University Centre in Svalbard

AT – 329

"Cold regions field investigations"

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As built control of the foundation pilings for Forskerhotellet

Group report by

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Task:

As field work for the DGPS part of the AT-329 Course "Cold regions field investigations" at the University centre of Svalbard (UNIS) an "as built" control of the foundation pilings for the Forskerhotellet was carried out. It is located close to the UNIS building below the Radisson hotel. Each group measured the position of twenty piles with a Leica Geosystems differential GPS. Exact positions were calculated in post processing.

The location of the measured piles is given by the red lines and numbers in the overview map. Unfortunately the used datum is unknown, and the shown coordinates on the map do not match the measured UTM (Euref89) coordinates.

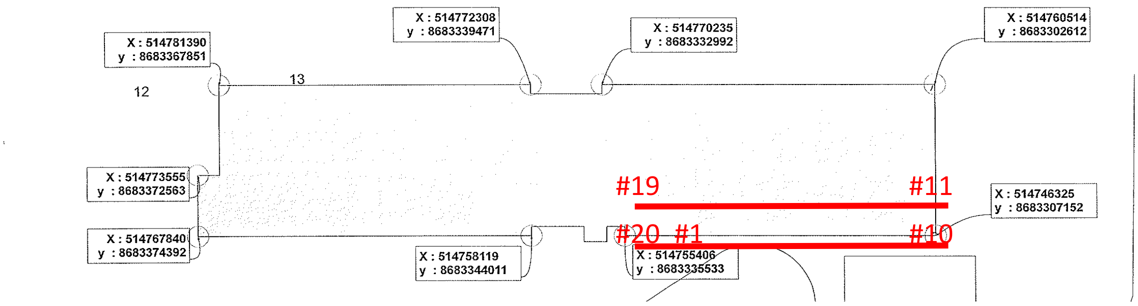


Fig. 1: Building plan of the forskerhotellet in Longyearbyen. Vei-100 is located on the lower edge of the map. Given UTM positions are not in EUREF-89 but probably a unknown local version of ED-50

Methods:

Fieldwork

The DGPS measurements where carried out with a Leica Geosystems phaseGPS receiver with a high accuracy. In post processing the data from the receiver was correlated to another fixed DGPS receiver on the known point NP124 near the Sysselmannen building only several hundred meters away from the building site. The coordinates of that point are well determined and given by:

Euref89-XYZ:	X=1257853.169	Y=351831.278	Z=6222104.929
Euref89-UTM:	Zone=33X	N=8683206.071	E=514280.722

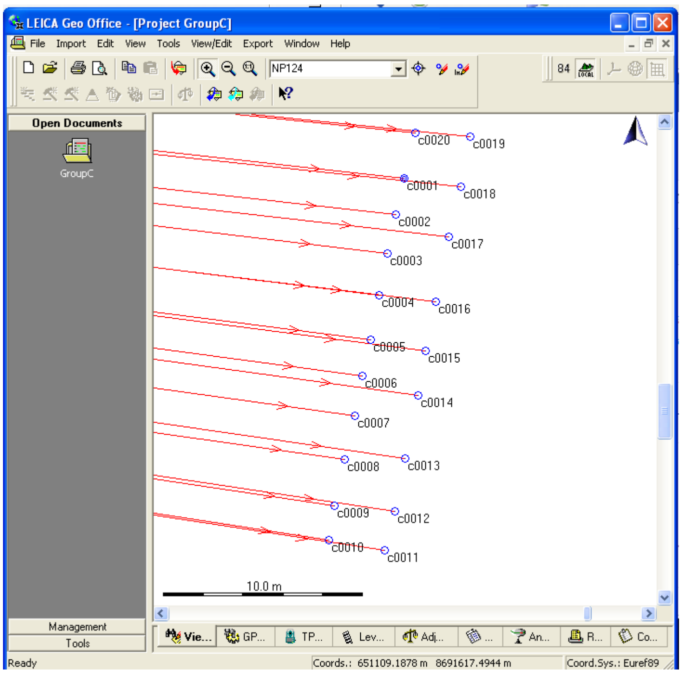
The DGPS was mounted in a height of 185 cm on a pole and was placed as close as possible beside the measured piles in a position 90 degrees out of line on the side not facing the adjacent road (Vei-100). As only relative positioning was controlled, this correction was not corrected in the measured pile positions. The wooden piles slightly shaded the sky view of the sensor but the signal quality was not reduced. Between 8 and 10 satellites in both bands L1 and L2 were reachable during the survey. As the field work was carried out during normal university schedules, a detailed previous mission planning to determine the best satellite constellations was not carried out. This reduces the total accuracy a bit, but the accuracy is still better than we were able to hold the sensor pole in a perfect position. Theoretical accuracy was determined in post processing.

Fig. 2: GPS measurements of the piles

Each position was measured for one minute, while positions 1 and 19 were measured for ten minutes to check if the system is working correctly.

The GPS sensors were configured with the following settings:

Parameters	Used
Cut-off angle:	15°
Ephemeris type (GPS):	Broadcast
Ephemeris type (GLONASS):	Broadcast
Solution type:	Phase: all fix
GNSS type:	GPS
Frequency:	Automatic
Fix ambiguities up to:	80 km
Min. duration for float solution (static):	5' 00"
Sampling rate:	2 sec
Tropospheric model:	Hopfield
Ionospheric model:	Computed
Use stochastic modelling:	Yes
Min. distance:	8 km
Ionospheric activity:	Automatic



Postprocessing:

The measured data was imported into the "Leica Geo Office" software where the Field measurements were correlated to the fixed and known position of the GPS receiver at the control point NP124 and exported again to transform the coordinates back into EUREF89-UTM coordinates and appropriate heights above sea level with the official WKSTRANS software from the Norwegian mapping authorities.

Fig. 3: Postprocessing of data in Leica Geo Office

Results:

The postprocessing revealed the following positions of the points:

EUREF89-UTM (Zone-33)

Point #	North	East	Ell. height
c0001	8683123.3039	514677.7372	43.8033
c0002	8683121.5046	514677.1580	43.9441
c0003	8683119.6163	514676.5472	44.0132
c0004	8683117.5876	514675.9165	44.1459
c0005	8683115.4155	514675.2784	44.1704

c0006	8683113.6369	514674.6792	44.2142
c0007	8683111.6989	514674.1036	44.3573
c0008	8683109.5692	514673.3650	44.4434
c0009	8683107.3197	514672.6210	44.5387
c0010	8683105.6246	514672.1316	44.6453
c0011	8683104.8243	514674.8520	44.6966
c0012	8683106.7264	514675.5626	44.5509
c0013	8683109.3107	514676.3651	44.4790
c0014	8683112.4027	514677.3553	44.3958
c0015	8683114.5622	514677.9362	44.2373
c0016	8683116.9516	514678.7025	44.1687
c0017	8683120.1325	514679.6785	43.9450
c0018	8683122.5511	514680.5274	43.8873
c0019	8683125.0220	514681.2419	43.7281
c0020	8683125.5018	514678.5296	43.7645

As an official transformation from ED50-UTM to EUREF89-UTM is not established, the positions were transformed to ED50 positions with the following conformal Hilbert-Transformation on the 2 control points NP124 and NP136:

$$N_{OLD} = 278.1890 + 0.9999920655 \cdot N_{NEW} - 1.33007 \cdot 10^{-5} \cdot E_{NEW}$$

$$E_{OLD} = -36.0839 + 1.33007 \cdot 10^{-5} \cdot N_{NEW} + 0.9999920655 \cdot E_{NEW}$$

This transforms the coordinates to:

ED50-UTM	North	South
c0001	8683325,751	514753,0612
c0002	8683323,952	514752,482
c0003	8683322,064	514751,8712
c0004	8683320,035	514751,2404
c0005	8683317,863	514750,6023
c0006	8683316,084	514750,0031
c0007	8683314,146	514749,4275
c0008	8683312,017	514748,6889
c0009	8683309,767	514747,9448
c0010	8683308,072	514747,4554
c0011	8683307,272	514750,1758
c0012	8683309,174	514750,8864
c0013	8683311,758	514751,6889
c0014	8683314,85	514752,6792
c0015	8683317,009	514753,2601
c0016	8683319,399	514754,0264
c0017	8683322,58	514755,0025
c0018	8683324,998	514755,8514
c0019	8683327,469	514756,5659
c0020	8683327,949	514753,8536

These calculated values almost match the UTM position given in an unknown datum on the overview map at pile 10:

measured and transformed to inofficial ED-50:	N: 8683308,072	E: 514747,455
from overview map (unknown datum):	N: 8683307,152	E: 514746,325
measured and transformed with WKStrans (ED-50):	N: 8683313.192	E: 514735.974

It seems like the given overview-map uses a local inofficial ED-50 datum but with a slightly different transformation formula, as the diferrence to our calculated ED-50 is about 1 meter. Due to this, the exact total positioning of the building cannot be determined on this databasis.

Heights:

As GPS measurements give only the ellipsoidal height, the measured heights have to be transformed. As there is no official height model in use on Svalbard, the conversion was done by comparison with the three control points in the surrounding (NP124, NP136, BH82). In the surroundings of Longyearbyen the ellipsoid is located 31,7m below mean sea level. This leads to the following heights:

Point	Ellipsoidal height	Height above mean sea level
c0001	43,8033	12,1033
c0002	43,9441	12,2441
c0003	44,0132	12,3132
c0004	44,1459	12,4459
c0005	44,1704	12,4704
c0006	44,2142	12,5142
c0007	44,3573	12,6573
c0008	44,4434	12,7434
c0009	44,5387	12,8387
c0010	44,6453	12,9453
c0011	44,6966	12,9966
c0012	44,5509	12,8509
c0013	44,479	12,779
c0014	44,3958	12,6958
c0015	44,2373	12,5373
c0016	44,1687	12,4687
c0017	43,945	12,245
c0018	43,8873	12,1873
c0019	43,7281	12,0281
c0020	43,7645	12,0645

The GPS data processing reveals an accuracy of height data of about half a centimeter. Again the positioning of the pole is by far not as precise at the measuring system could be, due to snow, ice and mud on the ground surface.

Precision of the piling:

The horizontal accuracy of the GPS measurement is calculated by the Geo Office software to around 1cm but the positioning of the sensor had only an accuracy of maybe ± 2-3 cm because of heavy wind conditions on the survey site. Positioning the sensor on a tripod would have delivered a higher accuracy. Still the accuracy is big enough to judge the precision of the foundation piling work:

The following numbers were calculated:

- Deviation from plan concerning distance between the piles along the line.
- Deviation from plan concerning distance to a corner pile along the line.
- Distance from the average (planned) line.

The numbering of the piles is counter clockwise like indicated in the map above:

Pile #	Deviation between piles [mm]	Deviations to a corner pile[mm]	distance from the line [mm]
c0020		114,0884	-16,7254
c0001	76,378	190,4664	66,02083
c0002	-49,7743	140,6921	67,58161
c0003	-110,371	30,32143	72,02999
c0004	19,47786	49,79929	52,51027
c0005	3,888253	53,68755	-3,80153
c0006	-63,1786	-9,49105	23,13355
c0007	-18,3276	-27,8186	-21,1364
c0008	94,14109	66,32246	31,22571
c0009	324,343	390,6655	52,11945
c0010	-390,665	0	0
c0011	120,6756	0	0
c0012	-124,498	124,4984	-95,3576
c0013	51,03266	73,46574	-69,5396
c0014	-53,3155	126,7813	-67,3257
c0015	-93,7341	220,5154	39,62432
c0016	249,2724	-28,757	40,26842
c0017	12,26627	-41,0233	83,17024
c0018	-21,7487	-19,2746	14,07253
c0019	312,1308	331,405	88,97624

The deviations are generally not exceeding much about more than ten centimeters, some are displaced a bit more along the line. Perpendicular to the lines, the difference is small (<10cm) and the distance between the lines (marked yellow in the table) is also almost as planned. All deviations should be no problem for building the structure, as the piling is done with a precision above average.

Discussion:

The method used in the field could have been better, we could have used a tripod to a certain height to position the GPS receiver with more accuracy. Moreover we could have placed the receiver on top of the piles instead of adding a certain distance in a certain direction to the measurements; this would have been more accurate. The positioning of the GPS device on the control point NP124 is very important as well because if an error is done on this point it will have some repercussions on all the other points we measured.

The cut off angle used was 15 degrees and the logging time interval was 2 seconds. This allows very accurate results. The total logging time was 10 minutes on the first point of each line which is more than enough and then 1 minute on each pile. The advantage is that it is quite fast and accurate for what we need. If we would have to done a work that needed to be more accurate we would have to use more logging time for each pile and another method for positioning the GPS receiver on the control point and on the measured points.

We used a given formula to transform the points from EUREF89 to ED50. And this formula was made using two known points in EUREF89 and ED50, it would have been more accurate to use more points to establish the formula and to do an average. Moreover this formula is a very local formula for Svalbard.

Concerning the height, there is no geoidal height model for Svalbard, so we have to take the closest measured point to establish our height above mean sea level: NP124. With a geoid height model it would have been more accurate since the height above sea level is could change even at this very short distance.