SERVICEABILITY PROBLEM OF LEVELLING NETWORKS BASED ON THE EXAMPLE OF BYDGOSZCZ NETWORK

Derezińska Agnieszka, Kujawski Edward
University of Technology and Life Sciences in Bydgoszcz

The terms commonly used in the engineering are: "reliability" and "serviceability". Related to products, they refer to facilities which are to fulfil defined useful purposes. In the engineering geodesy any types of survey networks are such products and their material elements are reference data permanently stabilised in the field. One of such products are benchmarks. Depending upon the designation, they create state or local elevation networks. The primary purpose of the state levelling network is to facilitate the establishing of selected points elevations in the state system. The purpose of local networks is to facilitate a land survey task for a given facility. In this range, they serve as height reference data for a realization of engineering investments or for monitoring of vertical displacements of structures. Therefore, to fulfil its useful feature of levelling network, it must transfer in a reliable manner the elevation reference system. "Reliable" means with the accuracy defined for a given control network. At the same time, this feature shall be maintained during the whole planned period of use. The maintenance of space stability of benchmarks which is equal to the maintenance of their height co-ordinate with the accuracy determined while positioning them, is defined as "operational reliability". It results from the above, that instability of benchmarks beyond a defined value shall disqualify a given network as not reliable.

To present the issue in a more general way, we may assume that knowing the purpose which a given network is to fulfil, we may define requirements of accuracy. In turn, they are implemented with the use of relevant measuring equipment, an optimum design of network shape, the proper technology of measurement and logically carried out statistical treatment of the data acquired. In the literature, in particular in the recent years, there have appeared several papers related thereto. Amongst Polish papers which deal with reliability problems, the following may be distinguished in the range of "reliability of network implementation" (Prószyński W., Kwaśniak M.; 2006) as well as those which attract attention to "operational reliability of networks" (Wolski B., Toś C.; 2005).

Wolski B., Toś C. (2005, 2006) suggest that the reliability of measurement procedures defined as a potential to fulfil the jobs assumed in defined terms and time periods may be determined in three various tasks:

- **while interpreting the accuracy of a measurement (standard error),**
- **while analysing the measuring process in the aspect of a hypothetical occurrence of a blunders,**
- **while determining the reliability of stability of control points during operation.**

In the comments to the latest task, this is claimed that the operational reliability makes up a measurement of the credibility of functioning of the whole network of points (control network) its fragments or individual benchmarks. It is expressed in the form of probability of occurrence of a typed feature, for instance vertical displacement. They

also draw attention to sometimes unjustified modelling of survey errors with a normal distribution. These remarks shall be extended by the fact that the operation of levelling networks (its operating use) is characterised frequently by lack of consequence in the approach to the fulfilment of standards and engineering recommendations by those carrying out land survey tasks. In particular, this refers to the operations of elevation transfer from a given benchmark. Taking the above into consideration, we can assume that the operational reliability of a levelling network remains under the impact of two factors:

- **the loss of elevation feature of its marks (benchmarks),**
- **the loss of technical possibilities to use the mark.**

Such reasons being assumed as having an impact on the operational reliability of levelling networks, we may claim that they may be detected by:

- **carrying out of control measurements in relation to other network benchmarks,**
- **visual evaluation of the condition of the benchmark and place where it is located.**

The purpose of this paper is to assess the reliability (understood as serviceability) of control network benchmarks which were visibly "damaged" or whose surrounding has been so transformed that their use makes it impossible to achieve the height with the foreseen class of accuracy. This feature of network reliability may be defined as durability of its reference points. The cases of total doing away with benchmarks being omitted, this paper presents commonly occurring cases of their "damaging". They are illustrated in photos 1-4.

The fact that the benchmarks presented on figures from 1a to 1d cannot be used in accordance with the principles, need not testify to their total elimination from use. For works, where the identification of a measuring place of such a benchmark is possible (with the required accuracy maintained) such a benchmark may be useful.

a)

b)

c) d)

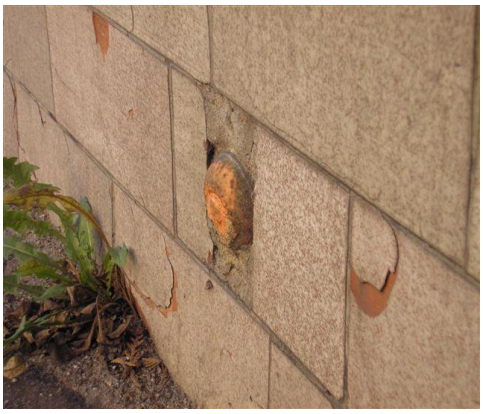

Fig. 1.: a and b - benchmarks, on which it is impossible to position a vertical staff of normal length, c and d - benchmarks, on which it was impossible to position a staff.

However, we must bear in mind the fact that such a decision must be supported by a control measurement with another point of elevation control network (the principle of height control for reference points selected for use). At the same time, in the case it is necessary to use such a benchmark many times, an individual benchmark (the so-called operating benchmark) shall be fixed nearby. The operating benchmark shall not be a standard shape but possibly it may be included into the specification of the local levelling network only based on the measuring procedure foreseen for the supplementing of networks.
The above-presented opinion, related to the exceptional use of damaged benchmarks shall not make up a "recipe" for the generally progressing loss of reliability of large areas of levelling networks. This refers, in particular, to municipal networks where in small distances (less than 500m) benchmarks should be positioned to fulfil the preciseness criteria of a given levelling class.

For a few years, the co-authoress of this paper has been analysing the problem of the progressing loss of benchmarks in the municipal levelling network of Bydgoszcz. Based on the archives which contain the inventory of levelling benchmarks carried out in 1969, it was found out that:

- **in the list of networks, 654 levelling benchmarks existed,**
- **from this number, 55 benchmarks were not found (no information could be obtained on their history),**
- **according to the local informers, 78 benchmarks were damaged (removed for various technical reasons),**
- **23 benchmarks showed damages, disqualifying them as unstable,**
- **30 benchmarks were in the area to which the entrance was closed.**

The above indicates that about 8% of benchmarks were not found in the network, 12% of benchmarks were destroyed (removed), and 4% of benchmarks were damaged. This gives a totality of 24% of benchmark loss in the network.

In the years 2003 and 2007, the authoress, within her own research, carried out an inventory of benchmarks in an area of a surface of 9km^2 presented in figure 2.

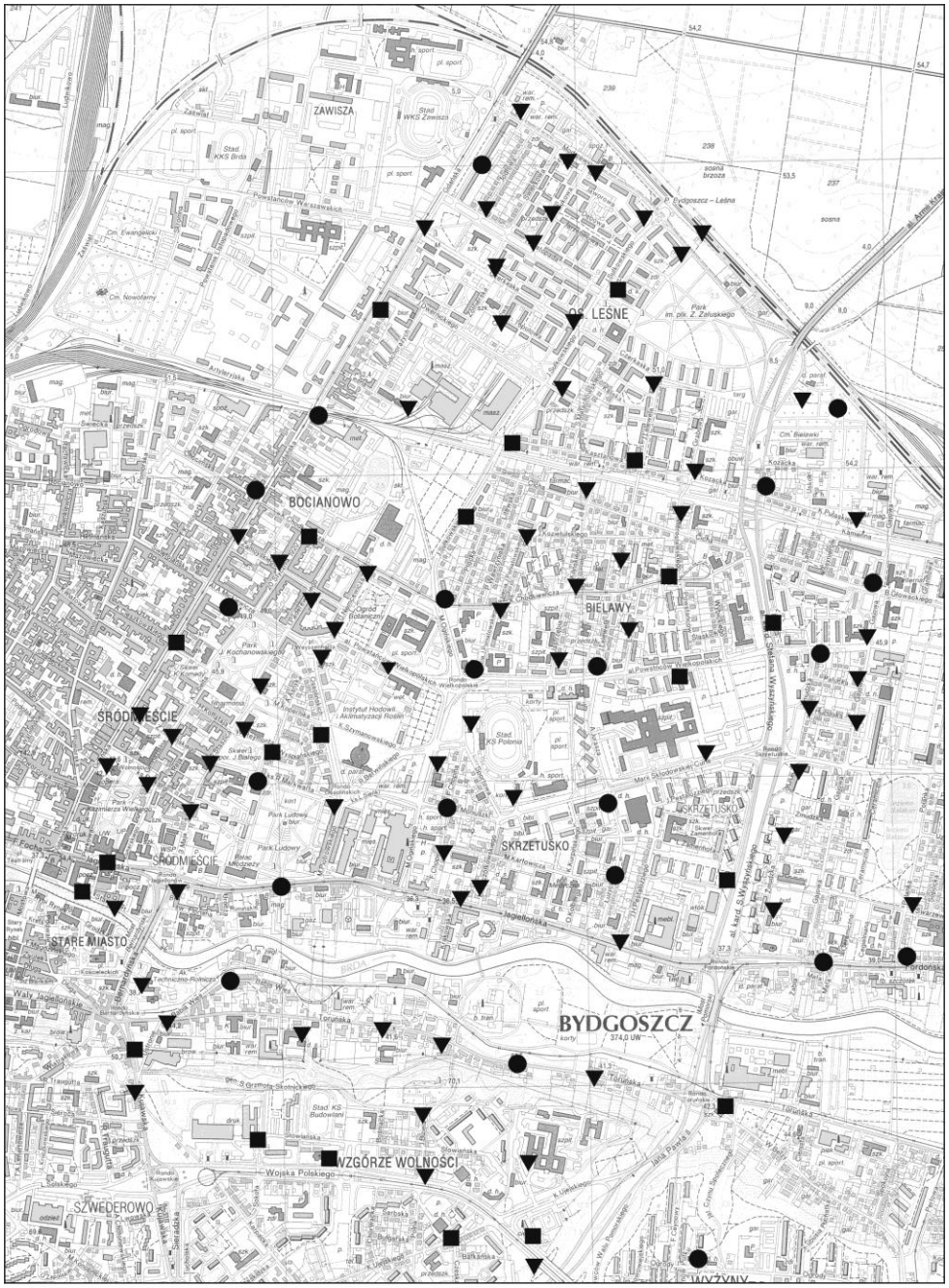

Fig. 2. A fragment of Bydgoszcz area covered by the research of benchmarks' durability.

As a result of inventory carried out in 2003, it was found out that per 114 benchmarks which should be found in this area:

- **10 benchmarks were removed or completely covered (covered in concrete or plaster which makes up about 9% of benchmarks sought for),**

- **the surroundings of 19 benchmarks were so transformed that it was not possible to position on them a typical levelling staff; this makes up about 17% of benchmarks sought for.**

In total, 26 per cent loss of benchmarks was ascertained on the analysed area.

In the repeated inventory of 2007, it was found out that:

- **21 benchmarks were removed or completely covered (with concrete or plaster),**
- **20 benchmarks on which it is not possible to position a typical levelling staff (of which 6 partly covered i.e. such on which it is not possible to position a staff because of their profound covering - see figure 1).**

In total, this makes up more than before, a 36 per cent loss of benchmarks in the analysed area.

Based on the above data, we may claim that between 1969 when the first inventory of the network was made, and 2003, from the sample of 114 benchmarks, 17% of benchmarks were eliminated. Between 2003 and 2007, from the same sample, a subsequent 19% of benchmarks were eliminated. In consequence, this means that in the period of the recent 4 years, there was a double increase in the rate of network damaging. The main reason for this state is the upgrading and insulating of building elevations where they are stabilised. We may assume that this tendency shall be braked down as the number of buildings being renovated is decreasing. However, to prevent it, the authors of this paper suggest an urgent information to be sent to the owners and managers of real estates in which the benchmarks were stabilised to draw their attention to this problem.

REFERENCES

Prószyński W. : (1989), ***Jeszcze jedna metoda identyfikacji wzajemnie stałych reperów odniesienia*****, Przegląd Geodezyjny 4-5.**

Prószyński W., Kwaśniak M.: 2002, ***Niezawodność sieci geodezyjnych*****, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.**

Prószyński W., Kwaśniak M.: 2006, ***Podstawy geodezyjnego wyznaczania przemieszczeń – pojęcia i elementy metodyki*****, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.**

Wolski B, Toś C.: 2005, ***Funkcje stabilności punktów osnowy wysokościowej*****, Prace Naukowe Instytutu Górnictwa Politechniki Wrocławskiej, Konferencje 114/45 Wrocław.**

Wolski B.: 2006, ***Monitoring metrologiczny obiektów geotechnicznych*****, Wydawnictwa Politechniki Krakowskiej, Kraków.**

Instrukcja techniczna G-2: 2000, ***Wysokościowa osnowa geodezyjna*****, Główny Geodeta Kraju, Warszawa.**