MEANS OF MONITORING THE BRIDGES BEHAVIOUR IN TIME

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***Abstract**: The purpose of monitoring the buildings behavior in time is to predict the displacements and deformations they suffer, in comparison to other points situated outside the influence of the building area or of the land that could suffer displacements and deformations. The paper shows theoretical and practical aspects needed in order to accomplish the projects of monitoring the building behavior in time, projects that are needed for warning and preventing disasters that could occur due to the destruction of those buildings because of the use of them at unsafe parameters.*

***Keywords:** monitoring, monitoring project, displacement, deformation, methods, models, monitoring network.*

1. Introduction

The monitoring of the buildings behavior in time lasts during the lifetime of the building, starting with the execution and it is a systematical activity of gathering and using (by means of interpretation, warning or alarming in order to prevent damages) the data resulted from observations and surveys on phenomena and sizes that are characteristic for the buildings properties during the interaction with the natural and technological environment.

The behavior properties, as the phenomena and the sizes related to them are identified for each construction, so that with the help of some criterias and quality conditions linked to the destination of the building, lead to apreciate the exploatation capacity, that has to corespond to the needs of the users.

The purpose of monitoring the building behavior in time is to obtain the neccesary information in order to assure the building skills for a normal use, for preventing fire, accidents and damage and also reducing material damage, life loss, and environment (natural, social, cultural) damage. It is also necessary in obtaining informations to make the road trasnport better. The monitoring of the building behavior is done in order to satisfy the levels of resistance, stability, durability and other essential levels of the building.

The monitorisation of the building behavior can be differentiated into two categories:

- Current monitorisation
- Special monitorisation

Current monitorisation consists of the action of monitoring buildings which consists of observing and recording issues, events and parameters that can indicate changes in the capacity of the building to meet the strength, stability and durability levels established by the project. Current monitorisation of the building behavior is carried out by direct visual inspection and if needed with the use of instruments commonly used permanent or temporary.

Special monitorisation consists of the action of monitoring buildings which consists of measuring, recording, processing and systematic interpretation of parameters values that define the extent to which buildings retain their strength requirements, stability and durability established by the project.

Special monitorisation of the building behavioris used in the following situations:

a) New constructions or constructions with exceptional importance determined by the project;

b) construction with dangerous development, recommended by the results of technical expertise or extensive inspections;

c) the owner's request, the State Construction Inspection, Public Works, Urbanism and Planning or bodies recognized by the specialized fields.

If special monitorisation is needed, than the monitorisation of the building will encompass the current monitorisation also.

Special monitorisation work is permanent or temporary, its duration is established on a case by case basis, in accordance to the project.

Special monitorisation of the buildings behavior consists of building a geodetic network, in which the coordinates of the points are determined with high precision and in case of making repeated measurements, at each measurement stage the stability of the fixed points will be checked. If there is significant displacement of one or more points in the geodetic network tracking, those points are considered to be mobile. In order to achieve a geodetic network one should take account of its geometry, represented by the position of points that make up the network. The coordinates of the determined points at different measurement periods characterise the displacement or deflection of building or land area monitored. To highlight how closely the phenomenon of displacement or distortion of the studied objective the coordinates of the geodetic points of the network will be determined for each measurement period, the following rigorous compensation block. Before the checking of the points located on the objective, the stability under prosecution will be determined, along with the stability of reference points in the network, so that the significant displacements of the marks placed on a student tracking will be located. Bridges are essential in building roads and their flaws and degradation can cause important damage in traffic, and could rise to close a whole traffic sector.

Since defects / failures that can occur in different parts of the bridge can be developed more or less slowly, inspection work is permanent, systematic, mandatory and must be performed at regular, predetermined intervals.

This paper refers to how real-time behavior of a road bridge over the river Moldova that links the villages of Tupilati and Hanul Ancuța (Neamt County) DJ G 208 km 34 430 respectively the link between the Iasi and Neamt Counties.

2. Types of measurements

To determine the fixed and observation points both classical geodetic methods (microtriangulation, microtrilateration - measuring directions and distances) and the geometric and trigonometric leveling are used.

Topo-geodetic methods are often the only methods that allow absolute determination of the size and direction of movement of a building or of an area of building land, as a mean of controling the movements and deformation measurements carried out in other ways (the methods negeodezice) .

- Topo-geodetic methods used to determine subsidence are different, each corresponding to certain working conditions and the requirements of accuracy using certain technologies work. Thus, the measurement methodused in case of may be the geometric leveling, the hydrostatic leveling method and sometimes polar method.

- To measure horizontal movements of heavy construction, the observation points, orientation points, checkpoints are placed nearby and the construction is subject to observation targeting fixed landmarks. Observation points, control points and network points of guidance form reference points against which to determine the movements of points on the onvestigated subject.

Determination of the movement of points can be obtained by traditional methods, and also by other surveying methods such as hydrostatic leveling or electro-optical measuring methods. The crucial issues in choosing the right method of measurement are: if the object is accessible, only practicable or possible target, the deformation speed of the object, time intervals for which measurements can be made without hindering the productive activity, etc.

- an irregular and unpredictable evolution of deformation by uncontrollable changes of tasks, for example through the influence of wind or temperature, can best seize the continuous measurements (electrical measuring methods, and tilt displacement transducers).
- staple measurements and surveys with extensometers, hydrostatic levels and other measuring instruments is performed at bridges, locks, buildings, etc.., for the installation of measuring devices continue to be disproportionately expensive and therefore uneconomical.

3. The materialization of the geodetic points of the network

One can make the difference on the types of points materialization: station points, points located on the investigated objective, control and orientation points.

- The materialization of the station points is changing according to the conditions of construction exploatation and also according to phisical-mecanical properties of the foundation land. Generally, station points are materialized with piles, that need to accomplish some conditions, like: a simple and stabile construction, with a mecanic centration appliance, in order to remove the reduction and centration errors.
- The materialization of the points situated on the investigated objective is done with the help of some fixed points that are placed on the inside or outside part of the building and that are moving along, altimetical and planimetric, with the buildings movements. These fixed marks are made out of plates that one should vise and they are connected to the walls through a hole filled up with concrete,or they can be made out of metal reflection targets that are fixed with bolts to the building. On the walls of the constructions, especially water barages the fixed points are made out of two plates fixed almost perpendiculary.
- The materialization of the control points consists of reinforceing concrete piles that assure the position of the teodolite and of the vise mark. This is used in case of the complete networks, that have the property that between the station and control points are two ways vises. This control points ought not to change their position in time. In order to assure this, the marks have to be placed in rocks, in the outside area of the building. If there are no rocks nearby, then the marks will be fixed only on lands where the level of underground water is at least 2m under the freezing point of the land.
- The materialization of the orientation points. As orientation points far away points placed on other buildings are used or triangulation points (marks very well centrated). As orientation points vertical straight elements of far away buildings (piles, churches top) are used.

4. Surveys processing

The purpose of geodetic planimetric networks processing is to determine the X(N) and Y(E) coordinates of the new points of the network. The compensation of the measurements of the geodetic network is the last step of the geodetic activity and as a result the final results are obtained.

As a mean of measurement processing the indirect observation method was used, known also as the compensation of the group of points, and the main advantage of this method is the fact that each observation has an ecuation of corection corespondent, that ease a good control on the functional model and a full automatisation of compensation process.

The compensation of the geodetic planimetry networks made by the method of indirect observations involves several stages, after each stage achieving results that allow you to choose more efficient models and more accurate values for the following calculation steps. These steps are:

- Preliminary processing of the geodetic observations in order to reduce the chosen reference surface
- Calculation of provisional elements
- Forming the functional training model - stochastic
- Transforming equations by the rules of equivalence;
- Normalization of the system of the linear equations corrections and solving the normal equation system
- Calculation and control of the compensated elements
- Assessing the accuracy of calculations.

Since the measurements provided in the topic of this paper are reduced to the project plan the preliminary observations proccess and their reduction to their project plan was not treated.

4.1. The calculation of the provisionally elements

Functional models are necessary for the formation of provisional values of unknown values that occur in the model. Case of geodetic planimetry networks, the provisional refers to the calculation of approximate coordinates of the points and also the provisional values of orientations of the stations at which observations were made. These values must be sufficiently close to the values most likely to waive the terms of the order II and higher in the Taylor development.

For the calculation of provisional elements any method can be used with the condition that at least two independent determinations are made. If the values obtained differ by small amounts, the provisional result from mediation. Steps involved in are:

- Calculation of orientation and distance between old items
- The orientation of known stations
- Calculation of provisional coordinates
- Calculation of provisional values of the orientations of the stations

4.2.1. The functional model

After the interim phase element calculations presented in the preceding paragraph provisional or final coordinates for all points of the network are resulted and also the provisional values for orientations of the stations. The provisional elements determined form a basis of functional model - used in processing stochastic observations in geodetic planimetry networks. As stated, these elements must be sufficiently close to the probable values .

Achieving the functional models used in the processing of observations by indirect measurement methods, the projection plane through some calculation steps involve determining:

- Type of correction equations for directions measured and reduced to the project plan;

$$v_{ij}^{\alpha} = -dz_i + a_{ij}dN_j + b_{ij}dE_j - a_{ij}dN_i - b_{ij}dE_i + l_{ij}^{\alpha} \quad (1)$$

Relation (1) is the general form of a correction equation for horizontal angles, measured between two new points.

- Type of correction equations for distances measured and reduced to the project plan

$$v_{ij}^{D} = A_{ij}dN_j + B_{ij}dE_j - A_{ij}dN_i - B_{ij}dE_i + l_{ij}^{D} \quad (2)$$

Relation (2) is the general form of an equation of corrections for a measured distance between two new points.

If in a geodetic network both angular and distance measurements were performed, followed by a block processing, then the free element of the distance equations has to be calculated in the same unity as the variation of the orientation: $d\theta\left[{}^{cc}/_{dm}\right] \rightarrow l_{ij}^{D}\left[dm\right]$ (3)

4.2.2. The stochastic model

- In the first case of compensation we use in processing the geodetic network measured directions. Thus in this case will have to form a stochastic model, have variance matrix - covariance measurements of directions. Directions are used to compensate planimetry geodetic networks are obtained by clearing station. Also from the station to obtain compensation and compensation standard deviation resulting from the station Usually is considered the standard deviation of the measured directions is equal to the standard abterea obtained to offset the station.

Thus for a measured standard deviation can be determined that this line:

$$\sigma_{\alpha ij} = \left(S_0'\right)_i \quad (4)$$

It may also be said that measurements are regarded as independent directions, so the matrix of variance - covariance directions, Σ_{α}, will be a diagonal matrix.

- In all three cases the compensation will be used in geodetic network processing of distance measurements, and in order to form the stochastic model, we have the matrix of variance - covariance measurements of distances. Standard deviation of a measured distance with electro-optical devices is given by:

$$\sigma_D = a + b \cdot D\left[km\right] \quad (5)$$

where *a,b* – are constants provided by the company or resulted after the calibration process.

Given that the distances are considered as independent measurements, the variance-covariance matrix of distances , Σ_D, will be a diagonal matrix.

- Determining the weighting matrix assumed to have measurements of variance-covariance matrix of all measurements of the geodetic network, Σ_M .

This matrix is obtained by assembling the matrices, Σ_{α}, Σ_u^{ind} or $\Sigma_u^{corelate}$, on one hand, according to the situation of compensation considered and to the Σ_D matrix, which will be present inprocessing sitations. Such variance-covariance matrix of measurements, Σ_M , will have the following form:

$$\sum_M = \left(\begin{array}{c|c} \Sigma_\alpha / \Sigma_u^{ind} / \Sigma_u^{corelate} & 0 \\ \hline 0 & \Sigma_D \end{array} \right) \quad (6)$$

Once the variance-covariance matrix of measurements is determined, we determined the weights matrix: $P = \sigma_0{}^2 \Sigma_M{}^{-1}$ (7)

4.3. Equivalent systems of correction equations

Two corrections systems of equations are called equivalent if, the normalization leads them to the same normal system and to the same solutions, in the end.

In the first case of compensation (which is performed using directions and distances) one can use equivalence rules to reduce the number of unknown and also the number of correction equations. There are three equivalence rules called Schreiber rules. In this paper only the first two rules will be presented.

4.4. Normalization and solving the equations system

This stage is mainly intended to determine the increases of the coordinates dX(dN) and dY(dE). Also in this phase corrections are calculated for angles of the orintation stations, *dz,* and the corrections v to be added in order to obtain the most probable values of the measurements.

4.5. Calculating the compensated elements

After calculating offset elements we have the required values of elements used in the calculation of the compensated elements

. The most probable values of the coordinates for a new item will be calculated with:

$$N_i = N_i^{\,0} + dN_i$$
$$E_i = E_i^{\,0} + dE_i \quad (8)$$

If the compensation of the directions and distances will be calculated and the most probable values of orientation angles of the stations where station measurements were made for horizontal angular directions:

$$z_i = z_i^{\,0} + dz_i \quad (9)$$

Ultimately the most probable values of measurements will be determined in accordance to the compensation situation addressed:

- For directions measured: $\alpha_{ij} = \alpha_{ij}^* + v_{ij}^\alpha$ (10)
- For angles of directions: $u_{jik} = u_{jik}^* + v_{jik}^u$ (11)
- For the measured distance $D_{ij} = D_{ij}^* + v_{ij}^D$ (12)

4.6. Control of the compensation

If compensation calculations are made by hand it is necessary that after calculation of offset elements to monitor compensation. Such elements must satisfy the offset functional model, according to the following relationships:

- For directions measured: $\alpha_{ij}^{*} + v_{ij}^{\alpha} = \theta_{ij}^{calculat} - \left(z_i^0 + dz\right)$ (10)
- For angles of directions: $u_{jik}^{*} + v_{jik}^{u} = \theta_{ik}^{calculat} - \theta_{ij}^{calculat}$ (11)
- For the measured distance $D_{ij}^{*} + v_{ij}^{D} = D_{ij}^{calculat}$ (12)

Relations which are control for elements of compensation $\theta^{calculat}$ and $D^{calculat}$ is calculated with the most probable values of the coordinates.

So: $\theta_{ij}^{calculat} = arctg \dfrac{E_j - E_i}{N_j - N_i}$ and: $D_{ij}^{calculat} = \sqrt{\left(N_j - N_i\right)^2 + \left(E_j - E_i\right)^2}$ (16)

4.7. Accuracies estimation

The estimation of accuracies in geodetic network processing of the measurements ends with planimetry precision indicators estimation.

4.7.1. Calculation of the accurancies indicators

- Standard deviation of unit weight selection is calculated taking into account the observations to calculate the amount $V^T PV$:

$$S_0 = \pm\sqrt{\frac{V^T PV}{n-h}} \tag{17}$$

where n - number of network metrics
h- number of unknowns.

Standard selection deviation of an offset measurement:

$$S_{Mi} = \pm\frac{S_0}{\sqrt{p_i}} \tag{18}$$

where: - p_i weight measurement of M_i .

Determining the unknown standard deviation of position:

$$\begin{aligned} S_{Ni} &= \pm S_0\sqrt{N_{NiNi}^{-1}} \\ S_{Ei} &= \pm S_0\sqrt{N_{EiEi}^{-1}} \end{aligned} \tag{19}$$

where: N_{NiNi}^{-1} şi N_{EiEi}^{-1} are the corresponding point, extracted from the main diagonal of the matrix N^{-1}.

- standard deviation of position. Helmert error:

$$S_{Hi} = \sqrt{S_{Ni} + S_{Ei}} \tag{20}$$

- Average standard deviation on the network:

$S_t = \dfrac{1}{n}\sum_{i=1}^{n} S_{Hi}$, where n is the number of new points in the network (21)

4.7.2. Calculation of the error ellipses of the elements

The field of confidence in planimetric position of a point is the error ellipse. Absolute ellipse is determined for each point. Ellipse is relative determined for each pair of new points between which measurements were made. One can calculate matrix elements initially, after which we can calculate the ellipse elements:

$$\lambda_{1,2} = \frac{Q_{xx} + Q_{yy}}{2} \pm \frac{1}{2}\sqrt{(Q_{xx} - Q_{yy})^2 + 4Q_{xy}^2}$$

$$a = s_0\sqrt{\lambda_1}; \quad a - \text{semiaxa mare}$$

$$b = s_0\sqrt{\lambda_2}; \quad b - \text{semiaxa mica} \tag{22}$$

Major axis of the orientation ellipse relative to the X-axis coordinate system is determined by the relationship $\varphi = \frac{1}{2}\text{arctg}\frac{2Q_{xy}}{Q_{xx} - Q_{yy}}$ (23)

5. Practical aspects

The main reason for establishing special tracking behavior was dangerous development of the objective and also the importance of building (B category of importance accoring to the Regulation on the categories of constructions - Construction Bulletin volume 4 / 1996).

Subject to special monitoring objectives are:

- Cell P1 and P4 cell
- water dam routing opening in the middle of the bridge
- Vestiges bridge (in terms of geometrical position)
- Vestiges bridge (in terms of degradation);
- bridge cells (in terms of geometric positions and degradation)
- Evolution of shore erosion
- Evolution of alluvial material deposition phenomenon
- evolution of the thalweg.

Geometrical position tracking of the infrastructure is designed to provide information on any shift, rotation, subsidence that can be produced under the action of water, operating actions, seismic action etc. To this purpose a geodetic network will be materialized on the ground, consisted of 4 points (stations) tracking (fixed reference). Approximate positioning of points (stations) will be tracking as it follows:

- two points on the left bank, one at ca. 100 m downstream of the bridge and the other at 100 m upstream of the bridge
- two points on the right side, one at ca. 100 m downstream of the bridge and the other at 100 m upstream of the bridge.

Final position of these points was established on land and will ensure that any visible point materialized can be seen by at least another three points. After materializing the points on the ground a local geodetic network was created, the planimetric accuracy of ± 2cm and altimetric of ± 1cm. Targets on the same side will be placed first at 0.5 m below the seat shells and the second at 1.00 m below the first seat shell. Readings will be conducted at each target separately and will be recorded as zero readings. Periods of tracking required by the project are: monthly, after the frosts, the floods of spring or autumn, and after earthquakes.

The inspection was carried out by a committee appointed by DEJD Neamț that was

OBSERVED INFRASTRUCTURE							
UPSTREAM				*DOWNSTREAM*			
Vertical distance between targets H1= (zero)				**Vertical distance between targets** H2= (zero)			
UP TARGET		*DOWN TARGET*		*UP TARGET*		*DOWN TARGET*	
Citiri de zero Nord**=** Est**=**	*Citiri la data de* **Nord= Est=**	Citiri de zero Nord**=** Est**=**	*Citiri la data de* **Nord= Est=**	Citiri de zero Nord**=** Est**=**	*Citiri la data de* **Nord= Est=**	Citiri de zero Nord**=** Est**=**	*Citiri la data de* **Nord= Est=**
Elevatie**=**	**Elevatie=**	Elevatie**=**	**Elevatie=**	Elevatie**=**	**Elevatie=**	Elevatie**=**	**Elevatie=**
Target deplasation Δ_1		**Target deplasation** Δ_2		**Target deplasation** Δ_3		**Target deplasation** Δ_4	
Line rotation Θ_1				**Line rotation** Θ_2			
COMMITY	**(name**	**forname**	**function**	**institution**	**signature)**		

part responsible for monitoring the behavior of special operations and a professional engineer surveyor. For readings and measurements an electronic total station with electronic field book was used, which allows data storage and automatic processing of horizontal angle readings - vertical angles - distance coordinate format Northeast Elevation (X, Y, Z). The data are recorded in a table like below:

Table 1. Data storage

$$\Delta_i = \sqrt{(N - N)^2 + (E - E)^2}, \qquad \Theta_1 = (\Delta_1 - \Delta_2)/H_1, \qquad \Theta_2 = (\Delta_3 - \Delta_4)/H_1 \tag{23}$$

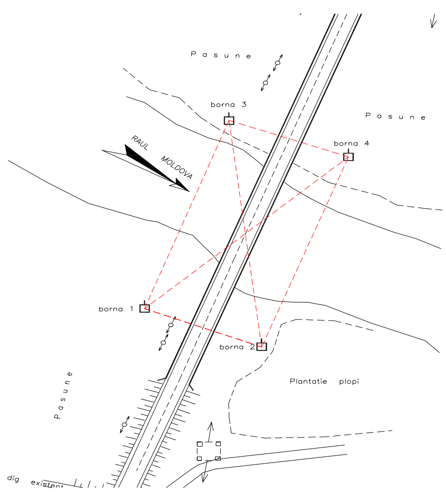

Fig. 1. The geodetic network

Geodetic network for classification precision according to tracking requirements imposed by the project, the network was determined in a local system with high precision equipment, pillars establish targets for sighting reflective material, respecting any conditions that lead to improved accuracy. Were placed around the bridge over the Siren, DJ 207C, Km 6 075 km, a total of 8 pillars (representing points up), placed in order to meet project requirements on: the stability zone location, visibility between terminals visibility target tracking is accomplished by tracking work geodetic network.

Pilasters were made of reinforced concrete and are embedded in an upper internally threaded metal pipe that voucher with a screw pump used to achieve centering forced. Also present at the superiară pillars marking the right height which is measured when the instrument is installed in the station.

Principles underlying the determination of displacement vectors and hence the strains, according to draft up are:

- perform a series of measurements called Zero, that help in the determination of geodetic network points tracking (pillars)
- Well established as a vibrant time stated in the draft prepared for time tracking behavior of the bridge, a series of measurements called 1 were made, consisting of checking network support (stability pillars) and determining the position of tracking points (targets) placed on target;
- the results obtained in two steps are compared, and if the differences of coordinates of points are within a predetermined tolerance, the points are considered to be stable
- always data obtained in a series of measurements are compared with those obtained in the zero cycle.

Each stage of measurements consists of measurements of distances and directions (horizontal and vertical). In the first phase the tracking network is redetermined and compared to the results with those from cycle 0 of measurements to verify the stability of the network points.

In order to achieve compensation and support of the network the methods of indirect measurements, weighted compensation block triangulations and trilateration method were chosen. Two methods were chosen taking into account that the equipment used can take both directions and distances between points. For calculation and compensation of the measured variables and determination of coordinates of points, TOPOEXIM software system was used.

TECHNICAL DATA OF THE SUPPORT NETWORK

Compensation method:

- weighted indirect observation method
- clearing the block triangulation and trilateration
- Network compelled on the old points.
- The total number of points in the network: 4
    - old points: 1
    - new items: 3
- area of the network approximately 0.01 km
- average length of a side: 79 m
- Total horizontal directions: 12
- Average number of directions in a station: 3
- precision of measuring directions: 2 cc
- maximum correction of directions: 18 cc
- average correction applied to directions: 1
- [pvv] directions: 1636
- Total measured distances: 12
- Average number of distance at a station: 3
- Accuracy of measuring the distance: 3 mm
- maximum correction of distance: 6 mm –
- average correction distance: 3 mm

- [pvv] distance: 12
- The lowest point of the network 2
- error in determining the x-axis: 1 mm
- error of determining the y-axis: 2 mm
- total error of determination: 2 mm
- average error for determining a point 1 mm

In step 1 processing and observations were made in accordance to the principles chosen to achieve this project, namely:

- network geometry is expressed by points coordinates and covariance matrix
- Process of the geodetic observations to determine the coordinates;
- Each set of measurements keep the same lines
- after each processing of the geodetic observations obtained at a certain stage of measurement movements will be analyzed
- After processing geodetic observations corresponding to a step it is necessary to apply a test to determine significant movements of points in the network

In the second set of measurements called Reading 1, the measurements consisted of:

- Comments on any point of network support (pillars)
- The support network redeterminated by calculating new positions of all points of network monitoring (target) .

After analyzing the results it shows that the network is stable and external factors have not acted on any item (column) as part of geodetic network support. Therefore, to determine target coordinates the original coordinates for points of support network will be used.

After calculating using the method of dual radiation, compensating and making weighted average to determine the coordinates of tracking targets were achieved the following results:

Table 2. Highlights of the target tracking

SPECIAL TRACKING
MOLDOVA – TUPILATI BRIDGE

COORDINATES OF THE POINTS

NR.PCT	COORDINATE X	COORDINATE Y	ELEVATION	CODE
11	632191.497	613248.150	298.070	99
12	632191.443	613248.277	297.060	99
13	632193.660	613241.060	297.970	99
14	632193.682	613240.906	297.010	99
21	632171.771	613241.713	298.050	99
22	632171.732	613241.723	297.030	99
23	632173.573	613235.814	298.070	99
24	632173.580	613235.782	297.060	99
31	632151.816	613235.822	298.130	99
32	632151.819	613235.850	297.130	99
33	632153.559	613229.898	298.150	99
34	632153.580	613229.882	297.150	99
41	632131.685	613230.347	298.120	99
42	632131.676	613230.463	297.130	99

In accordance to the project time tracking behavior of the bridge over the river Siret, tracking sheets are prepared for each bridge abutment and pile belonging:

Table 3. Tracking table

Observed infrastructure				PILE 1			
UPSTREAM Vertical distance between targets H1= 1.019				*DOWNSTREAM* Vertical distance between targets H2= 0.973			
UP TARGET		*DOWN TARGET*		*UP TARGET*		*DOWN TARGET*	
Citiri de zero	*Citiri la data de 15SEPT2009*	Citiri de zero	*Citiri la data de 15SEPT2009*	Citiri de zero	*Citiri la data de 15SEPT2009*	Citiri de zero	*Citiri la data de 15SEPT2009*
nord	**nord**	**nord**	**nord**	**nord**	**nord**	**nord**	**nord**
632191.497	**632191.497**	**632191.443**	**632191.443**	**632193.660**	**632193.660**	**632193.682**	**632193.682**
est	**est**	**est**	**est**	**est**	**est**	**est**	**est**
613248.150	**613248.150**	**613248.277**	**613248.277**	**613241.060**	**613241.060**	**613240.906**	**613240.906**
elevatie	**elevatie**	**elevatie**	**elevatie**	**elevatie**	**elevatie**	**elevatie**	**elevatie**
298.070	**298.070**	**297.060**	**297.060**	**297.970**	**297.970**	**297.010**	**297.010**
movement		**movement**		**movement**		**movement**	
0.000		**0.000**		**0.000**		**0.000**	
Line rotation 0.000				**Line rotation** 0.000			

6. Interpretation of the results. Conclusions

Unlike previous measurements, there is no change of position tracking points. Systematic errors arising due to differences in temperature during the measurement errors of the operator assigned to + 4 mm were not registered. No deformation is found on the bridge elements, giving them a fixed position.

Fată de măsurătorile efectuate anterior, nu se constată modificări ale poziției punctelor de urmărire. Erorile sistematice apărute datorită diferențelor de temperatură din timpul măsurătorilor, erorilor ale operatorului, încadrate până la ± 4 mm, nu au fost înregistrate, preluându-se coordonate obținute anterior. Nu se constată deformații asupra elementelor podului, acestea prezentând o poziționare fixă.

To avoid any dangerous occurrences must be continuous cycles of measurements in accordance with project tracking.

Tracking methodology, making observations, recording and data processing can be applied to all the road bridge in service.

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