EXAMPLE OF FOUNDATIONS DEFORMATION PROCESS BASED ON THE ALTIMERIC SURVEYS

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1. INTRODUCTION

The altimetric surveys performed during the geodesic intervention monitoring furnish necessary information on settlement of load-bearing structure parts in which the benchmarks have been installed. By measuring the settlement of given benchmarks stabilized in load-bearing walls or directly in the foundations, it is possible to determine the deformation of the load-bearing part, as well as the deformation of the entire examined structure. The deformations of structure are caused by the deformations of the subbase. The deformations may result from mining, which – in addition to continuos terrain deformations - causes also the non-continuous deformations. The latter are very hard to forecast in a longer time-frame, and their impact on a building are known as exceptional actions. Such phenomena include:
- local incontinuities of the subsidence basin profile, mainly as, thresholds and riffs, which can occur at large subbase deformations and in the area of tectonic faults,
- very intensive, continuous basin deformations caused by accumulation of multiple mining exploitations, which basic results is often an excessive deflection of buildings located in the basin edges,
- lowering of the building foundation level below the groundwater level, which may be related to the building becoming contaminated with moisture or partially flooded,
- sudden changes of the basin deformation increase caused by uneven progress of mining works,
- activation of large ground movements, such as landslides.
In addition to the exceptional phenomena relating to the mining, the masonry buildings are very much affected by uneven subbase settlement caused by the following factors: subbase heterogeneity, varying loads on subbase, disturbance of subbase stability, subbase movements caused by heaving forces, change of subbase water conditions.
The paper presents the examples of identifying the deformations of the subbase and the deformable foundations located in such subbase, based on the levelling measurements.

2. METHODS OF IDENTIFYING THE GROUND AND FOUNDATION DEFORMATIONS

The foundation can be treated as a rigid or deformable structural part. In case o deformability, it can be assumed that the foundation adapts to the shape of deforming subbase. The description by means of a function going through all benchmarks is a very time-consuming and complicated process. Therefore, when describing a shape of the flexibly deformed part, a 2nd degree parabola (1), (2) or a circular function are most often used.

$$s(X)=aX^2+bX+d \qquad (1)$$

$$s(X)=aX^2+bX+cY+d \quad (2)$$

Then, the settlement of each benchmark is approximated by means of the functions which describe the dislocation of the subbase in time. Examples of such functions based on the rheological (1) or consolidation (2) models are given below:

$$s_t = s_k \cdot \{1 - \exp[-\alpha \cdot t]\} \quad (1)$$

$$s_t = s_k \left\{ 1 - \left(\frac{8}{\pi^2} \right) \cdot \left[\sum_{m=0}^{\infty} (2m+1)^{-2} \cdot \exp\left[-(2m+1)^2 \cdot \alpha \cdot (t) \right] \right] \right\} \quad (2)$$

s_t – settlement in time t,
s_k – settlement in time $t \to \infty$,
α - coefficient characterizing relative settlement speed depending on physical and mechanical ground properties.

3. EXAMPLE OF FOUNDATIONS SETTLEMENT

The example presents the settlement of benchmarks located in the building at Unieście. The configuration of subbase layers is determined on the basis of the geological drillings performed before the building has been built and is shown in the table 1. Notice a 30-cm peat layer which ill significantly influence the settlement of the structure. The settlement of the building was observed between 1972 and 1999. The observed settlement cases, approximated with functions (1) and (2) have been shown on the basis of three chosen benchmarks.

Table 1. Results of geological drillings.

Elevation m n.p.m.	Ground
+1,0 ÷ +0,7	surface soil
+0,7 ÷ -4,1	medium sand
-4,1 ÷ -7,1	alluvial deposit
-7,1 ÷ -7,4	peat
-7,4 →	sandy loam

3.1 Rheological models

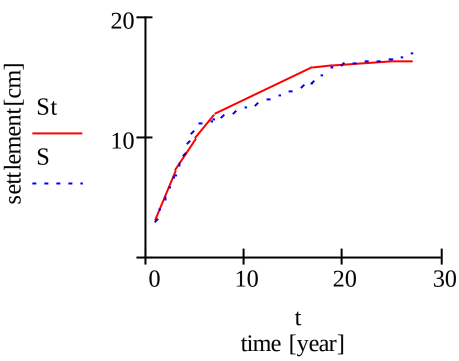

Fig. 1. Benchmark 1 settlement diagram
St – approximated settlement , S – measured settlement.

Standard deviation of approximation:
σ_{app}**=0.806**

Average values and standard deviations of estimated variables:
S_k**=16.44** σ_{sk}**=0.52**
α**=0.1807** σ_{α}**=0.0300**

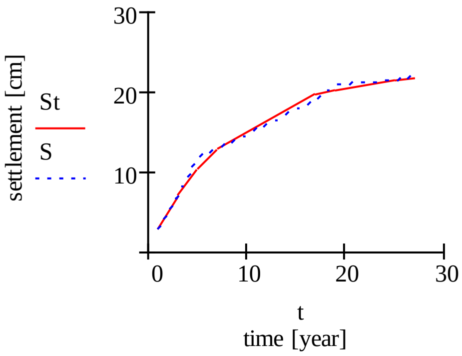

Fig. 2. Benchmark 2 settlement diagram
St – approximated settlement , S – measured settlement.

Standard deviation of approximation:
σ_{app}**=0.772**

Average values and standard deviations of estimated variables:
S_k**=22.40** σ_{sk}**=0.80**
α**=0.1200** σ_{α}**=0.0170**

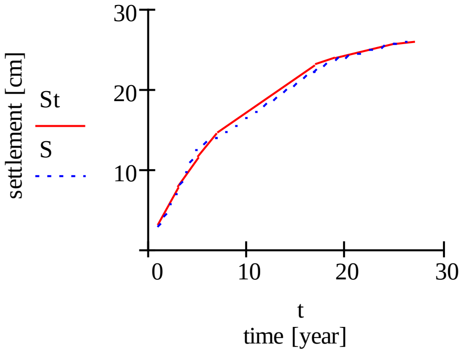

Fig. 3. Benchmark 3 settlement diagram
St – approximated settlement , S – measured settlement.

Standard deviation of approximation:
σ_{app}**=0.769**

Average values and standard deviations of estimated variables:
S_k**=27.51** σ_{sk}**=0.98**
α**=0.1057** σ_{α}**=0.0130**

3.2 Consolidation models

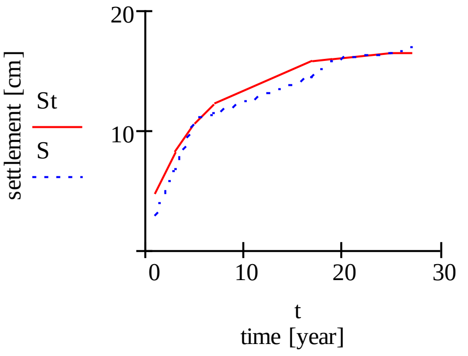

Fig. 4. Benchmark 1 settlement diagram
St – approximated settlement , S – measured settlement.

Standard deviation of approximation:
σ_{app}=0.780

Average values and standard deviations of estimated variables:

S_k=16.60 **σ_{sk}=0.56**
α=0.1600 **σ_α=0.0300**

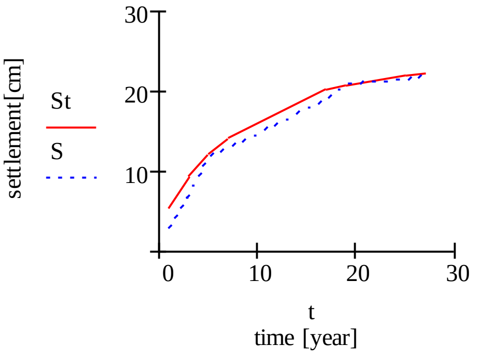

Fig. 5. Benchmark 2 settlement diagram
St – approximated settlement , S – measured settlement.

Standard deviation of approximation:
σ_{app}=0.768

Average values and standard deviations of estimated variables:

S_k=23.10 **σ_{sk}=0.98**
α=0.1060 **σ_α=0.0190**

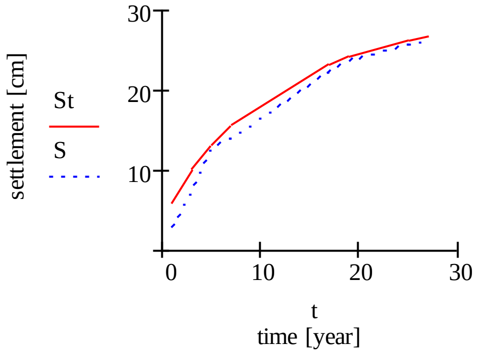

Fig. 6. Benchmark 3 settlement diagram
St – approximated settlement , S – measured settlement.

Standard deviation of approximation:
σ_{app}**=0.714**

Average values and standard deviations of estimated variables:

S_k**=29.35** σ_{sk}**=1.58**

α**=0.0788** σ_{α}**=0.0140**

4. RECAPITULATION

Altimeric surveys are an invaluable source of information when identifying the subbase deformation, and - indirectly – also the deformation of the deformable foundation. The results of precision levelling are approximated by means of the settlement functions based on rheological or consolidation models. The examples shown in this paper confirm the usefulness of the settlement functions even when the settlement of an examined structure lasts for many years.

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