Annex 3

Site Studies

Macao Solar Installation

REVISION HISTORY

Revision Level	Change Summary	Elaborated by	Approved by	Date

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GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE

Project ID: IG1827106
Client: Trina Solar
Consultant: GMS Internacional, SL

Edition	Date	Version	Revision Purpose	Written	Reviewed	Approved
1ª	01/04/2020	0	First issue of the report	J. Flores R. Rayo A. Galindo	A. Martínez	JP Singer

GEOTECHNICAL FINAL REPORT

PV PROJET MACAO, CHILE

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Re: Geotechnical Final Report PV Project Macao, Chile.

GMS Internacional, SL. has completed the Geotechnical Final Report PV Macao, Chile, for the project referenced above.

These services were performed in general accordance with the scope agreed with the client in "*P19_259_GMS_TrinaChile_Macao 18Ha_GEO_v.0_BoQ".*

This report presents the scope and results of the surface and subsurface exploration, provides preliminary assessment concerning the ramming depth and pull-out soil resistance for piled foundations as well as shallow foundation design and general recommendations with regards to the foreseen civil engineering works to be performed on site.

Kindly let us thank you in advance for the opportunity to be of service to Trina Solar on this project.

Please do not hesitate to contact us should you have any further questions regarding this report, or if we may be of further assistance.

GMS Internacional, SL

EXECUTIVE SUMMARY		
Chapter	***Summary***	***Section***
Site Address	The Project is in Talagante Province, Santiago Metropolitan Region in Chile.	2
Geological Settings	Survey area presents Mesozoic and Quaternary ages rocks. The project is located at Pleistocene-Holocene ages deposits, basically mixed fans of alluvial and fluvioglacial deposits with intercalations of volcaniclastic material (SERNAGEOMIN, 2006).	3.3
Geomorphology and Hydrology	Maipo river flows throughout 250 kilometres from its springs towards Valparaiso Region, entering in the Pacific Ocean southern of San Antonio port. At the time of undertaking the survey the site was fully cropped and no outcrops were tested nor geomorphological conditions assessed.	3.4
Seismic Conditions and liquefaction	According to official Chilean standard (*NCh 4.33 of 1996 modified in 2009*), the peak ground acceleration for the site is 2.94 m/s2, and it lays within the '2 Type' seismic zone.	3.5
Field works undertaken	12 Variable Energy Dynamic Cone Penetrometer (Panda2) 12 Trial Pits 24 pull-out tests at 12 test locations 4 Vertical Electrical Sounding (VES´s) 4 Thermal resistivity tests 5 CBR testing in situ (Panda2) 12 Laboratory samples	4.1
Ground Conditions Encountered	A description of shallow stratigraphy indicates two different areas with a rather uniform layering with layer depth and/or composition variations. The upper layer is a clayey SAND or a Sandy CLAY Its thickness is around 0.20-0.80 m. At the majority of the site, topsoil is underlain by a GREVELLY layer with boulders. A clayed layer may or may not show.	4.1.1

	Water table was found at around 3m depth in a couple of trial pits.	
Geotechnical tests, and Pull-Out tests. **Laboratory tests**	In order to assess the in-situ soil strength, 12 variable energy dynamic cone penetrometer tests (Panda2) were performed across the site to aid in the classification of soil type as well as the design of the pile foundations. Panda2 were performed close to the locations of trial pits, in order to allow for the identification of soil layers and enable the direct strength correlation for geological layers. Panda2 tests tip resistance is below 10 MPa from 0.00 to 0.5 m depth. Then the gravelly layer starts, and tip resistance increases to refusal in some tests. In other tests it keeps low until 1m depth.	4.1.2 – 4.1.6.
Geotechnical Assessment	<u>Shallow foundations:</u> The shallow foundation analysis was performed; loads and dimensions used are based on inhouse experience since no design information was provided at this stage. Based on the present analysis the **soil has sufficient capacity to support the loads assumed herein**. Please, keep in mind that bearing capacity results are only valid as long as recommendations herein are followed <u>Pile foundation and rammability analysis:</u> Pull-out tests were performed and showed that for the C150 pile horizontal tests failed. Furthermore, pile refusal was found in most piles before reaching scheduled depths due to presence of gravel layer. If C150 piles are to be used during construction, it is advised that predrilled holes are excavated, then filled in clean gravel. Finally, piles should be driven inside the hole up to desired depths. Alternatively ground improvement should be carried to clean uppermost softer layer and replace by improved layer that would support horizontal displacements. Finally, a larger pile (e.g.e IPE160) may be used instead. Such pile would be driven to scheduled ramming depths without predrilling.	5

<table>
<tr><td>Road materials classification</td><td>Tested materials in the lab showed following AASHTO classification:
<table><tr><th>AASHTO classification</th></tr><tr><td>A-4</td></tr><tr><td>A-2-6</td></tr><tr><td>A-3</td></tr><tr><td>A-2-4</td></tr><tr><td>A-4</td></tr><tr><td>A-2-4</td></tr><tr><td>A-1-a</td></tr><tr><td>A-4</td></tr><tr><td>A-4</td></tr><tr><td>A-6</td></tr><tr><td>-</td></tr><tr><td>-</td></tr></table></td><td>7</td></tr>
<tr><td>Soil corrosivity</td><td><u>Aggressivity to metal piles</u>
According to NACE and geoelectrical corrosion classification, soils may be classified as CORROSIVE to VERY SLIGHTLY CORROSIVE.</td><td>8</td></tr>
<tr><td colspan="3">This summary should be read in conjunction with the following final report.</td></tr>
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FIGURES

TABLES

ANNEXES

1. INTRODUCTION

1.1. Project background

GMS Internacional, SL (the Consultant) has been hired by Trina Solar (the Client) to carry out a Geotechnical survey on the Macao PV solar project.

The location tests were performed according to the plot accessibility and Trina Solar Staff indications during the execution. The survey area location is shown in the **Annex 1**.

Then, the study goals and features of the project site are shown, and the field test are described. Base on field tests a final report has been issued, including field test results and geotechnical interpretation as well as construction recommendations.

1.2. Goals

Geotechnical investigation main goal is the solar PV farm project geotechnical characterization and to provide the necessary information for the design of foundations and construction of anticipated structures.

1.3. Scope of works

The geotechnical survey and tests have resulted in a Final Report which contains the following information:

a) Description of the geological and geomorphological features as well as the natural risks for the site;

b) 12 trial pits (TP) to 3 m as maximum depth or refusal. The trial pits have been logged and pictures taken by GMS International´s engineer, including the resistance in-situ tests execution for the purpose of evaluating the physical properties of the ground;

c) 12 Variable Energy Dynamic Cone Penetrometer (Panda2) tests, up to 3 m as maximum depth or refusal, for the purpose of collecting geotechnical information of the soil strength, as well as to recognize any soil strength variations within the project area;

d) 4 Vertical Electrical Sounding (VES) for the purpose of supporting in the underground electrical wiring and earthing design.

e) 4 Thermal resistivity tests (TH);

f) 5 CBR tests;

g) 24 Pull-Out tests (POT) on 12 test location points;

h) 10 samples collected to test physical and chemical properties in the lab.

i) Final geotechnical report including field data analysis, geotechnical assessment on solar PV foundations, rammability assessment & design ramming depth.

1.4. Alterations

The field works, laboratory and geotechnical analysis satisfied the initial specifications as set out in the scope agreed with Trina Solar (P19_259_GMS_TrinaChile_Macao 18Ha_GEO_v. 0_BoQ).

It should be noted that the field tests location and trial pits were carried out based on the accessibility for every point and the indications by Trina Solar's technical staff.

2. LOCATION AND DESCRIPTION SITE

The Project is in Talagante Province, Santiago Metropolitan Region in Chile.

Santiago borders with following regions: to the north and west with Valparaiso; to the south with O´Higgins and to the east with Argentina.

The solar PV project area is about 18Ha and it is located approximately 5.20Km to the southeast of Talagante city.

	Site Location	**Project:** IG1827106 **Date:** 01/04/2020	**Figure 1: Site Location of Macao Project**	

3. CLIMATIC SETTING, PHYSIOGRAFY, GEOLOGY, HYDROLOGY AND SEISMICITY

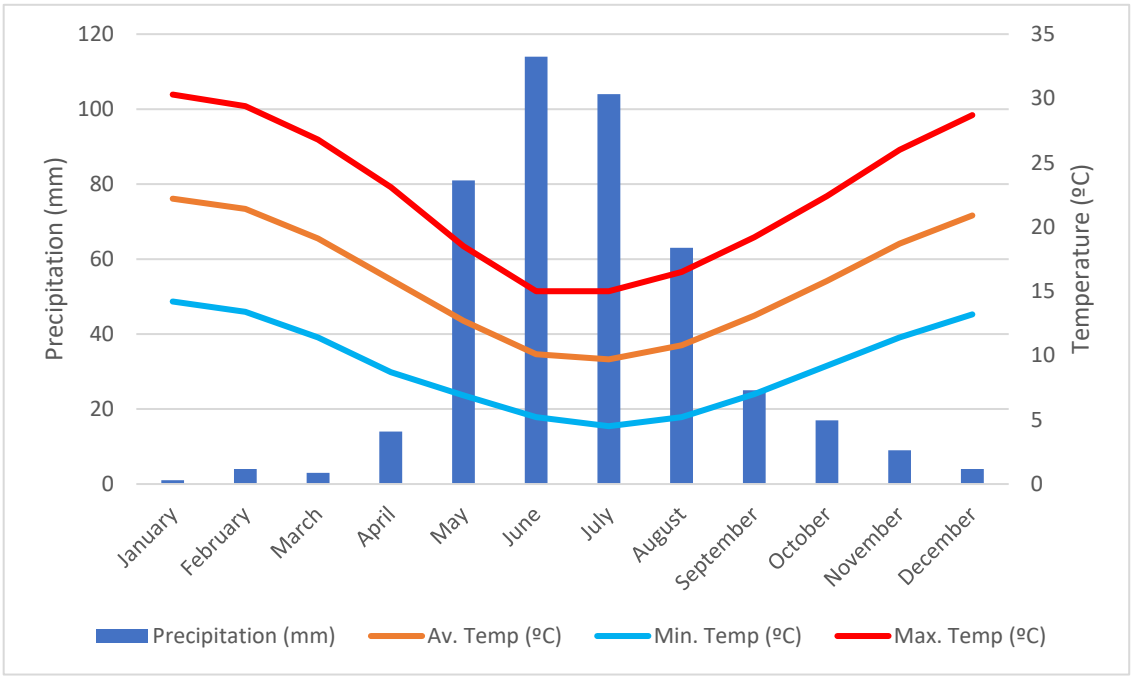
3.1. Climatic setting

The weather conditions in Talagante are generally warm and temperate. It is more rained in winter than summer. The Köppen-Geiger climate classification is **Csa**. The average temperature is 15.9°C and the average rainfall is 439mm.

January is the driest month, with precipitations of 1mm, otherwise, June is the rainiest month with an average of 114mm.

January is the hottest month of the year, with an average of 22.2°C, while July is the less hot with 9.7°C. average temperature.

*Data from Talagante Meteorological Station (Climate-data.org)

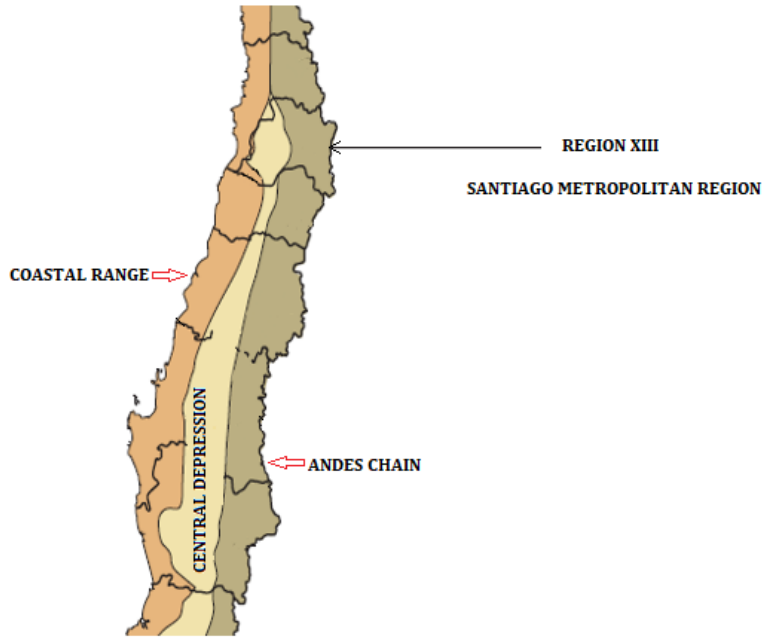


	Project: IG1827106 **Date:** 01/04/2020	**Figure 2:** Climatic setting of Talagante	

3.2. Physiography

Chile physiography is characterized by four land reliefs: Coastal Plain, Coastal Range, Central Depression and the Andes Chain.

The project site is in the Central Depression.

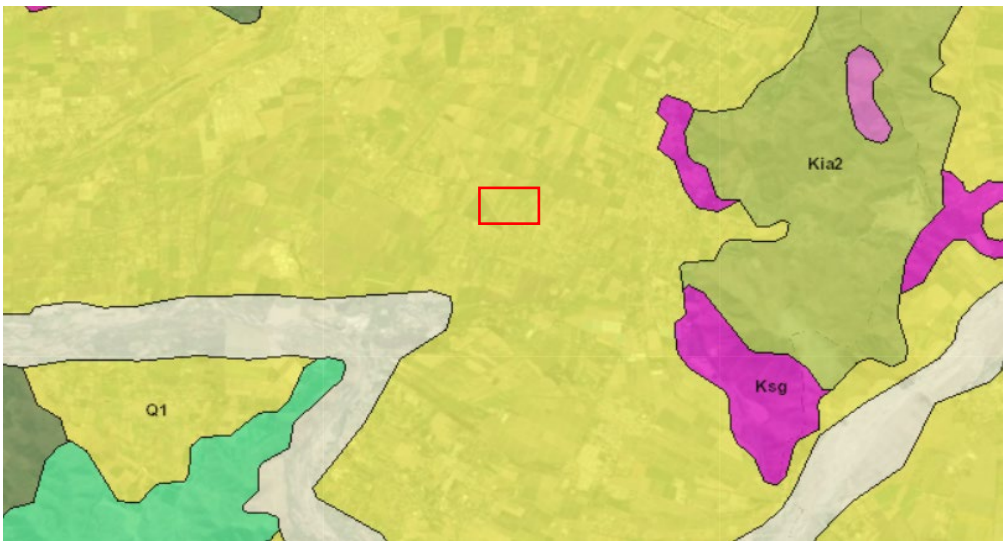


	Project: IG1827106 **Date:** 01/04/2020	**Figure 3:** Physiography of the site	

3.3. Geological Baseline Information

3.3.1. *Regional geology*

Survey area presents Mesozoic and Quaternary ages rocks. The project is located at Pleistocene-Holocene ages deposits, basically mixed fans of alluvial and fluvioglacial deposits with intercalations of volcaniclastic material (SERNAGEOMIN, 2006).



Q1
Pleistoceno-Holoceno
Depósitos aluviales, coluviales y de remoción en masa; en menor proporción fluvioglaciales, deltaicos, litorales o indiferenciados. En la Depresión Central, regiones Metropolitana a IX: abanicos mixtos de depósitos aluviales y fluvioglaciales con intercalación de depósitos volcanoclásticos.

Ksg
Cretácico Superior (90-65 Ma)
Monzodioritas, granodioritas, gabros y dioritas de piroxeno, biotita y hornblenda; pórfidos andesíticos y dioríticos. En la Precordillera, regiones I a III y entre las cordilleras de la Costa y Principal, regiones IV, V y Metropolitana; en la región XII: granitoides de las islas Wollaston y Navarino, Cordillera Darwin.

Kia2
Cretácico Inferior alto-Cretácico Superior bajo
Secuencias sedimentarias y volcánicas: rocas epiclásticas, piroclásticas y lavas andesíticas y basálticas con intercalaciones lacustres, localmente marinas. En la Precordillera y Cordillera de la Costa, regiones III a Metropolitana: formaciones Cerrillos, Viñita (occidental) y Las Chilcas.

Qf
Pleistoceno-Holoceno
Depósitos fluviales: gravas, arenas y limos del curso actual de los ríos mayores o de sus terrazas subactuales y llanuras de inundación.

Kia3
Cretácico Inferior alto
Secuencias y complejos volcánicos continentales: lavas y brechas basáticas a andesíticas, rocas piroclásticas andesíticas a riolíticas, escasas intercalaciones sedimentarias. En las regiones I y II: formaciones Suca, Punta Barranco y Estratos de Quebrada San Cristóbal; en la Cordillera Patagónica, región XI: Grupo Divisadero.

	Location:	**Project:** IG1827106 **Data:** 01/04/2020	**Figure 4:** Geology of the area	

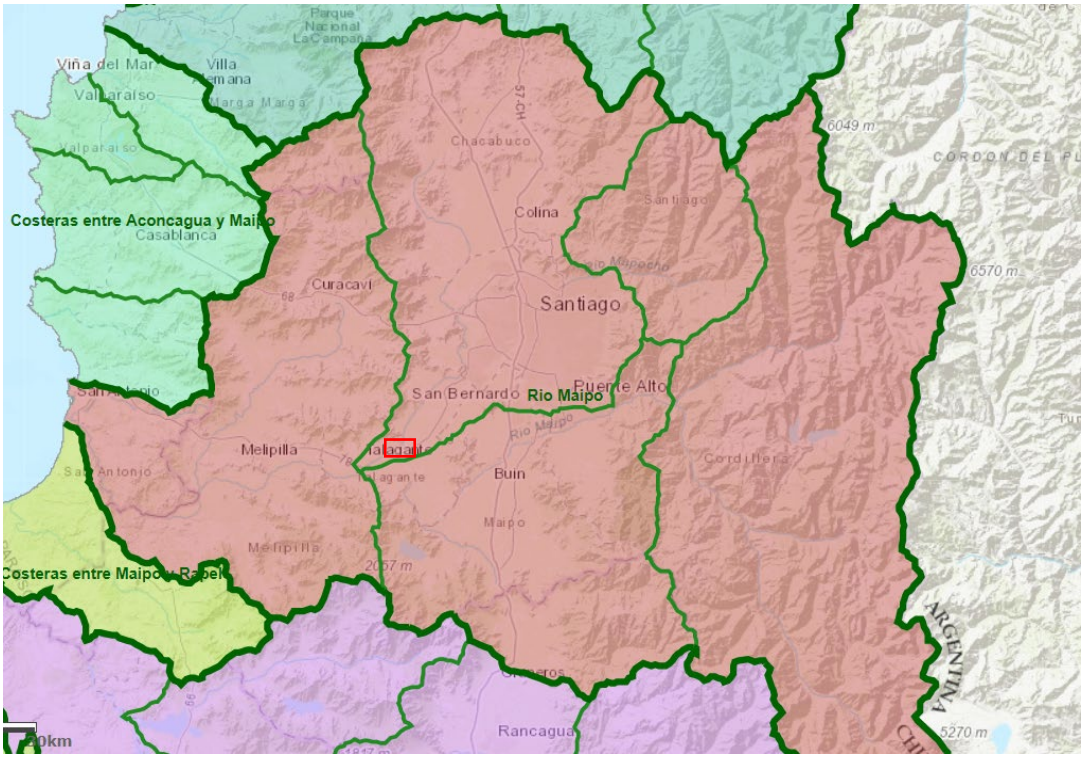
3.3.2. *Economic Geology*

Industrial, tourism and agriculture are important economic activities in the region. The main ground use is for cropping of fruits and vegetables. Mining is not an important activity, some minor mines are in Tiltil, Curacaví and Melipilla zones.

3.4. Hydrology

The survey area is in Maipo river basin, that covers approximately 15,274Km^2.

Maipo river flows throughout 250 kilometres from its springs towards Valparaiso Region, entering in the Pacific Ocean southern of San Antonio port.



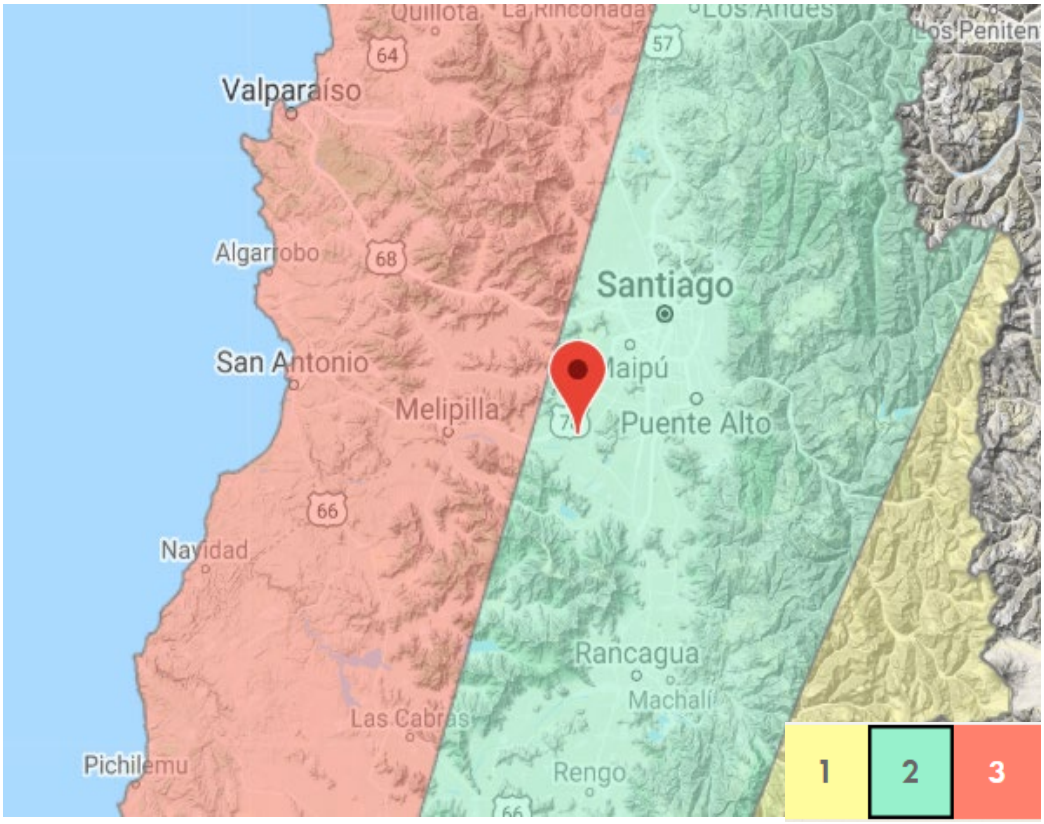
GMS	Location:	**Project:** IG1827106 **Date:** 01/04/2020	**Figure 5:** Basins and water bodies in the project area	Trinasolar

3.5. Seismicity and liquefaction

The analysis is based on available seismic information shown in **Figure 6** as well as the data collected during field works survey.

According to official Chilean standard (*NCh 4.33 of 1996 modified in 2009*), the peak ground acceleration for the site is 2.94 m/s2, and it lays within the '2 Type' seismic zone.

The potential for soil liquefaction is associated with groundwater presence, as well as with grain size of soil.



	Project: IG1827106 **Date:** 01/04/2020	**Figure 6:** Seismic regions in Chile	

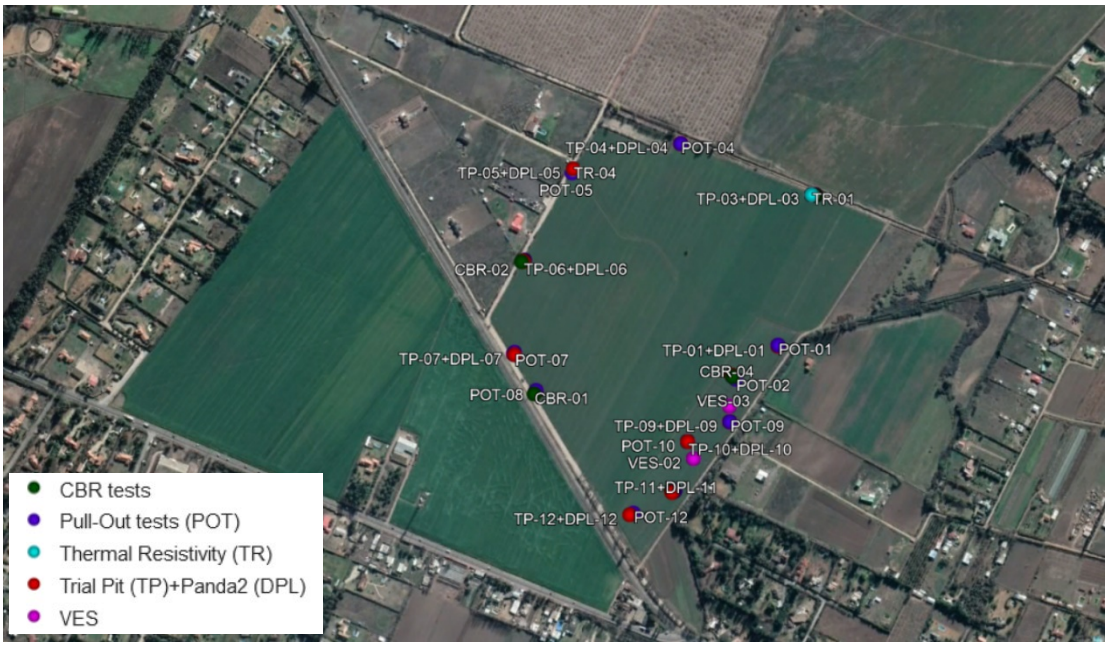
4. GEOTECHNICAL GROUND INVESTIGATION

4.1. Field works description

The field works were carried out on March 2020.

The scope of this survey was based on the proposal ref. *P19_259_GMS_TrinaChile_Macao 18Ha_GEO_v.0_BoQ.*

The following figure shows the location of in-situ tests within the survey area. Maps with the actual location for every field works group are shown in the corresponding annexes.



	Project: IG1827106 **Date:** 01/04/2020	**Figure 7:** Field works location	

4.1.1. *Trial pits*

A total of 12 mechanical excavated trial pits (TP) were performed. Trial pit walls were logged to determine the geomorphological features of the area such as local stratigraphy, lithology and geological surface processes. Trial pits locations and logs and pictures are shown in **Annex 3.**

A description of shallow stratigraphy according to TP logs indicates two different areas with a rather uniform layering. Three main geological units were observed and recognized, and are described hereunder.

The upper layer across the entire area is a topsoil made up of **clayey SAND** or **Sandy CLAY** with variable content of sub-angular gravels up to 5.0 cm size and roots, reaching 0.70 m depth, having an average thickness of 0.50 m. Considering that the area is being partially used for agricultural purposes, topsoil has been highly eroded, and it is expected to present

a high organic content. Towards the southern part of the plot, topsoil is underlain by a stiff wet **sandy CLAY,** reaching 1.10 m depth, having an average thickness of 0.70m. Sandy Clay is underlain by **GRAVEL** in a loose **clayey sandy matrix,** observed until at 3.00m depth (end of trial pits).

At the remaining locations, **TOPSOIL** is underlain by **GRAVEL** in a loose **clayey sandy matrix**, mostly towards the northern part of plot, which is observed until the end of the pit at 3.00m depth.

Water table was found at 3.00m depth in **TP-11** and **TP-12**, at the southern part of plot.

The following table shows the individual depths and location of the trial pits.

Table 1: Geographical coordinates of trial pits

TP Id	Date	Depth (m)	X (m E)	Y (m N)
TP-01	28/02/2020	3.00	325294	6269931
TP-02	28/02/2020	3.00	325217	6269882
TP-03	02/03/2020	2.00	325347	6270185
TP-04	02/02/2020	3.00	325126	6270267
TP-05	29/02/2020	3.00	324946	6270222
TP-06	29/02/2020	3.00	324865	6270066
TP-07	29/02/2020	3.00	324853	6269910
TP-08	28/02/2020	3.00	324890	6269849
TP-09	28/02/2020	3.00	325215	6269804
TP-10	28/02/2020	3.00	325145	6269770
TP-11	28/02/2020	3.00	325120	6269685
TP-12	28/02/2020	3.00	325050	6269647

In all trial pits, representative samples were collected which have been analysed afterwards and are included in **Annex 11**.

4.1.2. *Variable Energy Dynamic Cone Penetrometer (Panda2)*

In order to assess the in-situ soil strength, 12 variable energy dynamic penetrometer tests were performed across the site next to the trial pits.

The Panda2 Equipment is a dynamic penetrometer that uses variable energy to convert hammer energy into cone resistance energy. Its basic principle of operation is to penetrate into the ground through the impact of a 1.726 kg hammer, a 1-meter long rod with a 4 cm^2 conical tip. The purpose of these test is to record tip resistance of ground up to 3 meters deep or reach refusal.

The geographical coordinates of the tests are shown below in **Table 2**.

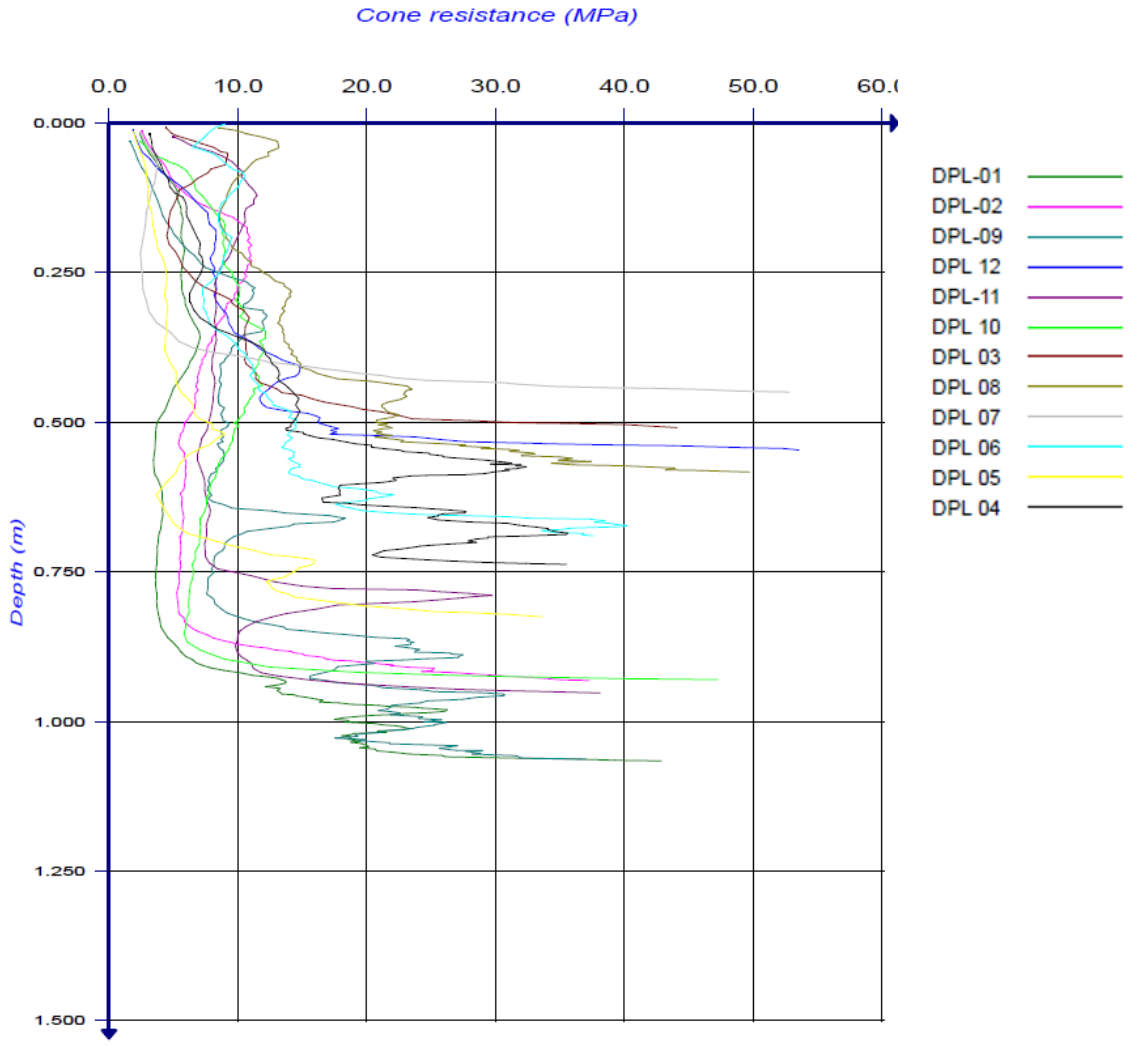
Table 2: Geographical coordinates of penetrometer tests

Panda Id	Depth (m)	X (m E)	Y (m N)
DPL-01	1.06	325294	6269931
DPL-02	0.93	325217	6269882
DPL-03	0.51	325347	6270185
DPL-04	0.74	325126	6270267
DPL-05	0.82	324946	6270222
DPL-06	0.69	324865	6270066
DPL-07	0.45	324853	6269910
DPL-08	0.58	324890	6269849
DPL-09	1.06	325215	6269804
DPL-10	0.93	325145	6269770
DPL-11	0.95	325120	6269685
DPL-12	0.55	325050	6269647

The variable energy dynamic cone penetrometer chart generally shows a tip resistance from 0.00 m to 0.50 m below 10 MPa. Below that, penetrometer tests show an increasing tip resistance of 25 MPa and a refusal related to presence of boulders up to 50 cm size from 0.50m to 1.10 m depth.

All Panda2 tests reached shallow refusal due to the size of the coarse material encountered below the topsoil.

In **Figure 8**, variable energy dynamic cone penetrometer (Panda2) results are shown.



	Project: IG1827106 **Date:** 01/04/2020	**Figure 8: Panda2 plot**	

4.1.3. *Vertical Electrical Soundings (VES´s)*

A total of 4 VES tests were performed in accordance with the proposed works. The tests were evenly distributed across the site to ensure that any variation in electrical resistance is captured. Test intervals for the short traverse were as follow: 0.60, 1.20, 1.80, 2.40, 3.60, 6.00, 9.00, 10.00, 12.00 and 15.00 meters and the tests reached a depth of circa15m below ground.

Test point locations as well as electrical resistivity measurements are shown in the map in **Annex 5.**

Common resistivities for different materials can be found in **Table 3**.

Table 3: Common resistivities in some materials and different states of water

MATERIAL	RESISTIVITY Ω-m
Clay	1-20
Sand	50-500
Sandstone	50-5,000
Sand and dry gravel	1,000-10,000
Sand and gravel with fresh water	50-500
Sand and gravel with saltwater	0.5-5
Clayey sand	50-300
Sand of quartz	30-10,000
Superficial fresh water	20-300
Seawater	<0.2
Distilled water	>500
Conglomerate	1,000-10,000
Limestone	300-10,000
Volcanic breccia	100-2,000
Schist graphited	0.5-5
Schist unaltered	300-3,000
Granite	300-10,000
Gneiss and granite unaltered	100-1,000
Gneiss unaltered	1,000-10,000
Gravel	100-10,000
Basalt	300-10,000
Silt	30-500
Marlstone	50-5,000
Slate	100-1,000
Volcanic tuff	20-100

The following table shows the geographical coordinates where the VES tests were performed.

Table 4: Geographical coordinates of the Vertical Electrical Sounding test

VES Id	X (m E)	Y (m N)
VES-01	324851	6269911
VES-02	325155	6269742
VES-03	325214	6269830
VES-04	325353	6270186

Resistivity results are shown in **Table 5** below.

Table 5: Vertical Electrical Sounding test results

VES Id	Rho (ohm·m)	Thickness (m)	Depth (m)
VES-01	7.13	0.25	0.25
	382.65	1.61	1.86
	121.37	13.14	15.00
VES-02	25.69	1.34	1.34
	356.65	7.78	9.13
	29.76	5.87	15.00
VES-03	37.37	0.56	0.56
	284.59	6.98	7.54
	79.92	7.46	15.00
VES-04	14.46	0.22	0.22
	504.72	0.45	0.67
	42.29	1.21	1.87
	148.96	13.79	15.00

4.1.4. *Thermal resistivity test*

The thermal resistivity ground measurement method is based on the theory that temperature rise rate in a linear heat source depends on the thermal constants in the medium in which it is applied. The objective to recover this information is the key for the thermal design of medium and high voltage earthing electrical wire.

This test was performed according to the technical specifications sent by the Client using the KD2Pro equipment.

A total of 4 tests were performed inside 4 trial pits. Three measurements were carried out in the trial pits walls at determined depth. Average results, as well as their equivalence compared to the thermal conductivity are presented in **Annex 6.**

The thermal resistivity tests location and performance date are presented in the table next page.

Table 6: Geographical coordinates of the Thermal Resistivity tests

TR Id	TP Id	Date	X (m E)	Y (m N)
TR-01	TP-03	02/03/2020	325347	6270185
TR-02	TP-10	28/02/2020	325145	6269770
TR-03	TP-07	29/02/2020	324853	6269910
TR-04	TP-05	29/02/2020	324946	6270222

The average thermal resistivity results for those tests range from 0.790 to 0.881 mk/W, with temperatures ranging from 19.7 to 23.3 °C (21.48 °C average).

In the next table, the results of the average thermal resistivity/conductivity and average temperature are presented.

Table 7: The thermal resistivity test results

ID	Location ID	Depth(m)	Average thermal resistivity (mK/W)	Average thermal conductivity (W/mK)	Average temperature (°C)
TR-01	TP-03	0.50	0.865	1.156	20.7
TR-02	TP-10	0.80	0.881	1.135	23.3
TR-03	TP-07	0.50	0.853	1.172	22.2
TR-04	TP-05	0.40	0.790	1.266	19.7

4.1.5. *CBR testing in situ (Panda2 – compaction mode)*

In this project a total of 5 CBR in situ tests were performed across the site. The tests were carried out using a portable variable energy dynamic cone penetrometer (Panda 2) in the compaction mode (2 cm^2 cone) with the aim of evaluating the soil strength and determine the subgrade materials quality for road design purposes. The CBR in situ testing results are detailed in the **Annex 4.**

The following table shows test locations.

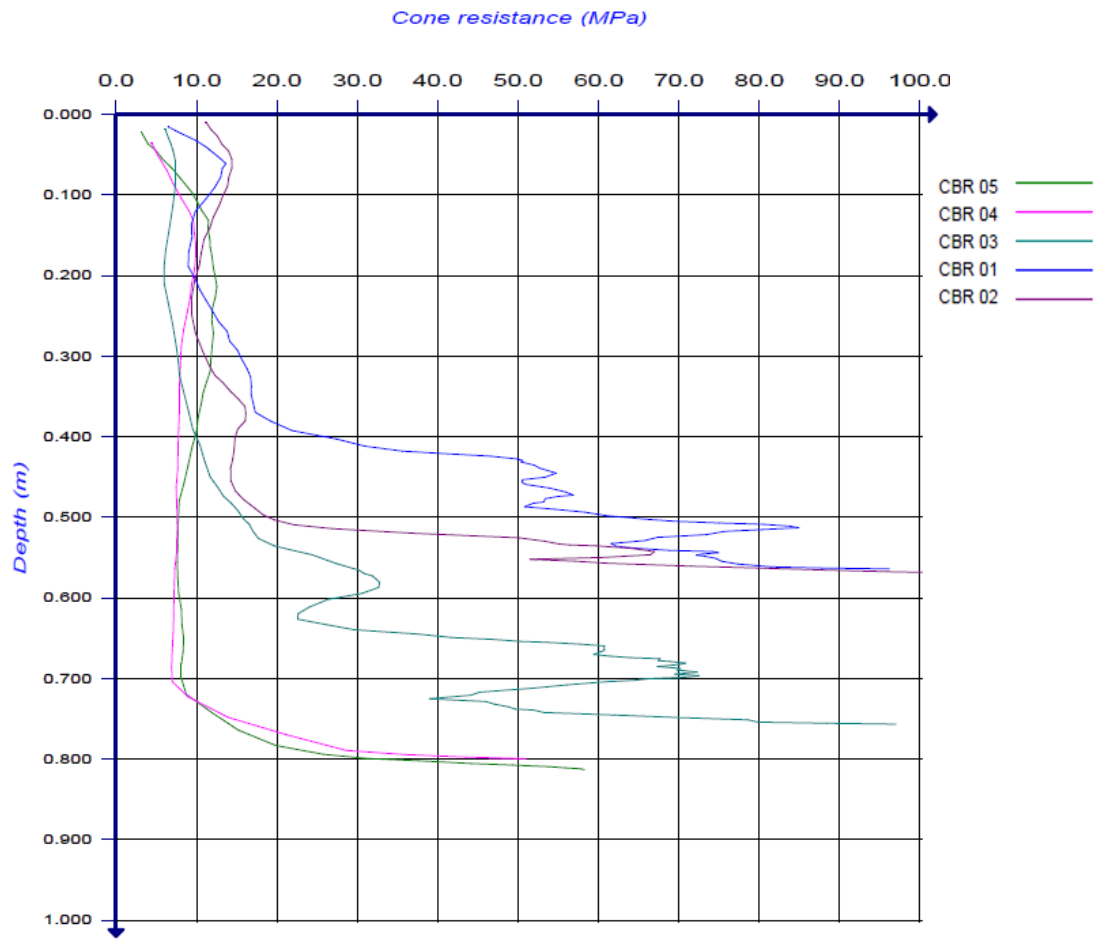
Table 8: Geographical coordinates of the CBR tests

CBR testing	X (m E)	Y (m N)
CBR-01	324887	6269845
CBR-02	324862	6270065
CBR-03	325354	6270184
CBR-04	325219	6269879
CBR-05	325119	6269689

In the plot next page (**Figure 9**) all CBR tests present a similar pattern, the results suggest an average high resistance.

Two CBR families may be observed throughout the study area. The first group, which includes CBR Test 01, 02, and 03 presents CBR values around 10MPa from 0.4m and up to 0.75m depth where refusal is reached. The second family includes CBR-04 and CBR-05, it presents CBR values up to 10MPa from 0m up to 0.80 meters depth, then refusal is reached suddenly due to the presence of gravels and boulders, suggesting a significantly higher soil bearing capacity in terms of road construction.

Results are analysed in Section 7 to allow for a preliminary road design.



	Project: IG1827106 **Date:** 01/04/2020	**Figure 9:** CBR in situ test results	

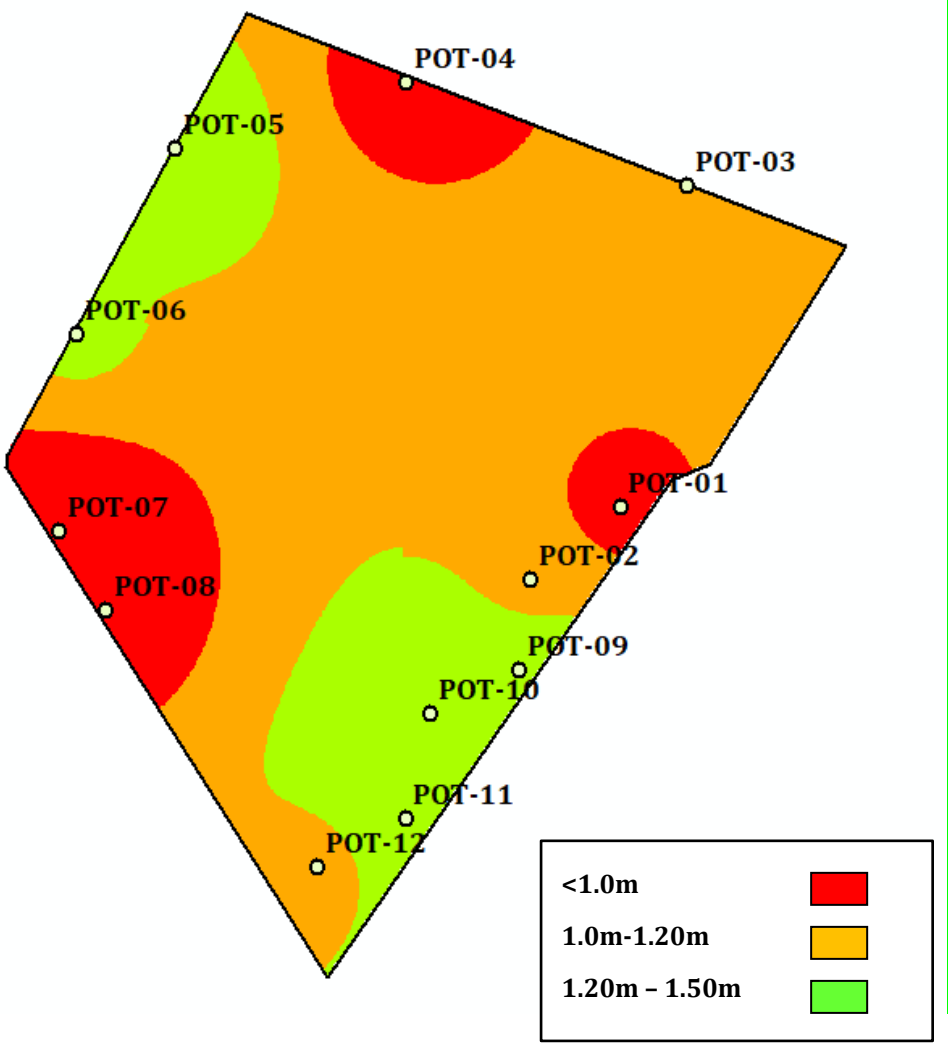
4.1.6. *Pull-Out test*

A total of 24 Pull-Out tests were performed in 12 different locations in accordance with proposed works. Lateral load test, compression test and Pull-Out test were tested for every profile, using a JCB 3CX backhoe excavator to apply loads. Pull-Out test locations are shown in table below.

Table 9: Geographical coordinates of the Pull-Out tests

Pull-Out Id	X (m E)	Y (m N)
POT-01	325294	6269933
POT-02	325224	6269875
POT-03	325347	6270185
POT-04	325126	6270267
POT-05	324944	6270215
POT-06	324867	6270068
POT-07	324853	6269914
POT-08	324890	6269851
POT-09	325215	6269804
POT-10	325145	6269770
POT-11	325125	6269688
POT-12	325056	6269650

Ramming depths in the pull-out tests are shown next page. Ramming depth at locations where pull-out tests were not performed are for reference only and should not be considered for design purposes.



	Project: IG1725716 **Date:** 27/03/2020	**Figure 10:** Ramming depth	

Failure criteria was **>25 mm** displacement at 0.05m above grade for horizontal tests and **>19 mm** for vertical tests, both for 100% design load. Additionally, **10mm** or greater of permanent deflection on horizontal test after 100% design load was also considered failure.

Most tested piles did not reach the scheduled depth. Only 8% did (2 piles out of 24).

Displacements greater than failure criteria for horizontal and vertical tests are shown in the table next page, ramming refusal depth is marked in red colour when above scheduled ramming depth.

Having those failure criteria in mind, all (100%) horizontal tests failed, while 29% pull-out tests failed, and 4% compression tests failed only.

Table 10: Pull-Out Summary

LOCATION			RAMMING DATA						HORIZONTAL TEST		VERTICAL TEST - TENSILE		VERTICAL TEST - COMPRESSION	
Nº TEST	Coord. X (m E)	Coord. Y (m S)	Objective Ramming Depth (m)	Achieved Ramming Depth (m)	Load Height (m)	Section Type	Ramming Time (s)	Installation Method	PeackLoad Aplied (kN)	Deflection (mm) at 0.05 m agl	Peack Tensile Load Aplied (kN)	Displacement (mm)	Peack Compressive Load Aplied (kN)	Displacement (mm)
POT-01 A	325294	6269933	2.0	**0.90**	0.77	C-150	24	DIRECT	6	22.4	10.8	11.0	15.0	1.55
POT-01 B			1.5	**1.05**	0.77	C-150	24	DIRECT	8	19.5	15.0	2.6	15.0	0.54
POT-02 A	325224	6269875	2.0	**1.10**	0.77	C-150	25	DIRECT	10	17	15.0	16.0	15.2	1.15
POT-02 B			1.5	**1.44**	0.77	C-150	58	DIRECT	10.4	22.9	16.0	9.0	15.0	1.06
POT-03 A	325347	6270185	2.0	**1.00**	0.77	C-150	90	DIRECT	2.2	17	15.0	6.5	15.0	1.5
POT-03 B			1.5	**1.00**	0.77	C-150	40	DIRECT	8	23	15.0	10.0	8.8	12
POT-04 A	325126	6270267	2.0	**0.90**	0.77	C-150	45	DIRECT	4	25	5.4	12.0	15.0	0.9
POT-04 B			1.5	**0.95**	0.77	C-150	46	DIRECT	4	17.5	15.0	18.0	15.0	1.35
POT-05 A	324944	6270215	2.0	**1.46**	0.77	C-150	80	DIRECT	4.0	8.8	15.2	9.8	15.0	0.8
POT-05 B			1.5	**1.40**	0.77	C-150	70	DIRECT	4.0	24.9	15.8	6.9	15.0	0.2
POT-06 A	324867	6270068	2.0	**1.55**	0.77	C-150	33	DIRECT	4.0	16.5	15.0	12.6	16.0	0.5
POT-06 B			1.5	**1.25**	0.77	C-150	40	DIRECT	**2.0**	**31.0**	2.7	0.2	14.5	2.5
POT-07 A	324853	6269914	2.0	**0.95**	0.77	C-150	40	DIRECT	4.0	8.5	15.0	15.0	15.0	2.3
POT-07 B			1.5	**0.70**	0.77	C-150	20	DIRECT	**2.0**	**25.0**	**2.7**	**23.0**	Rotated and tilted profile	
POT-08 A	324890	6269851	2.0	**1.35**	0.77	C-150	36	DIRECT	14.0	22.7	16.0	16.1	15.0	1.3
POT-08 B			1.5	**0.83**	0.77	C-150	36	DIRECT	10.0	22.9	16.0	13.0	15.0	1.1
POT-09 A	325215	6269804	2.0	**1.65**	0.77	C-150	38	DIRECT	10.0	17.1	15.9	1.4	15.0	0.4
POT-09 B			1.5	1.50	0.77	C-150	18	DIRECT	14.0	22.7	16.0	1.9	15.0	0.9
POT-10 A	325145	6269770	2.0	**1.44**	0.77	C-150	57	DIRECT	14.0	22.2	13.5	17.0	17.0	2.2
POT-10 B			1.5	**1.35**	0.77	C-150	41	DIRECT	14.0	22.0	15.0	5.4	15.0	0.5
POT-11 A	325125	6269688	2.0	**1.70**	0.77	C-150	30	DIRECT	10.0	19.8	15.0	0.1	15.3	4.3
POT-11 B			1.5	1.50	0.77	C-150	14	DIRECT	10.0	22.2	11.8	12.0	17.5	0.2
POT-12 A	325056	6269650	2.0	**1.40**	0.77	C-150	47	DIRECT	10.0	19.0	15.0	1.0	15.3	1.4
POT-12 B			1.5	**1.10**	0.77	C-150	37	DIRECT	8.0	23.9	13.5	0.4	16.0	0.7

Total tests failed are detailed in table below:

Figure 11: Passed vs Failed Tests

LOCATION	HORIZONTAL TEST	VERTICAL TEST - TENSILE	VERTICAL TEST - COMPRESSION		
Nº TEST	TEST RESULT	TEST RESULT	TEST RESULT	Max.Horiz. Load Aplied (kN)	Deflection (mm)
POT-01 A	FAILED	FAILED	PASSED	6,0	22,4
POT-01 B	FAILED	PASSED	PASSED	8,0	19,5
POT-02 A	FAILED	PASSED	PASSED	10,0	17
POT-02 B	FAILED	PASSED	PASSED	10,4	22,9
POT-03 A	FAILED	PASSED	PASSED	2,2	17
POT-03 B	FAILED	PASSED	FAILED	8,0	23
POT-04 A	FAILED	FAILED	PASSED	4,0	25
POT-04 B	FAILED	PASSED	PASSED	4,0	17,5
POT-05 A	FAILED	PASSED	PASSED	4,0	8,8
POT-05 B	FAILED	PASSED	PASSED	4,0	24,9
POT-06 A	FAILED	PASSED	PASSED	4,0	16,5
POT-06 B	FAILED	FAILED	PASSED	2,0	31
POT-07 A	FAILED	PASSED	PASSED	4,0	8,5
POT-07 B	FAILED	FAILED	Not performed	2,0	25
POT-08 A	FAILED	PASSED	PASSED	14,0	22,7
POT-08 B	FAILED	PASSED	PASSED	10,0	22,9
POT-09 A	FAILED	PASSED	PASSED	10,0	17,1
POT-09 B	FAILED	PASSED	PASSED	14,0	22,7
POT-10 A	FAILED	FAILED	PASSED	14,0	22,2
POT-10 B	FAILED	PASSED	PASSED	14,0	22
POT-11 A	FAILED	PASSED	PASSED	10,0	19,8
POT-11 B	FAILED	FAILED	PASSED	10,0	22,2
POT-12 A	FAILED	PASSED	PASSED	10,0	19
POT-12 B	FAILED	FAILED	PASSED	8,0	23,9

The Pull-Out test logs are presented in the **Annex 7.**

4.2. Laboratory works

4.2.1. *Laboratory works description*

All samples were collected and classified directly while in the field. The following list shows disturbed samples' scheduled tests.

Index Properties testing:

- 10 Moisture content in laboratory (UNE 103300/93)
- 10 Sieve analysis (grain size) (UNE 103101/95)
- 10 Atterberg limits (Plasticity test) (UNE 103103/94 - UNE 103104/94)
- 10 Density of soil (UNE 103301/94)

Chemical testing:

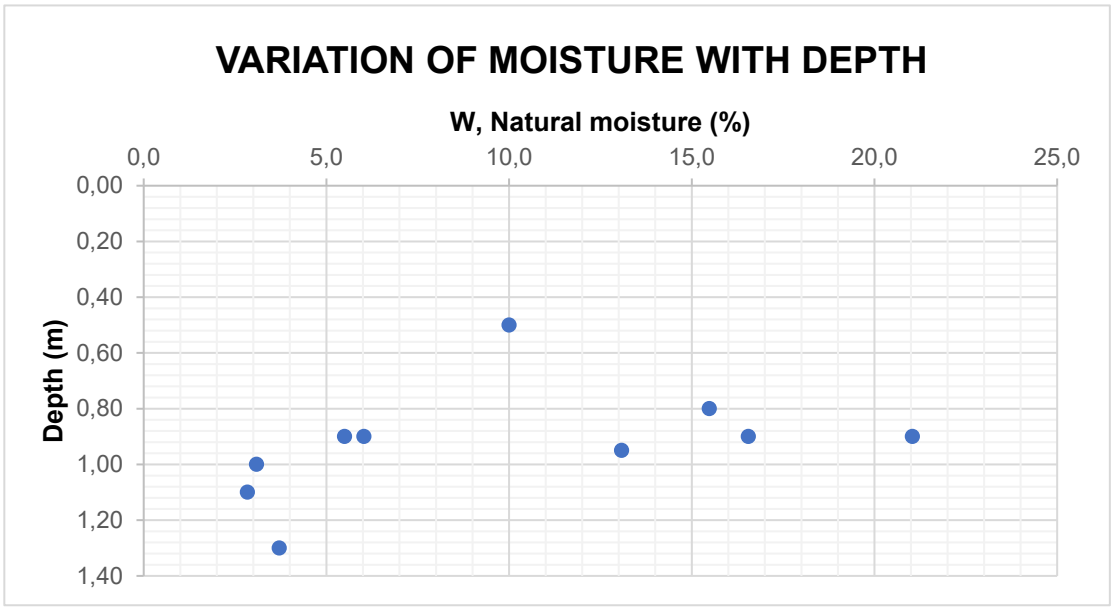
- 2 Chlorides content of soil (Standard Method)
- 2 Sulphate content of soil (UNE 103201/96)
- 2 pH tests
- 2 Organic Matter content (UNE 103204/93+ERR)
- 2 Soluble salts content of soil (NLT-114/99)

4.2.2. *Laboratory works results*

4.2.2.1. *Moisture Content*

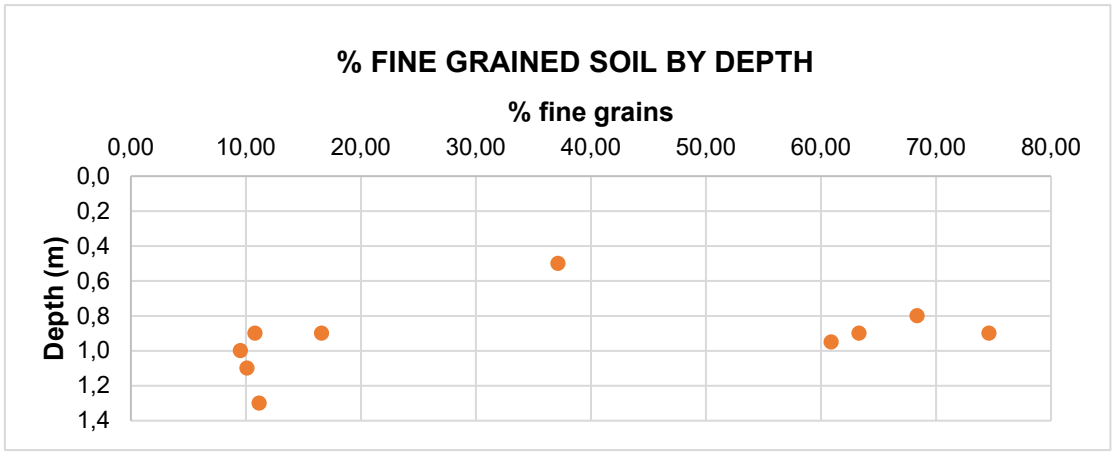
Based on ASTM D6907-05; ASTM D4220-14, ASTM D2216-10, moisture content was obtained.

Results show values from 2.84% to 21.04%. These values do not depend on depth as shown in the plot on the next page (**Figure 10**).

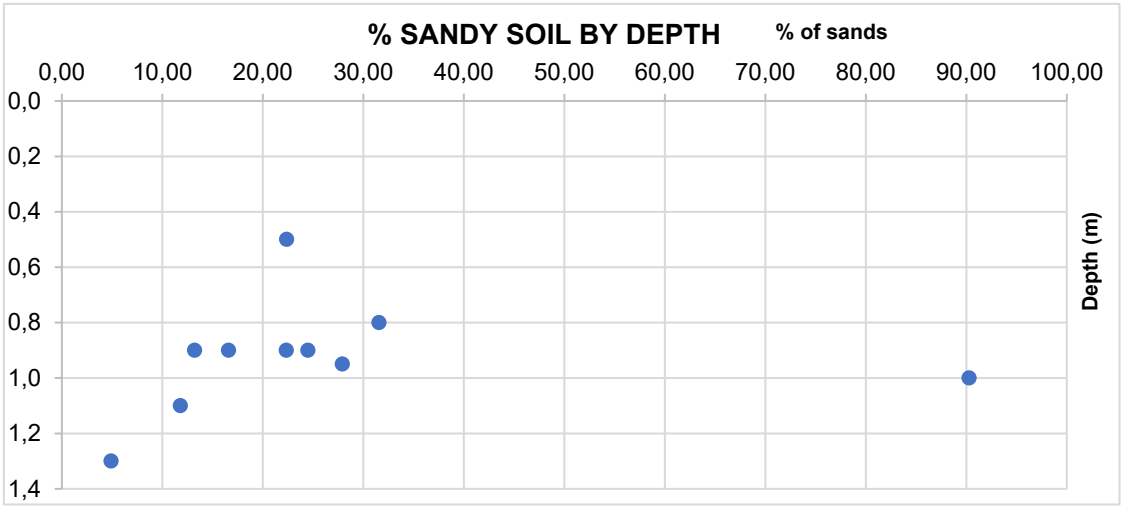


	Project: IG1827106 **Date:** 01/04/2020	**Figure 12:** Moisture content of soil samples	

4.2.2.2. *Fine and sand content*



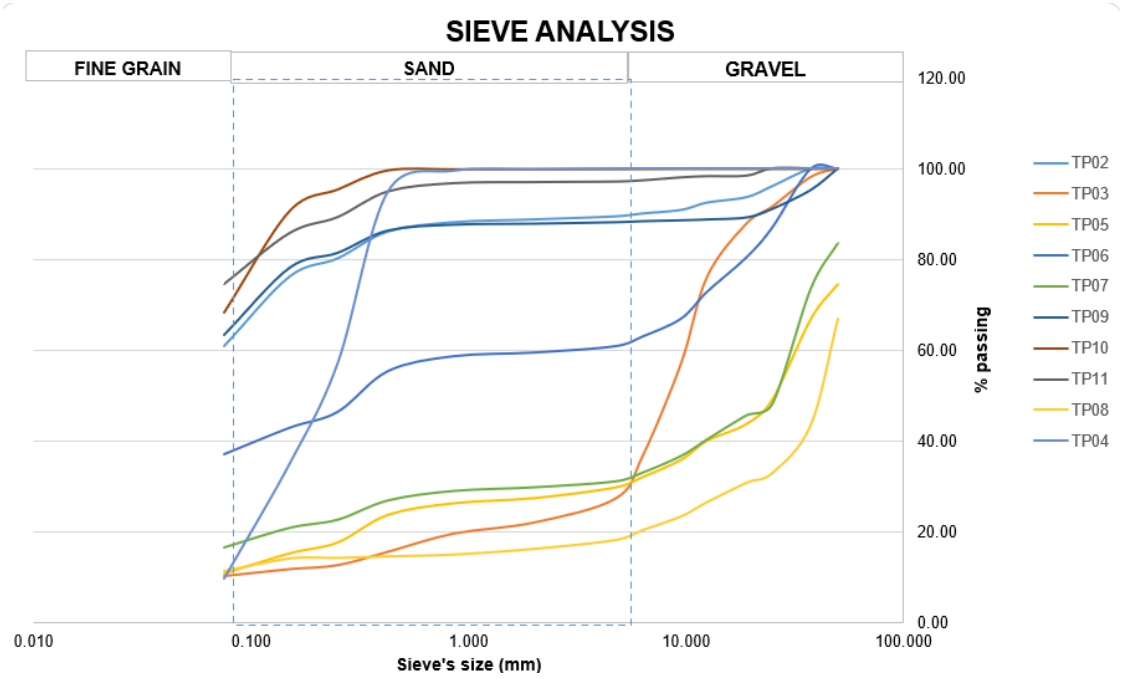
	Project: IG1827106 **Date:** 01/04/2020	**Figure 13:** Fine content of soil samples	



	Project: IG1827106 **Date:** 01/04/2020	**Figure 14:** Sand content of soils	

4.2.2.3. *Sieve analysis*

The sieve analysis of samples is shown in the plot below.



	Project: IG1827106 **Date:** 01/04/2020	**Figure 15:** Sieve Analysis	

5. GEOTECHNICAL ASSESSMENT

5.1. Formulation

The correlations used for the project design are summarized below:

Table 11: Correlations

Correlation	Formula	Author
Cone Resistance (MPa) to N_{spt}	$N_{spt} = q_d(MPa)/0.65$	Panda2; Soil Solution S.A. (2002)
N_{spt} to Uniaxial Compressive Strength; q_u (Tn/m²)	$q_u\left(\frac{Tn}{m^2}\right) = (40 \cdot N_{spt}) \cdot \left(\frac{3}{100}\right)$	Dr. Muzás F.; (2002)
Uniaxial Compressive Strength; q_u (Tn/m²) to Undrained Shear Strength; c_u (Tn/m²)	$c_u\left(\frac{Tn}{m^2}\right) = q_u\left(\frac{Tn}{m^2}\right) \cdot 1/2$	Rodríguez Ortiz et al, 1971
N_{spt} to Friction Angle; ϕ' (°)	$\phi'(°) = 27.1 + 0.30 \cdot N_{spt} - 0.00054 \cdot {N_{spt}}^2$	Peck; (1974)
N_{spt} to Horizontal reaction soil modulus; K_h (Tn/m³)	$K_h\left(\frac{Tn}{m^3}\right) = 40 \cdot N_{spt}/d(m)$	Dr. Muzás F.; (2002)
Horizontal reaction soil modulus; K_h (MPa) to Deformation modulus; E (MPa)	$E(MPa) = \frac{K_h(MPa) \cdot 2 \cdot r(m)}{3}$	Pochman, R, et al.; (1989)
N_{spt} to Deformation modulus; E (kN/m²)	$E\ (kN/m^2) = 21500 + (1060 * N_{SPT})$	d'Apolonia; (1970)
Saturated Density (kN/m³)	$\gamma_{sat} = (\gamma_{solids} + e \cdot \gamma_{water})/(1 + e)$	-

5.2. Geological Summary

Based on the information from the mechanical, physical as well as geophysical field data, the stratigraphy of the area was built up, and it is made up of 3 geotechnical units split into 2 different geotechnical zones.

Table 12: Summary of site stratigraphy

Stratigraphy	Geotechnical Unit	Depth (m)	Thickness (m)
TOPSOIL: clayey SAND	GU-01	Up to 0.30	Up to 0.30
Sandy CLAY	GU-02	From 0.30 to 1.20	0.80
GRAVEL with clayey sandy matrix	GU-03	From 0.30 to 3.00	2.70

In accordance with laboratory tests, as well as stratigraphy as described previously, the following mechanical parameters have been calculated for the proposed geotechnical units.

Table 13: Geotechnical characterization

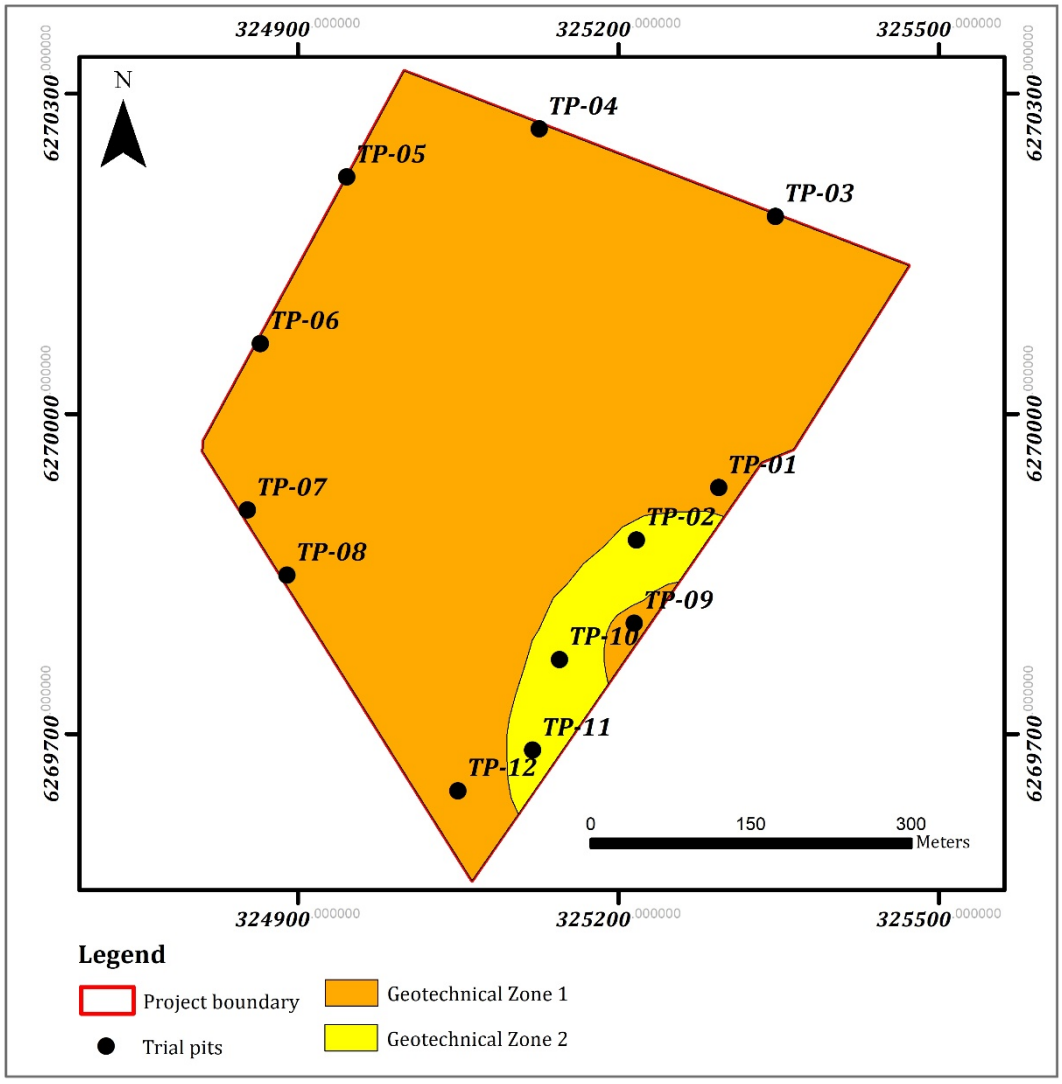
Unit	Material Description	N_{SPT}	Index Properties	Mechanical Properties		
			Dim. Weight (kN/m^3)	**Cohesion (kN/m^2)**	**Internal Friction Angle (º)**	**Elastic modulus (kN/m^2)**
GU-01	TOPSOIL: clayey SAND	6	14	-	16	39000
GU-02	Sandy CLAY	29	18	35	29	51000
GU-03	GRAVEL with clayey sandy matrix	36	21	-	36	60000

By observing the characteristics of materials (physical and mechanical properties), location as well as their behaviour, **two geotechnical zones** have been defined throughout the site. The stratigraphy is described below, and its location is presented in **Figure 16**.

NOTE: zoning has been based on available field data. Due to accessibility constraints (cropping ongoing in the plot) all areas were not surveyed and zoning may differ once the entire plot is cleared and made available for surveying.

Table 14: Geotechnical zones of site

Geotechnical Zone	Geotechnical Unit	Depth (m)	Material description
GZ-01	GU-01	0.0 - 0.30	TOPSOIL: clayey SAND
	GU-03	0.30 – 3.0	GRAVEL with clayey sandy matrix
GZ-02	GU-01	0.0 - 0.2	TOPSOIL: clayey SAND
	GU-02	0.2 - 1.2	Sandy CLAY
	GU-03	1.20 – 3.00	GRAVEL with clayey sandy matrix



	Project: IG1827106 **Date:** 01/04/2020	**Figure 16:** Geotechnical Zones	

5.3. Bearing capacity of shallow foundations

The transformer building shallow foundation has been analysed to be set in the transformer building or in the power station locations.

LoadCap® software has been used to evaluate the bearing capacity for shallow foundations. The calculations were performed using the different site soil profiles based on the geotechnical test performed at the different locations.

The following assumptions have been used to perform the analysis:

a) Computation as per layer's weighted averages;

b) Drained and undrained conditions as required;

c) Normative: Eurocode 7;

d) Depths of analysed foundations are 0.6, 1.0 and 1.5 m below ground level;

e) The two different geotechnical zones have been analysed;

f) Three different foundation solutions have been analysed: mat foundation, strip footing and isolated footing;

g) Efforts used to calculate bearing capacity are based on our in-house experience as no other information has been provided by the Client. The estimated weight of the proposed substation is a total of 150 kN, that will be uniformly distributed across the total foundation area.

h) For strip and isolated footing analysis, bending moments are not expected to occur on the foundation as horizontal loads shall be absorbed vertically by the foundation;

i) The induced seismic load was calculated based on the self-weight of the substation as well as the peak ground acceleration defined in Section 3.5.

j) Water table has been considered at 3.0m below ground level throughout the area.

Please, note that the shallow foundations assessment calculated using the assumptions summarised above are indicative only, as they are dependent on the input parameters assumed herein. Should actually design loads and/or foundation dimensions differ from those summarised above, the shallow foundation analysis would need to be revisited to ensure that the foundation has enough capacity to support loads exerted on it.

Not having actual design conditions of substation, the calculations presented below are indicative and it is responsibility of the designer and/or foundation designer to use actual loads for the design.

5.3.1. *Strip footing*

Two strip footings have been assumed to resist the transformer load in the defined geotechnical zones. Results obtained for the calculation of bearing capacity and ballast module for strip footings of 1.00x5.00 m side at 0.5, 1.0 and 1.5 m depth are shown below.

Table 15: Bearing capacity of Strip footing

B (m)	L (m)	Geotechnical Zone	D (m)	Bearing Capacity (kN/m²)	Design Resistance (kN/m²)	Ballast Module (kN/m³)
1.0	**5.0**	1	0.5	158.37	87.98	15502
			1.0	284.54	158.08	26629
			1.5	410.72	228.18	36984
		2	0.5	109.76	60.98	6330
			1.0	202.02	112.24	17551
			1.5	379.59	210.88	35590

5.3.2. *Isolated footing*

Four isolated footings have been assumed to resist the transformer load in defined geotechnical zones. Results obtained for calculation of bearing capacity and ballast module for isolated footings of 0.60 m side at 0.5, 1.0 and 1.5 m depth are shown below.

Table 16: Bearing Capacity isolated footing

B (m)	L (m)	Geotechnical Zone	D (m)	Bearing Capacity (kN/m²)	Design Resistance (kN/m²)	Ballast Module (kN/m³)
0.6	**0.6**	1	0.5	258.23	143.46	10329
			1.0	292.97	162.76	28459
			1.5	429.05	238.36	43736
		2	0.5	193.45	111.45	8024
			1.0	247.49	137.50	5307
			1.5	396.53	220.29	41451

5.3.3. *Mat foundation*

A mat foundation has been assumed to resist the transformer load. Results obtained for calculation of bearing capacity and ballast module for mat foundation of 1.00x5.00 m side at 0.5, 1.0 and 1.5 m depth are shown below.

Table 17: Bearing Capacity mat foundation

B (m)	L (m)	Geotechnical Zone	D (m)	Bearing Capacity (kN/m²)	Design Resistance (kN/m²)	Ballast Module (kN/m³)
3.0	**5.0**	1	0.5	231.49	128.60	27987
			1.0	240.98	133.88	38379
			1.5	274.58	135.88	49304
		2	0.5	165.44	91.91	20196
			1.0	270.90	150.50	33163
			1.5	230.40	128.00	47947

5.3.4. *Settlements*

As part of the geotechnical analysis, shallow foundations settlements were assessed. At this point, it is worth mentioning that oedometer tests were not performed on the retrieved samples, which would enable the direct calculation of expected settlements from laboratory data. However, settlements were therefore estimated based on the consistency and nature of the soil as well as other physical properties.

Based on the available information, excessive settlement of the foundation is not expected to occur across **Geotechnical Zone 2** below GU-01 due to low plasticity of existing clay and high granular content thereof. The soil is expected to instantly deform during the construction process and differential settlements are not anticipated. Mat foundation at 1.0m depth may experience 1.5mm settlement under a 240KN/m² load at the centre of the mat. Similarly, in **Geotechnical Zone 1**, 1.65mm settlement is anticipated for a mat foundation under 240KN/m2 load at 1.0m below ground level, at the centre of the mat.

5.4. Pile Foundation

The pull-out test results are present in Annex 7 and a summary of these results in Annex 8. Analysis may be found above in the report.

Due to horizontal failure of piles along with shallow refusal of most piles (before reaching scheduled ramming depths), it is assumed that predrill shall be required if similar piles to those tested are intended for construction. Predrill should be drilled at around 90% of the total scheduled ramming depth (e.g. at 1.85m for 2.0m ramming). Predrill hole diameter should at least be 2mm shorter that longest pile section length. Predrilled holes shall be filled in gravel, then piles shall be machine-driven inside the hole to ensure stability and serviceability of the pile.

A different option would be using a larger pile (e.g., IPE or HBE piles), large enough to ensure scheduled depths are reached and no failure horizontal deflections are reached.

One additional option would be replacing uppermost softer layer by improved ground that would enable for horizontal deflections below failure criteria.

5.5. Slope stability

General slope stability assessment of the site was carried out for the identified Geotechnical zones classified according to its stratigraphy.

Analysis has been performed for different slopes and for temporary and long-term conditions, its results are presented below.

Table 18: Slope Stability

Geotechnical Zone	Trench Depth (m)	Temporary slope (H/V)	Long-term slope (H/V)
1	1.0	1/1	3/2
	2.0	1/1	3/2
	3.0	3/2	3/2
2	1.0	1/2	1/1
	2.0	1/2	1/1
	3.0	1/1	3/2

5.6. Water table

During field works water table was found at 3.00 m depth on March 2020. Levels may fluctuate with rainfalls, drainage and levelling, as well as during seasonal changes. Please note that, if water level rises to upper layers, piles as well as shallow foundation's bearing capacity may be reduced at half of dry conditions.

If critical for the sake of the project, permanent piezometers should be installed to control water table depth and variations.

5.7. Seismicity and liquefaction

Liquefaction occurs when certain types of soils affected by earthquakes, develop high interstitial pressures quickly (without drainage), resulting in a loss of resistance to shear and soil breakage, which behaves as if it were a liquid (VALLEJO, L. I. G.; FERRER, M.; ORTUÑO, 2002).

This phenomenon causes foundation failure, slope breakage and landslides.

As observed in areas affected by liquefaction (VALLEJO, L. I. G.; FERRER, M.; ORTUÑO, 2002) this takes place in the following circumstances:

- Earthquakes with magnitude equal or greater than 5.5 with acceleration greater than or equal to 0.2g.
- Below 15 meters depth there have been no liquefaction.
- In most cases water table was shallow, less than 3 meters; below 5 meters liquefaction susceptibility is very low.

Properties that characterize liquefiable soils are the following:

- Degree saturation of 100%.
- Average diameter D_{50} between 0.05 and 1.00 mm.
- Coefficient of uniformity $Cu=D_{60}/D_{10}<15$.
- Fine content less than 10%.
- Low degree compaction: $N_{SPT}<10$ for depths < 10m and $N_{SPT}<20$ for depths >10.

The actual project is located within a high-risk seismic zone with an acceleration of 0.3g. Even though soil is predominantly granular, it presents $N_{SPT}>10$ figures within the first 3 meters and water table has been found in two of the trial pits at 3.00 meters depth.

Taking all above in mind, it is thought that **liquefaction of soil may not be expected** within the site area.

6. GEOELECTRICAL

A total of 4 VES tests were performed using Wenner configuration. The main goal for such tests is to determine the vertical distribution of electrical resistivity of each layer that sets out the surface of the study area, aiming to feature higher conductivity strata for the optimal design of the electrical grounding system, as well as to correlate resistivities within the different lithologies with its geophysical interpretation.

6.1. VES Test Summary Results

With the electrical layer model, results were classified according to the corrosion index criteria (Waters, 1952) as per the following table:

Table 19: Corrosion index criteria (Waters, 1952)

Resistivity (Ω.m)	Soil corrosivity index
< 9	Very corrosive
9-23	Rather corrosive
23-50	Moderately corrosive
50-100	Slightly corrosive
>100	Very slightly corrosive

Next page VES tests are analysed and tables shown.

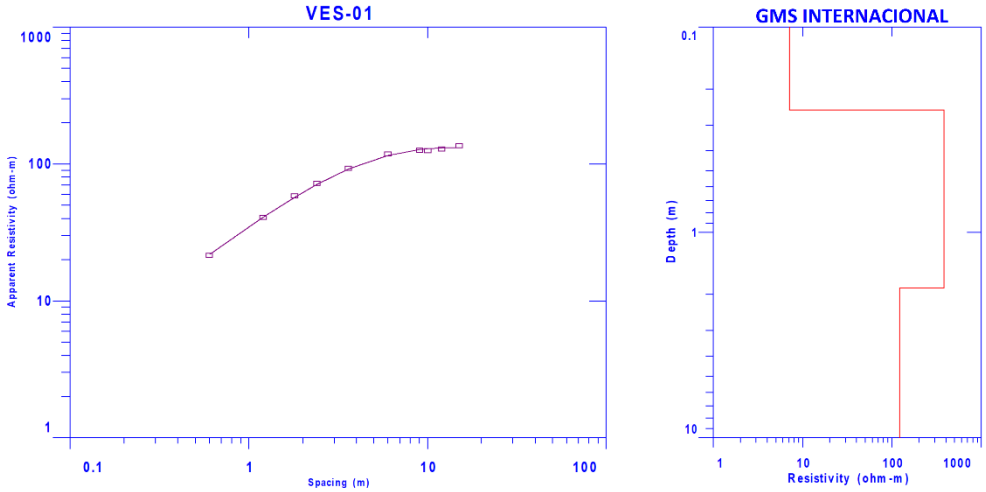


Table 20: VES-01

Layer	Thickness (m)	Resistivity (Ω.m)	Soil Corrosion index criteria
1	0.25	7.13	Very corrosive
2	1.61	382.65	Very slightly corrosive
3	13.14	121.37	Very slightly corrosive

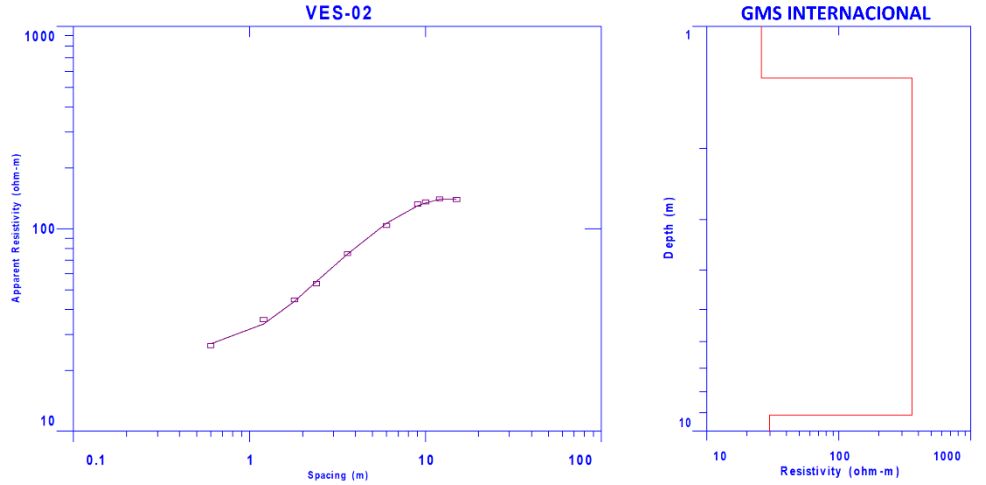


Table 21: VES-02

Layer	Thickness (m)	Resistivity (Ω.m)	Soil Corrosion index criteria
1	1.34	25.69	Moderately corrosive
2	7.78	356.65	Very slightly corrosive
3	5.87	29.76	Moderately corrosive

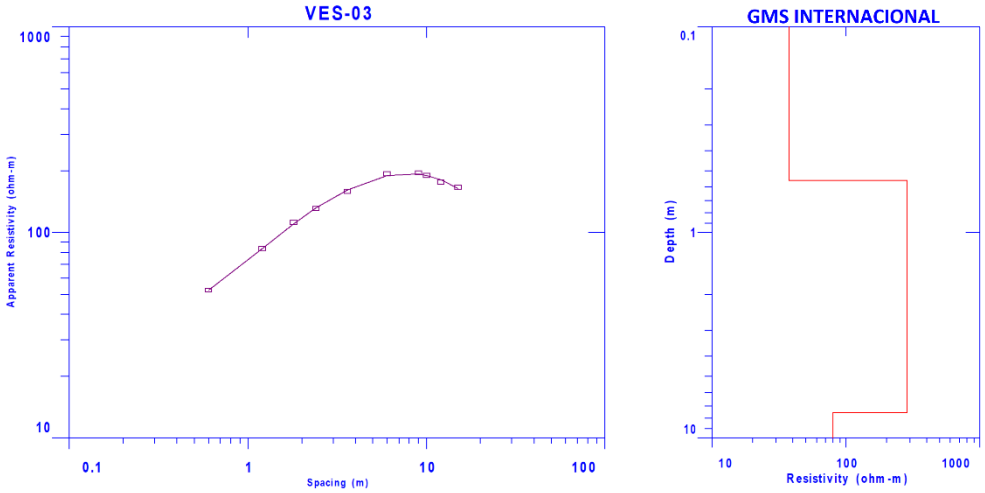


Table 22: VES-03

Layer	Thickness (m)	Resistivity (Ω.m)	Soil Corrosion index criteria
1	0.56	37.37	Moderately corrosive
2	6.98	284.59	Very slightly corrosive
3	7.46	79.92	Slightly corrosive

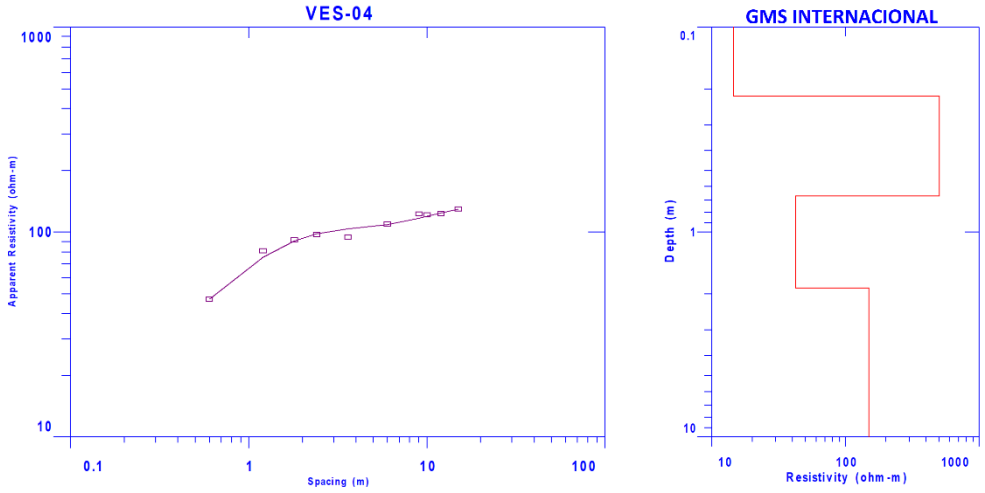


Table 23: VES-04

Layer	Thickness (m)	Resistivity (Ω.m)	Soil Corrosion index criteria
1	0.22	14.46	Rather corrosive
2	0.45	504.72	Very slightly corrosive
3	1.21	42.29	Moderately corrosive
4	13.79	148.96	Very slightly corrosive

The average soil corrosion index can be considered as '***rather corrosive***' according to the electrical resistivity tests.

6.2. VES Interpretation

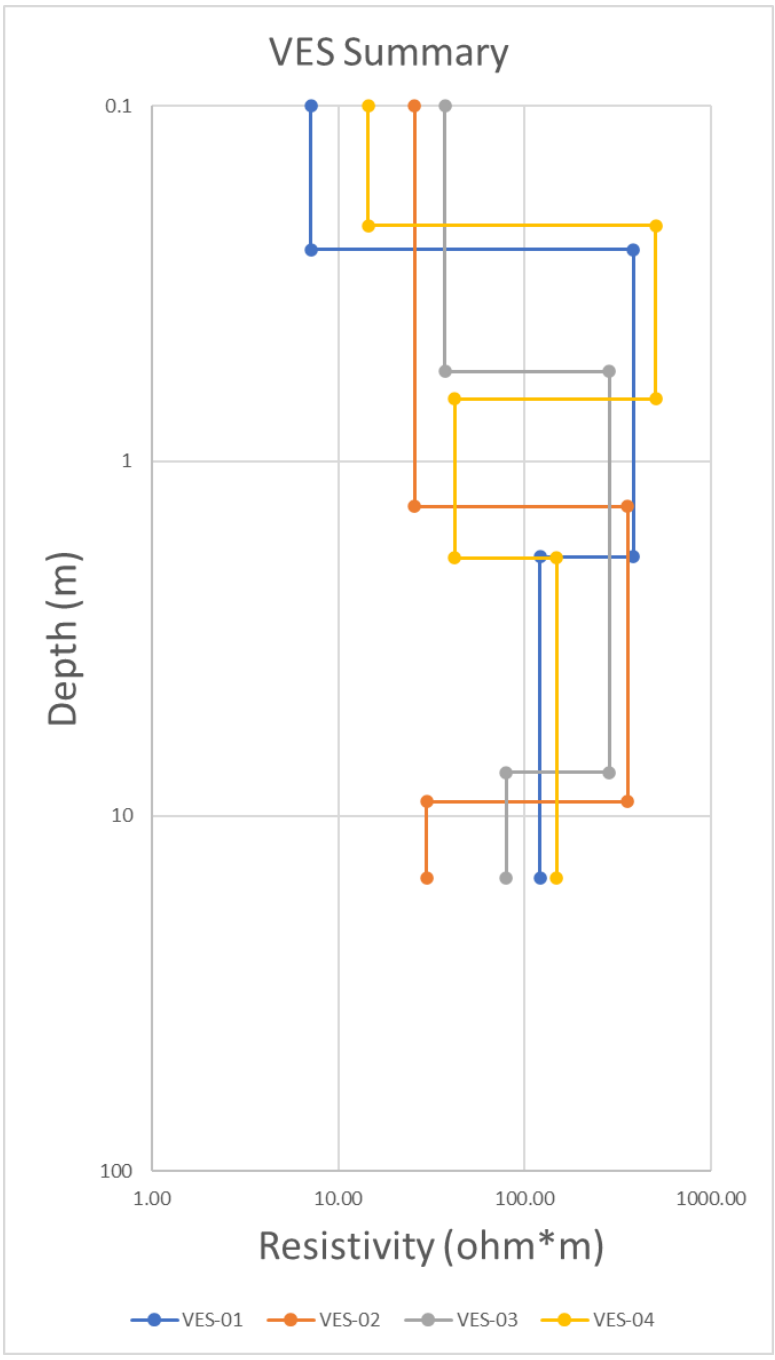
Resistivity results are rather homogeneous across the plot and all VES test show a similar stratigraphy. 3 to 4-layer models have been generated. Changes in resistivity values at different depths, may be due to the variability of layer thickness and the difference in heights at which VES were performed.

In all tests high differences in resistivities are shown with depth, changing from low in topsoil to medium-high in intermediate layer (gravel) to decrease again to low-medium values.

First range of values, from ground level up to 1.5m depth, present low resistivity values (7~37 Ohm·m), then results suddenly increase to 300~500 Ohm·m. After that, results decrease again to low-medium values (30~150 Ohm·m).

First low resistivity layer may be associated with topsoil or clayed layer (GU-01 and GU-02), showing higher thickness in SEV-02 and SEV-02 due to the presence of previously mentioned clayey layer (GU-02) meanwhile SEV-01 and SEV-04 do not present this unit and therefore, its low resistivity thickness is significantly thinner. Sudden change may be caused by the presence of gravel layer (GU-03), which is generally associated with high resistivity values, as show in performed tests. This layer's bottom is deeper than 3.0m and therefore, could not be detected; however, VES show an average thickness of 5.0m. Below this gravel layer, resistivity drops, and that may be associated either to a more cohesive material or to the presence of water.

Charted results are shown in figure next page.



	Project: IG1725716 **Date:** 27/03/2020	**Figure 17: VES Results**	

7. ROAD MATERIALS

The use and classification of the existing material as subgrade for the existing roads in the study area has been analysed.

The soil is classified based on the AASHTO Classification system to determine its suitability as subgrade material. Classification is based on the geotechnical laboratory tests properties of soil such as sieve analysis, Atterberg limits, and field geotechnical California Bearing Ratio results.

Based on Sieve analysis and Atterberg limits, soil is classified (according to the ASSHTO classification system) as shown in table below.

Table 24: AASHTO soil classification

Soil samples	AASHTO classification
TP01	A-4
TP02	A-2-6
TP03	A-3
TP04	A-2-4
TP05	A-4
TP06	A-2-4
TP07	A-1-a
TP08	A-4
TP09	A-4
TP10	A-6
TP11	-
TP12	-

8. SOIL CORROSIVITY ASSESSMENT

8.1. Soil Corrosivity against steel piles

Chemical laboratory tests have been performed on soil samples from the study area. Results are shown on the following table:

Table 25: Results of chemical tests

Sample ID	Depth (m)	Chloride	Sulphate (SO_4)	Sulphite (SO_3)	Soluble Salts	pH	Organic Matter
		ppm	ppm	ppm	%		%
TP-01	2.80	20.8	366.6	305.5	0.17	8.2	0.1
TP-12	2.50	19.8	383.1	319.3	0.12	7.8	0.1

According to NACE standard, soils are classified as:

Parameter	Corrosivity	Concentration (NACE) in ppm	Collected soil samples concentration in ppm	Associated corrosivity range
Chloride	Severe	>5000	19.8 – 20.8	**LOW**
	High	1500 – 5000		
	Corrosive	500 – 1500		
	Low	<500		
Sulphate	Severe	>10000	366.6 – 383.1	**CORROSIVE**
	High	1500 – 10000		
	Corrosive	150 – 1500		
	Low	<150		
pH	Severe	<5.5	8.2 – 7.2	**CORROSIVE – LOW**
	High	5.5 – 6.5		
	Corrosive	6.5 – 7.5		
	Low	9 – 7.5		

Additionally, electrical resistivity results (chapter 6) showed that soils may be **slightly to very slightly corrosive**.

9. CONCLUSIONS AND RECOMMENDATIONS

The Project is in Talagante Province, Santiago Metropolitan Region in Chile.

The solar PV project area is about 18 Ha and it is located approximately 5.20Km to the southeast of Talagante city.

9.1. Geological set up

Panda2 tests as well as trial pits showed common 1.0m depth layer made up of boulders and gravels within a clayed matrix. Such description correlates well with regional geology in the Chilean Geological Map.

Refusal depth started at 0.5m depth in some Panda2 tests while others showed deeper refusals. Uppermost layer is made up of a rather soft clayed sand and sandy clay.

9.2. Ground Associated Risks

9.2.1. *Geomorphological risks*

The project site is in a relatively flat area surrounded by low hills, forest and farmlands. No vegetation was found that could greatly impact the construction. At the time of undertaking the works cropping was ongoing and no outcrops could be tested.

9.2.2. *Hydrological risks*

Based on the existing field information, the existence of hydrological risks could not be assessed. It is recommended however that a Hydrological and Flooding risk study is carried out.

9.2.3. *Seismic risks*

According to official Chilean standard (*NCh 4.33 of 1996 modified in 2009*), the peak ground acceleration for the site is 2.94 m/s_2, and it lays within the '2 Type' seismic zone.

9.3. Geotechnical Risks

9.3.1. *Shallow foundations*

The shallow foundation analysis was performed; loads and dimensions used were based on inhouse experience since no design information was provided by client.

Based on the present analysis the **soil in Geotechnical Zones 01, and 02 would have sufficient capacity to support the loads assumed herein for a light weight structure (transformer building or the like).**

Please, keep in mind that bearing capacity results are only valid as long as recommendations are followed.

9.3.2. *Pile foundations and rammability analysis*

Due to failure of piles at horizontal pull-out test as well as refusal of 90% of piles before reaching the schedule ramming depth, a number of recommendations are suggested:

If C150 piles (tested piles) are to be used for construction, predrilled holes are advised up to scheduled depths (90% of scheduled ramming depth).

A different larger pile such as IPE160 or the like may be used. It is thought that direct ramming would be feasible up to scheduled ramming depths and no critical displacements would be developed.

Alternatively, ground improvement and/or removal of top-up softer layer (GU01) would be one suitable option if non-critical horizontal deformation is sought.

9.3.3. *Slope stability*

General slope stability assessment of the site was carried out for the identified Geotechnical zones identified considering its stratigraphy.

Analysis was performed for different slope depths and for temporary and long-term conditions and its results are presented in the report.

No critical issues were found.

9.3.4. *Soil Corrosion Risks to Steel Piles*

Soil corrosivity values were analysed against NACE standard based on chemical laboratory tests results, and based on geoelectrical resistivity tests as well.

Results suggested very slightly corrosive to corrosive soils, therefore coating to steel piles is recommended. Steel coating thickness is a matter of a different analysis that may be provided upon request.

9.4. Grading

Despite the aforementioned conditions, as a matter of good practice, it is advised that a gravel layer and/or geotextile along with a layer of insulation sheets (extending beyond de foundation area) is installed under the foundation to ensure that pore pressure build up does not occur under the proposed foundation.

Furthermore, it is advised that the ground is levelled, and all debris are removed prior to the foundation installation, to ensure eccentric loads are not acting in the foundation.

10. BIBLIOGRAPHY

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11. LIMITATIONS AND EXCEPTIONS

This geotechnical report has been prepared by GMS Internacional, SL for the exclusive use of Grupotec and their design team for specific application to the proposed project.

I. The work on the project has been carried out in accordance with reasonable and acceptable engineering practices. No other warranty, either written or implied, is applicable to this project.

II. Subsurface conditions may vary from those encountered at the test pits and test locations. The field tests and probe logs are intended to only represent the conditions at each location when the sampling occurred.

III. Classifications of the recovered soil samples are based on recognized standards.

IV. The interpretations and recommendations in this report are based solely on the information available at the time this report was prepared.

V. In the event that the location or design of the structures is altered, the conclusions and recommendations presented herein should not be considered valid unless GMS Internacional, SL has been given the opportunity to review the changes.

VI. It is strongly recommended that GMS Internacional, SL is provided with the opportunity for a general review of the final design and specifications in order that earthwork and foundation recommendations may be properly interpreted and implemented. If GMS Internacional, SL is not accorded the privilege of making this review, we can assume no responsibility for misinterpretation of our recommendations.

VII. The nature and extent of variations between exploration locations and observed conditions may not become evident until construction. It is suggested that GMS Internacional, SL be retained to provide continuous soil engineering services during the earthwork and foundation construction phases of the work. This is to observe compliance with the design concepts, specifications and/or recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated prior to construction.

VIII. The use of information contained in this report for bidding purposes should be done at the client's option and risk.

IX. This report including its conclusions, recommendations and findings should be related to the terms and conditions and the scope of works agreed between the Consultant and the Client. Words PRELIMINARY or DRAFT written on any page throughout the report means that the information contained thereof shall NOT be considered for construction design.

X. Both the Executive Summary and the Conclusions and Recommendations sections of this report should not be specifically relied upon out of the content of the whole report and particularly of the context and the development, if any, proposed.

XI. Any assessments made in this report are based on the ground conditions as revealed by the exploratory works, which may include boreholes, open pits or any further geotechnical and geophysical techniques, together with the results of any field or laboratory testing undertaken and, where appropriate, other relevant data which may have been obtained for the sites including previous site investigation reports. Any special conditions appertaining to the site which have not been revealed by the

abovementioned site investigation may therefore have not been taken into account in the report. The assessment may be subject to amendment in the light of additional information becoming available. Any amendments shall be issued after the Client has accepted initial version. This Consultant will inform the Client about any version released after the initial report has been accepted.

XII. Any recommendations and interpretations contained in this report represent the consultant's opinion only. This opinion has been arrived at in accordance with currently accepted geotechnical and geophysical industry practices at the time of reporting and based on current legislation in force at that time.

XIII. GMS Internacional does not hold any responsibility on stainless steel pile's structural calculations including connections between the stud and the superstructure, pile's resistance to external acting forces and pile's own structural settings including pile length.

XIV. Calculations in this report have been carried out following ultimate limit state models. Such models do not fully represent actual soil behaviour nor the behaviour of the structure. Hence, such models must be regarded as tentative only and they should solely be used in preliminary design stages. In situ tests as well as laboratory-based tests shall be carried out to validate the results herein.

XV. Ramming in and pull out tests shall be carried out whenever it is required in order to obtain actual traction and actual load parameters of soils validating or disregarding any assumptions and recommendations in this report. Lateral load test must be carried out on site in order to validate working hypothesis. Both horizontal and vertical stress shall be accounted for in all tests. Calculations and pull-out maps are therefore for orientation only and should not be used for design purposes without having verified actual pull-out strengths on the field.

XVI. Estimated refusal depths are for orientation purposes. Only locations where dynamic percussion tests (dynamic penetration or SPT tests) have been carried out hold actual information on refusal depth. Refusal depths different from those obtained in this report shall be conveniently determined.

XVII. Driving machine shall be powered enough to achieve desired ramming depth.

XVIII. Final studs (stain steel piles) design and length is the solely responsibility of The Client.

XIX. In no case, should studs be hammered until upper end is deformed. If required, upper excess stud length shall be cut off.

XX. Should further assessment on corrosion of studs is needed, additional soil samples shall be tested and full corrosivity tests performed. Where the data available from previous site investigation reports, supplied by the Client, have been used, it has been assumed that the information is correct. No responsibility can be accepted by the Consultant for inaccuracies within the data supplied.

XXI. The opinion of possible configuration of strata between or beyond exploratory holes, pit locations or such, or on the possible presence of features based on visual, verbal or published evidence, is for guidance only and no liability can be accepted for the accuracy.

XXII. Comments on groundwater conditions are based on observations made at the time of the investigation unless otherwise stated. It must be born I mind that groundwater levels vary due to seasonal or other effects.

XXIII. The copyright in this report and other plans and documents prepared by the Consultant is owned by him and no such report, plan or document may be reproduced, published or adapted without his written consent. Complete copies of this report may, however, be made and distributed by the Client as an expedient in dealing with matters related to its commission.

XXIV. This report is prepared and written in the context of the proposals stated in the introduction to this report and should not be used in a differing context. Furthermore, new information, improved practices and legislation may necessitate an alteration to the report in whole or in part after its submission. Therefore, with any change in circumstances or after the expiry of one year from the date of the report, the report should be referred to the Consultant for re-assessment and, if necessary, re-appraisal.

XXV. Whatever the materials and structures beyond survey limits (horizontal and vertical) are, they may have not been taken into consideration for bearing capacity and settlements analysis of shallow foundations and piles. Calculated bearing capacity and allowable settlement model are for information only; design figures should be taken from each individual SPT test.

GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE

Annex 1: Site Location Map

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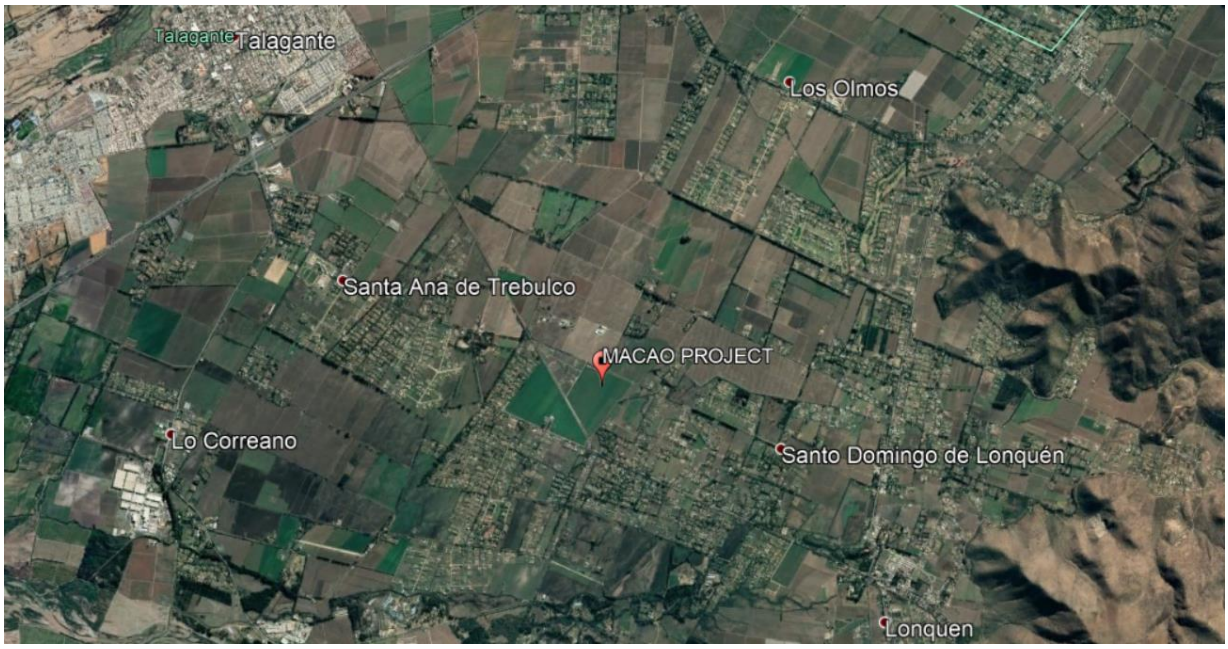
MACAO PROJECT


Mendoza
Valparaíso
Santiago
MACAO PROJECT
San Antonio Canyon
Rancagua
VI Región


Talagante
Talagante
Los Olmos
Santa Ana de Trebulco
MACAO PROJECT
Lo Correano
Santo Domingo de Lonquén
Lonquen

GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE

Annex 2: Variable Energy Dynamic Cone Penetrometer (Panda2) tests plots

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1. DPL's Location

Illustration 1: DPL (Panda2) Location.

2. DPL's Plots

Compaction control with variable energy dynamic penetrometer

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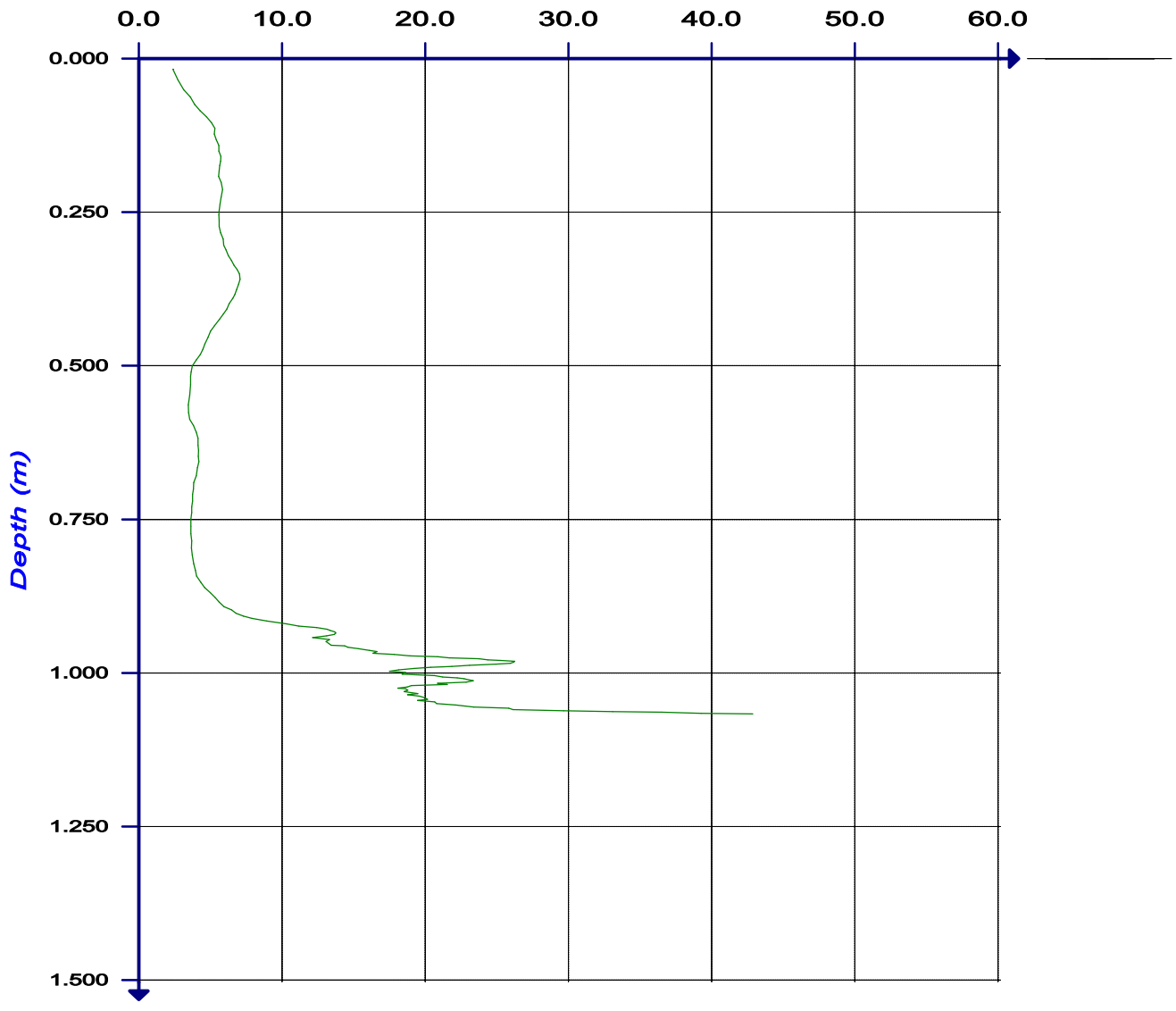

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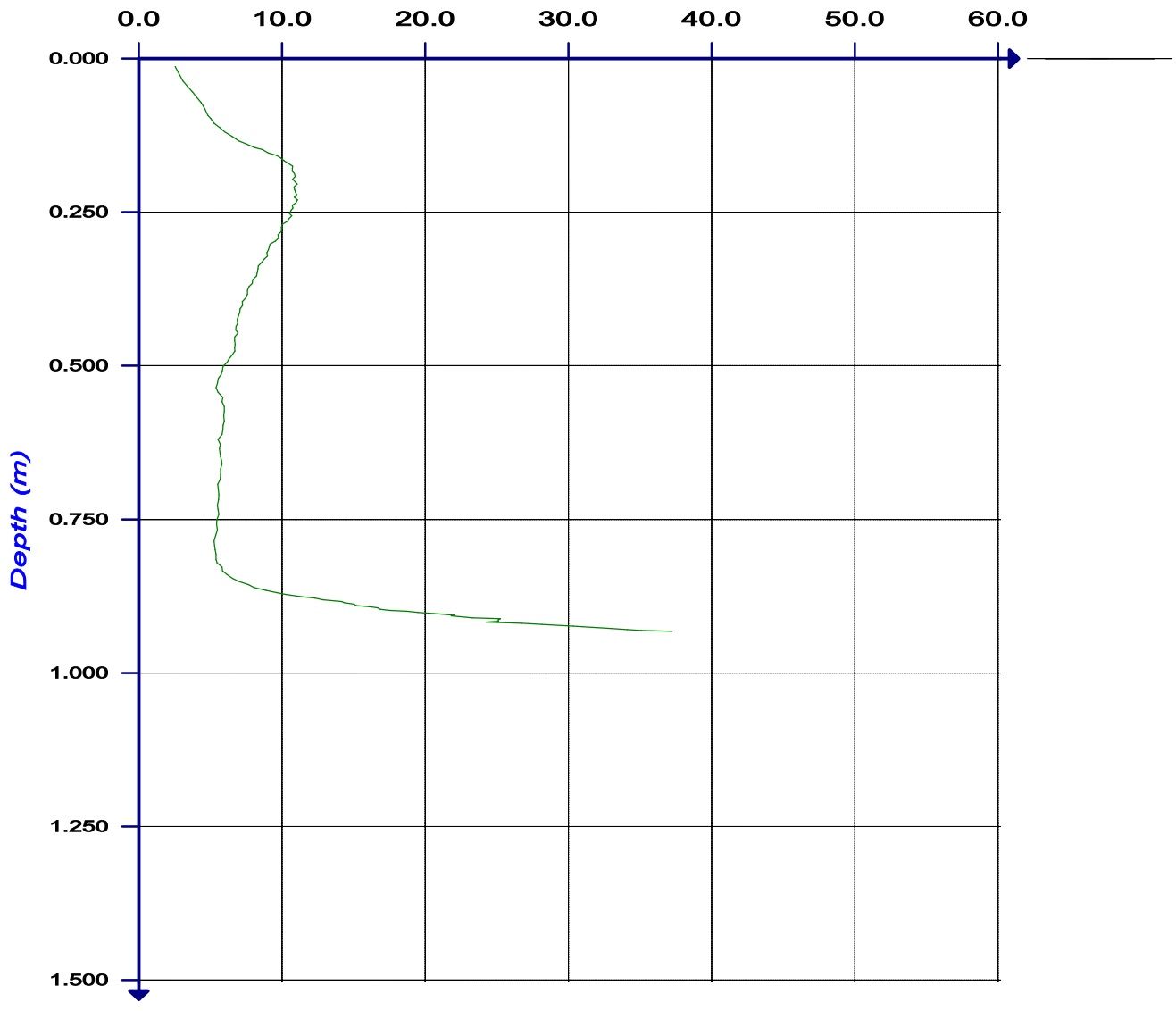

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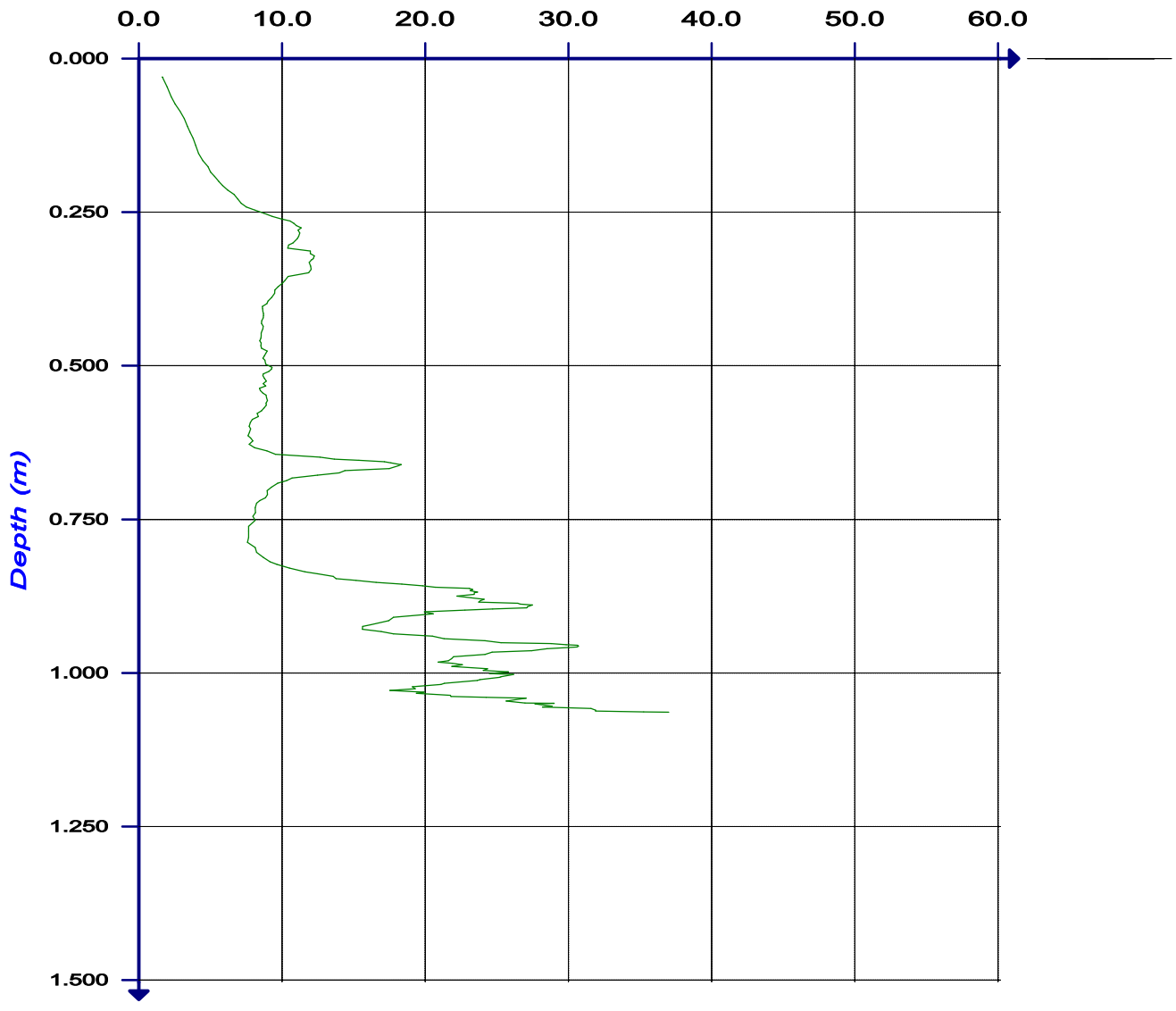

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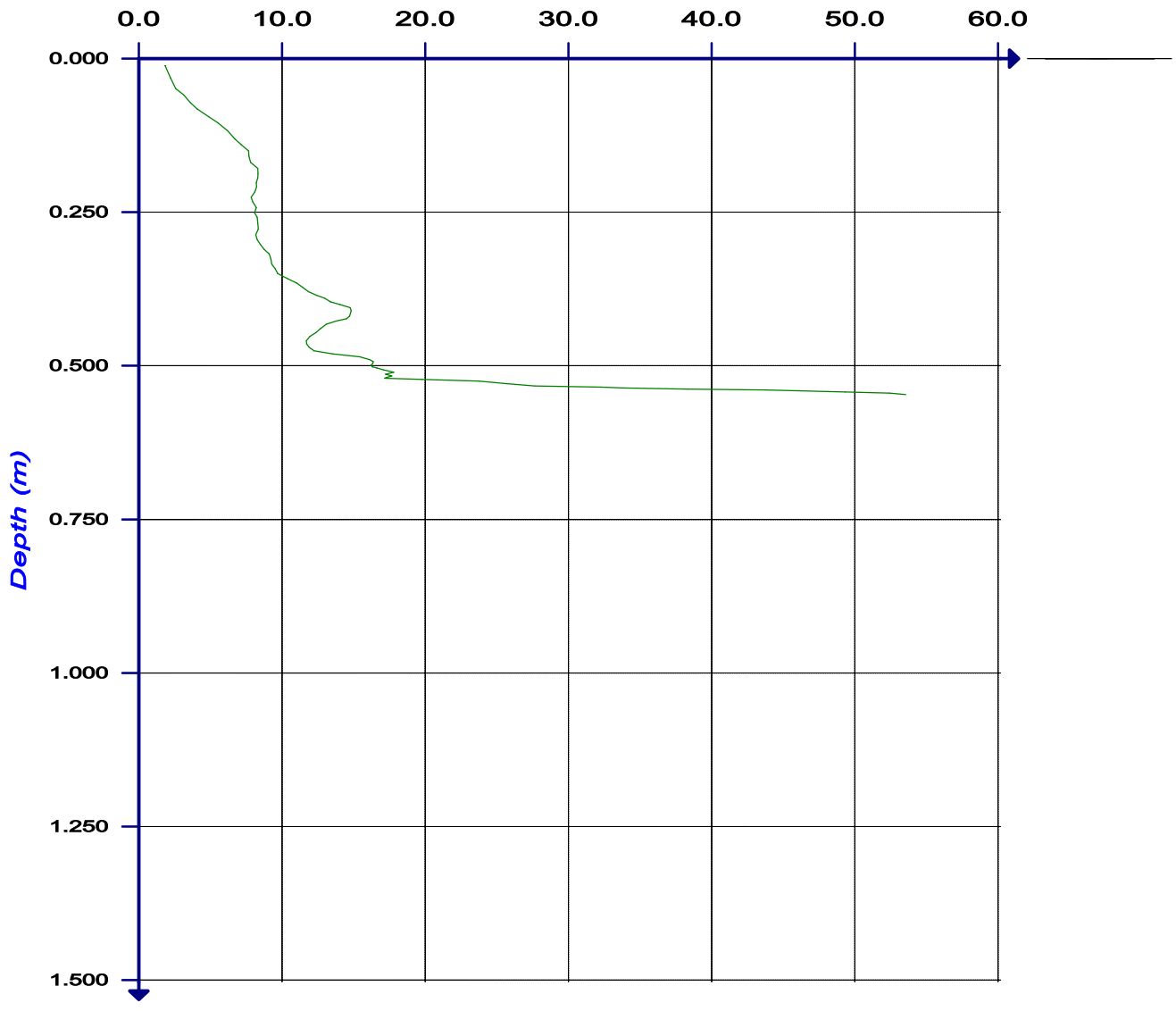

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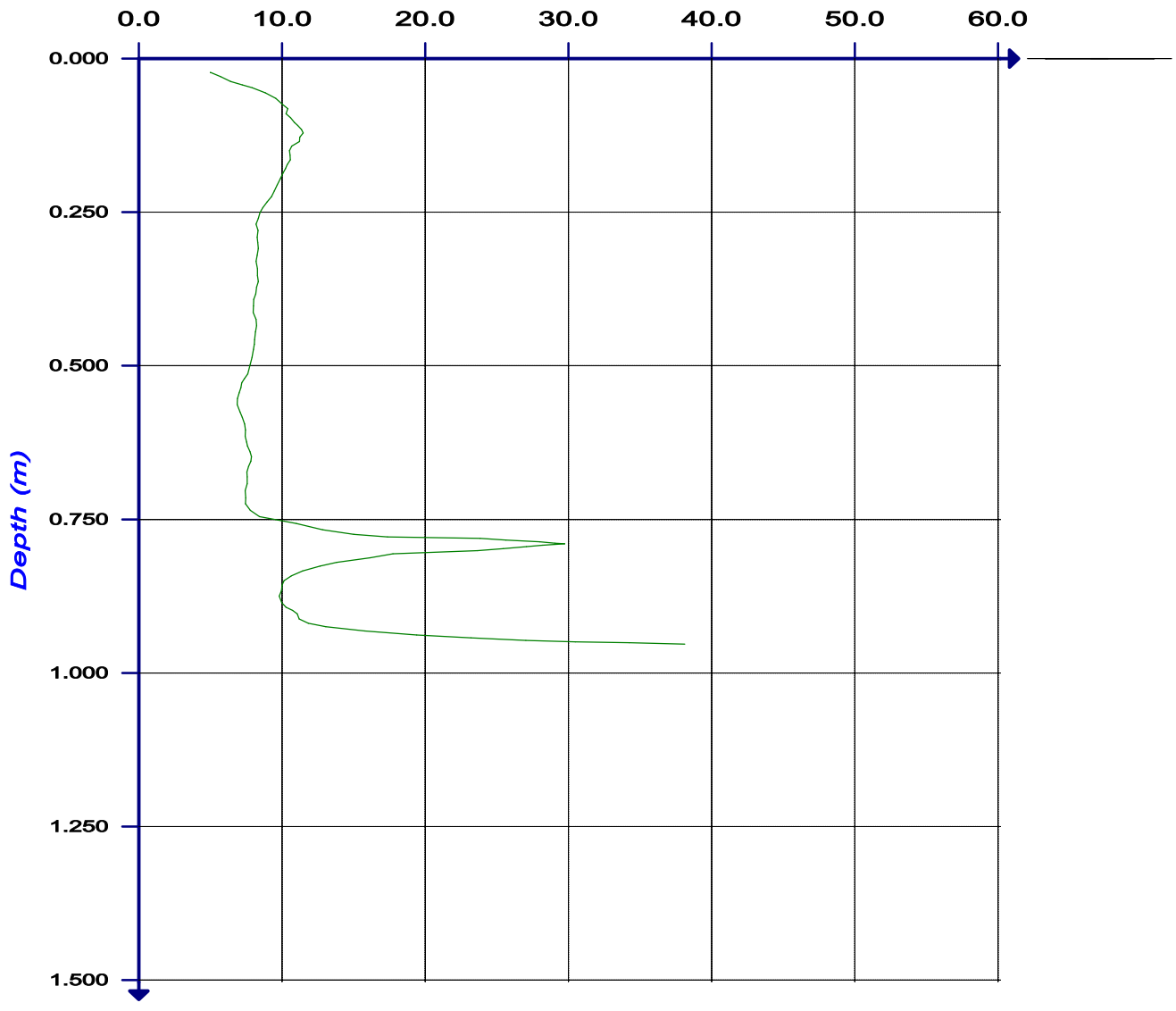

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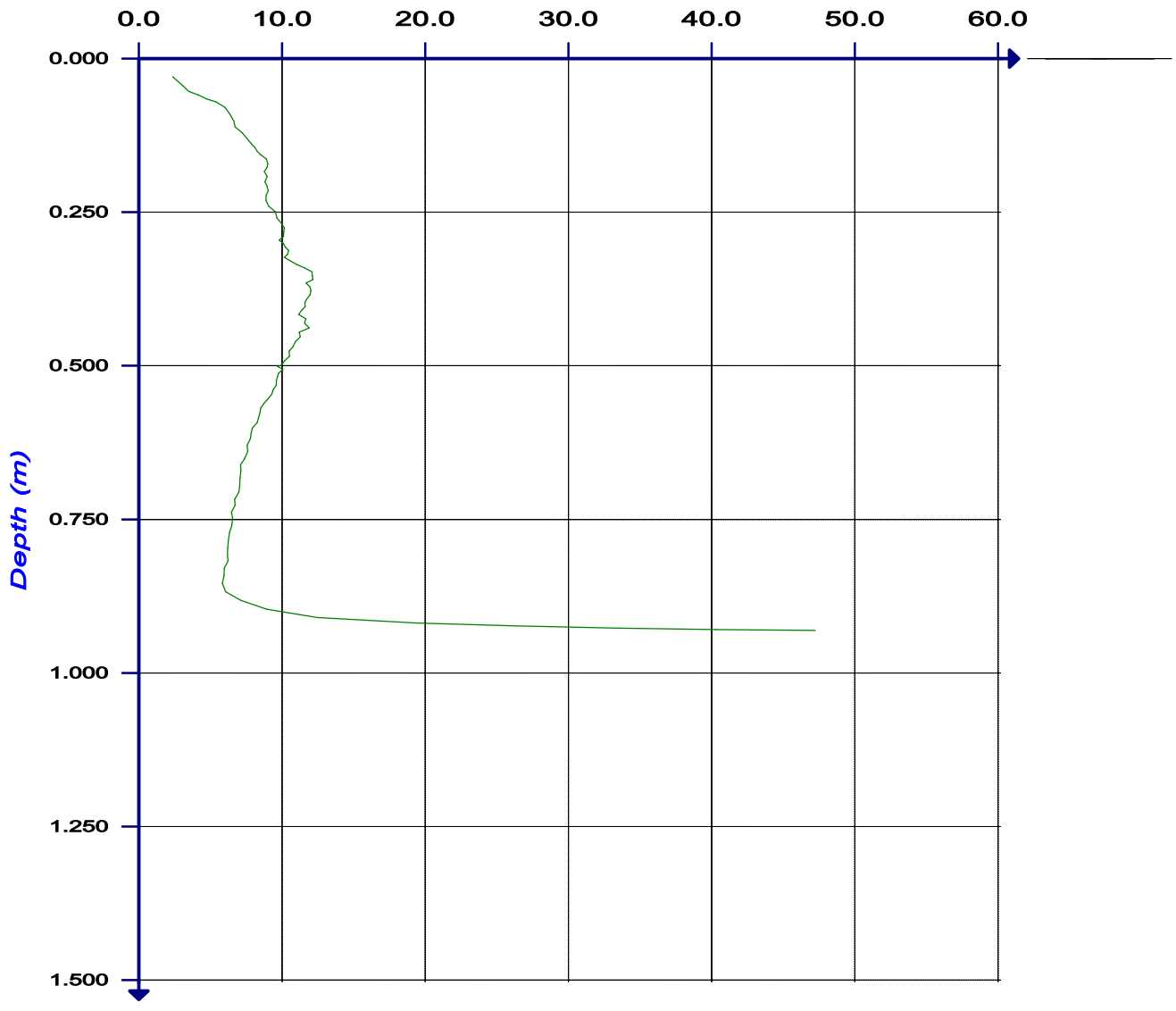

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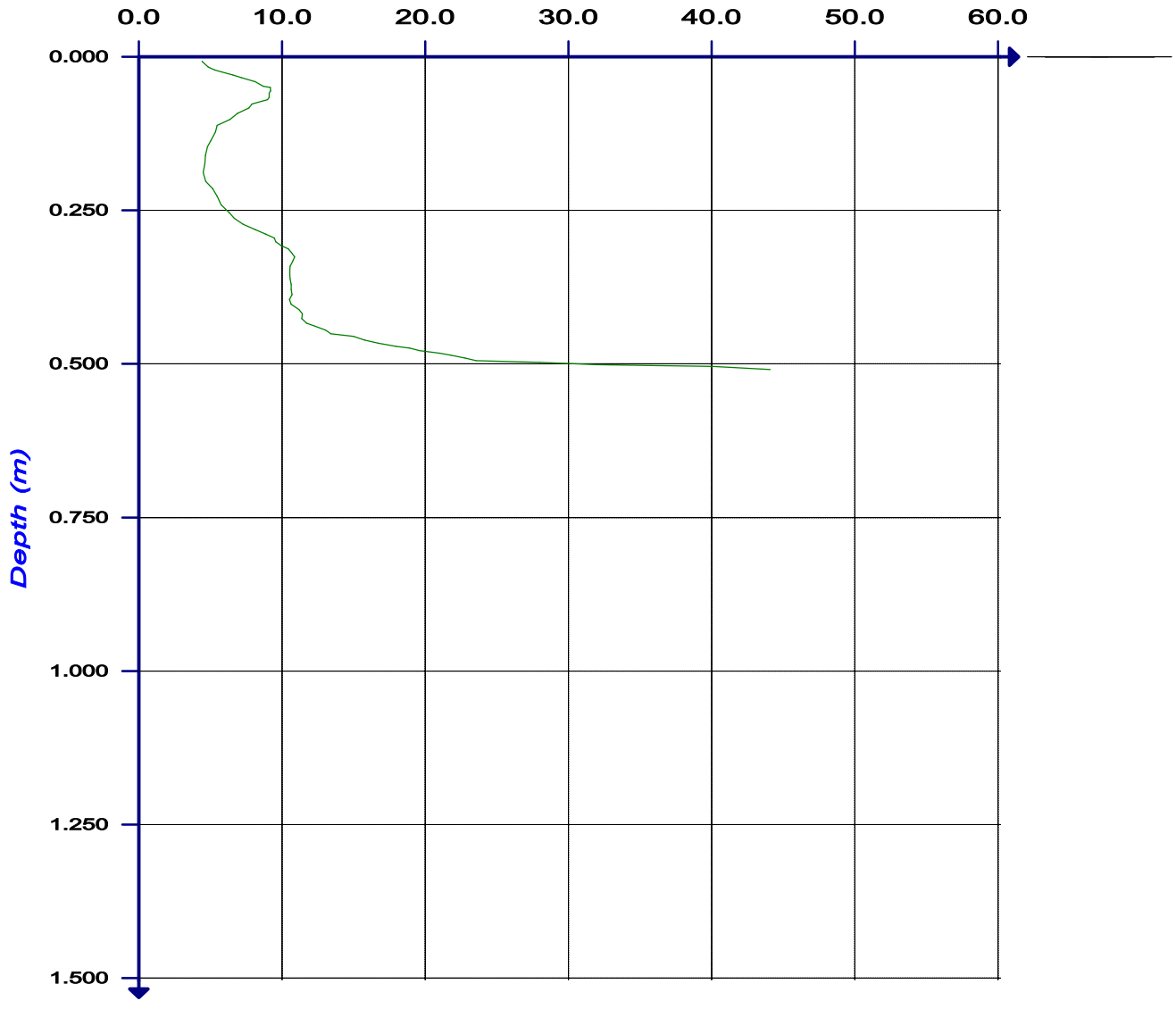

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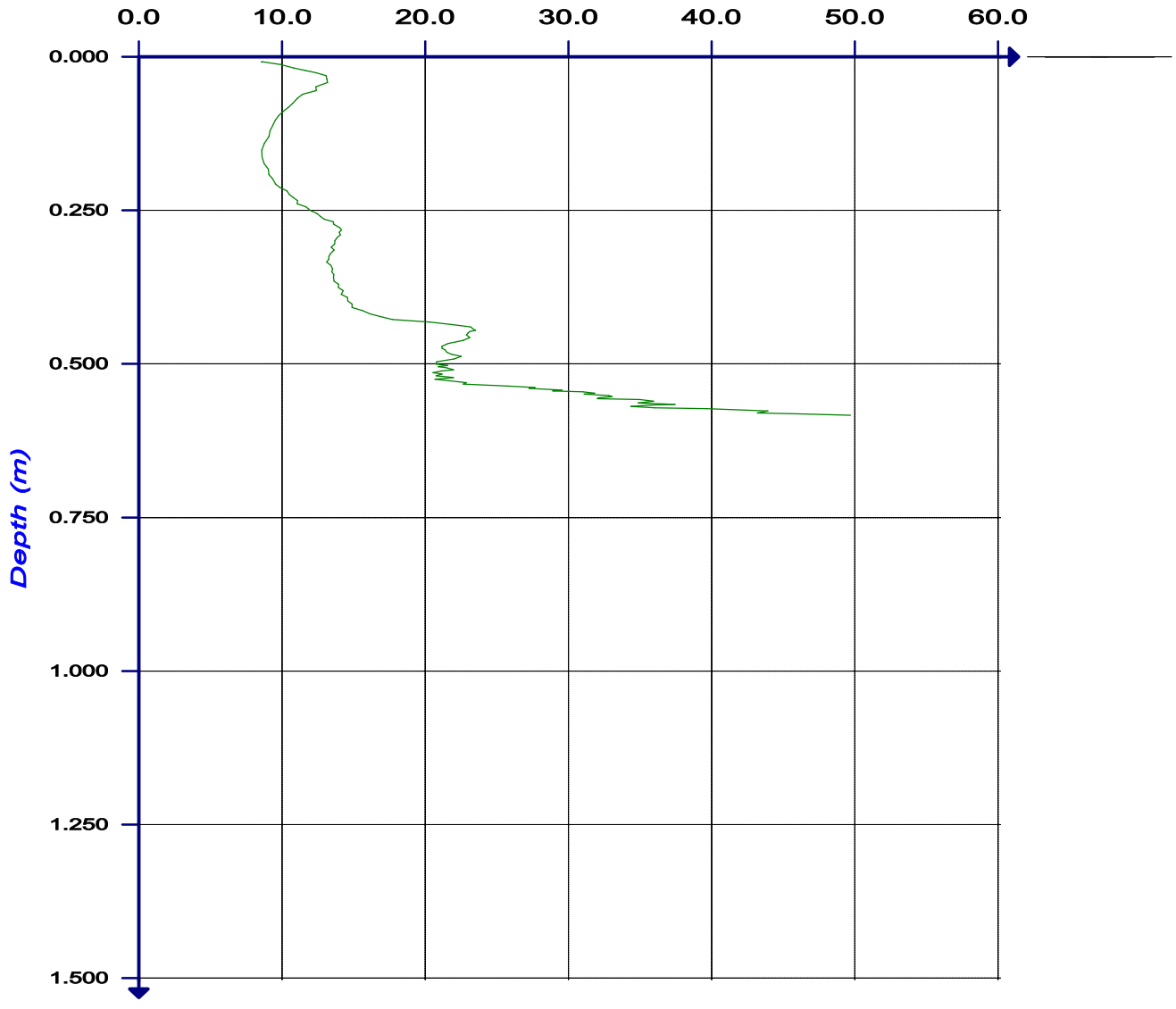

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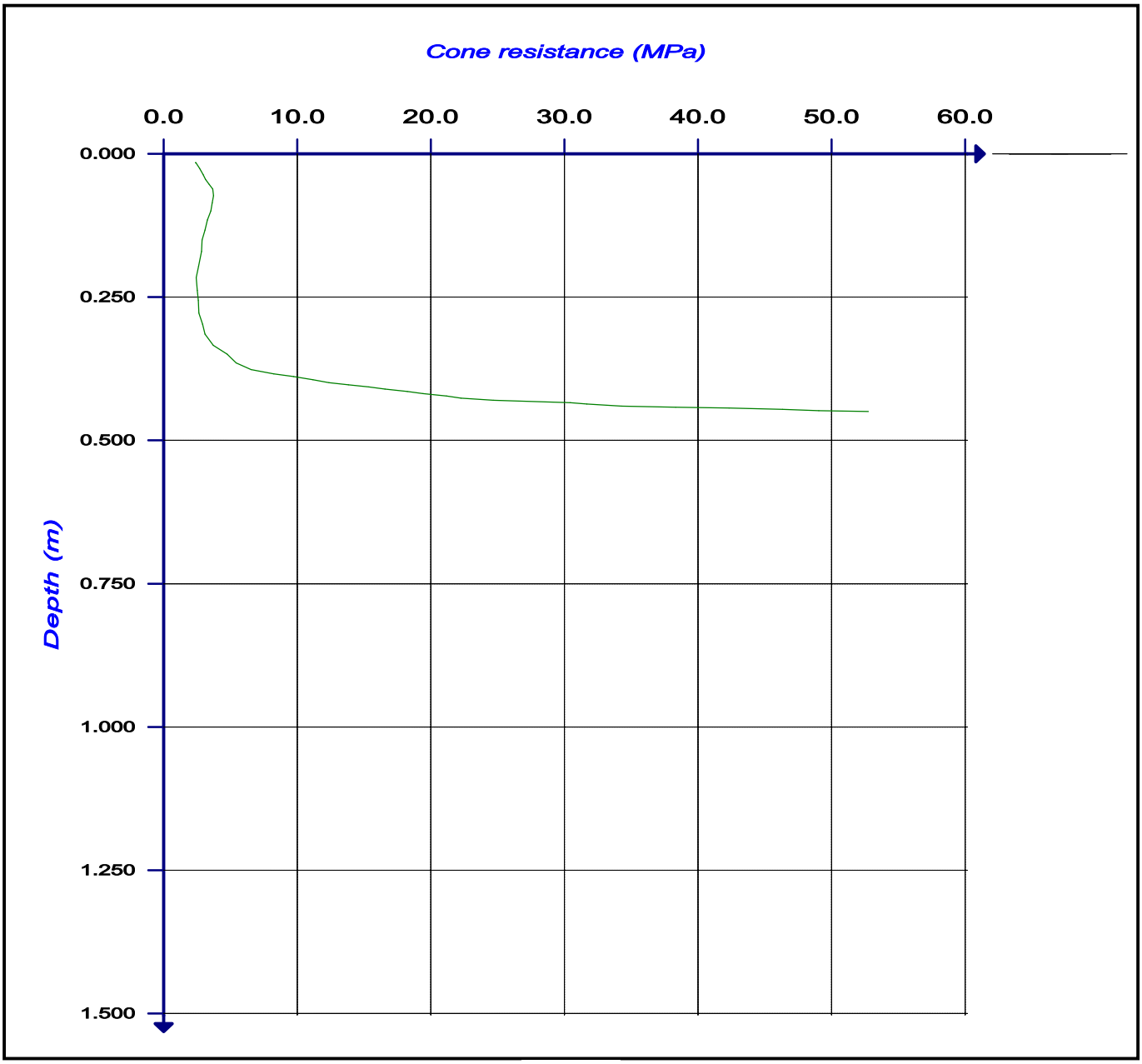

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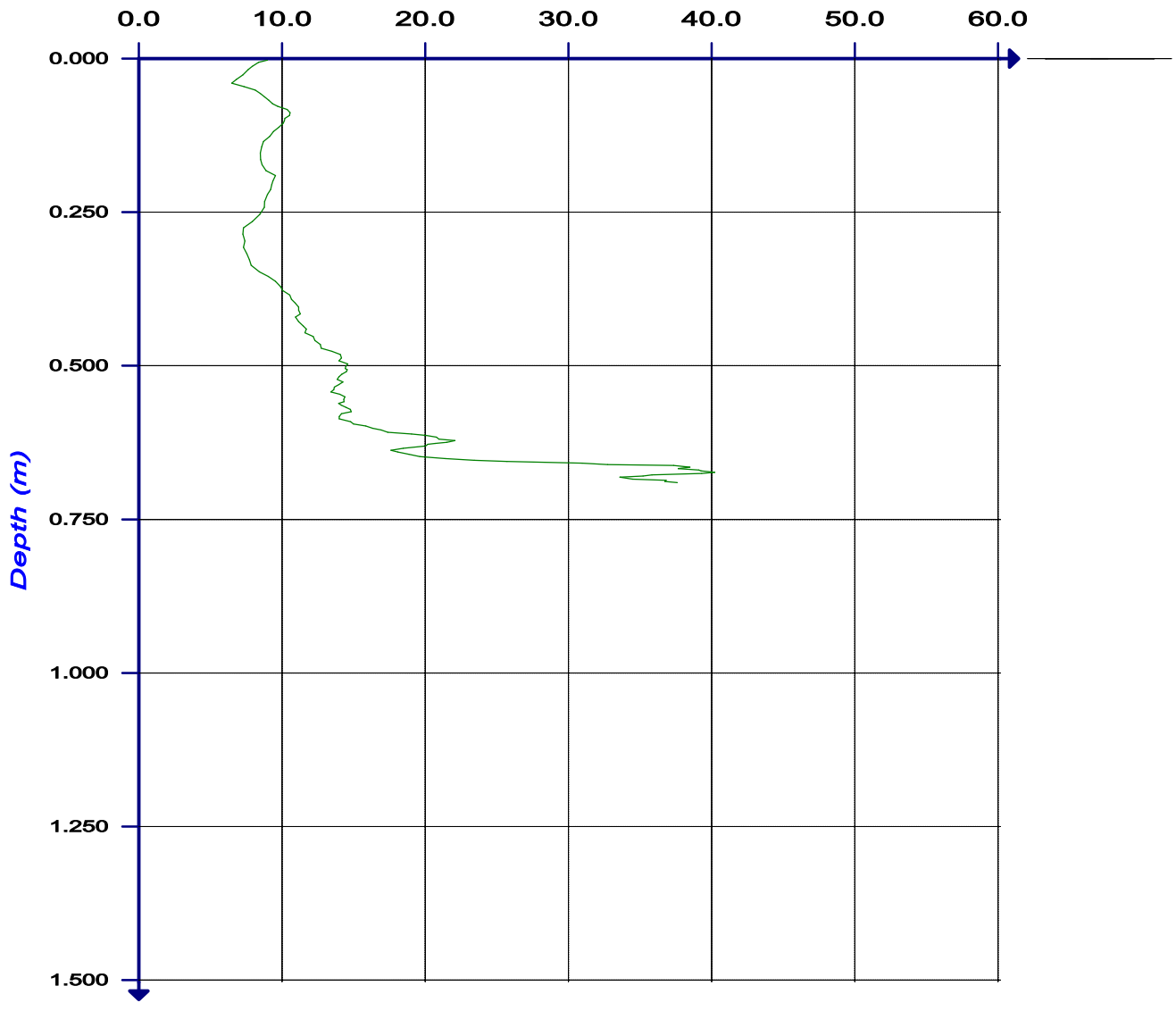

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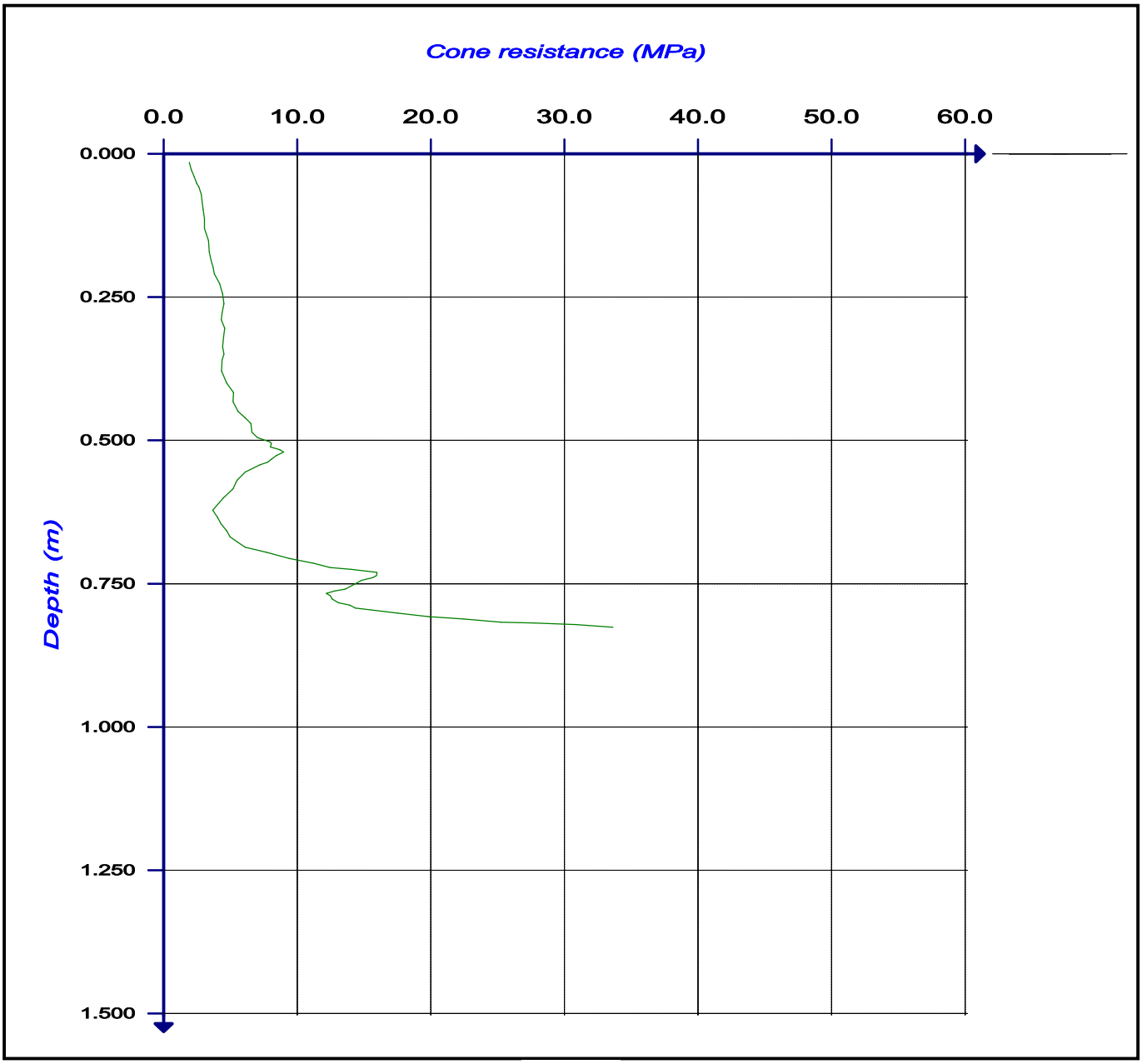

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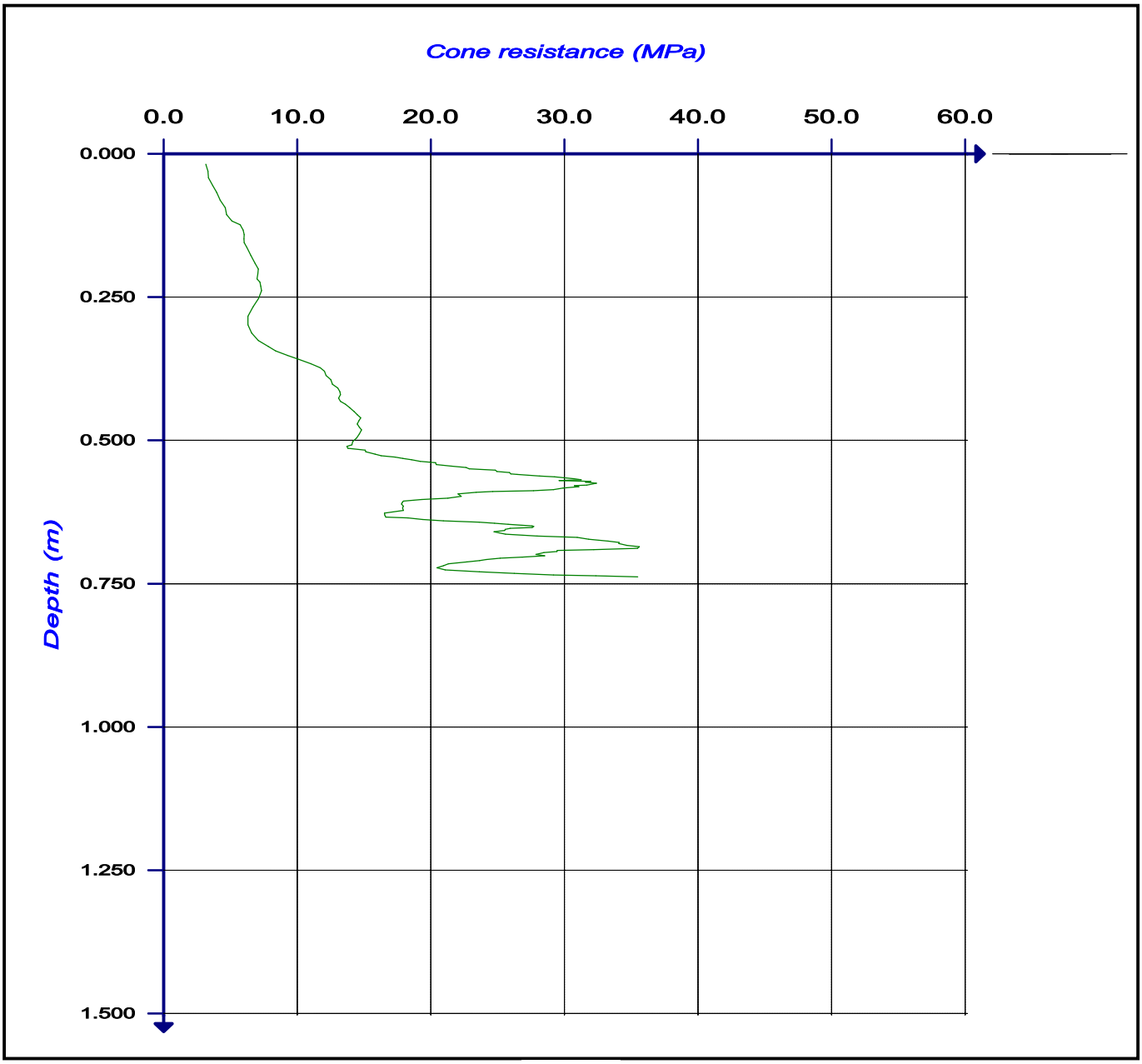

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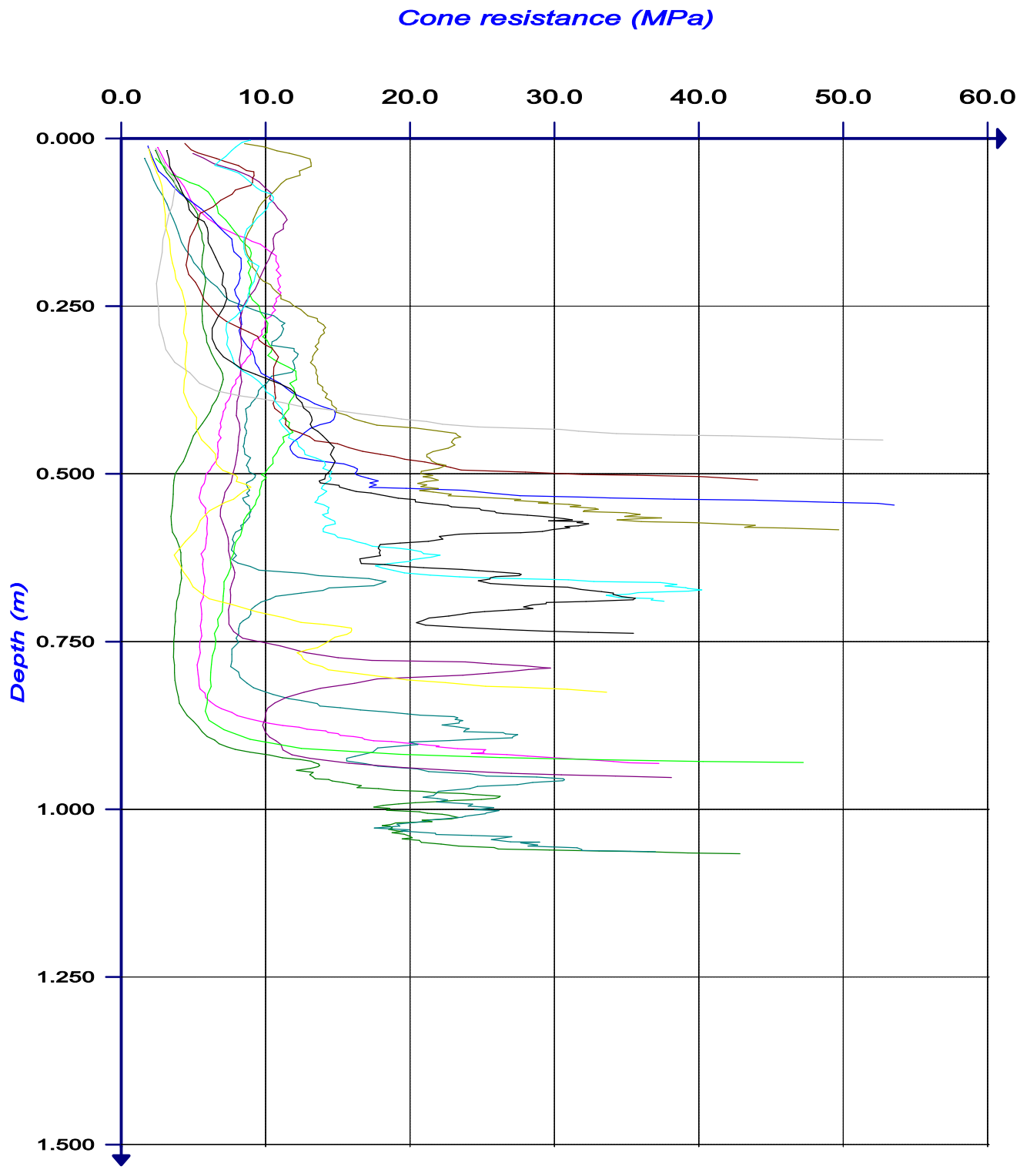
Site : MACAO



File site and sounding catalog

Document : Z:\PG02-Proyectos GMS\18271_Trina Solar\IG1827106_Macao\01_FIELD WORKS\Panda\MACAO.p

Site	Sounding	Date	Study	Courbe
MACAO	DPL-01	06/03/2020	Compaction	
MACAO	DPL-02	06/03/2020	Compaction	
MACAO	DPL-09	06/03/2020	Compaction	
MACAO	DPL 12	07/03/2020	Compaction	
MACAO	DPL-11	07/03/2020	Compaction	
MACAO	DPL 10	07/03/2020	Compaction	
MACAO	DPL 03	07/03/2020	Compaction	
MACAO	DPL 08	07/03/2020	Compaction	
MACAO	DPL 07	07/03/2020	Compaction	
MACAO	DPL 06	07/03/2020	Compaction	
MACAO	DPL 05	07/03/2020	Compaction	
MACAO	DPL 04	07/03/2020	Compaction	

GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE.

Annex 3: Trial Pit Logs.

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1. Project Location.

Illustration 1: Trial Pit Location.

2. Trial Pit Images

Illustration 2*: TP-01 image.*

Illustration 3: *TP-02 image.*

Illustration 4: TP-03 image.

Illustration 5: TP-04 image.

Illustration 6: TP-05 image.

Illustration 7: TP-06 image.

Illustration 8: TP-07 image.

Illustration 9: TP-08 image.

Illustration 10: TP-9 image.

Illustration 11: TP-10 image.

Illustration 12: TP-11 image.

Illustration 13: TP-12 image..

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-01
Coordinates X Y (m): X:325294; Y:6269931
Date: 28/02/2020

Comments
END OF TRIAL PIT: 3.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Medium dense wet dark brown clayey SAND with roots.	0.60				
1		Very loose wet dark brown GRAVEL with coarse grain sandy matrix. Sub-rounded boulders less than 40 cm are observed on the base.					
2				2.75 R 2.80			
3			3.00				

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-02
Coordinates X Y (m): X:325217; Y:6269882
Date: 28/02/2020

Comments
END OF TRIAL PIT: 3.0 m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Medium dense very wet dark brown clayey SAND with roots.	0.20				
		Very stiff wet dark brown CLAY with isolated sub-rounded gravels less than 4.0 cm. It presents low plasticity.	0.90	0.85 R 0.90			
1		Loose wet dark brown GRAVEL with coarse grain sandy matrix.Conglomerate is made up of sub-rounded volcanic gravels and boulders less than 40 cm.					
2							
			3.00				
3							

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-03
Coordinates X Y (m): X:325347; Y:6270185
Date: 02/03/2020

Comments
END OF TRIAL PIT: 2.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Loose wet dark brown clayey SAND with roots. Fine material content increase toward the base.	0.50			0.865mK/W	
		Dense wet brown GRAVEL with sandy-clayey matrix. This layer is made up of gravels and boulders.	1.00			0.50	
1		Dense wet brown GRAVEL in a sandy matrix. Gravel size is less than 5.0 cm.	1.30	1.05 R 1.10			
		Loose brown GRAVEL with sandy matrix. Layer is made up of boulders less than 40 cm.	2.00				
2							
3							

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-04
Coordinates X Y (m): X:325126; Y:6270267
Date: 02/03/2020

Comments
END OF TRIAL PIT: 3.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Loose to medium dense wet brown clayey SAND with few gravels less than 5.0 cm and roots.	0.70				
1		Loose wet brown GRAVEL with sandy matrix. Layer is made up of sub-rounded gravels and boulders, rising in size toward the base until 50 cm as maximum dia. At 1.40m depth, a loose wet coarse grain brown sand layer is observed, with a thickness of 10 cm.		1.35 R 1.40			
2			3.00				
3							

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-05
Coordinates X Y (m): X:324946; Y:6270222
Date: 29/02/2020

Comments
END OF TRIAL PIT: 3.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Loose wet dark brown clayey SAND with roots and sub-rounded gravels less than 5.0 cm.	0.60			0.790mK/W 0.40	
1		Loose wet brown GRAVEL with coarse grain sandy matrix. Layer is made up of gravels and boulders, rising in size toward the base.		0.85 R 0.90			
2							
3			3.00				

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-06
Coordinates X Y (m): X:324865; Y:6270066
Date: 29/02/2020

Comments
END OF TRIAL PIT: 3.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Loose wet dark brown clayey SAND with roots and sub-rounded gravels less than 5.0 cm.	0.50	0.45 R 0.50			
1		Loose dark brown GRAVEL with coarse grain sandy matrix. Layer is made up of sub-rounded volcanic gravels and boulders, rising in size toward the base until 40 cm as maximum.					
2							
			3.00				
3							

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-07
Coordinates X Y (m): X:324853; Y:6269910
Date: 29/02/2020

Comments
END OF TRIAL PIT: 3.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Loose wet dark brown clayey SAND with roots and few sub-rounded gravels less than 5.0 cm.	0.60			0.853mK/W 0.50	
1		Very loose wet dark brown GRAVEL with sandy matrix.Layer is made up of sub-rounded gravels and boulders, rising in size toward the base until 50 cm as maximum.		0.85 R 0.90			
2							
3			3.00				

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-08
Coordinates X Y (m): X:324890; Y:6669849
Date: 28/02/2020

Comments
END OF TRIAL PIT: 3.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Loose wet dark brown clayey SAND with roots and sub-rounded gravels less than 5.0 cm.	0.40				
1		Wet dark brown GRAVEL with sandy matrix. Layer is made up of sub-rounded gravels and boulders, rising in size toward the base until 50 cm as maximum.		1.25 R 1.30			
2							
			3.00				
3							

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-09
Coordinates X Y (m): X:325215; Y:6269804
Date: 28/02/2020

Comments
END OF TRIAL PIT: 3.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Soft wet dark brown sandy CLAY with roots.	0.20				
		Loose to medium dense wet light brown sandy SILT with isolated sub-rounded gravels less than 5.0 cm. Low plasticity	0.90	0.85 R 0.90			
1		Very loose dark brown GRAVEL with coarse grain sandy matrix.Layer is made up of sub-rounded volcanic gravels and boulders less than 30 cm.					
2			3.00				
3							

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-10
Coordinates X Y (m): X:325145; Y:6269770
Date: 28/02/2020

Comments
END OF TRIAL PIT: 3.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Loose to medium dense wet brown clayey SAND with roots and few sub-angular gravels less than 1.0 cm.	0.30				
1		Medium to soft wet light brown clayed SILTwith isolated sub-rounded gravels less than 7.0 cm. It presents low plasticity.	1.10	0.75 A 0.80		0.881mK/W 0.80	
2		Very loose dark brown GRAVEL with coarse grain sandy matrix. Layer is made up of sub-rounded volcanic gravels and boulder less than 30 cm.	3.00				
3							

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-11
Coordinates X Y (m): X:325120; Y:6269685
Date: 28/02/2020

Comments
END OF TRIAL PIT: 3.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
		TOPSOIL: Medium dense brown silty SAND with roots.	0.30				
		Very stiff wet dark brown sandy CLAY with isolated rounded to sub-rounded gravels less than 2.0 cm. It presents low-to-medium plasticity.	1.00	0.85 R 0.90			
1		Medium dense wet brown GRAVEL with sandy matrix.Layer is made up of sub-rounded cobbles and gravels less than 10 cm.	1.50				
		Medium dense wet coarse grain brown SAND with few sub-rounded gravels less than 5.0 cm.	1.80				
2		Very wet dark brown GRAVEL with coarse grain sandy matrix. Layer is made up of sub-rounded gravels and boulders less than 30 cm.	3.00		3.00		
3							

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: TRINA SOLAR
ID Project: IG1827106 - MACAO

Number: TP-12
Coordinates X Y (m): X:325050; Y:6269647
Date: 28/02/2020

Comments
END OF TRIAL PIT: 3.00m

Scale	Lithology	Description	Depth	Sample	Water Table	Resistivity mk/W	PANDA2
1		TOPSOIL: Medium to stiff dark brown sandy CLAY with roots and few gravels less than 2.0 cm.,	0.50				
2		Very loose wet dark brown GRAVEL with coarse grain sandy matrix. Layer is made up of sub-rounded gravels and boulders less than 25 cm.	2.20				
3		Very loose coarse grain dark brown SAND with gravels and few sub-rounded cobbles less than 10 cm.	3.00	2.45 A 2.50	3.00		

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked

GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE

Annex 4: CBR testing in situ logs (Panda2)

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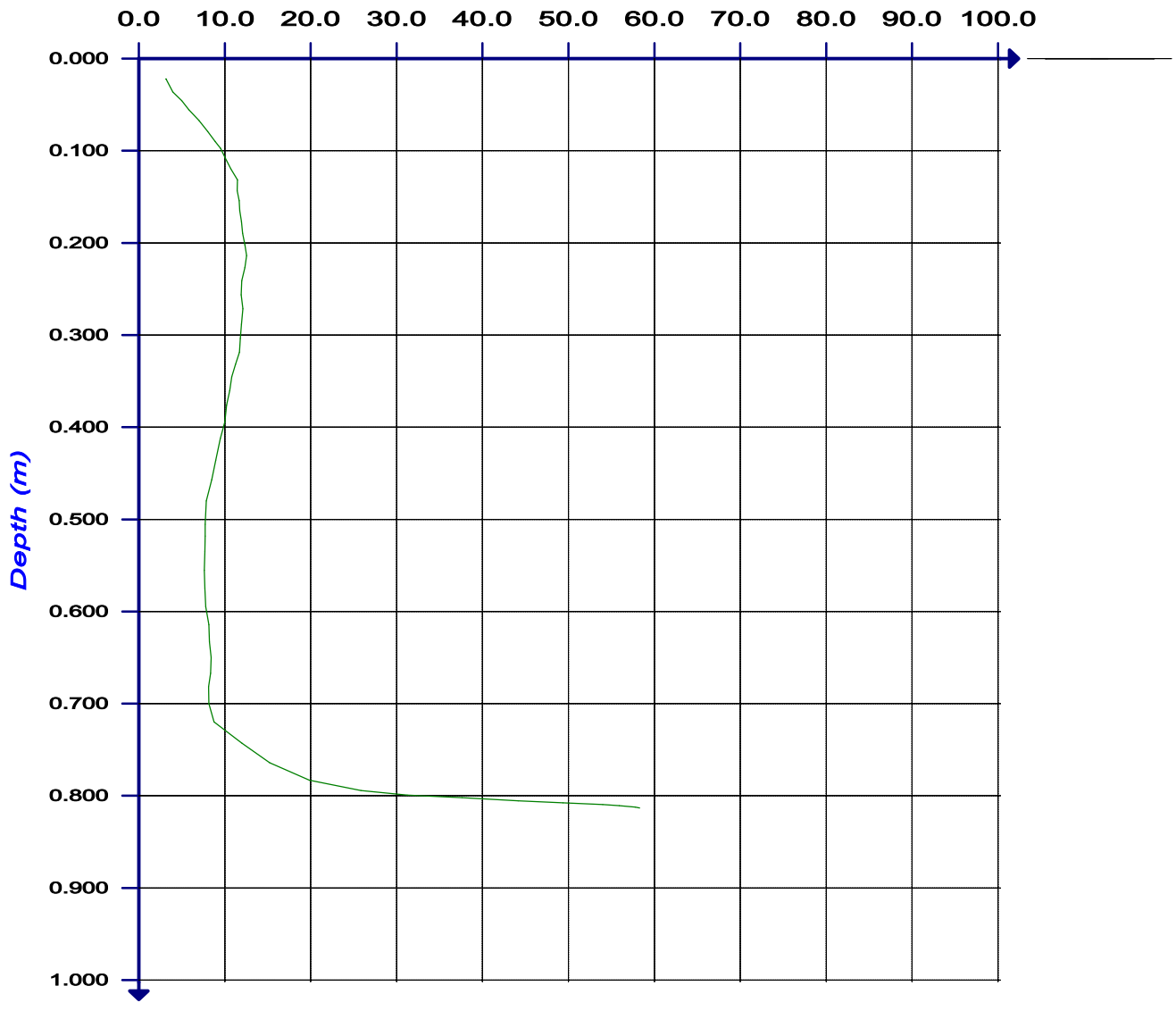
1.- CBR's Site Location.

Illustration 1: Location CBR

2.- CBR´s plots

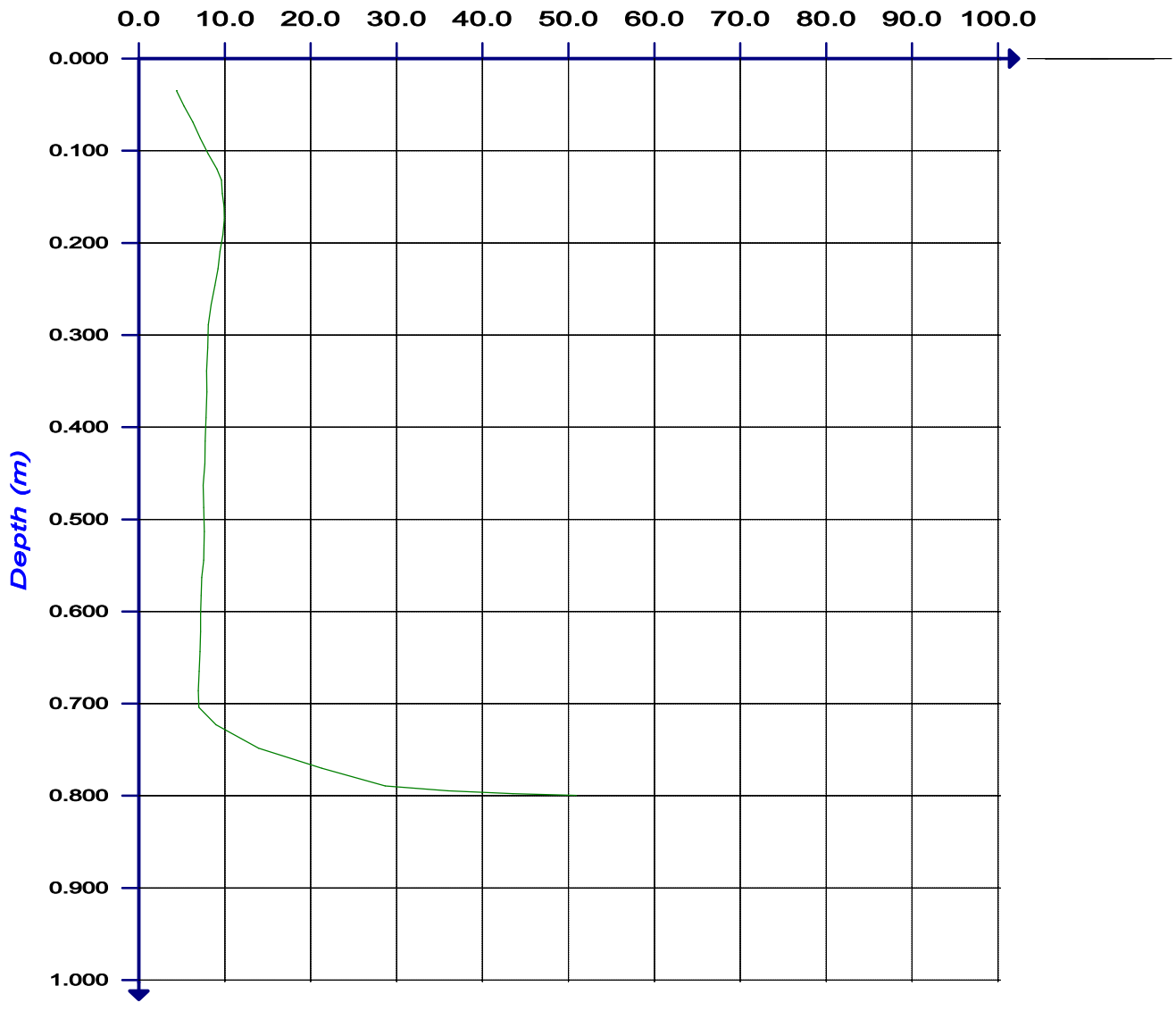
Compaction control with variable energy dynamic penetrometer

Document : Z:\PG02-Proyectos GMS\18271_Trina Solar\IG1827106_Macao\01_FIELD WORKS\Panda\MACAO.pd2			
Site : MACAO			
Sounding : CBR 05			
Tarmac : 0.00 m	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Indefinite
Weight : Panda 2 hammer	Breaking cond. : Temporary	Date : 07/03/2020	Hour : 02:30:00 p. m.
Operator :		Company :	
Comments :			



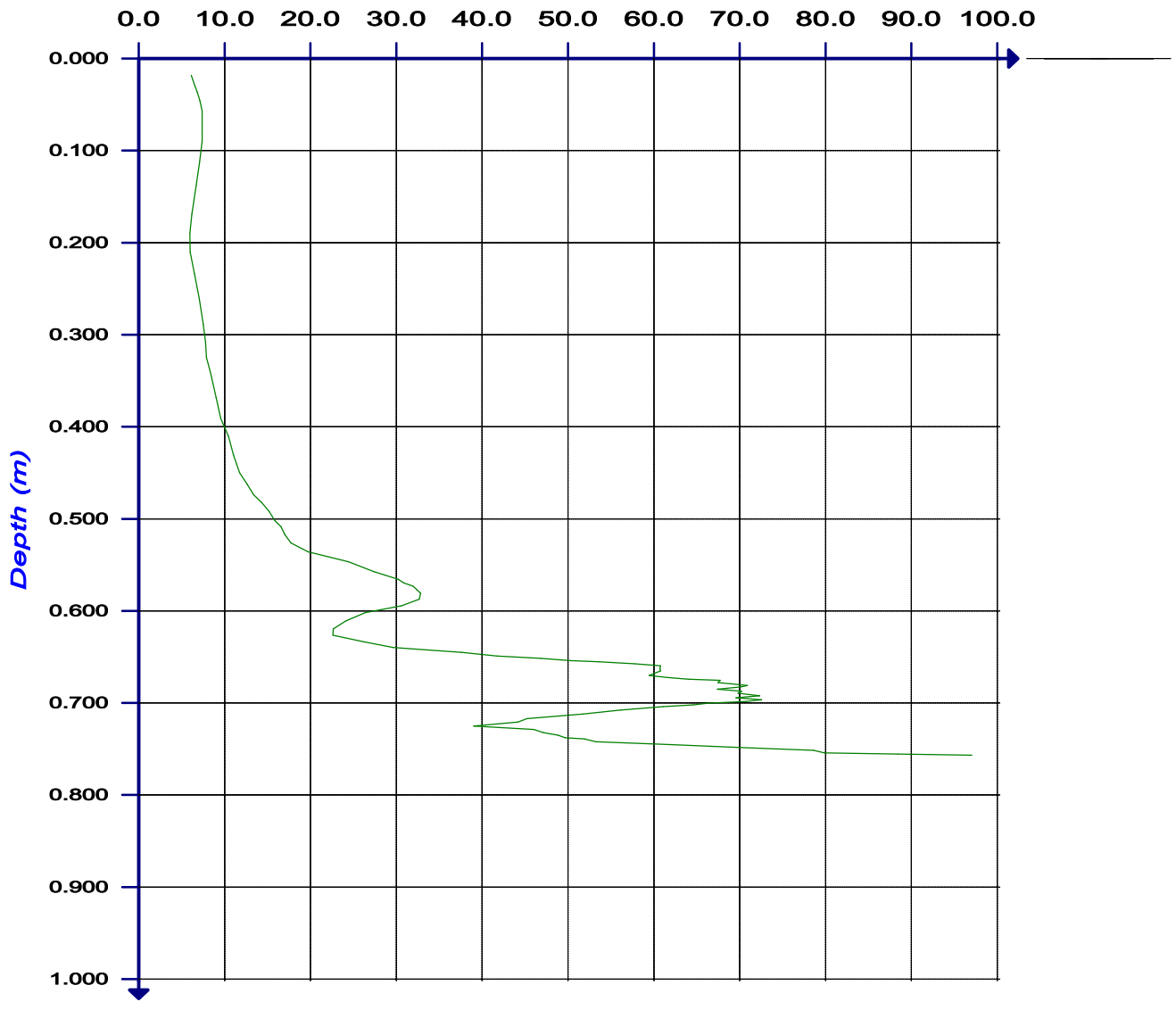
Compaction control with variable energy dynamic penetrometer

Document : Z:\PG02-Proyectos GMS\18271_Trina Solar\IG1827106_Macao\01_FIELD WORKS\Panda\MACAO.pd2			
Site : MACAO			
Sounding : CBR 04			
Tarmac : 0.00 m	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Indefinite
Weight : Panda 2 hammer	Breaking cond. : Temporary	Date : 07/03/2020	Hour : 03:07:00 p. m.
Operator :		Company :	
Comments :			



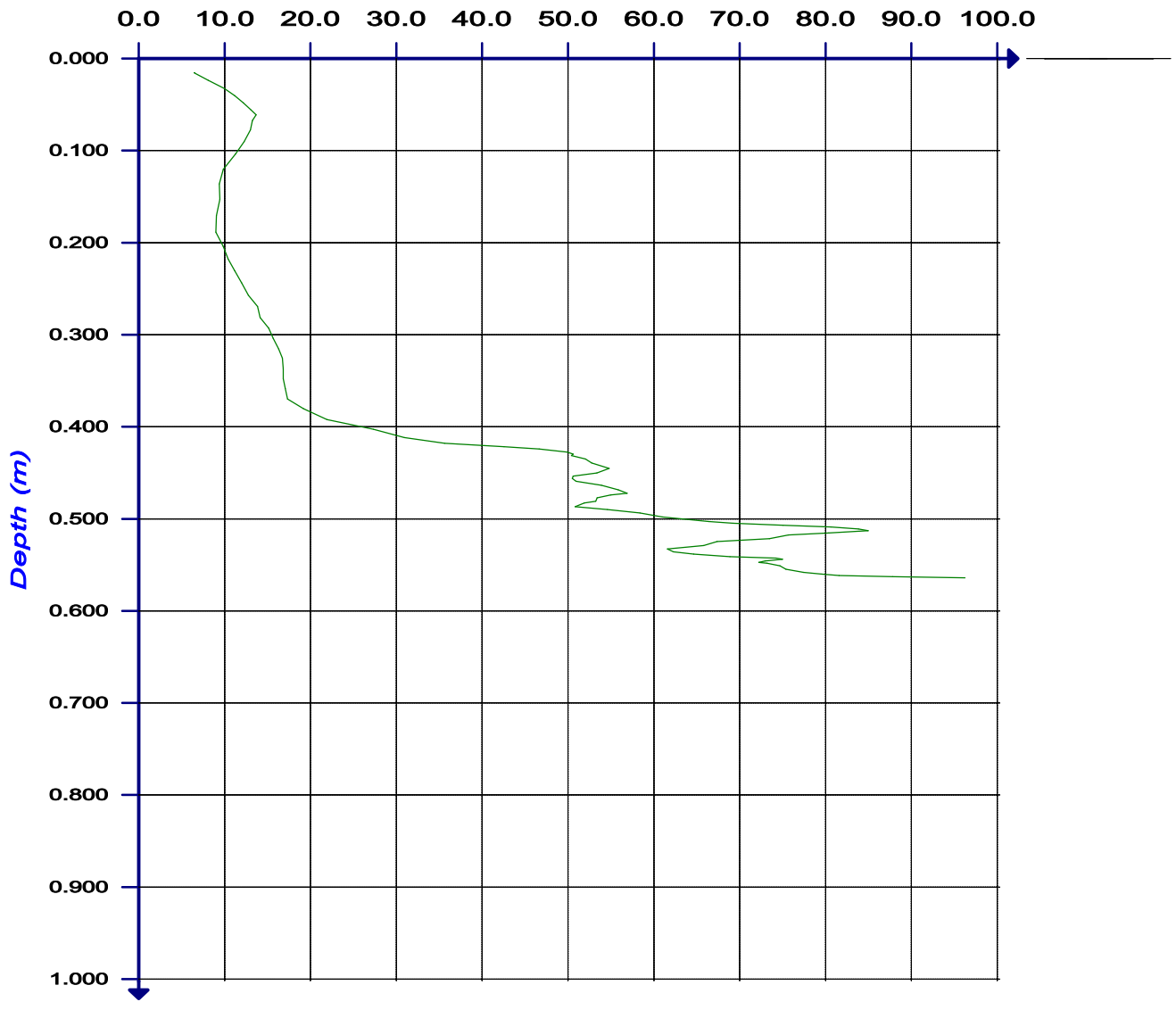
Compaction control with variable energy dynamic penetrometer

Document : Z:\PG02-Proyectos GMS\18271_Trina Solar\IG1827106_Macao\01_FIELD WORKS\Panda\MACAO.pd2			
Site : MACAO			
Sounding : CBR 03			
Tarmac : 0.00 m	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Indefinite
Weight : Panda 2 hammer	Breaking cond. : Temporary	Date : 07/03/2020	Hour : 03:26:00 p. m.
Operator :		Company :	
Comments :			



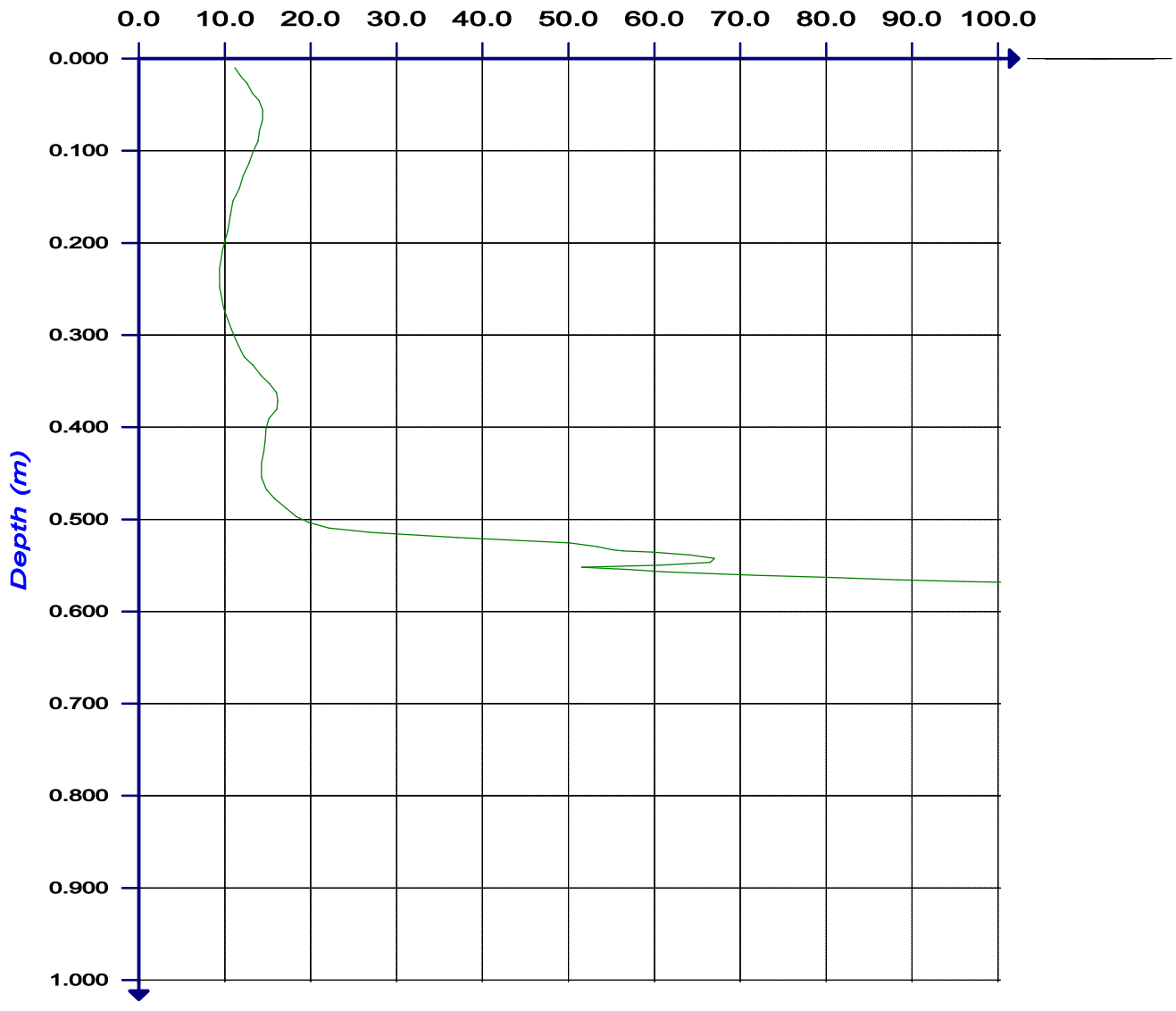
Compaction control with variable energy dynamic penetrometer

Document : Z:\PG02-Proyectos GMS\18271_Trina Solar\IG1827106_Macao\01_FIELD WORKS\Panda\MACAO.pd2			
Site : MACAO			
Sounding : CBR 01			
Tarmac : 0.00 m	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Indefinite
Weight : Panda 2 hammer	Breaking cond. : Temporary	Date : 07/03/2020	Hour : 04:02:00 p. m.
Operator :		Company :	
Comments :			



Compaction control with variable energy dynamic penetrometer

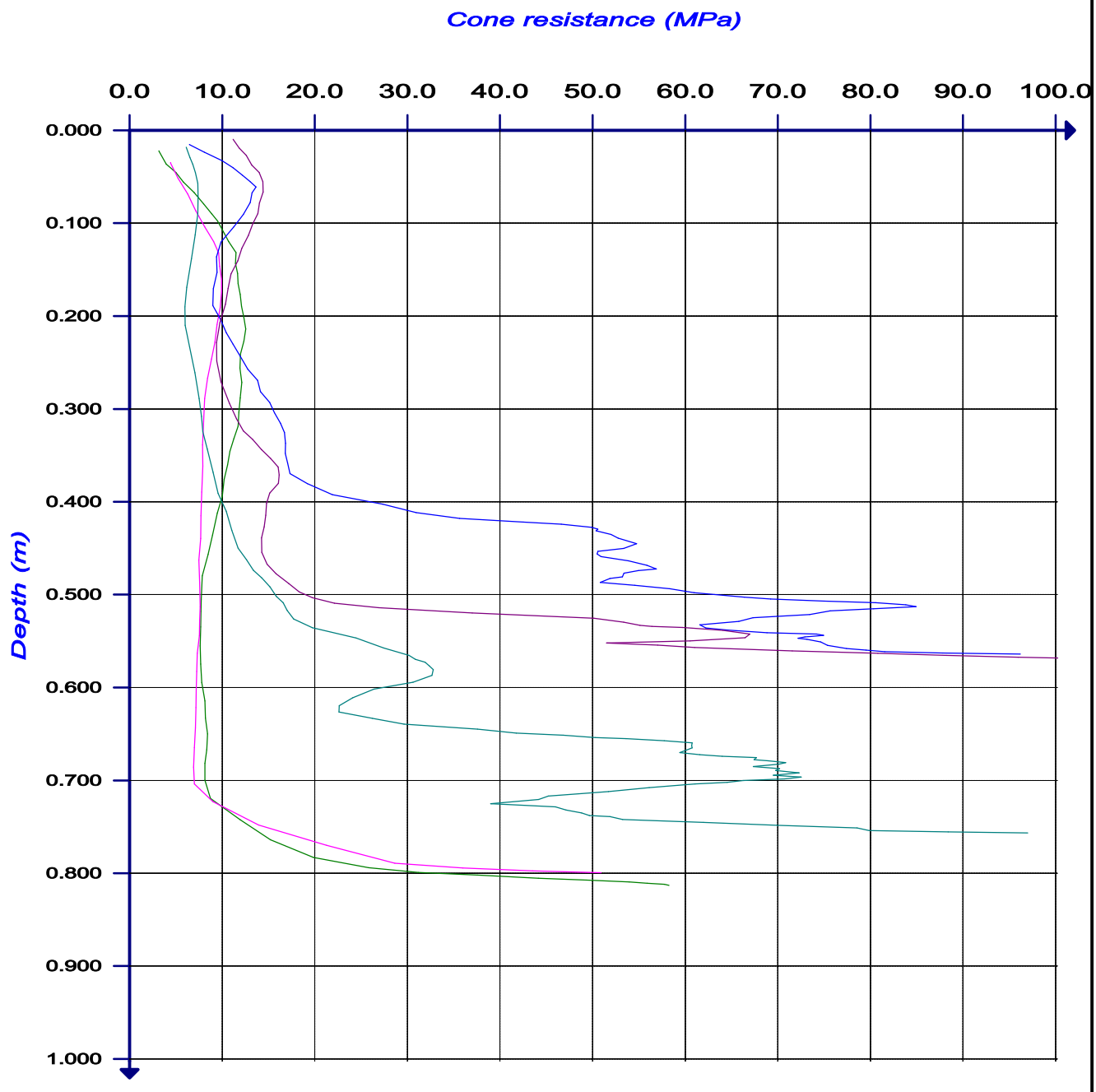
Document : Z:\PG02-Proyectos GMS\18271_Trina Solar\IG1827106_Macao\01_FIELD WORKS\Panda\MACAO.pd2			
Site : MACAO			
Sounding : CBR 02			
Tarmac : 0.00 m	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Indefinite
Weight : Panda 2 hammer	Breaking cond. : Temporary	Date : 07/03/2020	Hour : 04:49:00 p. m.
Operator :		Company :	
Comments :			



Compaction control with variable energy dynamic penetrometer

Document : Z:\PG02-Proyectos GMS\18271_Trina Solar\IG1827106_Macao\01_FIELD WORKS\Panda\MACAO.pd2

Site : MACAO



Site	Sounding	Date	Study	Courbe
MACAO	CBR 05	07/03/2020	Compaction	
MACAO	CBR 04	07/03/2020	Compaction	
MACAO	CBR 03	07/03/2020	Compaction	
MACAO	CBR 01	07/03/2020	Compaction	
MACAO	CBR 02	07/03/2020	Compaction	

Logiciel PANDA 2.7

GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE

Annex 5: Vertical Electric Sounding (VES)

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1. VES's Site Location

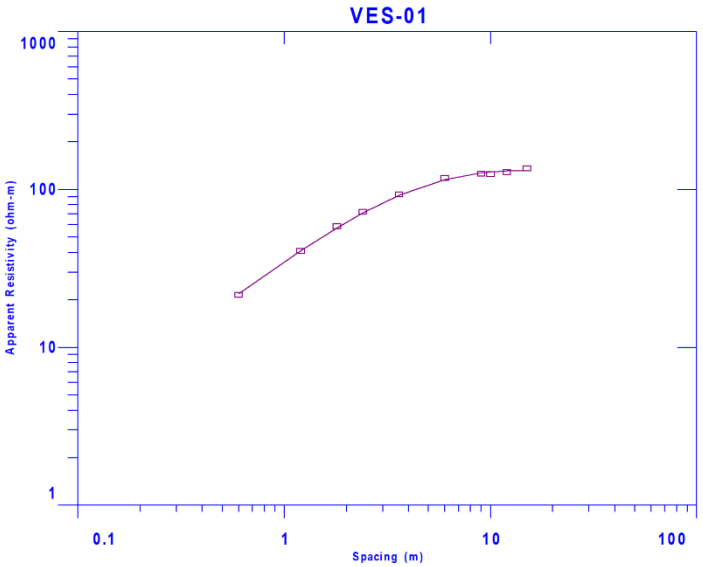
Figure 1: VES's site location

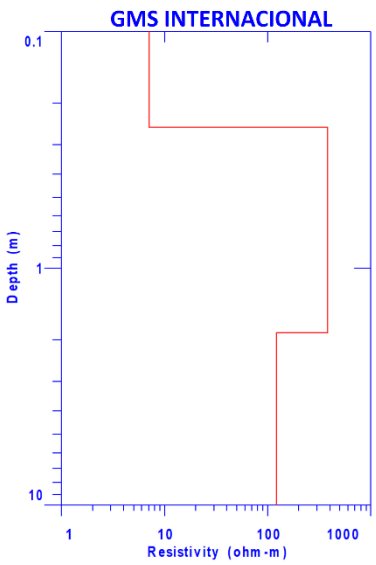
2. VES Summary

SEV	1	
PROJECT	MACAO	
DATE	01/03/2020	
CLIENT	Trina Solar	
COORDINATES		
X	Y	
324851	6269911	

WENNER ARRAY

Wenner Spacing a (m)	0-M/0-N Spacing (m)	0-A/0-B Spacing (m)	Voltage (mV)	Current (mA)	Apparent Resistivity (Ohm*m)	Error (%)
0.60	0.30	0.90	629.37	110.29	21.51	0.1
1.20	0.60	1.80	617.67	114.46	40.69	0.0
1.80	0.90	2.70	569.19	109.98	58.53	0.0
2.40	1.20	3.60	524.32	109.54	72.18	0.0
3.60	1.80	5.40	456.46	111.04	92.99	0.0
6.00	3.00	9.00	325.00	103.53	118.34	0.0
9.00	4.50	13.50	486.32	218.13	126.08	0.0
10.00	5.00	15.00	427.82	214.56	125.28	0.0
12.00	6.00	18.00	345.43	202.89	128.40	0.0
15.00	7.50	22.50	617.06	426.50	136.36	0.0

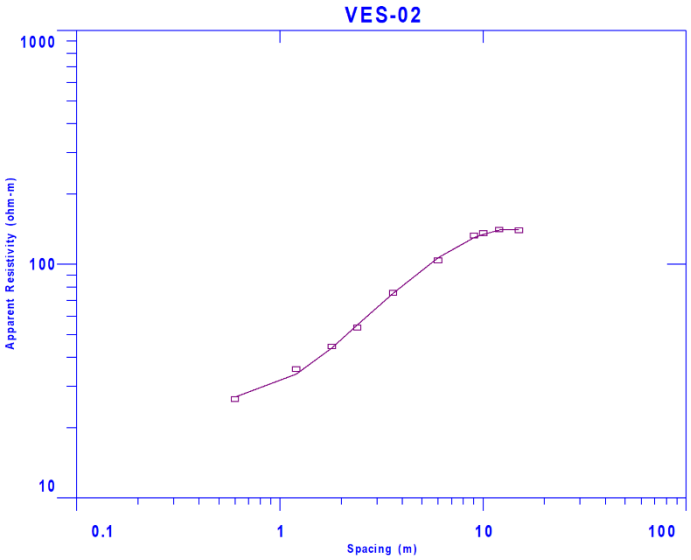


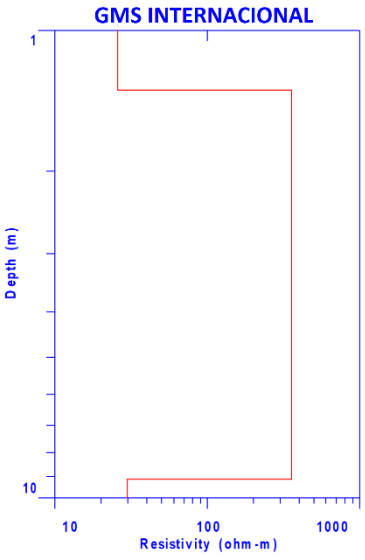


SEV	2
PROJECT	MACAO
DATE	01/03/2020
CLIENT	Trina Solar
COORDINATES	
X	Y
325155	6269742

WENNER ARRAY

Wenner Spacing a (m)	0-M/0-N Spacing (m)	0-A/0-B Spacing (m)	Voltage (mV)	Current (mA)	Apparent Resistivity (Ohm*m)	Error (%)
0.60	0.30	0.90	314.55	44.81	26.46	0.0
1.20	0.60	1.80	679.89	144.09	35.58	0.0
1.80	0.90	2.70	552.25	140.37	44.49	0.0
2.40	1.20	3.60	629.39	176.94	53.64	0.0
3.60	1.80	5.40	591.29	177.34	75.42	0.0
6.00	3.00	9.00	513.85	186.27	104.00	0.0
9.00	4.50	13.50	694.02	296.21	132.49	0.0
10.00	5.00	15.00	536.98	248.08	136.00	0.0
12.00	6.00	18.00	547.57	293.37	140.73	0.0
15.00	7.50	22.50	463.15	312.15	139.84	0.0

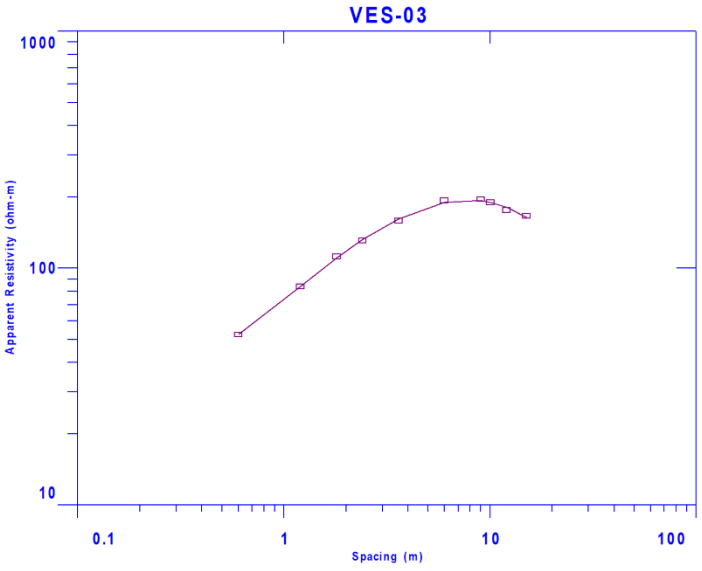


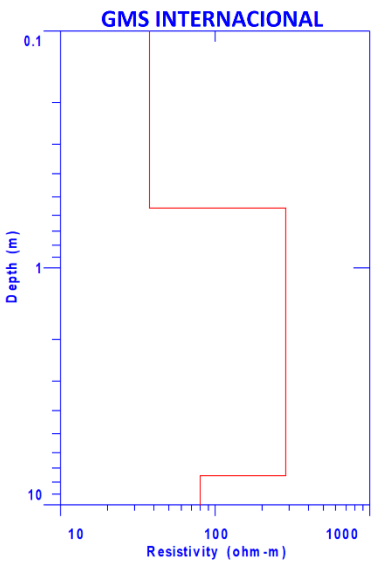


SEV	3
PROJECT	MACAO
DATE	01/03/2020
CLIENT	Trina Solar
COORDINATES	
X	Y
325214	6269830

WENNER ARRAY

Wenner Spacing a (m)	0-M/0-N Spacing (m)	0-A/0-B Spacing (m)	Voltage (mV)	Current (mA)	Apparent Resistivity (Ohm*m)	Error (%)
0.60	0.30	0.90	543.53	39.06	52.46	0.0
1.20	0.60	1.80	394.05	35.43	83.87	0.0
1.80	0.90	2.70	518.63	52.37	111.99	0.0
2.40	1.20	3.60	478.54	55.29	130.63	0.0
3.60	1.80	5.40	248.20	35.39	158.69	0.0
6.00	3.00	9.00	336.39	65.71	192.99	0.0
9.00	4.50	13.50	768.88	222.44	195.46	0.0
10.00	5.00	15.00	313.99	104.04	189.62	0.0
12.00	6.00	18.00	603.10	258.35	176.10	0.0
15.00	7.50	22.50	454.86	258.29	165.97	0.0

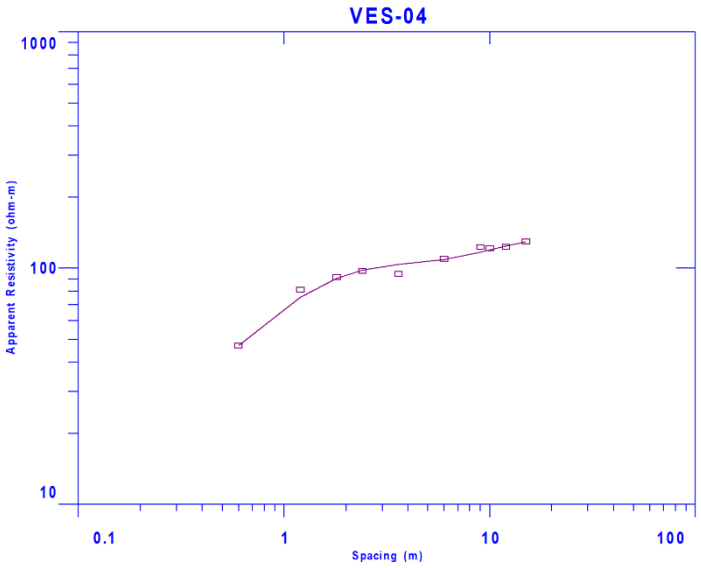


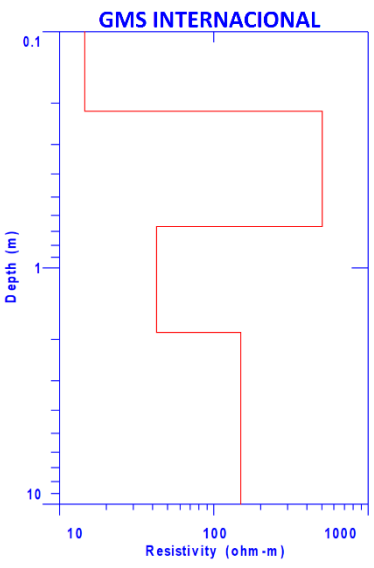


SEV	4
PROJECT	MACAO
DATE	01/03/2020
CLIENT	Trina Solar
COORDINATES	
X	Y
325353	6270186

WENNER ARRAY

Wenner Spacing a (m)	0-M/0-N Spacing (m)	0-A/0-B Spacing (m)	Voltage (mV)	Current (mA)	Apparent Resistivity (Ohm*m)	Error (%)
0.60	0.30	0.90	459.78	36.83	47.06	0.0
1.20	0.60	1.80	614.81	57.25	80.97	0.0
1.80	0.90	2.70	354.71	43.75	91.70	0.0
2.40	1.20	3.60	472.57	73.24	97.30	0.0
3.60	1.80	5.40	401.74	95.96	94.70	0.0
6.00	3.00	9.00	399.12	137.52	109.42	0.0
9.00	4.50	13.50	735.35	338.65	122.79	0.0
10.00	5.00	15.00	627.48	324.76	121.40	0.0
12.00	6.00	18.00	470.00	288.27	122.93	0.0
15.00	7.50	22.50	451.76	328.14	129.75	0.0





GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE.

Annex 6: Thermal Resistivity results

Prepared by:

GMS internacional, SL

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Submitted to:

Trina Solar Holding

Nueva Tajamar 555, of 1501
Las Condes, Santiago de Chile.
Chile
www.trinasolar.com

1. Thermal Resistivity Test Locations

Illustration 1: Thermal Resistivity test Location

			THERMAL CONDUCTIVITY 1	THERMAL CONDUCTIVITY 2	THERMAL CONDUCTIVITY 3	AVERAGE THERMAL CONDUCTIVITY	THERMAL RESISTIVITY 1	THERMAL RESISTIVITY 2	THERMAL RESISTIVITY 3	AVERAGE THERMAL RESISTIVITY	THERMAL CONDUCTIVITY 1	THERMAL CONDUCTIVITY 2	THERMAL CONDUCTIVITY 3	AVERAGE THERMAL CONDUCTIVITY	THERMAL RESISTIVITY 1	THERMAL RESISTIVITY 2	THERMAL RESISTIVITY 3	AVERAGE THERMAL RESISTIVITY	TEMPERATURA 1	TEMPERATURA 2	TEMPERATURA 3	TEMPERATURA MEDIA
ID	**Loc. ID**	**Depth (m)**	**W/mK**	**W/mK**	**W/mK**	**W/mK**	**mK/W**	**mK/W**	**mK/W**	**mK/W**	**w/cm°C**	**w/cm°C**	**w/cm°C**	**w/cm°C**	**cm°C/W**	**cm°C/W**	**cm°C/W**	**cm°C/W**	**°C**	**°C**	**°C**	**°C**
TR-01	TP-03	0.50	1.163	1.136	1.170	1.156	0.8598452	0.8802817	0.8547009	**0.865**	0.0116	0.0114	0.0117	0.0116	85.984523	88.02817	85.47009	86.5	20.73	20.61	20.67	20.7
TR-02	TP-10	0.80	1.120	1.128	1.158	1.135	0.8928571	0.8865248	0.8635579	**0.881**	0.0112	0.0113	0.0116	0.0114	89.285714	88.65248	86.35579	88.1	23.17	23.25	23.38	23.3
TR-03	TP-07	0.50	1.188	1.162	1.167	1.172	0.8417508	0.8605852	0.856898	**0.853**	0.0119	0.0116	0.0117	0.0117	84.175084	86.05852	85.6898	85.3	22.19	22.16	22.14	22.2
TR-04	TP-05	0.40	1.244	1.272	1.281	1.266	0.8038585	0.7861635	0.7806401	**0.790**	0.0124	0.0127	0.0128	0.0127	80.385852	78.61635	78.06401	79.0	19.57	19.73	19.78	19.7

GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE.

Annex 7: Pull-out test logs

Prepared by:

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Submitted to:

Trina Solar Holding

Nueva Tajamar 555, of 1501
Las Condes, Santiago de Chile.
Chile
www.trinasolar.com

1. Pull-Out test Locations

Illustration 1: Pull-Out test Location

2. Pull-Out tests results

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-01**
Test nº	**A**
UTM Coordinates (m):	325294
	6269933
Date of test:	06/03/2020

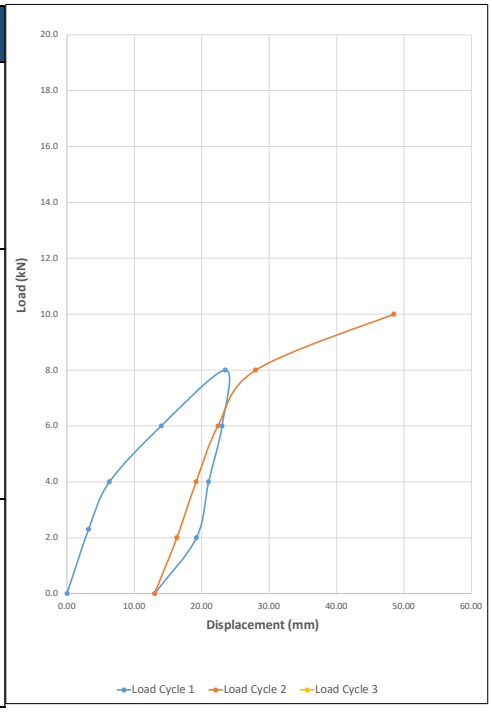
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.9
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	0.90
Ramming Time (s)	24"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

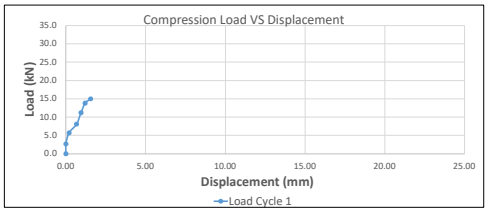
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.3	3.20	
3	22.22	4.0	4.0	6.30	
4	33.33	6.0	6.0	14.00	
5	44.44	8.0	8.0	23.50	Load Cycle 1
6	33.33	6.0	6.0	23.00	
7	22.22	4.0	4.0	21.00	
8	11.11	2.0	2.0	19.20	
9	0.00	0.0	0.0	13.00	
1	11.11	2.0	2.0	16.30	
2	22.22	4.0	4.0	19.15	
3	33.33	6.0	6.0	22.40	
4	44.44	8.0	8.0	**28.00**	
5	55.56	10.0	10.0	**48.50**	
6	66.67	12.0	12.0		Load Cycle 2
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



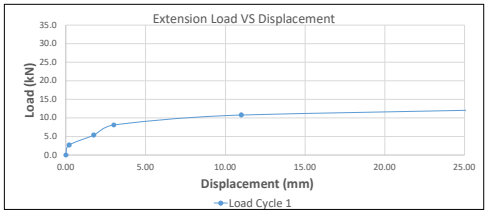
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.7	0.20	
3	60.00	8.1	8.1	0.67	Load Cycle 1
4	80.00	10.8	11.2	0.95	
5	100.00	13.5	13.8	1.20	
6	111.11	15.0	15.0	1.55	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.20	
2	40.00	5.4	5.4	1.75	
3	60.00	8.1	8.1	3.00	Load Cycle 1
4	80.00	10.8	10.8	11.00	
5	100.00	13.5	13.9	**50.00**	
6	111.11	15.0	15.0		



Annotations

Profile was cut 10.0 cm on top.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-01**
Test nº	**B**
UTM Coordinates (m):	325294
	6269933
Date of test:	06/03/2020

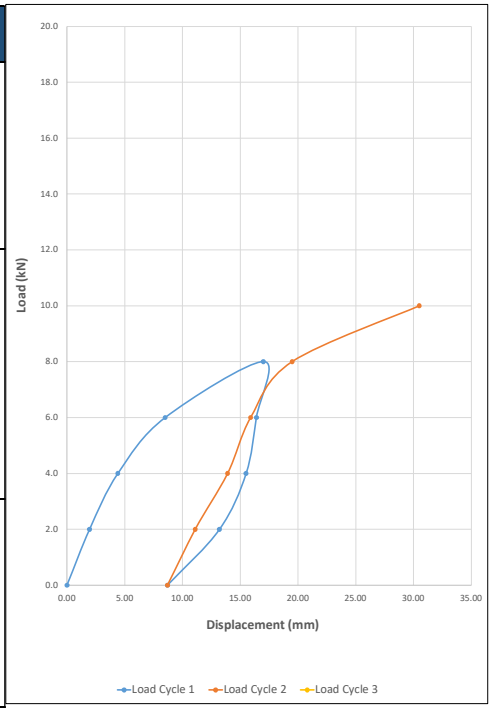
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.9
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	1.05
Ramming Time (s)	24"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

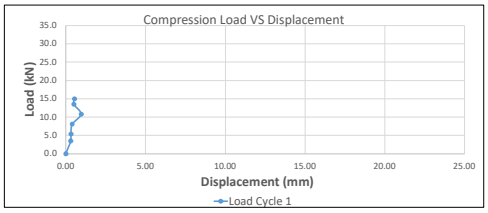
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	1.95	
3	22.22	4.0	4.0	4.40	
4	33.33	6.0	6.0	8.50	
5	44.44	8.0	8.0	17.00	Load Cycle 1
6	33.33	6.0	6.0	16.40	
7	22.22	4.0	4.0	15.50	
8	11.11	2.0	2.0	13.20	
9	0.00	0.0	0.0	8.70	
1	11.11	2.0	2.0	11.10	
2	22.22	4.0	4.0	13.90	
3	33.33	6.0	6.0	15.90	
4	44.44	8.0	8.0	19.50	
5	55.56	10.0	10.0	30.50	
6	66.67	12.0	12.0		
7	55.56	10.0	10.0		Load Cycle 2
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



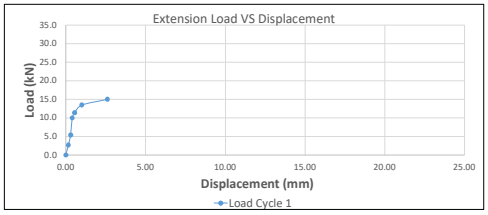
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	3.5	0.30	
2	40.00	5.4	5.4	0.32	
3	60.00	8.1	8.1	0.40	Load Cycle 1
4	80.00	10.8	10.8	0.96	
5	100.00	13.5	13.5	0.50	
6	111.11	15.0	15.0	0.54	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.15	
2	40.00	5.4	5.4	0.30	
3	60.00	8.1	10.0	0.40	Load Cycle 1
4	80.00	10.8	11.4	0.55	
5	100.00	13.5	13.5	1.00	
6	111.11	15.0	15.0	2.60	



Annotations

Profile was cut 10.0 cm on top.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-02**
Test nº	**A**
UTM Coordinates (m):	325224
	6269875
Date of test:	06/03/2020

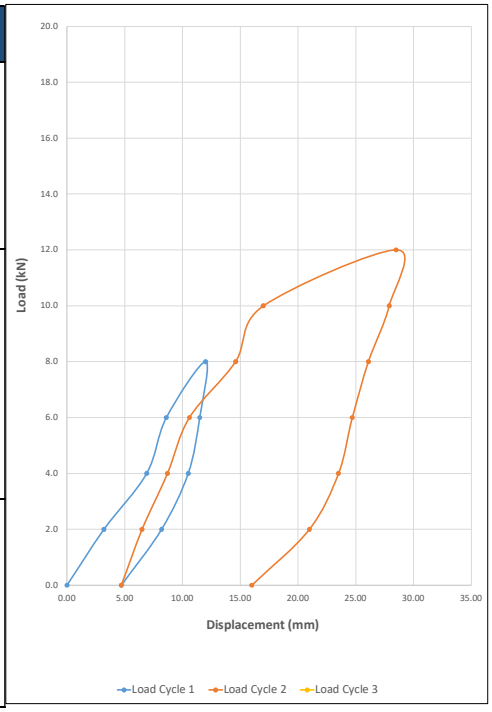
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.9
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	1.10
Ramming Time (s)	25"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

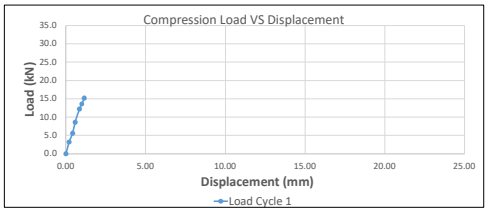
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	3.20	
3	25.56	4.6	4.0	6.90	
4	33.33	6.0	6.0	8.60	
5	44.44	8.0	8.0	12.00	Load Cycle 1
6	33.33	6.0	6.0	11.50	
7	25.56	4.6	4.0	10.50	
8	11.11	2.0	2.0	8.20	
9	0.00	0.0	0.0	4.70	
1	11.11	2.0	2.0	6.50	
2	22.22	4.0	4.0	8.70	
3	33.33	6.0	6.0	10.60	
4	44.44	8.0	8.0	14.60	
5	55.56	10.0	10.0	17.00	
6	66.67	12.0	12.0	**28.50**	Load Cycle 2
7	55.56	10.0	10.0	**27.90**	
8	44.44	8.0	8.0	**26.10**	
9	33.33	6.0	6.0	24.70	
10	22.22	4.0	4.0	23.50	
11	11.11	2.0	2.0	21.00	
12	0.00	0.0	0.0	16.00	
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



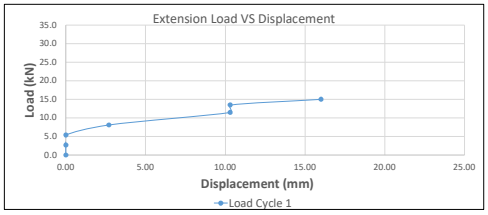
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	3.2	0.20	
2	40.00	5.4	5.6	0.42	
3	60.00	8.1	8.6	0.58	Load Cycle 1
4	80.00	10.8	12.2	0.85	
5	100.00	13.5	13.6	1.00	
6	111.11	15.0	15.2	1.15	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.4	0.00	
3	60.00	8.1	8.1	2.70	Load Cycle 1
4	80.00	10.8	11.5	10.30	
5	100.00	13.5	13.5	10.30	
6	111.11	15.0	15.0	16.00	



Annotations

Profile was cut 10.0 cm on top.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	POT-02
Test nº	B
UTM Coordinates (m):	325224
	6269875
Date of test:	06/03/2020

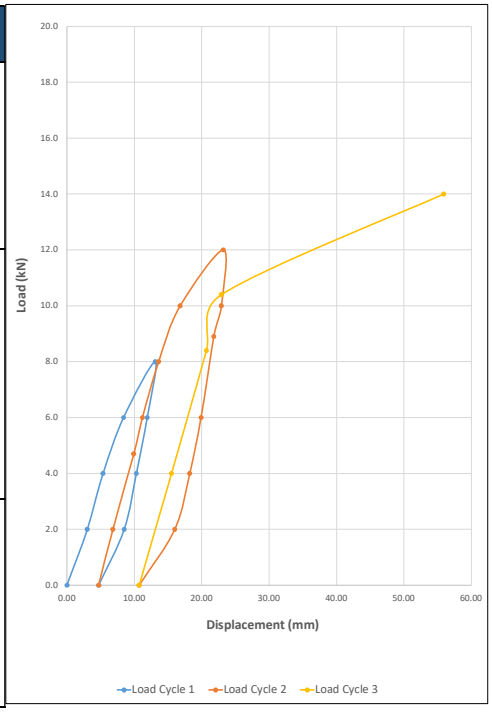
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.9
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	1.44
Ramming Time (s)	58"
Load application height (m)	##########################
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

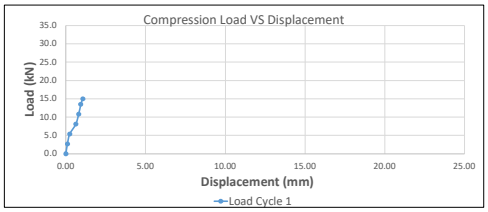
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	3.00	
3	22.22	4.0	4.0	5.35	
4	33.33	6.0	6.0	8.40	
5	44.44	8.0	8.0	13.10	Load Cycle 1
6	33.33	6.0	6.0	11.90	
7	22.22	4.0	4.0	10.30	
8	11.11	2.0	2.0	8.50	
9	0.00	0.0	0.0	4.70	
1	11.11	2.0	2.0	6.80	
2	22.22	4.0	4.7	9.90	
3	33.33	6.0	6.0	11.20	
4	44.44	8.0	8.0	13.60	
5	55.56	10.0	10.0	16.80	
6	66.67	12.0	12.0	23.20	
7	55.56	10.0	10.0	22.90	Load Cycle 2
8	44.44	8.0	8.9	21.80	
9	33.33	6.0	6.0	19.90	
10	22.22	4.0	4.0	18.20	
11	11.11	2.0	2.0	16.00	
12	0.00	0.0	0.0	10.70	
1	22.22	4.0	4.0	15.50	
2	44.44	8.0	8.4	20.70	
3	55.56	10.0	10.4	22.90	
4	77.78	14.0	14.0	55.90	
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



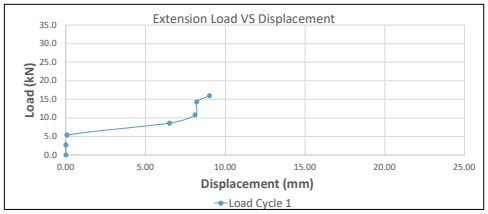
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.10	
2	40.00	5.4	5.4	0.24	
3	60.00	8.1	8.1	0.62	Load Cycle 1
4	80.00	10.8	10.8	0.80	
5	100.00	13.5	13.5	0.93	
6	111.11	15.0	15.0	1.06	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.4	0.07	
3	60.00	8.1	8.6	6.50	Load Cycle 1
4	80.00	10.8	10.8	8.10	
5	100.00	13.5	14.3	8.20	
6	111.11	15.0	16.0	9.00	



Annotations

Profile was cut 10.0 cm on top.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	POT-03
Test nº	A
UTM Coordinates (m):	325347
	6270185
Date of test:	06/03/2020

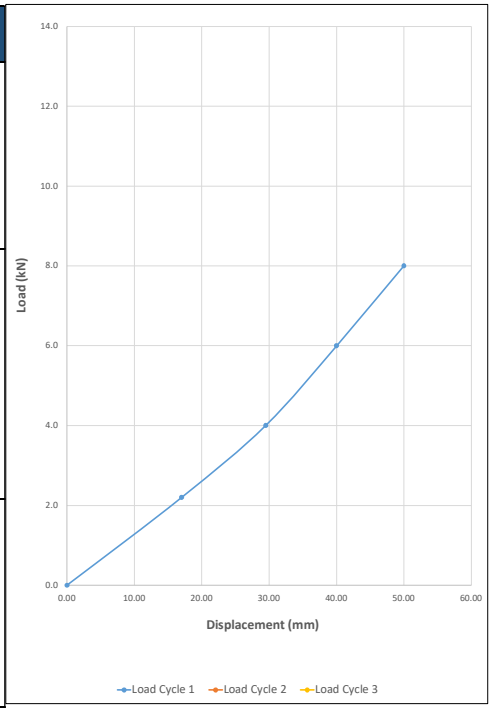
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	1.00
Ramming Time (s)	1'30"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

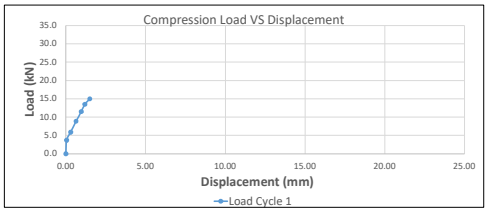
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.2	17.00	
3	22.22	4.0	4.0	29.50	
4	33.33	6.0	6.0	40.00	
5	44.44	8.0	8.0	50.00	Load Cycle 1
6	33.33	6.0	6.0		
7	22.22	4.0	4.0		
8	11.11	2.0	2.0		
9	0.00	0.0	0.0		
1	11.11	2.0	2.0		
2	22.22	4.0	4.0		
3	33.33	6.0	6.0		
4	44.44	8.0	8.0		
5	55.56	10.0	10.0		
6	66.67	12.0	12.0		
7	55.56	10.0	10.0		Load Cycle 2
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



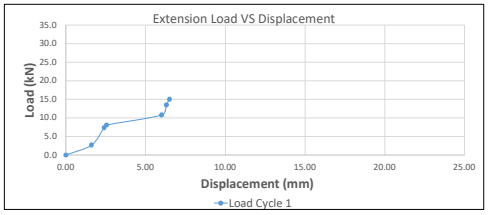
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	3.69	0.05	
2	40.00	5.4	5.90	0.30	
3	60.00	8.1	8.9	0.64	Load Cycle 1
4	80.00	10.8	11.5	0.96	
5	100.00	13.5	13.5	1.19	
6	111.11	15.0	15.0	1.50	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	1.60	
2	40.00	5.4	7.4	2.40	
3	60.00	8.1	8.1	2.55	Load Cycle 1
4	80.00	10.8	10.8	6.00	
5	100.00	13.5	13.5	6.30	
6	111.11	15.0	15.0	6.50	



Annotations

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-03**
Test nº	**B**
UTM Coordinates (m):	325347
	6270185
Date of test:	06/03/2020

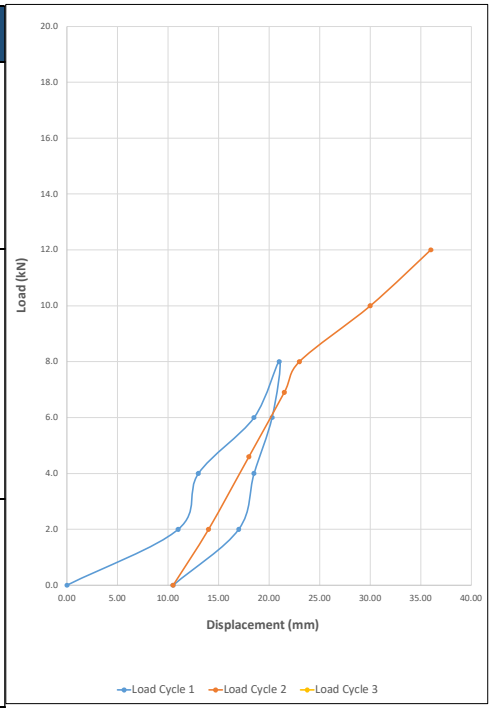
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	1.00
Ramming Time (s)	40"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

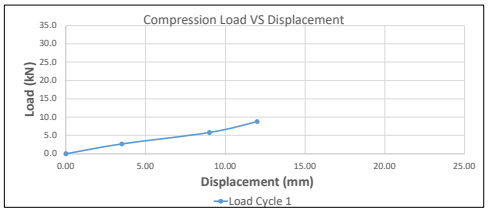
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	11.00	
3	22.22	4.0	4.0	13.00	
4	33.33	6.0	6.0	18.50	
5	44.44	8.0	8.0	21.00	Load Cycle 1
6	33.33	6.0	6.0	20.30	
7	22.22	4.0	4.0	18.50	
8	11.11	2.0	2.0	17.00	
9	0.00	0.0	0.0	10.50	
1	11.11	2.0	2.0	14.00	
2	22.22	4.0	4.6	18.00	
3	33.33	6.0	6.9	21.50	
4	44.44	8.0	8.0	23.00	
5	55.56	10.0	10.0	**30.00**	
6	66.67	12.0	12.0	**36.00**	Load Cycle 2
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



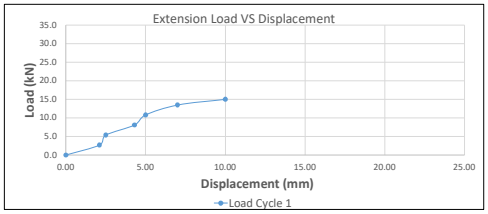
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	3.50	
2	40.00	5.4	5.8	9.00	
3	60.00	8.1	8.8	**12.00**	Load Cycle 1
4	80.00	10.8	10.8		
5	100.00	13.5	13.5		
6	111.11	15.0	15.0		



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	2.10	
2	40.00	5.4	5.4	2.50	
3	60.00	8.1	8.1	4.30	Load Cycle 1
4	80.00	10.8	10.8	5.00	
5	100.00	13.5	13.5	7.00	
6	111.11	15.0	15.0	10.00	



Annotations

Due to profile torsion, compression test was finished at 8.8 KN.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	POT-04
Test nº	A
UTM Coordinates (m):	325126
	6270267
Date of test:	06/03/2020

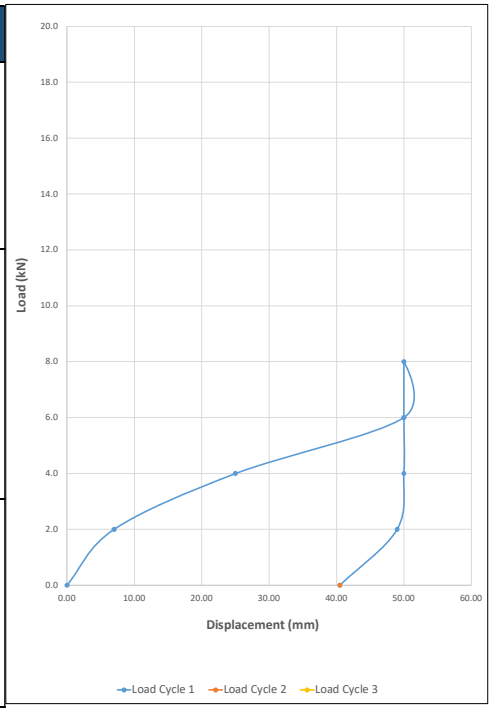
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	0.90
Ramming Time (s)	45"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

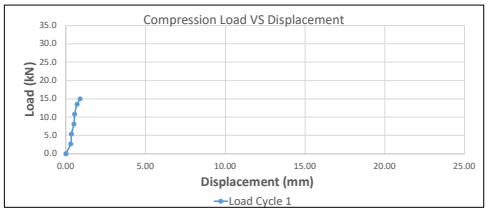
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	7.00	
3	22.22	4.0	4.0	25.00	
4	33.33	6.0	6.0	50.00	
5	44.44	8.0	8.0	50.00	Load Cycle 1
6	33.33	6.0	6.0	50.00	
7	22.22	4.0	4.0	50.00	
8	11.11	2.0	2.0	49.00	
9	0.00	0.0	0.0	40.50	
1	11.11	2.0	2.0		
2	22.22	4.0	4.0		
3	33.33	6.0	6.0		
4	44.44	8.0	8.0		
5	55.56	10.0	10.0		
6	66.67	12.0	12.0		
7	55.56	10.0	10.0		Load Cycle 2
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



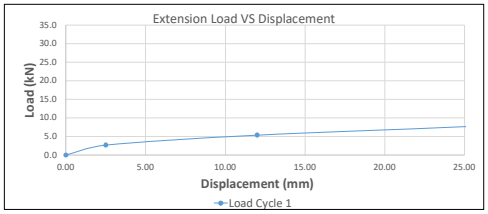
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.30	
2	40.00	5.4	5.4	0.35	
3	60.00	8.1	8.1	0.50	Load Cycle 1
4	80.00	10.8	10.8	0.55	
5	100.00	13.5	13.5	0.70	
6	111.11	15.0	15.0	0.90	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	2.50	
2	40.00	5.4	5.4	12.00	
3	60.00	8.1	8.1	27.00	Load Cycle 1
4	80.00	10.8	10.8	33.00	
5	100.00	13.5	13.5		
6	111.11	15.0	15.0		



Annotations

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	POT-04
Test nº	B
UTM Coordinates (m):	325126
	6270267
Date of test:	06/03/2020

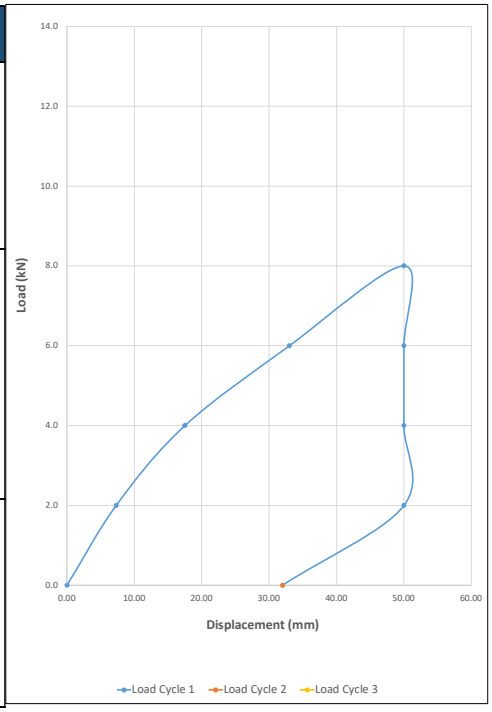
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	0.95
Ramming Time (s)	46"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

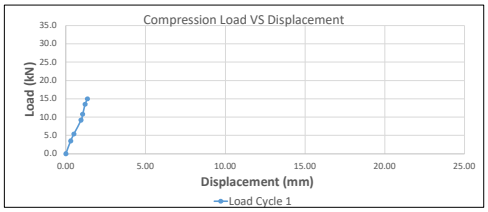
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	7.30	
3	22.22	4.0	4.0	17.50	
4	33.33	6.0	6.0	33.00	
5	44.44	8.0	8.0	50.00	Load Cycle 1
6	33.33	6.0	6.0	50.00	
7	22.22	4.0	4.0	50.00	
8	11.11	2.0	2.0	50.00	
9	0.00	0.0	0.0	32.00	
1	11.11	2.0	2.0		
2	22.22	4.0	4.0		
3	33.33	6.0	6.0		
4	44.44	8.0	8.0		
5	55.56	10.0	10.0		
6	66.67	12.0	12.0		Load Cycle 2
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



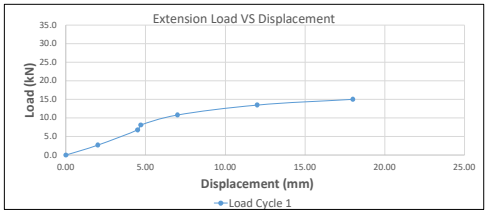
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	3.5	0.30	
2	40.00	5.4	5.4	0.50	
3	60.00	8.1	9.2	0.95	Load Cycle 1
4	80.00	10.8	10.8	1.05	
5	100.00	13.5	13.5	1.20	
6	111.11	15.0	15.0	1.35	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	2.00	
2	40.00	5.4	6.8	4.50	
3	60.00	8.1	8.1	4.70	Load Cycle 1
4	80.00	10.8	10.8	7.00	
5	100.00	13.5	13.5	12.00	
6	111.11	15.0	15.0	18.00	



Annotations
Flooded crop plot.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	POT-05
Test nº	A
UTM Coordinates (m):	324944
	6270215
Date of test:	04/03/2020

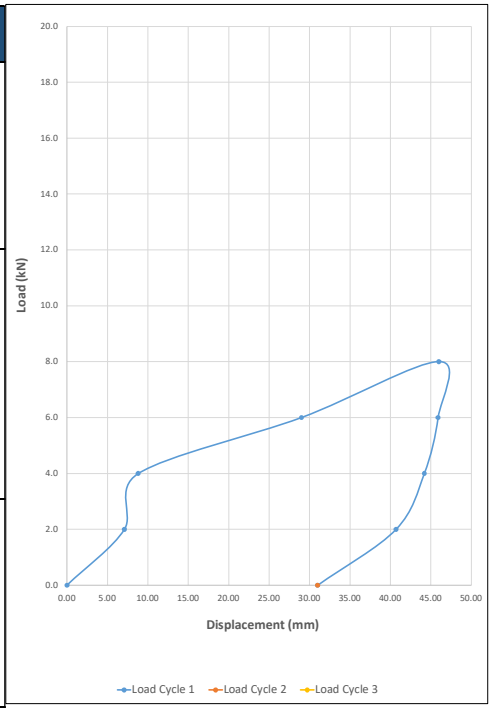
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.9
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	1.46
Ramming Time (s)	1´20"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	04/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

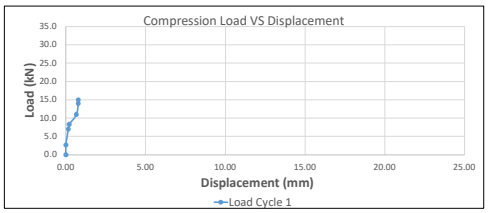
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	7.10	
3	22.22	4.0	4.0	8.80	
4	33.33	6.0	6.0	29.00	
5	44.44	8.0	8.0	46.00	Load Cycle 1
6	33.33	6.0	6.0	45.90	
7	22.22	4.0	4.0	44.20	
8	11.11	2.0	2.0	40.70	
9	0.00	0.0	0.0	31.00	
1	11.11	2.0	2.0		
2	22.22	4.0	4.0		
3	33.33	6.0	6.0		
4	44.44	8.0	8.0		
5	55.56	10.0	10.0		
6	66.67	12.0	12.0		
7	55.56	10.0	10.0		Load Cycle 2
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



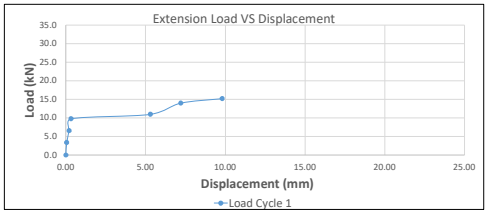
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	7.0	0.15	
3	60.00	8.1	8.3	0.21	Load Cycle 1
4	80.00	10.8	11.0	0.66	
5	100.00	13.5	14.0	0.78	
6	111.11	15.0	15.0	0.78	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	3.4	0.05	
2	40.00	5.4	6.6	0.20	
3	60.00	8.1	9.8	0.32	Load Cycle 1
4	80.00	10.8	11.0	5.30	
5	100.00	13.5	14.0	7.20	
6	111.11	15.0	15.2	9.80	



Annotations

Profile was cut 10.0 cm on top. Flooded crop plot.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	POT-05
Test nº	B
UTM Coordinates (m):	324944
	6270215
Date of test:	04/03/2020

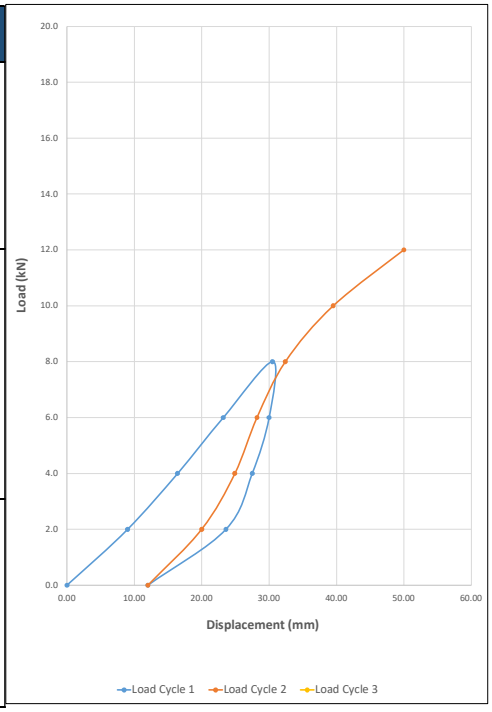
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.9
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	1.40
Ramming Time (s)	1'10"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	04/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

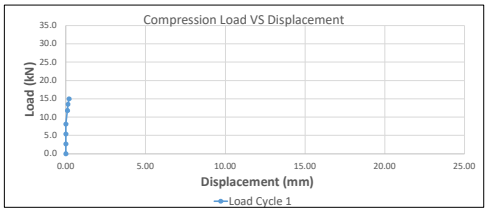
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	9.00	
3	22.22	4.0	4.0	16.40	
4	33.33	6.0	6.0	23.20	
5	44.44	8.0	8.0	30.50	Load Cycle 1
6	33.33	6.0	6.0	30.00	
7	22.22	4.0	4.0	27.50	
8	11.11	2.0	2.0	23.60	
9	0.00	0.0	0.0	12.00	
1	11.11	2.0	2.0	20.00	
2	22.22	4.0	4.0	24.90	
3	33.33	6.0	6.0	28.20	
4	44.44	8.0	8.0	32.40	
5	55.56	10.0	10.0	39.50	
6	66.67	12.0	12.0	50.00	Load Cycle 2
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



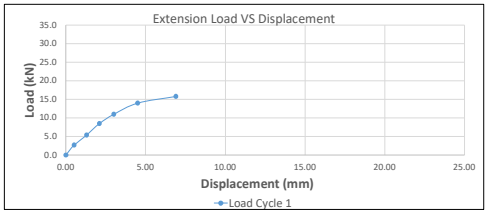
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.4	0.00	
3	60.00	8.1	8.1	0.00	Load Cycle 1
4	80.00	10.8	11.8	0.10	
5	100.00	13.5	13.5	0.13	
6	111.11	15.0	15.0	0.20	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.52	
2	40.00	5.4	5.4	1.30	
3	60.00	8.1	8.5	2.10	Load Cycle 1
4	80.00	10.8	11.0	3.00	
5	100.00	13.5	14.0	4.50	
6	111.11	15.0	15.8	6.90	



Annotations

Profile was cut 10.0 cm on top. Flooded crop plot.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	POT-06
Test nº	A
UTM Coordinates (m):	724867
	6270068
Date of test:	04/03/2020

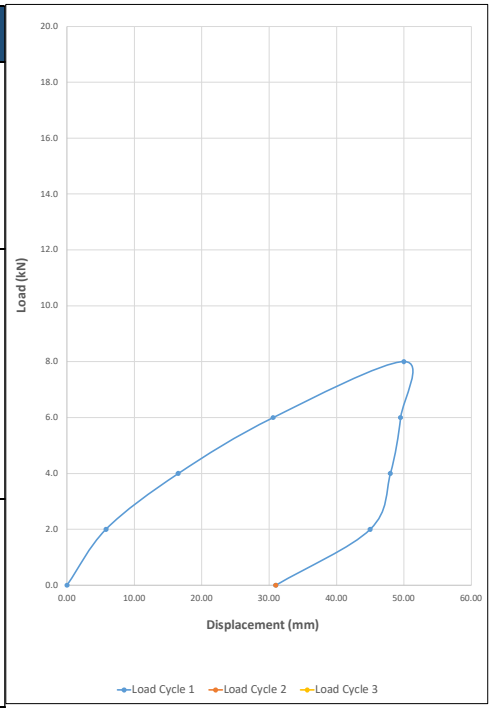
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	1.55
Ramming Time (s)	33"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

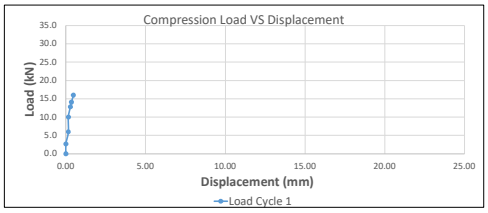
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	5.80	
3	22.22	4.0	4.0	16.50	
4	33.33	6.0	6.0	30.60	
5	44.44	8.0	8.0	50.00	Load Cycle 1
6	33.33	6.0	6.0	49.50	
7	22.22	4.0	4.0	48.00	
8	11.11	2.0	2.0	45.00	
9	0.00	0.0	0.0	31.00	
1	11.11	2.0	2.0		
2	22.22	4.0	4.0		
3	33.33	6.0	6.0		
4	44.44	8.0	8.0		
5	55.56	10.0	10.0		
6	66.67	12.0	12.0		
7	55.56	10.0	10.0		Load Cycle 2
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



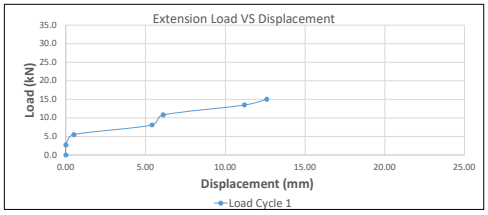
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	6.0	0.15	
3	60.00	8.1	10.0	0.16	Load Cycle 1
4	80.00	10.8	12.8	0.28	
5	100.00	13.5	14.1	0.35	
6	111.11	15.0	16.0	0.47	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.5	0.50	
3	60.00	8.1	8.1	5.40	Load Cycle 1
4	80.00	10.8	10.8	6.10	
5	100.00	13.5	13.5	11.20	
6	111.11	15.0	15.0	12.60	



Annotations
Flooded crop plot.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-06**
Test nº	**B**
UTM Coordinates (m):	324867
	6270068
Date of test:	04/03/2020

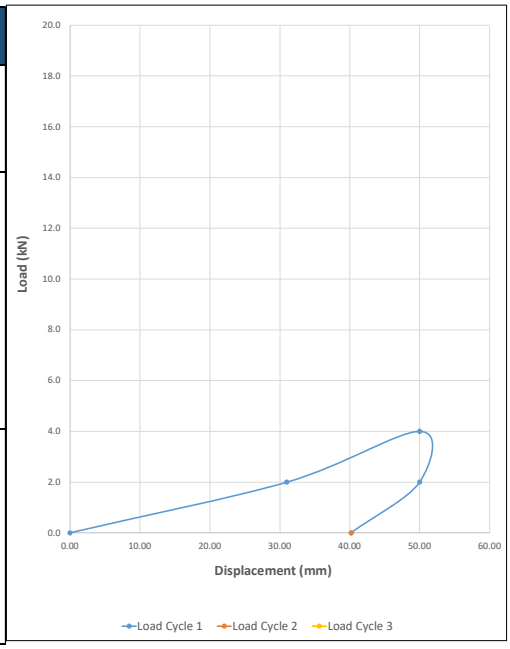
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.9
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	1.25
Ramming Time (s)	40"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

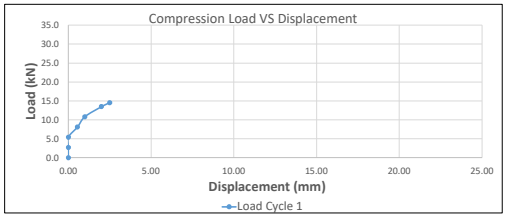
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	Load Cycle 1
2	11.11	2.0	2.0	31.00	
3	22.22	4.0	4.0	50.00	
4	11.11	2.0	2.0	50.00	
5	0.00	0.0	0.0	40.20	
1	11.11	2.0	2.0		Load Cycle 2
2	22.22	4.0	4.0		
3	33.33	6.0	6.0		
4	44.44	8.0	8.0		
5	55.56	10.0	10.0		
6	66.67	12.0	12.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		Load Cycle 3
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



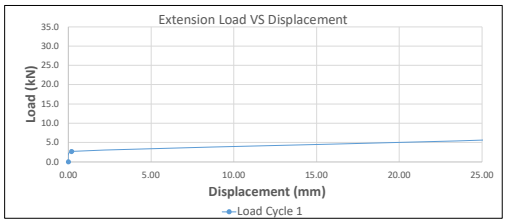
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	Load Cycle 1
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.4	0.00	
3	60.00	8.1	8.1	0.55	
4	80.00	10.8	10.8	1.00	
5	100.00	13.5	13.5	2.00	
6	111.11	15.0	14.5	2.50	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	Load Cycle 1
1	20.00	2.7	2.7	0.20	
2	40.00	5.4	5.8	26.00	
3	60.00	8.1	8.1	35.30	
4	80.00	10.8	10.8	50.00	
5	100.00	13.5	13.5		
6	111.11	15.0	15.0		



Annotations

Profile was cut 10.0 cm on top. Flooded crop plot.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-07**
Test nº	**A**
UTM Coordinates (m):	324853
	6269914
Date of test:	05/03/2020

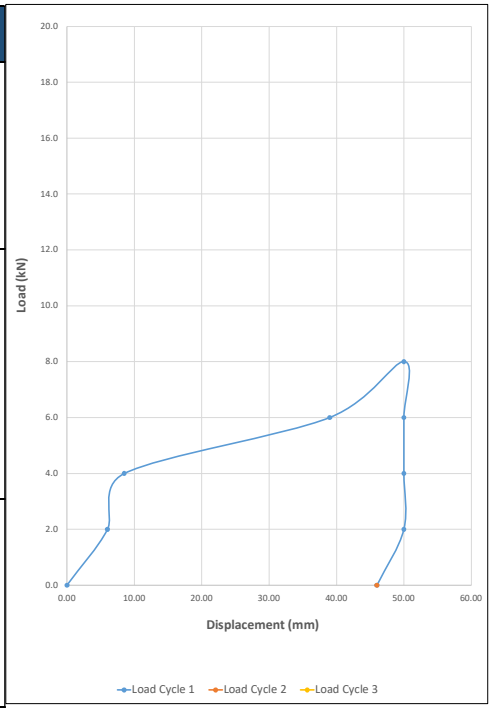
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.9
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	0.95
Ramming Time (s)	40"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

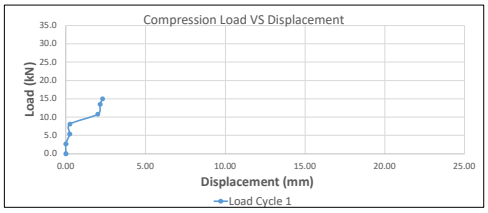
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	6.00	
3	22.22	4.0	4.0	8.50	
4	33.33	6.0	6.0	39.00	
5	44.44	8.0	8.0	50.00	Load Cycle 1
6	33.33	6.0	6.0	50.00	
7	22.22	4.0	4.0	50.00	
8	11.11	2.0	2.0	50.00	
9	0.00	0.0	0.0	46.00	
1	11.11	2.0	2.0		
2	22.22	4.0	4.0		
3	33.33	6.0	6.0		
4	44.44	8.0	8.0		
5	55.56	10.0	10.0		
6	66.67	12.0	12.0		Load Cycle 2
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



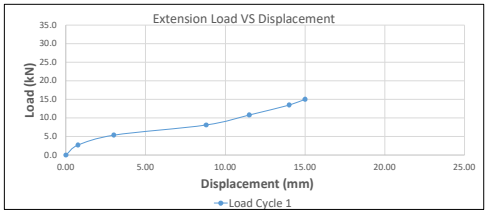
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.4	0.24	
3	60.00	8.1	8.1	0.25	Load Cycle 1
4	80.00	10.8	10.8	2.00	
5	100.00	13.5	13.5	2.15	
6	111.11	15.0	15.0	2.30	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.75	
2	40.00	5.4	5.4	3.00	
3	60.00	8.1	8.1	8.80	Load Cycle 1
4	80.00	10.8	10.8	11.50	
5	100.00	13.5	13.5	14.00	
6	111.11	15.0	15.0	15.00	



Annotations

Profile was cut 10.0 cm on top. Flooded crop plot.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	POT-07
Test nº	B
UTM Coordinates (m):	324853
	6269914
Date of test:	05/03/2020

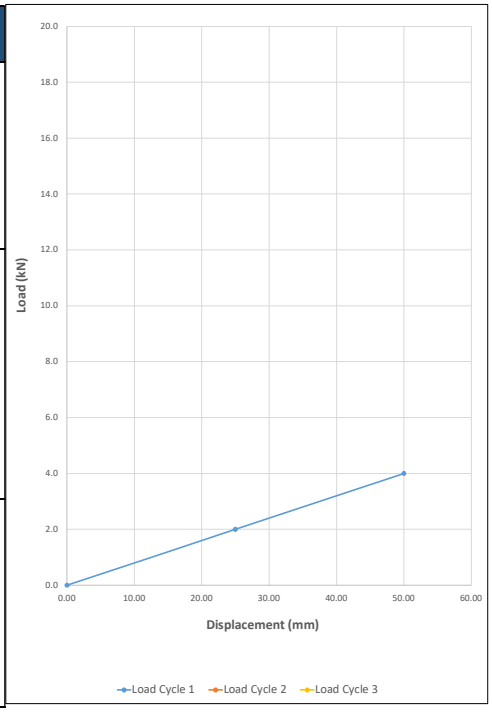
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	0.70
Ramming Time (s)	20"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

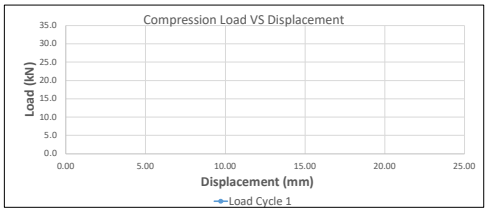
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	25.00	
3	22.22	4.0	4.0	50.00	
4	33.33	6.0	6.0		
5	44.44	8.0	8.0		Load Cycle 1
6	33.33	6.0	6.0		
7	22.22	4.0	4.0		
8	11.11	2.0	2.0		
9	0.00	0.0	0.0		
1	11.11	2.0	2.0		
2	22.22	4.0	4.0		
3	33.33	6.0	6.0		
4	44.44	8.0	8.0		
5	55.56	10.0	10.0		
6	66.67	12.0	12.0		
7	55.56	10.0	10.0		Load Cycle 2
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



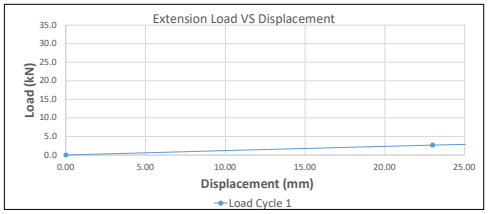
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0		
1	20.00	2.7	2.7		
2	40.00	5.4	5.4		
3	60.00	8.1	8.1		Load Cycle 1
4	80.00	10.8	10.8		
5	100.00	13.5	13.5		
6	111.11	15.0	15.0		



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	23.00	
2	40.00	5.4	5.4	50.00	
3	60.00	8.1	8.1		Load Cycle 1
4	80.00	10.8	10.8		
5	100.00	13.5	13.5		
6	111.11	15.0	15.0		



Annotations

Due to profile´s rotation and tild, it was not possible to carry out the compression test.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-08**
Test nº	**A**
UTM Coordinates (m):	324890
	6269851
Date of test:	05/03/2020

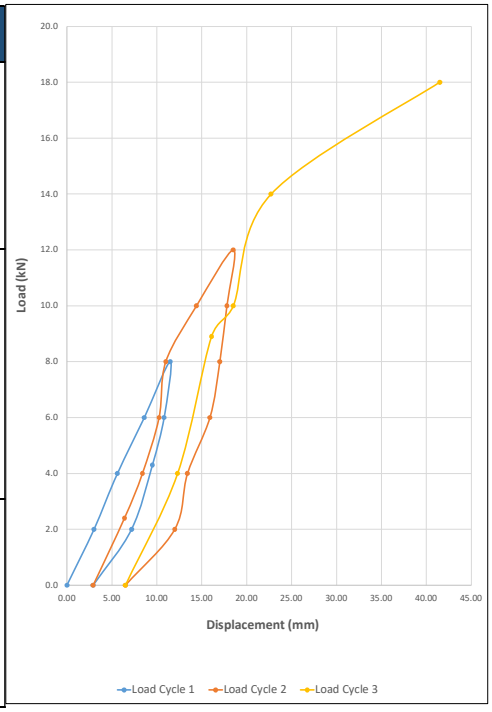
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.9
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	1.35
Ramming Time (s)	36"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

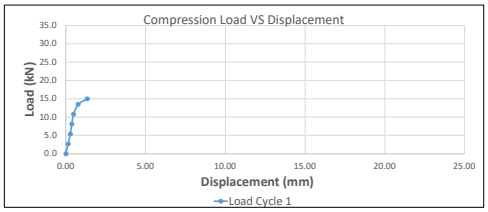
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	3.00	
3	22.22	4.0	4.0	5.60	
4	33.33	6.0	6.0	8.60	
5	44.44	8.0	8.0	11.50	Load Cycle 1
6	33.33	6.0	6.0	10.80	
7	22.22	4.0	4.3	9.50	
8	11.11	2.0	2.0	7.20	
9	0.00	0.0	0.0	2.90	
1	11.11	2.0	2.4	6.40	
2	22.22	4.0	4.0	8.40	
3	33.33	6.0	6.0	10.25	
4	44.44	8.0	8.0	11.00	
5	55.56	10.0	10.0	14.40	
6	66.67	12.0	12.0	18.50	Load Cycle 2
7	55.56	10.0	10.0	17.80	
8	44.44	8.0	8.0	17.00	
9	33.33	6.0	6.0	15.90	
10	22.22	4.0	4.0	13.40	
11	11.11	2.0	2.0	12.00	
12	0.00	0.0	0.0	6.50	
1	22.22	4.0	4.0	12.30	
2	44.44	8.0	8.9	16.10	
3	55.56	10.0	10.0	18.50	
4	77.78	14.0	14.0	22.70	
5	100.00	18.0	18.0	41.50	Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



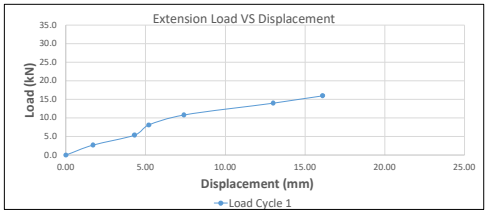
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.14	
2	40.00	5.4	5.4	0.28	
3	60.00	8.1	8.1	0.37	Load Cycle 1
4	80.00	10.8	10.8	0.48	
5	100.00	13.5	13.5	0.77	
6	111.11	15.0	15.0	1.34	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	1.70	
2	40.00	5.4	5.4	4.30	
3	60.00	8.1	8.1	5.20	Load Cycle 1
4	80.00	10.8	10.8	7.40	
5	100.00	13.5	14.0	13.00	
6	111.11	15.0	16.0	16.10	



Annotations

Profile was cut 10.0 cm on top.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-08**
Test nº	**B**
UTM Coordinates (m):	324890
	6269851
Date of test:	05/03/2020

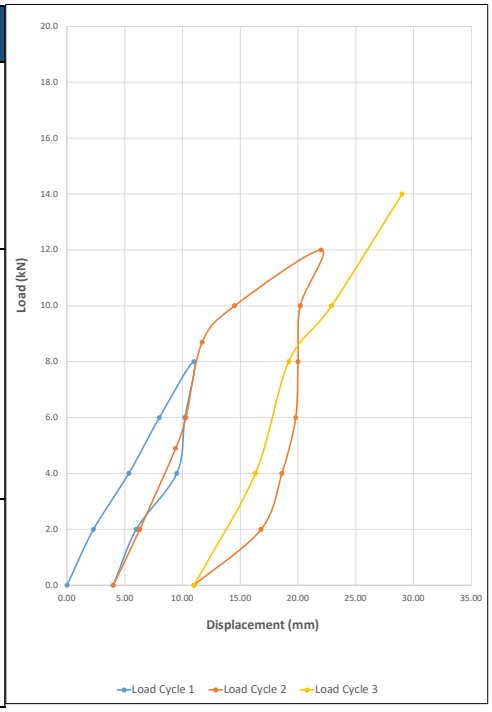
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.81
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	0.83
Ramming Time (s)	36"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

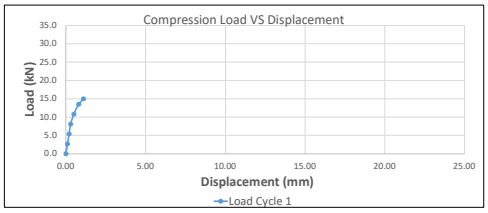
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	2.30	
3	22.22	4.0	4.0	5.35	
4	33.33	6.0	6.0	8.00	
5	44.44	8.0	8.0	11.00	Load Cycle 1
6	33.33	6.0	6.0	10.20	
7	22.22	4.0	4.0	9.50	
8	11.11	2.0	2.0	6.00	
9	0.00	0.0	0.0	4.00	
1	11.11	2.0	2.0	6.30	
2	22.22	4.0	4.9	9.40	
3	33.33	6.0	6.0	10.30	
4	44.44	8.0	8.7	11.70	
5	55.56	10.0	10.0	14.50	
6	66.67	12.0	12.0	22.00	
7	55.56	10.0	10.0	20.20	Load Cycle 2
8	44.44	8.0	8.0	20.00	
9	33.33	6.0	6.0	19.80	
10	22.22	4.0	4.0	18.60	
11	11.11	2.0	2.0	16.80	
12	0.00	0.0	0.0	11.00	
1	22.22	4.0	4.0	16.30	
2	44.44	8.0	8.0	19.20	
3	55.56	10.0	10.0	22.90	
4	77.78	14.0	14.0	**29.00**	
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



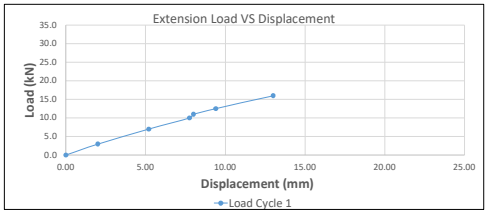
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.10	
2	40.00	5.4	5.4	0.20	
3	60.00	8.1	8.1	0.30	Load Cycle 1
4	80.00	10.8	10.8	0.50	
5	100.00	13.5	13.5	0.80	
6	111.11	15.0	15.0	1.10	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	3.0	2.00	
2	40.00	5.4	7.0	5.20	
3	60.00	8.1	10.0	7.75	Load Cycle 1
4	80.00	10.8	11.0	8.00	
5	100.00	13.5	12.5	9.40	
6	111.11	15.0	16.0	13.00	



Annotations

Profile was cut 19.0 cm on top.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	POT-09
Test nº	A
UTM Coordinates (m):	325215
	6269804
Date of test:	03/03/2020

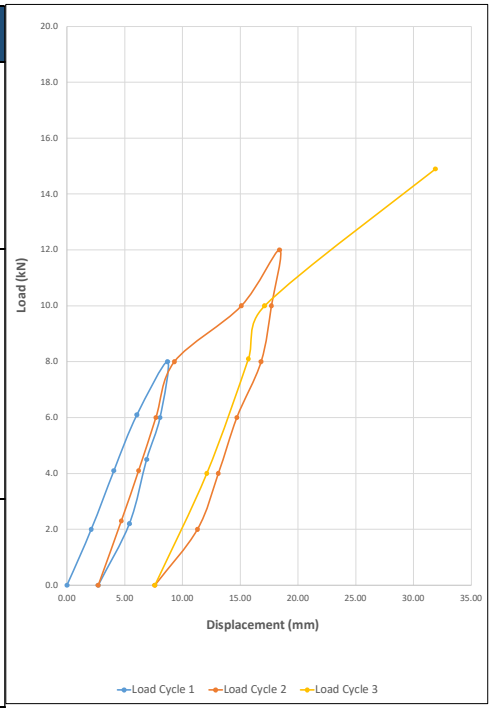
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	1.65
Ramming Time (s)	38"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

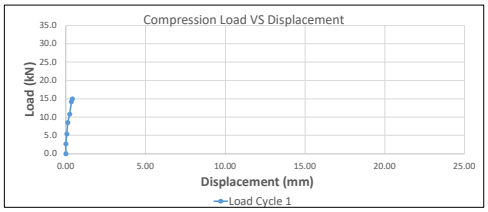
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	2.10	
3	22.22	4.0	4.1	4.05	
4	33.33	6.0	6.1	6.05	
5	44.44	8.0	8.0	8.70	Load Cycle 1
6	33.33	6.0	6.0	8.05	
7	22.22	4.0	4.5	6.90	
8	11.11	2.0	2.2	5.40	
9	0.00	0.0	0.0	2.70	
1	11.11	2.0	2.3	4.70	
2	22.22	4.0	4.1	6.20	
3	33.33	6.0	6.0	7.70	
4	44.44	8.0	8.0	9.30	
5	55.56	10.0	10.0	15.10	
6	66.67	12.0	12.0	18.40	Load Cycle 2
7	55.56	10.0	10.0	17.70	
8	44.44	8.0	8.0	16.80	
9	33.33	6.0	6.0	14.70	
10	22.22	4.0	4.0	13.10	
11	11.11	2.0	2.0	11.30	
12	0.00	0.0	0.0	7.60	
1	22.22	4.0	4.0	12.10	
2	44.44	8.0	8.1	15.70	
3	55.56	10.0	10.0	17.10	
4	77.78	14.0	14.9	31.90	
5	100.00	18.0	18.0		Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



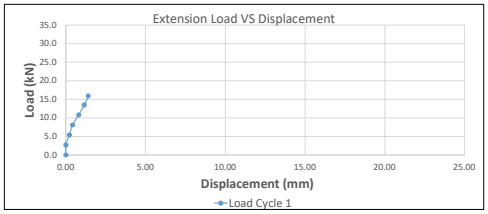
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.4	0.06	
3	60.00	8.1	8.5	0.12	Load Cycle 1
4	80.00	10.8	10.8	0.24	
5	100.00	13.5	14.2	0.35	
6	111.11	15.0	15.0	0.41	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.4	0.22	
3	60.00	8.1	8.1	0.42	Load Cycle 1
4	80.00	10.8	10.8	0.80	
5	100.00	13.5	13.5	1.15	
6	111.11	15.0	15.9	1.40	



Annotations

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	TOP-09
Test nº	B
UTM Coordinates (m):	325215
	6269804
Date of test:	03/03/2020

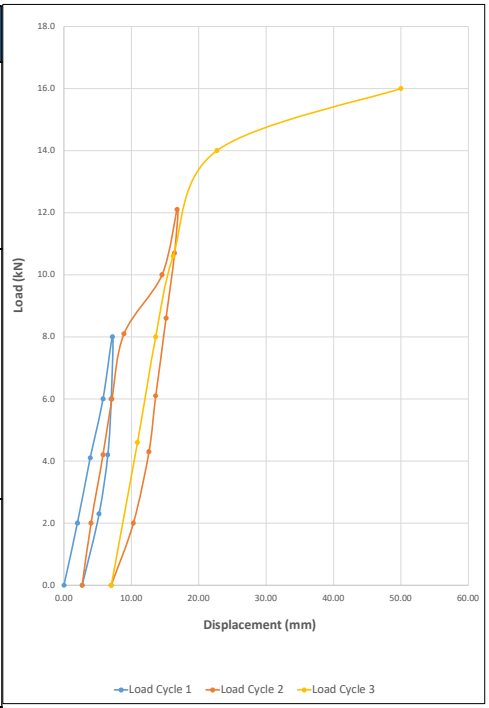
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	1.50
Ramming Time (s)	18"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

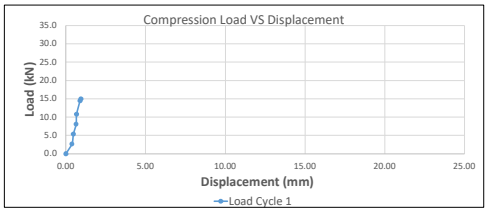
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	2.00	
3	22.22	4.0	4.1	3.90	
4	33.33	6.0	6.0	5.80	
5	44.44	8.0	8.0	7.20	Load Cycle 1
6	33.33	6.0	6.0	7.00	
7	22.22	4.0	4.2	6.50	
8	11.11	2.0	2.3	5.20	
9	0.00	0.0	0.0	2.70	
1	11.11	2.0	2.0	4.00	
2	22.22	4.0	4.2	5.80	
3	33.33	6.0	6.0	7.10	
4	44.44	8.0	8.1	8.90	
5	55.56	10.0	10.0	14.55	
6	66.67	12.0	12.1	16.80	Load Cycle 2
7	55.56	10.0	10.7	16.40	
8	44.44	8.0	8.6	15.15	
9	33.33	6.0	6.1	13.60	
10	22.22	4.0	4.3	12.60	
11	11.11	2.0	2.0	10.30	
12	0.00	0.0	0.0	7.00	
1	22.22	4.0	4.6	10.90	
2	44.44	8.0	8.0	13.60	
3	55.56	10.0	10.6	16.20	
4	77.78	14.0	14.0	22.70	
5	100.00	18.0	16.0	50.00	Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



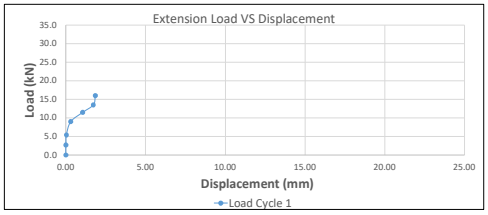
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.37	
2	40.00	5.4	5.4	0.47	
3	60.00	8.1	8.1	0.64	Load Cycle 1
4	80.00	10.8	10.8	0.67	
5	100.00	13.5	14.5	0.89	
6	111.11	15.0	15.0	0.94	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.4	0.03	
3	60.00	8.1	9.0	0.30	Load Cycle 1
4	80.00	10.8	11.5	1.05	
5	100.00	13.5	13.5	1.72	
6	111.11	15.0	16.0	1.85	



Annotations

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-10**
Test nº	**A**
UTM Coordinates (m):	325145
	6269770
Date of test:	03/03/2020

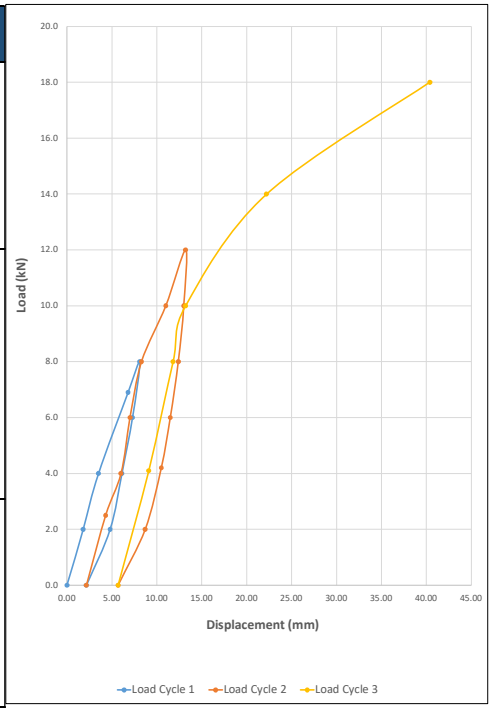
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	1.44
Ramming Time (s)	57"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

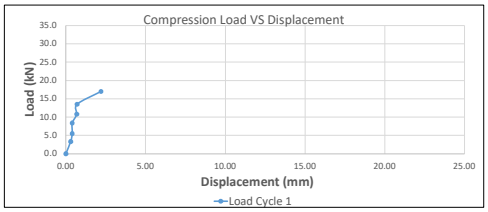
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	1.80	
3	22.22	4.0	4.0	3.50	
4	33.33	6.0	6.9	6.80	
5	44.44	8.0	8.0	8.10	Load Cycle 1
6	33.33	6.0	6.0	7.30	
7	22.22	4.0	4.0	6.10	
8	11.11	2.0	2.0	4.80	
9	0.00	0.0	0.0	2.15	
1	11.11	2.0	2.5	4.30	
2	22.22	4.0	4.0	6.00	
3	33.33	6.0	6.0	7.02	
4	44.44	8.0	8.0	8.30	
5	55.56	10.0	10.0	11.00	
6	66.67	12.0	12.0	13.20	
7	55.56	10.0	10.0	13.00	Load Cycle 2
8	44.44	8.0	8.0	12.40	
9	33.33	6.0	6.0	11.50	
10	22.22	4.0	4.2	10.50	
11	11.11	2.0	2.0	8.70	
12	0.00	0.0	0.0	5.70	
1	22.22	4.0	4.1	9.10	
2	44.44	8.0	8.0	11.80	
3	55.56	10.0	10.0	13.20	
4	77.78	14.0	14.0	22.20	
5	100.00	18.0	18.0	40.40	
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



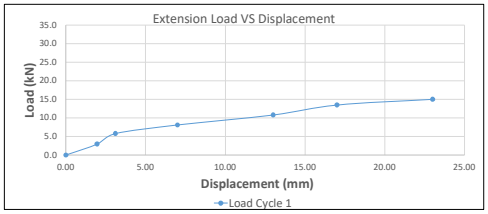
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	3.3	0.30	
2	40.00	5.4	5.5	0.40	
3	60.00	8.1	8.4	0.40	Load Cycle 1
4	80.00	10.8	10.8	0.68	
5	100.00	13.5	13.5	0.70	
6	111.11	15.0	17.0	2.20	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	3.0	1.95	
2	40.00	5.4	5.8	3.10	
3	60.00	8.1	8.1	7.00	Load Cycle 1
4	80.00	10.8	10.8	13.00	
5	100.00	13.5	13.5	17.00	
6	111.11	15.0	15.0	23.00	



Annotations

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-10**
Test nº	**B**
UTM Coordinates (m):	325145
	6269770
Date of test:	03/03/2020

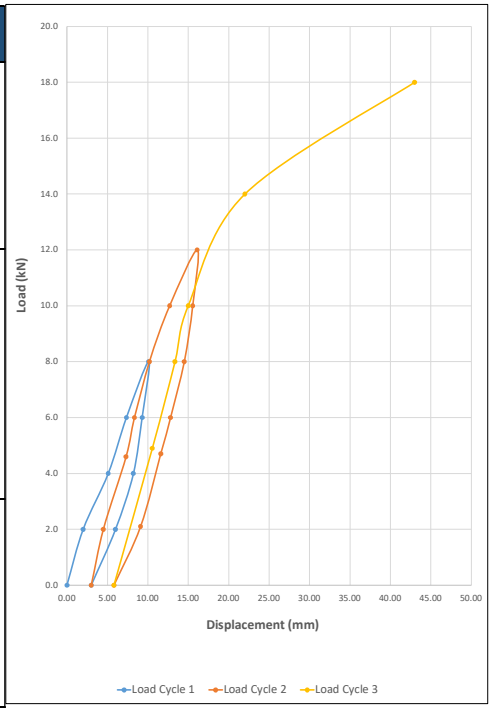
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.91
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	1.35
Ramming Time (s)	41"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

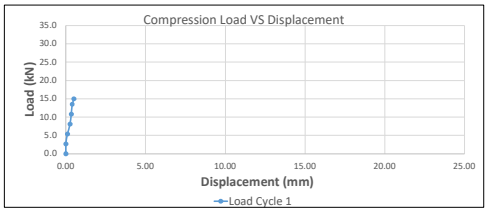
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	2.00	
3	22.22	4.0	4.0	5.10	
4	33.33	6.0	6.0	7.35	
5	44.44	8.0	8.0	10.10	Load Cycle 1
6	33.33	6.0	6.0	9.30	
7	22.22	4.0	4.0	8.20	
8	11.11	2.0	2.0	6.00	
9	0.00	0.0	0.0	3.00	
1	11.11	2.0	2.0	4.50	
2	22.22	4.0	4.6	7.30	
3	33.33	6.0	6.0	8.35	
4	44.44	8.0	8.0	10.20	
5	55.56	10.0	10.0	12.70	
6	66.67	12.0	12.0	16.10	Load Cycle 2
7	55.56	10.0	10.0	15.55	
8	44.44	8.0	8.0	14.50	
9	33.33	6.0	6.0	12.80	
10	22.22	4.0	4.7	11.60	
11	11.11	2.0	2.1	9.10	
12	0.00	0.0	0.0	5.80	
1	22.22	4.0	4.9	10.55	
2	44.44	8.0	8.0	13.35	
3	55.56	10.0	10.0	15.00	
4	77.78	14.0	14.0	22.00	
5	100.00	18.0	18.0	43.00	Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



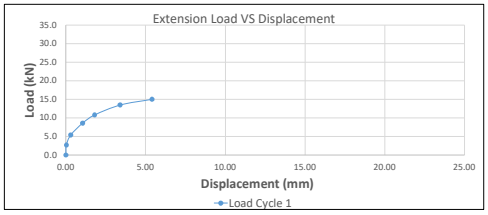
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.4	0.10	
3	60.00	8.1	8.1	0.26	Load Cycle 1
4	80.00	10.8	10.8	0.34	
5	100.00	13.5	13.5	0.40	
6	111.11	15.0	15.0	0.50	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.03	
2	40.00	5.4	5.4	0.30	
3	60.00	8.1	8.6	1.05	Load Cycle 1
4	80.00	10.8	10.8	1.80	
5	100.00	13.5	13.5	3.40	
6	111.11	15.0	15.0	5.40	



Annotations

Profile was cut 9.0 cm on top.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-11**
Test nº	**A**
UTM Coordinates (m):	325125
	6269688
Date of test:	03/03/2020

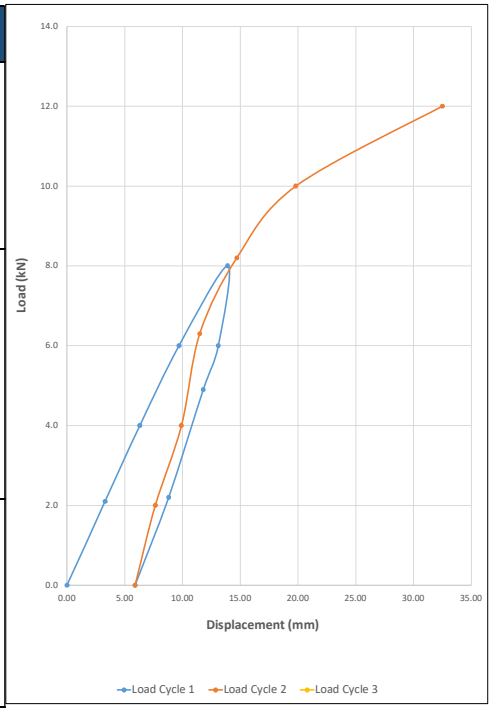
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	1.70
Ramming Time (s)	30"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	NUBLADO

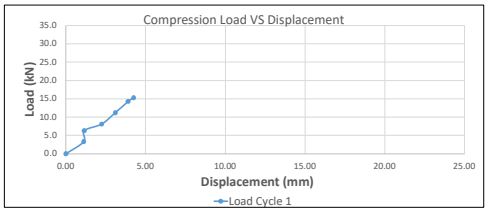
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.1	3.30	
3	22.22	4.0	4.0	6.30	
4	33.33	6.0	6.0	9.70	
5	44.44	8.0	8.0	13.90	Load Cycle 1
6	33.33	6.0	6.0	13.10	
7	22.22	4.0	4.9	11.80	
8	11.11	2.0	2.2	8.80	
9	0.00	0.0	0.0	5.90	
1	11.11	2.0	2.0	7.65	
2	22.22	4.0	4.0	9.90	
3	33.33	6.0	6.3	11.50	
4	44.44	8.0	8.2	14.70	
5	55.56	10.0	10.0	19.80	
6	66.67	12.0	12.0	**32.50**	Load Cycle 2
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	33.33	6.0	6.0		
10	22.22	4.0	4.0		
11	11.11	2.0	2.0		
12	0.00	0.0	0.0		
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



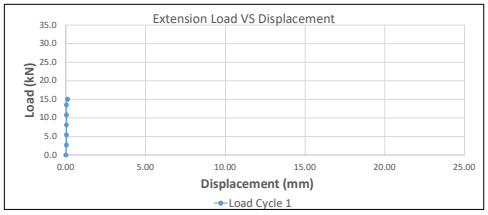
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	3.3	1.12	
2	40.00	5.4	6.3	1.15	
3	60.00	8.1	8.1	2.24	Load Cycle 1
4	80.00	10.8	11.2	3.10	
5	100.00	13.5	14.3	3.90	
6	111.11	15.0	15.3	4.25	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.03	
2	40.00	5.4	5.4	0.03	
3	60.00	8.1	8.1	0.03	Load Cycle 1
4	80.00	10.8	10.8	0.03	
5	100.00	13.5	13.5	0.03	
6	111.11	15.0	15.0	0.10	



Annotations

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-11**
Test nº	**B**
UTM Coordinates (m):	325125
	6269688
Date of test:	03/03/2020

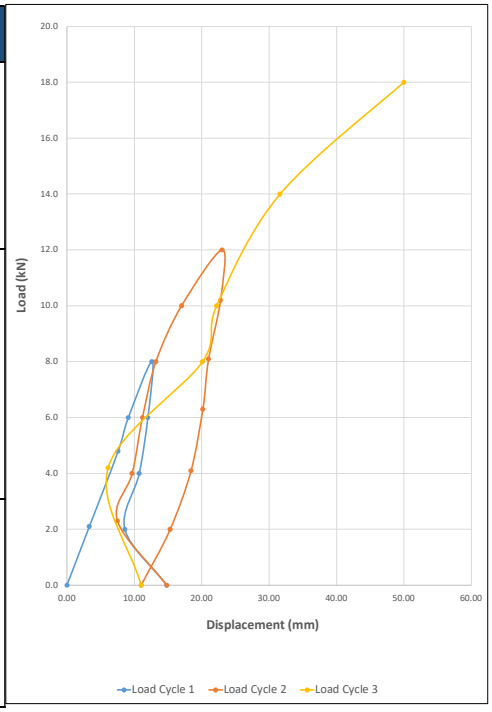
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	3.0
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	1.50
Ramming Time (s)	14"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

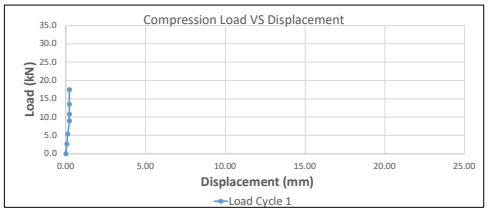
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.1	3.30	
3	22.22	4.0	4.8	7.60	
4	33.33	6.0	6.0	9.10	
5	44.44	8.0	8.0	12.60	Load Cycle 1
6	33.33	6.0	6.0	12.00	
7	22.22	4.0	4.0	10.70	
8	11.11	2.0	2.0	8.60	
9	0.00	0.0	0.0	14.81	
1	11.11	2.0	2.3	7.50	
2	22.22	4.0	4.0	9.65	
3	33.33	6.0	6.0	11.20	
4	44.44	8.0	8.0	13.20	
5	55.56	10.0	10.0	17.00	
6	66.67	12.0	12.0	23.00	Load Cycle 2
7	55.56	10.0	10.2	22.80	
8	44.44	8.0	8.1	21.00	
9	33.33	6.0	6.3	20.15	
10	22.22	4.0	4.1	18.40	
11	11.11	2.0	2.0	15.30	
12	0.00	0.0	0.0	11.00	
1	22.22	4.0	4.2	6.10	
2	44.44	8.0	8.0	20.10	
3	55.56	10.0	10.0	22.20	
4	77.78	14.0	14.0	**31.60**	
5	100.00	18.0	18.0	**50.00**	Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



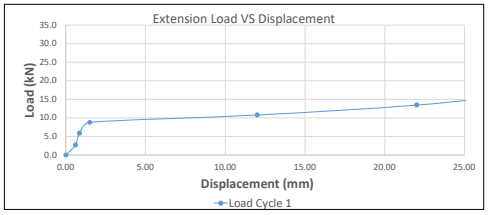
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.06	
2	40.00	5.4	5.4	0.12	
3	60.00	8.1	9.0	0.22	Load Cycle 1
4	80.00	10.8	10.8	0.22	
5	100.00	13.5	13.5	0.22	
6	111.11	15.0	17.5	0.22	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.60	
2	40.00	5.4	5.9	0.85	
3	60.00	8.1	8.8	1.50	Load Cycle 1
4	80.00	10.8	10.8	12.00	
5	100.00	13.5	13.5	**22.00**	
6	111.11	15.0	17.0	**30.00**	



Annotations

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-12**
Test nº	**A**
UTM Coordinates (m):	325056
	6269650
Date of test:	03/03/2020

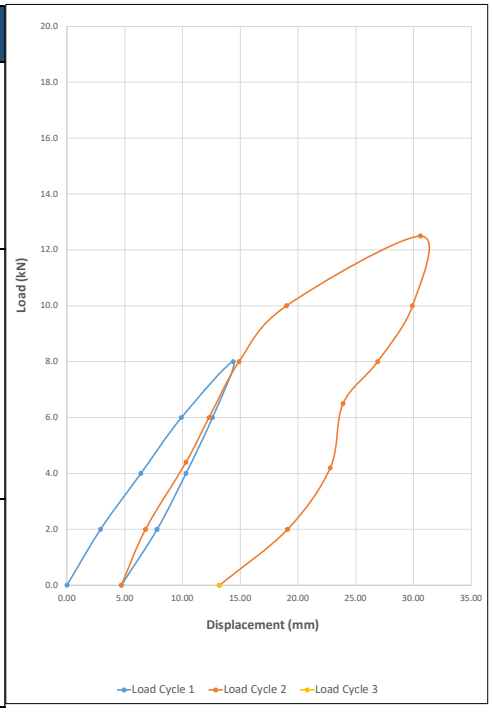
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.85
Ramming Depth (m)	2.00
Ramming Depth Reached (m)	1.40
Ramming Time (s)	47"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

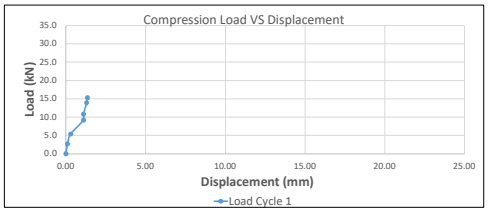
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	2.90	
3	22.22	4.0	4.0	6.40	
4	33.33	6.0	6.0	9.90	
5	44.44	8.0	8.0	14.40	Load Cycle 1
6	33.33	6.0	6.0	12.60	
7	22.22	4.0	4.0	10.30	
8	11.11	2.0	2.0	7.80	
9	0.00	0.0	0.0	4.70	
1	11.11	2.0	2.0	6.80	
2	22.22	4.0	4.4	10.30	
3	33.33	6.0	6.0	12.30	
4	44.44	8.0	8.0	14.90	
5	55.56	10.0	10.0	19.00	
6	66.67	12.0	12.5	**30.60**	Load Cycle 2
7	55.56	10.0	10.0	**29.90**	
8	44.44	8.0	8.0	**26.90**	
9	33.33	6.0	6.5	23.90	
10	22.22	4.0	4.2	22.80	
11	11.11	2.0	2.0	19.10	
12	0.00	0.0	0.0	13.20	
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		Load Cycle 3
6	77.78	14.0	14.0		
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



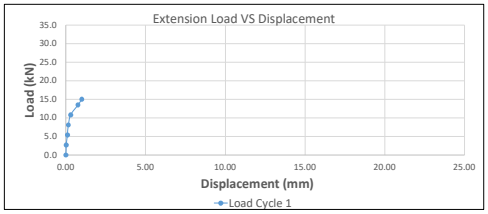
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.10	
2	40.00	5.4	5.4	0.30	
3	60.00	8.1	9.2	1.10	Load Cycle 1
4	80.00	10.8	10.8	1.10	
5	100.00	13.5	13.9	1.30	
6	111.11	15.0	15.3	1.35	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.02	
2	40.00	5.4	5.4	0.10	
3	60.00	8.1	8.1	0.15	Load Cycle 1
4	80.00	10.8	10.8	0.30	
5	100.00	13.5	13.5	0.75	
6	111.11	15.0	15.0	1.00	



Annotations

Profile was cut 15.0 cm on top.

Project Name (Project ID):	IG1827106
Client Name:	Trina Solar
Plot Name	MACAO
Location ID:	**POT-12**
Test nº	**B**
UTM Coordinates (m):	325056
	6269650
Date of test:	05/03/2020

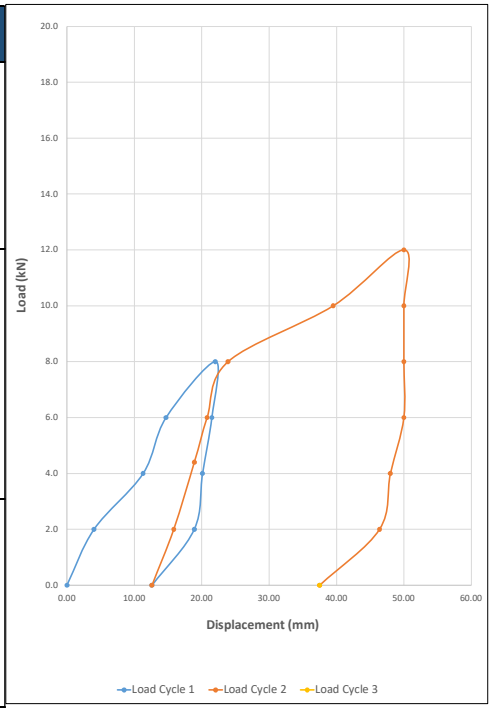
PILE PROPERTIES:

Pile type	C-150
Total Lenght (m)	2.8
Ramming Depth (m)	1.50
Ramming Depth Reached (m)	1.10
Ramming Time (s)	37"
Load application height (m)	0.77
Torsion Visual Check	

Date of ramming	02/03/2020
Pre-drill	-
Pre-drill Depth	-
Pre-drill Diameter	-
Weather Conditions	SOLEADO

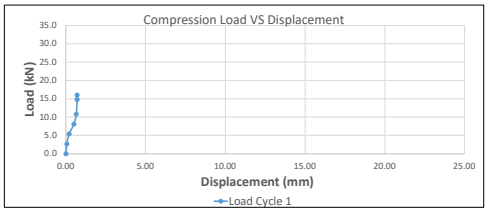
HORIZONTAL LOAD TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm) at 0.10m agl	Load Cycle
1	0.00	0.0	0.0	0.00	
2	11.11	2.0	2.0	4.00	
3	22.22	4.0	4.0	11.30	
4	33.33	6.0	6.0	14.70	
5	44.44	8.0	8.0	22.00	Load Cycle 1
6	33.33	6.0	6.0	21.50	
7	22.22	4.0	4.0	20.10	
8	11.11	2.0	2.0	18.90	
9	0.00	0.0	0.0	12.60	
1	11.11	2.0	2.0	15.85	
2	22.22	4.0	4.4	18.90	
3	33.33	6.0	6.0	20.80	
4	44.44	8.0	8.0	23.90	
5	55.56	10.0	10.0	**39.50**	
6	66.67	12.0	12.0	**50.00**	Load Cycle 2
7	55.56	10.0	10.0	**50.00**	
8	44.44	8.0	8.0	**50.00**	
9	33.33	6.0	6.0	**50.00**	
10	22.22	4.0	4.0	**48.00**	
11	11.11	2.0	2.0	**46.40**	
12	0.00	0.0	0.0	**37.50**	
1	22.22	4.0	4.0		
2	44.44	8.0	8.0		
3	55.56	10.0	10.0		
4	77.78	14.0	14.0		
5	100.00	18.0	18.0		
6	77.78	14.0	14.0		Load Cycle 3
7	55.56	10.0	10.0		
8	44.44	8.0	8.0		
9	22.22	4.0	4.0		
10	0.00	0.0	0.0		



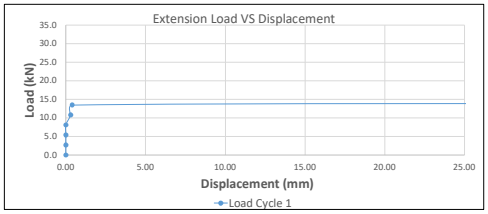
COMPRESSION TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.06	
2	40.00	5.4	5.4	0.20	
3	60.00	8.1	8.1	0.50	Load Cycle 1
4	80.00	10.8	10.8	0.65	
5	100.00	13.5	14.8	0.70	
6	111.11	15.0	16.0	0.70	



PULL OUT TEST

Load Step	% of Design Load	Nominal Load Value (kN)	Applied Load Value (KN)	δh(mm)	Load Cycle
0	0.00	0.0	0.0	0.00	
1	20.00	2.7	2.7	0.00	
2	40.00	5.4	5.4	0.00	
3	60.00	8.1	8.1	0.00	Load Cycle 1
4	80.00	10.8	10.8	0.30	
5	100.00	13.5	13.5	0.40	
6	111.11	15.0	14.0	**50.00**	



Annotations

Profile was cut 20.0 cm on top.

GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE

Annex 8: Pull-out Results Summary

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Submitted to:

Trina Solar Holding

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Las Condes, Santiago de Chile.
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LOCATION			RAMMING DATA						HORIZONTAL TEST		VERTICAL TEST - TENSILE		VERTICAL TEST - COMPRESSION		COMMENTS
Nº TEST	Coord. X (m E)	Coord. Y (m S)	Objective Ramming Depth (m)	Achieved Ramming Depth (m)	Load Height (m)	Section Type	Ramming Time (s)	Installation Method	Max. Horiz. Load Aplied (kN)	Deflection (mm) at 0.05 m agl	Max. Tensile Load Aplied (kN)	Displacement (mm)	Max. Compressive Load Aplied (kN)	Displacement (mm)	
POT-01 A	325294	6269933	2.0	0.90	0.77	C-150	24	DIRECT	6	22.4	10.8	11	15	1.55	Pile head deformation
POT-01 B			1.5	1.05	0.77	C-150	24	DIRECT	8	19.5	15	2.6	15	0.54	Pile head deformation
POT-02 A	325224	6269875	2.0	1.10	0.77	C-150	25	DIRECT	10	17	15	16	15.2	1.15	Pile head deformation
POT-02 B			1.5	1.44	0.77	C-150	58	DIRECT	10.4	22.9	16	9	15	1.06	Pile head deformation
POT-03 A	325347	6270185	2.0	1.00	0.77	C-150	90	DIRECT	2.2	17	15	6.5	15	1.5	
POT-03 B			1.5	1.00	0.77	C-150	40	DIRECT	8	23	15	10	8.8	12	Torsion of pile at 8.8kN Lateral
POT-04 A	325126	6270267	2.0	0.90	0.77	C-150	45	DIRECT	4	25	10.8	33	15	0.9	
POT-04 B			1.5	0.95	0.77	C-150	46	DIRECT	4	17.5	15	18	15	1.35	
POT-05 A	324944	6270215	2.0	**1.46**	0.77	C-150	80	DIRECT	4.0	8.8	15.2	9.8	15.0	0.8	Pile head deformation
POT-05 B			1.5	**1.40**	0.77	C-150	70	DIRECT	4.0	24.9	15.8	6.9	15.0	0.2	Pile head deformation
POT-06 A	324867	6270068	2.0	**1.55**	0.77	C-150	33	DIRECT	4.0	16.5	15.0	12.6	16.0	0.5	
POT-06 B			1.5	**1.25**	0.77	C-150	40	DIRECT	**2.0**	**31.0**	2.7	0.2	14.5	2.5	First Horiz. Load not passed
POT-07 A	324853	6269914	2.0	**0.95**	0.77	C-150	40	DIRECT	4.0	8.5	15.0	15.0	15.0	2.3	Pile head deformation
POT-07 B			1.5	**0.70**	0.77	C-150	20	DIRECT	**2.0**	**25.0**	**2.7**	**23.0**	Rotated and tilted profile		First Vert. & Horiz. Load not passed
POT-08 A	324890	6269851	2.0	**1.35**	0.77	C-150	36	DIRECT	14.0	22.7	16.0	16.1	15.0	1.3	Pile head deformation
POT-08 B			1.5	**0.83**	0.77	C-150	36	DIRECT	10.0	22.9	16.0	13.0	15.0	1.1	Pile head deformation
POT-09 A	325215	6269804	2.0	**1.65**	0.77	C-150	38	DIRECT	10.0	17.1	15.9	1.4	15.0	0.4	
POT-09 B			1.5	1.50	0.77	C-150	18	DIRECT	14.0	22.7	16.0	1.9	15.0	0.9	
POT-10 A	325145	6269770	2.0	**1.44**	0.77	C-150	57	DIRECT	14.0	22.2	15.0	23.0	17.0	2.2	
POT-10 B			1.5	**1.35**	0.77	C-150	41	DIRECT	14.0	22.0	15.0	5.4	15.0	0.5	
POT-11 A	325125	6269688	2.0	**1.70**	0.77	C-150	30	DIRECT	10.0	19.8	15.0	0.1	15.3	4.3	
POT-11 B			1.5	1.50	0.77	C-150	14	DIRECT	10.0	22.2	17.0	30.0	17.5	0.2	
POT-12 A	325056	6269650	2.0	**1.40**	0.77	C-150	47	DIRECT	10.0	19.0	15.0	1.0	15.3	1.4	Pile head deformation
POT-12 B			1.5	**1.10**	0.77	C-150	37	DIRECT	8.0	23.9	13.5	0.4	16.0	0.7	Pile head deformation

GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE

Annex 9: Equipment Description

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1. Trial Pit Excavation.

A trial pit is an excavation of the ground which helps to obtain very detailed information regarding composition, strength, stratification and discontinuities of subsurface. Trial Pits have been excavated using a JCB 3CX backhoe machine.

Figure 1. Backhoe machine using to carry out trial pits

The following information has been estimated/obtained from each trial pit:

- UTM Coordinates, given in WGS84 datum.
- Trial pits logging in accordance with BS 5930:2015 and BS EN 1997-2:2007.
- Photographic documentation.
- Identification and recording of the groundwater table, if it is present.
- Disturbed sampling for soil geotechnical laboratory testing.
- Samples labelling with project name, trial pit location, date and time collection and depth.

2. Vertical Electrical Sounding (VES)

Underground soil electrical surveying has long demonstrated to be very helpful for soil resistivity modelling purposes.

The tetraelectrodic disposal method has been chosen to meet resistivity modelling goals in current exercise. Vertical Electrical Surveys (VES) are very well known and documented in the industry. In this method DC electrical currents are transmitted to the ground by means of four pikes rammed into the ground; two pikes (electrodes) are used to introduce DC currents into the ground and two additional pikes (voltage or potential electrodes) are used to obtain resistant values. Final electrical current values are measured after a few seconds and electric potential difference arises between both electrodes. Pikes are aligned following the building main direction. The measurement is then repeated by placing pikes at different distances, that allowing different measurements at different depths. In order to calculate the actual resistivity that shall be devoted to earthing design, pikes drawing can be applied more accurately by using either Wenner, Schlumberger, Pole-Dipole or Dipole-Dipole arrangements. Wenner method has been selected for this project with a spacing of 0.60, 1.20, 1.80, 2.40, 3.60, 6.00, 9.00, 10.00, 12.00 y 15.00.

All above has been used to obtain data field curves. From raw field measurements, curves and apparent resistivity figures, a vertical arrange of depth, layer thickness and actual resistivity values are obtained.

Figure 2. Syscal kid equipment

3. Panda 2 CBR and DPL Testing Equipment

The Panda2 is a portable dynamic cone penetrometer used for the evaluation of the soil strength. Panda2 provides immediate repeatable results so that on-site decisions can be made right away. It can be used in confined spaces and locations with difficult access, with no support equipment required. It is used for soil investigations, ground investigations, site investigations and compaction control. The Panda2 (Figure 1) is a lightweight equipment (total weight of 20kg), hand held Dynamic Cone Penetrometer which uses variable energy and can be operated by a single person to test soil in almost any location to a depth of about 6 metres, by either using a 1.7kg hammer or an automatic hammer.

The NSPT correlation recommended by the manufacturer ranges NSPT= (0.30 to 0.60) *qd (MPa). NF-P-94-105 French Standard recommends the use of this method.

The metal rod that is driven into the soil consists of a stainless-steel cone having an area of 4 and 2 cm2 for the DPL and CBR respectively.

Figure 3. Panda2 equipment

4. Thermal Resistivity Measurement

The thermal resistivity of the site was carried out using KD-2 Pro device. The KD2 Pro is a battery-operated, menu-driven device that measures thermal conductivity and resistivity, volumetric specific heat capacity and thermal diffusivity. We designed the KD2 Pro for ease of use and maximum functionality.

The equipment consists of a control unit and needle sensor (TR-1). The large (10 cm long, 2.4 mm diameter) single needle TR-1 sensor measures thermal conductivity and thermal resistivity. The TR-1 was designed primarily for soil, and other granular or porous materials. It can either be inserted the pilot pin or drill an appropriately sized hole for the TR-1 sensor. The relatively large diameter and typically longer heating time of the TR-1 sensor minimize errors from contact resistance in granular samples or solid samples with pilot holes.

The read time is the time, in minutes, the KD2 Pro takes to gather data for computing thermal properties. It applies heat to the sensor for half of the set time and takes measurements over the full time. The KD2 Pro waits thirty seconds for temperature equilibration before heating starts, so the entire measurement time should be the “Read Time" plus 30 seconds. The sensor takes sixty temperature readings during the read time.

Figure 4. KD2 PRO equipment

5. Poll-Out Tests

LATERAL LOAD TEST

Lateral load test is carried out by pulling perpendicularly to the post with a given load. Then deformations are read in a 50KN load cell at or near grade. While loads are increased, horizontal displacements are recorded along with maximum and minimum loads. Displacements (strain) between loads are then measured at every step by means of one deflectometer with a 50mm range and 1/100 mm graduation at ground and top level (when structural deformations are measured).

JCB 3CX backhoe machine has been used for loading purposes allowing until 21KN pressure be applied.

Figure 5. Lateral load test

AXIAL LOAD TEST

Axial load test consists to apply a vertical load to the test beam. After driving the pile into the ground to desired depth.

- Pull-out test consists to apply an extensional load, pulling pile top in order to measure the displacement as a function of applied load even until to record pile fault. procedure follows as shown in picture:

Figure 6. Pull-Out test

- Compression test consists to apply a compressional load, pressing pile top in order to measure the displacement as a function of applied load.

Figure 7. Compression test

GEOTECHNICAL FINAL REPORT PV PROJECT MACAO, CHILE

Annex 10: Photographic Report

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1. Site Overview

Figure 1.1: General view of the site.

Figure 1. 2: General view of the site.

Figure 1.3: Backhoe machine use on site

2. Trial Pit

Figure 2.1: Trial Pit 01

Figure 2.2: Soil excavated in Trial Pit 05

3. Dynamic Cone Penetrometer (PANDA2)

Figure 3.1: Dynamic Cone Penetrometer being performed

4. Vertical Electrical Resistivity

Figure 4.1: Syscal Kid Equipment used in the field measurements

Figure 4.2: Survey line and equipment setup

5. Thermal Resistivity

Figure 5.1 KD2 pro equipment

6. CBR test

Figure 6.1: Panda2 equipment

7. Pull-Out test

Figure 7.1: Pull-out tests

Figure 7.2: Lateral load test

GEOTECHNICAL FINAL REPORT
PV PROJECT MACAO, CHILE

Annex 11: Laboratory Report

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CLIENT: TRINA SOLAR

PROJECT: MACAO

LOCATION: SANTIAGO METROPOLITAN REGION

SUMMARY OF CLASSIFICATION TEST RESULTS

SAMPLE ID	Depth (m)	Predominant Soil Fraction	Soil Index Properties																														Unified Soil Classification System (USCS)	AASHTO
			% Passing Given Standard Sieve														Sand	Grading Modulus (GM)	Dry Density	Bulk Density	Natural Moisture	LL	PI	Activity	Cr	Chloride	Sulphate (SO_4)	Sulphite (SO_3)	Sol Salts	pH	Organic Matter		
			50,000	37,500	25,000	19,000	12,500	9,500	6,300	4,750	2,000	0,850	0,425	0,250	0,150	0,075																	
			mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	%		g/cm^3	g/cm^3	%	%	%			ppm	ppm	ppm	(%)		(%)		
TP02	0,95	CLAY	100,00	100,00	96,19	93,74	92,53	90,92	90,13	89,50	88,82	88,20	86,15	80,25	76,23	60,90	27,92	0,64	1,78	2,09	13,08	25,90	8,70	0,14	1,47							CL	A-4
TP03	1,10	GRAVEL	100,00	98,10	91,62	87,84	76,10	57,04	36,45	27,21	21,90	19,44	15,44	12,50	11,61	10,10	11,80	2,53	1,35	1,39	2,84	39,30	14,90	1,48	2,45							GP GC	A-2-6
TP04	1,00	SAND	100,00	100,00	100,00	100,00	100,00	100,00	100,00	99,97	99,82	99,48	94,90	57,12	34,85	9,54	90,28	0,96	1,46	1,50	3,09											SP	A-3
TP05	0,90	GRAVEL	74,55	66,80	49,16	43,73	40,02	35,84	32,01	29,77	27,40	26,26	23,71	17,65	15,24	10,80	16,60	2,38	2,24	2,42	5,50	25,10	7,30	0,68	2,68							GP GC	A-2-4
TP06	0,50	GRAVEL	100,00	100,00	87,13	80,51	72,90	67,00	63,03	60,93	59,52	58,71	55,43	46,48	42,96	37,14	22,38	1,48	2,03	2,28	10,00	28,70	6,20	0,17	3,02							GM	A-4
TP07	0,90	GRAVEL	83,53	73,47	48,18	45,64	40,33	36,71	33,02	31,12	29,81	29,00	26,91	22,69	20,89	16,59	13,22	2,27	2,19	2,49	6,03	29,70	10,20	0,61	2,32							GC	A-2-4
TP08	1,30	GRAVEL	66,98	43,47	32,90	30,70	26,42	23,27	20,20	18,04	16,08	14,82	14,41	14,08	13,95	11,17	4,91	2,58	1,38	1,43	3,71	23,70	3,10	0,28	6,45							GP GM	A-1-a
TP09	0,90	SILT	100,00	95,24	91,09	89,19	88,74	88,55	88,35	88,13	87,81	87,58	86,30	81,40	78,10	63,32	24,49	0,63	1,07	1,25	16,55	24,90	2,00	0,03	4,18							ML	A-4
TP10	0,80	SILT	100,00	100,00	100,00	100,00	100,00	100,00	99,97	99,96	99,93	99,90	99,66	95,46	90,71	68,37	31,56	0,32	1,56	1,92	15,48	24,70	3,20	0,05	2,88							ML	A-4
TP11	0,90	CLAY	100,00	100,00	100,00	98,40	98,27	98,01	97,36	97,09	96,97	96,73	94,93	89,31	85,79	74,62	22,35	0,33	1,61	2,02	21,04	35,70	12,80	0,17	1,15							CL	A-6
TP01	2,80	GRAVEL																								20,8	366,6	305,5	0,17	8,2	0,1		
TP12	2,50	GRAVEL																								19,8	383,1	319,3	0,12	7,8	0,1		
12	12	12	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	9	9	9	9	2	2	2	2	2	2	10	10

Key:

LL: Liquid Limit, PL: Plastic Limit, PI: Plasticity Index, LS: Linear Shrinkage, NP: Non Plastic (Non Cohesive)

STANDARD: ASTM-D 2487-00 (USCS)

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GENERAL DATA	Sample Ref
	2020-170

Project ID	1827106
Location	MACAO, CHILE.
Trial Pit	2
Depth	0,95m
Sample type	Plastic bag
Sample condition	Disturbed
Sampling date	28/02/2020
Testing date	18/03/2020
Sample description according to EN ISO criteria	Dark brown sandy silty CLAY.

Soil type	USCS classification	CL
	USCS group lithology	Sandy CLAY of low plasticity
	AASHTO classification	A-4

TEST PERFORMED

Determination of moisture content - UNE 103300:93

Determination of density - UNE 103301:94

Determination of partilce size distribution (sieving method) - UNE 103101:95

Liquid limit, plastic limit and plasticity index of soil - UNE 103103:94 - UNE 103104:93

REMARKS

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DETERMINATION OF MOISTURE CONTENT - UNE 103300:93

Sample Ref

Project ID: 1827106 Date of the test: 18/03/2020
Location: Macao, Chile.
TP: 02 Depth: 0,95m

2020-170

EQUIPMENT
Balance KERN PCB
Oven SNOL 24/200

Data of soil moisture content	
Container ref	J2
Mass of Container + Wet Sample (g)	240,83
Mass of Container + Dry Sample (g)	223,13
Water (g)	17,70
Soil (g)	135,36
Moisture Content %	13,08

Observations: Analyst: D.B.

DETERMINATION OF DENSITY - UNE 103301:94

Sample Ref

Bulk density data

Soil (g)	52,33	Soil volume (cm3)	25,00
Soil + parafin wax (g)	54,18	Bulk density (g/cm3)	2,093
Parafin wax (g)	1,85	Dry density (g/cm3)	1,778
Weight in water (g)	27,10		
Paraffin wax volume (cm3)	2,08		
Soil + paraffin wax volume (cm3)	27,08		

Paraffin wax density=0,89Tn/m3

2020-170

EQUIPMENT
Balance KERN PCB

Results	
Bulk density (g/cm3)	2,093
Dry density (g/cm3)	1,778
Bulk density (kN/m3)	20,512
Dry density (kN/m3)	17,428

Observations: Analyst: D.B.

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PARTICLE-SIZE ANALYSIS OF SOIL - UNE 103101:95

Sample Ref

2020-170

Project ID: 1827106 Date of the test: 18/03/2020

Location: Macao, Chile.

TP: 02 Depth: 0,95m

EQUIPMENT
Standard sieve series Labopolis
Balance KERN PCB
Oven SNOL 24/200

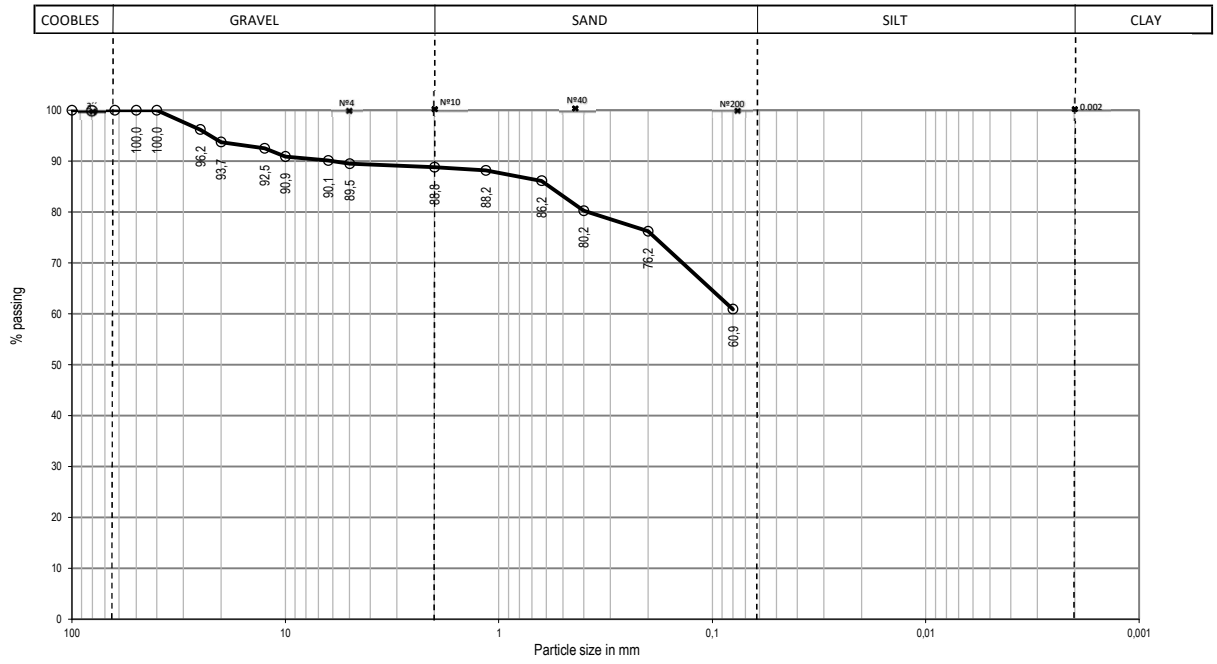
Sieves			Retained		Passing total sample	
ASTM		UNE mm				
Desig.	mm		Partial (g)	Total (g)	Total (g)	Percentage
4"	101,6	100	0	0	1237,7	100,00
3"	76,2	80	0	0	1237,7	100,00
2,5"	63,5	63	0	0	1237,7	100,00
2"	50,8	50	0	0	1237,7	100,00
1,5"	38,1	40	0	0	1237,7	100,00
1"	25,4	25	47,10	47,10	1190,6	96,19
3/4"	19,1	20	30,32	30,32	1160,3	93,74
1/2"	12,7	12,5	15,09	15,09	1145,2	92,53
3/8"	9,52	10	19,88	19,88	1125,3	90,92
1/4"	6,35	6,3	9,82	9,82	1115,5	90,13
Nº4	4,75	5	7,74	7,74	1107,8	89,50
Nº10	2	2	8,44	8,44	1099,3	88,82
Nº16	1,18	1,15	1,06	7,68	1091,6	88,20
Nº30	0,6	0,63	3,49	25,29	1066,3	86,15
Nº40	0,42	0,4	10,09	73,13	993,2	80,25
Nº70	0,21	0,2	6,85	49,65	943,6	76,23
Nº200	0,074	0,08	26,18	189,75	753,8	60,90
		Pan	0,12	0,87	752,9	60,83

Previous calculations	
Total dried sample (g)	1241
M > 20 mm,washed and dried total (g)	77
M < 20 mm, dried tested (g)	1164
M 20-2 mm, washed and dried (g)	60,97
M 20-2 mm, washed and dried total (g)	60,97
M > 2 mm, washed and dried (g)	138,39
M < 2 mm, dried tested (g)	152,13
M < 2 dried tested (g)	151,67
M < 2 mm, dried total (g)	1099,31
Total dried sample (g)	1237,70

Hygroscopic moisture (fraction <2mm)	0,3
Correction parameter (f)	1,00
Correction parameter (f1)	1,00
Correction parameter (f2)	7,25

SOIL TYPE ACCORDING TO ISO 14688

% GRAVEL > 2 mm		11,18	% SAND 2 - 0,063 mm	27,91	% FINES < 0,063 mm
% COBBLES > 63 mm	% Coarse gravel (63 - 20 mm)	6,26	% Coarse sand (2 - 0,63 mm)	2,66	60,83
0,00	% Medium gravel(20 - 6,3 mm)	3,62	% Medium sand (0,63 - 0,2 mm)	9,92	
	% Fine gravel (6,3 - 2 mm)	1,31	% Fine sand (0,2 - 0,08 mm)	15,33	



Observations:

Analyst: E.T.

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS - UNE 103103:94 - UNE 103104:93

Sample Ref

Project ID: 1827106 Date of the test: 18/03/2020

Location: Macao, Chile. **2020-170**

TP: 02 Depth: 0,95m

EQUIPMENT
Casagrande Apparatus Proeti
Balance KERN PCB
Oven SNOL 24/200

LIQUID LIMIT DATA

	Test 1	Test 2	Test 3
Number of drops	18	30	
Log (N)	1,26	1,48	
Tare name	45	55	
Tare mass (g)	22,12	22,36	
Tare + wet sample (g)	64,44	68,04	
Tare + dry sample (g)	55,22	58,95	
Wet mass (g)	42,32	45,68	
Dry mass (g)	33,10	36,59	
Water content	27,85	24,84	

LIQUID LIMIT: **25,9**

PLASTIC LIMIT DATA

	Test 1	Test 2	Test 3
Tare name	A1	A2	
Tare mass (g)	9,67	9,27	
Tare + wet sample (g)	16,05	14,96	
Tare + dry sample (g)	15,12	14,12	
Wet mass (g)	6,38	5,69	
Dry mass (g)	5,45	4,85	
Water content	17,06	17,32	
Number of individual tests	2	2	

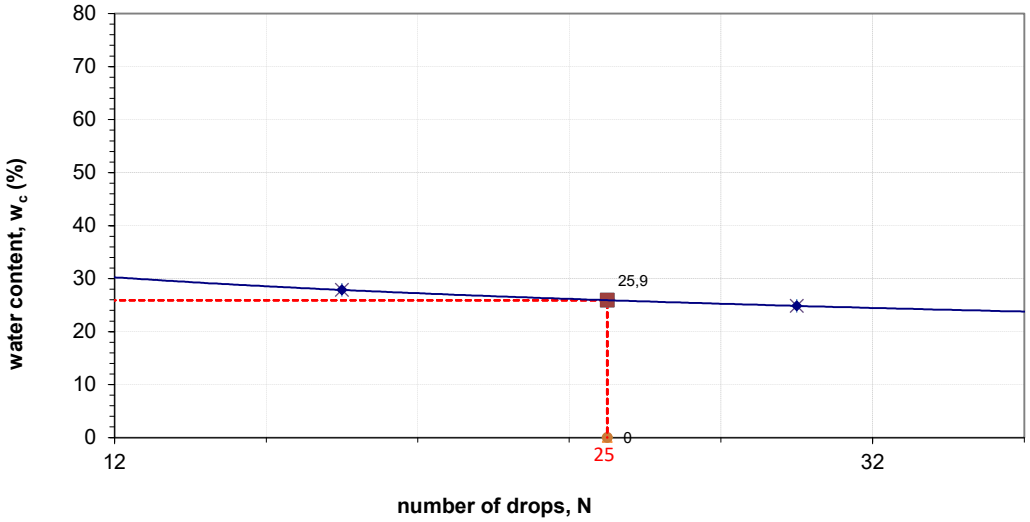
PLASTIC LIMIT: **17,2**

PLASTICITY INDEX: **8,7**

SUM OF RESULTS

LIQUID LIMIT, wL(%)	25,9
PLASTIC LIMIT, wP (%)	17,2
PLASTICITY INDEX, iP(%)	8,7

Natural moisture content, w(%)	13,08
Liquidity index, IL	-0,47
Consistency index, IC	1,47



Observations:

Analyst: E.T.

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GENERAL DATA	Sample Ref
	2020-171

Project ID	1827106
Location	MACAO, CHILE.
Trial Pit	3
Depth	1,10m
Sample type	Plastic bag
Sample condition	Disturbed
Sampling date	02/03/2020
Testing date	19/03/2020
Sample description according to EN ISO criteria	Light brown clayey sandy GRAVEL medium and small sized.

Soil type	USCS classification	GP GC
	USCS group lithology	Clayey sandy poorly graded GRAVEL
	AASHTO classification	A-2-6

TEST PERFORMED

Determination of moisture content - UNE 103300:93

Determination of density

Determination of partilce size distribution (sieving method) - UNE 103101:95

Liquid limit, plastic limit and plasticity index of soil - UNE 103103:94 - UNE 103104:93

REMARKS

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DETERMINATION OF MOISTURE CONTENT - UNE 103300:93

Sample Ref

Project ID: 1827106 Date of the test: 19/03/2020
Location: Macao, Chile.
TP: 3 Depth: 1,10m

2020-171

EQUIPMENT
Balance KERN PCB
Oven SNOL 24/200

Data of soil moisture content	
Container ref	J1
Mass of Container + Wet Sample (g)	298,10
Mass of Container + Dry Sample (g)	292,26
Water (g)	5,84
Soil (g)	205,32
Moisture Content %	2,84

Observations: Analyst: D.B.

DETERMINATION OF DENSITY

Sample Ref

2020-171

EQUIPMENT
Balance KERN PCB

Bulk density data

Internal diameter (mm)	33
Thickness of steel (mm)	4
Length (mm)	33
Mass of tube & sample (g)	512,83
Internal volume (mm3)	60726,20
Mass of Tube (g)	428,68

Sample Dimensions

Specimen volume (m3)	0,00006073
Mass (Kg)	0,084
Specimen length (mm)	71

Results	
Bulk density (g/cm3)	1,386
Dry density (g/cm3)	1,348
Bulk density (kN/m3)	13,582
Dry density (kN/m3)	13,206

Observations: Analyst: D.B.

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PARTICLE-SIZE ANALYSIS OF SOIL - UNE 103101:95

Sample Ref

2020-171

Project ID: 1827106 Date of the test: 19/03/2020

Location: Macao, Chile.

TP: 3 Depth: 1,10m

EQUIPMENT
Standard sieve series Labopolis
Balance KERN PCB
Oven SNOL 24/200

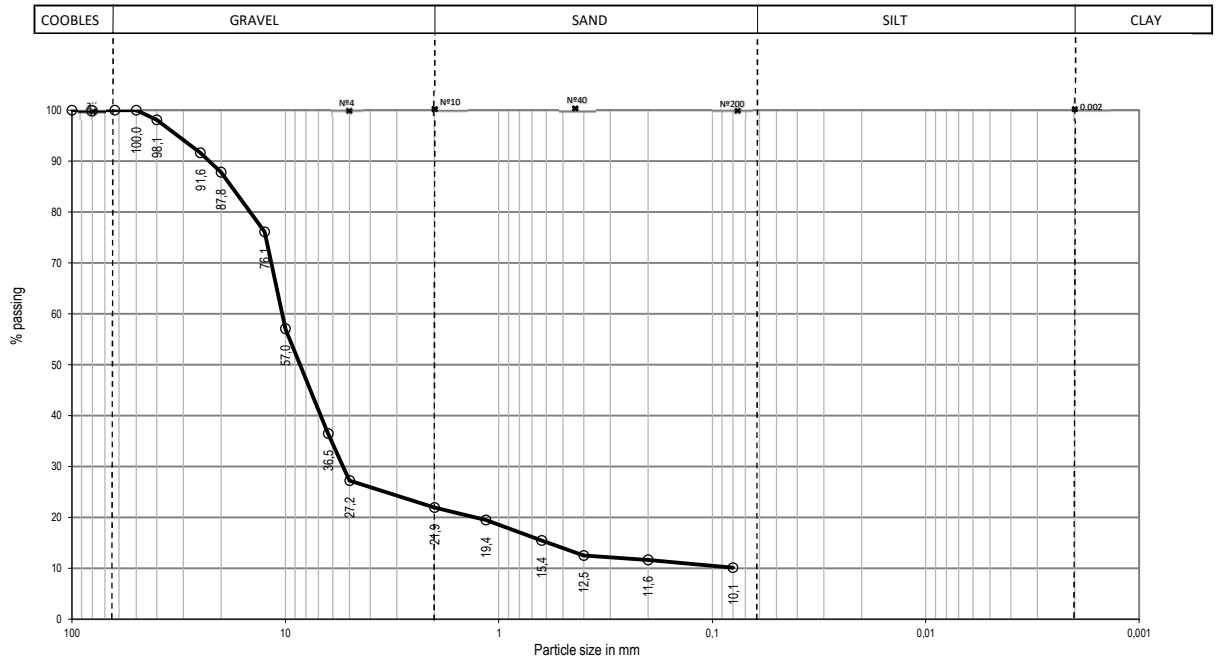
Sieves			Retained		Passing total sample	
ASTM		UNE mm				
Desig.	mm		Partial (g)	Total (g)	Total (g)	Percentage
4"	101,6	100	0	0	2818,9	100,00
3"	76,2	80	0	0	2818,9	100,00
2,5"	63,5	63	0	0	2818,9	100,00
2"	50,8	50	0	0	2818,9	100,00
1,5"	38,1	40	53,47	53,47	2765,4	98,10
1"	25,4	25	182,83	182,83	2582,6	91,62
3/4"	19,1	20	106,60	106,60	2476,0	87,84
1/2"	12,7	12,5	330,88	330,88	2145,1	76,10
3/8"	9,52	10	537,28	537,28	1607,9	57,04
1/4"	6,35	6,3	580,27	580,27	1027,6	36,45
Nº4	4,75	5	260,65	260,65	766,9	27,21
Nº10	2	2	149,53	149,53	617,4	21,90
Nº16	1,18	1,15	16,94	69,27	548,1	19,44
Nº30	0,6	0,63	27,58	112,77	435,4	15,44
Nº40	0,42	0,4	20,29	82,96	352,4	12,50
Nº70	0,21	0,2	6,17	25,23	327,2	11,61
Nº200	0,074	0,08	10,39	42,48	284,7	10,10
		Pan	0,16	0,65	284,0	10,08

Previous calculations	
Total dried sample (g)	2822
M > 20 mm,washed and dried total (g)	343
M < 20 mm, dried tested (g)	2479
M 20-2 mm, washed and dried (g)	1858,61
M 20-2 mm, washed and dried total (g)	1858,61
M > 2 mm, washed and dried (g)	2201,51
M < 2 mm, dried tested (g)	151,75
M < 2 dried tested (g)	151,00
M < 2 mm, dried total (g)	617,40
Total dried sample (g)	2818,91

Hygroscopic moisture (fraction <2mm)	0,5
Correction parameter (f)	1,00
Correction parameter (f1)	1,00
Correction parameter (f2)	4,09

SOIL TYPE ACCORDING TO ISO 14688

% GRAVEL > 2 mm		78,10	% SAND 2 - 0,063 mm	11,80	% FINES < 0,063 mm
% COBBLES > 63 mm	% Coarse gravel (63 - 20 mm)	12,16	% Coarse sand (2 - 0,63 mm)	6,46	
0,00	% Medium gravel(20 - 6,3 mm)	51,38	% Medium sand (0,63 - 0,2 mm)	3,84	10,08
	% Fine gravel (6,3 - 2 mm)	14,55	% Fine sand (0,2 - 0,08 mm)	1,51	



Observations:

Analyst: E.T.

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS - UNE 103103:94 - UNE 103104:93

Sample Ref

Project ID: 1827106 Date of the test: 19/03/2020

Location: Macao, Chile. **2020-171**

TP: 3 Depth: 1,10m

EQUIPMENT
Casagrande Apparatus Proeti
Balance KERN PCB
Oven SNOL 24/200

LIQUID LIMIT DATA

	Test 1	Test 2	Test 3
Number of drops	28	18	
Log (N)	1,45	1,26	
Tare name	45	55	
Tare mass (g)	22,13	22,37	
Tare + wet sample (g)	58,40	57,01	
Tare + dry sample (g)	48,32	46,83	
Wet mass (g)	36,27	34,64	
Dry mass (g)	26,19	24,46	
Water content	38,49	41,62	

LIQUID LIMIT: **39,3**

PLASTIC LIMIT DATA

	Test 1	Test 2	Test 3
Tare name	A1	A2	
Tare mass (g)	9,69	9,29	
Tare + wet sample (g)	13,86	13,24	
Tare + dry sample (g)	13,07	12,44	
Wet mass (g)	4,17	3,95	
Dry mass (g)	3,38	3,15	
Water content	23,37	25,40	
Number of individual tests	2	2	

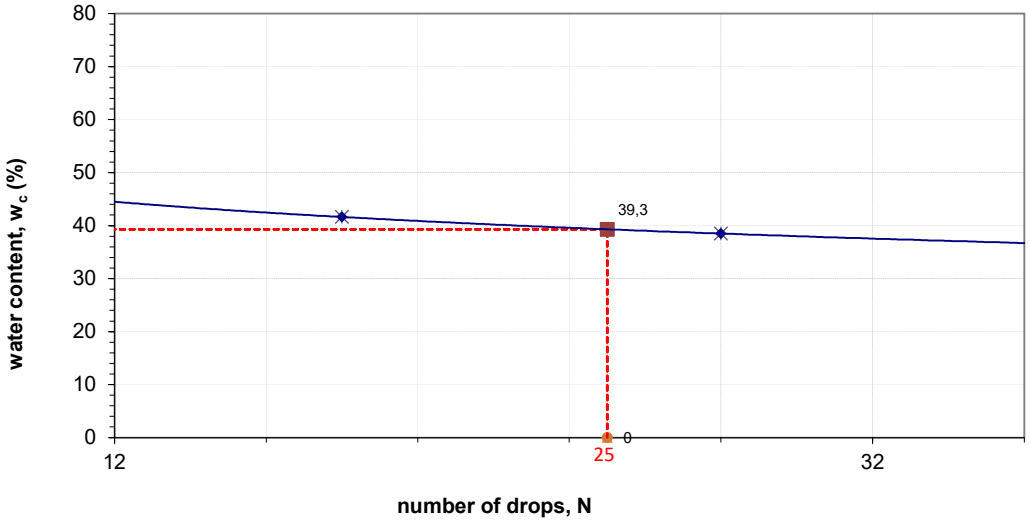
PLASTIC LIMIT: **24,4**

PLASTICITY INDEX: **14,9**

SUM OF RESULTS

LIQUID LIMIT, wL(%)	39,3
PLASTIC LIMIT, wP (%)	24,4
PLASTICITY INDEX, iP(%)	14,9

Natural moisture content, w(%)	2,84
Liquidity index, IL	-1,45
Consistency index, IC	2,45



Observations:

Analyst: E.T.

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GENERAL DATA	Sample Ref
	2020-172

Project ID	1827106
Location	MACAO, CHILE.
Trial Pit	4
Depth	1,00m
Sample type	Plastic bag
Sample condition	Disturbed
Sampling date	02/03/2020
Testing date	19/03/2020
Sample description according to EN ISO criteria	Yellowish brown loose SAND.

Soil type	USCS classification	SP
	USCS group lithology	Poorly graded silty SAND
	AASHTO classification	A-3

TEST PERFORMED

Determination of moisture content - UNE 103300:93

Determination of density

Determination of partilce size distribution (sieving method) - UNE 103101:95

Liquid limit, plastic limit and plasticity index of soil - UNE 103103:94 - UNE 103104:93

REMARKS

No cohesive content

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DETERMINATION OF MOISTURE CONTENT - UNE 103300:93

Sample Ref

Project ID: 1827106 Date of the test: 19/03/2020
Location: Macao, Chile.
TP: 4 Depth: 1,0m

2020-172

EQUIPMENT
Balance KERN PCB
Oven SNOL 24/200

Data of soil moisture content	
Container ref	H
Mass of Container + Wet Sample (g)	139,03
Mass of Container + Dry Sample (g)	135,60
Water (g)	3,43
Soil (g)	111,14
Moisture Content %	3,09

Observations: Analyst: D.B.

DETERMINATION OF DENSITY

Sample Ref

2020-172

EQUIPMENT
Balance KERN PCB

Bulk density data

Internal diameter (mm)	33
Thickness of steel (mm)	4
Length (mm)	33
Mass of tube & sample (g)	519,98
Internal volume (mm3)	60726,20
Mass of Tube (g)	428,68

Sample Dimensions

Specimen volume (m3)	6,073E-05
Mass (Kg)	0,091
Specimen length (mm)	71

Results	
Bulk density (g/cm3)	1,504
Dry density (g/cm3)	1,459
Bulk density (kN/m3)	14,736
Dry density (kN/m3)	14,294

Observations: Analyst: D.B.

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PARTICLE-SIZE ANALYSIS OF SOIL - UNE 103101:95

Sample Ref

2020-172

Project ID: 1827106 Date of the test: 19/03/2020

Location: Macao, Chile.

TP: 4 Depth: 1,0m

EQUIPMENT
Standard sieve series Labopolis
Balance KERN PCB
Oven SNOL 24/200

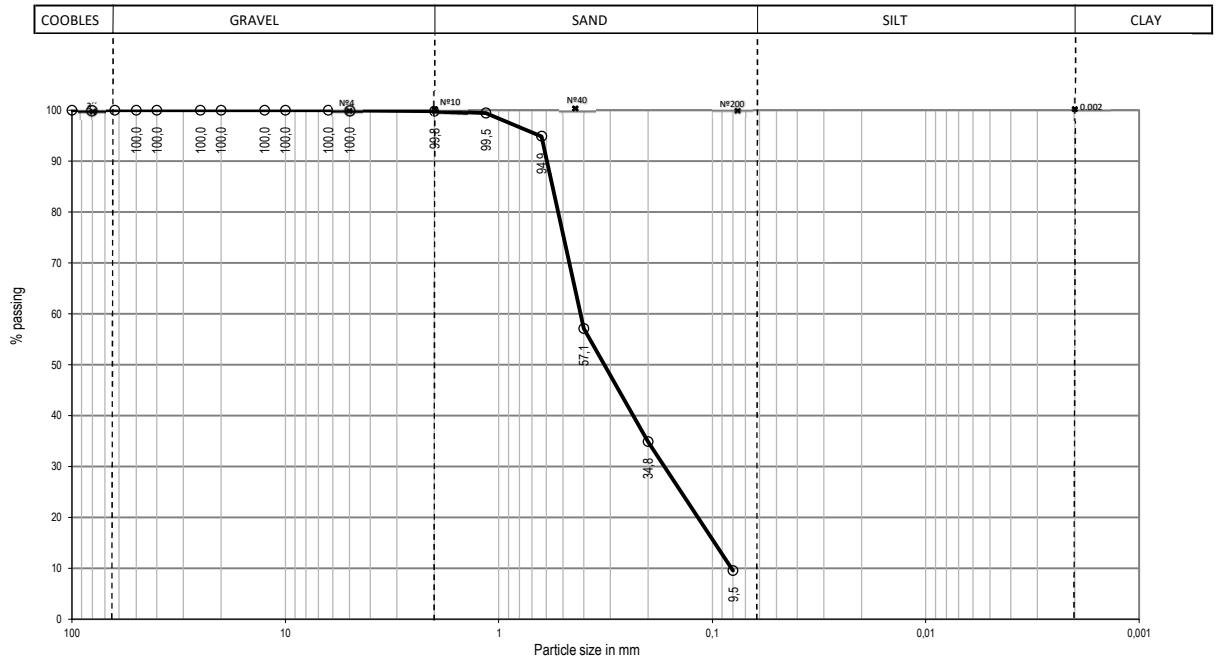
Sieves			Retained		Passing total sample	
ASTM		UNE mm				
Desig.	mm		Partial (g)	Total (g)	Total (g)	Percentage
4"	101,6	100	0	0	1862,4	100,00
3"	76,2	80	0	0	1862,4	100,00
2,5"	63,5	63	0	0	1862,4	100,00
2"	50,8	50	0	0	1862,4	100,00
1,5"	38,1	40	0	0	1862,4	100,00
1"	25,4	25	0	0	1862,4	100,00
MINATION OF DE	19,1	20	0	0	1862,4	100,00
1/2"	12,7	12,5	0	0	1862,4	100,00
3/8"	9,52	10	0	0	1862,4	100,00
1/4"	6,35	6,3	0	0	1862,4	100,00
Nº4	4,75	5	0,51	0,51	1861,9	99,97
Nº10	2	2	2,82	2,82	1859,1	99,82
Nº16	1,18	1,15	0,51	6,40	1852,7	99,48
Nº30	0,6	0,63	6,79	85,17	1767,5	94,90
Nº40	0,42	0,4	56,10	703,69	1063,8	57,12
Nº70	0,21	0,2	33,07	414,81	649,0	34,85
Nº200	0,074	0,08	37,57	471,26	177,7	9,54
		Pan	0,05	0,63	177,1	9,51

Previous calculations	
Total dried sample (g)	1894
M > 20 mm,washed and dried total (g)	0
M < 20 mm, dried tested (g)	1894
M 20-2 mm, washed and dried (g)	3,33
M 20-2 mm, washed and dried total (g)	3,33
M > 2 mm, washed and dried (g)	3,33
M < 2 mm, dried tested (g)	150,73
M < 2 dried tested (g)	148,21
M < 2 mm, dried total (g)	1859,07
Total dried sample (g)	1862,40

Hygroscopic moisture (fraction <2mm)	1,7
Correction parameter (f)	0,98
Correction parameter (f1)	1,00
Correction parameter (f2)	12,54

SOIL TYPE ACCORDING TO ISO 14688

% GRAVEL > 2 mm		0,18	% SAND 2 - 0,063 mm	90,28	% FINES < 0,063 mm
% COBBLES > 63 mm	% Coarse gravel (63 - 20 mm)	0,00	% Coarse sand (2 - 0,63 mm)	4,92	9,51
0,00	% Medium gravel(20 - 6,3 mm)	0,00	% Medium sand (0,63 - 0,2 mm)	60,06	
	% Fine gravel (6,3 - 2 mm)	0,18	% Fine sand (0,2 - 0,08 mm)	25,30	



Observations:

Analyst: E.T.

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GENERAL DATA	Sample Ref
	2020-173

Project ID	1827106
Location	MACAO, CHILE.
Trial Pit	TP05
Depth	0,90m
Sample type	Plastic bag
Sample condition	Disturbed
Sampling date	29/02/2020
Testing date	18/03/2020
Sample description according to EN ISO criteria	Dark brown slightly clayey sandy GRAVEL, small and big sized.

Soil type	USCS classification	GP GC
	USCS group lithology	Poorly graded clayey sandy GRAVEL
	AASHTO classification	A-2-4

TEST PERFORMED

Determination of moisture content - UNE 103300:93

Determination of density - UNE 103301:94

Determination of partilce size distribution (sieving method) - UNE 103101:95

Liquid limit, plastic limit and plasticity index of soil - UNE 103103:94 - UNE 103104:93

REMARKS

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DETERMINATION OF MOISTURE CONTENT - UNE 103300:93

Sample Ref

Project ID: 1827106 Date of the test: 18/03/2020
Location: Macao, Chile.
TP: 05 Depth: 0,90m

2020-173

EQUIPMENT
Balance KERN PCB
Oven SNOL 24/200

Data of soil moisture content	
Container ref	40
Mass of Container + Wet Sample (g)	266,89
Mass of Container + Dry Sample (g)	259,00
Water (g)	7,89
Soil (g)	143,36
Moisture Content %	5,50

Observations: Analyst: E.T.

DETERMINATION OF DENSITY - UNE 103301:94

Sample Ref

Bulk density data

Soil (g)	97,88	Soil volume (cm3)	40,44
Soil + parafin wax (g)	99,06	Bulk density (g/cm3)	2,420
Parafin wax (g)	1,18	Dry density (g/cm3)	2,243
Weight in water (g)	57,29		
Paraffin wax volume (cm3)	1,33		
Soil + paraffin wax volume (cm3)	41,77		

Paraffin wax density=0,89Tn/m3

2020-173

EQUIPMENT
Balance KERN PCB

Results	
Bulk density (g/cm3)	2,420
Dry density (g/cm3)	2,243
Bulk density (kN/m3)	23,717
Dry density (kN/m3)	21,983

Observations: Analyst: D.B.

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PARTICLE-SIZE ANALYSIS OF SOIL - UNE 103101:95

Sample Ref

2020-173

Project ID: 1827106 Date of the test: 18/03/2020

Location: Macao, Chile.

TP: 05 Depth: 0,90m

EQUIPMENT
Standard sieve series Labopolis
Balance KERN PCB
Oven SNOL 24/200

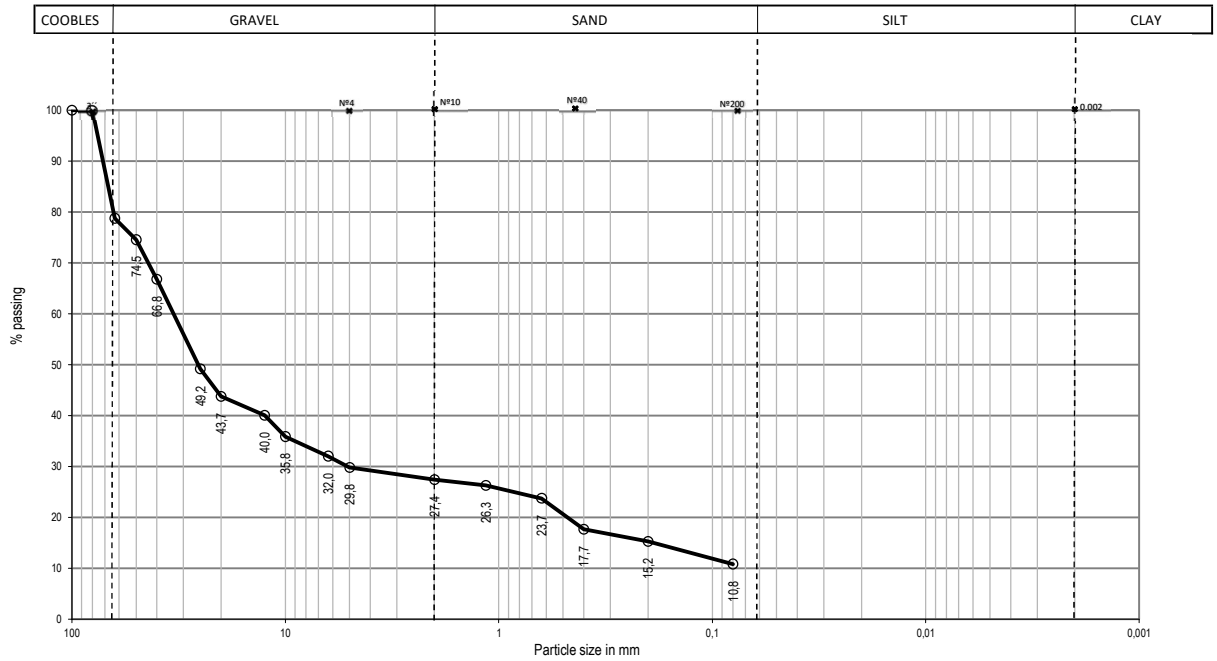
Sieves			Retained		Passing total sample	
ASTM		UNE mm				
Desig.	mm		Partial (g)	Total (g)	Total (g)	Percentage
4"	101,6	100	0	0	1963,0	100,00
3"	76,2	80	0	0	1963,0	100,00
2,5"	63,5	63	416,61	416,61	1546,4	78,78
2"	50,8	50	83,05	83,05	1463,3	74,55
1,5"	38,1	40	151,97	151,97	1311,3	66,80
1"	25,4	25	346,33	346,33	965,0	49,16
3/4"	19,1	20	106,58	106,58	858,4	43,73
1/2"	12,7	12,5	72,84	72,84	785,6	40,02
3/8"	9,52	10	82,01	82,01	703,6	35,84
1/4"	6,35	6,3	75,17	75,17	628,4	32,01
Nº4	4,75	5	43,98	43,98	584,4	29,77
Nº10	2	2	46,62	46,62	537,8	27,40
Nº16	1,18	1,15	6,29	22,41	515,4	26,26
Nº30	0,6	0,63	14,05	50,06	465,4	23,71
Nº40	0,42	0,4	33,36	118,86	346,5	17,65
Nº70	0,21	0,2	13,26	47,24	299,3	15,24
Nº200	0,074	0,08	24,51	87,32	211,9	10,80
		Pan	0,15	0,53	211,4	10,77

Previous calculations	
Total dried sample (g)	1964
M > 20 mm,washed and dried total (g)	1105
M < 20 mm, dried tested (g)	859
M 20-2 mm, washed and dried (g)	320,62
M 20-2 mm, washed and dried total (g)	320,62
M > 2 mm, washed and dried (g)	1425,16
M < 2 mm, dried tested (g)	151,24
M < 2 dried tested (g)	150,95
M < 2 mm, dried total (g)	537,82
Total dried sample (g)	1962,98

Hygroscopic moisture (fraction <2mm)	0,2
Correction parameter (f)	1,00
Correction parameter (f1)	1,00
Correction parameter (f2)	3,56

SOIL TYPE ACCORDING TO ISO 14688

% GRAVEL > 2 mm		51,38	% SAND 2 - 0,063 mm	16,60	% FINES < 0,063 mm
% COBBLES > 63 mm	% Coarse gravel (63 - 20 mm)	35,05	% Coarse sand (2 - 0,63 mm)	3,69	
21,22	% Medium gravel(20 - 6,3 mm)	11,72	% Medium sand (0,63 - 0,2 mm)	8,46	10,77
	% Fine gravel (6,3 - 2 mm)	4,62	% Fine sand (0,2 - 0,08 mm)	4,45	



Observations:

Analyst: E.T.

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS - UNE 103103:94 - UNE 103104:93

Sample Ref

Project ID: 1827106 Date of the test: 18/03/2020

Location: Macao, Chile. **2020-173**

TP: 05 Depth: 0,90m

EQUIPMENT
Casagrande Apparatus Proeti
Balance KERN PCB
Oven SNOL 24/200

LIQUID LIMIT DATA

	Test 1	Test 2	Test 3
Number of drops	16	33	
Log (N)	1,20	1,52	
Tare name	1	8	
Tare mass (g)	21,97	21,93	
Tare + wet sample (g)	60,24	62,79	
Tare + dry sample (g)	52,15	54,89	
Wet mass (g)	38,27	40,86	
Dry mass (g)	30,18	32,96	
Water content	26,81	23,97	

LIQUID LIMIT: **25,1**

PLASTIC LIMIT DATA

	Test 1	Test 2	Test 3
Tare name	B1	B2	
Tare mass (g)	9,34	9,32	
Tare + wet sample (g)	17,85	18,06	
Tare + dry sample (g)	16,55	16,76	
Wet mass (g)	8,51	8,74	
Dry mass (g)	7,21	7,44	
Water content	18,03	17,47	
Number of individual tests	2	2	

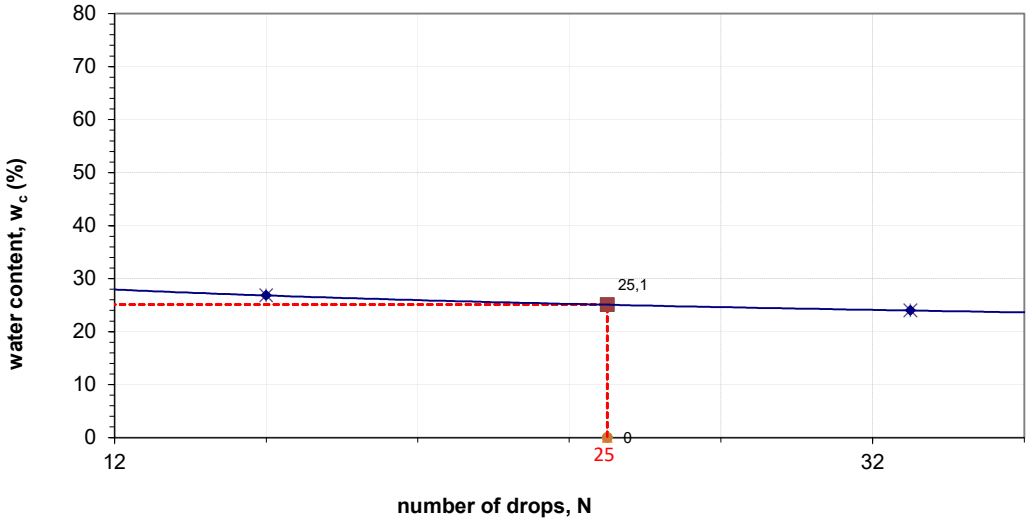
PLASTIC LIMIT: **17,8**

PLASTICITY INDEX: **7,3**

SUM OF RESULTS

LIQUID LIMIT, wL(%)	25,1
PLASTIC LIMIT, wP (%)	17,8
PLASTICITY INDEX, iP(%)	7,3

Natural moisture content, w(%)	5,50
Liquidity index, IL	-1,68
Consistency index, IC	2,68



Observations:

Analyst: E.T.

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GENERAL DATA	Sample Ref
	2020-174

Project ID	1827106
Location	MACAO, CHILE.
Trial Pit	6
Depth	0,50m
Sample type	Plastic bag
Sample condition	Disturbed
Sampling date	29/02/2020
Testing date	18/03/2020
Sample description according to EN ISO criteria	Dark brown slightly sandy silty GRAVEL.

Soil type	USCS classification	GM
	USCS group lithology	Silty GRAVEL with sand
	AASHTO classification	A-4

TEST PERFORMED

Determination of moisture content - UNE 103300:93

Determination of density - UNE 103301:94

Determination of partilce size distribution (sieving method) - UNE 103101:95

Liquid limit, plastic limit and plasticity index of soil - UNE 103103:94 - UNE 103104:93

REMARKS

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DETERMINATION OF MOISTURE CONTENT - UNE 103300:93

Sample Ref

Project ID: 1827106 Date of the test: 18/03/2020
Location: Macao, Chile.
TP: 06 Depth: 0,5m

2020-174

EQUIPMENT
Balance KERN PCB
Oven SNOL 24/200

Data of soil moisture content	
Container ref	41
Mass of Container + Wet Sample (g)	248,39
Mass of Container + Dry Sample (g)	236,04
Water (g)	12,35
Soil (g)	123,56
Moisture Content %	10,00

Observations: Analyst: D.B.

DETERMINATION OF DENSITY - UNE 103301:94

Sample Ref

Bulk density data

Soil (g)	77,13	Soil volume (cm3)	33,88
Soil + parafin wax (g)	78,75	Bulk density (g/cm3)	2,277
Parafin wax (g)	1,62	Dry density (g/cm3)	2,026
Weight in water (g)	43,05		
Paraffin wax volume (cm3)	1,82		
Soil + paraffin wax volume (cm3)	35,70		

Paraffin wax density=0,89Tn/m3

2020-174

EQUIPMENT
Balance KERN PCB

Results	
Bulk density (g/cm3)	2,277
Dry density (g/cm3)	2,026
Bulk density (kN/m3)	22,310
Dry density (kN/m3)	19,858

Observations: Analyst: D.B.

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PARTICLE-SIZE ANALYSIS OF SOIL - UNE 103101:95

Sample Ref

2020-174

Project ID: 1827106 Date of the test: 18/03/2020

Location: Macao, Chile.

TP: 06 Depth: 0,5m

EQUIPMENT
Standard sieve series Labopolis
Balance KERN PCB
Oven SNOL 24/200

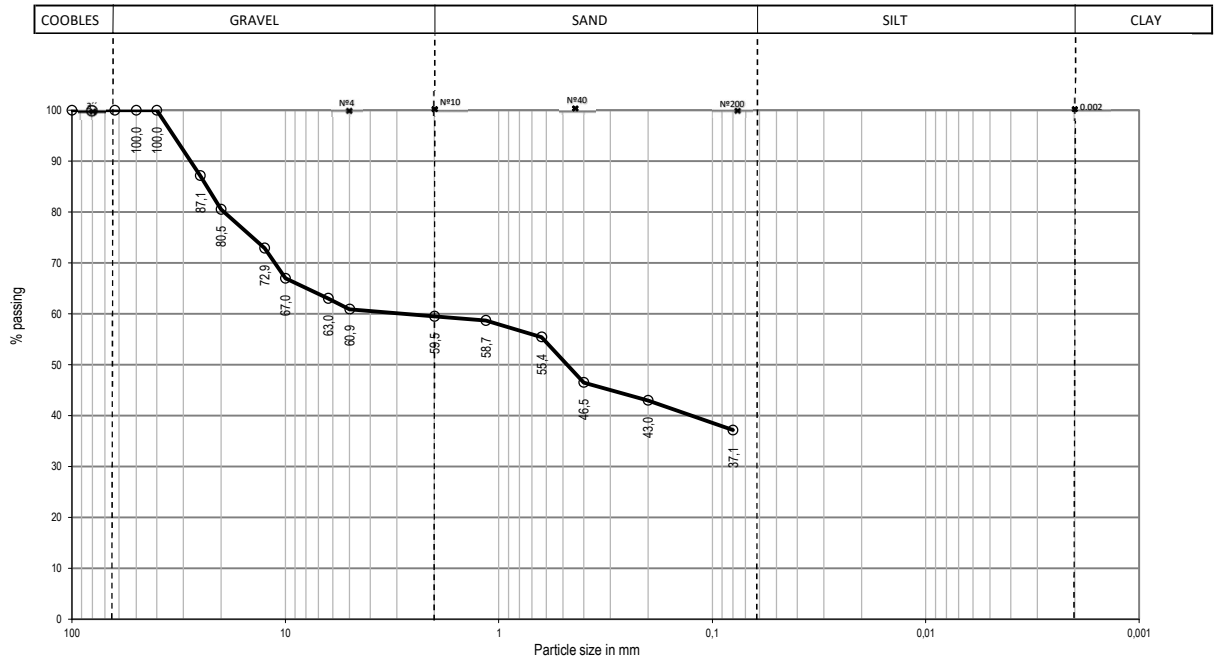
Sieves			Retained		Passing total sample	
ASTM		UNE mm				
Desig.	mm		Partial (g)	Total (g)	Total (g)	Percentage
4"	101,6	100	0	0	1723,0	100,00
3"	76,2	80	0	0	1723,0	100,00
2,5"	63,5	63	0	0	1723,0	100,00
2"	50,8	50	0	0	1723,0	100,00
1,5"	38,1	40	0	0	1723,0	100,00
1"	25,4	25	221,82	221,82	1501,2	87,13
3/4"	19,1	20	113,97	113,97	1387,2	80,51
1/2"	12,7	12,5	131,21	131,21	1256,0	72,90
3/8"	9,52	10	101,62	101,62	1154,4	67,00
1/4"	6,35	6,3	68,37	68,37	1086,0	63,03
Nº4	4,75	5	36,15	36,15	1049,8	60,93
Nº10	2	2	24,25	24,25	1025,6	59,52
Nº16	1,18	1,15	2,08	14,01	1011,6	58,71
Nº30	0,6	0,63	8,40	56,56	955,0	55,43
Nº40	0,42	0,4	22,89	154,13	800,9	46,48
Nº70	0,21	0,2	9,02	60,74	740,1	42,96
Nº200	0,074	0,08	14,89	100,26	639,9	37,14
		Pan	0,06	0,40	639,5	37,11

Previous calculations	
Total dried sample (g)	1724
M > 20 mm,washed and dried total (g)	336
M < 20 mm, dried tested (g)	1388
M 20-2 mm, washed and dried (g)	361,60
M 20-2 mm, washed and dried total (g)	361,60
M > 2 mm, washed and dried (g)	697,39
M < 2 mm, dried tested (g)	152,46
M < 2 dried tested (g)	152,31
M < 2 mm, dried total (g)	1025,58
Total dried sample (g)	1722,97

Hygroscopic moisture (fraction <2mm)	0,1
Correction parameter (f)	1,00
Correction parameter (f1)	1,00
Correction parameter (f2)	6,73

SOIL TYPE ACCORDING TO ISO 14688

% GRAVEL > 2 mm		40,48	% SAND 2 - 0,063 mm	22,39	% FINES < 0,063 mm
% COBBLES > 63 mm	% Coarse gravel (63 - 20 mm)	19,49	% Coarse sand (2 - 0,63 mm)	4,10	37,11
0,00	% Medium gravel(20 - 6,3 mm)	17,48	% Medium sand (0,63 - 0,2 mm)	12,47	
	% Fine gravel (6,3 - 2 mm)	3,51	% Fine sand (0,2 - 0,08 mm)	5,82	



Observations:

Analyst: E.T.

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS - UNE 103103:94 - UNE 103104:93

Sample Ref

Project ID: 1827106 Date of the test: 18/03/2020

Location: Macao, Chile. **2020-174**

TP: 06 Depth: 0,5m

EQUIPMENT
Casagrande Apparatus Proeti
Balance KERN PCB
Oven SNOL 24/200

LIQUID LIMIT DATA

	Test 1	Test 2	Test 3
Number of drops	28	16	
Log (N)	1,45	1,20	
Tare name	45	55	
Tare mass (g)	22,14	22,37	
Tare + wet sample (g)	61,38	60,95	
Tare + dry sample (g)	52,79	51,75	
Wet mass (g)	39,24	38,58	
Dry mass (g)	30,65	29,38	
Water content	28,03	31,31	

LIQUID LIMIT: **28,7**

PLASTIC LIMIT DATA

	Test 1	Test 2	Test 3
Tare name	B1	B2	
Tare mass (g)	9,34	9,34	
Tare + wet sample (g)	14,75	13,99	
Tare + dry sample (g)	13,74	13,15	
Wet mass (g)	5,41	4,65	
Dry mass (g)	4,40	3,81	
Water content	22,95	22,05	
Number of individual tests	2	2	

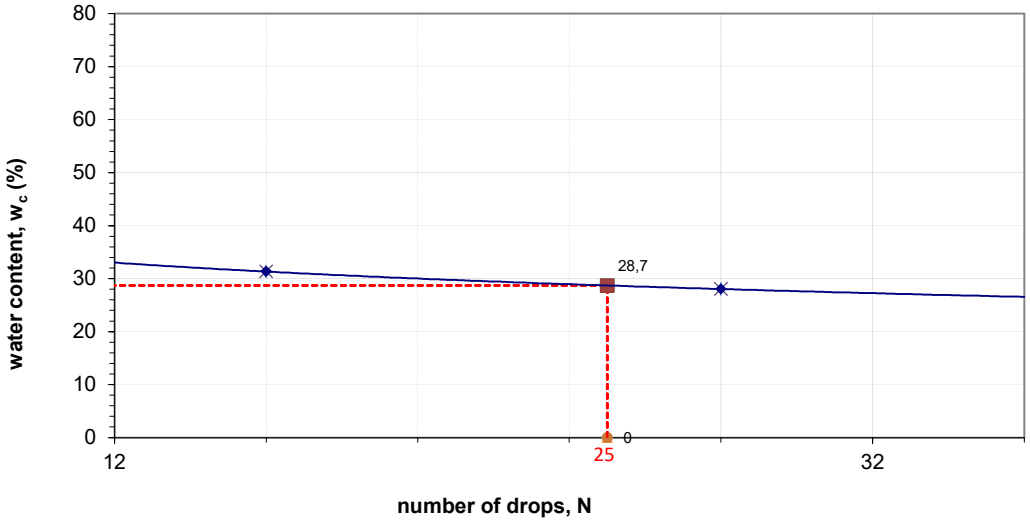
PLASTIC LIMIT: **22,5**

PLASTICITY INDEX: **6,2**

SUM OF RESULTS

LIQUID LIMIT, wL(%)	28,7
PLASTIC LIMIT, wP (%)	22,5
PLASTICITY INDEX, iP(%)	6,2

Natural moisture content, w(%)	10,00
Liquidity index, IL	-2,02
Consistency index, IC	3,02



Observations:

Analyst: E.T.

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GENERAL DATA	Sample Ref
	2020-175

Project ID	1827106
Location	MACAO, CHILE.
Trial Pit	7
Depth	0,90m
Sample type	Plastic bag
Sample condition	Disturbed
Sampling date	29/02/2020
Testing date	19/03/2020
Sample description according to EN ISO criteria	Greysih brown slightly sandy clayey GRAVEL.

Soil type	USCS classification	GC
	USCS group lithology	Clayey GRAVEL
	AASHTO classification	A-2-4

TEST PERFORMED

Determination of moisture content - UNE 103300:93

Determination of density - UNE 103301:94

Determination of partilce size distribution (sieving method) - UNE 103101:95

Liquid limit, plastic limit and plasticity index of soil - UNE 103103:94 - UNE 103104:93

REMARKS

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DETERMINATION OF MOISTURE CONTENT - UNE 103300:93

Sample Ref

Project ID: 1827106 Date of the test: 19/03/2020
Location: Macao, Chile.
TP: 07 Depth: 0,90m

2020-175

EQUIPMENT
Balance KERN PCB
Oven SNOL 24/200

Data of soil moisture content	
Container ref	G
Mass of Container + Wet Sample (g)	270,91
Mass of Container + Dry Sample (g)	257,42
Water (g)	13,49
Soil (g)	223,79
Moisture Content %	6,03

Observations: Analyst: D.B.

DETERMINATION OF DENSITY - UNE 103301:94

Sample Ref

Bulk density data

Soil (g)	95,13	Soil volume (cm3)	38,29
Soil + parafin wax (g)	96,84	Bulk density (g/cm3)	2,485
Parafin wax (g)	1,71	Dry density (g/cm3)	2,189
Weight in water (g)	56,63		
Paraffin wax volume (cm3)	1,92		
Soil + paraffin wax volume (cm3)	40,21		

Paraffin wax density=0,89Tn/m3

2020-175

EQUIPMENT
Balance KERN PCB

Results	
Bulk density (g/cm3)	2,485
Dry density (g/cm3)	2,189
Bulk density (kN/m3)	24,349
Dry density (kN/m3)	21,454

Observations: Analyst: D.B.

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PARTICLE-SIZE ANALYSIS OF SOIL - UNE 103101:95

Sample Ref

2020-175

Project ID: 1827106 Date of the test: 19/03/2020

Location: Macao, Chile.

TP: 07 Depth: 0,90m

EQUIPMENT
Standard sieve series Labopolis
Balance KERN PCB
Oven SNOL 24/200

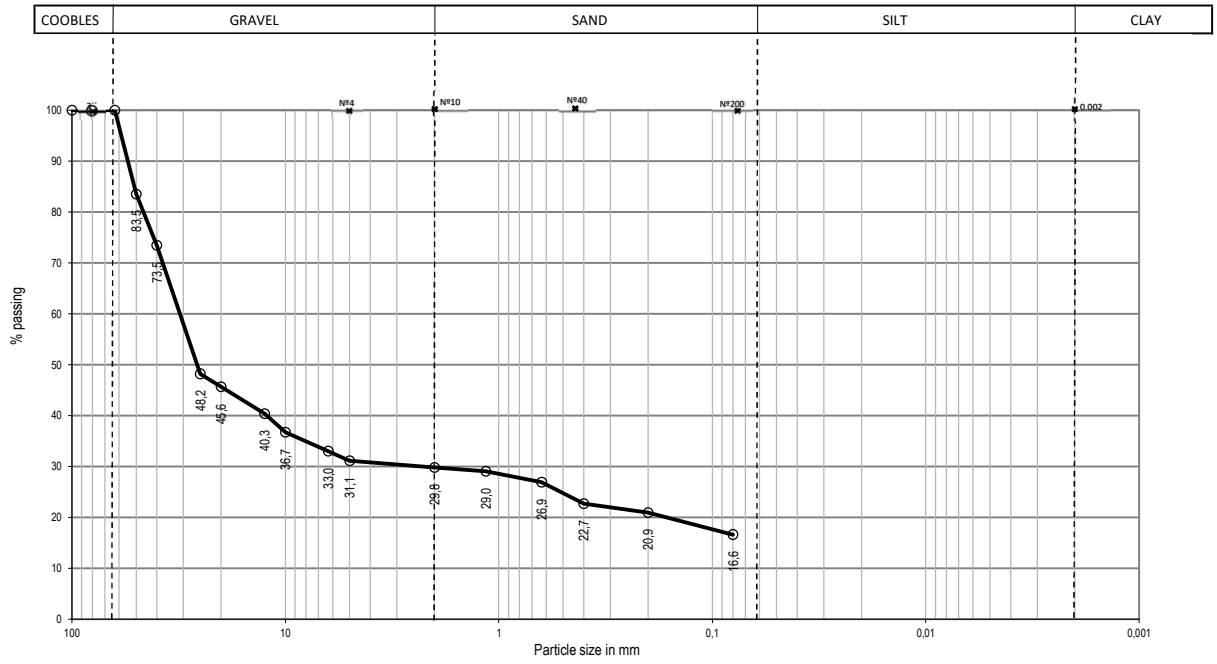
Sieves			Retained		Passing total sample	
ASTM		UNE mm				
Desig.	mm		Partial (g)	Total (g)	Total (g)	Percentage
4"	101,6	100	0	0	2319,8	100,00
3"	76,2	80	0	0	2319,8	100,00
2,5"	63,5	63	0	0	2319,8	100,00
2"	50,8	50	382,14	382,14	1937,7	83,53
1,5"	38,1	40	233,33	233,33	1704,3	73,47
1"	25,4	25	586,61	586,61	1117,7	48,18
3/4"	19,1	20	59,07	59,07	1058,6	45,64
1/2"	12,7	12,5	123,18	123,18	935,5	40,33
3/8"	9,52	10	83,92	83,92	851,5	36,71
1/4"	6,35	6,3	85,62	85,62	765,9	33,02
Nº4	4,75	5	43,99	43,99	721,9	31,12
Nº10	2	2	30,46	30,46	691,5	29,81
Nº16	1,18	1,15	4,01	18,81	672,7	29,00
Nº30	0,6	0,63	10,33	48,46	624,2	26,91
Nº40	0,42	0,4	20,85	97,80	526,4	22,69
Nº70	0,21	0,2	8,91	41,80	484,6	20,89
Nº200	0,074	0,08	21,26	99,73	384,9	16,59
		Pan	0,13	0,61	384,3	16,56

Previous calculations	
Total dried sample (g)	2344
M > 20 mm,washed and dried total (g)	1261
M < 20 mm, dried tested (g)	1083
M 20-2 mm, washed and dried (g)	367,17
M 20-2 mm, washed and dried total (g)	367,17
M > 2 mm, washed and dried (g)	1628,27
M < 2 mm, dried tested (g)	152,58
M < 2 dried tested (g)	147,42
M < 2 mm, dried total (g)	691,53
Total dried sample (g)	2319,80

Hygroscopic moisture (fraction <2mm)	3,5
Correction parameter (f)	0,97
Correction parameter (f1)	1,00
Correction parameter (f2)	4,69

SOIL TYPE ACCORDING TO ISO 14688

% GRAVEL > 2 mm		70,19	% SAND 2 - 0,063 mm	13,22	% FINES < 0,063 mm
% COBBLES > 63 mm	% Coarse gravel (63 - 20 mm)	54,36	% Coarse sand (2 - 0,63 mm)	2,90	
0,00	% Medium gravel(20 - 6,3 mm)	12,62	% Medium sand (0,63 - 0,2 mm)	6,02	16,56
	% Fine gravel (6,3 - 2 mm)	3,21	% Fine sand (0,2 - 0,08 mm)	4,30	



Observations:

Analyst: E.T.

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS - UNE 103103:94 - UNE 103104:93

Sample Ref

Project ID: 1827106 Date of the test: 19/03/2020

Location: Macao, Chile.

2020-175

TP: 07 Depth: 0,90m

EQUIPMENT
Casagrande Apparatus Proeti
Balance KERN PCB
Oven SNOL 24/200

LIQUID LIMIT DATA

	Test 1	Test 2	Test 3
Number of drops	23	35	
Log (N)	1,36	1,54	
Tare name	1	8	
Tare mass (g)	21,98	21,93	
Tare + wet sample (g)	67,79	59,69	
Tare + dry sample (g)	57,16	51,49	
Wet mass (g)	45,81	37,76	
Dry mass (g)	35,18	29,56	
Water content	30,22	27,74	

LIQUID LIMIT: **29,7**

PLASTIC LIMIT DATA

	Test 1	Test 2	Test 3
Tare name	A1	A2	
Tare mass (g)	9,67	9,27	
Tare + wet sample (g)	14,53	13,22	
Tare + dry sample (g)	13,73	12,58	
Wet mass (g)	4,86	3,95	
Dry mass (g)	4,06	3,31	
Water content	19,70	19,41	
Number of individual tests	2	2	

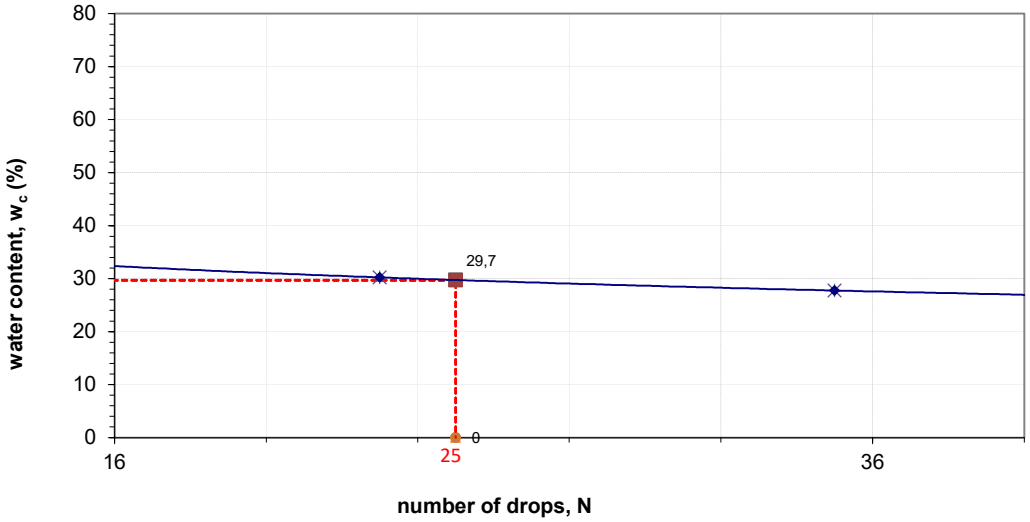
PLASTIC LIMIT: **19,6**

PLASTICITY INDEX: **10,2**

SUM OF RESULTS

LIQUID LIMIT, wL(%)	29,7
PLASTIC LIMIT, wP (%)	19,6
PLASTICITY INDEX, iP(%)	10,2

Natural moisture content, w(%)	6,03
Liquidity index, IL	-1,33
Consistency index, IC	2,33



Observations:

Analyst: E.T.

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GENERAL DATA	Sample Ref
	2020-176

Project ID	1827106
Location	MACAO, CHILE.
Trial Pit	8
Depth	1,30m
Sample type	Plastic bag
Sample condition	Disturbed
Sampling date	29/02/2020
Testing date	19/03/2020
Sample description according to EN ISO criteria	Brown slightly silty GRAVEL, ranging from small to big sized gravels.

Soil type	USCS classification	GP GM
	USCS group lithology	Poorly graded silty GRAVEL
	AASHTO classification	A-1-a

TEST PERFORMED

Determination of moisture content - UNE 103300:93

Determination of density

Determination of partilce size distribution (sieving method) - UNE 103101:95

Liquid limit, plastic limit and plasticity index of soil - UNE 103103:94 - UNE 103104:93

REMARKS

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DETERMINATION OF MOISTURE CONTENT - UNE 103300:93

Sample Ref

Project ID: 1827106 Date of the test: 19/03/2020
Location: Macao, Chile.
TP: 08 Depth: 1,3m

2020-176

EQUIPMENT
Balance KERN PCB
Oven SNOL 24/200

Data of soil moisture content	
Container ref	P
Mass of Container + Wet Sample (g)	291,01
Mass of Container + Dry Sample (g)	282,17
Water (g)	8,84
Soil (g)	238,09
Moisture Content %	3,71

Observations: Analyst: D.B.

DETERMINATION OF DENSITY

Sample Ref

2020-176

EQUIPMENT
Balance KERN PCB

Bulk density data	
Internal diameter (mm)	33
Thickness of steel (mm)	4
Length (mm)	33
Mass of tube & sample (g)	515,63
Internal volume (mm3)	60726,20
Mass of Tube (g)	428,68

Sample Dimensions	
Specimen volume (m3)	6,073E-05
Mass (Kg)	0,087
Specimen length (mm)	71

Results	
Bulk density (g/cm3)	1,432
Dry density (g/cm3)	1,381
Bulk density (kN/m3)	14,034
Dry density (kN/m3)	13,531

Observations: Analyst: D.B.

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PARTICLE-SIZE ANALYSIS OF SOIL - UNE 103101:95

Sample Ref

2020-176

Project ID: 1827106 Date of the test: 19/03/2020

Location: Macao, Chile.

TP: 08 Depth: 1,3m

EQUIPMENT
Standard sieve series Labopolis
Balance KERN PCB
Oven SNOL 24/200

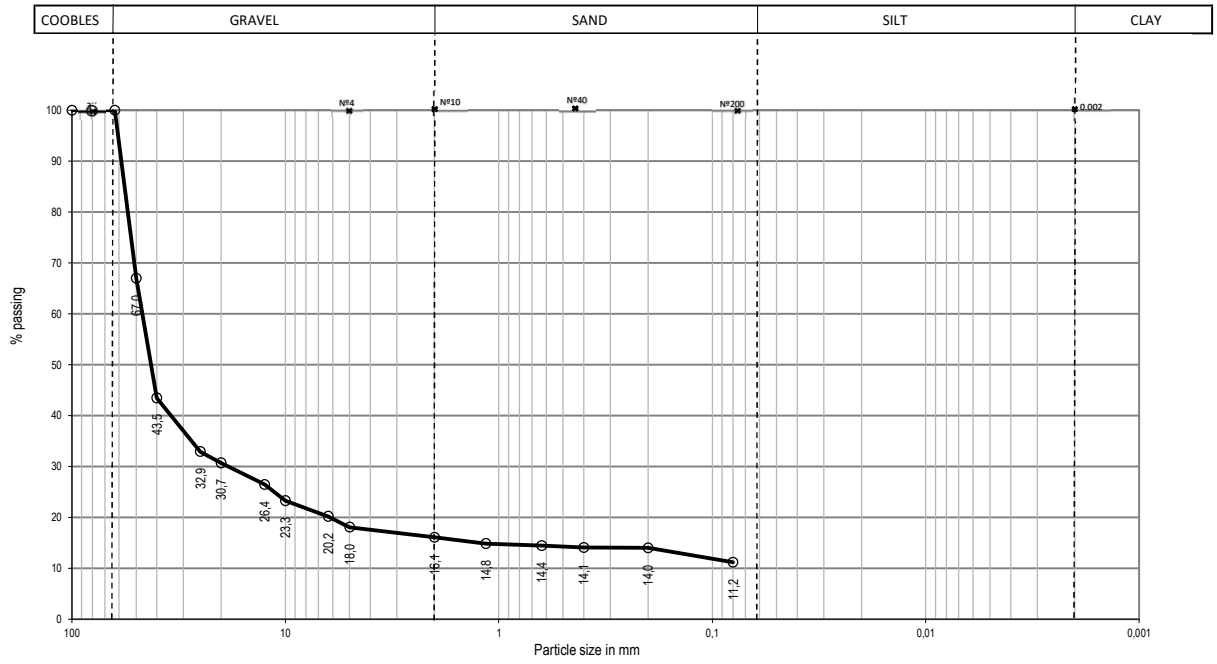
Sieves			Retained		Passing total sample	
ASTM		UNE mm				
Desig.	mm		Partial (g)	Total (g)	Total (g)	Percentage
4"	101,6	100	0	0	2821,7	100,00
3"	76,2	80	0	0	2821,7	100,00
2,5"	63,5	63	0	0	2821,7	100,00
2"	50,8	50	931,65	931,65	1890,1	66,98
1,5"	38,1	40	663,60	663,60	1226,5	43,47
1"	25,4	25	298,08	298,08	928,4	32,90
3/4"	19,1	20	62,03	62,03	866,4	30,70
1/2"	12,7	12,5	120,79	120,79	745,6	26,42
3/8"	9,52	10	89,03	89,03	656,6	23,27
1/4"	6,35	6,3	86,57	86,57	570,0	20,20
Nº4	4,75	5	61,06	61,06	508,9	18,04
Nº10	2	2	55,32	55,32	453,6	16,08
Nº16	1,18	1,15	11,75	35,49	418,1	14,82
Nº30	0,6	0,63	3,84	11,60	406,5	14,41
Nº40	0,42	0,4	3,05	9,21	397,3	14,08
Nº70	0,21	0,2	1,17	3,53	393,8	13,95
Nº200	0,074	0,08	25,99	78,50	315,3	11,17
		Pan	0,55	1,66	313,6	11,11

Previous calculations	
Total dried sample (g)	2824
M > 20 mm,washed and dried total (g)	1955
M < 20 mm, dried tested (g)	869
M 20-2 mm, washed and dried (g)	412,77
M 20-2 mm, washed and dried total (g)	412,77
M > 2 mm, washed and dried (g)	2368,13
M < 2 mm, dried tested (g)	150,93
M < 2 dried tested (g)	150,18
M < 2 mm, dried total (g)	453,60
Total dried sample (g)	2821,73

Hygroscopic moisture (fraction <2mm)	0,5
Correction parameter (f)	1,00
Correction parameter (f1)	1,00
Correction parameter (f2)	3,02

SOIL TYPE ACCORDING TO ISO 14688

% GRAVEL > 2 mm		83,92	% SAND 2 - 0,063 mm	4,90	% FINES < 0,063 mm
% COBBLES > 63 mm	% Coarse gravel (63 - 20 mm)	69,30	% Coarse sand (2 - 0,63 mm)	1,67	
0,00	% Medium gravel(20 - 6,3 mm)	10,50	% Medium sand (0,63 - 0,2 mm)	0,45	11,11
	% Fine gravel (6,3 - 2 mm)	4,12	% Fine sand (0,2 - 0,08 mm)	2,78	



Observations:

Analyst: E.T.

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS - UNE 103103:94 - UNE 103104:93

Sample Ref

Project ID: 1827106 Date of the test: 19/03/2020

Location: Macao, Chile. **2020-176**

TP: 08 Depth: 1,3m

EQUIPMENT
Casagrande Apparatus Proeti
Balance KERN PCB
Oven SNOL 24/200

LIQUID LIMIT DATA

	Test 1	Test 2	Test 3
Number of drops	15	30	
Log (N)	1,18	1,48	
Tare name	10	20	
Tare mass (g)	22,38	22,24	
Tare + wet sample (g)	62,87	55,58	
Tare + dry sample (g)	54,53	49,36	
Wet mass (g)	40,49	33,34	
Dry mass (g)	32,15	27,12	
Water content	25,94	22,94	

LIQUID LIMIT: **23,7**

PLASTIC LIMIT DATA

	Test 1	Test 2	Test 3
Tare name	B3	B5	
Tare mass (g)	9,34	9,59	
Tare + wet sample (g)	14,06	14,36	
Tare + dry sample (g)	13,27	13,53	
Wet mass (g)	4,72	4,77	
Dry mass (g)	3,93	3,94	
Water content	20,10	21,07	
Number of individual tests	2	2	

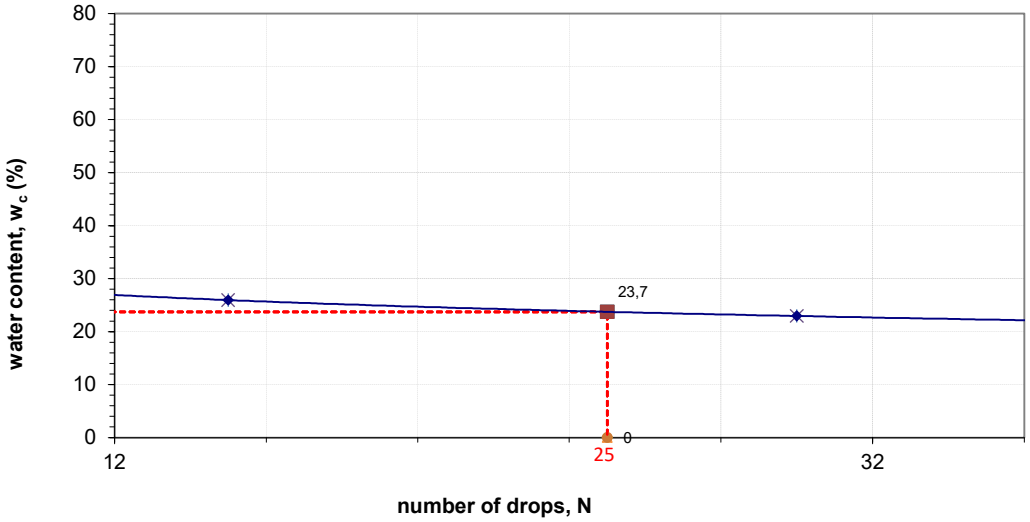
PLASTIC LIMIT: **20,6**

PLASTICITY INDEX: **3,1**

SUM OF RESULTS

LIQUID LIMIT, wL(%)	23,7
PLASTIC LIMIT, wP (%)	20,6
PLASTICITY INDEX, iP(%)	3,1

Natural moisture content, w(%)	3,71
Liquidity index, IL	-5,37
Consistency index, IC	6,37



Observations:

Analyst: E.T.

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GENERAL DATA	Sample Ref
	2020-177

Project ID	1827106
Location	MACAO, CHILE.
Trial Pit	9
Depth	0,90m
Sample type	Plastic bag
Sample condition	Disturbed
Sampling date	28/02/2020
Testing date	20/03/2020
Sample description according to EN ISO criteria	Orangish brown gravely sandy SILT.

Soil type	USCS classification	ML
	USCS group lithology	Sandy SILT of low plasticity
	AASHTO classification	A-4

TEST PERFORMED

Determination of moisture content - UNE 103300:93

Determination of density

Determination of partilce size distribution (sieving method) - UNE 103101:95

Liquid limit, plastic limit and plasticity index of soil - UNE 103103:94 - UNE 103104:93

REMARKS

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DETERMINATION OF MOISTURE CONTENT - UNE 103300:93

Sample Ref

Project ID: 1827106 Date of the test: 20/03/2020
Location: Macao, Chile.
TP: 09 Depth: 0,90m

2020-177

EQUIPMENT
Balance KERN PCB
Oven SNOL 24/200

Data of soil moisture content	
Container ref	D2
Mass of Container + Wet Sample (g)	257,11
Mass of Container + Dry Sample (g)	233,17
Water (g)	23,94
Soil (g)	144,67
Moisture Content %	16,55

Observations: Analyst: D.B.

DETERMINATION OF DENSITY

Sample Ref

2020-177

Bulk density data	
Internal diameter (mm)	33
Thickness of steel (mm)	4
Length (mm)	33
Mass of tube & sample (g)	504,71
Internal volume (mm3)	60726,20
Mass of Tube (g)	428,68

EQUIPMENT
Balance KERN PCB

Sample Dimensions	
Specimen volume (m3)	6,073E-05
Mass (Kg)	0,076
Specimen length (mm)	71

Results	
Bulk density (g/cm3)	1,252
Dry density (g/cm3)	1,074
Bulk density (kN/m3)	12,271
Dry density (kN/m3)	10,529

Observations: Analyst: D.B.

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PARTICLE-SIZE ANALYSIS OF SOIL - UNE 103101:95

Sample Ref

2020-177

Project ID: 1827106 Date of the test: 20/03/2020

Location: Macao, Chile.

TP: 09 Depth: 0,90m

EQUIPMENT
Standard sieve series Labopolis
Balance KERN PCB
Oven SNOL 24/200

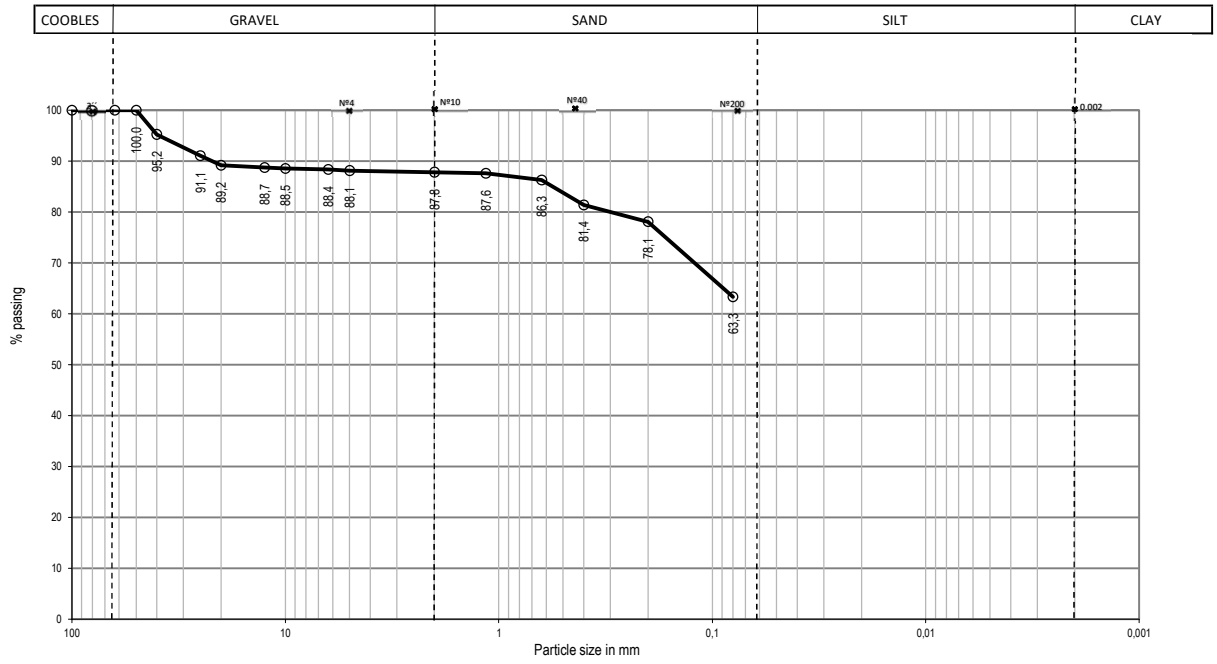
Sieves			Retained		Passing total sample	
ASTM		UNE mm				
Desig.	mm		Partial (g)	Total (g)	Total (g)	Percentage
4"	101,6	100	0	0	1196,8	100,00
3"	76,2	80	0	0	1196,8	100,00
2,5"	63,5	63	0	0	1196,8	100,00
2"	50,8	50	0	0	1196,8	100,00
1,5"	38,1	40	56,96	56,96	1139,9	95,24
1"	25,4	25	49,72	49,72	1090,2	91,09
3/4"	19,1	20	22,64	22,64	1067,5	89,19
1/2"	12,7	12,5	5,39	5,39	1062,1	88,74
3/8"	9,52	10	2,38	2,38	1059,8	88,55
1/4"	6,35	6,3	2,31	2,31	1057,4	88,35
Nº4	4,75	5	2,70	2,70	1054,7	88,13
Nº10	2	2	3,78	3,78	1051,0	87,81
Nº16	1,18	1,15	0,40	2,78	1048,2	87,58
Nº30	0,6	0,63	2,20	15,28	1032,9	86,30
Nº40	0,42	0,4	8,46	58,74	974,2	81,40
Nº70	0,21	0,2	5,68	39,44	934,7	78,10
Nº200	0,074	0,08	25,47	176,84	757,9	63,32
		Pan	0,07	0,49	757,4	63,28

Previous calculations	
Total dried sample (g)	1200
M > 20 mm,washed and dried total (g)	129
M < 20 mm, dried tested (g)	1071
M 20-2 mm, washed and dried (g)	16,56
M 20-2 mm, washed and dried total (g)	16,56
M > 2 mm, washed and dried (g)	145,88
M < 2 mm, dried tested (g)	151,82
M < 2 dried tested (g)	151,37
M < 2 mm, dried total (g)	1050,97
Total dried sample (g)	1196,85

Hygroscopic moisture (fraction <2mm)	0,3
Correction parameter (f)	1,00
Correction parameter (f1)	1,00
Correction parameter (f2)	1,00

SOIL TYPE ACCORDING TO ISO 14688

% GRAVEL > 2 mm		12,19	% SAND 2 - 0,063 mm	24,49	% FINES < 0,063 mm
% COBBLES > 63 mm	% Coarse gravel (63 - 20 mm)	10,81	% Coarse sand (2 - 0,63 mm)	1,51	63,28
0,00	% Medium gravel(20 - 6,3 mm)	0,84	% Medium sand (0,63 - 0,2 mm)	8,20	
	% Fine gravel (6,3 - 2 mm)	0,54	% Fine sand (0,2 - 0,08 mm)	14,78	



Observations:

Analyst: E.T.

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS - UNE 103103:94 - UNE 103104:93

Sample Ref

Project ID: 1827106 Date of the test: 20/03/2020

Location: Macao, Chile. **2020-177**

TP: 09 Depth: 0,90m

EQUIPMENT
Casagrande Apparatus Proeti
Balance KERN PCB
Oven SNOL 24/200

LIQUID LIMIT DATA

	Test 1	Test 2	Test 3
Number of drops	15	26	
Log (N)	1,18	1,41	
Tare name	C	D	
Tare mass (g)	18,92	19,55	
Tare + wet sample (g)	59,15	57,88	
Tare + dry sample (g)	49,67	50,35	
Wet mass (g)	40,23	38,33	
Dry mass (g)	30,75	30,80	
Water content	30,83	24,45	

LIQUID LIMIT: **24,9**

PLASTIC LIMIT DATA

	Test 1	Test 2	Test 3
Tare name	G	F2	
Tare mass (g)	25,01	26,34	
Tare + wet sample (g)	35,18	36,11	
Tare + dry sample (g)	33,28	34,29	
Wet mass (g)	10,17	9,77	
Dry mass (g)	8,27	7,95	
Water content	22,97	22,89	
Number of individual tests	2	2	

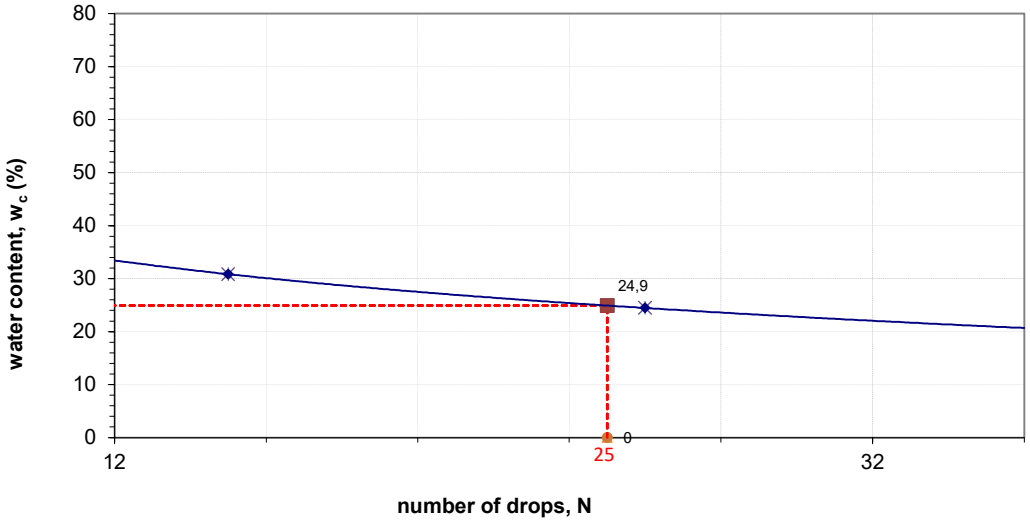
PLASTIC LIMIT: **22,9**

PLASTICITY INDEX: **2,0**

SUM OF RESULTS

LIQUID LIMIT, wL(%)	24,9
PLASTIC LIMIT, wP (%)	22,9
PLASTICITY INDEX, iP(%)	2,0

Natural moisture content, w(%)	16,55
Liquidity index, IL	-3,24
Consistency index, IC	4,24



Observations:

Analyst: E.T.

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GENERAL DATA	Sample Ref
	2020-178

Project ID	1827106
Location	MACAO, CHILE.
Trial Pit	10
Depth	0,80m
Sample type	Plastic bag
Sample condition	Disturbed
Sampling date	28/02/2020
Testing date	20/03/2020
Sample description according to EN ISO criteria	Orangish brown sandy clayey SILT.

Soil type	USCS classification	ML
	USCS group lithology	Sandy SILT of low plasticity
	AASHTO classification	A-4

TEST PERFORMED

Determination of moisture content - UNE 103300:93

Determination of density - UNE 103301:94

Determination of partilce size distribution (sieving method) - UNE 103101:95

Liquid limit, plastic limit and plasticity index of soil - UNE 103103:94 - UNE 103104:93

REMARKS

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DETERMINATION OF MOISTURE CONTENT - UNE 103300:93

Sample Ref

Project ID: 1827106 Date of the test: 20/03/2020
Location: Macao, Chile.
TP: 10 Depth: 0,8m

2020-178

EQUIPMENT
Balance KERN PCB
Oven SNOL 24/200

Data of soil moisture content	
Container ref	D1
Mass of Container + Wet Sample (g)	258,44
Mass of Container + Dry Sample (g)	235,91
Water (g)	22,53
Soil (g)	145,57
Moisture Content %	15,48

Observations: Analyst: D.B.

DETERMINATION OF DENSITY - UNE 103301:94

Sample Ref

Bulk density data

Soil (g)	53,52	Soil volume (cm3)	27,92
Soil + parafin wax (g)	55,12	Bulk density (g/cm3)	1,917
Parafin wax (g)	1,60	Dry density (g/cm3)	1,564
Weight in water (g)	25,40		
Paraffin wax volume (cm3)	1,80		
Soil + paraffin wax volume (cm3)	29,72		

Paraffin wax density=0,89Tn/m3

2020-178

EQUIPMENT
Balance KERN PCB

Results	
Bulk density (g/cm3)	1,917
Dry density (g/cm3)	1,564
Bulk density (kN/m3)	18,784
Dry density (kN/m3)	15,330

Observations: Analyst: D.B.

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PARTICLE-SIZE ANALYSIS OF SOIL - UNE 103101:95

Sample Ref

2020-178

Project ID: 1827106 Date of the test: 20/03/2020

Location: Macao, Chile.

TP: 10 Depth: 0,8m

EQUIPMENT
Standard sieve series Labopolis
Balance KERN PCB
Oven SNOL 24/200

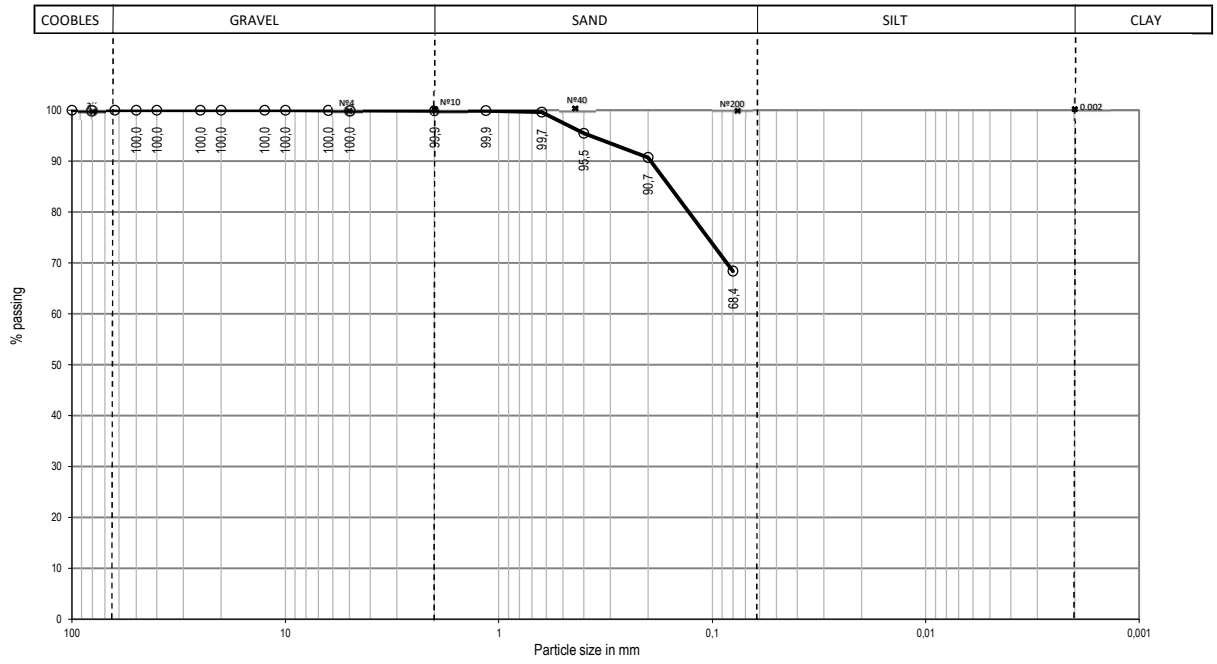
Sieves			Retained		Passing total sample	
ASTM		UNE mm				
Desig.	mm		Partial (g)	Total (g)	Total (g)	Percentage
4"	101,6	100	0	0	1004,1	100,00
3"	76,2	80	0	0	1004,1	100,00
2,5"	63,5	63	0	0	1004,1	100,00
2"	50,8	50	0	0	1004,1	100,00
1,5"	38,1	40	0	0	1004,1	100,00
1"	25,4	25	0	0	1004,1	100,00
3/4"	19,1	20	0	0	1004,1	100,00
1/2"	12,7	12,5	0	0	1004,1	100,00
3/8"	9,52	10	0	0	1004,1	100,00
1/4"	6,35	6,3	0,33	0,33	1003,8	99,97
Nº4	4,75	5	0,11	0,11	1003,7	99,96
Nº10	2	2	0,31	0,31	1003,3	99,93
Nº16	1,18	1,15	0,04	0,26	1003,1	99,90
Nº30	0,6	0,63	0,37	2,41	1000,7	99,66
Nº40	0,42	0,4	6,46	42,16	958,5	95,46
Nº70	0,21	0,2	7,31	47,71	910,8	90,71
Nº200	0,074	0,08	34,36	224,26	686,5	68,37
		Pan	0,16	1,04	685,5	68,27

Previous calculations	
Total dried sample (g)	1006
M > 20 mm,washed and dried total (g)	0
M < 20 mm, dried tested (g)	1006
M 20-2 mm, washed and dried (g)	0,75
M 20-2 mm, washed and dried total (g)	0,75
M > 2 mm, washed and dried (g)	0,75
M < 2 mm, dried tested (g)	154,02
M < 2 dried tested (g)	153,73
M < 2 mm, dried total (g)	1003,34
Total dried sample (g)	1004,09

Hygroscopic moisture (fraction <2mm)	0,2
Correction parameter (f)	1,00
Correction parameter (f1)	1,00
Correction parameter (f2)	6,53

SOIL TYPE ACCORDING TO ISO 14688

% GRAVEL > 2 mm		0,07	% SAND 2 - 0,063 mm	31,55	% FINES < 0,063 mm
% COBBLES > 63 mm	% Coarse gravel (63 - 20 mm)	0,00	% Coarse sand (2 - 0,63 mm)	0,27	68,27
0,00	% Medium gravel(20 - 6,3 mm)	0,03	% Medium sand (0,63 - 0,2 mm)	8,95	
	% Fine gravel (6,3 - 2 mm)	0,04	% Fine sand (0,2 - 0,08 mm)	22,33	



Observations:

Analyst: E.T.

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS - UNE 103103:94 - UNE 103104:93

Sample Ref

Project ID: 1827106 Date of the test: 20/03/2020

Location: Macao, Chile. **2020-178**

TP: 10 Depth: 0,8m

EQUIPMENT
Casagrande Apparatus Proeti
Balance KERN PCB
Oven SNOL 24/200

LIQUID LIMIT DATA

	Test 1	Test 2	Test 3
Number of drops	21	27	
Log (N)	1,32	1,43	
Tare name	10	20	
Tare mass (g)	22,39	22,22	
Tare + wet sample (g)	53,77	57,00	
Tare + dry sample (g)	47,34	50,22	
Wet mass (g)	31,38	34,78	
Dry mass (g)	24,95	28,00	
Water content	25,77	24,21	

LIQUID LIMIT: **24,7**

PLASTIC LIMIT DATA

	Test 1	Test 2	Test 3
Tare name	B3	B5	
Tare mass (g)	9,32	9,49	
Tare + wet sample (g)	15,62	16,60	
Tare + dry sample (g)	14,50	15,35	
Wet mass (g)	6,30	7,11	
Dry mass (g)	5,18	5,86	
Water content	21,62	21,33	
Number of individual tests	2	2	

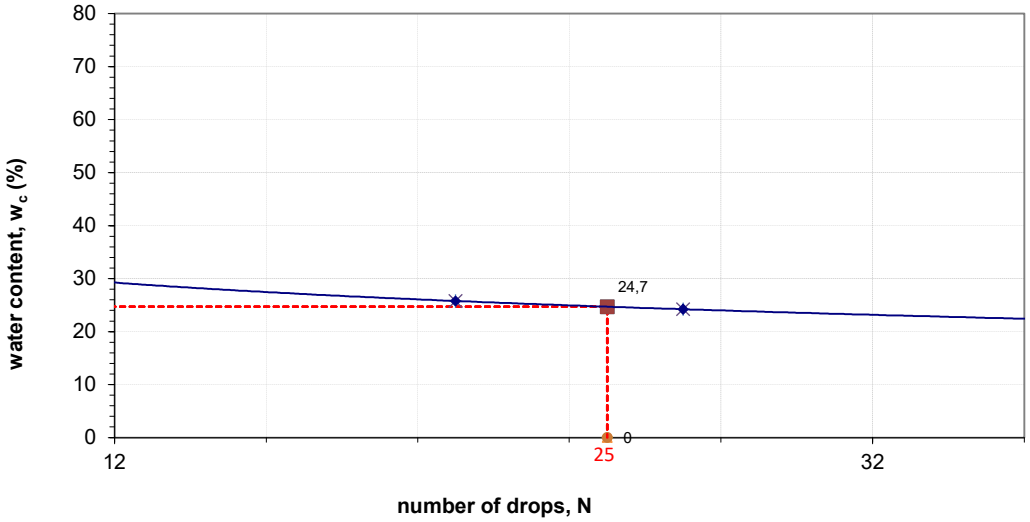
PLASTIC LIMIT: **21,5**

PLASTICITY INDEX: **3,2**

SUM OF RESULTS

LIQUID LIMIT, wL(%)	24,7
PLASTIC LIMIT, wP (%)	21,5
PLASTICITY INDEX, iP(%)	3,2

Natural moisture content, w(%)	15,48
Liquidity index, IL	-1,87
Consistency index, IC	2,87



Observations:

Analyst: E.T.

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GENERAL DATA	Sample Ref
	2020-179

Project ID	1827106
Location	MACAO, CHILE.
Trial Pit	11
Depth	0,90m
Sample type	Plastic bag
Sample condition	Disturbed
Sampling date	29/02/2020
Testing date	20/03/2020
Sample description according to EN ISO criteria	Dark brown sandy CLAY.

Soil type	USCS classification	CL
	USCS group lithology	Sandy CLAY of medium plasticity
	AASHTO classification	A-6

TEST PERFORMED

Determination of moisture content - UNE 103300:93

Determination of density - UNE 103301:94

Determination of partilce size distribution (sieving method) - UNE 103101:95

Liquid limit, plastic limit and plasticity index of soil - UNE 103103:94 - UNE 103104:93

REMARKS

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DETERMINATION OF MOISTURE CONTENT - UNE 103300:93

Sample Ref

Project ID: 1827106 Date of the test: 20/03/2020
Location: Macao, Chile.
TP: 11 Depth: 0,90m

2020-179

EQUIPMENT
Balance KERN PCB
Oven SNOL 24/200

Data of soil moisture content	
Container ref	D3
Mass of Container + Wet Sample (g)	234,83
Mass of Container + Dry Sample (g)	209,37
Water (g)	25,46
Soil (g)	121,02
Moisture Content %	21,04

Observations: Analyst: D.B.

DETERMINATION OF DENSITY - UNE 103301:94

Sample Ref

Bulk density data

Soil (g)	110,57	Soil volume (cm3)	54,68
Soil + parafin wax (g)	112,32	Bulk density (g/cm3)	2,022
Parafin wax (g)	1,75	Dry density (g/cm3)	1,612
Weight in water (g)	55,67		
Paraffin wax volume (cm3)	1,97		
Soil + paraffin wax volume (cm3)	56,65		

Paraffin wax density=0,89Tn/m3

2020-179

EQUIPMENT
Balance KERN PCB

Results	
Bulk density (g/cm3)	2,022
Dry density (g/cm3)	1,612
Bulk density (kN/m3)	19,816
Dry density (kN/m3)	15,794

Observations: Analyst: D.B.

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PARTICLE-SIZE ANALYSIS OF SOIL - UNE 103101:95

Sample Ref

2020-179

Project ID: 1827106 Date of the test: 20/03/2020

Location: Macao, Chile.

TP: 11 Depth: 0,90m

EQUIPMENT
Standard sieve series Labopolis
Balance KERN PCB
Oven SNOL 24/200

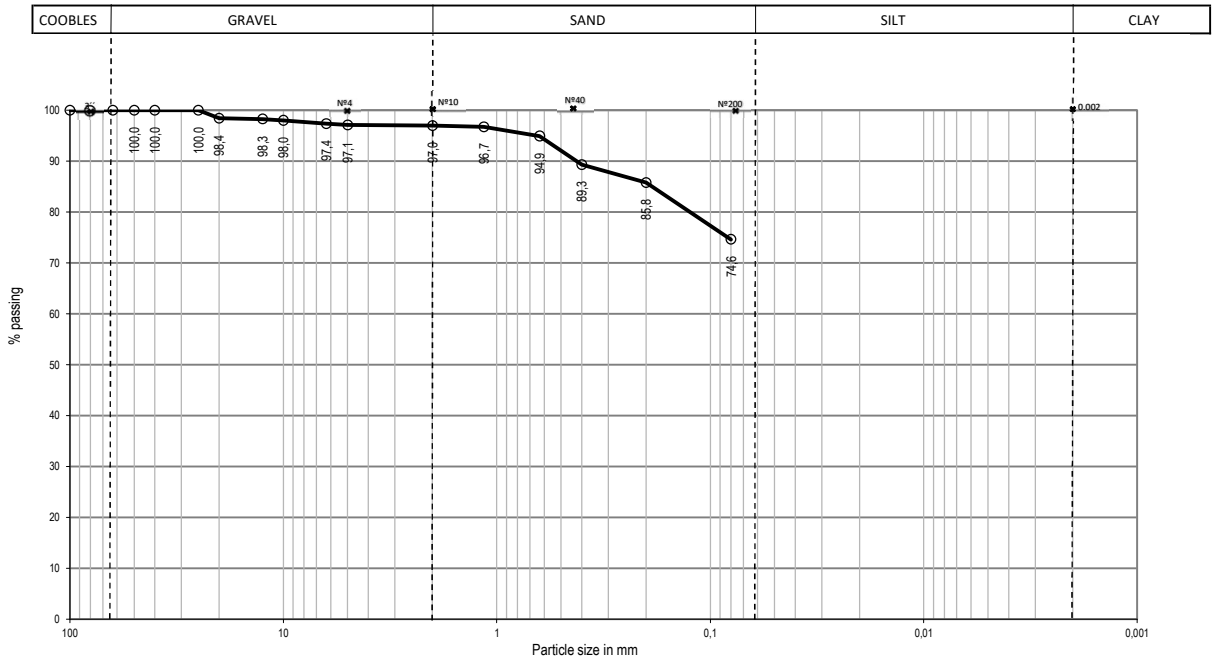
Sieves			Retained		Passing total sample	
ASTM		UNE mm				
Desig.	mm		Partial (g)	Total (g)	Total (g)	Percentage
4"	101,6	100	0	0	866,3	100,00
3"	76,2	80	0	0	866,3	100,00
2,5"	63,5	63	0	0	866,3	100,00
2"	50,8	50	0	0	866,3	100,00
1,5"	38,1	40	0	0	866,3	100,00
1"	25,4	25	0	0	866,3	100,00
3/4"	19,1	20	13,85	13,85	852,5	98,40
1/2"	12,7	12,5	1,11	1,11	851,4	98,27
3/8"	9,52	10	2,30	2,30	849,1	98,01
1/4"	6,35	6,3	5,60	5,60	843,5	97,36
Nº4	4,75	5	2,32	2,32	841,1	97,09
Nº10	2	2	1,08	1,08	840,1	96,97
Nº16	1,18	1,15	0,37	2,05	838,0	96,73
Nº30	0,6	0,63	2,82	15,64	822,4	94,93
Nº40	0,42	0,4	8,77	48,63	773,7	89,31
Nº70	0,21	0,2	5,50	30,50	743,2	85,79
Nº200	0,074	0,08	17,46	96,82	646,4	74,62
		Pan	0,01	0,06	646,4	74,61

Previous calculations	
Total dried sample (g)	868
M > 20 mm,washed and dried total (g)	14
M < 20 mm, dried tested (g)	854
M 20-2 mm, washed and dried (g)	12,41
M 20-2 mm, washed and dried total (g)	12,41
M > 2 mm, washed and dried (g)	26,26
M < 2 mm, dried tested (g)	151,80
M < 2 dried tested (g)	151,50
M < 2 mm, dried total (g)	840,06
Total dried sample (g)	866,32

Hygroscopic moisture (fraction <2mm)	0,2
Correction parameter (f)	1,00
Correction parameter (f1)	1,00
Correction parameter (f2)	5,55

SOIL TYPE ACCORDING TO ISO 14688

% GRAVEL > 2 mm		3,03	% SAND 2 - 0,063 mm	22,35	% FINES < 0,063 mm
% COBBLES > 63 mm	% Coarse gravel (63 - 20 mm)	1,60	% Coarse sand (2 - 0,63 mm)	2,04	74,61
0,00	% Medium gravel(20 - 6,3 mm)	1,04	% Medium sand (0,63 - 0,2 mm)	9,13	
	% Fine gravel (6,3 - 2 mm)	0,39	% Fine sand (0,2 - 0,08 mm)	11,18	



Observations:

Analyst: E.T.

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS - UNE 103103:94 - UNE 103104:93

Sample Ref

Project ID: 1827106 Date of the test: 20/03/2020

Location: Macao, Chile. **2020-179**

TP: 11 Depth: 0,90m

EQUIPMENT
Casagrande Apparatus Proeti
Balance KERN PCB
Oven SNOL 24/200

LIQUID LIMIT DATA

	Test 1	Test 2	Test 3
Number of drops	16	31	
Log (N)	1,20	1,49	
Tare name	1	8	
Tare mass (g)	21,98	21,97	
Tare + wet sample (g)	63,22	61,14	
Tare + dry sample (g)	52,03	50,98	
Wet mass (g)	41,24	39,17	
Dry mass (g)	30,05	29,01	
Water content	37,24	35,02	

LIQUID LIMIT: **35,7**

PLASTIC LIMIT DATA

	Test 1	Test 2	Test 3
Tare name	B1	B2	
Tare mass (g)	9,35	9,35	
Tare + wet sample (g)	16,24	13,64	
Tare + dry sample (g)	14,97	12,83	
Wet mass (g)	6,89	4,29	
Dry mass (g)	5,62	3,48	
Water content	22,61	23,28	
Number of individual tests	2	2	

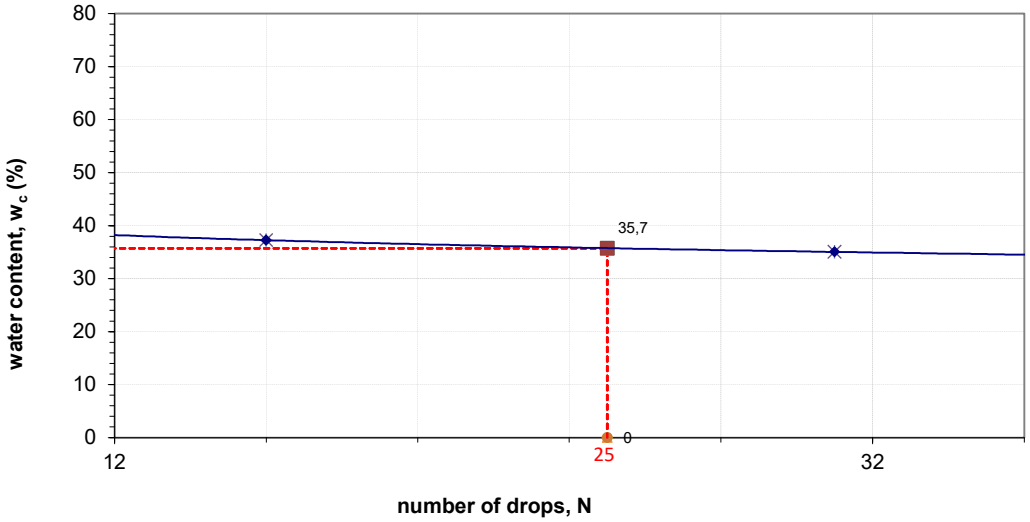
PLASTIC LIMIT: **22,9**

PLASTICITY INDEX: **12,8**

SUM OF RESULTS

LIQUID LIMIT, wL(%)	35,7
PLASTIC LIMIT, wP (%)	22,9
PLASTICITY INDEX, iP(%)	12,8

Natural moisture content, w(%)	21,04
Liquidity index, IL	-0,15
Consistency index, IC	1,15



Observations:

Analyst: E.T.

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DETERMINATION OF PH IN SOILS - BS 1377-1:1990 cl9

Sample Ref

Project ID: 1827106 Date of the test: 18/03/2020

Location: Macao, Chile.

TP: 01 Depth: 2,80m

2020-180

EQUIPMENT

Balance KERN PCB
PH-METER PCE-228

Analyzed soil mass (g): 35,30g

Measures	PH values	Temperature ºC
1	8,19	20,1
2	8,20	20,1
3	8,21	20,1
4	8,20	20,1
5	8,20	20,1
RESULT	8,20	

DETERMINATION OF PH IN SOILS - BS 1377-1:1990 cl9

Sample Ref

Project ID: 1827106 Date of the test: 18/03/2020

Location: Macao, Chile.

TP: 12 Depth: 2,50m

2020-181

EQUIPMENT

Balance KERN PCB
PH-METER PCE-228

Analyzed soil mass (g): 35,56g

Measures	PH values	Temperature ºC
1	7,81	20,1
2	7,80	20,1
3	7,79	20,1
4	7,81	20,1
5	7,80	20,1
RESULT	7,80	

Observations:

Analyst: E.T.

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GEOTECNIA I CONTROL DE QUALITAT S.A.

CLIENT:

Company: GMS INTERNACIONAL SL
Address: C. SAGRERA, 99 BAIXOS. 08027-BARCELONA

Mr./Mrs.: DANIEL BAANANTE

PROJECT:

IG1827106 MACAO. CHILE

Number of laboratory test report

2020-3524-03338

Samples: Sent by the client
Materials tested: Soils
Date first reception: 18-03-20
Date last reception:

SUMMARY OF WORKS:

- SAMPLES Nº	2
- CHEMICAL ANALYSIS - Chlorides soils	2
- SOIL CHEMICAL ANALYSIS - Sulphates	2
- SOIL CHEMICAL ANALYSIS - Organic matter	2
- SOIL CHEMICAL ANALYSIS - Soluble salts	2

DOCUMENT CONTROL:

Version	Date	Pages	Modifications	Written by	Checked by	Approved by
1	24-03-20	8		FRANCESC GARCÍA FERNÁNDEZ	FRANCESC GARCÍA FERNÁNDEZ	FRANCESC GARCÍA FERNÁNDEZ

Validation date: 24-03-20

GEOTECHNICAL LABORATORY MANAGER

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FRANCESC GARCÍA FERNÁNDEZ
Geologist
COLLEGIATE ICOG 1885

GEOTECNIA I CONTROL DE QUALITAT S.A.

SUMMARY OF TESTS

GMS INTERNACIONAL SL
IG1827106 MACAO. CHILE

2020-3524-03338

SAMPLES Nº	2020-2262	2020-2263
Situation	TP01	TP12
Sample type	BAG	BAG
Depth (m)	-	-
CHEMICAL ANALYSIS		
Chlorides soils (mg/kg)	20.8	19.8
SOIL CHEMICAL ANALYSIS		
Sulphates (% SO4)	0.0367	0.0383
Sulphates (% SO3)	0.0305	0.0319
Sulphates (mg/kg SO4)	366.61	383.14
Sulphates (mg/kg SO3)	305.50	319.28
Organic matter (%)	0.1	0.1
Soluble salts (%)	0.17	0.12

Aproved:
Francesc García Fernández
Geotechnical Laboratory Manager

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GEOTECNIA I CONTROL DE QUALITAT S.A.

Report number:	2020-3524-03338
Edition date:	24-03-20

LOCATION: TP01 BAG

OPENING AND DESCRIPTION OF THE SAMPLE IN LABORATORY - IT-300

Sample reference **2020-2262**

Code: CC-OL-RA-0001 Rv.00

General data

Petitioner	
Client	GMS INTERNACIONAL SL
Project	IG1827106 MACAO. CHILE

Sample data

Client reference	
Situation	TP01
Top depth, m	
Bottom depth, m	
Sample type	BAG
Diameter, cm	
Length, cm	
Acquisition date	
Reception date	18-3-20

Opening and preparation data

Opening date	19-3-20
Analyst	FRANCESC GARCÍA
Type of opening	MANUAL
Storage	LABORATORY
Environment test	GEOTECHNICAL LAB.

Soil type

USCS classification	
AASHTO classification	

Sample description

Lithological description according to the subjective criterion of the analyst who opens	Depth m	Observations P-Penetrometer V-Vane-Test (kPa)
GRAVEL WITH SOME SAND DARK BROWN COLOUR		

NOTE: The soil is described primarily by its main majority fraction. For secondary fractions the following terms are used: Less than 5% is not indicated. From 5% to 10%, SIGNS. From 10% to 20%, SOME. From 20% to 35%, ENOUGH. More than 35%, Y/EY termination.

TESTS CARRIED OUT

DETERMINATION OF CHLORIDES IN SOIL - STANDARD METHOD
QUANTITATIVE DETERMINATION OF SOLUBLE SULPHATE CONTENT OF A SOIL - UNE 103201/96
OXIDIZABLE ORGANIC MATTER CONTENT. POTASIUM PERMANGANATE METHOD - UNE 103204/93+ERR
SOIL SOLUBLE SALTS CONTENT - NLT-114/99

Aproved:
Francesc García Fernández
Geotechnical Laboratory Manager

REMARKS

COLLAPSE AND SWELLING TEST HAS NOT BEEN POSSIBLE: DISAGREGATED SAMPLE

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GEOTECNIA I CONTROL DE QUALITAT S.A.

Report number:	2020-3524-03338
Edition date:	24-03-20

LOCATION: TP01 BAG

Sample reference **2020-2262**

SOIL CHEMICAL ANALYSIS

* QUANTITATIVE DETERMINATION OF SOLUBLE SULPHATE CONTENT OF A SOIL - UNE 103201/96

Analyst: RUBÈN ROMERO — Test final date: 20-03-20

Analyzed soil mass: 10.0087 g

RESULT: **0.0367 % SO4**
0.0305 % SO3
366.61 mg/kg SO4
305.5 mg/kg SO3

Equipment:
MUFLA OVEN DINKO D-61 D AND PROETI AGITATOR
BALANCE GRAM 0.0001G

* OXIDIZABLE ORGANIC MATTER CONTENT. POTASIUM PERMANGANATE METHOD - UNE 103204/93+ERR

Analyst: RUBÈN ROMERO — Test final date: 23-03-20

Analyzed soil mass: 0.2131 g

RESULT: **0.1 %**

Equipment:
GLASS MATERIAL
BALANCE GRAM 0.0001G

* SOIL SOLUBLE SALTS CONTENT - NLT-114/99

Analyst: RUBÈN ROMERO — Test final date: 23-03-20

Analyzed soil mass: 50.0063 g

RESULT: **0.17 % fraction < 2 mm**
0.17 % total sample
% other than gypsum

Equipment:
GLASS MATERIAL AND PROETI AGITATOR
BALANCE GRAM 0.0001G

Aproved:
Francesc García Fernández
Geotechnical Laboratory Manager

REMARKS

GEOTÈCNIA I CONTROL DE QUALITAT S.A.
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GEOTECNIA I CONTROL DE QUALITAT S.A.

Report number:	2020-3524-03338
Edition date:	24-03-20

LOCATION: TP01 BAG

Sample reference **2020-2262**

CHEMICAL ANALYSIS

* DETERMINATION OF CHLORIDES IN SOIL - STANDARD METHOD

Analyst: RUBÈN ROMERO

Test final date: 23-03-20

Sample mass analyzed: 5.0013 g

RESULT: **20.8 mg/kg**

Equipment:
PHOTO ANALIZER DINKO INSTRUMENT D-105
BALANCE DENVER INSTRUMENT APX-200

Aproved:
Francesc García Fernández
Geotechnical Laboratory Manager

REMARKS

GEOTÈCNIA I CONTROL DE QUALITAT S.A.
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GEOTECNIA I CONTROL DE QUALITAT S.A.

Report number:	2020-3524-03338
Edition date:	24-03-20

LOCATION: TP12 BAG

OPENING AND DESCRIPTION OF THE SAMPLE IN LABORATORY - IT-300

Sample reference **2020-2263**

Code: CC-OL-RA-0001 Rv.00

General data

Petitioner	
Client	GMS INTERNACIONAL SL
Project	IG1827106 MACAO. CHILE

Sample data

Client reference	
Situation	TP12
Top depth, m	
Bottom depth, m	
Sample type	BAG
Diameter, cm	
Length, cm	
Acquisition date	
Reception date	18-3-20

Opening and preparation data

Opening date	19-3-20
Analyst	FRANCESC GARCÍA
Type of opening	MANUAL
Storage	LABORATORY
Environment test	GEOTECHNICAL LAB.

Soil type

USCS classification	
AASHTO classification	

Sample description

Lithological description according to the subjective criterion of the analyst who opens	Depth m	Observations P-Penetrometer V-Vane-Test (kPa)
GRAVEL WITH SOME SAND DARK BROWN COLOUR		

NOTE: The soil is described primarily by its main majority fraction. For secondary fractions the following terms are used: Less than 5% is not indicated. From 5% to 10%, SIGNS. From 10% to 20%, SOME. From 20% to 35%, ENOUGH. More than 35%, Y/EY termination.

TESTS CARRIED OUT

DETERMINATION OF CHLORIDES IN SOIL - STANDARD METHOD
QUANTITATIVE DETERMINATION OF SOLUBLE SULPHATE CONTENT OF A SOIL - UNE 103201/96
OXIDIZABLE ORGANIC MATTER CONTENT. POTASIUM PERMANGANATE METHOD - UNE 103204/93+ERR
SOIL SOLUBLE SALTS CONTENT - NLT-114/99

Aproved:
Francesc García Fernández
Geotechnical Laboratory Manager

REMARKS

COLLAPSE AND SWELLING TEST HAS NOT BEEN POSSIBLE: DISAGREGATED SAMPLE

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GEOTECNIA I CONTROL DE QUALITAT S.A.

Report number:	2020-3524-03338
Edition date:	24-03-20

LOCATION: TP12 BAG

Sample reference **2020-2263**

SOIL CHEMICAL ANALYSIS

* QUANTITATIVE DETERMINATION OF SOLUBLE SULPHATE CONTENT OF A SOIL - UNE 103201/96

Analyst: RUBÈN ROMERO

Test final date: 20-03-20

Analyzed soil mass: 10.009 g

RESULT: **0.0383 % SO4**
0.0319 % SO3
383.14 mg/kg SO4
319.28 mg/kg SO3

Equipment:
MUFLA OVEN DINKO D-61 D AND PROETI AGITATOR
BALANCE GRAM 0.0001G

* OXIDIZABLE ORGANIC MATTER CONTENT. POTASIUM PERMANGANATE METHOD - UNE 103204/93+ERR

Analyst: RUBÈN ROMERO

Test final date: 23-03-20

Analyzed soil mass: 0.2215 g

RESULT: **0.1 %**

Equipment:
GLASS MATERIAL
BALANCE GRAM 0.0001G

* SOIL SOLUBLE SALTS CONTENT - NLT-114/99

Analyst: RUBÈN ROMERO

Test final date: 23-03-20

Analyzed soil mass: 50.0023 g

RESULT: **0.12 % fraction < 2 mm**
0.12 % total sample
% other than gypsum

Equipment:
GLASS MATERIAL AND PROETI AGITATOR
BALANCE GRAM 0.0001G

Aproved:
Francesc García Fernández
Geotechnical Laboratory Manager

REMARKS

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GEOTECNIA I CONTROL DE QUALITAT S.A.

Report number:	2020-3524-03338
Edition date:	24-03-20

LOCATION: TP12 BAG

Sample reference **2020-2263**

CHEMICAL ANALYSIS

* DETERMINATION OF CHLORIDES IN SOIL - STANDARD METHOD

Analyst: RUBÈN ROMERO

Test final date: 23-03-20

Sample mass analyzed: 5.0028 g

RESULT: **19.8 mg/kg**

Equipment:
PHOTO ANALIZER DINKO INSTRUMENT D-105
BALANCE DENVER INSTRUMENT APX-200

Aproved:
Francesc García Fernández
Geotechnical Laboratory Manager

REMARKS

PROYECTO FOTOVOLTAICO

MACAO

ESTUDIO DE RIESGO DE INUNDACIÓN

JULIO 2020

REVISIÓN					DETALLES DE REVISIÓN
Nº	POR	REV.	APR.	FECHA	
B	HSF	WWC	JB	30-07-2020	Emitido para el Cliente
A	HSF	WWC	WWC	12-07-2020	Revisión Interna

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1 INTRODUCCIÓN

1.1 Introducción General

El presente informe fue solicitado por Julie Baudry, Technical Due Diligence Manager – Southern Cone (ISBU) de la empresa TrinaSolar. El estudio tiene por finalidad de determinar el riesgo de inundación del proyecto Fotovoltaico denominado Macao de una potencia 9 MW, ubicado en la comuna de Talagante, provincia de Talagante, región del Metropolitana de Santiago.

Para cumplir con lo anterior, se han desarrollado una serie de labores dentro de las que se encuentran:

- ✓ Descripción de las principales variables hidrometeorológicas.
- ✓ Revisión de planes reguladores.
- ✓ Visita a terreno.
- ✓ Revisión de imágenes satelitales históricas.
- ✓ Confección de informe.

A continuación, se presenta el detalle de las labores realizadas.

1.2 Ubicación Zona en Estudio

El proyecto Fotovoltaico Macao, se ubica en la comuna de Talagante, provincia de Talagante, región del Metropolitana de Santiago. Específicamente la zona del proyecto se aproximadamente a 5 km al sur oriente de la ciudad de Talagante. La ubicación general del Proyecto se observa en la Figura 1.

Figura 1. Mapa de ubicación Proyecto Fotovoltaico Macao.

Fuente: Google Earth

2 VARIABLES HIDROMETEOROLOGICAS

Con el fin de saber las principales variables hidrometeorológicas de la zona de estudio, se procedió a realizar una línea base en base a información bibliográfica, la que se presenta a continuación.

i. "Balance Hídrico de Chile". Ministerio de Obras Públicas (MOP). Dirección General de Aguas. 1988.

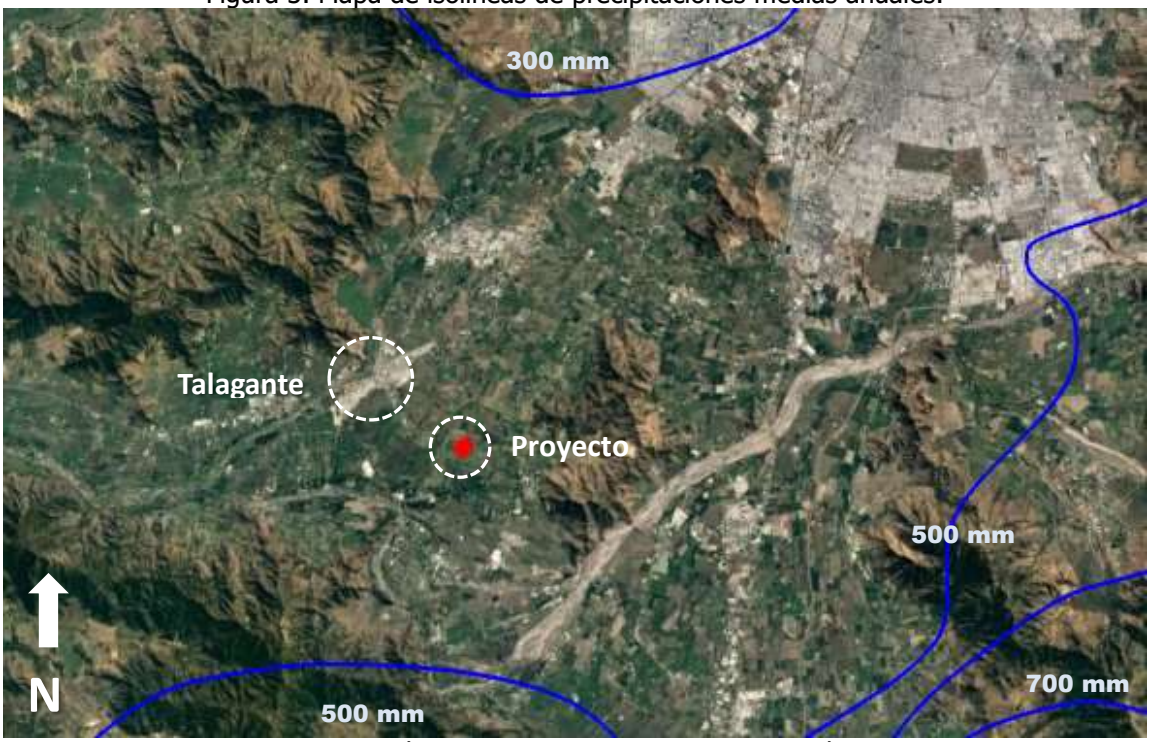
En el Balance Hídrico de Chile, se presenta un análisis a nivel nacional de las precipitaciones, temperatura, evaporación y otras variables hidrológicas. Específicamente para la zona de proyecto, en la Figura 2 se presentan las isolíneas o isoyetas de temperatura (color rojo). Si bien el mapa de isoyetas para la zona no es detallado, las temperaturas medias anuales esperadas en la zona de proyecto variarían en torno a 14°C.

Figura 2. Mapa de isolíneas de temperatura.

Fuente: Balance Hídrico de Chile. Base Google Earth. Elaboración propia.

En laFigura 3 , se presenta el mapa de isolíneas o isoyetas de precipitaciones medias anuales. El valor medio anual de las precipitaciones para la zona de proyecto se encuentra en torno a los 400 mm/año.

Figura 3. Mapa de isolíneas de precipitaciones medias anuales.



Fuente: Balance Hídrico de Chile. Base Google Earth. Elaboración propia.

ii. "Precipitaciones Máximas en 1, 2 y 3 días". Ministerio De Obras Públicas (MOP). Dirección General de Aguas (DGA). Santiago. Chile. 1987.

Las precipitaciones máximas en 24 horas en la zona de estudio, con un periodo de retorno de 10 años, se pueden observar en la Figura 4. Los valores estimados para la zona de proyecto son de 98 mm/día.

Figura 4. Mapa de precipitaciones máximas en 24 horas.

Fuente: Base Google Earth. Isoyetas del estudio "Precipitaciones Máxima del 1, 2 y 3 días"

En cuanto a las precipitaciones sólidas, en el Manual de Crecidas sin Información Fluviométrica, recomiendan para la zona del proyecto, considerar como base la cota de nieve determinada por Peña y Vidal. De acuerdo la ubicación del proyecto, latitud 33,7° la cota de nieve esperada estaría ubicada aproximadamente a los 1.835 m.s.n.m.

Tabla 1. Líneas de nieve promedio en zona de estudio.

Latitud (grados)		Peña - Vidal (*) (m.s.n.m)		Escobar - Vidal Promedio junio-Octubre (m.s.n.m.)	
27,5	VI Región al norte	2690	Area Pluvial y Nival		
28,0		2620			
28,5		2550			
29,0		2490			
29,5		2420			
30,0		2350			
30,5		2280			
31,0		2210			
31,5		2150			
32,0		2080			
32,5		2010			
33,0		1940			
33,5		1870			
34,0		1780			
34,5		1640			
35,0	VII Región al sur	1470	Area Nival	1980	Area Pluvial (**)
35,5		1300		1820	
36,0		1150		1680	
36,5		1000		1510	
37,0		920		1420	
37,5		880		1390	
38,0		850		1360	
38,5		800		1330	
39,0		770		1300	

Fuente: "Precipitaciones Máximas en 1, 2 y 3 días". DGA.

Dada que la altura máxima en la zona de estudio corresponde 350 m.s.n.m no se espera la presencia permanente de nieve en la zona.

iii. Explorador eólico Universidad de Chile.

De acuerdo con la información del explorador eólico de la Universidad de Chile, se tiene que la velocidad media diaria del viento a 5 metros de altura es de 1,6 ± 0,1 m/s alcanzando un máximo diario de 3,8 ± 0,2 m/s. El detalle de la variación del año se presenta en la

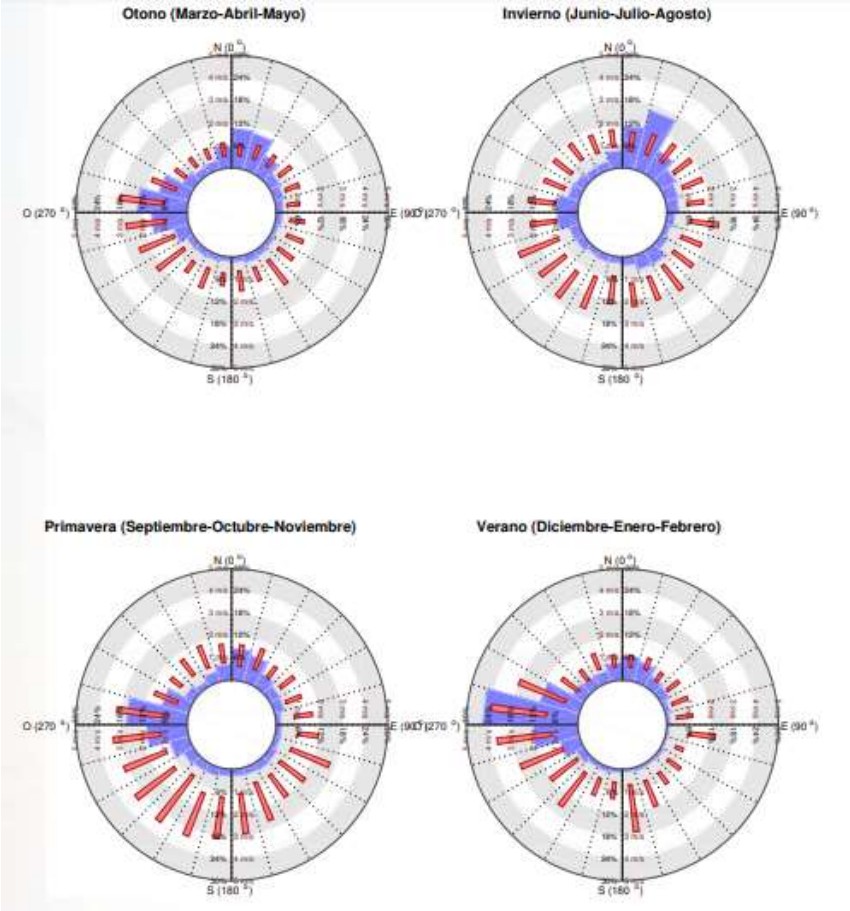
Tabla 2 y en la Figura 5 se presenta la rosa de los vientos según las diferentes temporadas.

Tabla 2. Estadística básica de la velocidad del viento. Promedio diario. Altura 5 m.

Mes	Medio Diario	Mínimo Diario	Máximo Diario	Variabilidad
	m/s	m/s	m/s	m/s
Enero	1.8 ± 0.3	0.3 ± 0.1	4.5 ± 0.8	0.3 ± 0.1
Febrero	1.8 ± 0.3	0.3 ± 0.0	4.2 ± 0.8	0.3 ± 0.1
Marzo	1.5 ± 0.3	0.3 ± 0.0	3.5 ± 0.6	0.3 ± 0.1
Abril	1.2 ± 0.2	0.2 ± 0.0	2.9 ± 0.5	0.2 ± 0.1
Mayo	1.3 ± 0.2	0.3 ± 0.0	2.9 ± 0.5	0.4 ± 0.1
Junio	1.8 ± 0.3	0.4 ± 0.1	3.7 ± 0.7	1.0 ± 0.4
Julio	1.6 ± 0.3	0.4 ± 0.1	3.6 ± 0.6	0.5 ± 0.2
Agosto	1.5 ± 0.3	0.3 ± 0.1	3.2 ± 0.6	0.4 ± 0.1
Septiembre	1.5 ± 0.3	0.3 ± 0.1	3.4 ± 0.6	0.4 ± 0.1
Octubre	1.9 ± 0.3	0.3 ± 0.1	4.5 ± 0.8	0.4 ± 0.2
Noviembre	1.7 ± 0.3	0.2 ± 0.0	4.3 ± 0.8	0.4 ± 0.2
Diciembre	1.9 ± 0.3	0.3 ± 0.1	4.4 ± 0.8	0.3 ± 0.1
TODOS	1.6 ± 0.1	0.3 ± 0.0	3.8 ± 0.2	0.5 ± 0.1

Fuente: Explorador Eólico Universidad de Chile.

Figura 5. Rosa de los vientos según estación del año. Zona de proyecto.



Fuente: Explorador eólico Universidad de Chile.

3 ANTECEDENTES DISPONIBLES

Los antecedentes disponibles utilizados para la realización del presente estudio de riesgo de inundación se presentan a continuación.

3.1 Bases de Datos

Se revisaron los planes mapas de planificación territorial:

- ✓ Zonificación planes reguladores comunales (PRC) Región del Metropolitana de Santiago, comuna de Talagante: el terreno del proyecto se encuentra fuera de la zona de planificación territorial de la comuna.
- ✓ Zonificación Plan Regulador Metropolitano de Santiago (PRMS): El proyecto se encuentra en un sector de riesgo de "Área de Riesgo de Origen Natural, Inundación Napas Freáticas". Además, se manifiesta que el proyecto se ubica en un sector de "Área de Interés Agropecuario Exclusivo", en donde se prohíbe el uso de suelo distinto a "Instalación de agroindustrias que procesen productos frescos".

Desde el punto de los sistemas de planificación territorial existentes en la Región del Metropolitana de Santiago, el proyecto se encuentra ubicado en una zona de "riesgo de origen natural, área de inundación y/o protección de cauces naturales y cuerpos de agua". En específico, el proyecto se encuentra en una zona considerada como inundable por napas freáticas. De acuerdo al Plano Regulador Metropolitano de Santiago (PRMS) en su artículo 8.2.1, a.2 acerca de napas freáticas, se tiene que:

"*La autorización de obras de urbanización y/o edificación en estas áreas, deberá condicionarse al cumplimiento de lo siguiente:*

- La napa freática no podrá tener una profundidad menor a 5 m en la época más desfavorable del año.
- La napa freática deberá estar a más de 3 m, bajo el sello de fundación.

Para verificar las condiciones señaladas en el inciso anterior, se deberán realizar sondajes y medir la profundidad del acuífero durante 3 días a lo menos. En caso de no cumplir tales condiciones en forma natural, la urbanización deberá considerar las obras de drenaje que resuelvan dicho aspecto."

En conjunto con lo anterior, se consultó la base de datos de la Dirección General de Aguas (DGA) y se identificó que el proyecto se ubica sobre el acuífero Maipo, en el sector hidrogeológicos de aprovechamiento común denominado El Monte Nuevo, el cual se encuentra sin sobre agotamiento, pero con restricción previsional de acuerdo a la resolución DGA N° 277 del 24-09-2008. Además, el sector tiene declaración de escasez hídrica de acuerdo al Decreto MOP N° 15 del 21-02-2020.

3.2 Visita a terreno

El día 11 de julio de 2020 se llevó a cabo la visita técnica a la zona de proyecto, donde se visitaron los principales puntos dentro de interés. En la Figura 6, en color magenta se presenta el recorrido realizado en terreno. Mientras que en rojo se marca el perímetro del proyecto.

Figura 6. Recorrido realizado en terreno.

Fuente: Google Earth. Track GPS Garmin 64S.

En las siguientes fotografías se presenta una visión general de los diferentes puntos recorridos en terreno.

Figura 7. Camino al ingreso del terreno. Vista general.

Figura 8. Vista general terreno Proyecto Macao. Vista Acequia aguas abajo.

Figura 9. Vista general terreno Proyecto Macao. Vista Acequia aguas arriba.

Figura 10. Vista general terreno Proyecto Macao. Vista Acequia aguas arriba, divisoria de aguas.

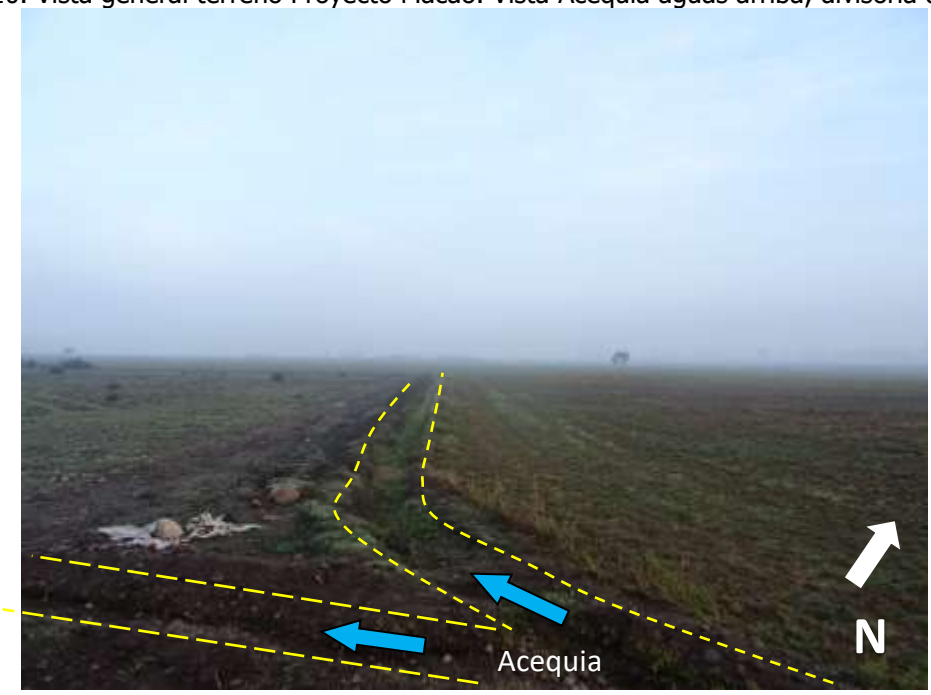


Figura 11. Pozo ubicado en extremo nororiente del terreno.

Figura 12. Entrega agua de pozo hacia canal.

Figura 13. Acequia agua de pozo.

Figura 14. Vista general terreno. Borde norte.

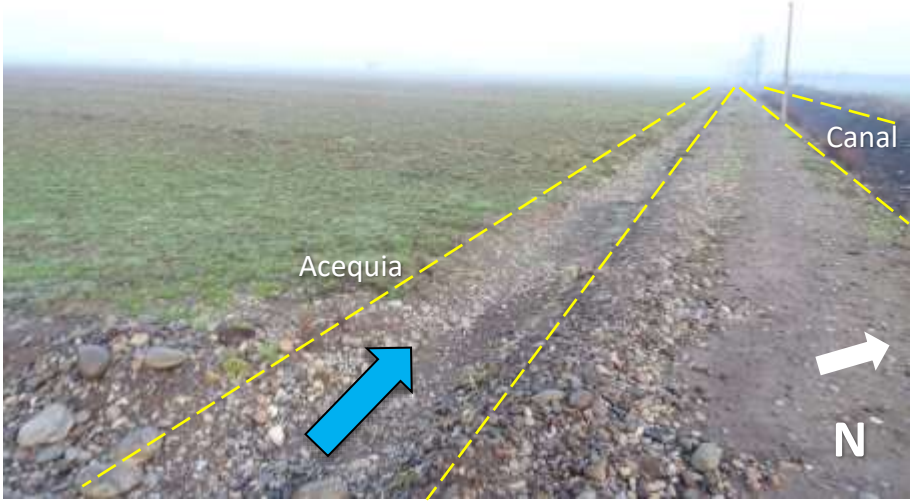


Figura 15. Camino al norte del terreno. Tranque colector.

Figura 16. Tranque colector.

En la visita se realizaron las siguientes observaciones de terreno:

- ✓ En el recorrido por el terreno se observó la presencia de dos pozos, posiblemente con fines de riego. Sumado con lo anterior se observó un tranque de riego en el extremo nor poniente del terreno (Ver Figura 16).

- ✓ El canal de tierra que pasa al norte del terreno es de dimensiones aproximadas de 2-3 metros de ancho en su coronamiento, mientras que se estima una profundidad de 1,5 metros. Dicho canal recoge derrames de riego de los diferentes predios del sector y en época de lluvias, capta las escorrentías productos de las aguas lluvias. Se hace mención que, de acuerdo a lo conversado con vecino del sector, el canal no lleva agua desde derrames desde aproximadamente el año 2015.

- ✓ De acuerdo con lo conversado con vecino del sector, en el predio en estudio existen dos pozos pero en general ésta se encuentra cercana a los 30 metros de profundidad.

- ✓ No existe presencia de afloramiento de aguas subterráneas como tampoco puntos bajos que puedan generar encharcamiento o estancamiento de aguas lluvias.

3.3 Topografía

Para la realización del presente informe se contó con la topografía denominada "Generación de Topografía Digital 1:250, Proyecto Macao" realizada por la empresa AV SAN en agosto de 2019, la que se presenta en la Figura 17. En dicha topografía se puede observar que no existen puntos bajos y que la pendiente del terreno es hacia el sur poniente.

Figura 17. Topografía zona de Proyecto.

Fuente: "Generación de Topografía Digital 1:250, Proyecto Macao" AV SAN, agosto 2019.

3.4 Análisis de imágenes satelitales

En base a las imágenes Google Earth de enero de 2005 y enero de 2020 no se aprecian cambios significativos en el terreno, ni tipo de uso de suelo. De acuerdo con lo observado en la visita, el terreno se ha utilizado probablemente como sector de uso agrícola.

Figura 18. Imagen Google Earth fecha 13-01-2020.

Figura 19. Imagen Google Earth fecha 17-01-2005.

4 ESTUDIO DE RIESGO

4.1 Introducción

A continuación, se realiza un análisis de los posibles riesgos asociados inundación por desborde de canales, aguas lluvias y aguas subterráneas, además de riesgo de erosión producto de la escorrentía superficial. Estos riesgos se determinarán en forma cualitativa, tomando como base la visita a terreno, entrevistas con lugareños y la experiencia del consultor en proyectos similares. Además, se presentarán obras a nivel de ingeniería conceptual para mitigar los efectos no deseados del agua al interior del Parque, así como recomendaciones constructivas y de ubicación de obras las que deberán ser optimizadas en próximas etapas de ingeniería.

A continuación, se desarrolla cada uno de los puntos antes mencionados.

4.2 Definiciones utilizadas

Para definir los parámetros utilizados en la evaluación del riesgo natural debe considerarse la escala o dimensiones del área a evaluar, la presencia e importancia de los elementos a evaluar y los efectos o consecuencias que podrían producirse ante determinado evento, la vulnerabilidad del medio a evaluar, entre otros. De modo que podrían utilizarse o elegir los parámetros más adecuados para cada caso. Lo anterior se puede escribir de las siguientes maneras:

RIESGO = AMENAZA O PELIGRO X VULNERABILIDAD (1)

RIESGO = AMENAZA O PELIGRO x CONSECUENCIA (2)

La evaluación del riesgo hace necesaria la observación de terreno con la ayuda primordial de las imágenes satelitales de diferente fecha y en ocasiones programas computacionales que permitan determinar elementos de ayuda por ejemplo mapas de pendientes, mapas topográficos, mapas geológicos, geomorfológicos y otros.

En esta evaluación de riesgo se eligió el presente en la siguiente expresión, que es simple y no necesita cálculos numéricos y parámetros difíciles de estimar o evaluar:

$$R = P \times C \quad (3)$$

Donde:
P : Amenaza o peligro
C : Consecuencia

La evaluación puede expresarse en escala de valores como:

Tabla 3. Valoración del Peligro.

Criterio	Descripción de la ocurrencia	Valor
Peligro o amenaza o Probabilidad (P)	En la mayor parte de las ocasiones, ocurrirá el evento. Ha ocurrido muchas veces. Es posible que ocurra frecuentemente durante un año.	Alto 8
	Ha ocurrido en algunas ocasiones.	Medio 4
	Ha ocurrido en una ocasión. El incidente podría ocurrir a veces.	Bajo 2
	Altamente improbable que ocurra. Nunca ha ocurrido	Insignificante o muy bajo 1

Fuente: Libro Mundo Ciencias Sociales / Unidad 2 / Hilario Cortéz Avilán. Ediciones SM. Bogotá.

Tabla 4. Valoración de las Consecuencias.

Criterio	Descripción de la ocurrencia	Valor
Consecuencia (C)	Daños cuantiosos a obras civiles y propiedad privada.	Alto 8
	Daños a la propiedad o infraestructura reparables con prontitud o fácilmente.	Medio 4
	Daños menores a la infraestructura.	Bajo 2
	Daños menores a la infraestructura.	Insignificante o muy bajo 1

Fuente: Libro Mundo Ciencias Sociales / Unidad 2 / Hilario Cortéz Avilán. Ediciones SM. Bogotá.

Tabla 5. Valoración del Riesgo.

Clasificación de los riesgos	Valor
Inaceptable o alto	32 – 64
Moderado o medio	8 – 16
Aceptable o bajo	2 – 4
Insignificante o muy bajo	1

Fuente: Libro Mundo Ciencias Sociales / Unidad 2 / Hilario Cortéz Avilán. Ediciones SM. Bogotá.

4.3 Peligro de inundación por cauces superficiales

En base a la información generada en la visita a terreno, se determinó que el Proyecto Fotovoltaico posee una probabilidad **baja** de inundación por cauces superficiales, ya que existe un canal en el extremo norte del Proyecto, que bajo un evento de crecida podría desbordar, sin embargo su probabilidad de ocurrencia es baja.

4.4 Peligro de inundación aguas subterráneas

En la zona de proyecto se observó la existencia de dos pozos los cuales poseerían niveles de aguas subterráneas en torno a los 30 metros de acuerdo a lo indicado por un vecino del sector. Luego, en base a los antecedentes antes mencionados y a lo observado en la visita de terreno, se tiene que la inundación debido a aguas subterráneas tiene una ocurrencia **muy baja**.

4.5 Peligro de inundación o encharcamiento por aguas lluvias

La ocurrencia de inundaciones por aumento del nivel del agua sobre el terreno producto del encharcamiento de las aguas lluvias es **muy bajo**, ya que el proyecto se ubica en un sector con pendientes que permiten que el agua escurra hacia sectores más bajos y/o a micro cauces.

4.6 Peligro de erosión por aguas lluvias

En base a la visita y a las características del terreno, el riesgo de erosión de suelo producto de la escorrentía de las aguas lluvias es **muy bajo**, debido a que el agua no se concentra en el terreno y que las velocidades esperada del agua de dicha agua no concentrada en la zona son bajas.

4.7 Consecuencia esperada en la infraestructura

Dado que el nivel de las aguas máximas esperadas en la zona de proyecto sería menor a 0,50 m, el nivel de consecuencia esperado sobre la infraestructura crítica del proyecto, centros de transformación y cajas combinadoras, correspondería a daños menores con una valorización baja o muy baja. Para efectos del presente informe, se ha tomado la consecuencia con un valor de **bajo** (2).

4.8 Valorización del riesgo

La valorización del riesgo asociado a cada uno de los puntos antes mencionados se presenta en la siguiente tabla.

Tabla 6. Valoración del Riesgo. Proyecto Fotovoltaico Macao.

Riesgo	Peligro	Consecuencia	Valor Asignado
Inundación por cauces superficiales	2	2	4 Bajo
Inundación aguas subterráneas	1	2	2 Bajo
Inundación o encharcamiento por aguas lluvias	1	2	2 Bajo
Erosión aguas lluvias	1	2	2 Bajo

Fuente: Elaboración propia.

4.9 Mitigaciones y recomendaciones

Las recomendaciones para evitar o minimizar el riesgo sobre los principales equipos y componentes del proyecto Fotovoltaico se presentan en la siguiente tabla.

Tabla 7. Medidas de mitigación y recomendaciones.

Riesgo	Mitigación y Recomendaciones
Inundación por cauces superficiales	✓ Ubicación de centros de transformación en punto más alto del terreno en base a la topografía generada. ✓ Cajas combinadoras deben ubicarse en los puntos altos del predio por sobre el nivel de terreno. La altura mínima de la caja combinadora será 0,5 m, privilegiando alturas mayores. ✓ Manejo de pendientes al interior del Proyecto para dirigir las aguas a los puntos bajos. ✓ Realizar mantención a los diferentes canales que se encuentra al norte o este del predio, de tal manera de evitar desbordes en la zona del proyecto. Lo anterior se deberá realizar con una frecuencia anual o antes de un evento extremo.

Fuente: Elaboración propia.

Figura 20. Ejemplo fundación Centro de transformación.

Figura 21. Ejemplo Caja combinadora.

4.10 Valorización del riesgo considerando mitigaciones

La valorización del riesgo asociado a cada uno de los puntos antes mencionados, considerando que se realizan las mitigaciones y recomendaciones sugeridas en la Tabla 8, se presenta en la siguiente tabla.

Tabla 8. Valoración del Riesgo considerando mitigaciones y recomendaciones.

Riesgo	Peligro	Consecuencia	Valor Asignado
Inundación por cauces superficiales	1	2	2 Bajo
Inundación aguas subterráneas	1	2	2 Bajo
Inundación o encharcamiento por aguas lluvias	1	2	2 Bajo
Erosión aguas lluvias	1	2	2 Bajo

Fuente: Elaboración propia.

5 CONCLUSIONES Y RECOMENDACINES

Las principales conclusiones del presente estudio de riesgo de inundación son las siguientes:

- ✓ En la zona de proyecto, se espera una lluvia media anual en torno a los 400 mm y una precipitación máxima en 24 horas con periodo de retorno de 10 años en torno a 98 mm/día. La temperatura media esperada para el proyecto se estima en 14 °C.

- ✓ La valorización de riesgo de las diferentes componentes analizadas son las siguientes:

Tabla 9. Valoración del Riesgo. Proyecto Fotovoltaico Macao.

Riesgo	Peligro	Consecuencia	Valor Asignado
Inundación por cauces superficiales	2	2	4 Bajo
Inundación aguas subterráneas	1	2	2 Bajo
Inundación o encharcamiento por aguas lluvias	1	2	2 Bajo
Erosión aguas lluvias	1	2	2 Bajo

Las principales medidas para mitigar los riesgos desde el punto de vista de las obras civiles del proyecto son las siguientes:

- ✓ Ubicación de centros de transformación en punto más alto del terreno en base a la topografía generada.
- ✓ Cajas combinadoras deben ubicarse en los puntos altos del predio por sobre el nivel de terreno. La altura mínima de la caja combinadora será 0,5 m, privilegiando alturas mayores.
- ✓ Manejo de pendientes al interior del Proyecto para dirigir las aguas a los puntos bajos.
- ✓ Realizar mantención a los diferentes canales que se encuentra al norte o este del predio, de tal manera de evitar desbordes en la zona del proyecto. Lo anterior se deberá realizar con una frecuencia anual o antes de un evento extremo.

Luego, considerando las mitigaciones antes mencionadas, la valorización del riesgo de inundación se presenta en la siguiente Tabla.

Tabla 10. Valoración del Riesgo considerando mitigaciones y recomendaciones. Proyecto Fotovoltaico Macao.

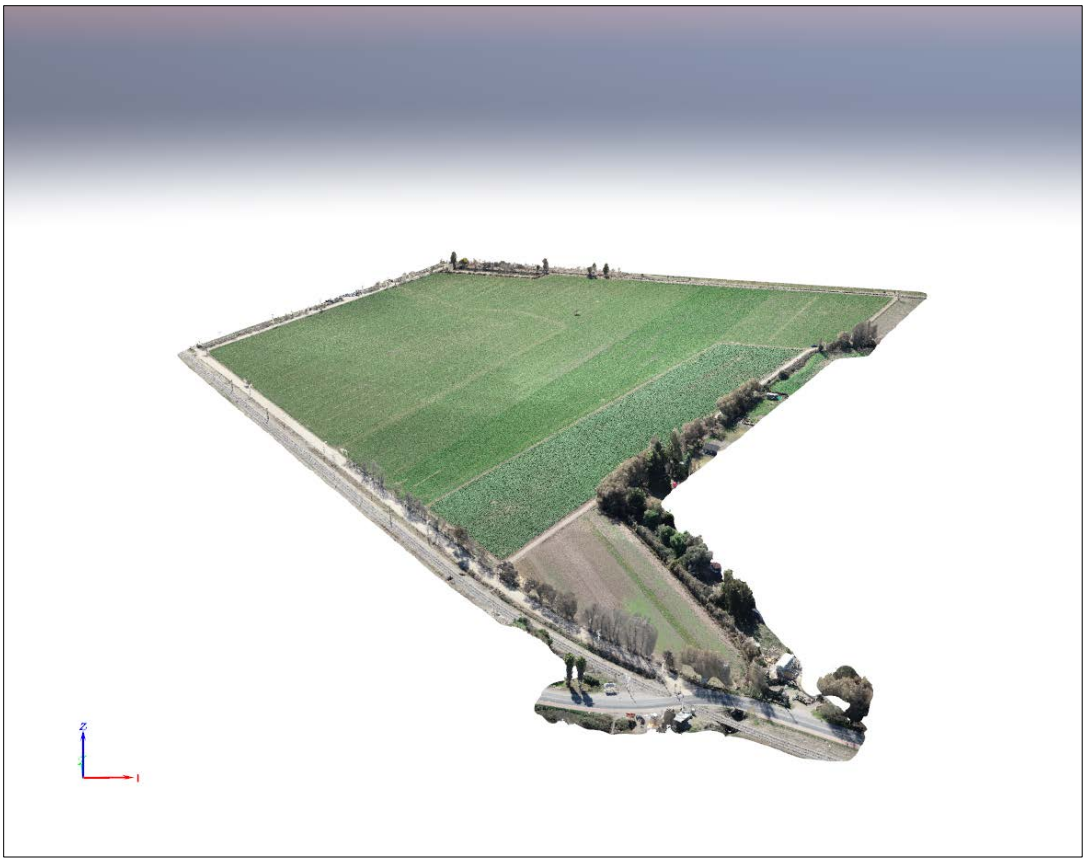
Riesgo	Peligro	Consecuencia	Valor Asignado
Inundación por cauces superficiales	1	2	2 Bajo
Inundación aguas subterráneas	1	2	2 Bajo
Inundación o encharcamiento por aguas lluvias	1	2	2 Bajo
Erosión aguas lluvias	1	2	2 Bajo

Para cumplir con el PRMS, se deberá realizar la medición de 3 días consecutivos del nivel de pozos cercanos, de tal manera de tener los antecedentes para poder justificar el cambio del plano regulador en la zona de estudio.

Especialistas en servicios UAV

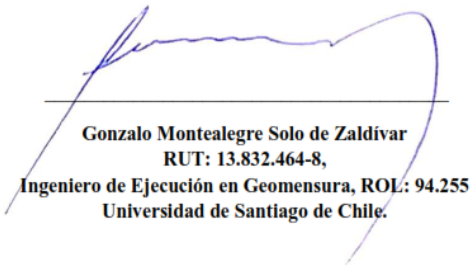
Levantamiento y Restitución Aerofotogramétrica

Sistema Aéreo No-Tripulado



Generación de Topografía Digital 1:250
PROYECTO MACAO

Santiago, 20 Agosto 2019

Título del Proyecto	***Generación de Topografía Digital 1:250 Proyecto Macao***
Preparado por:	***- Gabriel Díaz (Operador UAV´s AVSAN)*** ***- Christopher Rojas (Ing. Geomensor AVSAN)*** ***- Gonzalo Montealegre (Ing. Geomensor AVSAN)*** ***- Victor Pinto (Operador UAV´s y Jefe de Proyectos AVSAN)***
Revisado por :	 **Víctor Pinto Taylor** Jefe Área Técnica AVSAN vpinto@avsan.cl | www.avsan.cl
Aprobado por:	 **Gonzalo Montealegre Solo de Zaldívar** **RUT: 13.832.464-8,** **Ingeniero de Ejecución en Geomensura, ROL: 94.255** **Universidad de Santiago de Chile.**

Contenido

1. Antecedentes Generales.

1.1- Área de Interés.

AVSAN es una empresa presente en el mercado desde el año 2012 prestando servicios de Percepción Remota y Teledetección mediante UAV's contando en la actualidad con cámaras RGB de alta resolución, Sensores Multiespectrales y Termales los que permiten capturar datos en una zona del espectro electromagnético que parte en el Infrarrojo hasta el espectro Visible (Resolución Espectral: desde los 25 μm hasta los 900 nm).

Además, cuenta con personal altamente calificado y entrenado en la operación de sus plataformas UAV como también el equipo de procesamiento de datos y elaboración de productos finales cuenta con una vasta experiencia y la colaboración de profesionales idóneos en la materia.

Los operadores de nuestros UAV's cuentan con más de 6 años de experiencia en operaciones en terreno a lo largo de Chile y además en varios países de Centro y Sudamérica.

Bajo este contexto, la empresa Emanagement, por intermedio de la Señorita Tamara Fuenzalida, ha solicitado la elaboración de topografía y cartografía en escala 1:250 para un predio emplazado en la Región Metropolitana a 3.6 kilómetros al Norponiente de Lonquén y su área de interés es de aproximadamente 31 Hectáreas, este se denominara Proyecto Macao. Además, se encarga la elaboración de una Ortófoto de alta resolución para toda la zona de interés.

***Figura.1**: Ubicación del predio. (Superficie 31 Hectáreas aproximadamente)*

1.2- Tecnología Utilizada.

1.2.1- Aeronaves No-Tripuladas

Para realizar el proyecto, AVSAN utilizó tecnología UAV la cual consiste en la captura de imágenes mediante un sensor aerotransportado por una aeronave no tripulada. Esta aeronave es el PHANTOM 4 RTK

A continuación, se muestran características e imágenes de la plataforma.

AIRCRAFT	
Takeoff Weight	1391 g
Diagonal Distance	350 mm
Max Service Ceiling Above Sea Level	19685 ft (6000 m)
Max Ascent Speed	6 m/s (automatic flight); 5 m/s (manual control)
Max Descent Speed	3 m/s
Max Speed	31 mph (50 kph)(P-mode) 36 mph (58 kph)(A-mode)
Max Flight Time	Approx. 30 minutes
Operating Temperature Range	32° to 104° F (0° to 40°C)
Operating Frequency	2.400 GHz to 2.483 GHz (Europe, Japan, Korea) 5.725 GHz to 5.850 GHz (United States, China)
Transmission Power (EIRP)	2.4 GHz CECE (Europe) / MIC (Japan) / KCC (Korea) : < 20 dBm 5.8 GHz SRRC (China) / FCC (United States) /(Taiwan,China): < 26 dBm
Hover Accuracy Range	RTK enabled and functioning properly: Vertical: ±0.1 m; Horizontal: ±0.1 m RTK disabled Vertical: ±0.1 m (with vision positioning) ; ±0.5 m (with GNSS positioning) Horizontal: ±0.3 m (with vision positioning) ; ±1.5 m (with GNSS positioning)
Image Position Offset	The position of the camera center is relative to the phase center of the onboard D-RTK antenna under the aircraft body's axis:(36, 0, and 192 mm) already applied to the image coordinates in Exif data. The positive x, y, and z axes of the aircraft body point to the forward, rightward, and downward of the aircraft, respectively.
MAPPING FUNCTIONS	

GNSS	
Single-Frequency, High-Sensitivity GNSS Module	GPS+BeiDou+Galileo* (Asia); GPS+GLONASS+Galileo* (other regions) Frequency Used: GPS: L1/L2; GLONASS: L1/L2; BeiDou: B1/B2; Galileo*: E1/E5a First-Fixed Time: < 50 s Positioning Accuracy: Vertical 1.5 cm + 1 ppm (RMS) ; Horizontal 1 cm + 1 ppm (RMS) 1 ppm means the error has a 1mm increase for every 1 km of movement from the aircraft. *Available soon

GIMBAL	
Stabilization	3-axis (tilt, roll, yaw)
Pitch	-90° to +30°
Max Controllable Angular Speed	90°/s
Angular Vibration Range	±0.02°

INFRARED	
Obstacle Sensing Range	0.6-23 ft(0.2 - 7 m)
FOV	70°(Horizontal) ±10°(Vertical)
Measuring Frequency	10 Hz
Operating Environment	Surface with diffuse reflection material, and reflectivity > 8% (such as wall,trees, humans, etc.)

Tabla1.1: Características técnicas UAV´s propiedad de AVSAN.

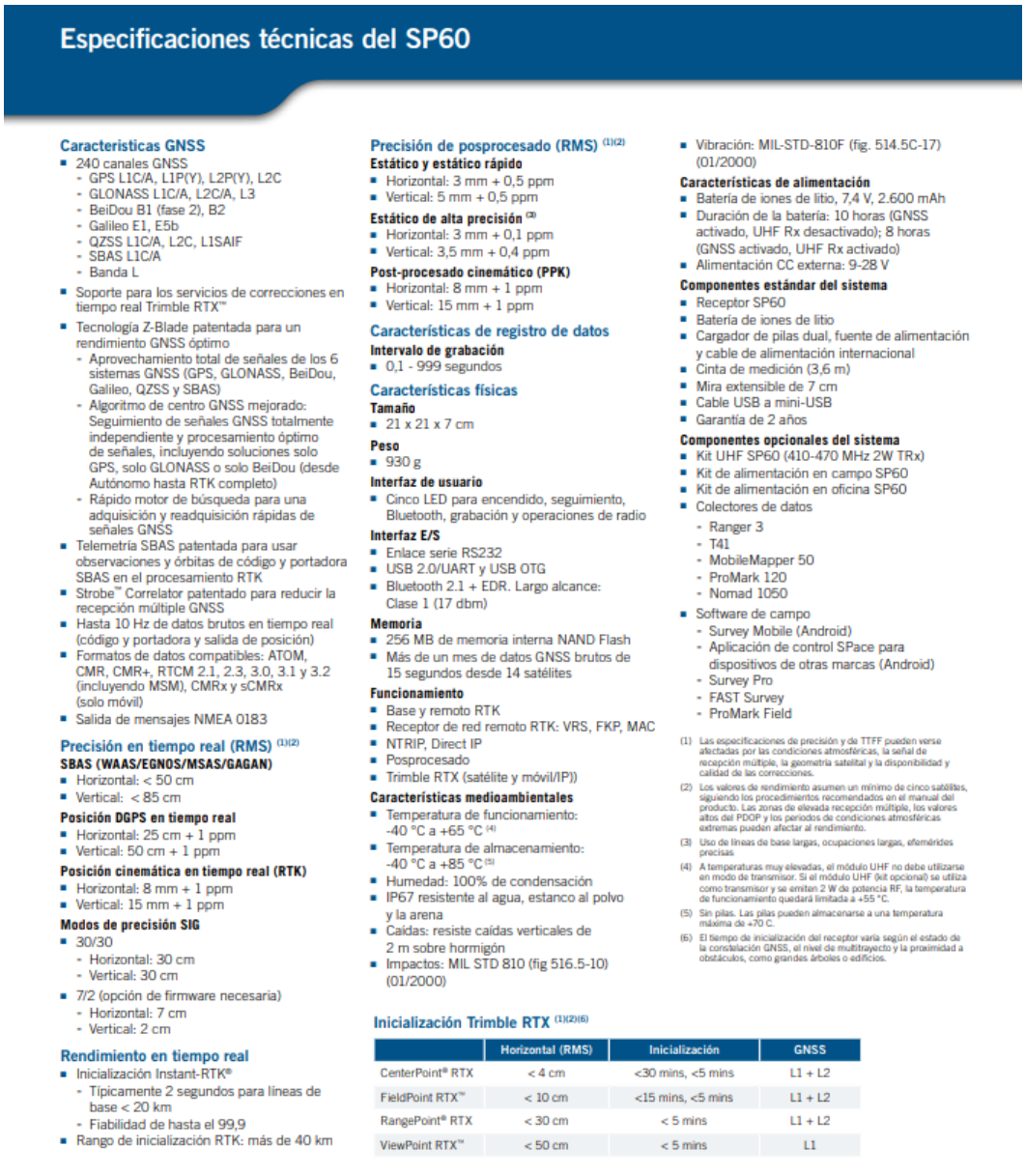
***Figura1.2**: UAV utilizado durante las operaciones.*

1.2.2 GPS Geodésico Doble Frecuencia.

Con el apoyo de la Tecnología GNSS, se desarrollará un levantamiento cinemático con GPS doble frecuencia (SPECTRA SP60) en toda la zona de interés, levantando puntos GPS en donde el terreno lo permita, lo cual tiene como objetivo generar una malla de datos que nos permita ajustar o minimizar aún más cualquier error que exista en el MDT o DEM generado por aerofotogrametría.

Con esta técnica, apuntamos a la redundancia de datos para lo obtención de un producto de excelencia y además preciso en sus ejes X, Y, Z.

El equipo que a utilizar para esta tarea es el SPECTRA SP60 y todos los accesorios necesarios que componen el sistema GNSS.



Especificaciones técnicas del SP60

Características GNSS
- 240 canales GNSS
  - GPS L1C/A, L1P(Y), L2P(Y), L2C
  - GLONASS L1C/A, L2C/A, L3
  - BeiDou B1 (fase 2), B2
  - Galileo E1, E5b
  - QZSS L1C/A, L2C, L1SAIF
  - SBAS L1C/A
  - Banda L
- Soporte para los servicios de correcciones en tiempo real Trimble RTX™
- Tecnología Z-Blade patentada para un rendimiento GNSS óptimo
  - Aprovechamiento total de señales de los 6 sistemas GNSS (GPS, GLONASS, BeiDou, Galileo, QZSS y SBAS)
  - Algoritmo de centro GNSS mejorado: Seguimiento de señales GNSS totalmente independiente y procesamiento óptimo de señales, incluyendo soluciones solo GPS, solo GLONASS o solo BeiDou (desde Autónomo hasta RTK completo)
  - Rápido motor de búsqueda para una adquisición y readquisición rápidas de señales GNSS
- Telemetría SBAS patentada para usar observaciones y órbitas de código y portadora SBAS en el procesamiento RTK
- Strobe™ Correlator patentado para reducir la recepción múltiple GNSS
- Hasta 10 Hz de datos brutos en tiempo real (código y portadora y salida de posición)
- Formatos de datos compatibles: ATOM, CMR, CMR+, RTCM 2.1, 2.3, 3.0, 3.1 y 3.2 (incluyendo MSM), CMRx y sCMRx (solo móvil)
- Salida de mensajes NMEA 0183

Precisión en tiempo real (RMS) [1][2]

SBAS (WAAS/EGNOS/MSAS/GAGAN)
- Horizontal: < 50 cm
- Vertical: < 85 cm

Posición DGPS en tiempo real
- Horizontal: 25 cm + 1 ppm
- Vertical: 50 cm + 1 ppm

Posición cinemática en tiempo real (RTK)
- Horizontal: 8 mm + 1 ppm
- Vertical: 15 mm + 1 ppm

Modos de precisión SIG
- 30/30
  - Horizontal: 30 cm
  - Vertical: 30 cm
- 7/2 (opción de firmware necesaria)
  - Horizontal: 7 cm
  - Vertical: 2 cm

Rendimiento en tiempo real
- Inicialización Instant-RTK®
  - Típicamente 2 segundos para líneas de base < 20 km
  - Fiabilidad de hasta el 99,9
- Rango de inicialización RTK: más de 40 km

Precisión de posprocesado (RMS) [1][2]

Estático y estático rápido
- Horizontal: 3 mm + 0,5 ppm
- Vertical: 5 mm + 0,5 ppm

Estático de alta precisión [3]
- Horizontal: 3 mm + 0,1 ppm
- Vertical: 3,5 mm + 0,4 ppm

Post-procesado cinemático (PPK)
- Horizontal: 8 mm + 1 ppm
- Vertical: 15 mm + 1 ppm

Características de registro de datos

Intervalo de grabación
- 0,1 - 999 segundos

Características físicas

Tamaño
- 21 x 21 x 7 cm

Peso
- 930 g

Interfaz de usuario
- Cinco LED para encendido, seguimiento, Bluetooth, grabación y operaciones de radio

Interfaz E/S
- Enlace serie RS232
- USB 2.0/UART y USB OTG
- Bluetooth 2.1 + EDR. Largo alcance: Clase 1 (17 dbm)

Memoria
- 256 MB de memoria interna NAND Flash
- Más de un mes de datos GNSS brutos de 15 segundos desde 14 satélites

Funcionamiento
- Base y remoto RTK
- Receptor de red remoto RTK: VRS, FKP, MAC
- NTRIP, Direct IP
- Posprocesado
- Trimble RTX (satélite y móvil/IP))

Características medioambientales
- Temperatura de funcionamiento: -40 °C a +65 °C [4]
- Temperatura de almacenamiento: -40 °C a +85 °C [5]
- Humedad: 100% de condensación
- IP67 resistente al agua, estanco al polvo y la arena
- Caídas: resiste caídas verticales de 2 m sobre hormigón
- Impactos: MIL STD 810 (fig 516.5-10) (01/2000)
- Vibración: MIL-STD-810F (fig. 514.5C-17) (01/2000)

Características de alimentación
- Batería de iones de litio, 7,4 V, 2.600 mAh
- Duración de la batería: 10 horas (GNSS activado, UHF Rx desactivado); 8 horas (GNSS activado, UHF Rx activado)
- Alimentación CC externa: 9-28 V

Componentes estándar del sistema
- Receptor SP60
- Batería de iones de litio
- Cargador de pilas dual, fuente de alimentación y cable de alimentación internacional
- Cinta de medición (3,6 m)
- Mira extensible de 7 cm
- Cable USB a mini-USB
- Garantía de 2 años

Componentes opcionales del sistema
- Kit UHF SP60 (410-470 MHz 2W TRx)
- Kit de alimentación en campo SP60
- Kit de alimentación en oficina SP60
- Colectores de datos
  - Ranger 3
  - T41
  - MobileMapper 50
  - ProMark 120
  - Nomad 1050
- Software de campo
  - Survey Mobile (Android)
  - Aplicación de control SPace para dispositivos de otras marcas (Android)
  - Survey Pro
  - FAST Survey
  - ProMark Field

(1) Las especificaciones de precisión y de TTFF pueden verse afectadas por las condiciones atmosféricas, la señal de recepción múltiple, la geometría satelital y la disponibilidad y calidad de las correcciones.

(2) Los valores de rendimiento asumen un mínimo de cinco satélites, siguiendo los procedimientos recomendados en el manual del producto. Las zonas de elevada recepción múltiple, los valores altos del PDOP y los periodos de condiciones atmosféricas extremas pueden afectar al rendimiento.

(3) Uso de líneas de base largas, ocupaciones largas, efemérides precisas

(4) A temperaturas muy elevadas, el módulo UHF no debe utilizarse en modo de transmisor. Si el módulo UHF (kit opcional) se utiliza como transmisor y se emiten 2 W de potencia RF, la temperatura de funcionamiento quedará limitada a +55 °C.

(5) Sin pilas. Las pilas pueden almacenarse a una temperatura máxima de +70 C.

(6) El tiempo de inicialización del receptor varía según el estado de la constelación GNSS, el nivel de multitrayecto y la proximidad a obstáculos, como grandes árboles o edificios.

Inicialización Trimble RTX [1][2][6]

	Horizontal (RMS)	Inicialización	GNSS
CenterPoint® RTX	< 4 cm	<30 mins, <5 mins	L1 + L2
FieldPoint RTX™	< 10 cm	<15 mins, <5 mins	L1 + L2
RangePoint® RTX	< 30 cm	< 5 mins	L1 + L2
ViewPoint RTX™	< 50 cm	< 5 mins	L1

***Figura 1.3**: Hoja de Datos del GPS SPECTRA SP60*

***Figura 1.4**: Equipo GPS SPECTRA SP60 utilizado para las labores de terreno.*

2. Metodología.

Los procesos que llevaran entonces a la obtención de la información solicitada por el cliente son en primera etapa la implementación de una red de puntos de control en terreno para darle precisión sub-métrica al modelo, luego elaboración y planificación de líneas de vuelo a la cual se capturara la información para finalmente realizar un procesamiento y Orto rectificación de las imágenes obtenidas.

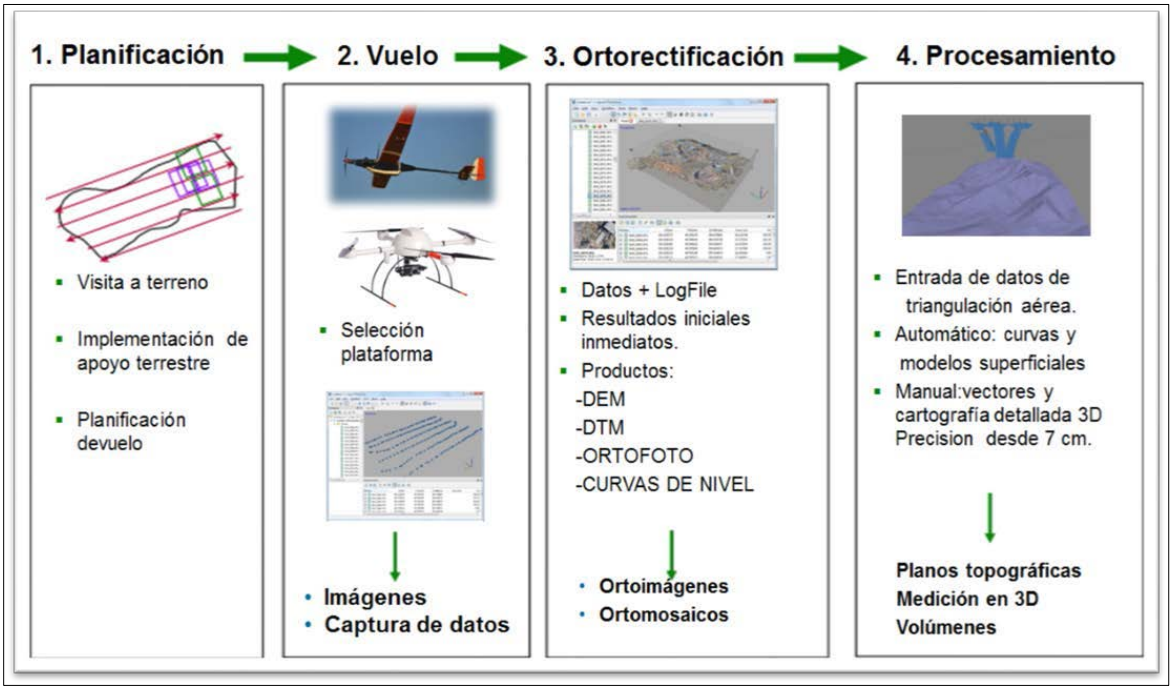


Figura 2.1: *Flujo de trabajo realizado por AVSAN.*

2.1- Apoyo Terrestre Mediante GPS.

El Sistema de Posicionamiento Global – GPS, permite determinar y transportar coordenadas de puntos materializados sobre la superficie terrestre, referidas a la superficie analítica que representa la Tierra, el elipsoide del sistema geodésico mundial WGS-84.

Con observación de la fase portadora, se puede determinar vectores relativos (ΔX, ΔY, ΔZ) con precisión planimétrica en latitud y longitud (Φ, λ) o norte y este (N, E) del orden de ± (0,005m + 1 a 2ppm) (partes por millón de la longitud del vector), es decir 1 a 2mm/km; por ejemplo, las coordenadas Norte y Este transportadas a una distancia de 1.000 m, tendrán una precisión relativa de 6 a 7 mm, lo que corresponde a una precisión relativa horizontal entre 1/166.000 y 1/ 142.000. Por otra parte, la precisión altimétrica (h), respecto al elipsoide, es algo menos precisa que la planimétrica, alcanzando el orden de ± (0,010m + 3 a 4ppm). Estas precisiones se alcanzan empleando los procedimientos y bajo las condiciones citadas en los Aspectos Normativos de las Secciones 2.304.7 y 2.312.9 del Manual de Carreteras, Versión 2001.

2.2- Determinaciones Altimétricas.

Se consideran dos superficies de referencias para la coordenada altimétrica: el ELIPSOIDE y el GEOIDE. El elipsoide es la figura donde se realizan los cálculos geodésicos y donde se representan las coordenadas planimétricas, latitud y longitud o de donde se proyectan las coordenadas planas, norte y este. Siendo el elipsoide un concepto puramente analítico, no tiene aplicación en la ingeniería ni en la geodesia aplicada, en consecuencia, las alturas deben referirse a la superficie definida por el Nivel Medio del Mar – NMM. Esta última superficie es equipotencial, lo que significa que en ella se tiene un valor de atracción gravitacional constante, es una superficie que no puede ser representada analíticamente, por lo que se recurre a modelos que la representen. En el caso particular de este proyecto, las alturas utilizadas provienen de la Estación de Referencia de Bienes Nacionales Rancagua y Santiago y cuyos identificadores son BN06 y BN13 respectivamente. La estación de referencia y los resultados generados están referidos al modelo Elipsoidal y Geoidal respectivamente.

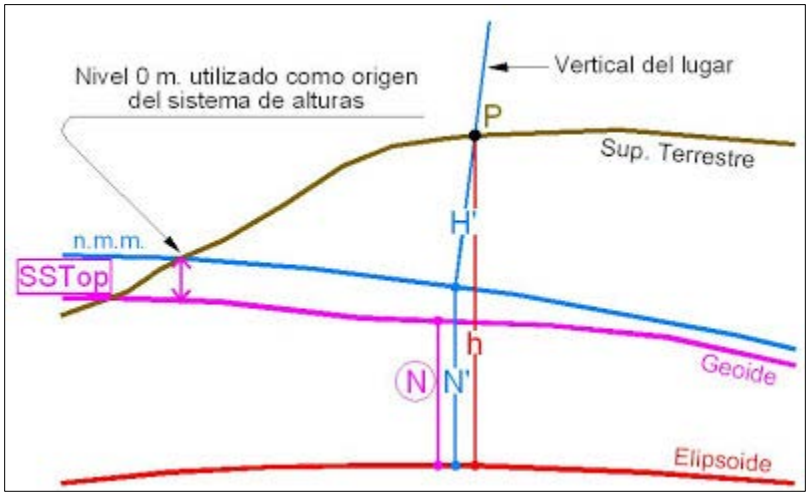


Figura 2.2: *Representación gráfica de ondulación geoidal.*

2.3- Vértice Geodésico de Apoyo.

En el Área de estudio, no existe una Red de Pr's ya monumentados, por este motivo se generaron dos PR's durante las distintas etapas del proyecto siendo estas referidas a la Estación Activa Bienes Nacionales BN06 y BN13.

BN06

COORDENADAS GEODÉSICAS Y UTM				
LATITUD	34° 10' 14.8180''S	**NORTE**	6,217,540.359m	ITRF 2008 ÉPOCA 2013.0 CERT. IGM NOV./2014
LONGITUD	70° 44' 22.5430"W	**ESTE**	339,665.191m	
ALTURA ELIPSOIDAL	539.541 m	**HUSO UTM**	19	
RECEPTOR GNSS		**ANTENA GNSS**		
MARCA	TOPCON	MARCA	TOPCON	
MODELO	NET-G3A	MODELO	TPSPG_A1+GP NONE	

BN13

COORDENADAS GEODÉSICAS Y UTM				
LATITUD	33º 26' 35.7477''S	**NORTE**	6,298,359.090m	ITRF 2008 ÉPOCA 2013.0 CERT. IGM NOV./2014
LONGITUD	70º 38' 47.1931''W	**ESTE**	346,961.542m	
ALTURA ELIPSOIDAL	616.798m	**HUSO UTM**	19	
RECEPTOR GNSS		**ANTENA GNSS**		
MARCA	TOPCON	MARCA	TOPCON	
MODELO	NET-G3A	MODELO	TPSPG_A1+GP NONE	

***Tabla 2.1**: coordenadas Geodésicas y UTM WGS84 para las estaciones de Referencia a la cual fue vinculado el proyecto.*

2.4- Medición Topográfica.

Una vez que la Base GPS ha sido instalada se da inicio a las distintas mediciones Topográficas para la zona de interés.

La medición será realizada mediante aerofotogrametría con DRON, que consiste en realizar restituciones a partir de fotografías rectificadas (ortomosaicos), que son georreferenciados a partir de puntos de apoyo terrestre, que son materializados en terreno a partir de los vértices de la red geodésica.

La medición de los puntos de apoyo terrestre PAF o GCPS será realizada con tecnología GPS RTK (Real Time Kinematic, o Gps en tiempo real), este procedimiento implica utilizar equipos GPS geodésicos, provistos de radios internas, lo que permite la transmisión del cálculo de ambigüedades. Con esto, se pueden obtener resultados inmediatamente, eliminando una etapa de post-procesamiento de la información.

2.5- Medición de Puntos de Control (GCP).

Previo al vuelo se propuso para la zona de interés una malla de puntos de control con 13 GCP's (Ground Control Point) a fin de tener una correcta y precisa georreferenciación del proyecto en el Dátum de referencia WGS84.

Los puntos de control fueron implementados con 2 láminas de Durolax 3mmel cual es Biodegradable y cuyas dimensiones son de 60 x 25 cm formando una "L", la cual tendrá durabilidad suficiente mientras se lleve a cabo la captura de información.

Estos puntos fueron ubicados en los sectores más críticos de la zona con tal de obtener un modelo de elevación que se ajuste a las coordenadas absolutas tanto en altimetría como planimetría.

Figura 2.4: *Distribución de puntos de control propuestos para la ejecución del Proyecto.*

El equipo técnico utilizado para el trabajo de la implementación de la red de puntos de control fue el siguiente:

- 2 GPS marca Spectra Modelo SP60.
- 1navegador Garmin Montana 650
- 2 trípodes de madera.
- 1 Jalón extensible de fierro y aluminio.
- 2 bases Tribrach.
- Baterías con cargador.
- Huincha medición metálica 3M.
- 01camioneta 4x4

Previo a poner los puntos de control se realizó una visita a terreno para conocer la zona y visualizar todo tipo de circunstancia que pudiera entorpecer el trabajo, así mismo se realizó un trabajo de gabinete el que consistió en ubicar la zona del vuelo en Google Earth, para poder ubicar los puntos de control más idóneos.

Dado que el requerimiento establecido en la propuesta técnica solicita que el Sistema de Referencia sea el Dátum WGS84 S19, los puntos de control fueron medidos en formato RTK y no se realizó ningún post proceso de datos ya que afortunadamente no existieron puntos que al estar alejados de la base perdieran conexión de radio teniendo que medirlos en modalidad de Estático.

Figura 2.5: *Puntos de Control implementados en terreno para la georreferenciación del proyecto*

Tanto el receptor como el móvil utilizado permiten trabajar en método RTK, estático y estático rápido ambos con post-proceso de datos.

El tipo de medición que se eligió para este trabajo fue el de RTK, el cual consiste en dejar midiendo un receptor en el punto base que corresponde a un Vértice monumentados en un lugar definido como “BASE” y con un móvil efectuar mediciones para cada GCP´s que componen la red de puntos de control, según lo que establece el manual de carreteras.

2.6- Planificación de los Vuelos UAV.

Una vez terminada la campaña de implementación de GCP's, se procedió a la definición de las líneas de vuelo para poder llevar a cabo la total cobertura del área deseada. En base a los requerimientos y la evaluación que se pudo hacer en terreno se determinó que la altura a la cual los vuelos se llevarían a cabo seria de 120m.

Dadas las condiciones geográficas, meteorológicas y de vientos predominantes en las zonas de operación, se determinó que las líneas de vuelo del Proyecto debían tener orientación Oriente-Poniente y rumbos de vuelo de 118º cuando el UAV se dirige hacia la parte Poniente del polígono y 298º cuando el UAV se dirige hacia la parte Oriente del polígono.

En términos de aseguramiento del traslape de cada fotografía y por ende cobertura total del terreno se estableció que dada la velocidad crucero del UAV y que corresponde a 25 km/h se debía tomar una fotografía cada 2 segundos con el fin de asegurar un traslape horizontal del 85% y la separación entre líneas de vuelo debía ser de 60 m con el fin de garantizar un traslape lateral del 70%.

Así finalmente se capturaron 808 fotografías RGB. Durante el vuelo se registró para cada una de las fotografías la coordenada donde fue tomada, la hora, la inclinación alar del avión, el rumbo del avión en ese momento y la posición de actitud de la nariz del avión con respecto al horizonte a fin de que el software PIX4D MAPPER® identificara correctamente la posición de la foto y permitiera llevar a la perfección la Orto rectificación de cada una de las imágenes.

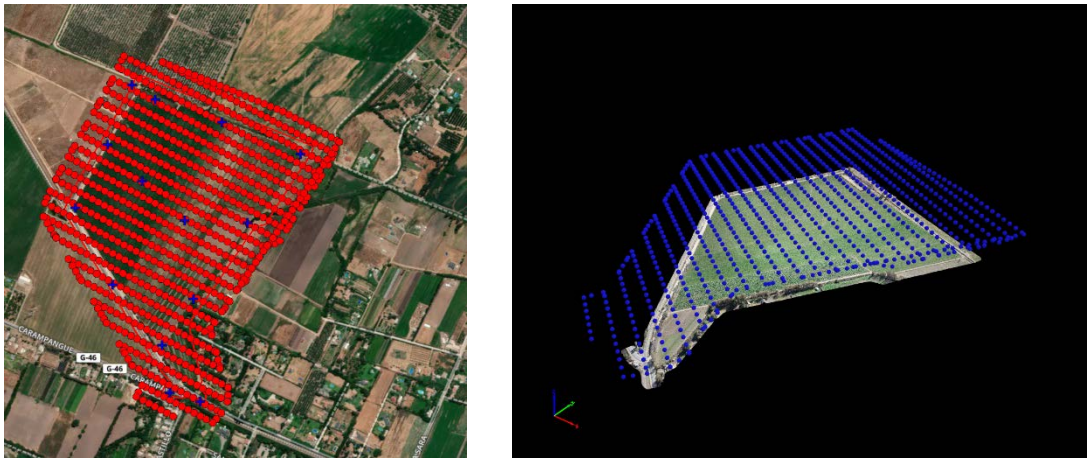


***Figura 2.6**: Líneas de vuelo ejecutadas y fotografías capturadas*

2.7- Procesamiento Aerofotogramétrico.

Una vez capturadas las fotografías aéreas del sector de interés, se procedió a su ingreso y posterior procesamiento en el sistema de restitución Aerofotogramétrica llamado PIX4D MAPPER®.

A este sistema se ingresaron las 1039 fotografías capturadas desde los dispositivos ópticos utilizados, junto con los archivos que contienen las actividades de vuelo para cada una de las fotografías capturadas.

La actitud de vuelo corresponde a una serie de 4 parámetros de posición del avión en cada momento que se captura una imagen (foto) Los parámetros son:

- Guiñada (Yaw)
- Cabeceo (Pitch)
- Alabeo (Roll)
- Coordenada GPS
- Alturas AGL (above ground level)

Cada uno de estos parámetros se registra para cada una de las fotografías capturadas, junto a los datos de posición y de hora correspondiente, se almacenan en un archivo de vuelo.

Con las fotografías y el archivo de vuelo se ejecuta la primera fase del procesamiento, que corresponde a la orientación de las fotografías, y que corresponde a la ubicación aproximada de cada una de las fotografías para generación de un mosaico en un espacio 3D. Dependiendo de la cantidad de datos a procesar, este primer proceso puede llegar a durar más de 48 horas.

Con las fotografías aéreas ya orientadas, y aproximadamente georreferenciadas, se debe crear la geometría del modelo de elevación en el área de interés. Esta geometría es aproximada y previa al ingreso de puntos de control capturados en terreno. El objetivo de esta etapa es la generación del modelo de elevación (Restitución altimétrica).

Una vez generado el modelo, se debe dar inicio a la etapa de ingreso de puntos de control, que corresponde a la etapa más importante de todas durante el proceso de manejo de datos y en la que el modelo generado se ajusta a la realidad del terreno dentro del área de interés.

Ya ingresados los puntos de control (GCP) al modelo, el sistema debe nuevamente crear la geometría, pero esta vez ajustada al terreno real gracias a los datos aportados por los puntos de control recolectados en terreno. Este proceso puede llegar a demorar otras 24 horas, solo después de transcurrido este tiempo es posible generar el modelo de elevación digital (en adelante DEM, por sus siglas en inglés para Digital Elevation Model) y el ortofotomosaico (Mosaico RGB de las imágenes capturadas).

3. Resultados

Una vez que se tienen todos los resultados de las distintas etapas, se verifica que los Productos a entregar cumplan con los requisitos de la propuesta técnica- económica elaborada por AVSAN para la empresa Emanagement. De esta manera se elaboran los productos en los formatos acordados entre ambas partes.

Se detallará a continuación los resultados obtenidos de las distintas actividades llevadas a cabo en la zona de interés.

3.1- Puntos de Control

Los resultados de la campaña de implementación y medición de la red de puntos de control para el área de interés es la siguiente:

NOMBRE	ESTE/LATITUD	NORTE/LONGITUD	COTA/ALTURA
PAF01	325323,329	6269937,789	348,987
PAF02	325140,393	6269940,755	347,298
PAF03	325014,402	6270053,581	348,018
PAF04	325170,187	6269714,046	345,17
PAF06	325194,91	6269416,966	344,995
PAF08	324933,467	6269751,038	344,834
PAF09	324821,248	6269971,811	346,272
PAF10	324911,629	6270157,218	348,262
PAF11	324979,233	6270331,732	349,544
PAF12	325048,083	6270290,339	348,972
PAF13	325244,247	6270228,637	350,445
PAF14	325475,236	6270139,943	351,925

Tabla 3.1: coordenadas UTM Zona 19S WGS84.

PUNTOS DE CONTROL PROYECTO MACAO

Figura 3.1: *GCP´s logrados durante la campaña topográfica ubicados en la imagen.*

Como se mencionó anteriormente, se había propuesto una red de puntos de control con un total de 14 GCP, la cual se logró implementar sin mayores contratiempos.

Es necesario mencionar que la disposición de los puntos de control obedece a una lógica en la que se deben generar zonas de triangulación para que al momento de realizar la restitución Aero fotogramétrica el modelo digital resultante sea representativo de la topografía de la zona de interés.

Además, la ubicación final del punto de control tiene una tolerancia de aproximadamente 5 metros en relación a la ubicación propuesta, dado que muchas veces las condiciones del terreno hacen que el posicionamiento en el lugar exacto no sea factible.

3.2- Líneas de Vuelo y cobertura de imágenes.

En base a los cálculos realizados producto del sensor fotográfico del DRON y que corresponde a un Sensor Exmor R® CMOS tipo 1,0" de 20,2 MP y además a las observaciones hechas en terreno se estableció cuáles serían las líneas de vuelo para llevar a cabo la total captura de información en la zona de interés.

En términos de traslape de las imágenes, los resultados se muestran en la gráfica 3.2 para el polígono de interés en este proyecto.

Se aprecia en la figura 3.2 que para toda la zona de interés el número de imágenes que cubren cada punto en el suelo es mayor a 5 imágenes, lo que asegura según los principios básicos de la aerofotogrametría que la calidad de los productos obtenidos sea óptima debido a la estereoscopia resultante para el terreno en donde se desarrolló la captura de datos.

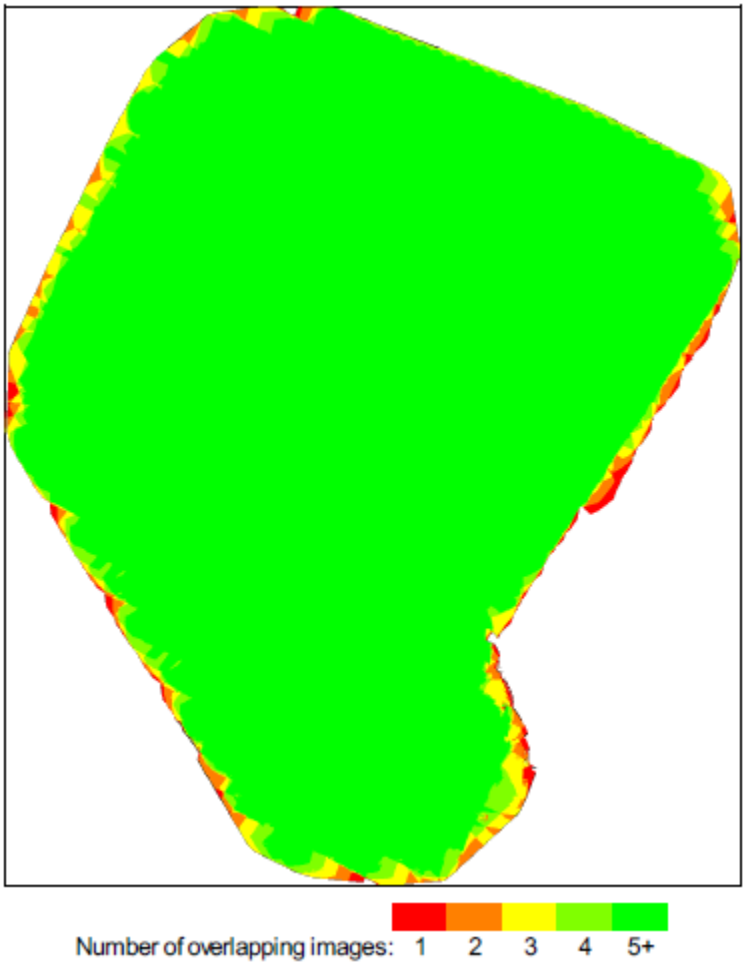


Figura 3.2: *Diagrama del traslape para las imágenes capturadas en el proyecto.*

3.3- Procesamiento Aerofotogramétrico

Puesto que los requerimientos técnicos exigen una precisión de acuerdo con la escala topográfica 1:250 para los productos finales y una resolución de la Ortófoto RGB no superior a 5 cm/pixel para la elaboración de productos Cartográficos y Topográficos acordes a la escala de exigencia.

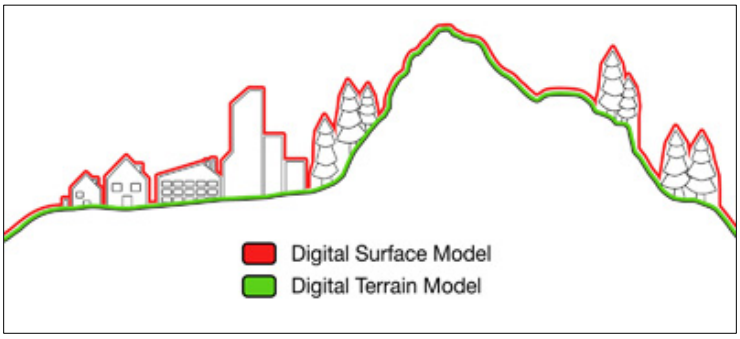
AVSAN logro una resolución de 2.98 cm/pixel para la imagen RGB de la zona del Proyecto Macao con una cobertura superior a 33.6 hectáreas.

Figura 3.3: *Ortófoto RGB generada por AVSAN para la zona de interés correspondiente a 2.98 cm/pixel.*

3.4- Modelos de Elevación Digital.

Gracias a los datos recopilados y a la generación de una nube de puntos densa, se pueden obtener los modelos de elevación para representar la superficie y el terreno desnudo de la manera más fiable posible.

Los modelos generados obedecen al siguiente diagrama:



Los resultados son los siguientes:

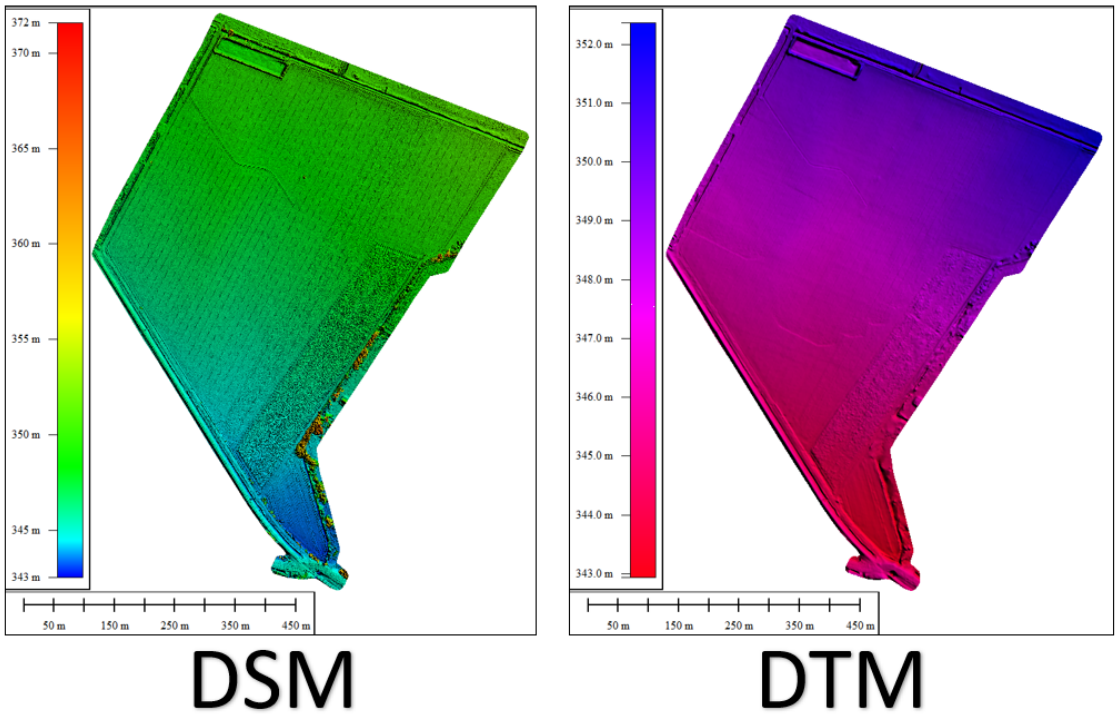


Figura 3.6: *DSM y DTM generado por fotogrametría y rectificado con puntos obtenidos del levantamiento RTK.*

La generación del DTM a partir del DSM, se realizó con el Software 3DReshaper, el cual permite trabajar nubes de puntos muy densas, clasificar los puntos, limpiar las nubes y generar mallas de triángulos que representen el terreno sin perder las precisiones topográficas del proyecto.

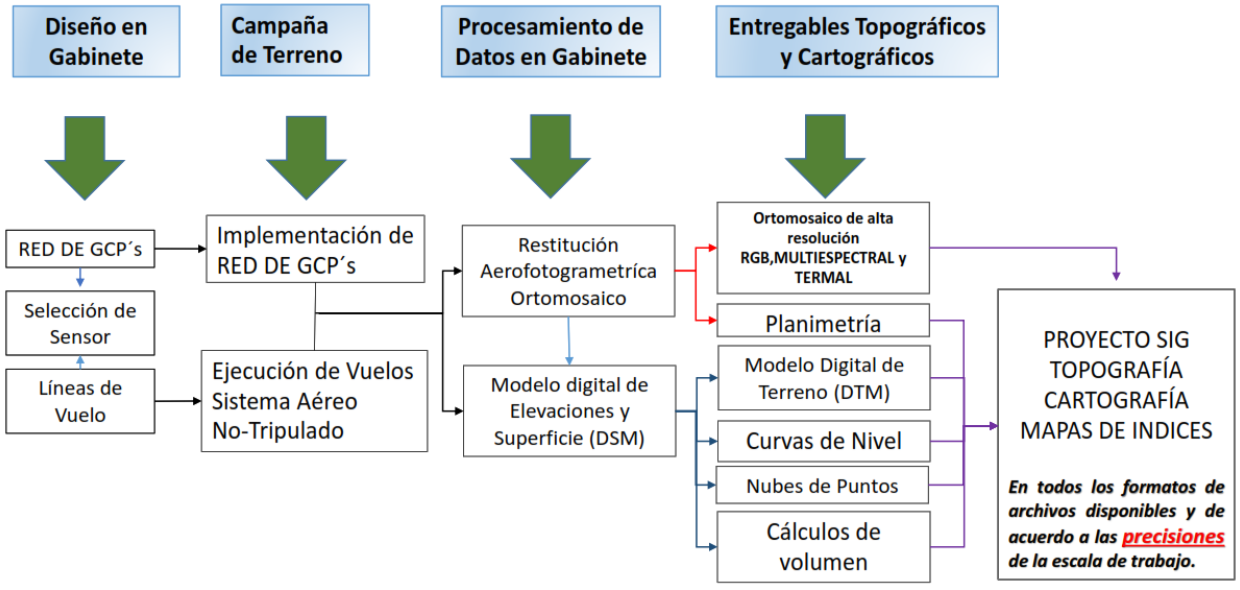
3.5- Puntos de Referencia implementados en terreno.

Como parte de las labores ejecutadas en terreno, se materializaron 02 PR´s con el objetivo de ser utilizados en futuras labores de Topografía o Geomensura dentro del Proyecto Macao. Se adjunta en los anexos de este informe sus respectivas monografías.

Sus coordenadas son las siguientes:

NOMBRE	*ESTE*	*NORTE*	*ALTURA ELIPSOIDAL*
PR00	325.097,577	6.270.256,235	376,541 m
PR01	325.329,242	6.269.955,764	349,076 m

4. Diagrama Resumen Metodología.



En el diagrama anterior demuestra como las diversas etapas del trabajo desarrollado por AVSAN están relacionadas y como a través de nuestro flujo de trabajo se generan los distintos productos que nos llevaran a cumplir el requisito de la propuesta técnica generada por AVSAN.

5. Resumen de resultados.

	Proyecto Macao
Sistema de Referencia para el Proyecto	WGS84 UTM Zona 19S Elipsoide EGM2008
Resolución Ortófoto	GSD =2.98 cm/pixel
Superficie Ortófoto	33.6 hectáreas
Planimetría	Desarrollada según indicaciones del cliente.
Escala Topografía	1:250
Curvas de Nivel	Generadas con intervalo altimétrico de 0.25m
Error medio cuadrático x,y,z	X= 3.27 cm / Y=2.58 cm / Z= 4.71 cm RMS = 3.5 cm
Densidad y resolución Modelos de elevación digital	DSM = 175.11 puntos/m^2 Resolución: 2.94 cm/pixel. DTM = 14.1 puntos/m^2 Resolución: GSD x 5= 25.2 cm/pixel.

ANEXO 1: MONOGRAFIA DE PUNTOS DE REFERENCIA

PR00

MONOGRAFIA PUNTO DE REFERENCIA
PROYECTO MACAO

MONOGRAFÍA DEL VÉRTICE GEODÉSICO			
Datum Horizontal: WGS84	**Datum Vertical:** WGS84/EGM08	**Proyección:** UTM (m)	**Zona:** 19 Sur
Lugar: Macao	Región Metropolitana	**Nombre:** PR MACAO 00	**Código:** PR00
Latitud: 33°41'35,72000" S	**Longitud:** 70°53'13,43062" O	**Altura Elipsoidal:** 376,541 m	**Año:** 2019
Norte: 6.270.256,235	**Este:** 325.097,577	**Altura Ortométrica:** 350,871m	
Descripción:	Poyo de Hormigón color naranjo con un fierro delgado en su centro, marcado con una cruz en el centro de la parte superior. El poyo queda visible con respecto al piso, emergiendo unos 10 cm desde el suelo.		
Localización:	Macao, Región Metropolitana.		
Cómo llegar:	Por el camino a Carampangue en la intersección con la vía férrea, seguir camino de tierra local con acceso a sitios interiores, luego de doblar a la derecha casi llegando al final de tramo de camino, ubicar tranque. El punto de referencia está situado en zona cerca a hombro Sur de tranque.		

Ingeniero Geomensor: Christopher Rojas, AVSAN.

PR01

MONOGRAFIA PUNTO DE REFERENCIA
PROYECTO MACAO

MONOGRAFÍA DEL VÉRTICE GEODÉSICO			
Datum Horizontal: WGS84	**Datum Vertical:** WGS84/EGM08	**Proyección:** UTM (m)	**Zona:**19 Sur
Lugar: Macao	Región Metropolitana	**Nombre:** PR MACAO 01	**Código:** PR01
Latitud: 33°41'45,60822" S	**Longitud:** 70°53'04,64966" O	**Altura Elipsoidal:** 374,750 m	**Año:** 2019
Norte: 6.269.955,764	**Este:** 325.329,242	**Altura Ortométrica:** 349,076 m	
Descripción:	Poyo de Hormigón color naranjo con un fierro delgado en su centro, marcado con una cruz en el centro de la parte superior. El poyo queda visible con respecto al piso, emergiendo unos 10 cm desde el suelo.		
Localización:	Macao, Región Metropolitana.		
Cómo llegar:	Por el camino a Carampangue en la intersección con la vía férrea, seguir camino de tierra local con acceso a sitios interiores. Acceder por portón a sitio y seguir camino hasta que éste presente un quiebre, ubicar punto a mano izquierda.		

Ingeniero Geomensor: Christopher Rojas, AVSAN.

ANEXO 2: MONOGRAFIA DE VERTICE GEODESICO

ESTACIONES ACTIVAS BN06 y BN13

IGM
INSTITUTO GEOGRÁFICO MILITAR
Cartografía Oficial del Estado de Chile

CERTIFICADO DE COORDENADAS GEOGRÁFICAS PLANAS Y ALTURA

13 de noviembre de 2014
O/T Nº 1791-14

Solicitadas por : **MINISTERIO DE BIENES NACIONALES**

Datum : SIRGAS
Elipsoide : GRS-80
Unidad : N, E y Altura en metros

Nombre Estación	Coordenadas Geográficas Latitud	Longitud	Coordenadas Planas Norte	Este	Altura Elipsoidal	Zona
BIENES NACIONALES RANCAGUA (BN06)	34° 10' 14.8180"	70° 44' 22.5430"	6217540.359	339665.191	539.541	19

NOTAS: Los valores de coordenadas están referidos a la época 2013.0

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IGM
INSTITUTO GEOGRÁFICO MILITAR
Cartografía Oficial del Estado de Chile

CERTIFICADO DE COORDENADAS GEOGRÁFICAS PLANAS Y ALTURA

13 de noviembre de 2014
O/T Nº 1791-14

Solicitadas por : **MINISTERIO DE BIENES NACIONALES**

Datum : SIRGAS
Elipsoide : GRS-80
Unidad : N, E y Altura en metros

Nombre Estación	Coordenadas Geográficas Latitud	Longitud	Coordenadas Planas Norte	Este	Altura Elipsoidal	Zona
BIENES NACIONALES SANTIAGO (BN13)	33° 26' 35.7477"	70° 38' 47.1931"	6298359.090	346961.542	616.798	19

NOTAS: Los valores de coordenadas están referidos a la época 2013.0

SERGIO ROZAS BORNES
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