OVERVIEW ON THE USE OF THE PROFILE FUNCTIONS METHOD IN FORECASTING THE SUBSIDENCE PHENOMENON IN THE JIU VALLEY MINING BASIN

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***Abstract**: underground excavations of thick multi-layered deposits, frequently lead to the displacement of rocks, damaging the terrestrial civilian and industrial targets. In order to avoid catastrophic situations, through specific methods and ways, specialists should first identify and track the phenomena peculiar to the areas affected by groundwater exploitation. This paper presents one of the methods mostly used in forecasting the phenomenon of subsidence due to exploitation of multi-layered deposits, method belonging to the profile functions methods.*

***Keywords:** exploitation, displacement, forecast, profile functions method.*

1. Introduction

The forecasting methods currently used are based on research conducted on the horizontal layers, of low thickness, for critical exploitation areas of simple geometric form, and the calculations were made for the final stage of the movement.

The problem's general aspects, which relate to exploitation areas of certain form during intermediate or transient phases, of medium and large gradients of the layers, are treated based on a broader generalization and calling on simplifying assumptions. [7].

These methods consist in adopting forecasting calculation relations of the main parameters that define the diving bed. [11].

To do this, we apply one of the calculation methods that was developed for geological and mining conditions similar to the conditions of the reservoir to be tapped, a method that has been checked and which led to satisfactory results.

Currently, the specialized literature covers a multitude of forecasting methodologies for calculating these parameters, of which results were confirmed in practice. [5].

A topo-geodetic tracking properly conducted on the benchmarks leads to reliable results that can be used to obtain a forecast of the subsidence due to multi-layered deposits exploitation.

Figure 1. The negative effects of subsidence.
Building existing in the influence area of the layer 3 operation, Block III – Comparison between February 2008 and April 2015, Petrila. [2].

The forecasting methods used in analysing the phenomenon of subsidence due to exploitation of multi-layered deposits fall into two broad categories: empirical methods and phenomenological methods [3], [9], [10].

Empirical methods are those methods which are based on observations and research in the field. Over time, the empirical methods have proven to be some of the most accurate forecasting methods used in forecasting the subsidence phenomena.

Phenomenological methods are those methods based on the principles of modelling using equivalent materials, where rock layers are subject to subsidence. They are mathematically represented as ideal materials that obey the laws of mechanics continuity. Comparative investigation and comparison between the two methods currently lead to the premise that the most successful one is the empirical method.

Empirical forecasting methods used in analysing the phenomenon of subsidence are: graphical methods; profile functions methods and influence functions methods.

Herein is presented the only Romanian method and one of the most often used in forecasting the phenomenon of subsidence due to exploitation of multi-layered deposits, namely the I.C.P.M.C. method, which is framed among the empirical methods.

2. Presentation of the I.C.P.M.C. method

As presented in the introductory part of the paper, the empirical method is one of the most successful methods used in the calculations of the forecast of subsidence due to the exploitation of multi-layered deposits. For this paper, we have chosen from the classification of empirical methods, the method of profile functions as a method of work. Profile functions method is a method that includes all the derivatives of mathematical models that may be used in determining a complete profile in the analysis of the subsidence phenomenon. These methods differ from the phenomenological methods in that the requirements to the profile functions are empirically derived from the results on the ground.

The profile functions method that is to be shown in the contents of this work was developed based on extensive research conducted by the specialists of the Institute of Coal Mining Research and Design in Petrosani, in collaboration with the Institute of Mines Petrosani and with other specialized research institutes such as ICEMIN and INCERC Bucharest, with the support of the technical staff of the Mining Factory in Petrosani and of the mines in the Jiu Valley, in the context of experience exchanges with researchers from other countries with significant mining experience.

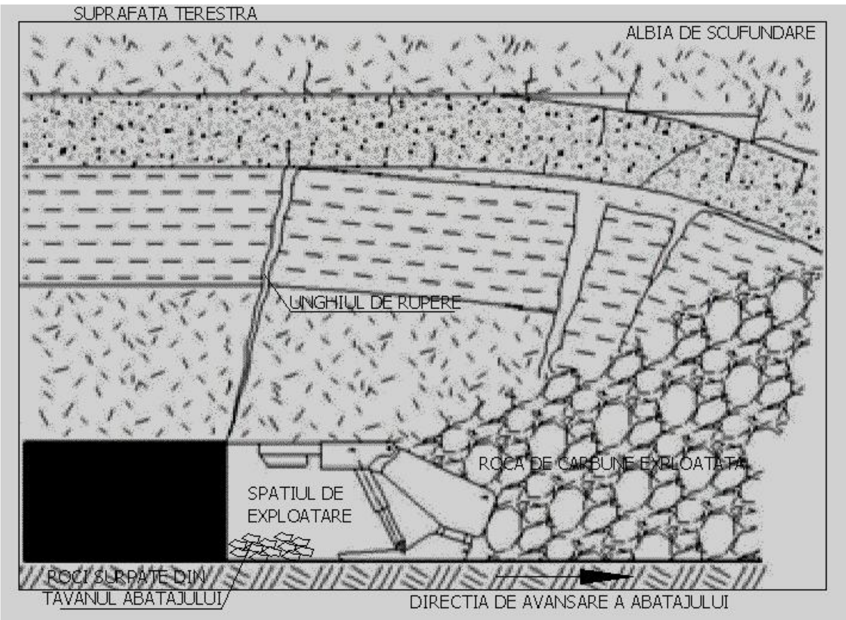

Fig. 2. The way of creating the diving bed.

3. The main parameters used within the I.C.P.M.C. method

The outcome of displacement and deformation is called diving area and is defined by the following parameters:

Sinking (S_i) – is defined as the vertical component of the displacement vectors of the points on the surface, in the riverbed.

$$S_i = H_i - H^*_i, \text{ in mm} \quad (1)$$

- where: H^*_i is the share of point *i* at measurement zero; H_i – the share of point *i* at a certain moment.

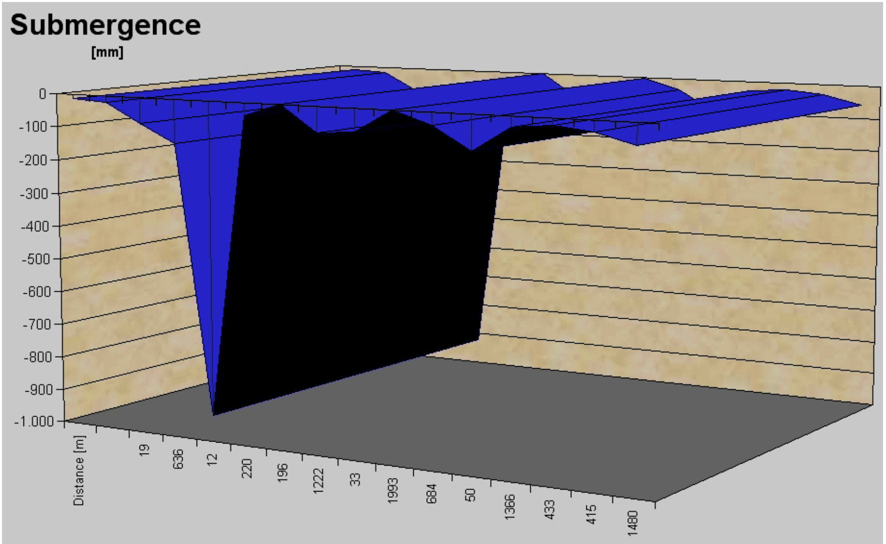

Fig. 3. The submergence resulting for the time frame of September 2009 to April 2015.

Inclination (I) – is the differential variance of the vertical movement and shall be obtained by making the proportion between the difference of diving between two consecutive landmarks from the dive and the horizontal distance between them.

$$I_i = \frac{S_{i+1} - S_i}{D_{0_{i,i+1}}} \text{, in mm/m} \qquad (2)$$

- where: S_i is the sinking of the current marker i; $S_{i,i+1}$ – the sinking of the following marker $i+1$; $D_{0_{i,i+1}}$ – the horizontal distance between the two landmarks.

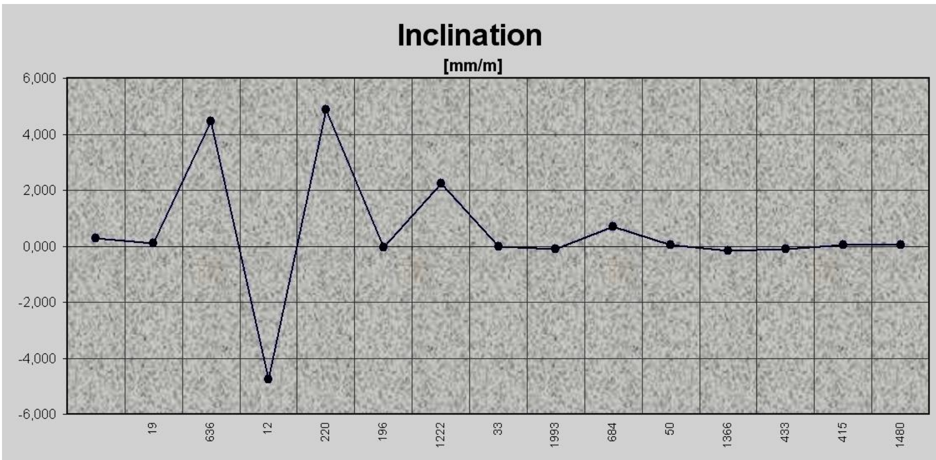

Fig. 4. The inclination resulting for the time frame of September 2009 to April 2015.

The curvature of the immersion riverbed (K) – is defined as the proportion between the difference of inclination of two adjacent intervals and their semi-sum. Basically the curvature is equal to the inclination derivative or is equal to the second derivative of immersion in relation to the horizontal variable.

$$K = \frac{I_{i+1} - I_i}{D_{0_{i,i+2}}} \text{, in mm/m}^2 \qquad (3)$$

- where: I_i is the terrain inclination between the landmarks i and i+1; $I_{i+1;}$ terrain inclination between landmarks i+1 and i+2; $D_{0_{i,i+2}}$ – the horizontal distance between points $i \rightarrow i$+1 and i+1 $\rightarrow i$+2.

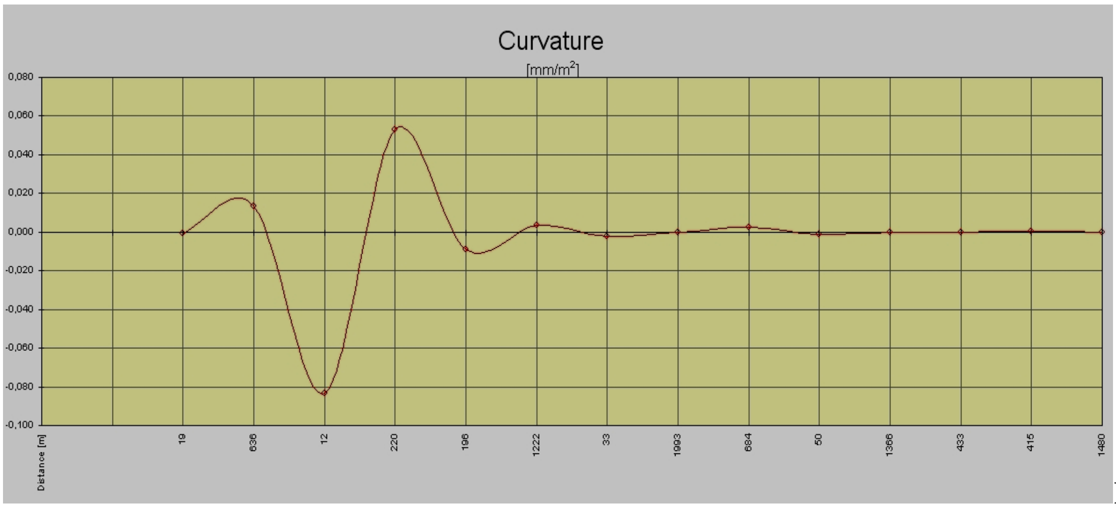

Fig. 5. The curvature of the diving riverbed resulting for the time frame of September 2009 to April 2015.

The radius of the surface curvature – is the radius of the circle of curvature of the sinking curve, carried through three of its points. Is the reciprocal of curvature.

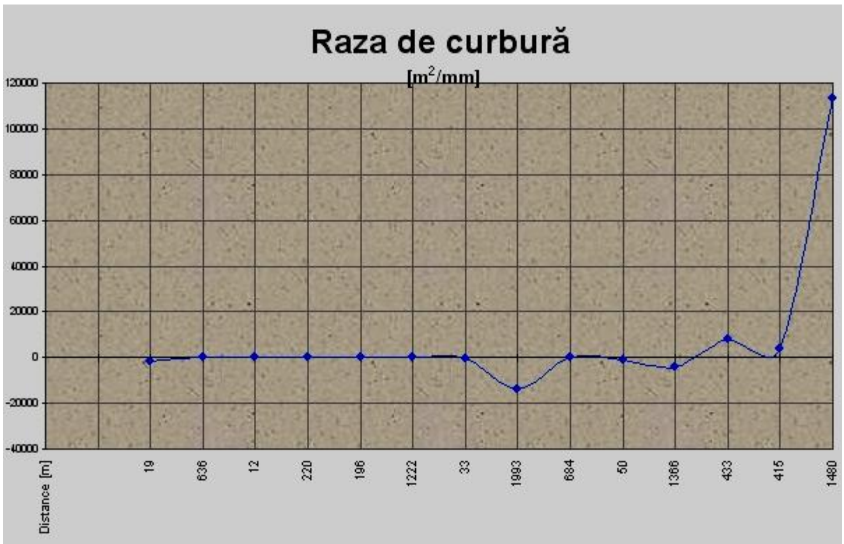

Fig. 6. The radius of curvature resulting for the time frame of September 2009 to April 2015.

Horizontal displacement (ΔD_i) - is the horizontal component of the displacement vectors of the points located in the movement synclinal. Two neighbouring points located in the surface movement area depict a similar route but it appears that the distance that originally separates them ($D^*_{0_{i,i+1}}$) is not the same at the end of the movement ($D^c_{0_{i,i+1}}$).

$$\Delta D_i = D^c_{0_{i,i+1}} - D^*_{0_{i,i+1}}, \text{ in mm} \quad (4)$$

- where: $D^{c}_{0_{i,i+1}}$ is the horizontal distance between two consecutive points of the current measurement; $D^{*}_{0_{i,i+1}}$ - the horizontal distance between two consecutive points at measurement zero.

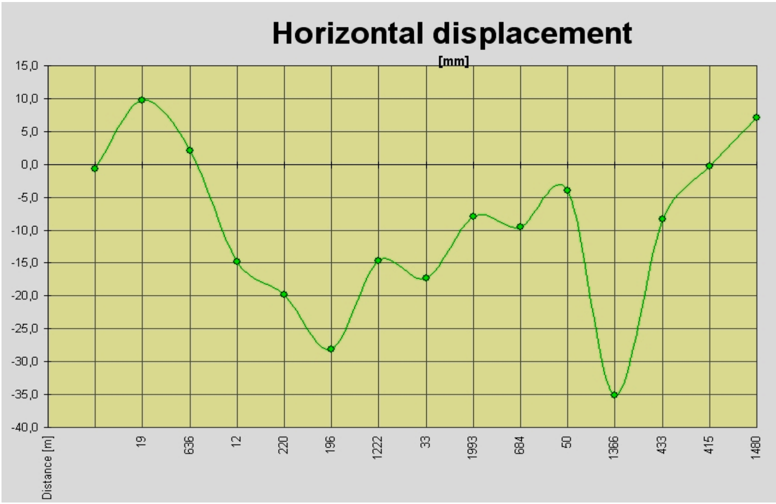

Fig. 7. The horizontal displacement resulting for the time frame of September 2009 to April 2015.

The specific horizontal deformation (ε_i) - expresses the variation in the length interval between two consecutive points in relation to the length of the basic measurement.

$$\varepsilon_i = \frac{\Delta D_i}{D^{*}_{0_{i,i+1}}}, \text{ in mm/m} \qquad (5)$$

- where: ΔD_i is the horizontal displacement of landmark i; $D^{*}_{0_{i,i+1}}$ - the horizontal distance between landmark i and landmark $i+1$ at the initial measurement.

Fig.8. The specific horizontal deformation resulting for the time frame of September 2009 to April 2015.

The bank's critical length is defined as the length for which the surface immersion is absolute maximum in a single point. This parameter is determined separately both on the advancement direction and on the direction of the bank front.

The coefficient of the surface sinking is defined as the ratio between the maximum immersion and the thickness of the third layer of coal mining. This coefficient shall be determined according to the technology of mining pressure in slaughter.

Calculations of the forecast of surface displacements and deformations cannot be completed without knowing the values of the diving limit angles and of the maximum dive angles.

Diving limit angles are the angles formed by the horizontal line and the right line that binds the edge of the exploited area and the surface point of which dive is 0.1 Smax, but no more than 20 mm. [1]

It represents the most important parameter and it is used for dimensioning the safety straddles and to establish the dimensions of the diving riverbed.

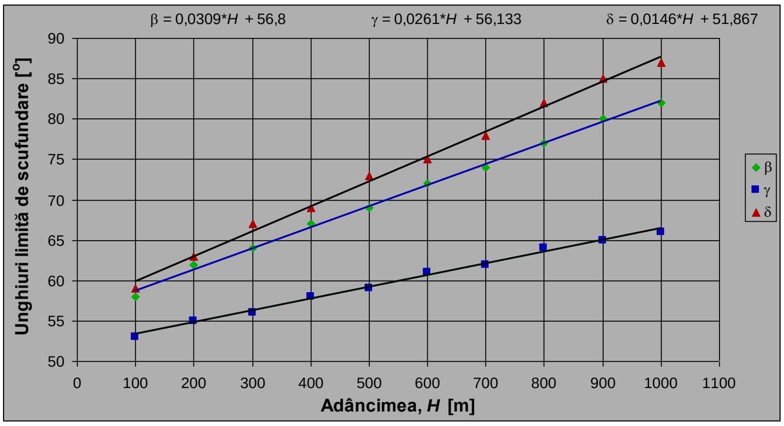

Fig.9 Graphics of the diving limit angles depending on the exploitation depth. [4].

Maximum diving angles – are the angles formed by the horizontal line and the right line that binds the edge of exploited area and the maximum submergence surface point. The maximum diving angles must be determined separately in the direction of the layer (d*) and transversal, downstream (b*) and upstream towards the exploited area (g*). [1].

4. Conclusions

The mathematical-analytical methods used in the forecast calculation consist in adopting theories based on the mathematical relationships used for the forecasting of the surface movement parameters, based on observations achieved through topographic methods.

In order to understand the subsidence phenomenon, in addition to an overview of the movement of the whole package of rocks from the exploitation layer to the surface, it is also necessary to define the parameters that influence the process of the surface's displacement and deformation.

The method presented is aimed to highlight the entire results of a great amount of topographical observations (measurements) conducted within the monitoring stations established in all the mining perimeters of the Jiu Valley mining basin.

The ICPMC method allows a forecasting of the subsidence phenomenon, a calculation of the safety depth, and if necessary, also the design of safety straddles.

The ICPMC method is a method which falls into the group of profile function, methods, trying to render as truthfully as possible the shape of the diving riverbed through the graph of a mathematical function.

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