MODELLING OF SHAFT DEFORMATION IN THE AREA OF MINING ACTIVITY

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Abstract

The deformation of the rock mass in the area of mining activity has influence on the safety of the mine shaft. When planning mining activity, deformation of the shaft should be considered at that stage. The authors have developed a method for predicting the effects of mining on the stability of the mine shafts. In the analysis the Drucker-Prager elasto-plastic model of the rock mass is used. The Finite Element Method and GAMMA method with software ABAQUS were used in modelling shaft deformation of the coal mine. This analysis gives information on the behaviour of the rock mass in the area of the mine shaft.

1. Introduction

In the region with mining headings, deformations are generated, and they must be controlled in shafts located within range-zones remaining under the influence of mining exploitation. There is a close relation between geological structure of a rock mass and a factual mining situation, and the generated deformations must not create danger to shafts during mining exploitation work. Shafts must always be absolutely safe during mining exploitation. Thus, when designing headings, their impact on deformations in shafts must be expected and involved. An adequate design of a heading must incorporate the forecast of their impact on shafts. Such a forecast can be made using modeling investigations that include the geological structure of a rock mass. Contemporary methods of modeling investigations of rock mass contain all the factors influencing the occurring deformations. However, the application of such methods requires a detailed analysis of a rock mass on the base of geological survey, and also their verification using geodetic measurements of deformation. A rock mass is a very complex medium, and its thorough study with regard to the rock's geo-mechanical properties is practically impossible. So, it is necessary to accomplish an initial analysis of forecasted effects, as well as the geodetic verification of those effects.

2. Modeling of the shaft deformation using GAMMA method.

Some investigations have already been performed that aimed on forecasting possible deformations of a mining shaft located within a range-zone of mining heading's influence. Those investigations allowed for the determination of the headings' influence range-zone, and for the deformation forecast of the shaft.

A spatial model of a rock mass includes its geologic structure and location of a heading within the shaft. An elastic-plastic Drucker and Prager model has been applied showing a non-linear relation between stress and strain in a rock mass. A shearing yield point was applied as a criterion of plastic strain. Prior to their use, those assumptions have been practically verified with use of one Polish stone-coal mine. In Faculty of Mining Surveying and Environmental Engineering from University of Mining and Metallurgy, a GAMMA method (Geotechnical Applications Method of Modeling Analysis) was developed by Krzysztof Pietruszka.

Its basic postulations involve the determination of relations existing between geological structure and mining situation whereas the geological structure is characterized by interactions among stresses and the deformation in individual layers, and the mining situation – by the headings' geometry, spatial location of headings, direction of exploitation. A Finite Element Methods was utilized in calculations performed by the ABAQUS software. Thanks to this solution applied, it is possible to carry out a complete analysis of anticipated consequences within the mass rock as well as of their effects in the mining shaft.

3. Geomechanical properties of the layers in rock mass

A detailed analysis of relations among strain and stress in separate rock mass's layers was made, too. Data obtained from the library of geotechnical software ABAQUS applications were employed [1],(Table.1). Those data characterized the rock mass at various depth levels.

Table 1 Soil data using Drucker-Prager model

Soil layer	elastic propertis	Inelastic propertis	Hardening behavior	
[m]				[MPa]
0-213	E=124 MPa	β=36.9°	0.0000	0.075
	ν=0.3		0.058	0.083
			0.116	0.075
213-335	E=328 MPa	d=1.38 [MPa]	0.0000	2.75
	ν=0.17	β=36.9°	0.0200	4.14
			0.0500	5.51
			0.0900	62.00
335-368	E=434 MPa	d=1.38 [MPa]	0.0000	1.38
	ν=0.17	β=39.4 °	0.0200	4.14
			0.0400	6.89
			0.1000	55.10
368-427	E=546 MPa	d=1.38 [MPa]	0.0000	1.38
	ν=0.19	β=42°	0.0200	3.45
			0.0400	13.80
			0.0600	62.00
427-550	E=411 MPa	d=1.2 [MPa]	0.0000	1.38
	ν=0.2	β=40.0°	0.0200	5.03
			0.1000	6.90
			0.3000	62.00
550-610	E=494 MPa	d=1.38 [MPa]	0.0000	2.75
	ν=0.17	β=40.4°	0.0200	4.83
			0.0400	5.15
			0.0800	62.00
610-732	E=775 MPa	d=1.7 [MPa]	0.0000	2.76
	ν=0.17	β=50.2°	0.0050	4.14
			0.0200	7.58
			0.0500	62.00
732-915	E=1121 MPa	d=1.7 [MPa]	0.0000	3.44
	ν=0.17	β=58.5°	0.0060	4.14
			0.0120	7.58
			0.0300	67.60
E – Young's modulus, ν- Poisson's ratio, β- friction angle, d=cohesion				

Non linerar strain-stress behavor for geological layers are shown in figure 1.

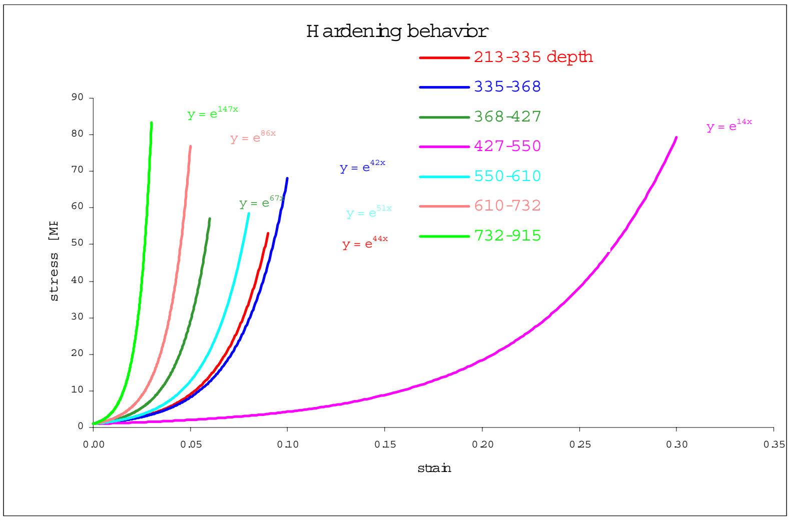

Figure 1

4. Three dimentional model of rock masses

Figure 2 shows the three dimentional model of the rock masses with the shaft in central part. Extracted volume is in coal 2 layer, in upper right side of the layer

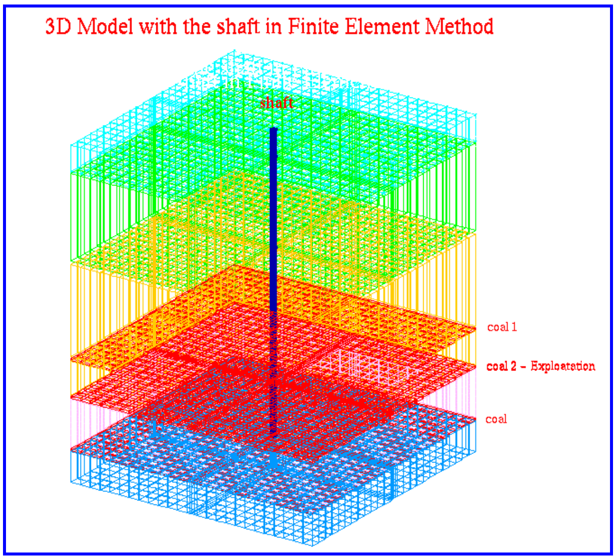

Figure 2

Figure 3 shows vertical cross-section by 3D model

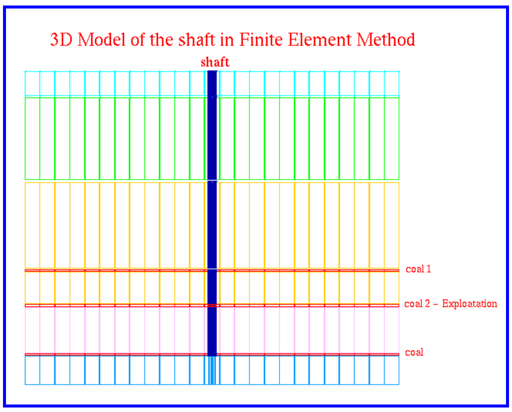

Figure 3

5. Results of the computations

The conducted computations made it possible to work out an analytical function (Figure 4) identifying the influence range-zone of a mining heading. The general shape of functions describing the influence range-zone is expressed by the following equation:

$$y = a \cdot \sin(x^b) \cdot e^{cx}$$

for : a = -4; b = 1.5; c = -1, (x and y – in local coordinete radius of influence)

The given parameters need, however, to be verified under specified, real conditions; also, further modeling investigations are required.

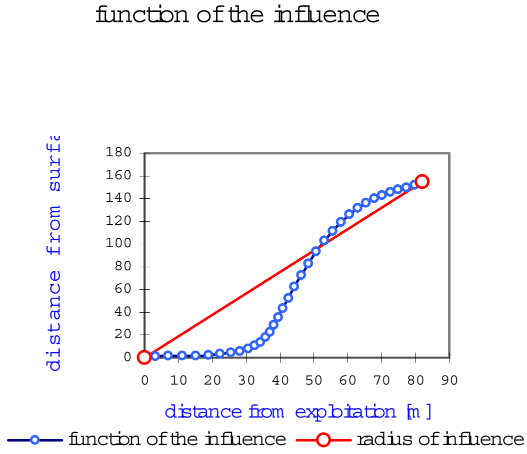

Figure 4

The suggested method of rock mass investigations allows for a thorough analysis of results expressed both in analytical and graphical form, and thanks to this fact the interpretation of those outcomes is efficiently facilitated.
Figure 5 shows surface and all model magnitude deformations

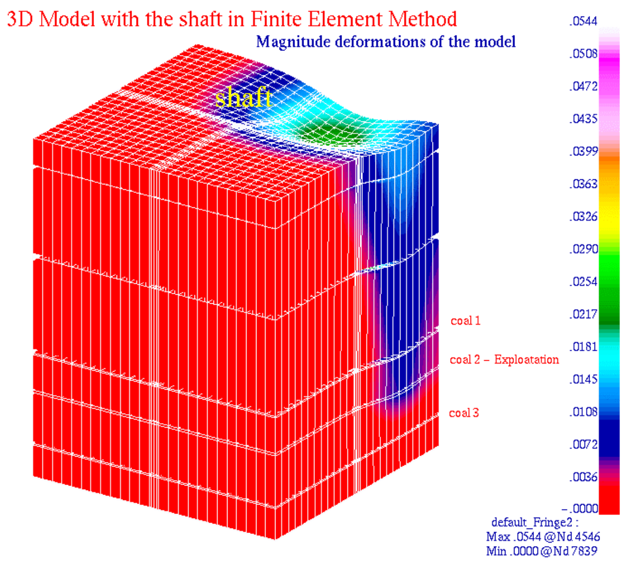

Figure 5

Figure 6 shows shaft magnitude deformations .

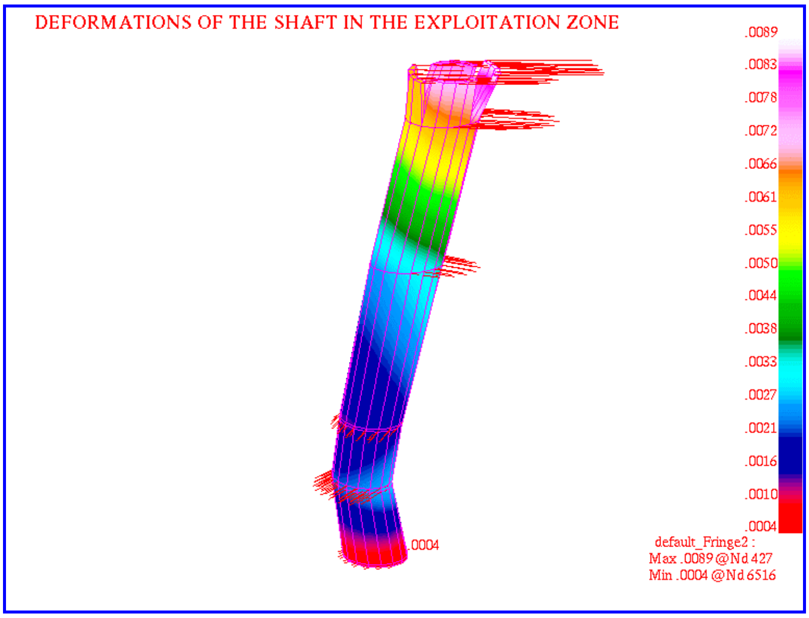

Figure 6

Figure 7 shows displacements [m] in cross-sections XX and YY in the shaft

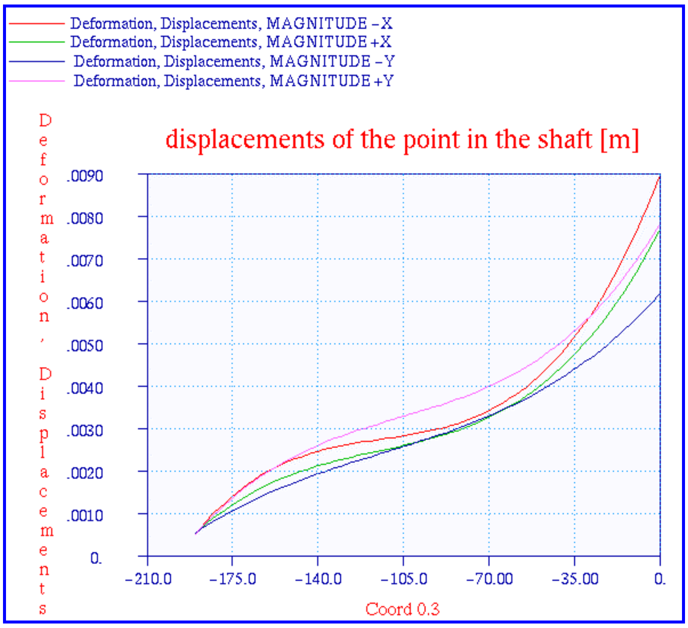

Figure 7

6. Conclusions.

The presented example of application of GAMMA method, shows that it is possible to obtain results describing comprehesively the phenomena that took place within the rock mass. Thanks to application Finite Element Method in GAMMA model, it is possible to calkulate the components of displacements vector and to calculate any indexes or indicators characterising the state of the rock mass and shaft in zone of mining activity.

7. References

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