ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ 1994

Seria : GÓRNICTWO z. 221 Nr kol. 1256

Josef ALDORF , E. HRUBEŠOVÁ
VŠB-Technical University Ostrava
Department of Mining Geotechnics and Underground Civil Engineering
CZECH REPUBLIC

CONTRIBUTION TO THE PROBLEM OF GEOMECHANICAL MONITORING IN THE GREAT DEPTH AND POSSIBILITY OF THE BACK ANALYSIS

Summary. The paper discusses the algorithm of the sequence and method of inversion (back) analysis of the primary stress state in rock mass using data obtained by measurements with the help of multilevel extensometers around the underground excavations.

PRZYCZYNEK DO ZAGADNIENIA GEOMECHANICZNEJ KONTROLI NA DUŻEJ GŁĘBOKOŚCI I MOŻLIWOŚCI ANALIZY ODWROTNEJ

Streszczenie. W artykule omówiono algorytm postępowania i metodę analizy odwrotnej pierwotnego stanu naprężenia w górotworze na podstawie danych pochodzących z pomiarów wykonanych za pomocą wielopoziomowych tensometrów zainstalowanych w otoczeniu wyrobisk podziemnych.

К ВОПРОСУ ГЕОМЕХАНИЧЕСКОГО КОНТРОЛЯ НА БОЛЬШОЙ ГЛУБИНЕ И ВОЗМОЖНОСТИ ОБРАТНОГО АНАЛИЗА

Резюме. В работе представлен альгоритм выполнения и метод обратного анализа первоначального напряженного состояния в горном массиве на основании данных, полученных во время измерений при помощи тензометров разного уровня, установленных в среде, окружающей горные выработки.

Observation of underground working by monitoring makes available a great number of data and informations on the behaviour of rock strata and roadway support (convergence development, disturbance zones, loading, stress and deformation projection needs, but they should be applied especially for creation of a geomechanic model by which development of the whole system behaviour, critical condition achievement, support reinforcement need etc could be predicted. Thus conceived geomechanic model, however, requires a continuous precisioning updating of input parameters which could be achieved by inversion analysis methods (IA) (back analysis) usually by the same computing model. Data required for such ap, roach can be obtained as follows:

- by convergence measurement (on excavation section, or support)
- by deformation measurement (on support)
- by dynamometric measurement (on support)
- by dynamometric measurements of support loading or stress within support
- by extensometric measurement (dislocations of points within rock strata).

By inversion calculation then shape and size of support loading pattern, size of original stress tensor components, parameters of rock strata deformational features etc can be determined. In lit. ref. [1] programming systems of inversion analysis for convergence, deformation and dynamometric measurements are described. In the paper presented here its autors intentions is to inform about a single model IA based on extensometric

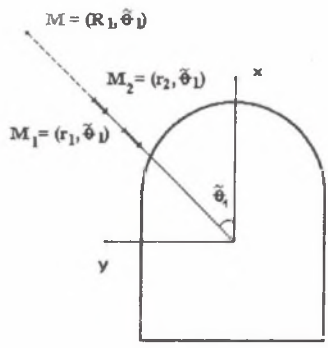

Fig. Scheme of computing model

Rys. Schemat modelu obliczeniowego

measurements (see Fig.) which when compared with the other above-mentioned systems are advantageous as they make available information on behaviour of broader roadway surroundings. The application of multi-level extensometers additionally gives more precise solution results as it allows the use of very accurate differential dislocation values between pairs of extensometer heads installed in various levels.

The elaborated calculation system named INVERZE 4 is based on the description of deformation condition in the surroundings of underground roadway of arbitrary shape (representable by means of conform representation) and enables a determination of size of original stress tensor components in rock strata.

$$S_1 = g.\,h$$

$$S_2 = K_b.\; g\,.\;h \qquad (1)$$

$$S_1/S_2 = K_b$$

The solution of this task is based on application of Kolosoff-Muschelishvili method with utilization of Melenteyeff method for determination of coefficients of conform representation. Stresses which have been caused by roadway drivage and which participate in dislocation genesis can be described by an abbreviated formula as follows:

$$\sigma_\rho = S_1\, k_1(r,\theta) + S_2\, k_2(r,\theta)$$

$$\sigma_\theta = S_1\, k_3(\rho,\theta) + S_2\, k_4(r,\theta) \qquad (2)$$

The magnitudes of functions k_1 up to k_4 can be found out in (2). The magnitude of radial dislocation of M-point (see Fig. 1) can be determined by correlation (see below) and numeric integration. For representation of abscissa $u_{(M)}$ (i.e. $u_{(M)} = W(\theta)$) in the plane S_1 (conform representation) an iterative procedure by means of Newton method is applied.

$$u_{(M)} = \sum_{i=1}^{n} \int_{\rho_i}^{\rho_{i+1}} \frac{1}{E} \left[\sigma_\rho(\rho,\theta_i)\left(1-\mu^2\right) - \sigma_\theta(\rho,\theta_i)\;\left(\mu+\mu^2\right)\right] \frac{\delta/w(\rho,\theta)}{\delta\rho} \qquad (3)$$

The upper limit of integral (3) is a certain point $M(R_1, 0)$ in which the difference between additional and original stress components does not exceed 1% of original stress. In this point a virtually non-existent drivage caused dislocation can be experted.
If we write out the equation (3) for adjacent points M_1, M_2. Then after an adjustment the following can be obtained:

$$\Delta u = u_{(M_1)} - u_{(M_2)} = \frac{1}{E}\left(S_1\{(1-\mu^2)A - (\mu+\mu^2)C\} + \right.$$

$$\left. + S_2\{(1-\mu)B - (\mu+\mu^2)D\}\right) \tag{4}$$

where the functions A,B,C,D represent integrals from the equation (3). If we designate

$\Delta \vec{u}^* = (\Delta u_1^*, \ldots\ldots, \Delta u_k^*)$ - vector of measured values

$\Delta \vec{u} = (\Delta u_1 \ldots\ldots \Delta u_k)$ - vector of calculated values

of pairs of measuring points (Fig. 1) the unknown values of S_1, S_2 can be determined by a least squre method, i.e. by seeking a function minimum $f = \Sigma\,(\Delta \vec{u}_i - \Delta \vec{u}_i^*)$
Out of extreme conditions the following results after adjustment from the equations (4)

$$S_2 = K_b \gamma h = \frac{\left(\sum\limits_{j=1}^{n} \Delta u_j^* L_2^j\right)\left(\sum\limits_{j=1}^{k} L_1^{j2}\right) - \left(\sum\limits_{j=1}^{k} \Delta u_j^* L_1^j\right)\left(\sum\limits_{j=1}^{k} L_1^j L_2^j\right)}{\sum\limits_{j=1}^{k} L_2^{j2} \sum\limits_{j=1}^{k} L_1^{j2} - \left(\sum\limits_{j=1}^{k} L_2^j L_1^j\right)^2}$$

$$L_1^j = \frac{1}{E}\left[(1-\mu^2)A_j - (\mu+\mu^2)C_j\right]$$

$$L_2^j = \frac{1}{E}\left[\left(1-\mu^2\right)B_j - \left(\mu+\mu^2\right)D_j\right]$$

In this way a computing program INVERZE 4 has been compiled which brings a solution of the above-mentioned problem and determines the values of original stress tensor components of rock strata S_1, S_2 and of lateral stress coefficients $K = S_2/S_1$.

References

[1] Aldorf J., Hrubešová E., Korínek R.: Features and methods of monitoring observation and inversion analysis applied on stability of shafts of Frenštát Colliery. TEZ VOKD 1/1981

[2] Final report of VÚ SPZV II-6-1/04.05 entitled "Stability and support of long roadways in a difficult underground natural conditions. Mining University VŠB Ostrava, 1990

Recenzent : Prof. zw. dr hab. inż. Mirosław CHUDEK

Wpłynęło do Redakcji w maju 1994 r.

SOLUTION OF THE PRIMARY STATE STRESS
****
(back analysis based on extensometric measurements)
INPUT DATA:

Cross section of working:ARCH
Poissons ratio of rock:0.300
Elasticity modulus of rock:500.0 MPa

TABLE OF EXTENSOMETRIC MEASUREMENTS:

measur. no.	angle [st.]	rad.of 1th p. [m]	rad.of 2nd p. [m]	measur.v. [m]
1.	0.0	3.50	4.50	-0.00300
2.	90.0	4.50	6.00	-0.00180
3.	120.0	3.50	4.50	-0.00150

PRIMARY STRESS STATE:
****
N1=6.897 MPa
N2/N1=0.9187

COMPARATIVE TABLE

actual values [m]	fitted values [m]
-0.00300	-0.00296
-0.00180	-0.00152
-0.00150	-0.00181