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THE SURFACE'S STABILITY ANALYSIS WITH FINITE ELEMENT METHOD UNDER THE COAL MINING AT E.M. LIVEZENI

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Abstract

Long-term global economic growth may not be a realistic target since are not provided the appropriate and available mineral resources, which extraction affects – most often negative – the land surface stability. Therefore, it is necessary to reduce, if not to eliminate, impacts from mining activity through finding solutions based on monitoring the land surface movement. The main goal of the research is to achieve a better prognosis of the phenomenon, to protect the objectives located in the influence area of the underground mining, preventing their destruction.

***Key words**: deformation, finite element method, subsidence, underground mining.*

INTRODUCTION

Exploitation of coal deposits (or any kind of useful minerals) creates inevitably significant environmental problems. Thus, coal preparation and long-distance transportation of coal to generate electricity, is producing coal dust, methane, nitrogen oxides, sulfur dioxide and carbon monoxide, etc. Mining exploitation in careers causes problems by destroying landscapes, woodlands, agricultural land, loss of groundwater reserves etc.

In this paper will be used frequently the term subsidence. This term refers to the whole phenomenon of displacement of the land surface as a result of groundwater exploitation.

MATERIALS AND METHODS

After extracting a volume of useful mineral substances in a reservoir, solid state voltage changes, leading to a destruction of surrounding rock stability. Following redistribution the surrounding rock stress are sitting occupying space created after exploitation (Onica 2001).

The most important factors that determine the movement area are (Figure 1): size of the gap resulting from exploitation, mining depth, layer thickness and inclination of useful mineral, mining method and technology used, the way of controlling the pressure, geomechanical characteristics of the rock, structure and tectonics deposit, length of service, etc. Depending on these factors, in some cases, massive movement of rock occurs only over a certain height, without affecting the integrity of the land surface, but most of the time, this movement is transmitted to the surface, affecting it and also producing a certain degradation of civil and industrial targets located in the influence area of operation. Thus, following the massive movement of rocks on the surface, it appears a cavity known as diving bed (Bell et. Al. 2000).

The main parameters that define the diving bed, defined in the literature by several authors (Anghiuş 2002, Marian 2011, Onica 2001, Ortelecan 1997) are as follows (Figure 1): dip angles (β_s downstream, γ_s upstream, δ_s directional); breaking angles: β_r, γ_r, δ_r; sinking or vertical movement: W , in mm; horizontal displacement: U, in mm; the specific horizontal deformation: ε, in mm/m; tilt: T, in mm/m; curvature: K, in m^{-1}.

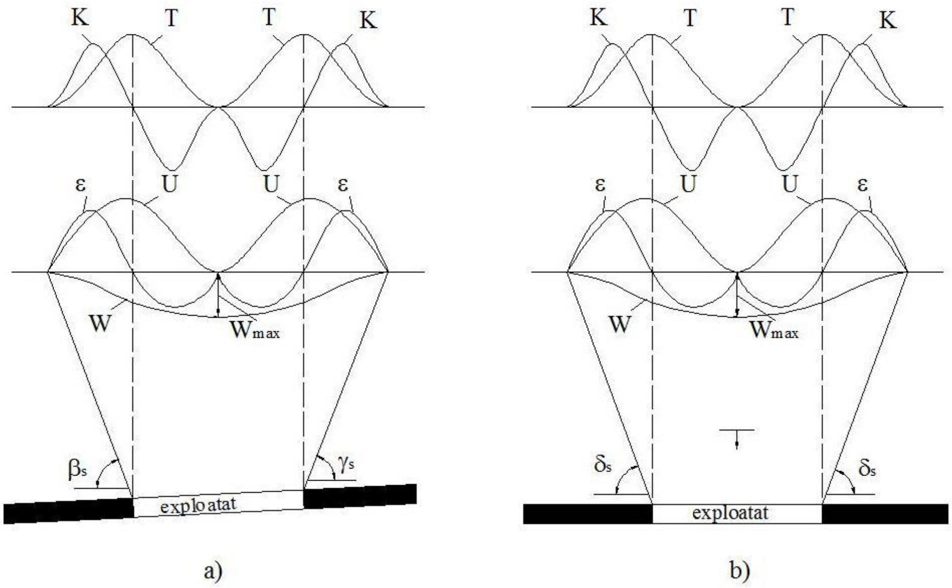


Figure 1. Displacement curves and deformation of the terrain for horizontal layers and small tilt

The knowledge of these parameters is necessary to take some measures to protect the surface and the targets located on the surface.

The movement begins with bending the rock layers above the working front and the collapse of the directly roof. As advancing the working front, there are put in motion new portions of undermined layers package and if the exploited space is large, the mass movement of rocks gets to the surface.

According to the mining methods that are currently used the roof rocks mined layer crumbles as the working front advances (Figure 2).

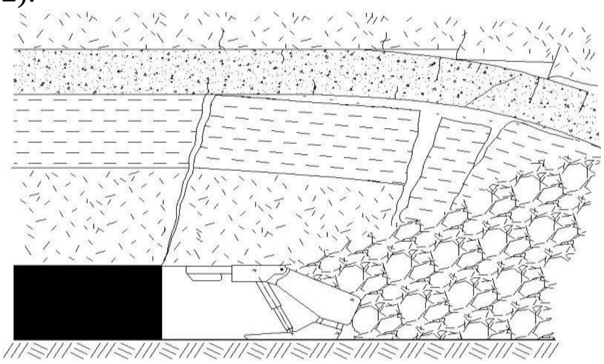


Figure 2. The behaviour of rock mass above and behind the working front

Massive movement of rocks from the mining layer until the surface is within a pyramid shaped space, space delimited by some inclined levels from the horizontal with the dip angles (β_s, on tilt and γ_s δ_s directional).

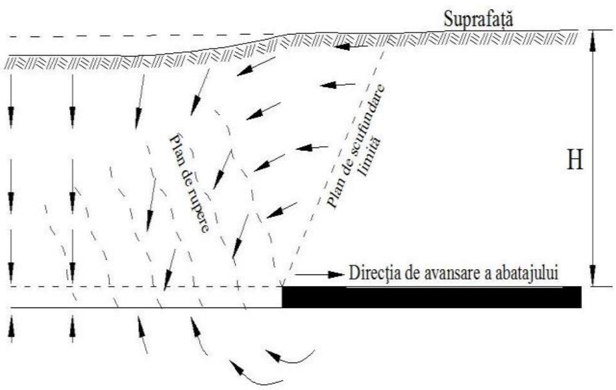


Figure 3. The movement in massive rocks as the working front advances (Marian 2011)

The principle of finite element method consists in replacing the deformable body (in this case the entire solid), through an articulated structure composed of triangular finite elements or square (two-dimensional case). Therefore, one can speak of a finite element structure that substitutes the real structure.

The finite element method has developed a series of finite elements (Figure 4) that in terms of the form may be classified as follows (Marian 2011):

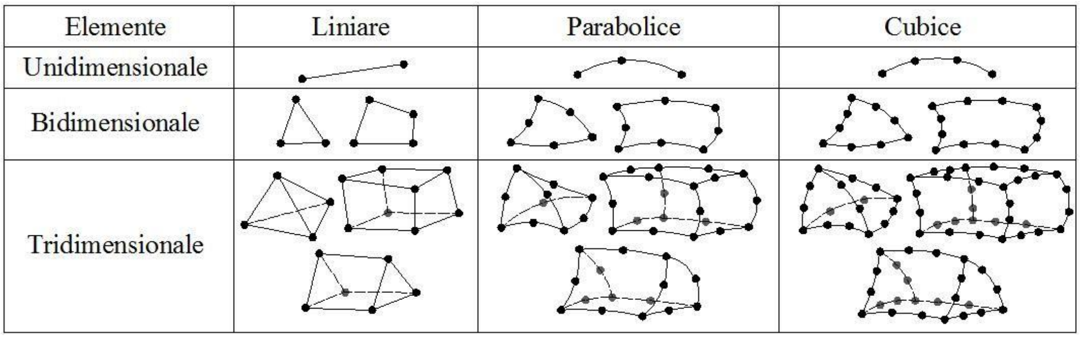


Figure 4 Types of finite elements (Marian 2011)

To achieve the calculations models with finite elements in 2D and 3D was used a program named CESAR-LCPC which includes the CLEO 2D and CLEO 3D processor.

The average values of the main mechanical and elastic characteristics of rocks that are used in the analysis of land surface stability at the Livezeni Mine are shown in Table 1 (Hirian 1981).

Table 1. The average values of the main mechanical and elastic characteristics of rocks

Feature	**Symbol**	**UM**	**Rocks**		**Coal layer 3**
			roof	**litter**	
Apparent specific gravity	γ_a	kN/m^3	26,63	27,01	14,5
Elasticity module	E	kN/m^2	5 035 000	5 268 000	1 035 000
Poisson coefficient	ν	adim.	0,19	0,20	0,13
Compressive strength	σ_c	kN/m^2	43 500	46 000	12 500
Tensile resistance	σ_t	kN/m^2	4 600	4 950	1 000
Cohesion	C	kN/m^2	6 130	6 630	1 300
Internal friction angle	φ	^{o}	55	56	50

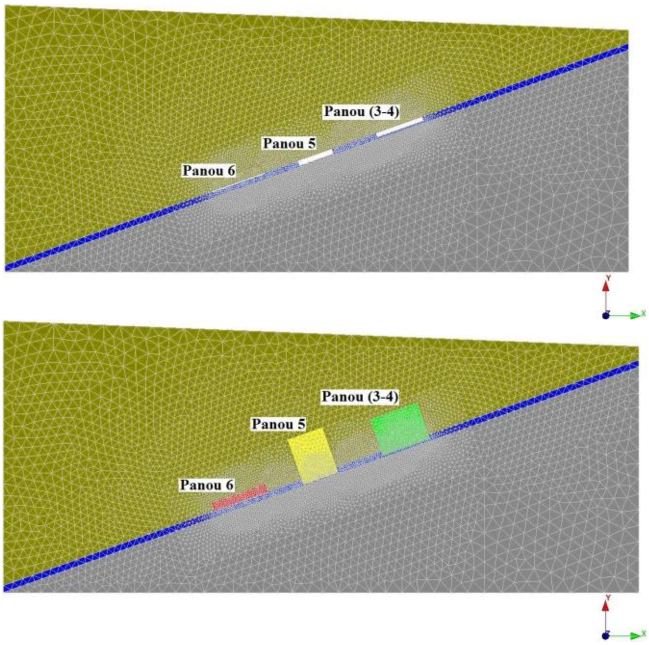
RESULTS AND DISCUSSIONS

On 2D model, to determine the surface displacement field, at the Livezeni Mine, where land is affected by the operation of three working fronts, were developed two different models assuming plane strain, namely (Marian 2011):

- the model with "exploitation goals" resulting from the extraction of coal (Figure 5.a);
- the model with "open excavations" (a height of 8 or exploited thickness of the layer) resulting from the collapse of roof rocks in mining voids (Figure 5.b).

For a better precision the calculations were made patterns with length of about X=1500m and Y = 690m (taking into account a distance of 500m from the end of the model run to the edge of exploited areas).

Mesh model of each region respectively, was achieved by surface triangular finite elements with quadratic interpolation; mesh model was made with a total of 23,448 nodes and 11,661 elements surface.

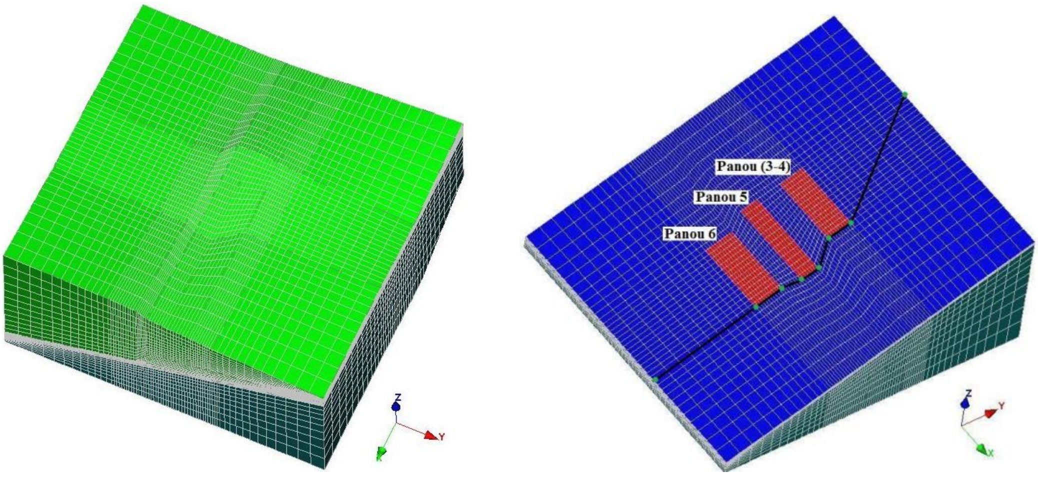


a) b)

Figure 5. Finite Element Mesh model:
a) model "operational goals", b) model with "open excavations"

The best possible accuracy results were achieved extended 3D models, size about X = 1440m, Y=1500m and Z = 650m, taking into account a distance of 500m from the end of the model run to the edge of space, to avoid the influence of the model limits the results (Figure 6.a).

Figure 6.b showns a 3D model that reveals the layer couch, the coal layer and the three "operational goals", and the follow of the approx. route around the station area land movement.



a) b)

Figure 6 a) Mesh 3D finite element model (model "operational goals")
b) The route around the station ground surface movement tracking

The mesh model of each region respectively, was achieved by hexahedral finite element with linear interpolation, resulting in a total of 95,611 nodes and 89,244 volume elements.
The diving bed obtained by numerical modeling in 3D, following the path in Figure 8.b, is represented in Figure 7 compared to the diving bed stop tracking measured surface subsidence and sinking bed obtained by 2D numerical modeling.

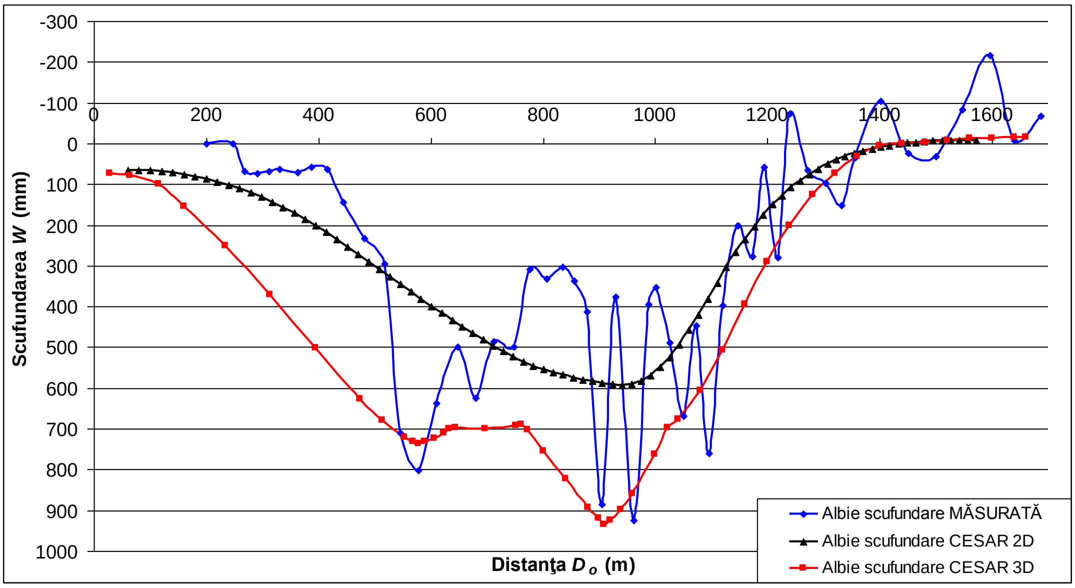
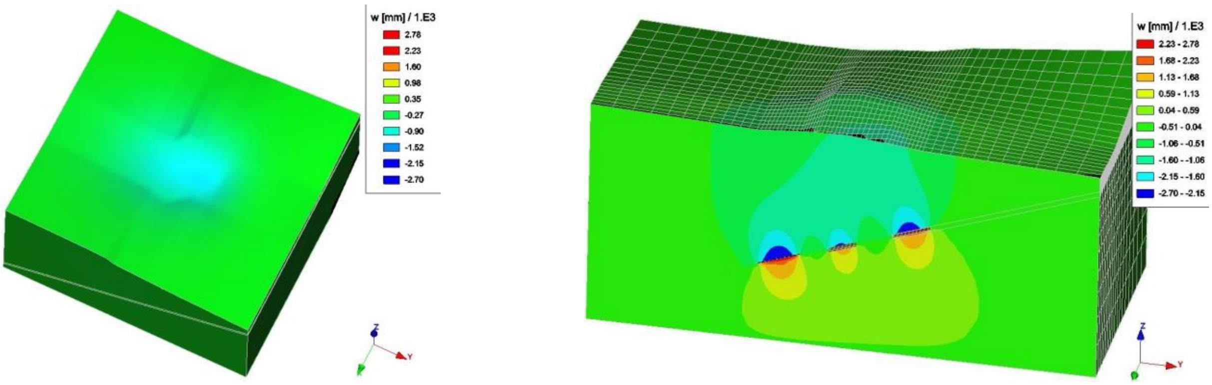


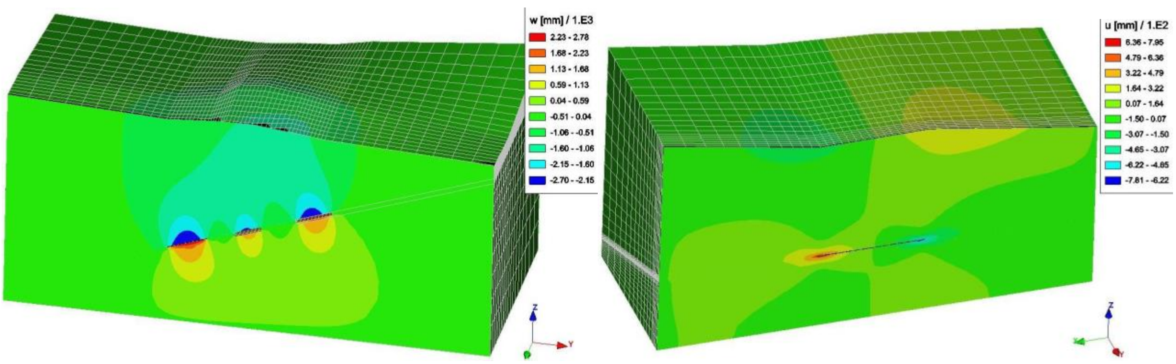
Figure 7 white dip obtained by numerical modeling in 2D and 3D, compared with measured diving bed.

The vertical displacements of the surface (sinking) obtained on the 3D model are shown in Figure 8 on a scalar form and horizontal displacements by X and Y axis in Figure 9 and 10.



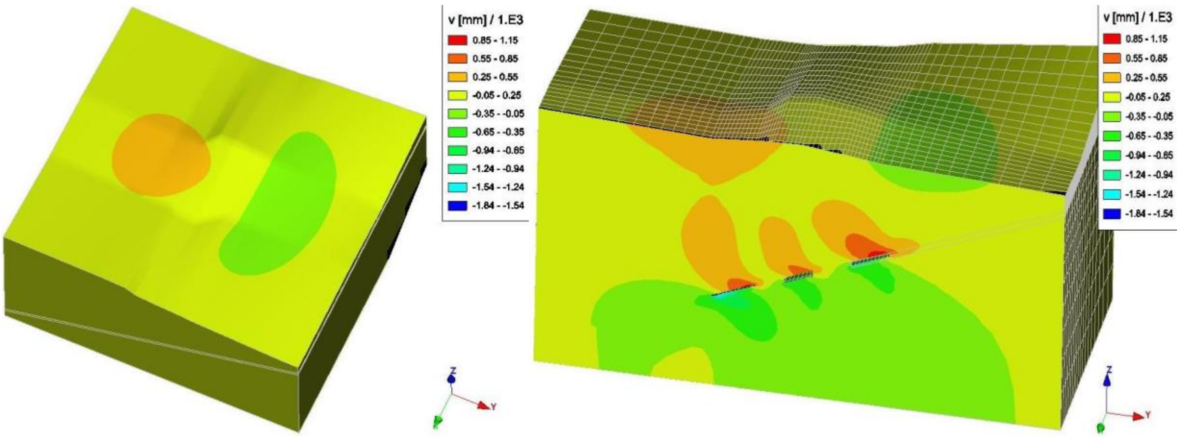
a) b)

Figure 8 a) Immersion *w* in mm - scalar representation, b) Main cross-section



a) b)

Figure 9 a) Horizontal movements after axis X, *u* in mm - scalar representation; b) Directional section by panel 6



a) b)

Figure 10 a) Horizontal displacements after axis Y, *v* in mm - scalar representation;
b) Main cross-section

Calculations for the two models were made in two situations, namely:
a) assuming elastic behavior of the massive;
b) assuming elastic-plastic behavior Mohr-Coulomb type without ecruisaj (without cruing).

Maximum immersion obtained in the 2D model is Wmax = 592mm and horizontal displacement is between U = + 125 and U =-232mm;

The maximum immersion obtained in the 3D model is Wmax = 936mm and horizontal
movements after axis Y varies between the values V=252mm and V = - 168mm;

The results of these studies provide a basis for protection on new fields of working fronts which will come into exploitation and the protection of underground and surface construction against the destructive effects of underground mines.

Numerical modeling of subsidence phenomenon is particularly useful because it provides information on the distribution of stresses and strains throughout the massive space operated from the surface.

CONCLUSIONS

After analyzing the results obtained from finite element numerical modeling to mine Livezeni we conclude that:

The diving bed surfaced, obtained by numerical modeling in 2D, has a simple form different from that obtained from measurements

The 3D numerical modeling of dipping bed obtained following approximate route tracking station is close to the bed of immersion measured.

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