# MEASUREMENT METHODS USED IN TRACKING BEHAVIOR IN TIME OF CONSTRUCTION

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***Abstract**: Tracking behavior while construction takes place throughout the life of the assets from its execution and is an activity systematic collection and use of information derived from observation and measurements of phenomena and sizes characterizing properties of construction in the process of interaction with the environment ambient and technology.While tracking the behavior of construction refers to changes in position and shape of all or some elements of it, and referral emergence of evolutionary phenomena that may affect construction safety. This allows taking speedy measures to prevent accidents, disasters and even loss of life.*

***Keywords:** deflections, triangulation method, Mixed method, Photogrammetric method, Tilt determination*

## 1. Introduction

Tracking constructions behavior is an activity that consists in measuring, recording, processing and interpretation of parameter values that define extent that buildings retain their demands strength, stability and durability.

## 2. Installation Sites of Signals

Marks the tap is installed, usually in building foundations bearing coming to the surface. The spread signal is shown in fig. 1.b. For comments on the historical and architectural monuments, changing the appearance of the building, closed signals are used (fig.1.c). These marks are installed in the same plane with the wall (2) and open it during the observations.

Installation sites of signals are determined depending on the requirements of observations. Typical for industrial and civil buildings they are placed on the perimeter with range of 10 m, bearing construction inside buildings and on both sides of the building subsidence joints.

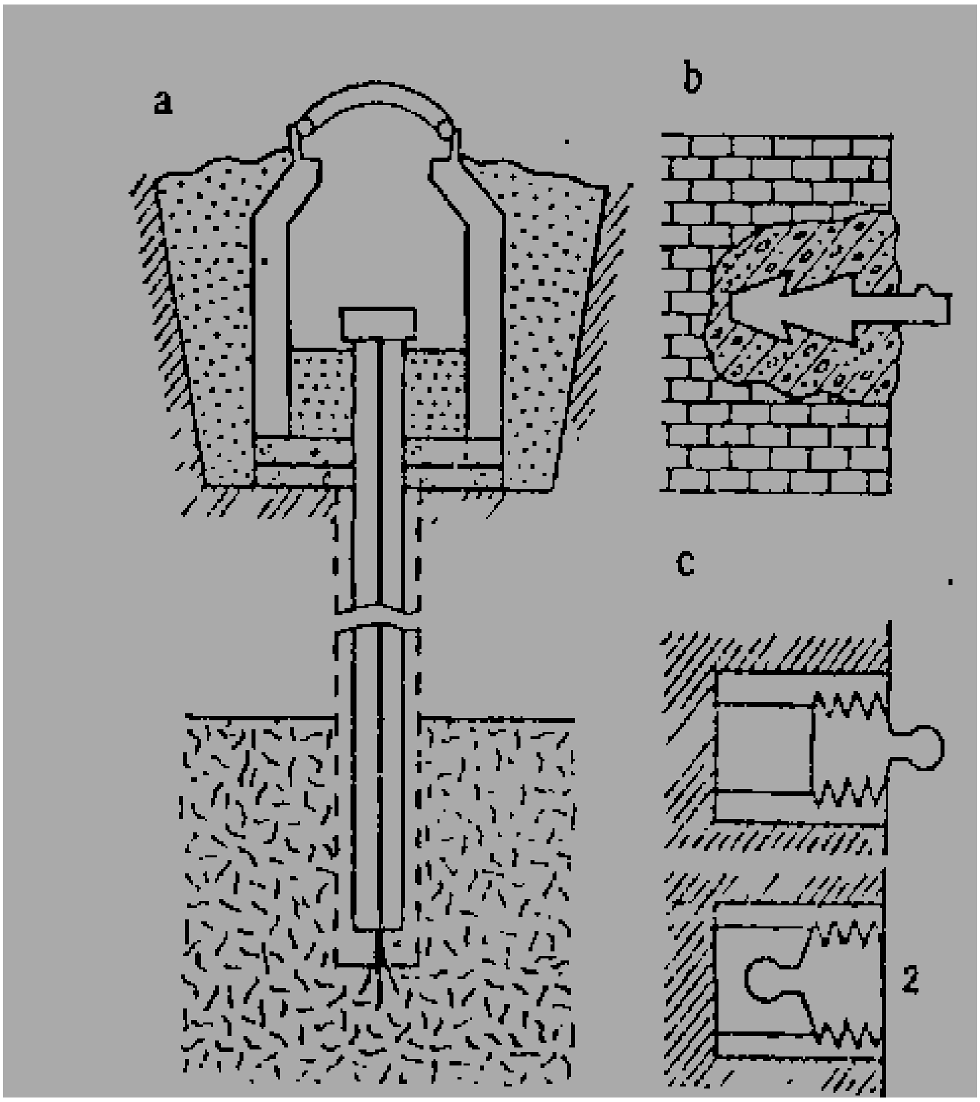


Fig. 1. Signals Fixing points for making observations on settlements bridges
a) depth cues; b) parts (branded) compaction; c) benchmark closed form slump

Mark j i compaction cycle is calculated as follows:

$$\Delta\, ij = H\, o\, j - H\, ij$$

Where:

- Høj - quota zero mark in the cycle of measurements;
- H i j - brand share observations and j cycle.

When measuring the deflections of structural elements located above, or to measure displacements of points above which are obstacles, use short groom several tens of centimeters, made of a light metal and divided as invar groom belt.

Depending on needs, the groom sits on landmarks, verticalized into a circular vial is suspended or strip or bar of constructs examined in detail.

The lower end of the tape, which was suspended weighs surprised that sank in a bowl of water. When examining construction steel bands or bars are welded suspension of test patterns followed by the construction element. During measurements will note the air temperature to calculate changes in the length of the suspension strips or bars to take them into account in deflections to be determined.

Mira band fits easily through rods with nuts and is being carried out using precision level readings are placed on special pillars, tall or tripod and connected with a leveling screed.

Sizes calculated displacements are usually present simultaneously in foram tables and charts the fall and particulars concerning the state of the object examined air and water temperature, time status etc.

Bridge beams to measure arrows mark is placed on top of the superstructure. Executing geometric leveling, during the test sample can be measured with great precision arrows actual construction. This leveling runs to landmarks fixed precision instruments.

## 3. Measurement of Deflections (Arrows) Side Pillars Endorsement Process

This process is used to determine the bending columns, pillars, etc., in the industrial hall. Checked the sector, some distance "l". The axis of the array of pillars A - A1 (about 1 meter) plot a parallel axis A1 - A111, marked the ends of them.

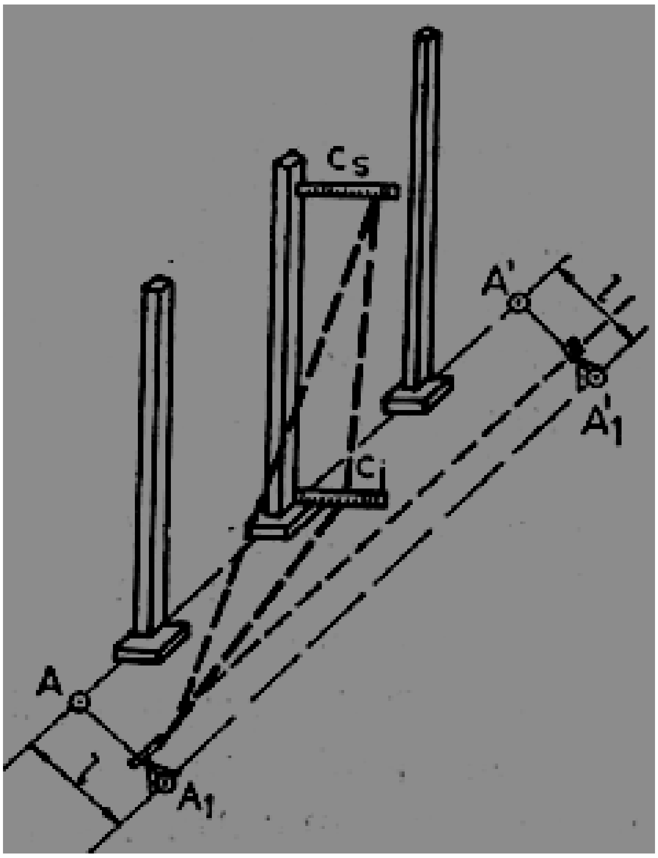


Fig. 2 The process targeting two side theodolite

Above these signs shall be installed and carefully crosses the theodolite and brand of sight.

The difference of the readings in the two (three) of the theodolite vertical position of the circle at the bottom of the pillar C1, Cm medium and C3 is the deflection of the top of the pillar cross.

$$\Delta l \text{ i}= Cij - Cmj$$

$$\Delta aj = l - Cij.$$

## 4. Triangulation method

For this method basic signals A and B are located at a distance stable ground rather than the object of observation, and the construction of the dam example, to install the pillars of observation I, II, III and regularly (in cycles ) method of triangulation to determine their coordinates.

For this purpose are determined with a very high precision, for example by electro-finder length AB and the base angles of all the triangles is measured.

After processing the data for each cycle is acquired coordinates studied.

Movements observation points (pillars) in X and Y axis directions is calculated as the difference between cycles corresponding coordinates. The results of determining movements are inscribed on schemes drawn up for each cycle of observations. Absolute size of the total movement is determined as Dx diagonal rectangle with sides and ΔY.

$$\Delta = \sqrt{\Delta X_2 + \Delta Y_2}$$

If the construction of the points studied, for example the walls of the building can not be installed theodolite, the method guidelines. With this method the angles are measured only at points A and B signals basic and determined the coordinates of points 1, 2, 3 is calculated as the angular intersections. This method does not work so precise triangulation method, but requires a smaller works.

In the cases analyzed movements are determined points in the direction of two axes (the plan) and high reliability. But compared to the volume alignment method of land measurement and processing results are much higher.

## 5. Mixed method

Using this method the basic signals A and B are placed in the ground, set at a distance from the object and observation pillars I and II, which forms the alignment of I-II -at a distance not far from the object. Construction installs deformation marks 1, 2 and 3. When making observations in zero cycle, coordinates pillars of observation. $X^0_I$, $Y^0_I$ and $X^0_{II}$, $Y^0_{II}$ determined by the method of triangulation and deviations $c^0_1$, $c^0_2$ and $c^0_3$ deformation of the marks 1, 2 and 3 alignment face additional I-II is measured from the pillars.

In the second cycle of observations measurements are repeated in the same sequence, determine the coordinates of observation pillars $X^I_{II}$, $Y^I_I$; $X^I_{II}$, $Y^I_{II}$ and measure deviations $C^1_1$, $C^l_2$ and $C^l_3$, deformation of measures to alignment.

If deviations pillars observation

$$\Delta X^I_I = X^0_I - X^I_I - X^I_{II}$$

and

$$X^I_{II} = X^0 II - \boldsymbol{X^l_{II}}$$

on X axis error not exceeding determining the coordinates determined by measurement results through triangulation method, then moving it marks strain determine the method of alignment.

If $\Delta X^I_I$ movements and $\Delta X^I_{II}$, errors are larger than the determination of coordinates, then the measurement results alignment deviations from $C^1$, $C^l{}_2$ and $C^l_3$ corrections are introduced.
To determine corrections we will analyze; whether the observations given cycle has become a pillar $\Delta X^I_I$ away from the point I was moved II; Pillar II observations gained movement $X^I_{II}$ and II was moved to point III. In this case the corrected values of deviations marks deformation can be calculated formulas:

$$c^I_{1cor} = c^I_1 + \delta_1 \,;\; c^I_{2cor} = c^I_2 + \delta_2 \,;\; c^I_{3cor} = c^I_3 + \delta_3$$

The method combines observations mixed triangulation method safe and simple method alignments. Compared with the method of triangulation method is significantly reduced volume mixed measurements (in particular a large number of marks), and compared with the method of alignment is significantly increased reliability of the results, since it causes the movement of the alignment points I and II.

## 6. Measuring subsidence and deformation construction methods and terrestrial photogrammetric and stereofotogrammetric

Fotogrametric and stereofotogrammetric methods land and can be used successfully to measure the construction deformations.

Their advantage over other methods is that they set with sufficient precision constants and temporary deformations (in two or three dimensions) taking place under the action of static and dynamic applications, and can be applied in various technical-engineering purposes (housing, industrial and hydraulic construction, testing bridges, shipyards, studying landslides etc).

Shooting marks deformations is done using phototheodolite in all seasons and in a very short time. Further processing cabinet is made from aerial photographs etereo-comparator during the performer agreed. In addition, photographs of the object photographed with marks obtained deformation is an objective document that secures the position of building space to the shooting date.

However, photogrammetric and stereophotogrammetric methods be applied in those cases when this is indicated in economic terms.

**Photogrammetric method** for determining the subsidence and deformation construction consists of sequential shooting of special signs on the building before and after deformation.

**Stereophotogrammetric** of the method is particularity stereoscopic vision to perceive depth space, which allows determining the movement of a certain point in the construction of three measurements.

When construction has a significant or great height and length does not fit on one of the frames, for total coverage of the object shooting is performed as follows:

a) phototheodolite optical axis, horizontal and parallel to each other, inclined to the perpendicular by the angle ± φ to the base;
b) perpendicular to the optical axis of phototheodolite based and parallel to each other, but inclined to do with the angle of ± ω horizon.

In this case the spatial coordinates of the mark in each cycle observations will determine the formulas given special courses stereophotogrammetric. We note that the accuracy of determining the construction of strains in each of cycles depends on the constancy observation height of phototheodolite position and orientation constancy. Basically, these requirements is a difficult task.

With sufficient precision to solve it is necessary to have each of not less than 2-3 frames checkpoints whose position should be determined in advance by surveying methods. Let us analyze some peculiarities and requirements of photogrammetric method and stereophotogrammetric that must be taken into account when measuring the strains construction.

The best signals for comment on construction deformations using phototheodolite are:

a) pilasters supporting section 40 x 40 cm-pits to the stable layers of foundation and provided with special centering device to ensure consistency and establish phototheodolite in some of the same points pilasters head.
b) Brands deformations fixed for all observation period in building walls or other parts of the building. The marks are flat metal plates of dimensions 6 x 6 cm and a length of tie rods fixed with 5.6 cm of cement paste target is observed.

On the face of the brand are the concentric circles with diameters of 10, 30 and 50 mm and thickness of 5 mm perimeter, which are painted, ranging from alternative center with black and white paint. It can fund the plate to square with white paint and draw on this fund to a black cross that is made up of two mutually perpendicular lines l0-12 mm wide.

Such a mark appears on the negative form of circles black or white cross, which creates conditions for precise targeting to target black mark on the center brand image deformation.

## 7. Tilt determination by leveling high geometric constructions (or the size of subsidence foundations)

Tilting higher buildings can be determined, as in the case of subsidence measurement foundations by using trademarks quotas wall planted in four opposite sides of each foundation on which these constructions are executed.

Shares slump marks is determined by a geometric leveling traverse supported by a leveling A landmark located about. 40-50 m building.

The principle of this method is to determine the difference in level between two points A and B based on observations made with a high performing tool horizontal lines and vertical observation groom placed on two points A and B. The two heights are and the $I_B$ the difference is clear that the drop between point-to-$I_B$ = $H_{AB}$. With this difference of line B share is

$$H_B = H_A + h_{ab};$$

$$H_B = H_A + I_A\text{-}I_B,$$

$$H_A + l_A = H_B$$

share comments or share horizon line

$$H_Z\text{-}H_B = I_B.$$

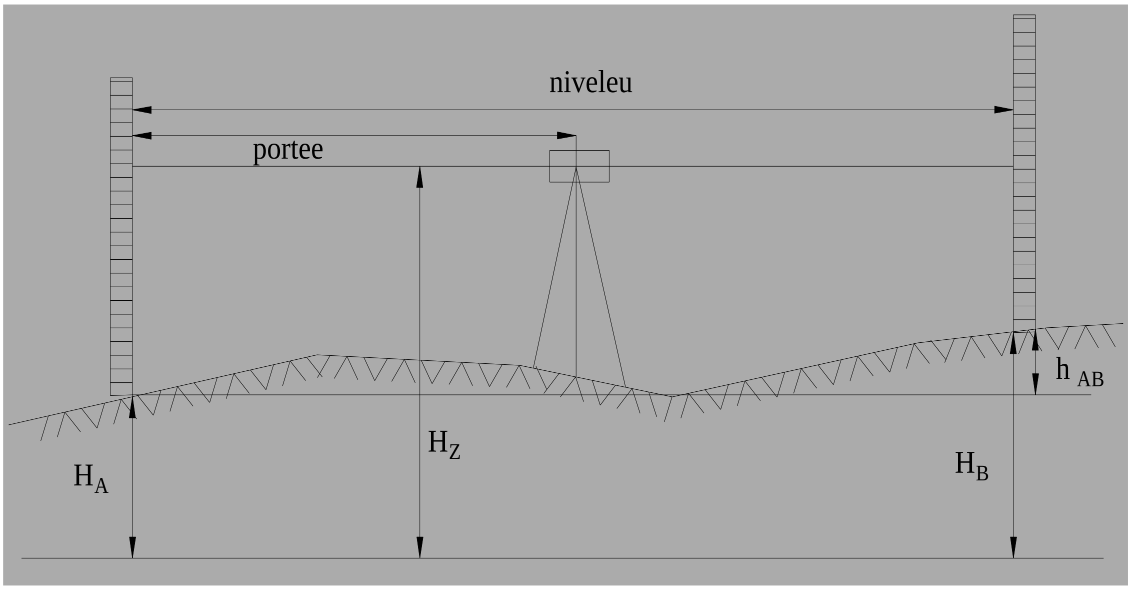


Fig. 3 Geometric levelling method

The instruments used in measurements of heights groom are called vertical levels; Their range is very high, but differs significantly between them, both through constructive principles and in particular through precision. Thus, there are tools that provides accuracies of 1 mm by approximation, called technical tools (technical levels). There are also tools that provide an accuracy of± 0,005mm, called precision instruments used in technical papers and specialty papers.

Regardless of the type of instrument measurements in leveling geometric are usually a point roughly the same distance from point A and B and that to eliminate some errors that occur during the measurement, the main one being the error of collimation (the mismatch between the optical axis and the axis of the rear window visa).

It is easy to understand that horizontal line of observation, tilt it causes errors in$\varepsilon$determined by the existence of an angle measuring heights and L b equal, equal to X, the distance from S to A and that B will be equal.

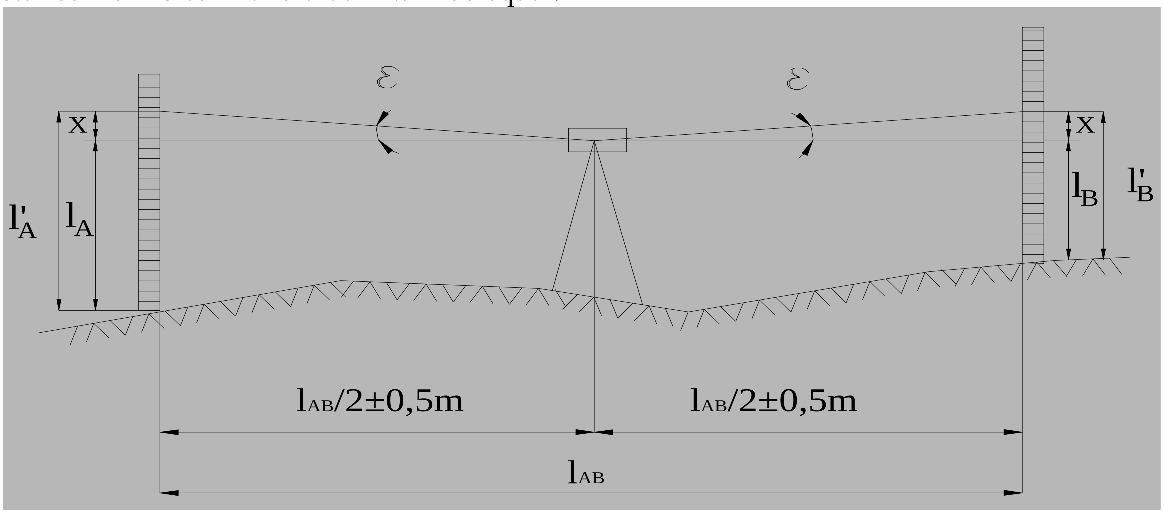


Fig. 4 Collimation error in leveling influence of geometric means

Because of this error are obtained places:

$$l_A' = l_A + X\ ;$$

$$l_B' = l_B + X$$

Level difference:

$$h_{AB} = l_A' - l_B' = (l_A + X) - (l_B + X) = l_A - l_B$$

It is noted that in this way the error X is canceled. There are times when it is preferred a different point, namely a point S be A or B, which leads to the following situation:

$$H_B = H_A + h_{AB}\ ;$$

$$h_{AB} = i_A - l_B;$$

$$H_B = H_A + i_A - l_B;$$

$$H_B = H_S - l_B\ ;$$

$$H_S = H_A + i_{AA}$$

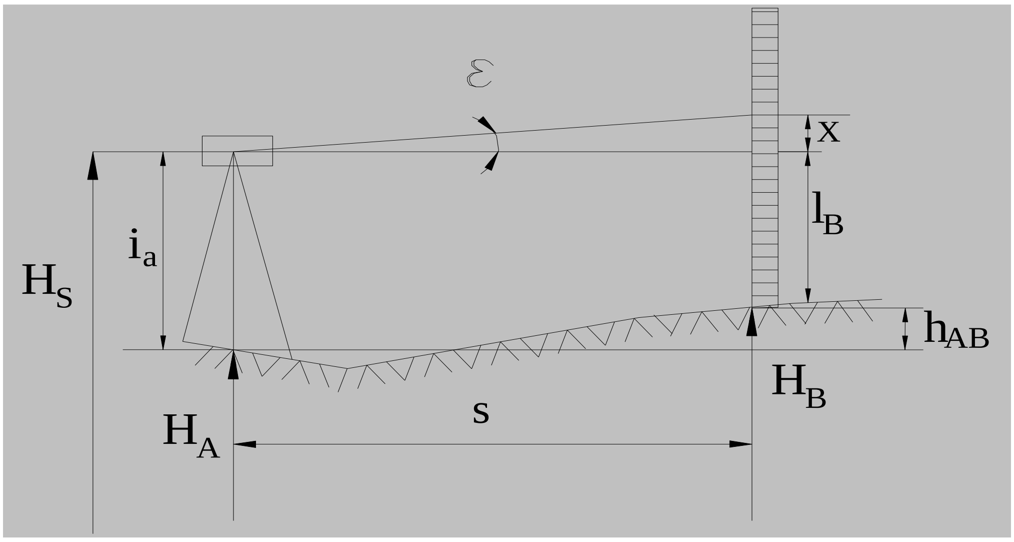


Fig. 5 Collimation error in geometric leveling end

In this case an error occurs, an individual error CS, which is no longer canceled. When point S is A or B there geometric leveling again.

## 8. Conclusions

The study aims at building knowledge and explains certain parameters that characterize the behavior of local or overall construction investigated. Changes resulting from requests for static or dynamic or factors such as: the nature of the soil foundation, variation in groundwater level, the weight of the own the foundation, temperature variations, wind action, are highlighted from the results from measurements taken during testing during construction and after construction and commissioning them into operation.

Through ongoing collaboration branches of engineering, construction activity correlates very often supplemented with the adoption and application of geodetic methods and technologies that come to record, process and represent the behavior of buildings subjected to various disturbing factors.

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