TIME MONITORING OF THE COMERCIAL COMPLEX CORA

Ioana Andreea Bonța*

*Stuttgart University, Geschwister-Scholl-Str. 24D-70174 Stuttgart
E-mail: andreea_bonta@yahoo.com

Abstract
The paper is called "Time monitoring of the commercial complex Cora", and the construction in case was built on an old garbage dump, situation that makes that the complex need a close monitoring. "Cora" Complex is situated in Pantelimon district in Bucharest and the first measurements on this building were made in April 2003. In its approach, the overall objective was to present methods of determining the settlements for the construction in question, their determination and deformation analysis. All the operation necessary for time monitoring were used; the study is focusing on two cycles of measurements (November 2011 and February 2012) but is taking in consideration also all the measurements done until this dates. Post-processing was made with HANNA program and analysis deformation was made applying the global test of congruence. The overall result was that we have no major deformations but still, some of the leveling marks had suffered vertical changes.

Keywords: settlement, deformation, monitoring

1. INTRODUCTION

Since the design phase of a building, strength and stability computations are made. These are verified by measurements that are performed either on experimental research, either on objects in nature.
Periodic measurements and observations in the execution phase of the construction or in the exploitation phase certify or deny the correctness of the construction system and calculation assumptions that should be considered in design.
Under the action of gravity forces of the building, due to changes in humidity and temperature of the foundation soil or due to disasters, displacement of soil particles can occur that will lead to settlement, bulging or displacement of the field. As a result of the movement of the soil foundation, terrestrial movements or movements of some parties of the foundation of buildings occur.
Results from experimental tests, data from statistical calculations and also measurements performed on objects, help at finding a diagnosis of the current behavior of the construction or its behavior over time. Experience has shown that all buildings and constructions are subject to displacements and deformations. A stationary and non-deformable construction does not exist in nature!

2. MATERIAL AND METHOD

Methods for determining absolute size and direction of displacement of a building site area are in most cases topographical surveying methods. In determining settlements, topographical-surveying measurements that are used, vary depending on the conditions, the desired precision and technology work. Thus, we encounter three methods for determining settlements: geometric leveling, trigonometric leveling and hydrostatic leveling; benchmarks for subsidence are installed in the building structure, marks that are observed periodical in order to determine their heights. When measuring the heights, in most cases, *geometric leveling method*, with high precision small visas is used. Measurements for time monitoring of a building are usually made by making leveling observations on marks that are placed on the building. Marks are fixed inside the building, based on the project made before measurements start, a project regarding how measurements should be made. These cues embedded in construction, usually called settlement marks, will go along with the construction, so that the observation will determine the periodic movement of some parts of the building or even for the whole building.

For time monitoring of the “Cora”, settlements marks were placed outside and on all sides of the construction. Also, marks were placed inside the pillars of the resistance structure in order to monitor the behavior of the whole structure. Marks on the side of the building are located at a distance of 20-60m. Reference marker is located outside the area of influence of construction in the south part of the complex, and it is a landmark of depth.
For the measurements, we used a digital geometric precision leveling tool, Topcon DL-101C and stadia with barcode of 2 m. The instrument provides a standard deviation of 0,4 mm/double km of leveling.

Figure 1. Topcon DL-101C

Being a newly built complex, also the subsidence phenomenon is more intense, thing that led to the proposal of making measurements every 3 months.
Precision geodetic leveling was performed, where the principle of equal sides was followed and that the maximum length should be 30m. As the reference benchmark, the depth benchmark RN1, located in the southern part of the complex was used.
In this type of measurements, at least 3 benchmarks should be used, but because the others were destroyed during the construction of the complex, and because is a depth benchmark (is very stabile), RN1 was enough.
Two leveling networks closed on the starting point were made. The poligonometric measurements respected the conditions required by STAS 1745/90 for settlement determination with high precision. Condition were created to be stationed all settlements marks that on which determinations were made in previous cycles , though in some marks, measurements were hampered by mounting various items next to them or on them. Also difficulties were encountered when measuring in some areas (deposit areas inside the complex) due to low visibility conditions. Reduced visibility or impossibility of performing measurements may affect the accuracy of determining the height of the marks.

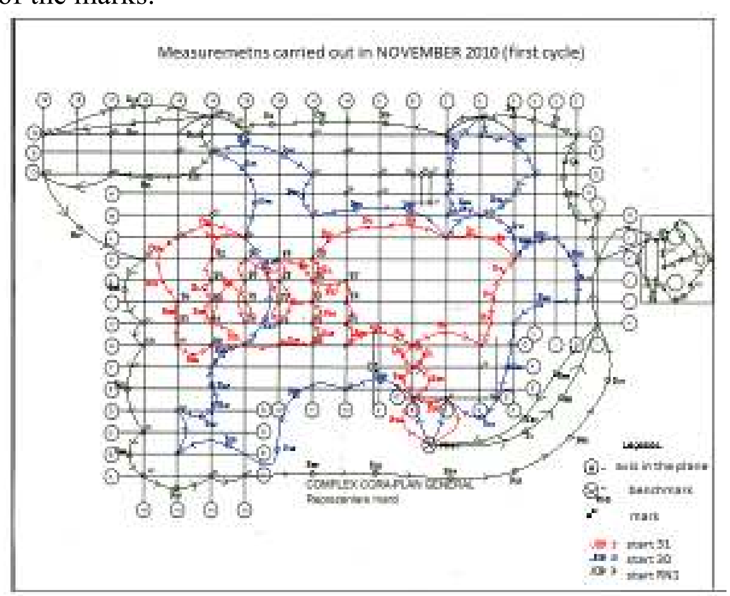

Figure 2. Cycle 33 of measurements

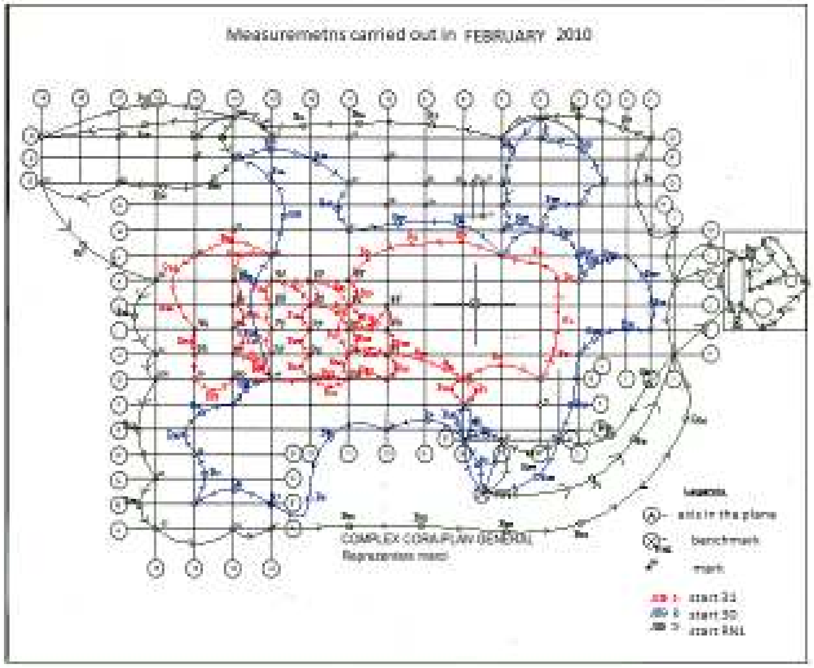

Figure 3. Cycle 34 of measurements

For the study of deformations, the following configuration for leveling was chosen for both cycles of measurements.

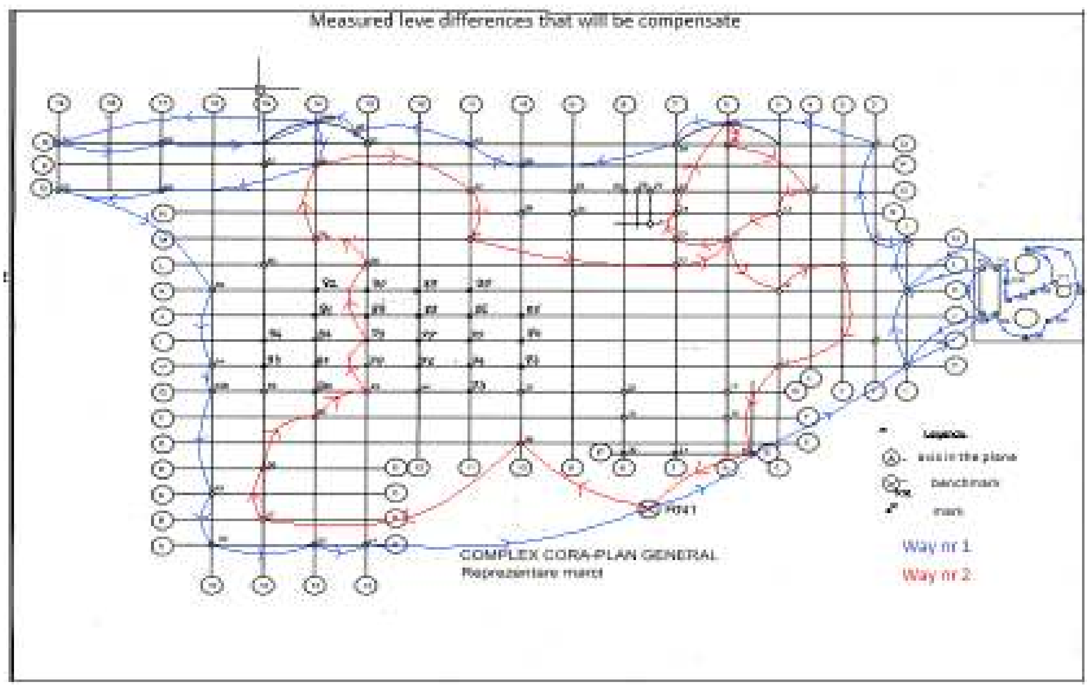

Figure 4. Measured level differences that will be post-processed

3. RESULTS AND DISCUSSIONS

For processing the geometric leveling measurements, HANNA compensation program was used; program that is based in the processing of the indirect measurements.

Entry data for processing is a txt file in a notepad format, and is shown in the figure below:

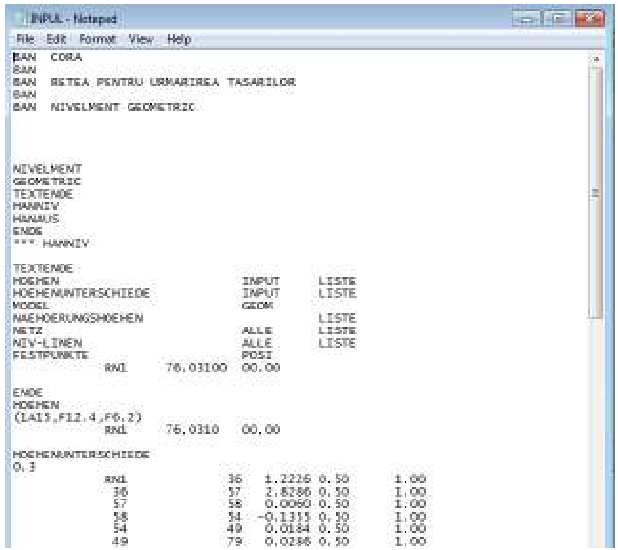

Figure 5. Introducing data in Hanna

After processing with Hanna program, will get compensated level differences, the deviations that determine each level difference, compensated heights of the marks and also the program provides the corrections that were applied.

Table 1. Data provided by Hanna for Job 3(cycle 33)

Nr	**From**	**To**	**Δhij(m)**	**v(mm)**	**mm**
1	RN1	36	1.22264	0.04	0.3
2	36	57	2.82864	0.04	0.3
3	57	58	0.00604	0.04	0.3
4	58	54	-0.13546	0.04	0.3
5	54	49	0.01844	0.04	0.3
6	49	79	0.02864	0.04	0.3
7	79	50	0.07304	0.04	0.3
8	50	56	0.01354	0.04	0.3
9	56	42	-0.00834	0.06	0.29
10	42	41	-0.00914	0.06	0.29
11	41	22	-0.05294	0.06	0.29
12	22	18	-0.05184	0.06	0.29
13	18	23	-0.45269	-0.19	0.28
14	23	24	0.01251	-0.19	0.28
15	24	25	-0.07099	-0.19	0.28
16	25	20	0.56181	-0.19	0.28
17	20	19	0.04332	-0.08	0.28
18	19	8	-0.05968	-0.08	0.28
19	8	13	-0.11408	-0.08	0.28
20	13	18	0.79820	-0.08	0.28
21	18	12	-0.21523	0.17	0.29
22	12	7	0.22367	0.17	0.29
23	7	4	-0.02043	0.17	0.29
24	4	11	-2.79093	0.17	0.29
25	11	15	0.32370	0.17	0.29
26	15	RN1	1.16272	-0.38	0.21

Table 2. Heights of marks after processing (cycle 33)

Nr	Mark	Hi[m]	x_i[mm]	Q_{xi}	S_{hi}[mm]
1	RN1	76.031	0.0	0.0821	0
2	36	77.2536	0.0	0.1484	0.3
3	57	80.0823	0.1	0.199	0.4
4	58	80.0883	0.1	0.2337	0.5
5	54	79.9529	0.2	0.2527	0.5
6	49	79.9713	0.2	0.2559	0.5
7	79	79.9999	0.2	0.2433	0.5
8	50	80.073	0.3	0.2149	0.5
9	56	80.0865	0.3	0.2511	0.5
10	42	80.0782	0.4	0.264	0.5
11	41	80.069	0.4	0.2534	0.5
12	22	80.0161	0.5	0.2195	0.5
13	18	79.9643	0.6	0.2649	0.5
14	23	79.5116	0.4	0.2809	0.5
15	24	79.5241	0.2	0.2676	0.5
16	25	79.4531	0.0	0.2249	0.5
17	20	80.0149	-0.2	0.2676	0.5
18	19	80.0582	-0.3	0.2809	0.5
19	8	79.9985	-0.4	0.2649	0.5
20	13	79.8844	0.6	0.2239	0.5
21	12	79.749	0.7	0.2084	0.5
22	7	79.9727	0.9	0.173	0.5
23	4	79.9523	1.1	0.1178	0.4
24	11	77.1614	1.3	0.0427	0.4
25	15	77.1937	-0.4	0.1188	0.2
26	1	77.1692	-0.3	0.1529	0.4
27	101	77.3861	-0.3	0.2297	0.4
28	103	77.4236	-0.4	0.2913	0.5
29	107	76.9676	-0.4	0.3376	0.6
30	109	76.968	-0.5	0.3687	0.6
31	112	76.9738	-0.6	0.3846	0.6
32	110	76.9359	-0.7	0.3853	0.6
33	111	76.9697	-0.8	0.3707	0.6
34	106	76.9383	-0.9	0.3409	0.6
35	105	76.9725	-0.9	0.2959	0.6
36	108	76.934	-1.0	0.2357	0.6
37	104	77.3935	-1.1	0.1602	0.5
38	2	77.193	-0.1	0.1843	0.4
39	102	77.424	-0.2	0.2046	0.5
40	3	77.1469	0.0	0.2302	0.5
41	5	77.1603	0.1	0.237	0.5

The same steps were made also for the measurements from cycle 34 (February 2012).
In order to analyze the deformations that occur in both stages of measurements, I used the global test of congruence. For this, the two networks were considered to have the same configuration and the same datum (initial heights were considered to be the same for both cycles). Global congruence test involves applying the statistical test "Fischer" that can tell us if between two cycles of measurements changes have occurred. To be able to apply Fischer test, vector of discrepancies (d), cofactor matrix (Q_{dd}) of the discrepancies vector and standard deviation for each epoch(s_o) is needed.

$\mathbf{d^T * Q_{dd} * d =}$ 0.011494

$\mathbf{s_{0(november)}} =$ 1.03 mm/km

$\mathbf{s_{0(february)}} =$ 1 mm/km

$\mathbf{s_0^2} =$ 2.0609 mm.km

h= 54

$\mathbf{F_{computed}} =$ 0.000197

$\mathbf{F_{test}} =$ 1.535345

After comparing the actual value with the the limit value F I concluded that networks are congruent, so there are no deformations.
Although the application of the global congruence test revealed that no deformations exists, I applied the "Student" test to see which are the marks that have suffered some deformations, and I concluded that some of them have suffered displacements.
To see which marks are moved I calculated the test size "t" for each point of the network, value that I had to compare it with a theoretical value that depends on the degrees of freedom "f" and risk coefficient "α=0.05".

Table 3. Deforamtion localization by applying Student test (not or the result are presents- all marks that suffered displacements are presented in this table)

Nr	Mark	S_{mark}(mm)	t_{mark}(mm)	T_{test}	Conclusion
1	RN1	1.04	0.0000	1.99773	stabile
2	36	1.40	-0.7122	1.99773	stabile
3	57	1.63	-1.7224	1.99773	stabile
4	58	1.76	-0.8513	1.99773	stabile
5	54	1.83	0.6004	1.99773	stabile
6	49	1.84	-0.3255	1.99773	stabile
7	79	1.80	0.5563	1.99773	stabile
8	50	1.69	-0.5919	1.99773	stabile
9	56	1.83	-0.3833	1.99773	stabile
10	42	1.87	-0.5341	1.99773	stabile
11	41	1.83	-0.0545	1.99773	stabile
12	22	1.71	-0.4685	1.99773	stabile
13	18	1.88	-0.4798	1.99773	stabile
14	23	1.93	-0.5177	1.99773	stabile
15	24	1.89	-0.7957	1.99773	stabile
16	25	1.73	-1.6200	1.99773	stabile
17	20	1.89	-0.2652	1.99773	stabile

18	19	1.93	-1.1390	1.99773	stabile
19	8	1.88	-0.8530	1.99773	stabile
20	13	1.72	0.0000	1.99773	stabile
31	112	2.26	-1.4159	1.99773	stabile
32	110	2.26	-1.5915	1.99773	stabile
33	111	2.22	-1.3070	1.99773	stabile
34	106	2.13	-1.2689	1.99773	stabile
35	105	1.98	-2.0681	1.99773	*moved*
36	108	1.77	-1.5261	1.99773	*moved*
37	104	1.46	-2.1251	1.99773	*moved*
38	2	1.56	-1.9174	1.99773	stabile
39	102	1.65	-1.6985	1.99773	stabile
40	3	1.75	-1.4869	1.99773	stabile
41	5	1.77	-2.8183	1.99773	*moved*
42	6	1.85	-2.4348	1.99773	*moved*
43	28	1.88	0.0000	1.99773	stabile
:	:	:	:	:	stabile
55	47	0.63	1.4252	1.99773	stabile

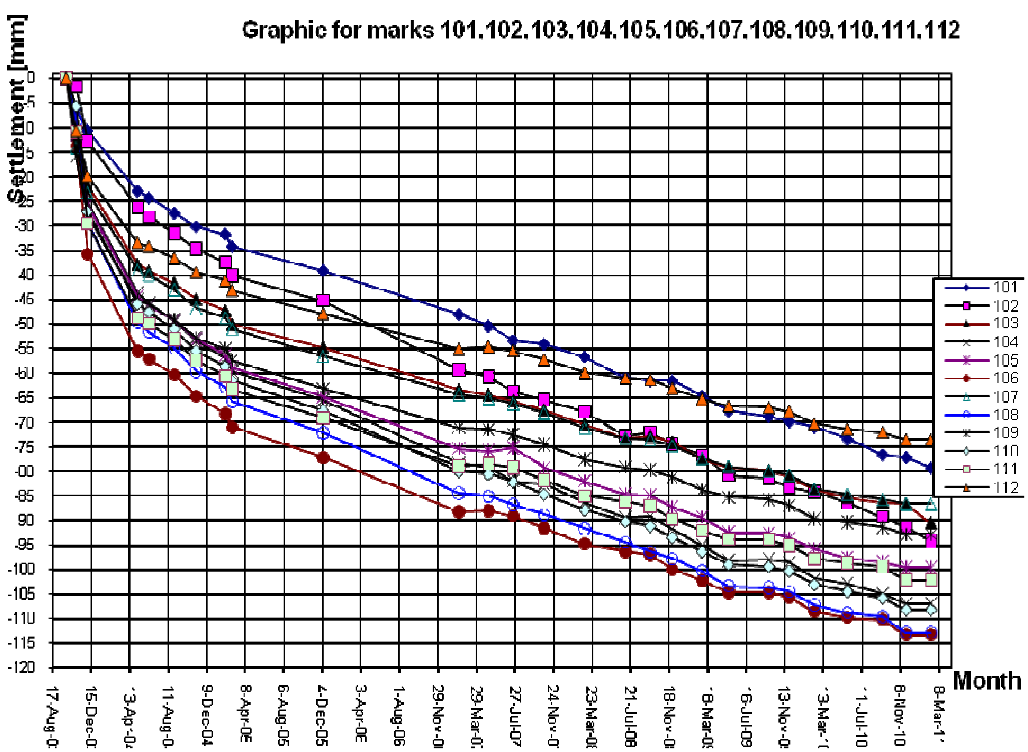

Figure 6. Graphic showing settlements in reservoir area

4. CONCLUSIONS

After analyzing the result obtained with the Student test shown above, we see that there are settlements in the reservoir area, located in the east part of the complex, settlements that are insignificant for the area of interest.

In order to provide a complete picture of the phenomenon of subsidence, I draw graphics that are grouped in various area of the commercial complex. Absolute settlements vary from the initial cycle with values between 0.00 and 113.7 mm in the area of study. The analysis of the values made on the adjacent pillars in the same area, shows a similar trend in the process.

5. ACKNOWLEDGEMENTS

The measurements were made with the help and the instruments of Technical University of Civil Engineering Bucharest.

6. REFERENCES

Coşarcă.C. (2003) Topografie Inginerească, MATRIX ROM Bucharest.

Danciu V. (2008-2009) notes Compensarea măsurătorilor şi statistică matematică.

Dragomir P. (2009) Bazele măsurătorilor inginereşti, Conspre.

Moldoveanu M. (2002) Geodezie-Noţiuni de geodezie fizică şi elipsoidală, MATRIX ROM Bucharest.

Neamțu M, Onose D, Neuner J. (1988) Măsurarea topografică a deplasărilor şi construcțiilor, Construction Institut Bucharest.

Online: www.scribd.com. Topcon DL-101C/102 C Manual.

Online: http://www.ngs.noaa.gov/heightmod/Leveling/leveling_index.html.