Conducting underground digging works by classic and modern working methods

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Abstract: *When doing underground works, such as mining work, road and railroad tunnels, a perfect coordination of the planimetric and height topographic surveys is needed. The paper presents the topographic surveys that apply in such works, by using both classical and modern methods.*

Keywords: *mining work, underground, tunnel, direction, slope*

1. Introduction

The underground activity, either we are talking of mining, or road and railroad tunnels, imposes that in the phases of work execution, a series of topographical operations for determining both planimetrical and level related elements should be carried out.

2. Stake out axis and slope of mining works

An underground horizontal work can be defined by its planimetric position and by its longitudinal and transversal sections.

From topographical point of view, an underground horizontal work that is in fact a mining work, is characterized by an axis, defined as an intersection of a vertical symmetry plan (V – V), (fig. 1) with an horizontal plan situated 1 meter height from the level of the mining work or from the edge of the rail, if present. In the section of the mining work, the transport axis is also defined at the distance *m* from the main axis.

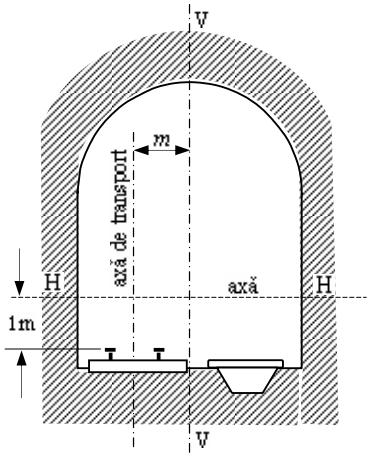

Fig 1. Defining the work axis

The stake out of underground works is carried out by maintaining constant distances like „abştiguri" from the axis of the mining work or the stake out axis from the side walls. This way, we have: left abştig „a_s"and right abştig „a_d"(fig. 2. a). The works are simplified if the stake out of the mining work is made after an auxiliary stake out axis, identical with the transport axis. (fig. 2. b). We can conclude the following:

$$a_s = \frac{l_V}{2} - m; \tag{1}$$

$$a_d = \frac{l_V}{2} + m, \tag{2}$$

where:

l_V – width/latitude of the level of the mining work;

m – deviation axis.

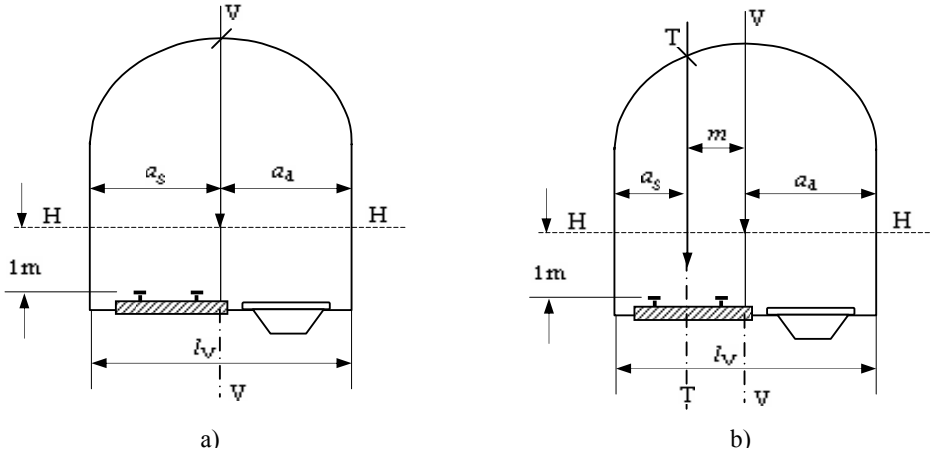

Fig. 2. Stake out axis of the works

Consequently, the matter of precise and simultaneous stake out of the mining work and of the runaway is solved.

Abştig a_s and a_d are maintained constant during the entire digging works.

The stake out axis is materialized in the underground by at least 4 direction lines – lead lines.

Abştig are measured horizontally with an adequate measuring tape.

Meanwhile, the mining work must be conducted, taking into consideration a given inclination „i" or a given curve p‰ (fig. 3).

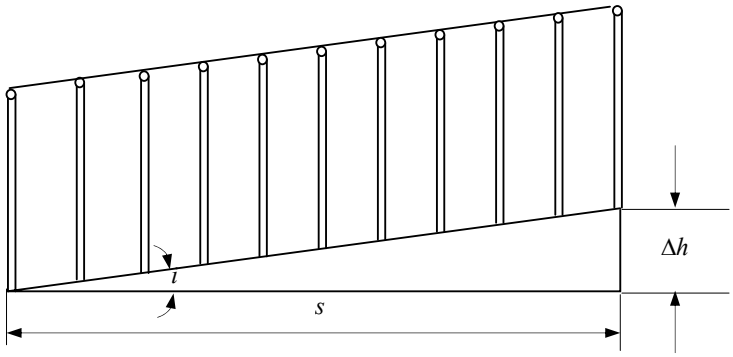

Fig. 3. The slope of the mining work

The slope or the tilt factor is given by the ratio between the difference of level between two points and the horizontal distance between the same two points:

$$p‰ = \frac{\Delta h}{s} \cdot 1000. \tag{3}$$

Conducting the mining work in slope is carried out with the help of the curve guide. (fig. 4). This is made out of board with a length of $L = 2,\ 3$ or 4 m, a thickness of 2 – 2,5 cm and height of 12 – 15 cm. The cutting out form the centre improves the handling of this device. At the extremity situated near the curve, a metallic spur has been attached; the height of the spur p is calculated according to the imposed curve:

$$p = \frac{p‰}{1000} L. \tag{4}$$

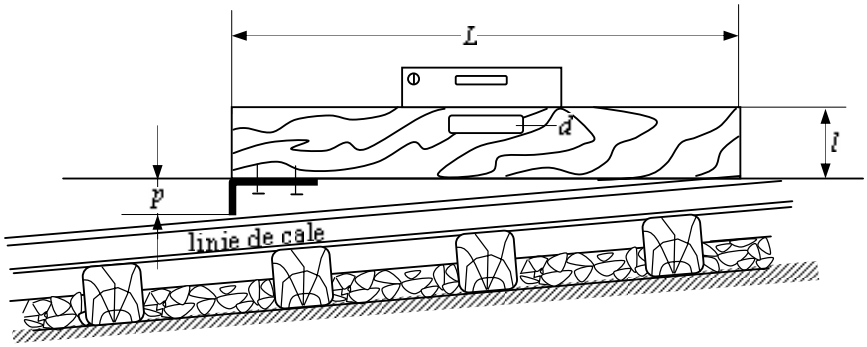

Fig. 4. Slope guide

Example: for a curve of 7‰ and a length L of 3 m, the height of the spur will be:

$$p = \frac{7‰}{1000} \cdot 3000 = 21 \text{ mm}. \tag{5}$$

The slope guide will be positioned on the level or on the edge of the rail, the superior side will be positioned horizontally with the aid of a level instrument.

3. Transition curves

In the current underground activity it is necessary to carry out both horizontal rectilinear activities and circular activities with different curve radius. Proceeding from a rectilinear activity to a curve activity, must be accomplished with the help of transition curves.

The most characteristic element of a transition curve is the transition radius „*R*", entirely dependent on the transportation means, object of the transport, speed, gauge, load, wheel base etc. In accordance with the topographical orientation of the alignments, the apical angle of the two alignments and radius, the constructive elements of the transition curve are determined. To exemplify, we considered a transition curve having the shape of a quarter of a circle, where the centre angle is $\beta = 90^0$ (fig. 5). Thus, we have considered a gallery with the width of the level of 3,400 m.

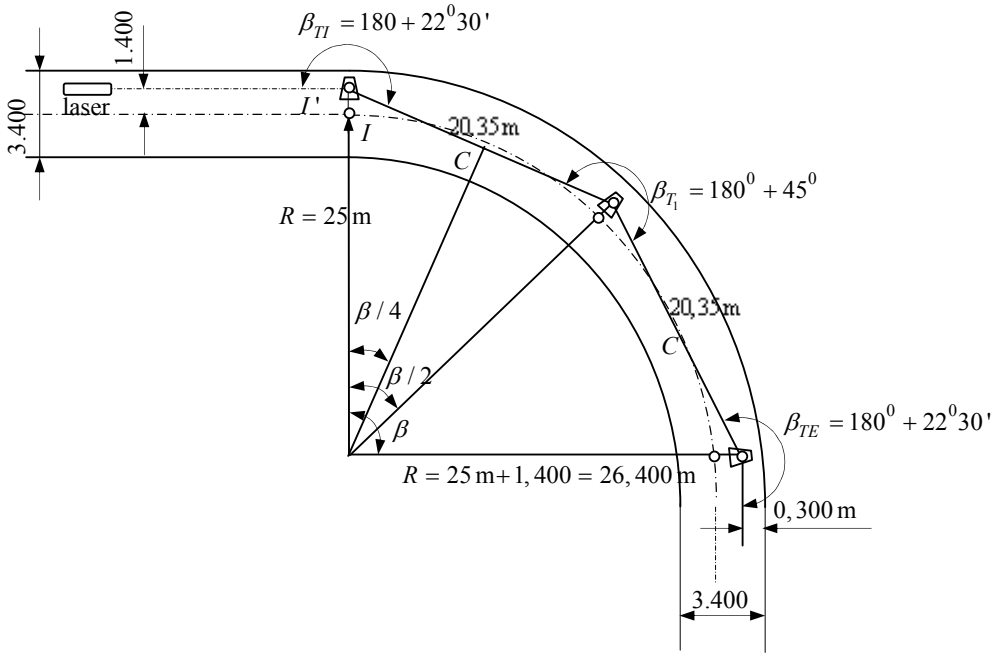

Fig. 5. Stake out elements of the gallery

In the same order, the transition radius R will have the value of 25 m and the shaping of the rectilinear gallery has been accomplished with an deviated auxiliary: $m = 1,400$ m. The angle is divided at the centre β in 2 parts. By applying the method of the inscribed polygon the transition angles will be:

- at the beginning of the curve:

$$\beta_{T_I} = 180^0 + \beta/4 = 180^0 + 22^0 30'; \quad (6)$$

- in the intermediary point:

$$\beta_{T_1} = 180^0 + \beta/2 = 180^0 + 45^0; \quad (7)$$

- at the end of the curve:

$$\beta_{T_E} = 180^0 + \beta/4 = 180^0 + 22^0 30'; \quad (8)$$

and the length of the chord will be

$$c = 2R \sin\frac{\beta}{4} = 20,75 \text{ m}. \quad (9)$$

The first 3 – 4 m resulting from the crossing of a curve will be executed without a previous supervision, the crossing elements will be later projected in the field.

4. Using a laser system in underground works

The process of conducting a digging in a mining work requests a continuous inspection of the planimetrical and level related elements.

By using a laser system fixed on the mining work, the possibility of continuous supervision of works will be generated, nevertheless the atmosphere in the underground must be considered and consequently solutions must be found so that the atmosphere won’t influence the laser beam.

Taking into account all these conditions, new methods and procedures for the use of lasers in the underground can be generated, especially in the field of topographical works.

In order to accomplish the transition from a direction to another, deviation prisms with a certain established fractal angle are used (fig.6).

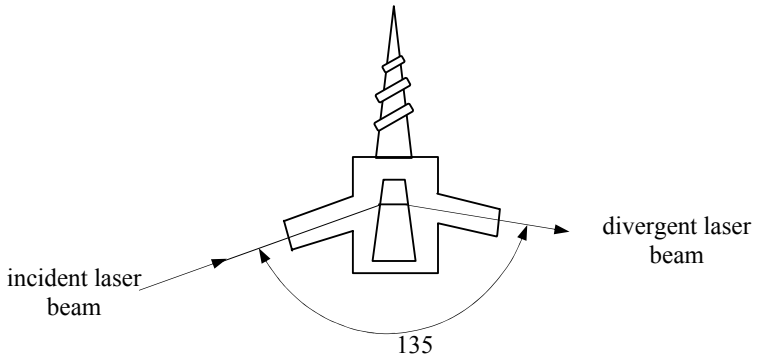

Fig. 6. Deviation prism for an intermediate point

The walls of the mining work are continued towards the staking out directions. We distinguish two cases for sustaining the mining works: with individual casing and sustaining with concrete or masonry walls.

In both cases, it is necessary to set up a stake out plan. On a board with the biggest scale, a transition curve is reported with the side walls positioned accordingly with the reinforcement monograph. Being aware that among the reinforcements, the distance-field must be under the value of 0,6 m, the exterior wall is divided with a spacer in equal parts that are as close as possible to the value of 0,60 m. The result is a number of 35 de intervals – fields. These partitions are unified with the centre of the circle, resulting in the position of the reinforcements of the interior wall in the curve. The large filed is measured graphically towards the exterior (fig. 7), the small filed towards the interior wall. The median field C_0 is calculated or measured.

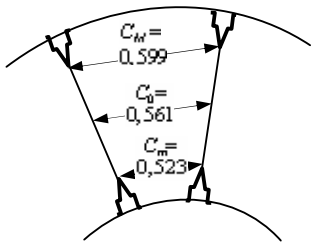

Fig. 7. The length of the fields

In the following stage, the distances between the chord and the interior and exterior walls and these values are registered in the blueprint. (fig. 8).

In the underground mining work, the distances between the laser beam and reinforcements are measured and separately the distances between the reinforcements-fields are measured. After digging, stake out and setting-up of the chord I.1 a new prism is positioned in the intermediary point 1 and the same technology is followed for the arc 1E. We must note that there is no longer necessary to use the curve guide, as the slope is staked out by maintaining the height at the value of 1 m reported to the laser beam from the level of the mining work or the edge of the rail.

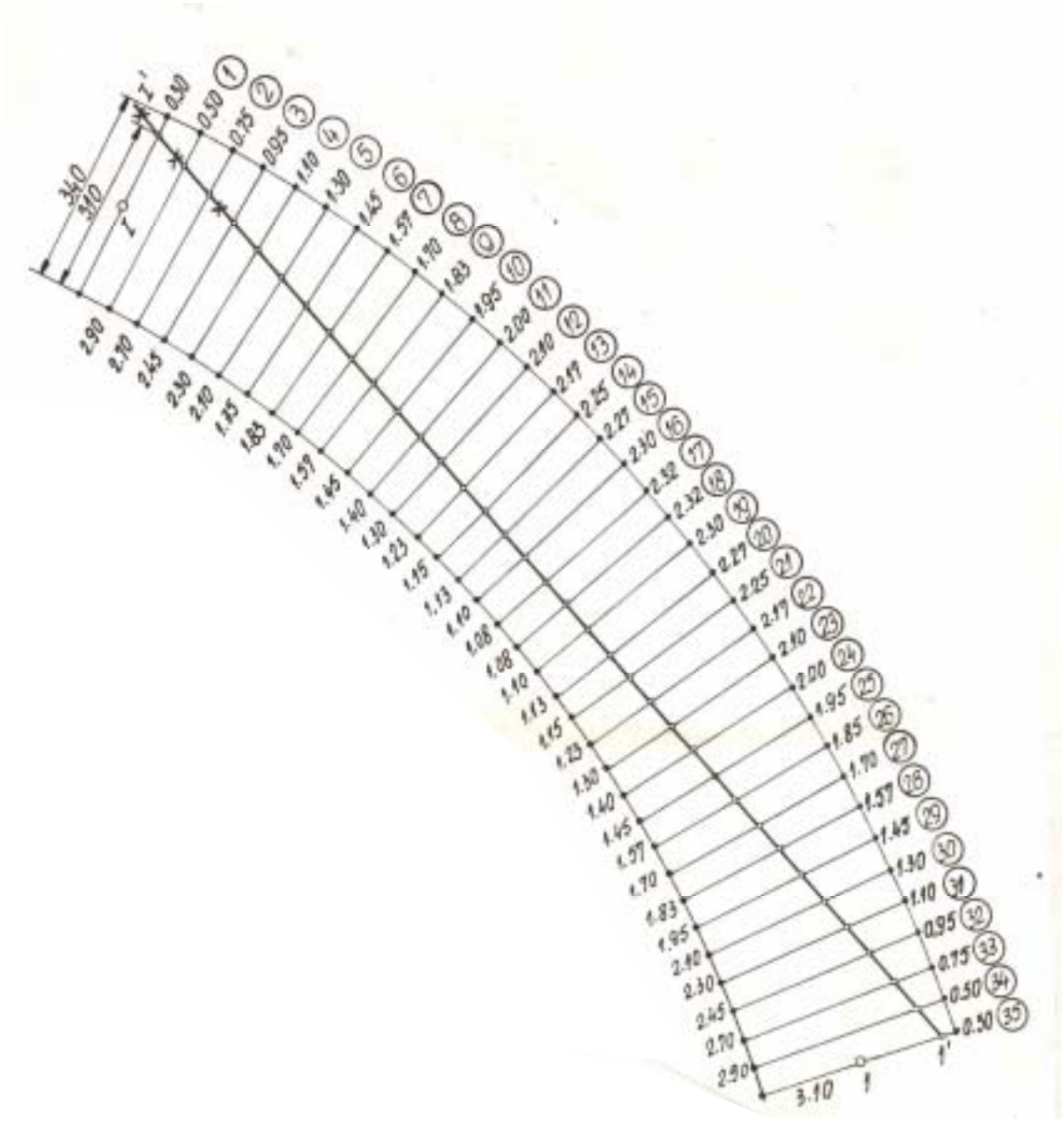

Fig. 8. The position of the reinforcements for the gallery

For galleries with masonry and concrete walls, the stake out method is simplified, as there is no longer the need for positioning the individual reinforcements, the walls are staked out with the method of ordinates and abscissas. On the chord (the laser beam), we choose abscissas equal with 1m to which we measure perpendicular ordinates equal with the measures from fig.9. With the help of a prism that deviates the laser beam, the ordinates can be correctly deviated in a right angle. The measuring of the ordinates of the abscissas can be done with the help of a metallic roulette, where the laser beam indicates the dimensional elements.

Likewise, the slope is staked out by maintaining a constant height of 1 m above the level or edge of the rail.

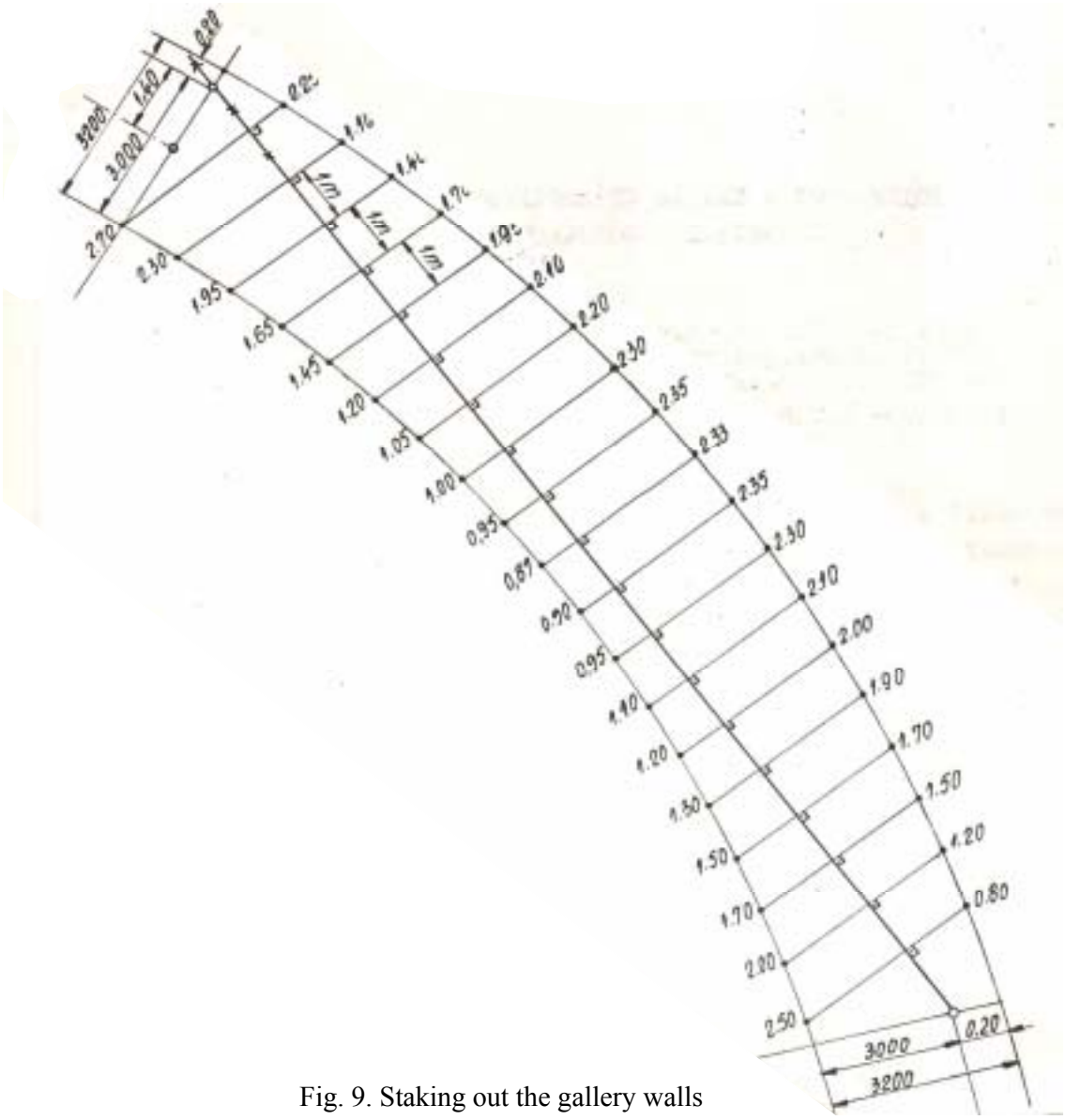

Fig. 9. Staking out the gallery walls

3. Conclusions and proposals

Topographical works in the underground are accomplished in small spaces, poor light and an atmosphere specific for closed spaces.

Conducting diggings in mining works with classical methods imposes a great volume of work, several topographical operations being needed and the possibility of error appearances exists if these works are not verified.

Using laser beams in the underground, in mining topographical works, gives a higher precision rate, avoiding errors of different measurements. Likewise, approximations in measurements for the targeted direction are not made, instead readings on roulette are made with the help of the laser beam. Another advantage is the fact that the mining works are staked out both planimetric and altimetric.

4. Bibliography

1. *Dima, N., Pădure, I., Herbei, O. – Topografie minieră, Editura Corvin, Deva, 1996.*
2. *Ortelecan, M., Palamariu, M., Jurca, T. – Trasarea lucrărilor miniere, Editura Infomin, Deva, 1999.*
3. **** - Studii privind utilizarea sistemelor laser.*