2019:00158- Unrestricted

Report

Impact of changing climate on infrastructure in Longyearbyen: stability of foundations on slope terrain – case study

Field and Laboratory Report 2018 – Geotechnical Investigations

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Rock and Soil Mechanics
2018-10-23

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KEYWORDS:
Geotechnics
Field
Laboratory
Permafrost
Slope
Solifluction
Thermistor string

VERSION 1.0	**DATE** 2018-10-23
AUTHOR(S) Anatolii Sinitsyn	
CLIENT(S) Svalbard Environmental Protection Fund Longyearbyen Lokalstyre Store Norske Spitsbergen Kulkompani AS	**CLIENT'S REF.** Heidi Eriksen Kjersti Olsen Ingero Sveinung Lystrup Thesen
PROJECT NO. 102015174	**NUMBER OF PAGES/APPENDICES:** 12

ABSTRACT
SINTEF Building and Infrastructure is performing a study funded by Svalbards Miljøvernfond, Longyearbyen Lokalstyre and Store Norske Boliger AS. The project is named "Impact of changing climate on infrastructure in Longyearbyen: stability of foundations on slope terrain – case study". A part of this project is to collect information of subsoil properties. This report describes the soil investigations performed in spring 2018 in a slope in Longyearbyen.

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APPROVED BY Lisbeth-Ingrid Alnæs	SIGNATURE Lisbeth Alnæs Digitally signed by Alnæs Lisbeth-Ingrid Date: 2019.03.05 15:23:12 +01'00'

REPORT NO.	ISBN	CLASSIFICATION	CLASSIFICATION THIS PAGE
2019:00158	978-82-14-06856-6	Unrestricted	Unrestricted

Document history

VERSION	DATE	VERSION DESCRIPTION
1.0	2018-10-23	Field report

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APPENDICES

1 Introduction

SINTEF Building and Infrastructure is performing a study funded by Svalbard Environmental Protection Fund, Longyearbyen Lokalstyre and Store Norske Boliger AS. The project is named "Impact of changing climate on infrastructure in Longyearbyen: stability of foundations on slope terrain – case study". A part of this project is to collect information of subsoil properties.

The first field campaign took place in spring 2017, results of which are presented in [1].

This report presents results of the field campaign which took place in 2018. Geotechnical soil investigations were performed at the building No.33, road 236 in Longyearbyen. This building was chosen for the case study by the project partners in the project meeting ([2]), which took place on February 14th 2018.

Geotechnical investigations were performed within the AT-205 course "Frozen Ground Engineering for Arctic Infrastructures" at UNIS. Dr. Anatolii Sinitsyn (SINTEF) and Professor Arne Aalberg (UNIS) made planning of fieldworks and laboratory work. The fieldwork was led by Senior Engineer Magne Wold (UNIS) and accomplished by the students. Laboratory work was led by Anatolii Sinitsyn and accomplished by the students.

This report presents summary of three student reports.

2 Background

Background for this fieldwork is presented in [1, 3, 4].

3 Location

The drilling campaign took place at Svalbard in Longyearbyen (see Figure 1). The location of the soil investigation was at the building No.33 in road 236 as shown in Figure 2. Approximate location of the two boreholes made during fieldwork is shown in Figure 3.

Figure 1 Overview map of the Svalbard Archipelago ([5]).

Figure 2. Location of the site in Longyearbyen ([6]).

Figure 3. Approximate location of boreholes at the building No.33 in road 236 ([6]).

4 Fieldwork

4.1 Methods and Equipment

Soil sampling was performed by using auger, and the soil samples were collected from the auger flights.

Fieldwork is performed with SINTEFs custom built Geotech 504 drilling rig. The drilling rig can be disassembled to make it easy to transport in parts with helicopter if necessary. The drilling rig is equipped for different types of drilling and sounding, cone penetration testing, permafrost coring and conventional piston sampling. The drilling rig in operation at the building No.33 in road 236 is shown in Figure 4.

Figure 4. Fieldwork at the building No.33 in road 236.

4.2 Borehole information

Two boreholes have been drilled at the site of field investigations (see Figure 3), and the coordinates for the boreholes based on measurements with hand-held GPS are presented in Table 1.

Table 1. Borehole information.

Borehole	Drilled depth	Elevation above sea level (m.a.s.l.[1])	Latitude	Longitude	UTM 33	UTM 33
	m	m	degrees	degrees	East	North
A	4,6	45,5	78.2182600	015.6560400	514953.35	8682811.51
B	3	40,7	78.2180800	015.6562600	514958.58	8682791.48

Plastic casing for deployment of thermistor string was installed in borehole A.

[1] m.a.s.l. – mean average sea level.

The samples were kept in sealed plastic bags in a freezing room, to keep their properties and to avoid moisture loss. Different laboratory tests were carried out on these samples to make the soil classification possible. Overview of soil samples is presented in Table 2.

Hard soil, identified as a bedrock, was encountered at the depth 4.6 in borehole A.

Table 2. Overview of soil samples.

Sampling depth, m	
Borehole A	**Borehole B**
0.0 – 0.5	0.0 – 1.0
0.5 – 1.0	1.0 – 2.0
1.0 –1.5	2.0 – 2.6
1.5 – 2.0	
2.0 – 2.5	
2.5 – 3.0	
3.0 – 3.5	
3.5 – 4.05	
4.05 – 4.8	

5 Laboratory work

The laboratory work has been performed within the AT-205 course at UNIS. Laboratory tests were performed based on the ASTM standards where possible. The following parameters were determined:

- The total water content is defined by the ratio of weight of water in soil to the mass of dry solids. Mass of dry soil solids was obtained by drying the soil sample at 110 °C for 24 hours.
- Density of soil particles was measured with the use of pycnometer.
- Salinity was measured in some cases by handheld refractometer, or by conductivity meter. For refractometer measurements the pore moisture was extracted by compressed air from thawed soil sample placed in a small (ca 50 ml) custom-made chamber. For conductivity meter measurements the sample of soil was diluted in distilled water (mass of distilled water was 10 times the mass of soil), of which conductivity was measured afterwards.
- Grain size distribution was measured by combined wet sieving and hydrometer.
  Wet-sieving is performed for particles down to a grain size of 0,074 mm, and hydrometer analyses has been performed on the part of the sample smaller than 0,074 mm. Soil was classified according to the Unified Soil Classification System.
- The liquid limit was obtained by using the Casagrande cup.
- The plastic limit was obtained by rolling of soil threads.
- Freezing point depression was obtained by the cooling curve.

Overview of laboratory tests is presented in Table 3.

Table 3. Results of laboratory tests.

	The total water content, *w*, %	**Density of soil particles, ρ_s, kg/m^3**	**Salinity, %**	**Grain size distribution (sieving and hydrometer)**	**The liquid limit, w_l %**	**The plastic limit, w_p %**	**Freezing point depression, °C**
Borehole A, sampling depth, m.							
0.0 – 0.5	101,5						
0.5 – 1.0	78,5	2620	0.08	Silt or silt-clay of low plasticity (OL)	38	11	0
1.0 –1.5	54,9						
1.5 – 2.0	25,7	2724	0,6	Inorganic silt or clay, border line case ML-CL	18,5*	14,6*	0
2.0 – 2.5	26,8	–	–	–	–	–	–
2.5 – 3.0	25,4	–	–	–	–	–	–
3.0 – 3.5	21	2786	0.3	Sand with fines, border line case, SM or SC	–	–	0
3.5 – 4.05	23	–	–	–	–	–	–
4.05 – 4.8	14	–	–	–	–	–	–
Borehole B, sampling depth, m.							
0.0 – 1.0	5			Gravel (visual observations)	NA	NA	NA
1.0 – 2.0	11			Gravel (visual observations)	NA	NA	NA
2.0 – 2.65	8,2		0.012	Fine-grained soil	–	–	–

Note: * - results of these tests were considered to be possibly corrupted.

6 Thermistor installation and readings

A thermistor string (Geo Precision GmbH), serial number A538B5, access code 94B3 was installed in the borehole "A".

The thermistor string is composed from M-Log5W-DALLAS mini logger, DALLAS sensors (resolution 0,065 °C, accuracy +/- 0,5 °C from -10 to +60 °C. Data downloading is carried out via wireless USB adapter FGII, software FG2_Shell is available for downloading at: ftp://80.153.164.175/GeoPrec/Docu_Software/GP_Wireless .

Elevations of the sensors with reference to the ground level are presented in Table 4.

The thermistor was tested in an ice bath (ca 10 l of crushed ice–water mixture, ca 90% crushed ice, minimum duration of test – 1 h). Actual duration of test was 2 h 15 min. Readings from the thermistor string were taken for each minute, average readings for each thermistor sensor are presented in Table 4. Calculations are presented in the attached Excel file "Calibration_A538B5".

One can see that the readings deviate from 0 °C, hence corresponding individual corrections for each sensor were introduced into the program of device (i.e. data from the device does already include mentioned corrections). It is assumed (based on information from Geo Precision GmbH) that the off-set at 0 °C remains constant through the total calibration curve.

Table 4. Readings on thermistor string in the end of test in the ice bath.

Sensor	Elevation of the sensor with reference to the ground level, m	Mean reading at 0 °C	Off-set introduced in the software, °C	Standard deviation of the mean readings (SD)	Readings on Oct 222018, including introduced off-set, °C
#1	+0,4 (on the outer wall of casing)	0,31	-0,31	0,01	3,31
#2	-0,02	0,04	-0,04	0,03	0,46
#3	-0,02	0,37	-0,37	0,00	1,06
#4	-0,02	0,22	-0,22	0,03	0,71
#5	0,00	0,82	-0,82	0,02	1,49
#6	-0,2	0,10	-0,10	0,03	0,02
#7	-0,4	0,23	-0,23	0,03	-0,05
#8	-0,6	0,27	-0,27	0,03	-0,15
#9	-0,8	0,18	-0,18	0,1	-0,30
#10	-1,0	0,08	-0,08	0,03	-0,39
#11	-1,2	0,26	-0,26	0,26	-0,51
#12	-1,4	0,06	-0,06	0,01	-0,62
#13	-1,6	0,13	-0,13	0,02	-0,69
#14	-1,8	0,11	-0,11	0,02	-0,86
#15	-2,0	0,14	-0,14	0,03	-0,89
#16	-2,2	0,10	-0,10	0,03	-1,03
#17	-2,4	0,17	-0,17	0,02	-1,10
#18	-2,6	0,25	-0,25	0,01	-1,18
#19	-2,8	0,09	-0,09	0,03	-1,21
#20	-3.0	0,15	-0,15	0,03	-1,32
#21	-3,5	0,04	-0,04	0,03	-1,47
#22	-4,0	0,06	-0,06	0,01	-1,62
#23	-4.6	0,12	-0,12	0,00	-1,80

The calibrated thermistor string was installed in a 50mm diameter plastic casing in Borehole A on October 21nd 2018. Reading of temperature from the thermistor string in the "air-filled" casing was performed on

October 22nd 2018 (see Table 4), and is shown in Figure 5. Ground temperature at the depth -4.5 m was recorded as -1.8 °C.

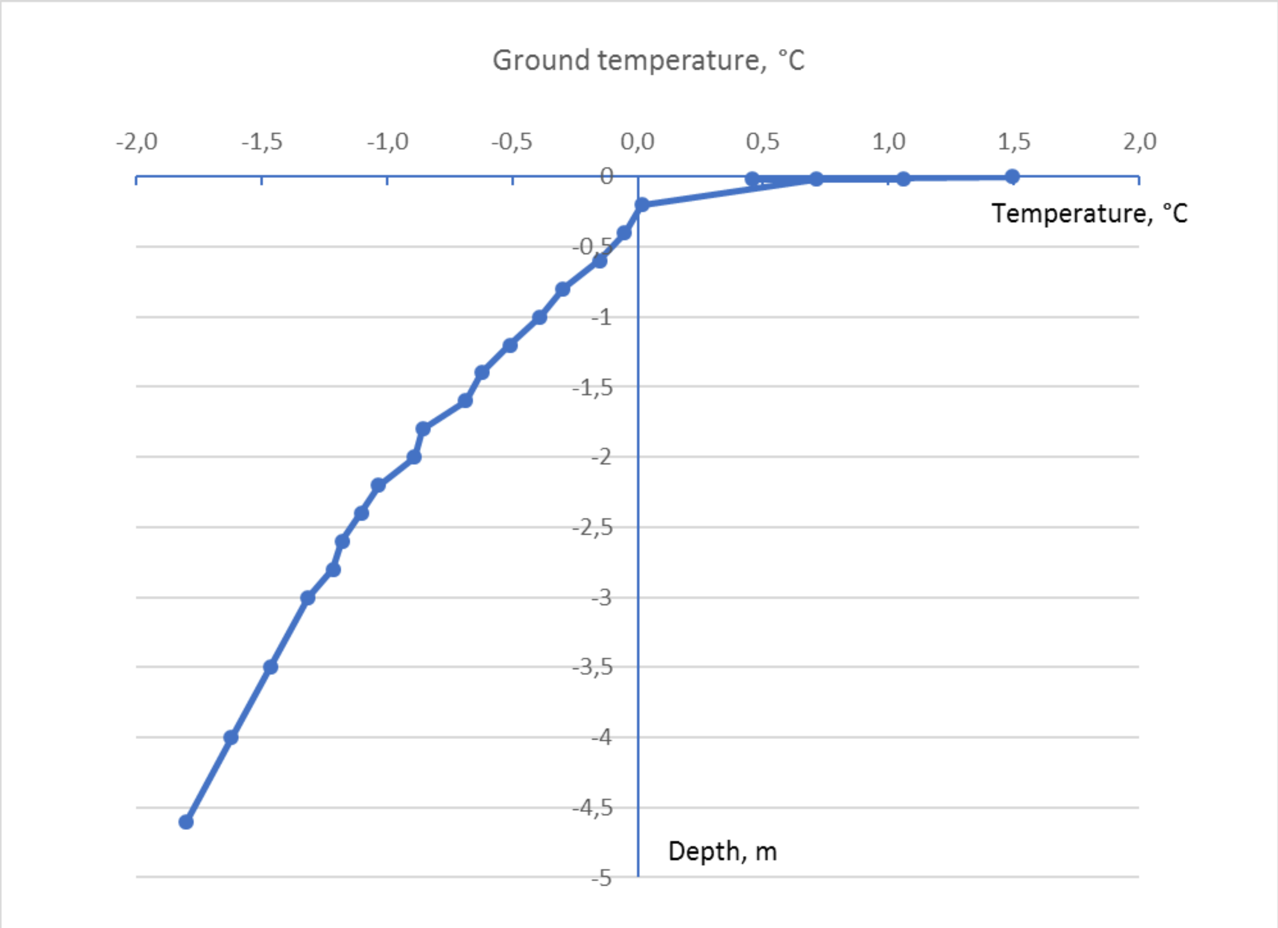

Figure 5. Ground temperatures in Borehole A on Oct 22nd 2018.

Acknowledgements

The financial support for this study from Svalbard Miljøvernfond, Longyearbyen Lokalstyre and Store Norske Spitsbergen Kulkompani AS is greatly acknowledged. The field and laboratory work of AT-205 students is greatly appreciated.

Report information

Svalbard's Miljøvernfond project number: 16/87.
SINTEF project number: 102015174.
RiS database project number: 10968.

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