

REFLECTIONS AND COMMENTS ON THE PROCESS OF TRACKING THE BEHAVIOR OF CONSTRUCTIONS OVER TIME

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Abstract: *It is well known that the activity of monitoring the in situ behavior of buildings and land in our country is regulated by Law no. 10/1995 regarding quality in constructions, with subsequent amendments and additions, as well as by a series of STASs and Normatives, among which we mention Normative P 130-1999 regarding the behaviour of constructions over time, which was submitted for public consultation at the end of 2023, in order to amend, complete, improve and update it, and which will enter into force after publication in the Official Gazette. Thus, having the technical and legislative support, the specialists who participate in such geodetic engineering works, of great complexity, precision and responsibility, have the obligation to respect them. Therefore, the beneficiaries/owners of the constructions are the ones who have the legal obligation to initiate the process of monitoring the deformations in order to ensure and verify the suitability for use, the specialists in the field to perform these works, and those responsible, according to the law, to verify all these aspects.*

Keywords: *deformation monitoring; in situ behavior of constructions; legislation; responsibility assumption*

1. Introduction

The objective of monitoring the *in situ* behaviour of constructions is to detect inconsistencies between expectations/previsions and reality, in order to be able to prevent and remove any risk of loss of the qualities that define the suitability for exploitation of the studied constructions. Both the physical aspect (settlement, cracking, corrosion, humidity, etc., i.e. the state of degradation/defect) and the functional aspect (incident, accident, damage, etc.) are subject to monitoring.

The activity of monitoring the *in situ* behavior of constructions is regulated in Romania by Law no.10/1995 regarding quality in constructions, with subsequent amendments and additions. It is also regulated by Normative P130-1999 regarding the behavior of buildings over time and Normative GE-032-97 regarding the execution of maintenance and repair works on buildings and special constructions. Normative P130-1999 was submitted to public consultation at the end of 2023, in the sense of its amendment, completion, improvement and update, being expected to come into effect after publication in the Official Gazette.

According to the legislation in force, the monitoring of the behavior in operation of constructions is done through regular monitoring and special monitoring - which also includes the monitoring of the behavior by topo-geodesic methods. Monitoring the behavior over time of massive constructions (dams, sluices, viaducts, etc.), operated in special environmental

conditions, takes place during the entire period of exploitation of the construction. Constructions operated under normal conditions, without particular risks, such as civil, industrial, agricultural, works of art, etc., are monitored for a shorter period of time, of three to four years, until deformations and displacements have subsided and the construction stabilizes.

Over time, if evolutionary phenomena affecting the construction appear, the measurements are resumed, the causes are determined and rehabilitation/consolidation works are carried out, including maintenance works. When special events take place, such as the occurrence of a high or very high intensity earthquake, it is mandatory to urgently resume measurements to track the behavior over time, at least of massive constructions, in order to avoid the danger of catastrophes, by taking urgent measures, such as rectifying any defects or alerting and quickly evacuating the population.

The improvement of geodetic instruments and equipment, methods and technologies of measurement and automated data processing have created new possibilities for their use in the study of constructions in all stages of execution and operation. Tracking the *in situ* behaviour of buildings using topo-geodetic methods ensures a high accuracy of measurements and indicates the absolute magnitudes of any displacements and deformations they may undergo over time.

2. Reflections and comments

The extensive process of deformation monitoring by geometric methods requires the use of high-performance, highly accurate measuring equipment and the rigorous processing of the observations made in each measurement cycle. Beforehand, it is necessary to check the stability of the landmarks in the local geodetic monitoring network, which are considered fixed.

When designing a local geodetic tracking network, it is absolutely necessary to establish an optimal number of fixed landmarks. It has been statistically proven that a number of 3-4 fixed landmarks can ensure high accuracy and good performance both in terms of time execution, as well as from an economic point of view (Fig. 1), at least in the context of determining the horizontal displacement vector of the studied construction [2]. To obtain the vertical displacement vector, the number of fixed landmarks will be at least two.

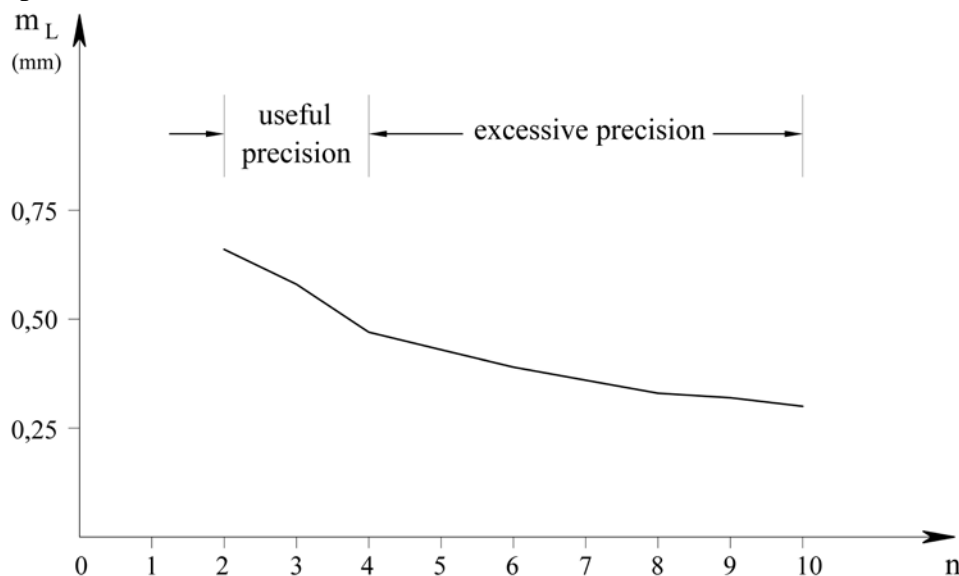


Fig. 1 Optimal number of fixed points

The fixed landmarks have the role of creating a comparison plane against which the displacements of the control points are determined. They are placed outside the area of influence of the observed construction, below the frost depth and down to the bedrock or are embedded in old existing constructions (massive and stable) or in rock, in accessible places for observations (Fig. 2).



Fig. 2 Fixed landmarks

Unfortunately, reality shows us that there are situations when the choice of location for materializing fixed landmarks is not the most suitable (Fig. 3).



Fig. 3 Landmarks considered fixed

According to Normative P130-1999, which is still in force, special monitoring is carried out on the basis of a *Special Monitoring Project*, which is performed by a specialized firm in collaboration with specialists in the field of experimental research of building elements and structures, specialists in the field of measurement and control equipment as well as specialists in automation and automatic data processing. Also, the regulation stipulates that the State Inspectorate in Construction is responsible for inspecting and verifying compliance with the special monitoring projects, which form the basis of the monitoring process of behavior over time.

In reality, there are cases in which not all the specialists who should be involved do participate in the development of these monitoring projects, as stipulated by the above-mentioned normative. Without the involvement of the geodetic specialist in the implementation of special monitoring projects, it can be practically impossible to fully comply with these projects or to obtain results that may not accurately reflect the real situation in terms of the evolution over time of the monitored objective. This can also occur if the specialist who performs the cyclic monitoring does not comply with the technical regulations in force, standards, norms, technical instructions, etc.

The use of advanced equipment and technologies in the deformation monitoring process does not automatically guarantee the attainment of the most precise results, which accurately reflect the real field situation. The accuracy of the obtained results depends primarily on the manner in which the local geodetic monitoring network is established and determined, the experience of the specialist conducting the measurements and on compliance with the basic principles of geodetic measurements.

When handing in the *Special Monitoring Report* for the respective observation/measurement cycle, prepared by the geodetic specialist, in accordance with the requirements of P130-1999, the *Measurement Logbook* and the *Rigorous Compensation Report* should not be omitted, in addition to the *Plan with the location of fixed landmarks and control points*, *Sketch of the tracking marks in the microtriangulation network*, *Sketch of the high-precision geometric levelling lines*, *Sheets/Tables* with the results obtained (horizontal and vertical displacements/deformations), *Graphs*, *Conclusions and recommendations*, etc.

A special case involves the constructions under the ownership of the Romanian state, particularly the large dams. These structures are mandated by law to undergo ongoing monitoring throughout their lifespan. Per the current legislative regulations, the responsibility for awarding these monitoring contracts rests with the beneficiaries, who conduct a public tender to select contractors. Thus, the executor of geodetic measurements for the respective objective may change annually, which is not exactly beneficial, considering the fact that each executor/specialist/operator may use different equipment, have different experience, a different approach, etc. Another aspect that, unfortunately, is not taken into account, is that, often, the awarding of tenders is done strictly on the principle of the lowest purchase price, which can have repercussions on the quality of the work performed. A solution to eliminate inconveniences of this nature could be the implementation by the Romanian state, through the Romanian National Water Administration, of *Deformation Monitoring Management Systems*, which have the enormous advantage of knowing the evolution of the monitored objective in real time, at any moment.

3. Conclusions and recommendations

From a legislative perspective, the activity related to monitoring the behavior during construction execution and operation is regulated by Laws, Regulations, Standards (STAS), Technical Instructions, etc.

Special monitoring should be done only by geodetic specialists, based on a Special Monitoring Project, in which the geodetic expert should be mandatory involved.

The State Inspectorate in Construction conducts the control and verification of the accuracy of monitoring behaviors over time on objectives that, as mandated by law, are obligated to fulfill this duty.

In order to have the technical ability to properly verify the *Special Monitoring Reports*, executed by geodesists, the State Inspectorates in Construction should have a geodesic expert in the control team.

To maintain permanent control of the evolution over time of large dams in our country and to avoid possible catastrophes, the so-called real-time *Spatial deformation Monitoring Systems* can be implemented.

4. References

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