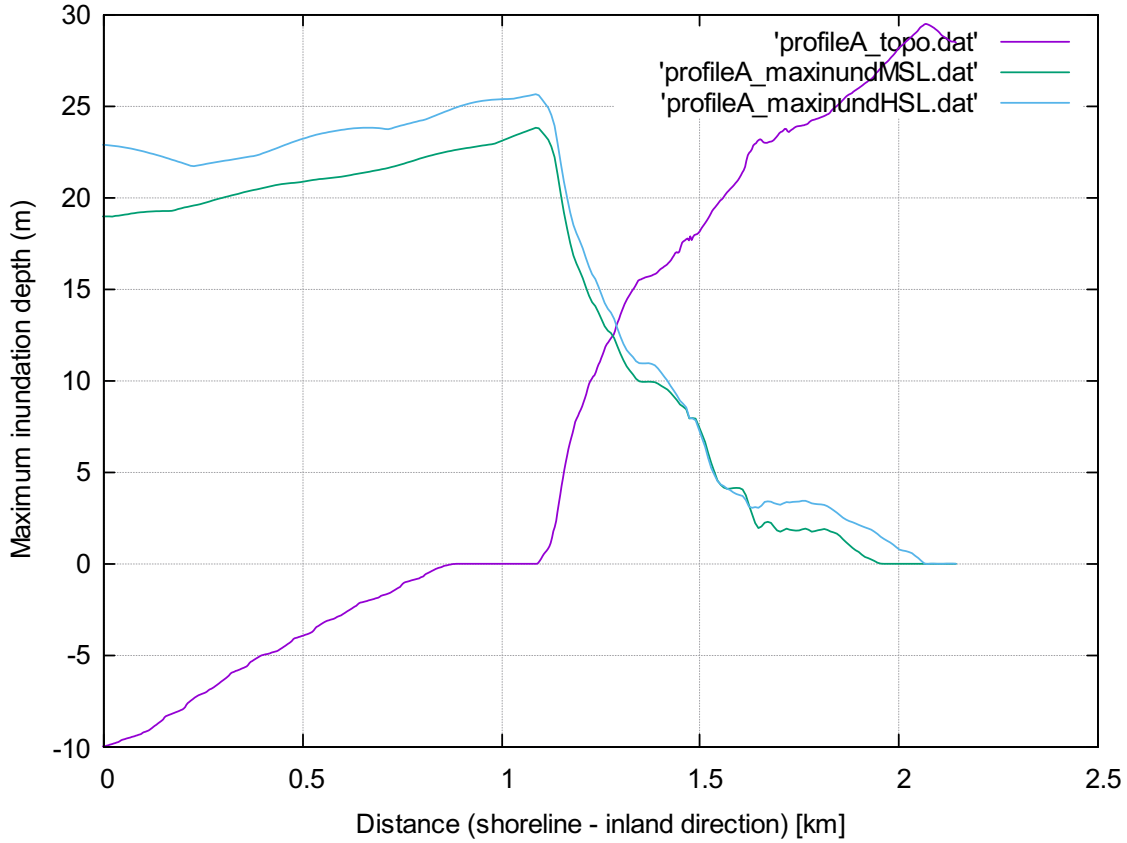


Figure 3: Areas of inundation considering mean- (top) and high-sea level (bottom) considerations. Magenta line represents previous simulation solution.



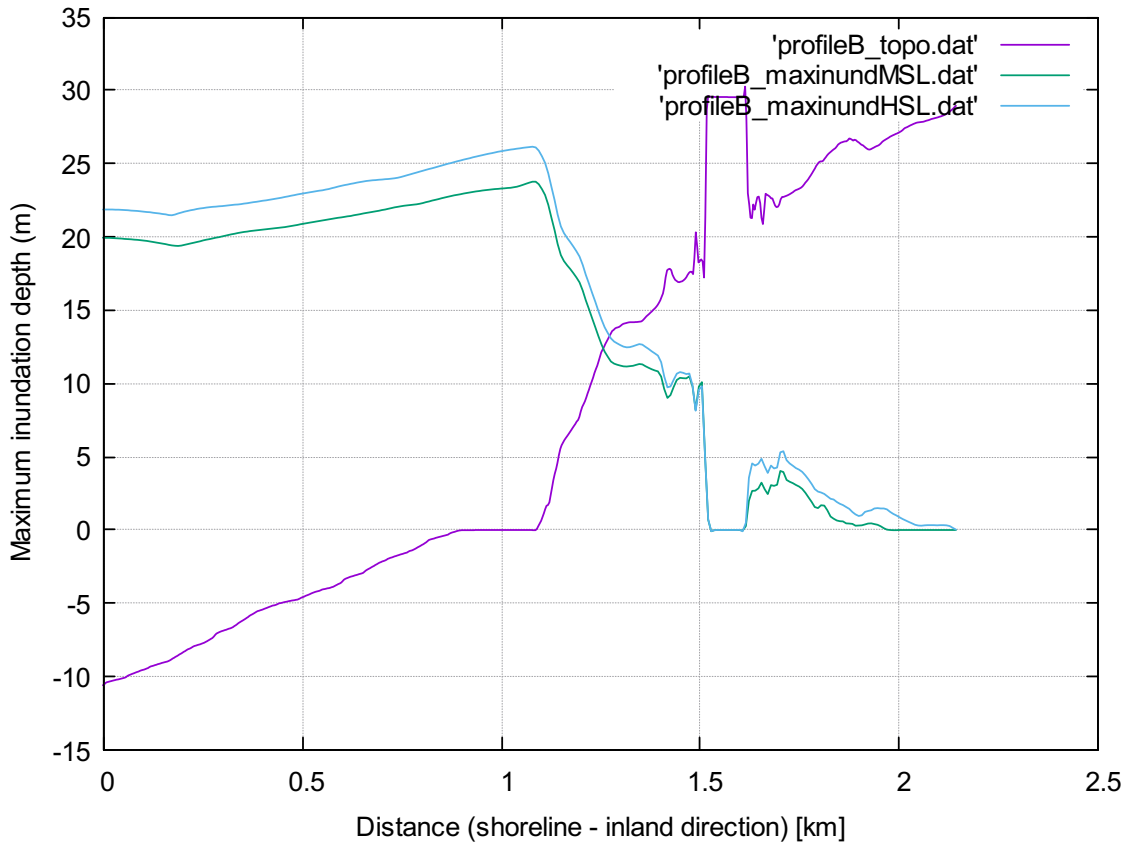


Figure 4: Topo-bathymetric conditions and maximum inundation depth at profiles A, B and C, considering characteristic inundation for MSL and HSL scenarios. Cont.

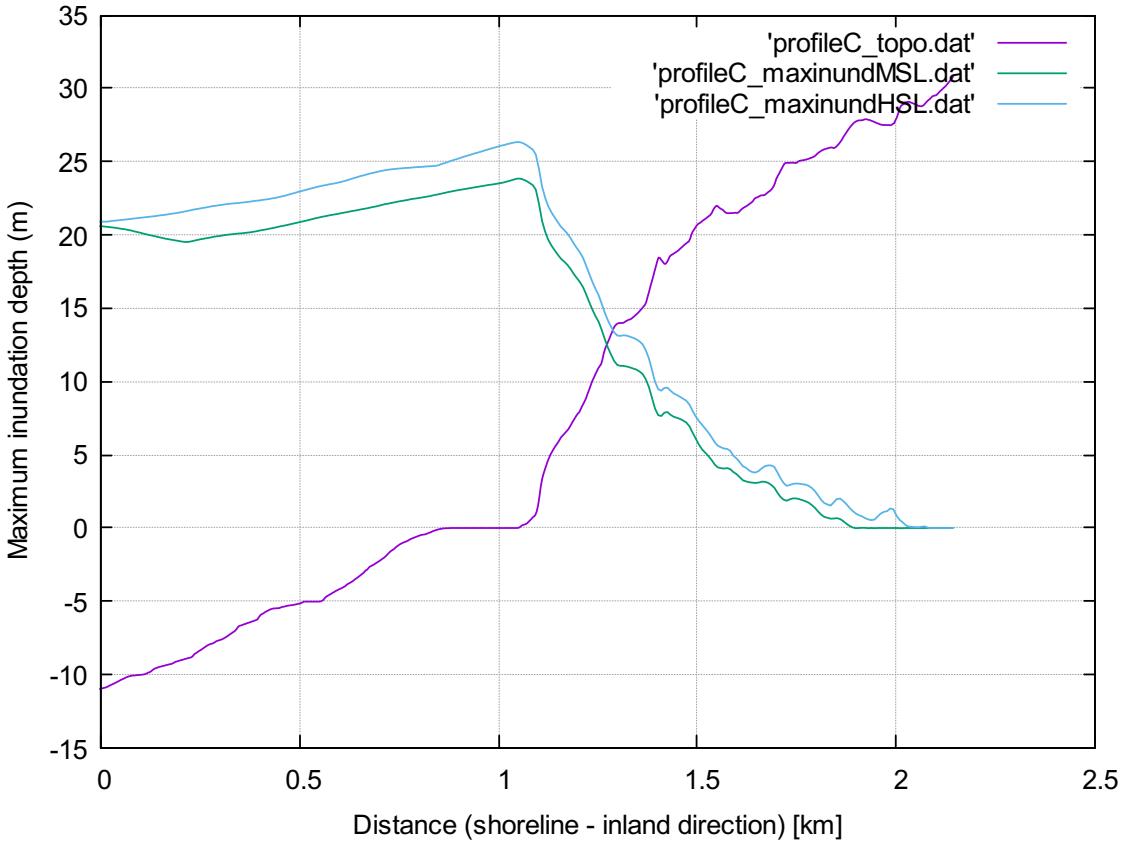


Figure 5: Cont.: Topo-bathymetric conditions and maximum inundation depth at profiles A, B and C, considering characteristic inundation for MSL and HSL scenarios.

4 Tsunami hydrodynamic force

Since 2016 that the North American design standards developed by the American Society of Civil Engineers (ASCE) includes a chapter dedicated to tsunami loads. The 6^{th} chapter of the *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* American Society of Civil Engineers (2016) recommends approaches to assess *Tsunami Loads and Effects*. For tsunami-prone regions, depending on the level of importance of the structure, simplified Energy Grade Line analysis or semi-analytical approaches are recommended to assess tsunami forces on the coastal structures within tsunami-prone regions.

The latter, for higher levels of importance, is based on Bernoulli's Principle, which is related to the conservation of energy, the pressure, flow height and velocity are correlated such that the sum of internal, kinetic and potential energy remains constant along a streamline of the fluid. The potential energy is directly related to the hydrostatic component of the force, where as the kinetic energy relates to the hydrodynamic component of the force Reis et al. (2021). The tsunami force exerted on the NEST building is calculated using Eqs. 1 and 2, which adopt empirically calibrated coefficients to represent potential influences on the tsunami flow.

The hydrodynamic force applied on the horizontal direction is derived from the maximum flux momentum and is given by Eq. 1.

$$F_{dynamic} = \frac{1}{2} I_{tsu} \rho C_d B (hu^2)_{max} \tag{1}$$

where $\rho = 1025\, kg/m^3$ is the density of seawater mass, I_{tsu} is a tsunami importance factor accounting with the category/level of importance of the structure being designed (I_{tsu} = 1.25 to 1.5 for structures in category IV), C_d = 1.75 is the drag coefficient (ASCE recommendation, function of ration between building width and inundation depth), B = $103.5\, m$ the characteristic width of the solid subjected to the action of the fluid and hu^2 is the momentum flux. The hu^2 was calculated using quantities computed for the stream-wise direction at different VG in the vicinity of the NEST building, as represented in Fig. 2 for MSL and HSL scenarios represented in Fig. 3.

The hydrostatic force applied on the horizontal direction is function of inundation depth,

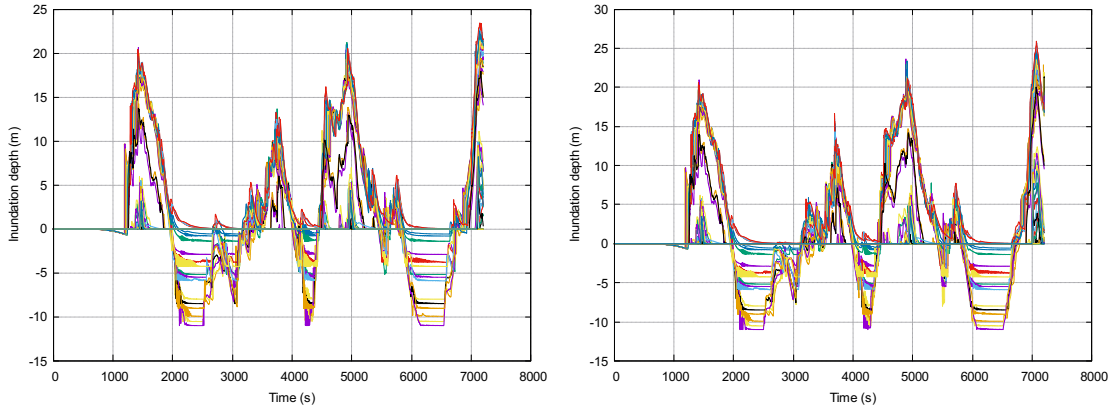


Figure 6: Time-histories of inundation depth capture by all VGs.

given by Eq. 2:

$$F_{static} = \frac{1}{2}\,\gamma\, b h_{max}^2 \tag{2}$$

where $\gamma = 1.13\,kN/m^3$ is the seawater specific weight density accounting with suspended solids and debris flow-embedded smaller objects, b width of object subjected to force and h is tsunami inundation depth above grade plane at the structure.

The calculation of the peak forces using the semi-empirical analytic approach (Eqs. 1 and 2) rely on identifying the maximum inundation depth and corresponding instant. The time-histories of tsunami inundation depth at the various VGs surrounding the NEST building (represented in Fig. 2) were computed to aid on the identification of that instant, for both MSL and HSL conditions. The tsunami hydrodynamic quantities at $t = t_{peak}$ were then used to infer the values of $F_{dynamic}$ and F_{static}. Fig. 6 depict the time histories of tsunami inundation depth computed at all VGs scattered along profiles A, B and C, for MSL and HSL conditions.

Two main aspects are highlighted by Fig. 6. The first observation is the first wave arriving to shoreline, about $0:25\,h$ after the earthquake, not being the highest wave. An $1:25\,h$ after the earthquake a wave slightly higher than the first is still smaller than the highest one verified $2\,h$ after being generated by the composite faults rupture.

The second observation from the extreme scenario considering a combined MPPBF faults rupture are that waves of about $20^{+}\,m$ can be expected to arrive nearshore the Start Campus location. After the shoreline, the abrupt topography variations towards Start

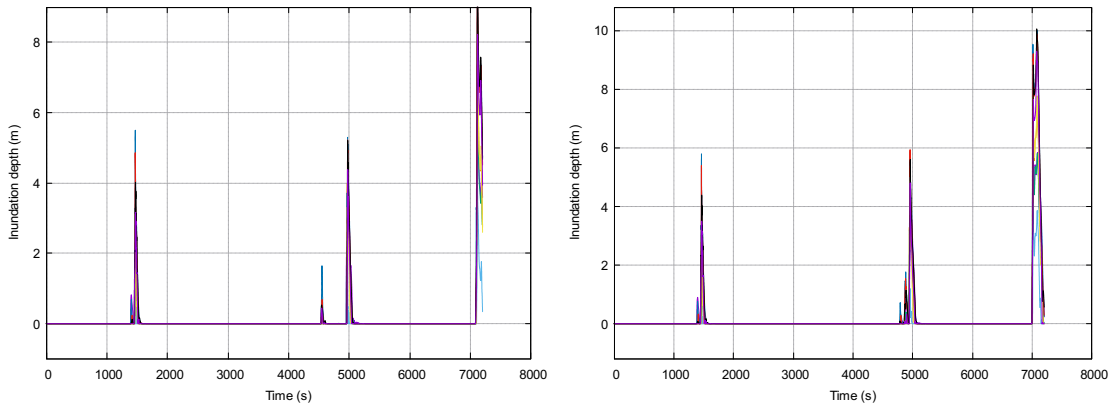


Figure 7: Time-histories of inundation depth capture by VGs implemented in front of NEST building.

Campus hub (see Fig. 2, from $0\,m$ at the beach up to about $20\,m$ at Start Campus in only about half a kilometer), contributes to reducing the tsunami threat at the Start Campus property. For MSL conditions, the inundation depths in the frontal façade of the NEST building are up to $8.5\,m$ and up to $10\,m$ for MSL and HSL conditions, respectively. Fig. 7 depicts the inundation depth at NEST building.

The tsunami peak forces are then calculated adopting Eqs. 1 and 2 and using the peak hydrodynamic quantities. For MSL (Eq. 3), at $t_{sim} = 7100\,s$, values of $8,5\,m$ for peak inundation depth have corresponding flow velocity of $3.5\,m/s^2$, resulting into a peak force of $\approx 185kN$ per longitudinal meter of the building (B). For HSL (Eq. 4), at $t_{sim} = 7100\,s$, values of $10\,m$ for peak inundation depth have corresponding flow velocity of $3.0\,m/s^2$, resulting into a peak force of $\approx 185kN$ per longitudinal meter of the building (B).

$$\begin{cases} F_{dynamic} = \frac{1}{2} \times 1.5 \times 1.025 \times 1.75 \times 8.5 \times 3.5^2 \times B \\ F_{static} = \frac{1}{2} \times 1.23 \times 8.5^2 \times B \\ F_{total} = F_{dynamic} + F_{static} \approx 185B \end{cases} \tag{3}$$

$$\begin{cases} F_{dynamic} = \frac{1}{2} \times 1.5 \times 1.025 \times 1.75 \times 10 \times 3.3^2 \times B \\ F_{static} = \frac{1}{2} \times 1.23 \times 10^2 \times B \\ F_{total} = F_{dynamic} + F_{static} \approx 208B \end{cases} \tag{4}$$



Figure 8: Distribution of PGA.

5 Seismic PGA

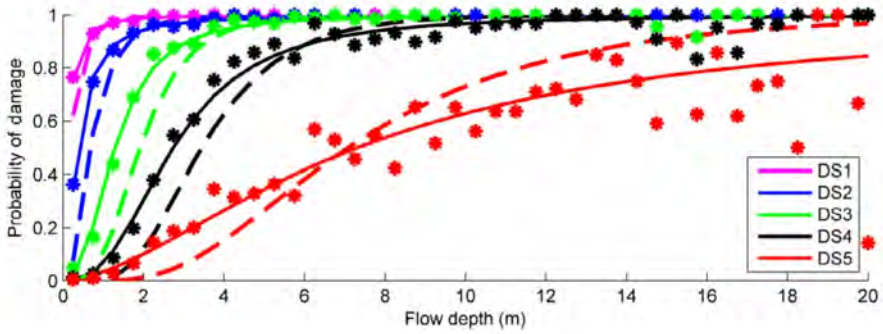
The PGA value was previously estimated for Sines neglecting the site influences posed by the type of soil. In Report II (15October2022), a rocky nature was associated to the soil of Start Campus hub. To investigate possible missing amplification factors, the model was re-evaluated with the soil characteristics described in the project narrative. the geotechnical conditions refer a (top-to-bottom order) a $3.6\,m$ layer of 8 to 19 NSPT of sand and $0.15\,m$ to $0.40\,m$ layer of organic soil, an $11\,m$ layer of dense sand with NSPT between 12 and 48, up to a rigid formation of NSPT greater than 60. The new results show PGA values between $0.46\,g$ and $0.61\,g$ (see Fig. 8).

6 Future works

After our last meeting, the priorities were established to define a cascading seismic and tsunami loading. At this point, a static characterization of cascading design loading pattern is provided for NEST building: PGA between $0.46\,g$ and $0.61\,g$ and average $F \approx 200\,kN.m$.

Currently, lacks data to introduce the implementation of the new buildings on the topographic data. Such data is needed to perform a similar analysis to infer the tsunami

loads. However, the seismic design considering the PGA value between $0.46\,g$ and $0.61\,g$ is most likely sufficient to withstand tsunami forces induced by inundation depth under $1\,m$ (assessed via some brief estimates, but neglecting the group effects of the buildings implementation). For example, the surveu after the 2011, Japan tsunami showed that from all damaged buildings, 2.62% were RC buildings. Fig. 9 depicts the corresponding fragility curves of RC buildings as defined in by Suppasri et al. 2015 Suppasri et al. (2015) using the damage state classification proposed by the Japanese Ministry of Land, Infrastructure, Transport and Tourism.



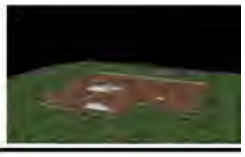
Damage State (*Survey*)	Classification	Description	Condition	Illustration
DS1	Minor damage	No significant structural or non-structural damage, only minor flooding	Possible to use after minor floor and wall cleanup	
DS2	Moderate damage	Slight damage to non-structural components	Possible to use after moderate reparation	
DS3	Major damage	Heavy damage to some walls but no damage in columns	Possible to use after major reparations	
DS4	Complete damage	Heavy damage to several walls and some columns	Possible to use after complete reparation and retrofitting	
DS5	Collapse	Destructive damage to walls (more than half of wall density) and several columns (bent or destroyed)	Loss of functionality (system collapse). Non-repairable or great cost of retrofitting	
DS6	Washed away	Washed away, only foundations remained, total overturn	Non-repairable, requires total reconstruction	

Figure 9: Fragility curves of RC buildings function of inundation depth.

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