Displacement monitoring on surrounding buildings of an excavation using a total station

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Abstract: *In present, the engineering structures such as buildings, tunnel walls, bridges, railroad tracks are monitored for ensuring early warning of structural failure. The displacements of the structures are measured currently by using accelerometers, GNSS and geodetic total stations. In this paper, the monitoring and analysis results of displacement, which are created by the underground parking construction locates in Kağıthane-Yeşilce District (Istanbul, Turkey), on the surrounding buildings by using total station are presented. Total station is a measurement device which defines the coordinate of a point indirectly from measured angles and distances. Total station measures the distance by using the travel time of a light wave for reaching a point (monitoring prism) and reflecting back. In this study, 20 monitoring prisms were mounted to four surrounding buildings of the exaction area. The buildings were monitored for 13 days (from 06.07.2017 to 29.07.2017) and the interval of the measurements was 20 hours. Finally, the displacements of the buildings are found generally at north directional and 2D and 3D displacements are monitored in the buildings.*

I. Introduction

The total station is used for monitoring the movements of the engineering structures such as bridges [e.g. 1,2], dams [e.g. 3] railways [e.g. 4], buildings [e.g. 5, 6], besides, for monitoring the landslide [e.g. 7], for archeological sites [e.g. 8, 9], for volume calculations [10]. Additionally, total station is applied as a tool for geologic mapping [e.g. 11, 12], topographic surveys, stream studies [e.g. 13], for logging paleoseismic trenches [e.g. 14, 15], and for controlling the accuracy of United States Geological Survey digital elevation models (DEM) [16].

The total station is a measurement device which combines the angle measuring capabilities of theodolite with an electronic distance measurement for defining the horizontal angle, vertical angle and the distance to the certain point [17]. The coordinates of an unknown point respect to a known coordinate can be defined with the total station by having a direct line of sight between the two points. Therefore, the angles and distances are measured from the total station to the observation points. Then, by using trigonometry and triangulation, the coordinates of the observation points respect to the total station position are computed [17]. In other words, the monitoring prisms are mounted on the critical points of the structures, the vertical angles, the horizontal angles and the distances to the prisms are measured and therefore, the displacements are calculated by the total station [18, 19].

The total station device must be located within a reference system for receiving Northing (X), Easting (Y) and elevation (Z) data from total station measurements. An arbitrary or a known coordinate system can be chosen for the reference system. In an arbitrary system, the observation points are located respect to the device location and arbitrary reference item. On the other hand, in a known coordinate system, at least one known point location is needed. Before starting the measurements, the device is installed on a known point, the reference item is measured and the triangulation is realized from two or more known points in the known coordinate system [12]. The control network should be created by choosing reference stations. Respectively stable structures are chosen as the reference stations around the total station and monitoring prisms are installed on these points. The reference stations are observed by the total stations for correcting the positions of the total stations before each measurement sets [20]. Subsequently, the spatial coordinates of each prism are computed. The magnitude and direction of the displacement is determined by comparing the initial and last coordinates. Differences in the positions of monitoring prisms represent that the structure has movement [21]. Additionally, the intervals of the measurements are regulated according to the high risk of the engineering structures [22].

In this paper, for monitoring the effects of an underground parking construction to the surroundings, the monitoring prisms were installed to the four surrounding buildings and the positions of the buildings were monitored by using the total station.

Finally, if the displacement values and graphics of the monitoring prisms on Building No:7, No: 9, No: 11 and No: 13 are analyzed, it can be said that the displacements of these buildings are seen generally at North directional and besides, 2D and 3D displacement are monitored.

II. Case Study

The underground parking construction was begun at 2017 in Kağıthane-Yeşilce District in Istanbul city (Fig. 1). For monitoring the effect of the underground parking construction to the surrounding buildings, twentymonitoring prisms (Fig. 2) were placed on the facades of four surrounding buildings. The buildings were named with their apartment gate numbers as 7, 9, 11 and 13, respectively (Fig. 3). Four monitoring prisms were placed on the building No: 7 and these prisms called as point no; 10, 11, 23 and 24. On the building No: 9, four monitoring prisms were mounted with point numbers; 12, 13, 21 and 22. Seven monitoring prisms and five monitoring prisms were placed on building no: 11 and building no: 13, respectively. The prisms numbers of building no: 11 were 14, 15, 16, 17, 18, 19 and 20. The point no: 14 and 15 were placed on the side facades and the others were on the facades. The prisms numbers of building no: 13 were called as 25, 26, 27, 28 and 29. Among them, the point no: 25 and 26 were placed on the side facades and no: 27, 28 and no: 29 were on the facades.

Figure 1. The view of the underground parking construction which locates in Kağıthane-Yeşilce District in Istanbul city
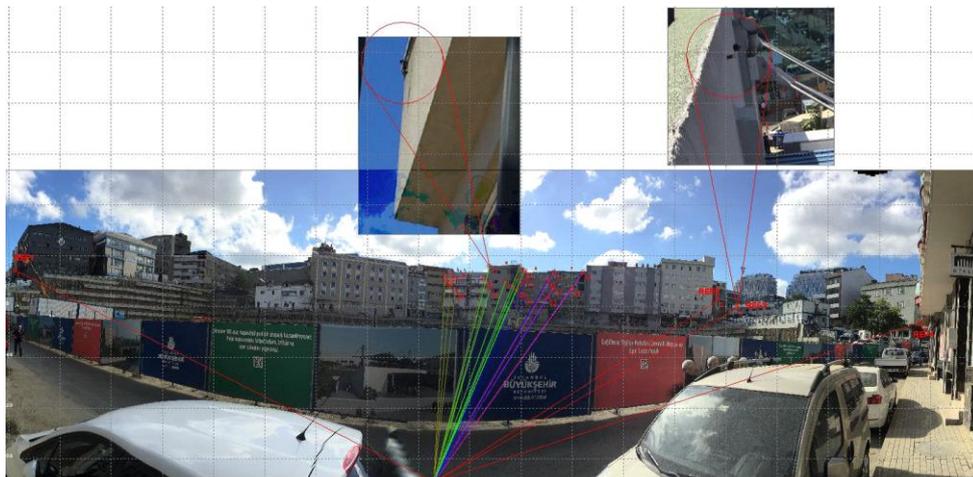
Figure 2: The view of underground parking construction, the monitored buildings and the monitoring prisms and reference points.
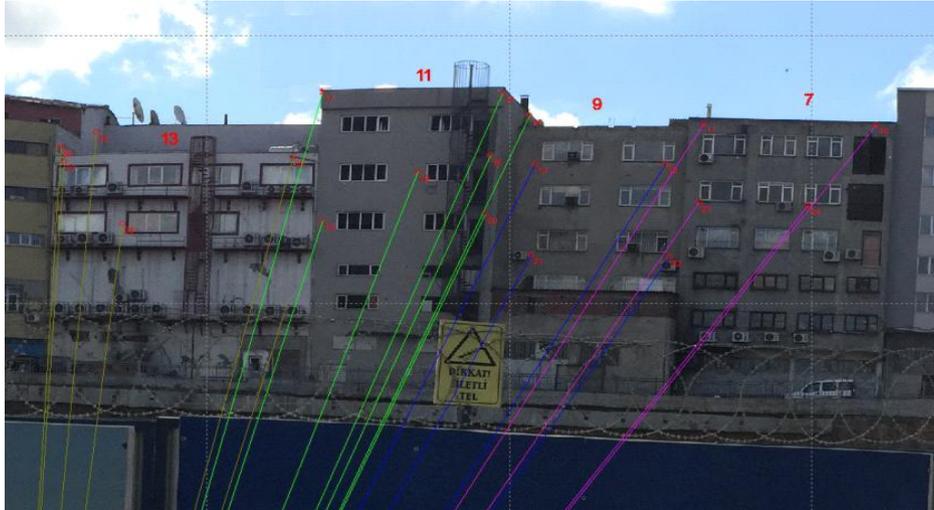
Figure 3: The monitored surrounding buildings named with the apartment gate number with 7, 9, 11 and 13. The numbers shown on the buildings present the point numbers of the monitoring prisms.

Before starting to deformation monitoring, four reference points were chosen on the four different buildings around the parking construction except the monitored buildings which coordinates were given at Table 1. These points were called as REF1, REF2, REF3 and REF4. The monitoring prisms were placed on these reference points. A temporary reference point was generated by using GNSS device and a total station was emplaced and four full range measurements were obtained on REF1, REF2, REF3 and REF4(the reference stations were named from left to right of the study area as REF1, REF2, REF3 and REF4) (Fig.2). In these measurements Trimble S5-1 total station with angle precision 1" (0.3 mgon) and monitoring prism (25 mm) with RMSE (Root Mean Square Error) 2 mm +2 ppm were used.

Table 1: The coordinates of the reference points.

The Coordinates of Reference points			
Name of the points	X	Y	Z
REF1	4551624.1361	416126.5072	124.3675
REF2	4551391.1470	416220.6058	127.1235
REF3	4551355.5519	416238.5711	128.9208
REF4	4551412.1321	416133.1028	117.3625

(a)   (b)

Figure 4: a) Trimble S5-1 Total station [23]   b) Monitoring prism (25mm) [24]

The total station was positioned precisely with resection from REF1, REF2, REF3 and REF4 and after providing self-consistency at total station, the measurements with four full ranges were begun for deformation points. The interval of the measurements was 20 hours. The measurements which obtained at 6th July 2017 were chosen as the base measurements and the coordinates of the observation points (Fig. 2) were given at Table 2.

Table 2: The coordinates of the observation points (monitoring prisms) which were chosen as the base measurements.

Observation date: 06.07.2017			
Observation Point No:	Coordinates		
	Northing (m)	Easting (m)	Elevation (m)
10	4551450.9951	416212.7059	128.0165
11	4551460.4370	416216.6495	128.0221
12	4551461.8530	416218.9049	125.8059
13	4551468.3820	416221.8082	126.7142
14	4551468.3507	416225.3063	129.5152
15	4551470.7194	416219.0365	129.5290
16	4551471.2149	416218.6723	126.2390
17	4551480.5977	416222.0916	129.5026
18	4551479.8340	416222.1580	121.2176
19	4551475.0850	416220.2536	123.9208
20	4551471.3927	416218.7477	120.8386
21	4551467.8281	416221.5730	119.9722
22	4551461.3255	416218.6989	120.7027
23	4551459.9211	416216.4294	122.9789
24	4551453.2349	416213.6619	122.9418

After the base measurements which were obtained at 6th July 2017, the measurements were obtained between the days 7th July - 27th July 2017 for 13 days. For only observation point no: 10, the measurement was obtained at 29th July 2017 instead of 27th July 2017.

III. Results

The coordinates were measured from 7th July up to 27th July 2017 (for monitoring prism No: 10, instead of 27th 2017, the observation was realized at 29th July 2017) and the deformation caused by the construction of underground parking area was monitored on surrounding buildings by total station and monitoring prisms and the position differences on 3 components (north, east and elevation) were calculated and given at Tables 3-19.

The observation points (monitoring prisms) no: 10, 11, 23 and 24 which were placed on the building no: 7 were given at Table 3, 4, 5 and Table 6, respectively.

Table 3: The measured coordinates of observation point No: 10 and obtained differences at horizontal and vertical positions.

Observation Point No: 10	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551450.9951	416212.7059	128.0165	0.000	0.000	0.000
07.07.2017	4551450.9924	416212.7062	128.0179	0.0027	-0.0003	-0.0014
08.07.2017	4551450.9950	416212.7057	128.0183	0.0001	0.0002	-0.0018
09.07.2017	4551450.9930	416212.7036	128.0160	0.0021	0.0023	0.0005
10.07.2017	4551450.9967	416212.7047	128.0175	-0.0016	0.0012	-0.0010
11.07.2017	4551450.9950	416212.7038	128.0175	0.0001	0.0021	-0.0010
12.07.2017	4551450.9956	416212.7037	128.0170	-0.0005	0.0022	-0.0005
13.07.2017	4551450.9957	416212.7047	128.0169	-0.0006	0.0012	-0.0004
14.07.2017	4551450.9933	416212.7033	128.0165	0.0018	0.0026	0.0000
15.07.2017	4551450.9962	416212.7044	128.0173	-0.0011	0.0015	-0.0008
16.07.2017	4551450.9936	416212.7040	128.0162	0.0015	0.0019	0.0003
17.07.2017	4551450.9949	416212.7033	128.0166	0.0002	0.0026	-0.0001
23.07.2017	4551450.9930	416212.7044	128.0153	0.0021	0.0015	0.0012
29.07.2017	4551450.9940	416212.7028	128.0159	0.0011	0.0031	0.0006

Table 4: The measured coordinates of observation point No: 11 and obtained differences at horizontal and vertical positions

Observation Point No: 11	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551460.4370	416216.6495	128.0221	0.0000	0.0000	0.0000
07.07.2017	4551460.4331	416216.6503	128.0230	0.0039	-0.0008	-0.0009
08.07.2017	4551460.4361	416216.6492	128.0235	0.0009	0.0003	-0.0014
09.07.2017	4551460.4341	416216.6474	128.0213	0.0029	0.0021	0.0008
10.07.2017	4551460.4389	416216.6476	128.0227	-0.0019	0.0019	-0.0006
11.07.2017	4551460.4368	416216.6476	128.0227	0.0002	0.0019	-0.0006

12.07.2017	4551460.4372	416216.6473	128.0222	-0.0002	0.0022	-0.0001
13.07.2017	4551460.4377	416216.6479	128.0221	-0.0007	0.0016	0.0000
14.07.2017	4551460.4350	416216.6469	128.0217	0.0020	0.0026	0.0004
15.07.2017	4551460.4375	416216.6473	128.0220	-0.0005	0.0022	0.0001
16.07.2017	4551460.4347	416216.6481	128.0212	0.0023	0.0014	0.0009
17.07.2017	4551460.4368	416216.6462	128.0216	0.0002	0.0033	0.0005
23.07.2017	4551460.4346	416216.6483	128.0207	0.0024	0.0012	0.0014
27.07.2017	4551460.4357	416216.6468	128.0213	0.0013	0.0027	0.0008

Table 5: The measured coordinates of observation point No: 23 and obtained differences at horizontal and vertical positions

Observation Point No: 23	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551459.9211	416216.4294	122.9789	0.0000	0.0000	0.0000
07.07.2017	4551459.9162	416216.4297	122.9794	0.0049	-0.0003	-0.0005
08.07.2017	4551459.9187	416216.4289	122.9799	0.0024	0.0005	-0.0010
09.07.2017	4551459.9172	416216.4269	122.9781	0.0039	0.0025	0.0008
10.07.2017	4551459.9228	416216.4278	122.9791	-0.0017	0.0016	-0.0002
11.07.2017	4551459.9205	416216.4277	122.9791	0.0006	0.0017	-0.0002
12.07.2017	4551459.9210	416216.4270	122.9787	0.0001	0.0024	0.0002
13.07.2017	4551459.9212	416216.4280	122.9785	-0.0001	0.0014	0.0004
14.07.2017	4551459.9183	416216.4271	122.9779	0.0028	0.0023	0.0010
15.07.2017	4551459.9211	416216.4267	122.9782	0.0000	0.0027	0.0007
16.07.2017	4551459.9189	416216.4274	122.9777	0.0022	0.0020	0.0012
17.07.2017	4551459.9206	416216.4262	122.9779	0.0005	0.0032	0.0010
23.07.2017	4551459.9176	416216.4281	122.9774	0.0035	0.0013	0.0015
27.07.2017	4551459.9186	416216.4267	122.9773	0.0025	0.0027	0.0016

Table 6: The measured coordinates of observation point No: 24 and obtained differences at horizontal and vertical positions

Observation Point No: 24	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551453.2349	416213.6619	122.9418	0.0000	0.0000	0.0000
07.07.2017	4551453.2302	416213.6614	122.9430	0.0047	0.0005	-0.0012
08.07.2017	4551453.2327	416213.6604	122.9436	0.0022	0.0015	-0.0018
09.07.2017	4551453.2325	416213.6588	122.9416	0.0024	0.0031	0.0002
10.07.2017	4551453.2365	416213.6603	122.9429	-0.0016	0.0016	-0.0011
11.07.2017	4551453.2341	416213.6600	122.9430	0.0008	0.0019	-0.0012
12.07.2017	4551453.2348	416213.6596	122.9425	0.0001	0.0023	-0.0007
13.07.2017	4551453.2352	416213.6599	122.9421	-0.0003	0.0020	-0.0003
14.07.2017	4551453.2323	416213.6588	122.9414	0.0026	0.0031	0.0004
15.07.2017	4551453.2353	416213.6590	122.9419	-0.0004	0.0029	-0.0001
16.07.2017	4551453.2326	416213.6599	122.9414	0.0023	0.0020	0.0004
17.07.2017	4551453.2345	416213.6592	122.9415	0.0004	0.0027	0.0003
23.07.2017	4551453.2314	416213.6608	122.9417	0.0035	0.0011	0.0001
27.07.2017	4551453.2322	416213.6590	122.9411	0.0027	0.0029	0.0007

The observation points no: 12, 13 and 21 which were placed on the building no: 9 were given at Table 7, 8 and Table 9, respectively.

Table 7: The measured coordinates of observation point No: 12 and obtained differences at horizontal and vertical positions**.**

Observation Point No: 12	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551461.8530	416218.9049	125.8059	0.0000	0.0000	0.0000
07.07.2017	4551461.8487	416218.9053	125.8075	0.0043	-0.0004	-0.0016
08.07.2017	4551461.8514	416218.9034	125.8075	0.0016	0.0015	-0.0016
09.07.2017	4551461.8499	416218.9028	125.8052	0.0031	0.0021	0.0007
10.07.2017	4551461.8542	416218.9031	125.8069	-0.0012	0.0018	-0.0010
11.07.2017	4551461.8522	416218.9028	125.8070	0.0008	0.0021	-0.0011
12.07.2017	4551461.8530	416218.9019	125.8064	0.0000	0.0030	-0.0005

13.07.2017	4551461.8531	416218.9020	125.8061	-0.0001	0.0029	-0.0002
14.07.2017	4551461.8504	416218.9013	125.8053	0.0026	0.0036	0.0006
15.07.2017	4551461.8528	416218.9018	125.8056	0.0002	0.0031	0.0003
16.07.2017	4551461.8505	416218.9032	125.8049	0.0025	0.0017	0.0010
17.07.2017	4551461.8521	416218.9016	125.8052	0.0009	0.0033	0.0007
23.07.2017	4551461.8495	416218.9022	125.8044	0.0035	0.0027	0.0015
27.07.2017	4551461.851	416218.9015	125.8048	0.0024	0.0034	0.0011

Table 8: The measured coordinates of observation point No: 13 and obtained differences at horizontal and vertical positions.

Observation Point No: 13	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551468.3820	416221.8082	126.7142	0.0000	0.0000	0.0000
07.07.2017	4551468.3771	416221.8095	126.7151	0.0049	-0.0013	-0.0009
08.07.2017	4551468.3800	416221.8084	126.7154	0.0020	-0.0002	-0.0012
09.07.2017	4551468.3789	416221.8063	126.7131	0.0031	0.0019	0.0011
10.07.2017	4551468.3831	416221.8076	126.7151	-0.0011	0.0006	-0.0009
11.07.2017	4551468.3810	416221.8071	126.7151	0.0010	0.0011	-0.0009
12.07.2017	4551468.3817	416221.8062	126.7146	0.0003	0.0020	-0.0004
13.07.2017	4551468.3819	416221.8067	126.7144	0.0001	0.0015	-0.0002
14.07.2017	4551468.3793	416221.8051	126.7136	0.0027	0.0031	0.0006
15.07.2017	4551468.3813	416221.8054	126.7138	0.0007	0.0028	0.0004
16.07.2017	4551468.3794	416221.8054	126.7128	0.0026	0.0028	0.0014
17.07.2017	4551468.3808	416221.8056	126.7134	0.0012	0.0026	0.0008
23.07.2017	4551468.3786	416221.8056	126.7130	0.0034	0.0026	0.0012
27.07.2017	4551468.3795	416221.8061	126.7135	0.0025	0.0021	0.0007

Table 9: The measured coordinates of observation point No: 21 and obtained differences at horizontal and vertical positions.

Observation Point No: 21	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551467.8281	416221.5730	119.9722	0.0000	0.0000	0.0000
07.07.2017	4551467.8243	416221.5731	119.9725	0.0038	-0.0001	-0.0003
08.07.2017	4551467.8267	416221.5728	119.9726	0.0014	0.0002	-0.0004
09.07.2017	4551467.8236	416221.5715	119.9712	0.0045	0.0015	0.0010
10.07.2017	4551467.8303	416221.5707	119.9717	-0.0022	0.0023	0.0005
11.07.2017	4551467.8282	416221.5704	119.9717	-0.0001	0.0026	0.0005
12.07.2017	4551467.8285	416221.5694	119.9710	-0.0004	0.0036	0.0012
13.07.2017	4551467.8285	416221.5694	119.9710	-0.0004	0.0036	0.0012
14.07.2017	4551467.8255	416221.5698	119.9705	0.0026	0.0032	0.0017
15.07.2017	4551467.8286	416221.5702	119.9707	-0.0005	0.0028	0.0015
16.07.2017	4551467.8261	416221.5698	119.9697	0.0020	0.0032	0.0025
17.07.2017	4551467.8282	416221.5690	119.9703	-0.0001	0.0040	0.0019
23.07.2017	4551467.8242	416221.5698	119.9690	0.0039	0.0032	0.0032
27.07.2017	4551467.8259	416221.5693	119.9692	0.0022	0.0037	0.0030

The observation points no:14, 15, 16, 17, 18, 19 and 20 which were placed on the building no: 11 were given at Table 10, 11, 12, 13, 14, 15 and Table 16, respectively.

Table 10: The measured coordinates of observation point No: 14 and obtained differences at horizontal and vertical positions

Observation Point No: 14	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551468.3507	416225.3063	129.5152	0.0000	0.0000	0.0000
07.07.2017	4551468.3467	416225.3077	129.5163	0.0040	-0.0014	-0.0011
08.07.2017	4551468.3495	416225.3058	129.5165	0.0012	0.0005	-0.0013
09.07.2017	4551468.3465	416225.3046	129.5145	0.0042	0.0017	0.0007
10.07.2017	4551468.3526	416225.3055	129.5165	-0.0019	0.0008	-0.0013
11.07.2017	4551468.3506	416225.3045	129.5164	0.0001	0.0018	-0.0012
12.07.2017	4551468.3513	416225.3041	129.5159	-0.0006	0.0022	-0.0007
13.07.2017	4551468.3517	416225.3041	129.5155	-0.0010	0.0022	-0.0003
14.07.2017	4551468.3486	416225.3038	129.5154	0.0021	0.0025	-0.0002

15.07.2017	4551468.3511	416225.3039	129.5156	-0.0004	0.0024	-0.0004
16.07.2017	4551468.3487	416225.3041	129.5141	0.0020	0.0022	0.0011
17.07.2017	4551468.3509	416225.3031	129.5149	-0.0002	0.0032	0.0003
23.07.2017	4551468.3475	416225.3040	129.5143	0.0032	0.0023	0.0009
27.07.2017	4551468.3492	416225.3036	129.5148	0.0015	0.0027	0.0004

Table 11. The measured coordinates of observation point No: 15 and obtained differences at horizontal and vertical positions

Observation Point No: 15	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551470.7194	416219.0365	129.5290	0.0000	0.0000	0.0000
07.07.2017	4551470.7159	416219.0377	129.5295	0.0035	-0.0012	-0.0005
08.07.2017	4551470.7184	416219.0360	129.5300	0.0010	0.0005	-0.0010
09.07.2017	4551470.7168	416219.0344	129.5281	0.0026	0.0021	0.0009
10.07.2017	4551470.7216	416219.0353	129.5300	-0.0022	0.0012	-0.0010
11.07.2017	4551470.7195	416219.0348	129.5299	-0.0001	0.0017	-0.0009
12.07.2017	4551470.7201	416219.0343	129.5294	-0.0007	0.0022	-0.0004
13.07.2017	4551470.7204	416219.0343	129.5292	-0.0010	0.0022	-0.0002
14.07.2017	4551470.7178	416219.0337	129.5286	0.0016	0.0028	0.0004
15.07.2017	4551470.7202	416219.0342	129.5285	-0.0008	0.0023	0.0005
16.07.2017	4551470.7176	416219.0341	129.5272	0.0018	0.0024	0.0018
17.07.2017	4551470.7196	416219.0325	129.5278	-0.0002	0.0040	0.0012
23.07.2017	4551470.7167	416219.0333	129.5277	0.0027	0.0032	0.0013
27.07.2017	4551470.7183	416219.0329	129.5280	0.0011	0.0036	0.0010

Table 12: The measured coordinates of observation point No: 16 and obtained differences at horizontal and vertical positions

Observation Point No: 16	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551471.2149	416218.6723	126.2390	0.0000	0.0000	0.0000
07.07.2017	4551471.2112	416218.6730	126.2393	0.0037	-0.0007	-0.0003
08.07.2017	4551471.2133	416218.6717	126.2401	0.0016	0.0006	-0.0008
09.07.2017	4551471.2110	416218.6704	126.2380	0.0039	0.0019	0.0021
10.07.2017	4551471.2165	416218.6700	126.2393	-0.0016	0.0023	-0.0013
11.07.2017	4551471.2146	416218.6696	126.2393	0.0003	0.0027	0.0000
12.07.2017	4551471.2151	416218.6690	126.2388	-0.0002	0.0033	0.0005
13.07.2017	4551471.2153	416218.6699	126.2387	-0.0004	0.0024	0.0001
14.07.2017	4551471.2124	416218.6692	126.2382	0.0025	0.0031	0.0005
15.07.2017	4551471.2153	416218.6691	126.2382	-0.0004	0.0032	0.0000
16.07.2017	4551471.2127	416218.6696	126.2374	0.0022	0.0027	0.0008
17.07.2017	4551471.2149	416218.6682	126.2376	0.0000	0.0041	-0.0002
23.07.2017	4551471.2118	416218.6697	126.2371	0.0031	0.0026	0.0005
27.07.2017	4551471.2131	416218.6683	126.2374	0.0018	0.0040	-0.0003

Table 13: The measured coordinates of observation point No: 17 and obtained differences at horizontal and vertical positions

Observation Point No: 17	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551480.5977	416222.0916	129.5026	0.0000	0.0000	0.0000
07.07.2017	4551480.5939	416222.0933	129.5033	0.0038	-0.0017	-0.0007
08.07.2017	4551480.5953	416222.0911	129.5038	0.0024	0.0005	-0.0012
09.07.2017	4551480.5943	416222.0904	129.5015	0.0034	0.0012	0.0011
10.07.2017	4551480.5997	416222.0899	129.5033	-0.0020	0.0017	-0.0007
11.07.2017	4551480.5975	416222.0898	129.5035	0.0002	0.0018	-0.0009
12.07.2017	4551480.5980	416222.0886	129.5028	-0.0003	0.0030	-0.0002
13.07.2017	4551480.5980	416222.0894	129.5028	-0.0003	0.0022	-0.0002
14.07.2017	4551480.5955	416222.0885	129.5022	0.0022	0.0031	0.0004
15.07.2017	4551480.5975	416222.0888	129.5025	0.0002	0.0028	0.0001
16.07.2017	4551480.5954	416222.0896	129.5012	0.0023	0.0020	0.0014
17.07.2017	4551480.5973	416222.0877	129.5016	0.0004	0.0039	0.0010
23.07.2017	4551480.5949	416222.0878	129.5008	0.0028	0.0038	0.0018
27.07.2017	4551480.5963	416222.0884	129.5016	0.0014	0.0032	0.0010

Table 14: The measured coordinates of observation point No: 18 and obtained differences at horizontal and vertical positions

Observation Point No: 18	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551479.8340	416222.1580	121.2176	0.0000	0.0000	0.0000
07.07.2017	4551479.8305	416222.1589	121.2179	0.0035	-0.0009	-0.0003
08.07.2017	4551479.8326	416222.1574	121.2186	0.0014	0.0006	-0.0010
09.07.2017	4551479.8302	416222.1561	121.2165	0.0038	0.0019	0.0011
10.07.2017	4551479.8362	416222.1559	121.2178	-0.0022	0.0021	-0.0002
11.07.2017	4551479.8342	416222.1555	121.2177	-0.0002	0.0025	-0.0001
12.07.2017	4551479.8345	416222.1554	121.2174	-0.0005	0.0026	0.0002
13.07.2017	4551479.8351	416222.1556	121.2172	-0.0011	0.0024	0.0004
14.07.2017	4551479.8322	416222.1552	121.2161	0.0018	0.0028	0.0015
15.07.2017	4551479.8350	416222.1550	121.2163	-0.0010	0.0030	0.0013
16.07.2017	4551479.8321	416222.1549	121.2155	0.0019	0.0031	0.0021
17.07.2017	4551479.8344	416222.1537	121.2159	-0.0004	0.0043	0.0017
23.07.2017	4551479.8310	416222.1554	121.2156	0.0030	0.0026	0.0020
27.07.2017	4551479.8327	416222.1544	121.2152	0.0013	0.0036	0.0024

Table 15: The measured coordinates of observation point No: 19 and obtained differences at horizontal and vertical positions

Observation Point No: 19	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551475.0850	416220.2536	123.9208	0.0000	0.0000	0.0000
07.07.2017	4551475.0805	416220.2557	123.9214	0.0045	-0.0021	-0.0006
08.07.2017	4551475.0833	416220.2535	123.9217	0.0017	0.0001	-0.0009
09.07.2017	4551475.0815	416220.2527	123.9199	0.0035	0.0009	0.0009
10.07.2017	4551475.0871	416220.2528	123.9214	-0.0021	0.0008	-0.0006
11.07.2017	4551475.0850	416220.2523	123.9213	0.0000	0.0013	-0.0005
12.07.2017	4551475.0855	416220.2517	123.9208	-0.0005	0.0019	0.0000
13.07.2017	4551475.0856	416220.2515	123.9205	-0.0006	0.0021	0.0003
14.07.2017	4551475.0827	416220.2510	123.9196	0.0023	0.0026	0.0012
15.07.2017	4551475.0855	416220.2510	123.9197	-0.0005	0.0026	0.0011
16.07.2017	4551475.0830	416220.2520	123.9187	0.0020	0.0016	0.0021
17.07.2017	4551475.0849	416220.2505	123.9193	0.0001	0.0031	0.0015
23.07.2017	4551475.0821	416220.2517	123.9190	0.0029	0.0019	0.0018
27.07.2017	4551475.0832	416220.2512	123.9190	0.0018	0.0024	0.0018

Table 16: The measured coordinates of observation point No: 20 and obtained differences at horizontal and vertical positions

Observation Point No: 20	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551471.3927	416218.7477	120.8386	0.0000	0.0000	0.0000
07.07.2017	4551471.3883	416218.7488	120.8385	0.0044	-0.0011	0.0001
08.07.2017	4551471.3915	416218.7483	120.8394	0.0012	-0.0006	-0.0008
09.07.2017	4551471.3898	416218.7466	120.8377	0.0029	0.0011	0.0009
10.07.2017	4551471.3946	416218.7463	120.8387	-0.0019	0.0014	-0.0001
11.07.2017	4551471.3923	416218.7457	120.8387	0.0004	0.0020	-0.0001
12.07.2017	4551471.3929	416218.7449	120.8383	-0.0002	0.0028	0.0003
13.07.2017	4551471.3933	416218.7466	120.8382	-0.0006	0.0011	0.0004
14.07.2017	4551471.3903	416218.7459	120.8378	0.0024	0.0018	0.0008
15.07.2017	4551471.3935	416218.7460	120.8379	-0.0008	0.0017	0.0007
16.07.2017	4551471.3906	416218.7457	120.8369	0.0021	0.0020	0.0017
17.07.2017	4551471.3930	416218.7450	120.8373	-0.0003	0.0027	0.0013
23.07.2017	4551471.3897	416218.7461	120.8360	0.0030	0.0016	0.0026
27.07.2017	4551471.3911	416218.7453	120.8371	0.0016	0.0024	0.0015

The observation points no: 25, 28 and 29 which were placed on the building no: 13 were given at Table 17, 18 and Table 19, respectively.

Table 17: The measured coordinates of observation point No: 25 and obtained differences at horizontal and vertical positions

Observation Point No:25	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551494.7688	416234.3193	128.4255	0.0000	0.0000	0.0000
07.07.2017	4551494.7688	416234.3193	128.4255	0.0000	0.0000	0.0000
08.07.2017	4551494.7688	416234.3193	128.4255	0.0000	0.0000	0.0000
09.07.2017	4551494.7688	416234.3193	128.4255	0.0000	0.0000	0.0000
10.07.2017	4551494.7686	416234.3193	128.4250	0.0002	0.0000	0.0005
11.07.2017	4551494.7666	416234.3192	128.4250	0.0022	0.0001	0.0005
12.07.2017	4551494.7674	416234.3174	128.4243	0.0014	0.0019	0.0012
13.07.2017	4551494.7676	416234.3185	128.4241	0.0012	0.0008	0.0014
14.07.2017	4551494.7655	416234.3189	128.4231	0.0033	0.0004	0.0024
15.07.2017	4551494.7664	416234.3177	128.4238	0.0024	0.0016	0.0017
16.07.2017	4551494.7661	416234.3182	128.4221	0.0027	0.0011	0.0034
17.07.2017	4551494.7689	416234.3163	128.4226	-0.0001	0.0030	0.0029
23.07.2017	4551494.7628	416234.3182	128.4220	0.0060	0.0011	0.0035
27.07.2017	4551494.7646	416234.3183	128.4227	0.0042	0.0010	0.0028

Table 18: The measured coordinates of observation point No: 28 and obtained differences at horizontal and vertical positions

Observation Point No: 28	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551482.886	416222.9237	125.4369	0.0000	0.0000	0.0000
07.07.2017	4551482.886	416222.9237	125.4369	0.0000	0.0000	0.0000
08.07.2017	4551482.886	416222.9237	125.4369	0.0000	0.0000	0.0000
09.07.2017	4551482.886	416222.9237	125.4369	0.0000	0.0000	0.0000
10.07.2017	4551482.8855	416222.9237	125.4366	0.0004	0.0000	0.0003
11.07.2017	4551482.8836	416222.9231	125.4366	0.0023	0.0006	0.0003
12.07.2017	4551482.8839	416222.9221	125.4361	0.0020	0.0016	0.0008
13.07.2017	4551482.8842	416222.9223	125.4357	0.0017	0.0014	0.0012
14.07.2017	4551482.8811	416222.9218	125.4353	0.0048	0.0019	0.0016
15.07.2017	4551482.8839	416222.9221	125.4351	0.0020	0.0016	0.0018
16.07.2017	4551482.8813	416222.9230	125.4343	0.0046	0.0007	0.0026
17.07.2017	4551482.8838	416222.9211	125.4348	0.0021	0.0026	0.0021
23.07.2017	4551482.8799	416222.9221	125.4339	0.0060	-0.0010	0.0030
27.07.2017	4551482.8820	416222.9221	125.4346	0.0039	0.0000	0.0023

Table 19: The measured coordinates of observation point No: 29 and obtained differences at horizontal and vertical positions

Observation Point No: 29	Coordinates			Position		
Observation Date	Northing (m)	Easting (m)	Elevation (m)	dN (m)	dE (m)	dH (m)
06.07.2017	4551492.683	416224.8526	121.2918	0.0000	0.0000	0.0000
07.07.2017	4551492.683	416224.8526	121.2918	0.0000	0.0000	0.0000
08.07.2017	4551492.683	416224.8526	121.2918	0.0000	0.0000	0.0000
09.07.2017	4551492.683	416224.8526	121.2918	0.0000	0.0000	0.0000
10.07.2017	4551492.6821	416224.8526	121.2910	0.0007	0.0000	0.0008
11.07.2017	4551492.6801	416224.8525	121.2909	0.0027	0.0001	0.0009
12.07.2017	4551492.6803	416224.8513	121.2905	0.0025	0.0013	0.0013
13.07.2017	4551492.6809	416224.8523	121.2901	0.0019	0.0003	0.0017
14.07.2017	4551492.6776	416224.8528	121.2895	0.0052	-0.0002	0.0023
15.07.2017	4551492.6804	416224.8519	121.2897	0.0024	0.0007	0.0021
16.07.2017	4551492.6773	416224.8515	121.2888	0.0055	0.0011	0.0030
17.07.2017	4551492.6802	416224.8501	121.2893	0.0026	0.0025	0.0025
23.07.2017	4551492.6767	416224.8523	121.2878	0.0061	0.0003	0.0040
27.07.2017	4551492.6785	416224.8502	121.2883	0.0043	0.0024	0.0035

Additionally, for monitoring the position differences on north, east, elevation, two-dimensions (2D) and three-dimensions (3D), the graphics were created by using Trimble 4D lite software [25]. The deformation graphics of monitoring prisms no: 10, 11, 23 and 24 which were placed on the building no: 7 are given at Fig.4, Fig. 5, Fig. 6 and Fig. 7, respectively.
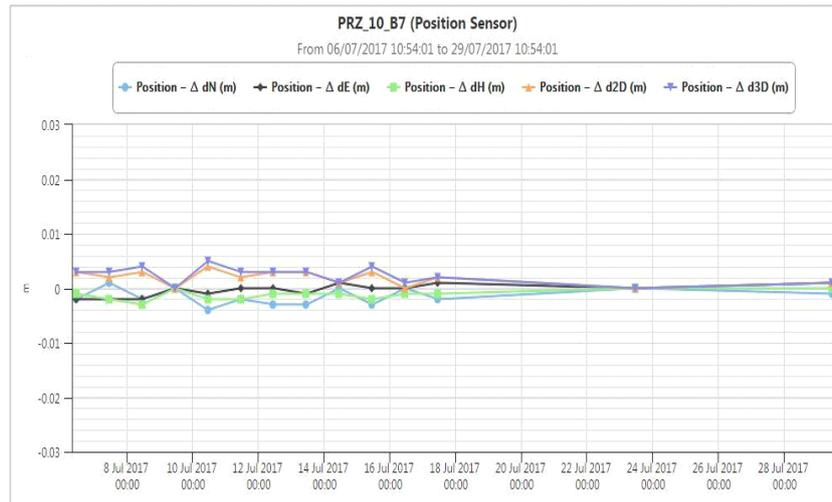
Figure 4: The observed position differences between the days 06.07.2017- 29.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 10 placed on building No: 7.
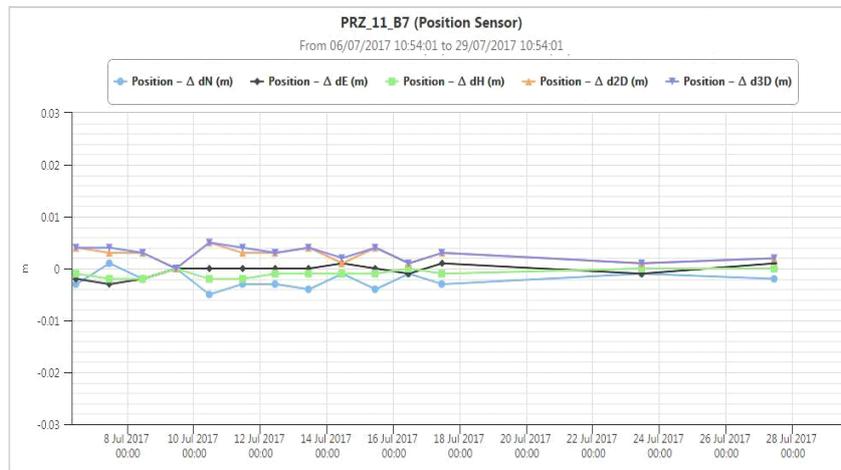
Figure 5: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 11 placed on building No: 7.
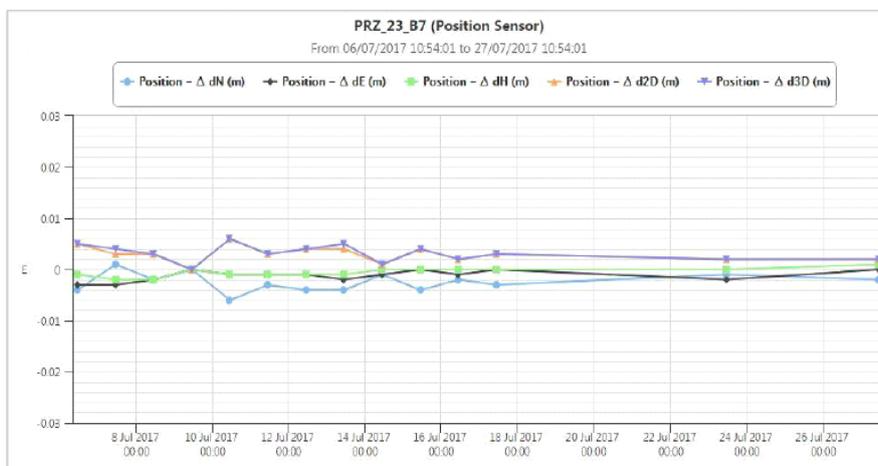
Figure 6: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 23 placed on building No: 7.
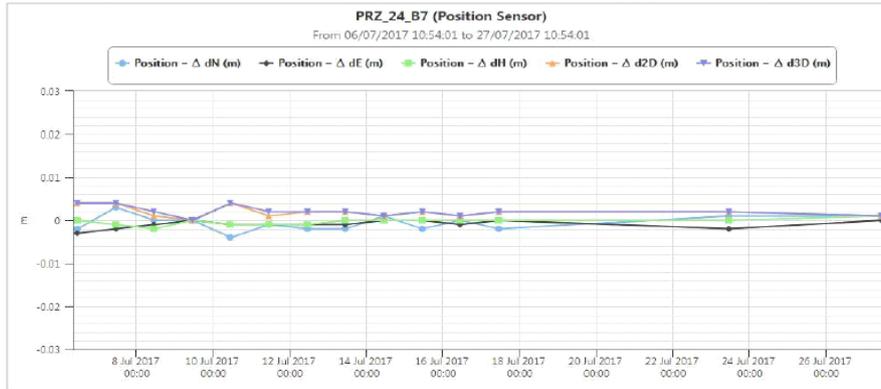
Figure 7: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 24 placed on building No: 7.

The deformation graphics of monitoring prisms no: 12, 13 and 21 which were placed on the building no: 9 are given at Fig.8, Fig. 9 and Fig. 10, respectively.
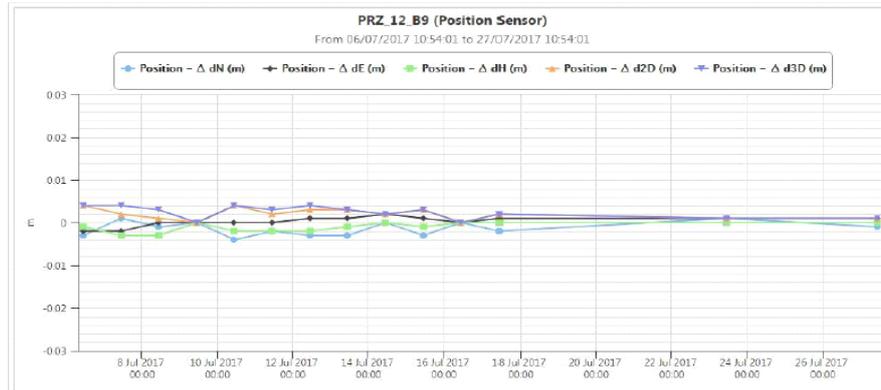
Figure 8: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 12 placed on building No: 9.
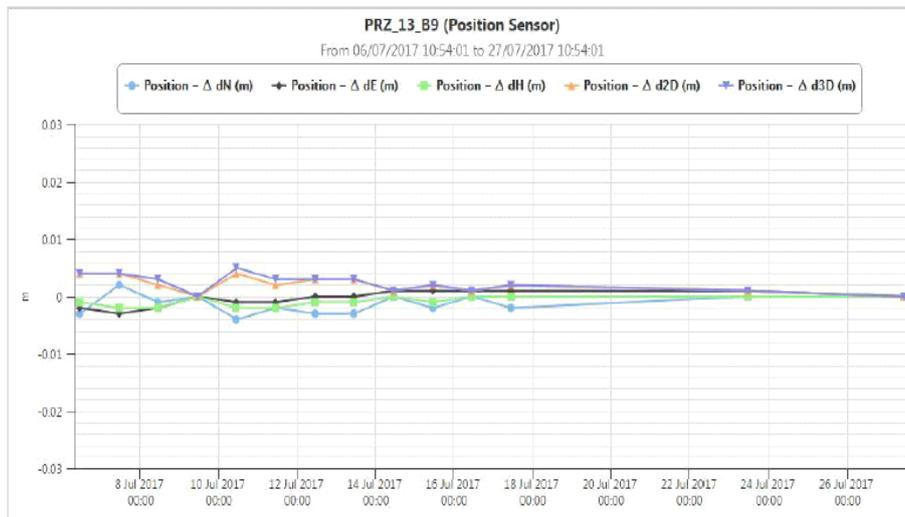
Figure 9: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 13 placed on building No: 9.
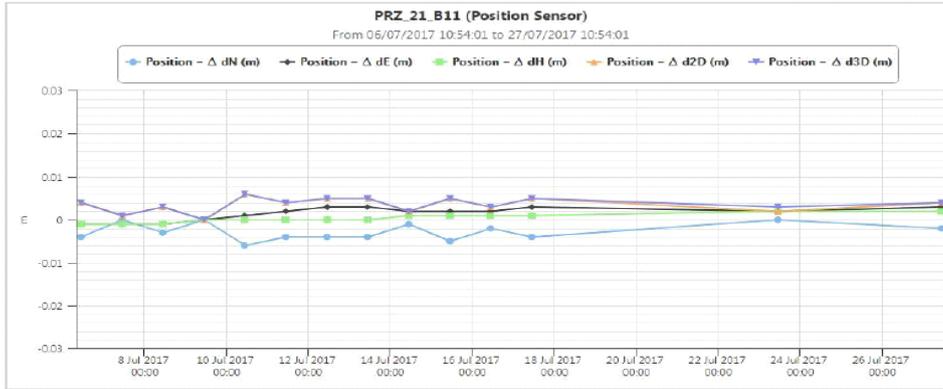
Figure 10: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 21 placed on building No: 9.

The deformation graphics of monitoring prisms no: 14, 15, 16, 17, 18, 19 and 20 which were placed on the building no: 11 are given at Figs.11-17, respectively.
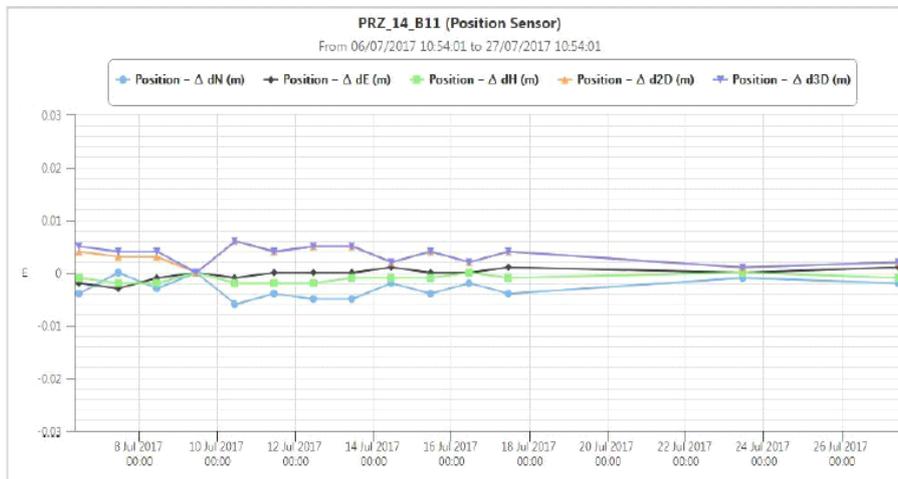
Figure 11: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 14 placed on building No: 11.
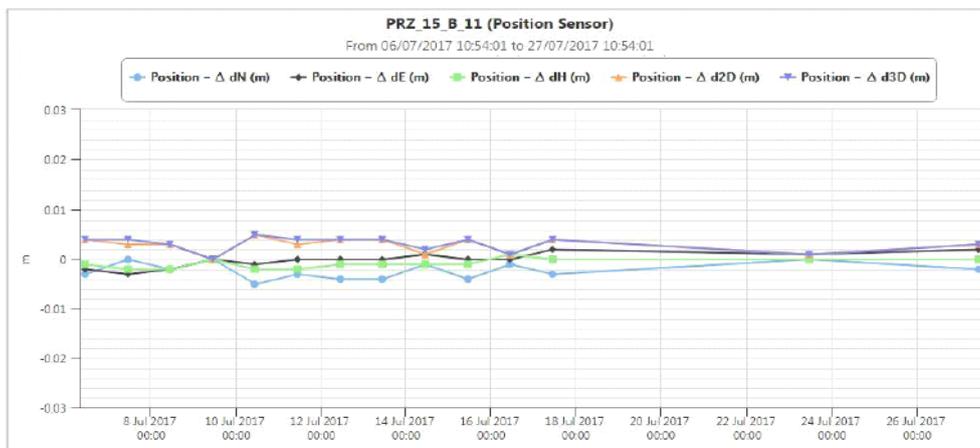
Figure 12: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 15 placed on building No: 11.
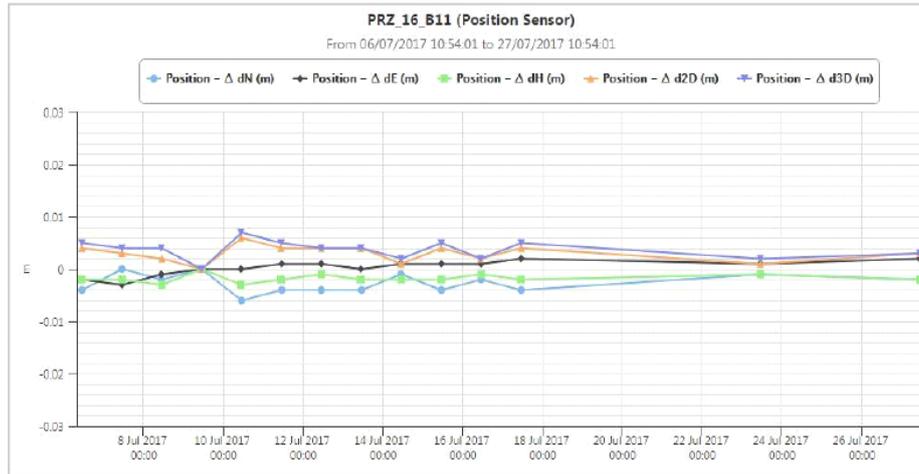
Figure 13: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 16 placed on building No: 11.
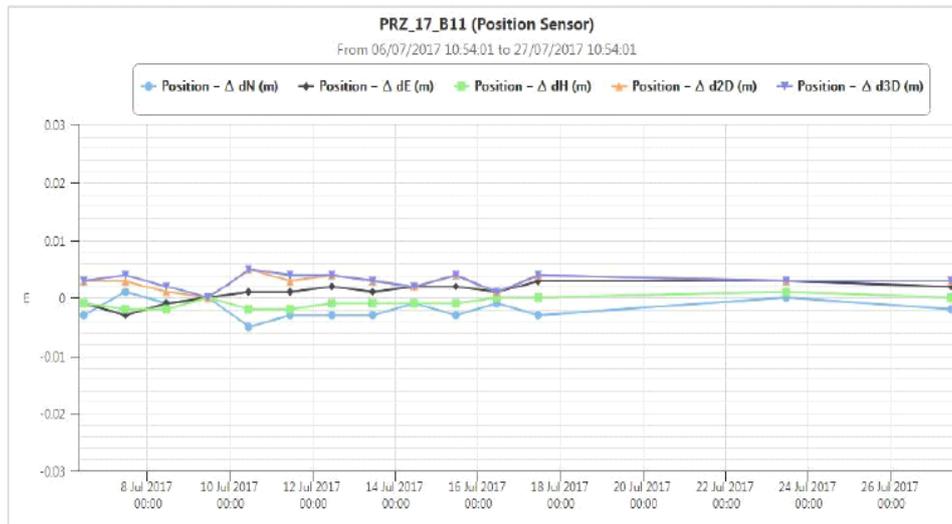
Figure 14: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 17 placed on building No: 11.
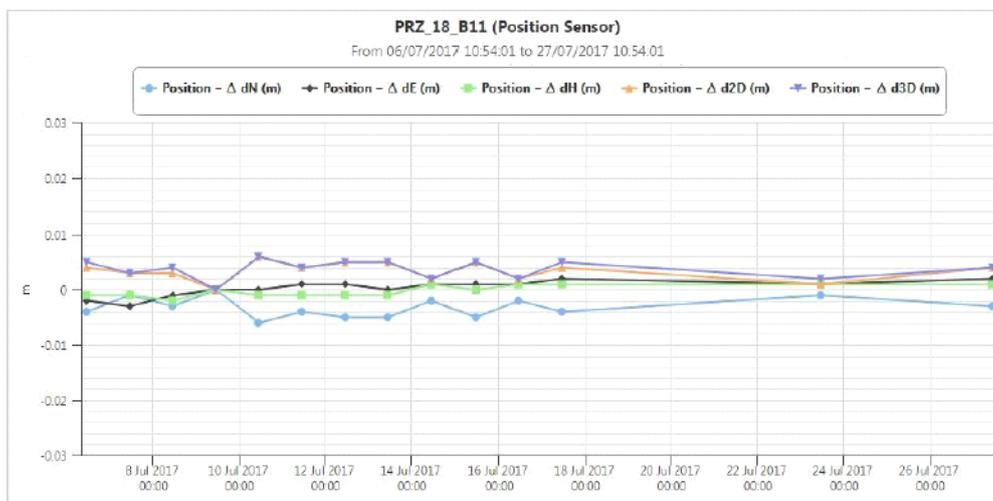
Figure 15: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 18 placed on building No: 11.
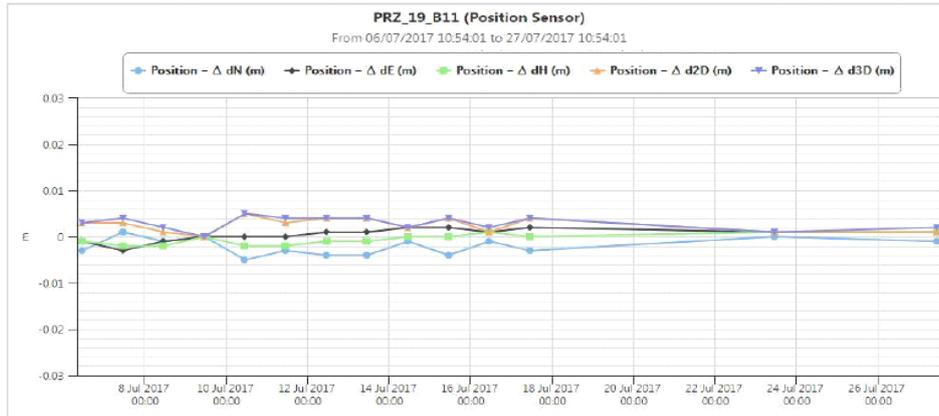
Figure 16: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 19 placed on building No: 11.
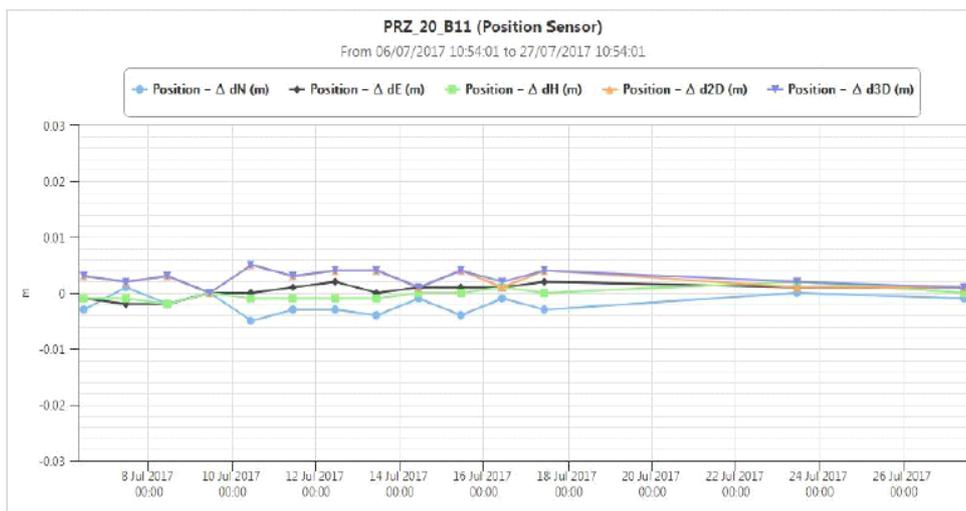
Figure 17: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 20 placed on building No: 11.

The deformation graphics of monitoring prisms no: 25, 28 and 29 which were placed on the building no: 13 are given at Fig.18, Fig. 19 and Fig. 20, respectively
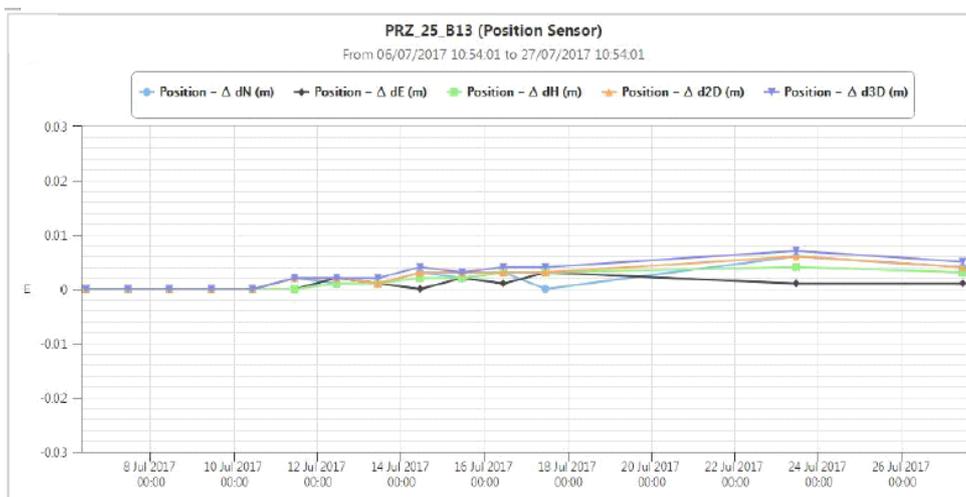
Figure 18: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 25 placed on building No: 13.
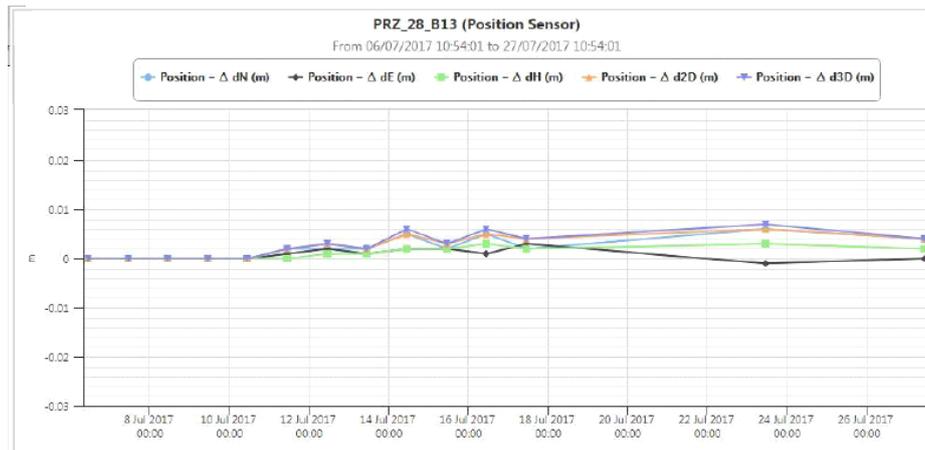
Figure 19: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 28 placed on building No: 13.
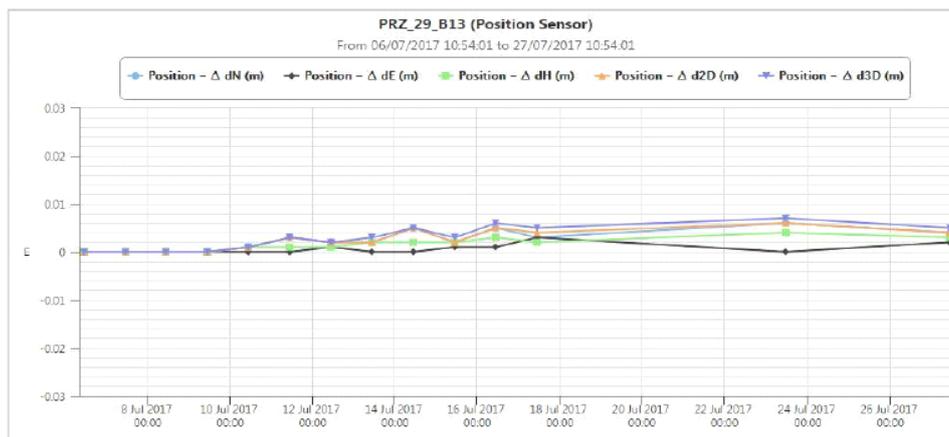
Figure 20: The observed position differences between the days 06.07.2017- 27.07.2017 on north (dN), east (dE), elevation (dH), 2D (d2D) and 3D (d3D) of monitoring prism No: 29 placed on building No: 13.

If the displacements of the observed four surrounding buildings (Fig. 21) are examined, the movements at horizontal (Northing and Easting) and vertical (elevation, (High)) components need to be analyzed.

The monitoring prisms No: 10, 11, 23 and 24 are located on building No:7. If the measurement in 06.07.2017 assumed as the reference, for monitoring prism No:10, the position ranges between 0.0027 m (observed in 07.07.2017) and -0.0016 m (observed in 10.07.2017) at North, ranges between -0.0003 m (observed in 07.07.2017) and 0.0031 m. (29.07.2017) at East and ranges between -0.0018 (08.07.2017) and 0.0012 m (23.07.217) at elevation (Table 3). For prism No:11, the position ranges between 0.0039 m (07.07.2017) and -0.0019 m (10.07.2017) at North, ranges between -0.0008 m (07.07.2017) and 0.0033 m (17.07.2017) at East, ranges between -0.0014 m (08.07.217) and 0.0014 m (23.07.2017) at elevation (Table 4). For prism No:23, the position ranges between 0.0049 m (07.07.2017) and -0.0017 m (10.07.2017) at North, ranges between -0.0003 m (07.07.2017) and 0.0032 m (17.07.2017) at East, ranges between -0.0010 m (08.07.2017) and 0.0016 m (27.07.2017) at elevation (Table 5). For prism No:24, the position ranges between 0.0047 m (07.07.2017) and -0.0016 m (10.07.2017) at North, ranges between 0.00 m (06.07.2017) and 0.0031 m (09.07.2017) at East, ranges between -0.0012 m (07.07.2017) and 0.0007 m (27.07.2017) at elevation (Table 6). Therefore, the monitoring prism No: 10, the max. displacement at North is 4.3 mm, at East is 3.4 mm and at elevation is 3.0 mm. The max. displacement at North, East and at elevation is 5.8 mm, 4.1 mm and 2.8 mm, respectively for the monitoring prism No: 11. The max. displacement at North, East and at elevation is 5.6 mm, 3.5 mm and 2.6 mm, respectively for the monitoring prism No: 23. The max. displacement at North, East and at elevation is 6.3 mm, 3.1 mm and 1.9 mm, respectively for the monitoring prism No: 23. If these values and the Figs. 4, 5, 6 and Fig. 7 are evaluated together, it can be said that the displacement on building No:7 is seen generally at North directional and 2D and 3D displacement are monitored.

The monitoring prisms No: 12, 13 and 21 are located on building No:9. If the measurement in 06.07.2017 assumed as the reference, for monitoring prism No:12, the position ranges between 0.0043 m (07.07.2017) and -0.0012 m (10.07.2017) at North, ranges between -0.0004 m (07.07.2017) and 0.0036 m.

(14.07.2017) at East and ranges between -0.0016 (07.07.2017) and 0.0015 m (23.07.2017) at elevation (Table 7). For prism No:13, the position ranges between 0.0049 m (07.07.2017) and -0.0011 m (10.07.2017) at North, ranges between -0.0013 m (07.07.2017) and 0.0031 m (14.07.2017) at East, ranges between -0.0012 m (08.07.2017) and 0.0014 m (16.07.2017) at elevation (Table 8). For prism No:21, the position ranges between 0.0045 m (09.07.2017) and -0.0022 m (10.07.2017) at North, ranges between -0.0001 m (07.07.2017) and 0.0040 m (17.07.2017) at East, ranges between -0.0004 m (08.07.2017) and 0.0032 m (23.07.2017) at elevation (Table 9). Therefore, the monitoring prism No: 12, the max. displacement at North is 5.5 mm, at East is 4.0 mm and at elevation is 3.1 mm. The max. displacement at North, East and at elevation is 6.0 mm, 4.4 mm and 2.6 mm, respectively for the monitoring prism No: 13. The max. displacement at North, East and at elevation is 6.7 mm, 4.1 mm and 3.7 mm, respectively for the monitoring prism No: 21. If these values and the Figs.8, 9 and Fig. 10 are evaluated together, it can be said that the displacement on building No:9 is seen generally at North directional and 2D and 3D displacement are monitored.

The monitoring prisms No: 14, 15, 16, 17, 18, 19 and 20 are located on building No:11. If the measurement in 06.07.2017 assumed as the reference, for monitoring prism No:14, the position ranges between 0.0042 m (09.07.2017) and -0.0019 m (10.07.2017) at North, ranges between -0.0014 m (07.07.2017) and 0.0032 m. (17.07.2017) at East and ranges between -0.0013 (08.07.2017) and 0.0011 m (16.07.2017) at elevation (Table 10). For prism No:15, the position ranges between 0.0035 m (07.07.2017) and -0.0022 m (10.07.2017) at North, ranges between -0.0012 m (07.07.2017) and 0.004 m (17.07.2017) at East, ranges between -0.0010 m (08.07.2017) and 0.0018 m (16.07.2017) at elevation (Table 11). For prism No:16, the position ranges between 0.0039 m (09.07.2017) and -0.0016 m (10.07.2017) at North, ranges between -0.0007 m (07.07.2017) and 0.0041 m (17.07.2017) at East, ranges between 0.0021 m (09.07.2017) and -0.0013 m (10.07.2017) at elevation (Table 12). For prism No:17, the position ranges between 0.0038 m (07.07.2017) and -0.0020 m (10.07.2017) at North, ranges between -0.0017 m (07.07.2017) and 0.0039 m (17.07.2017) at East, ranges between -0.0012 m (08.07.2017) and 0.0018 m (23.07.2017) at elevation (Table 13). For prism No:18, the position ranges between 0.0038 m (09.07.2017) and -0.0022 m (10.07.2017) at North, ranges between -0.0009 m (07.07.2017) and 0.0043 m (17.07.2017) at East, ranges between -0.0010 m (08.07.2017) and 0.0024 m (27.07.2017) at elevation (Table 14). For prism No:19, the position ranges between 0.0045 m (07.07.2017) and -0.0021 m (10.07.2017) at North, ranges between -0.0021 m (07.07.2017) and 0.0031 m (17.07.2017) at East, ranges between -0.0009 m (08.07.2017) and 0.0021 m (24.07.2017) at elevation (Table 15). For prism No:20, the position ranges between 0.0044 m (07.07.2017) and -0.0019 m (10.07.2017) at North, ranges between -0.0011 m (07.07.2017) and 0.0028 m (12.07.2017) at East, ranges between -0.0008 m (08.07.2017) and 0.0026 m (23.07.2017) at elevation (Table 16). Therefore, the monitoring prism No: 14, the max. displacement at North is 6.1 mm, at East is 5.6 mm and at elevation is 2.4 mm. The max. displacement at North, East and at elevation is 5.7 mm, 1.6 mm and 2.8 mm, respectively for the monitoring prism No: 15. The max. displacement at North, East and at elevation is 5.5 mm, 4.8 mm and 3.4 mm, respectively for the monitoring prism No: 16. The max. displacement at North, East and at elevation is 5.8 mm, 5.6 mm and 3.0 mm, respectively for the monitoring prism No: 17. The max. displacement at North, East and at elevation is 6.0 mm, 5.2 mm and 3.4 mm, respectively for the monitoring prism No: 18. The max. displacement at North, East and at elevation is 6.6 mm, 5.2 mm and 3.0 mm, respectively for the monitoring prism No: 19. The max. displacement at North, East and at elevation is 6.3 mm, 3.9 mm and 3.4 mm, respectively for the monitoring prism No: 20. If these values and the Figs. 11-17 are evaluated together, it can be said that the displacement on building No:11 is seen generally at North directional and 2D and 3D displacement are monitored. Besides, it can be said that the east directional displacement is more on building No: 11 according to Buildings No:7 and No:9.

The monitoring prisms No: 25, 28 and 29 are located on building No:13. If the measurement in 06.07.2017 assumed as the reference, for monitoring prism No:25, the position ranges between -0.0001 m (17.07.2017) and 0.0060 m (23.07.2017) at North, ranges between 0.00 m (06.07.2017) and 0.0030 m (17.07.2017) at East and ranges between -0.00 (06.07.2017) and 0.0035 m (23.07.2017) at elevation (Table 17). For prism No:28, the position ranges between 0.00 m (06.07.2017) and 0.0048 m (14.07.2017) at North, ranges between 0.0026 m (17.07.2017) and -0.0010 m (23.07.2017) at East, ranges between 0.00 m (06.07.2017) and 0.0030 m (23.07.2017) at elevation (Table 18). For prism No:29, the position ranges between 0.00 m (06.07.2017) and 0.0061 m (23.07.2017) at North, ranges between -0.0002 m (14.07.2017) and 0.0025 m (17.07.2017) at East, ranges between 0.00 m (06.07.2017) and 0.0040 m (23.07.2017) at elevation (Table 19).Therefore, the monitoring prism No: 25, the max. displacement at North is 6.1 mm, at East is 3.0 mm and at elevation is 3.5 mm. The max. displacement at North, East and at elevation is 4.8 mm, 3.6 mm and 3.0 mm, respectively for the monitoring prism No: 29. The max. displacement at North, East and at elevation is 6.1 mm, 2.7 mm and 4.0 mm, respectively for the monitoring prism No: 29. If these values and the Figs. 18, 19 and Fig. 20 are evaluated together, it is seen that the building did not move between the days 06.07.2017- 09.07.2017. The first displacements were observed in 10.07.2017. Besides, it can be said that the displacement on building No:13 is seen generally at North directional and 2D and 3D displacement are monitored.

Finally, if the displacement values and graphics of the monitoring prisms on Building No:7, No: 9, No: 11 and No: 13 are analyzed, it can be said that the displacements of these buildings are seen generally at North directional and additionally, 2D and 3D displacement are monitored in these buildings. Consequently, it can be said that the monitoring the displacement of the buildings around excavations is very important for ensuring early warning of structural failure.

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