Novi Sad

iNDiS 2012

UNIVERSITY OF NOVI SAD
FACULTY OF TECHNICAL SCIENCES
DEPARTMENT OF CIVIL ENGINEERING
AND GEODESY

12

iNDiS 2012

PLANNING, DESIGN, CONSTRUCTION AND RENEWAL IN THE CIVIL ENGINEERING

International Scientific Conference

PROCEEDINGS
Novi Sad, Serbia 28 - 30 November 2012

EDITORS
V. Radonjanin, R. Folić, Đ. Lađinović

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iNDiS 2012

This year, Department of Civil Engineering and Geodesy, Faculty of Technical Sciences - Novi Sad, organizes Twelfth International Scientific Conference "iNDiS 2012".

The first conference took place in the 1976 with main topic „Industrial construction of apartments“ as current. In the following years, conference topics were extended to “Industrialization in civil engineering“, and soon, papers form all areas of construction, from urbanism planning and designing buildings to maintenance and major interventions on engineering structures. It has caused the expansion of the area covered by this conference and, beside civil engineers in various fields, urban planners, architects, engineers in other fields who work in construction, sociologists, economists and others took a part.

The present moment is characterized by, among other things, a crisis in investment sector, especially in new construction, but, as in the world, more and more resources must be directed to building management. This requires a transformation of our activities in construction and adaptation to these trends. This conference, as well as several previous ones, includes problems of planning, design, construction and renewal, which led to an adequate response of foreign and domestic participants. This wide area includes not only the aforementioned researchers, planners and designers but also the contractors, including installation and finishing works in construction, i.e. all professions whose work is connected to architecture, construction and the built environment.

It is our pleasure that a number of members of the International Scientific Committee actively participated in the preparation of the Conference and wrote papers published in this Proceeding. These, as well as other papers, contain a variety of ideas and results of experimental and theoretical research that became the basis for formulating adequate calculation models of structures and models used in other areas of civil engineering and environmental protection. It is expected that, using experience from abroad, adjustment to the legislation already adopted in Europe will be easier. In addition, it is expected to point out the main directions of the development of civil engineering in order to meet modern conditions and needs.

Two Proceedings were published for this conference, one in the Serbian and the other in the English language, which allows better communication and exchange of experiences with colleagues from foreign countries as well as establishing new and strengthening of existing professional and collegial relationship.

The editors would like to express sincere gratitude to all authors for the effort invested in writing papers and for the contribution to this event.

Novi Sad, November 2012 Editors

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KEYNOTE PAPERS

EXPERIMENTAL AND THEORETICAL ANALYSIS OF STRUCTURES

Andrey KASYANENKO [1]
Stanislav RODZIN [2]

UDK: 624.93

STUDY OF EFFECT HARD ROCK LAYER HAS ON FLOOR HEAVING IN COAL MINE BY FINITE ELEMENT METHOD

Abstract: This paper presents the results of analytical study of the effect the hard rock layer has on floor heaving in mind by the finite element method using software solution SolidWorks Simulation (COSMOSWorks).In our experiments we analyzed the results of floor heaving with uniform structure. We made quantitative measures in relative metrics. The performance of limestone as a hard rock layer has been used, and claystone has been used as a basic rock in the model. Variations of thickness and layer depth of hard rock enables us to give more precise evaluation of changes in deflected mode which lead to displacement of floor rocks. The results obtained in the course of analytical research have qualitative value and can be applied in developing different criteria of evaluating occurrence and forecasting floor heaving.

Key words: Mine working, Rock pressure, Floor heave, Hard rock layer, Finite elements method, SolidWorks Simulation

ISTRAŽIVANJE EFEKTA PROSLOJKA ČVRSTE STENE NA IZDIZANJE PODA U RUDNIKU PRIMENOM METODE KONAČNIH ELEMENATA

Rezime: U radu su prikazani rezultati analitičkog ispitivanja efekta proslojka čvrste stene na izdizanje poda u rudniku primenom metode konačnih elemenata pomoću softverskog paketa SolidWorks Simulation (COSMOSWorks). U našim eksperimentima smo analizirali rezultate izdizanja poda sa uniformnom konstrukcijom. Prebacili smo kvantitativne mere u relativni metrički sistem. Svojstva krečnjaka su korišćena radi definisanja čvrste stene u modelu, dok je glina određivala baznu stenu. Varijacije debljine sloja i dubine čvrstog proslojka omogućava nam precizniju procenu promena u režimu ugiba koji dovode do pomeranja podnih stena. Rezultati dobijeni u ovom analitičkom istraživanju imaju kvalitativnu vrednost i mogu se primeniti u razvoju različitih kriterijuma procene pojave i predviđanje izdizanja poda.

Ključne reči: Radovi u rudniku, pritisak stene, izdizanje poda, proslojak čvrste stene, metoda konačnih elemenata, SolidWorks Simulation

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1. INTRODUCTION

For deep mines of Ukraine, in particular geologic industrial districts of the Donets Basin, the basic problem of keeping up preparatory roadway is loss of their section because of considerable displacement of surrounding rocks.

The considerable displacement of surrounding rocks leads to impairment of a ventilation roadway, to growth of a traumatism of miners and increase in expenses for carrying out roadway repair such as ripping and retimbering. In addition, it's worth mentioning that most part of roadway repairs (60-80%) is caused by floor heaving.

With hard rocks being present in floor of roadway their ripping is carried out by means of drilling-and-blasting, so it essentially complicates repair work due to the increase in the amount of hand work used in the process.

2. STATEMENT OF RESEARCH PROBLEM

Floor heave is the most complex geomechanical process affected by a various geologic and technological factors [1]. Nowadays the research target in this field is to find the appropriate mathematical models for mining methods as well as looking for effective ways achieving stability of roadway within the zone of coal-face works. There are many hypotheses explaining process of floor heaving, as a rule, by means of verifying analytical solutions. As far as elasticity theory is concerned the specification statement of this process is presented in the form of a model of a uniform isotropic body [2]. However, the real massif is constituted by laminated composition of rocks of various strength and thickness consisting of coalbed and surrounding rocks, such as claystone, sandstone and limestone.

Results of previous studies carried out at Abakumov Mine of the state enterprise «Donetsk Coal Energy Company» were revealed by features of floor movement and its deformation by features of floor movement and its deformation [3,4]. The amount of floor heaving was approximately 0.4-2.1 m along the whole roadway. The stratigraphic column shows that the roadway floor contains limestone and sandstone. Particularly they are adjacent to claystone. It has been discovered that displacement of the floor layer results in the creation of longitudinal asymmetry incurvation at a distance of 0.8-0.9 m from the goafside. Its vertical axis is tilted towards a goafside at an angle 35-50°. Floor displacement rate gradually decreased after the maximum achievement. Begins at about 35 m from face advance and the roadway does not satisfy with safety rules. Thus, it is made with the help of ripping and retimbering where necessary. The miners had to dig out the heaving rock in the floor of the belt roadway to keep it in order. In such a way this extra work is giving rise to financial problems and labour costs.

Thus, the purpose of the research under consideration is the analytical specification statement of the feature floor heaving in laminated floor constituted by hard rock layer (like limestone).

3. COMPUTATIONAL MODEL

The problem in focus can be solved through application of numerical methods. The most widely applied in geomechanics is that by finite element method (FME) which is actively exploited by science [5]. Solution of a given problem was carried out in some stages:

- Developing the Computational model accounting for original and limit conditions

- Defining the complexes of required magnitudes and the source data
- Developing calculation algorithm
- Problem solving
- Checking and improving the solution
- Defining the area of rational application of the solution

The model by programmatic complex SolidWorks Simulation (COSMOSWorks) which can be used for defining the tension of massif by finite element method [6] has been constructed.

The research was based on the following specifications of the model $B\times B\times 0.1B$, where B - roadway width, for the majority of coal mines B=5 m around.

Load-carrying model was accepted for specific properties at Abakumov Mine with constant side pressure being

$$\lambda P = \gamma Hg = 860 \times 2.67\cdot 10^3 \times 9.81 = 23 \text{ MPa} \quad (1)$$

Where:

γ – average density surrounding rocks of roadway, kg/m^3

H – depth of a location of roadway, m

g – gravitational acceleration, m/s^2

λ - ratio horizontal stress, approximation is defined as λ=0.5

At studying the dependence of the influence of a hard layer on variation definition displacement of floor rocks center floor surface U_n, on two influencing factors - its thickness – Δ and layer depth in floor – Δh. The variation of features related to the affixment of roadway width is considered to be: Δh = 0.1÷0.9 B, Δ = 0.1÷0.5B (Figure 1).

For more detailed vision the model consisted of the basic weak rock like claystone, with limestone being used as a hard layer rock , the values of the parameters describing rock types are presented in model in Table 1.

Table 1- Values of the parameters describing of rock types in model

Rock types	Compressive strength, σ_c, MPa	Tensile strength, σ_t, MPa	Density, ρ, kg/m^3	Elastic modulus, E, GPa	Poisson's ratio, ν
Claystone	120	13	2530	50	0.23
Limestone	30	3	2780	90	0.31

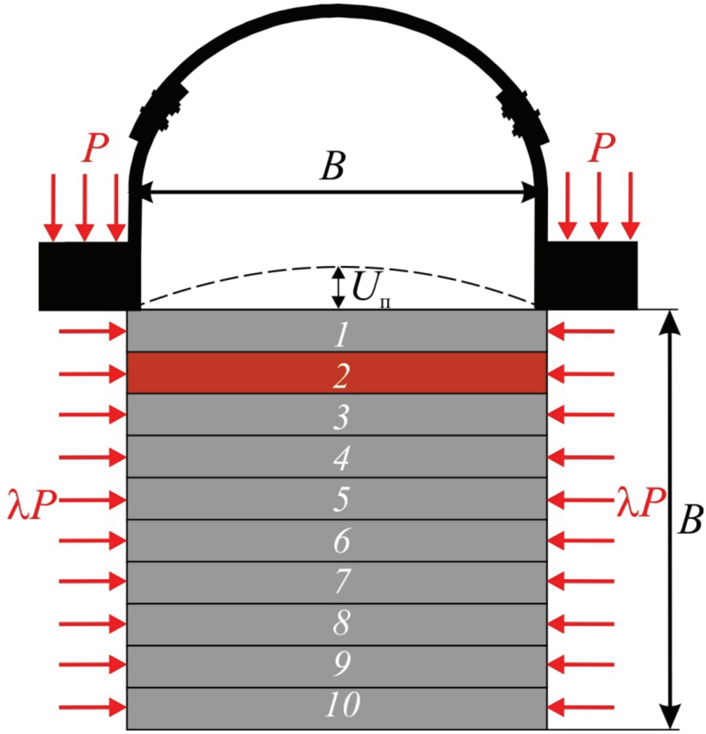

Figure 1 – Computational model for defining displacement of floor rocks caused by side pressure (1-10 - layer number, B – roadway width, Un – measurable displacement center floor surface, λP - side pressure)

The variation of thickness of a hard layer will enable to determine more precisely the variation of stresses and deformations. As a matter of fact, there is insignificant change in layer depth in floor. The study is based on models of five variations, for various thickness of a hard layer being accepted, in particular: I – 0.1*B*; II – 0.2*B*; III – 0.3*B*; IV – 0.5*B*; V – *B* (uniform massif); with variation of hard layer depth in floor for each given thickness dropping to limit *B*. Therefore, a total of 21 models have been studied (Figure 2).

The following assumptions were used In the computational model:

- Floor deforming is viewed as the collection of deformations of separate layer
- Magnitudes of displacements of underlayer in a direction perpendicular and parallel to lamination are accepted equal to zero point
- In each layer at a flexure occur zero displacements located near the bottom contact of a layer
- At incurvation layers tightly lay down against each other, with function of normal components of displacement vector being continuum
- Functions of horizontal displacements and horizontal deformations (in a rock stratification direction) are continuum only within a layer deformed without breaking-up on internal contacts of stratification
- Results of model were compared to a uniform massif of model

Results of computational model are shown in Figure 3.

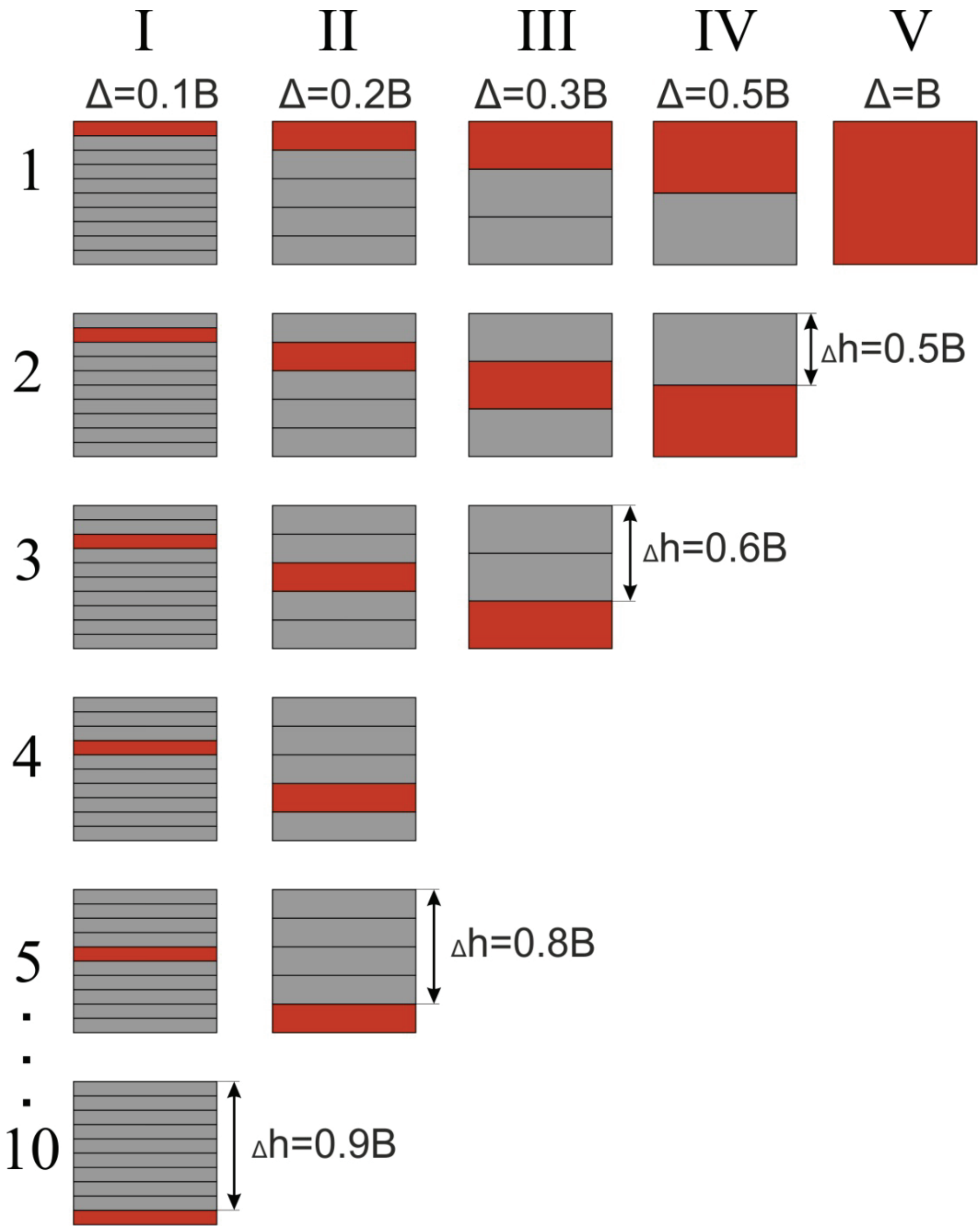

Figure 2 – Variation of computational models for defining displacement of floor rocks caused by side pressure (I-V –various thickness hard layer rock, Δ; 1-10 –variation hard layer rock depth in floor, Δh)

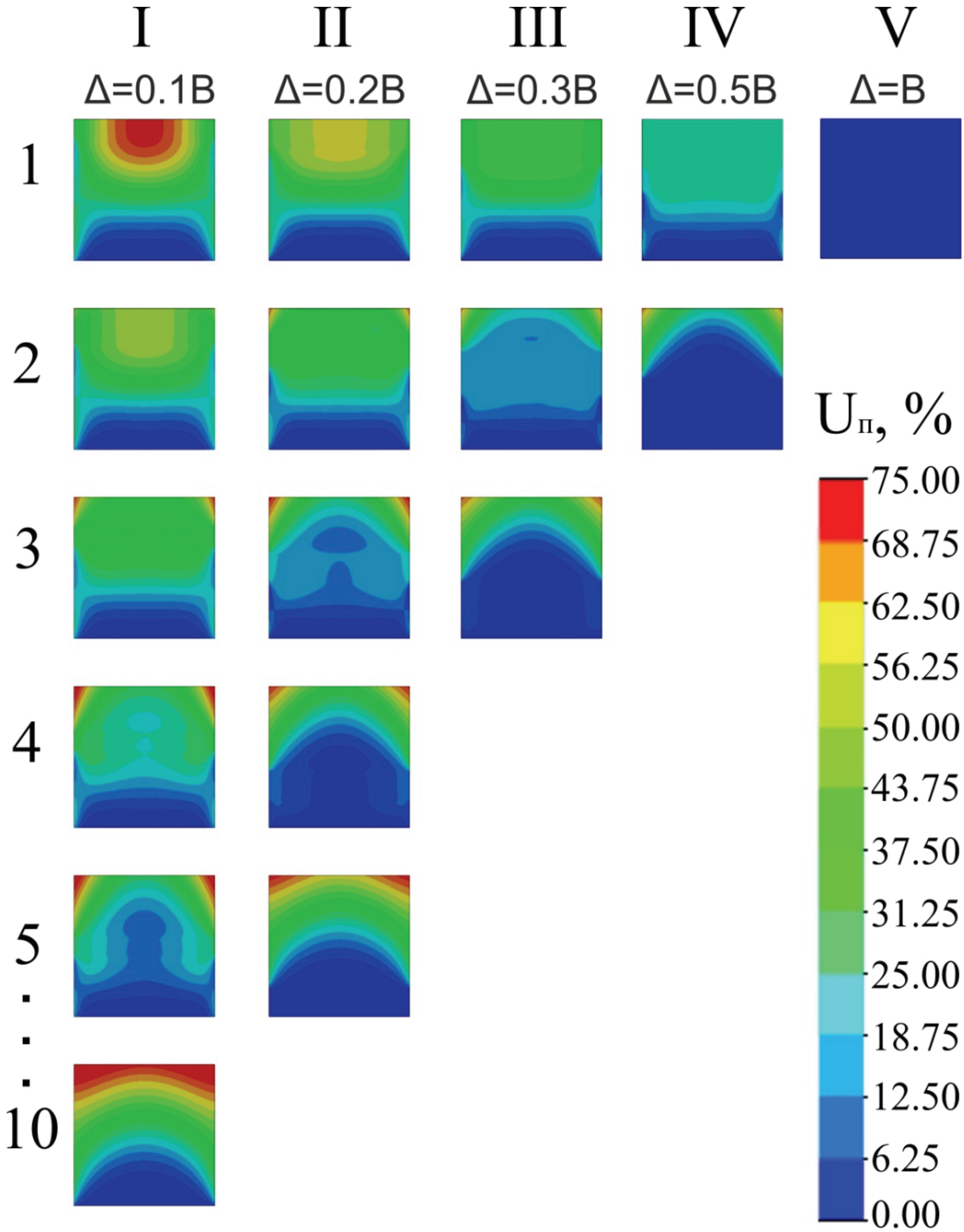

Figure 3 – Type of change allocation in rocks displacement in computational model by programmatic complex SolidWorks Simulation (I-V –various thickness hard layer rock, Δ; 1-10 – variation hard layer rock depth in floor, Δh, Un – percentage ratio to displacement in a uniform massif).

4. ANALYSIS RESULTS

On the basis of a serial computational model shown on figure 3 define movement of floor rocks center floor surface on which was graph given in figure 4 in terms of percentage ratio to displacement in a uniform massif on the thickness hard layer rock and its depth in floor.

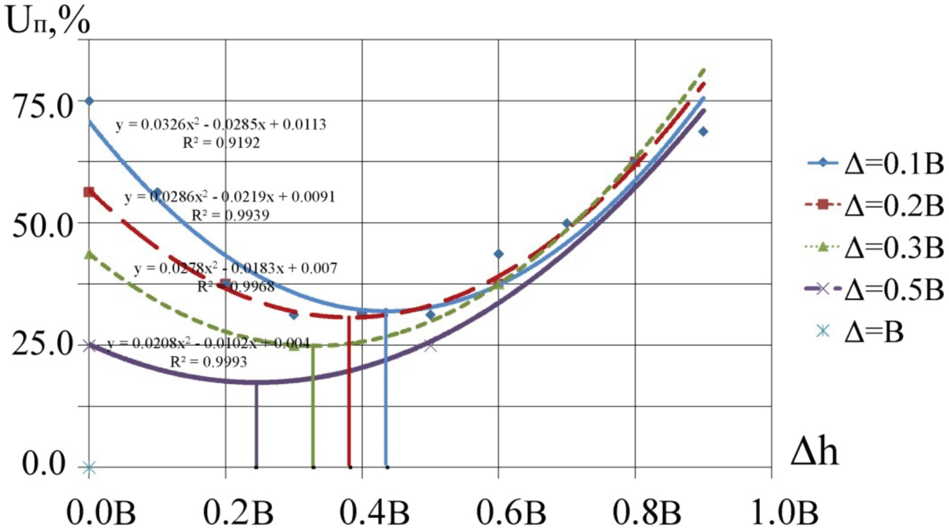

Figure 4 – Floor movement in terms of percentage ratio to displacement in a uniform massif on the thickness hard layer rock and its depth in floor

(Δ – thickness hard layer rock,; Δh –depth hard layer rock in floor,

Un – percentage ratio to displacement in a uniform massif).

Point-to point line of each value of hard layer sickness enabled to develop a regression equation and define reliability approximation and values of extremums (table 2).

Table 2- Regression equation, reliability approximation and values of extremums for each values of thickness hard layer

Number hard layer rock in model	Value thickness hard layer *Δ*	Regression equation	Reliability approximation, R^2	Value of the extremum, *Δh*
I	0.1*B*	$y = 0.0326x^2 - 0.0285x + 0.0113$	0.92	0.437*B*
II	0.2*B*	$y = 0.0286x^2 - 0.0219x + 0.0091$	0.99	0.383*B*
III	0.3*B*	$y = 0.0278x^2 - 0.0183x + 0.0070$	0.99	0.329*B*
IV	0.5*B*	$y = 0.0208x^2 - 0.0102x + 0.0040$	0.99	0.245*B*

On the basis of the graph given in Figure 4 the following assumption has been made:

- Active effect of a hard layer is beginning to 0.5B and the harder the layer is the lower the value of the displacement is as related to a uniform massif
- Starting from depth 0.6B thickness hard layer rock does not effect for floor displacement and its to grow-up
- Extremum function of the received dependences for each thickness there corresponds certain depth of a hard layer (see vertical lines in figure 4): *f(0.1B)=0.437B, f(0.2B)=0.383B, f(0.3B)=0.329B, f(0.5B)=0.245B,* it is the max effect of a hard layer for each thickness at such depth at which one displacement will be minimum relative to a uniform massif

5. CONCLUSION

Results of this study were obtained dependences that enabled to conclude that the thickness of hard layer rock and its depth considerable effects displacement of the floor in relation to a uniform massif.

Further research will be focused on the reasons and developing protection support methods for controlling floor heave. Study will be carried out in order to keep the floor displacement in the acceptable limits in accordance with safety rules.

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