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Computer Modelling of Geomechanical Processes in Underground Working of Coal Seams

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ABSTRACT: A new methodology of experimental-analytical approach has been developed. It is used in the building of an information geomechanical monitoring system (Gm MS) for computer modelling of geomechanical (Gm) processes during the working of coal seams. The approach synthesizes experimental (in-sini) measurements of rock pressure manifestation at separate points, methods of numerical modelling of processes on the rock boundary with goaf and seam, and analytical calculations of the spatial strained state of the rock mass.

1 INTRODUCTION

For the building of an information geomechanical monitoring system (Gm MS), a new methodology is used. It is the methodology of experimental-analytical modelling of Gm processes at the working of coal seams. Experimental-analytical modelling in mining geomechanics means the use of data as boundary conditions in solving problems with analytical methods, namely: adjoining rock shift, measured experimentally or calculated through momentary measurements İn mine conditions. Such synthesizing is conducted on the basis of the worked-out model of shift (overhang) formation of adjoining roof rock and of the experimental-analytical method of determination of changes in the rock mass Gm state at the working of coal seams.

2 THEORY OF ROCK MASS KINEMATICS

Adjoining rock shifts during seam working present an integral characteristic of the rock mass geomechanical state and are an informative and simple form of rock pressure manifestations (BnaceHKo,1993). According to data from mine instrumental observations on adjoining rock movements in the locality of coal faces during seam working, İt has been found that rock roof shift results from face advance in coal winning and temporary processes in the rock.

The schemes of formation of the working excavation given in Figure 1 show the one-type development of various forms of workings. The main element of the development is the face movement along the front line. A trapezoidal form of working excavation (Figure lb) may be considered more general. From this, workings of rectangular (a), triangular (c) and other forms are carried out, including workings with a skew angle line of the extraction front. One of these forms is the formation of a working excavation of compound form, for example, with a broken front line (Figure lc), and the description algorithms of configurations of cavities having compound forms with a broken face üne at the working of the seam are simple enough. In coal workings, individual face advances cause shifts of roof points in its locality. The geometrical place of normal-to-seam shifts of roof boundary points presents the surface of shift increments as a result of face advance (Figure 2d, e).

Surface of shift increments due to track working and die advance of the extraction front is formed as a result of face movement along the front line on shift surfaces due to individual face advances. Shift surfaces as a result of front advance, forming the coal face, constitute die final surface of roof shifts due to panel mining. Surfaces of shift increments and of final shifts are elements of roof boundary shifts. Surfaces of shifts due to face advance, which can be determined as an individual surface of shifts or an element of rock pressure manifestations (Figure 2d, e), are characterized by the parameters: location coordinates, direction and rate of face advance; maximum value of shifts and location relative to the face; degree of the decrease in shifts about die face. These physical parameters are applied to the analytical description of shift formation are general enough for various technologies (from me point of view of strata control methods) of seam workings and are suitable for determining parameters and computing from observations in situ,

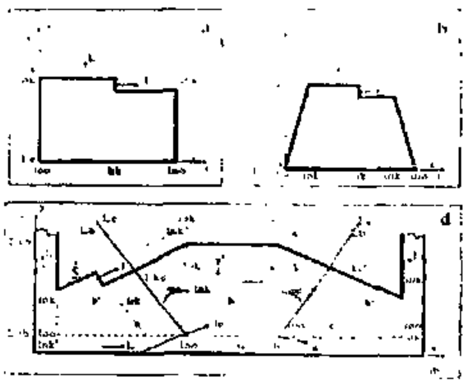

Figure 1. Schemes of coal face forming (a - straight shape; b - trapezoid shape; c- triangular shape (as a type of trapezoid) wilh inclined Iront line; d - compound shape with non-straight front line and developement workings).

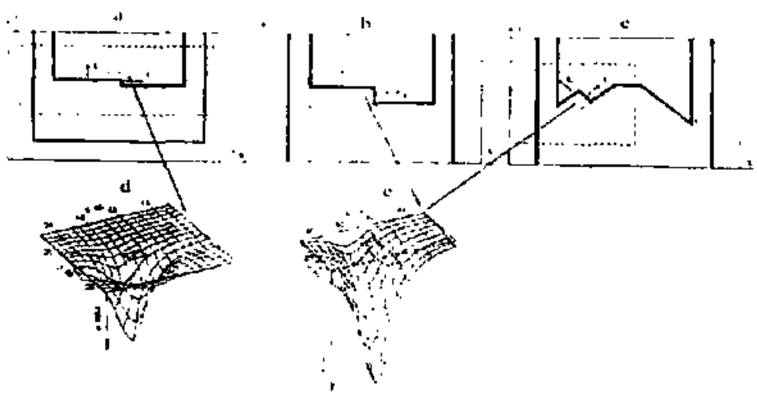

Figure 2. Elements of rock pressure manifestation in coal faces (a - longwalls with narrow web face; b - in longwalls with wide web face; c - in longwalls with non-straight wide web face: d,e - surfaces of shifts increments due to individual advances of narrow web (d) and wide web (c) faces; |"j-calculation range of rock pressure

The worked-out method of calculation of rock shift surface formation (Bjiacemco, 1993) is a generalizing description and interpretation of shift experimental investigations most commonly used in me research of rock pressure manifestations during the mining of seam deposits. The calculation method provides an opportunity to work out a method (metJiodics) of shift modelling for different technological schemes of working. Taking basic increments of shifts due to individual face advance for a known face scheme, for example, during the movement of a narrow web face (Figure 2a, d), it is possible to design a shift element due to individual face advance with set parameters, for example, of a wide web face (Figure 2b, c, e), and calculate shift surfaces for designed technological schemes of working.

Figure 3 shows the results of computer modelling of roof rock mass kinematics for spatial systems of working with different schemes of coal seam mining.

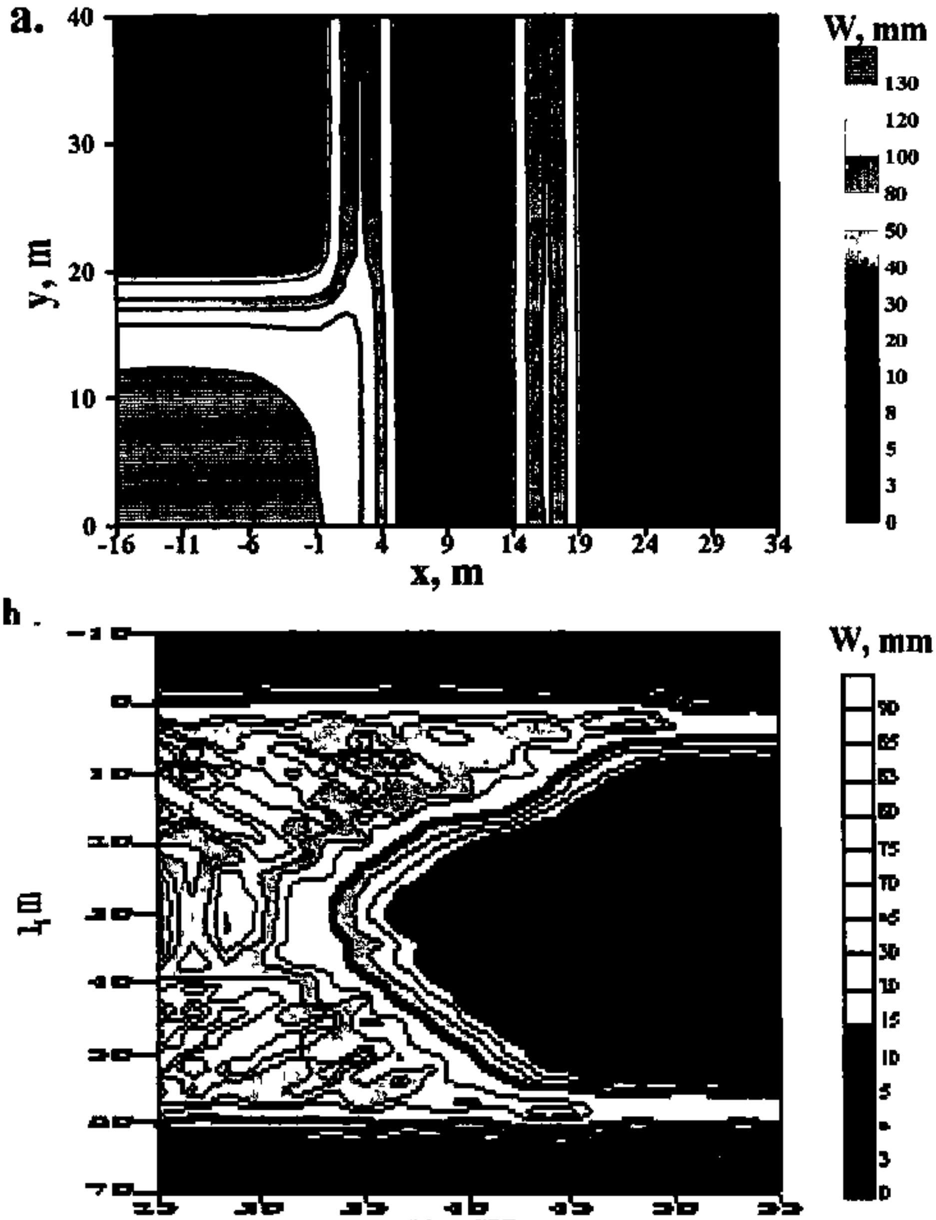

Figure 3 Picture of lines of surface levels of roof rock shifts in the neighborhood of coal face and development working system at the mining of coal seam by technological schemes with a pillar (a) and a non-straight (convex) wide-web face

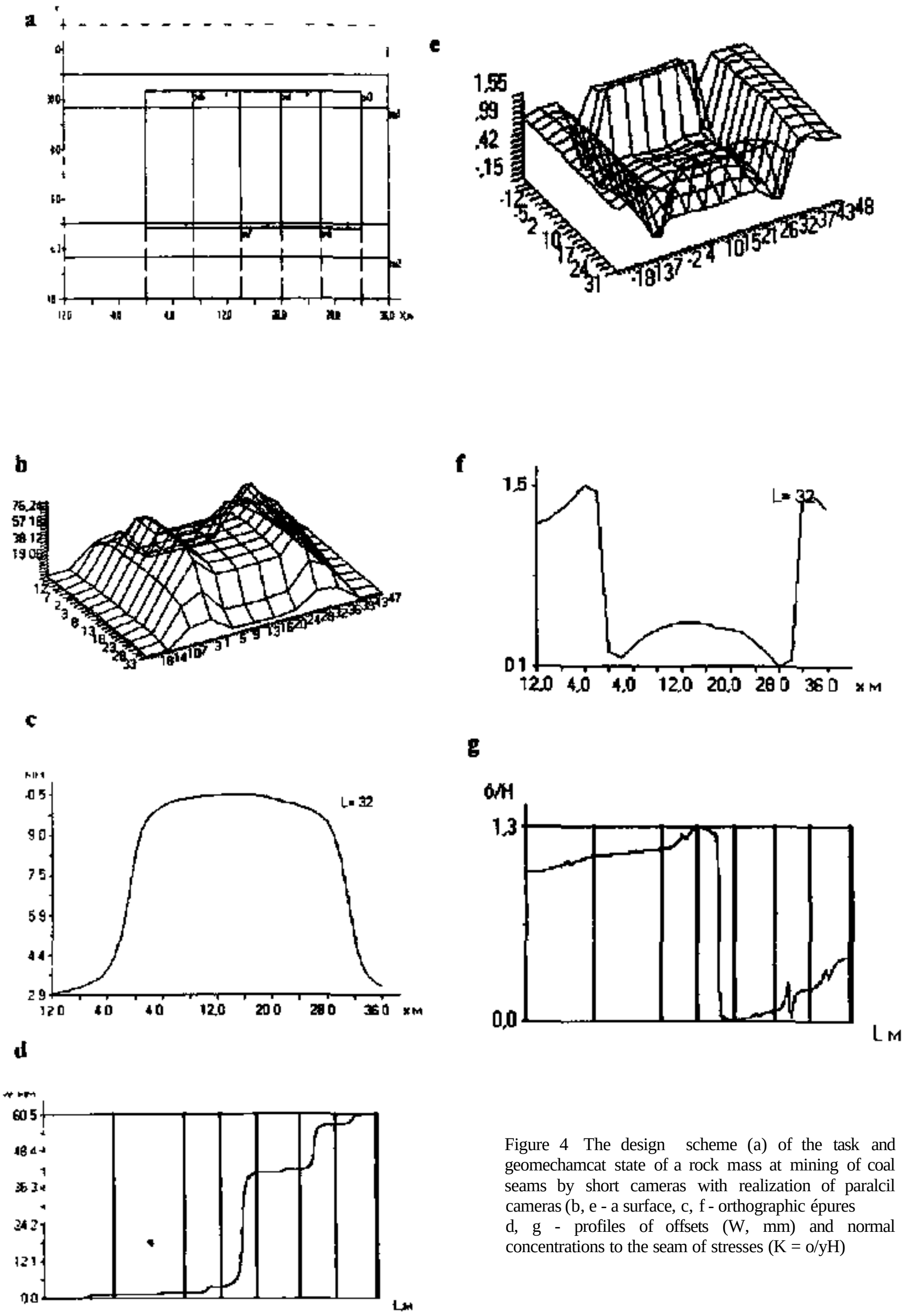

Figure 4 The design scheme (a) of the task and geomechamcat state of a rock mass at mining of coal seams by short cameras with realization of paralcil cameras (b, e - a surface, c, f - orthographic épures d, g - profiles of offsets (W, mm) and normal concentrations to the seam of stresses (K = o/yH)

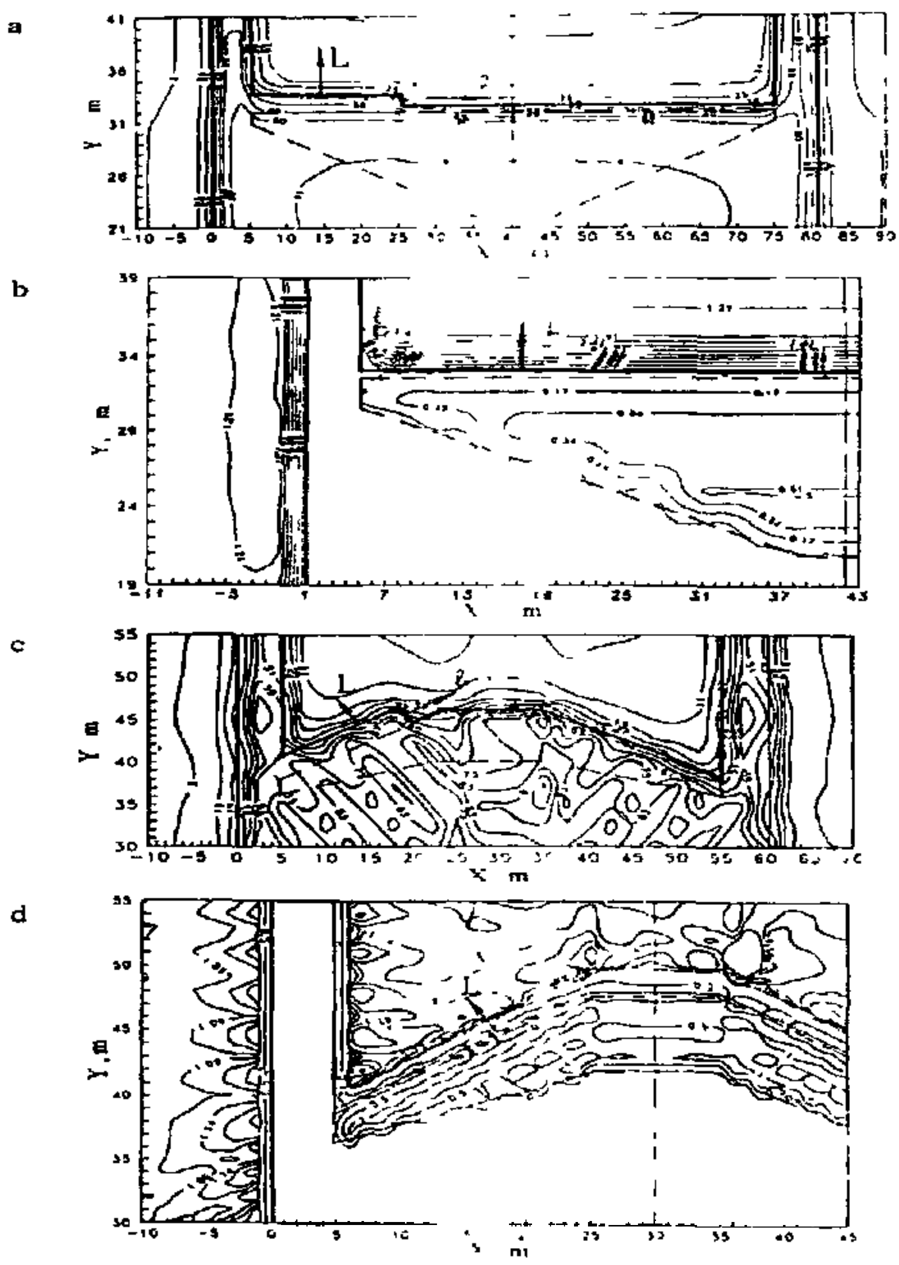

Figure 5 Rock pressure manifeslations in longwalls with straight narrow web (a b) and non-straight (concave shape) wide web faces (a, e - lines of levels of roof surface, mm b, d- isolinesofconcentration surface of abutment pressure upon seam and of reaction support, *K-a/yH)*

3 EXPERIMENTAL ANALYTICAL METHOD OF INVESTIGATIONS

The processes of change in the rock mass Gm state in underground raining may be investigated not only with different methods or a combination of methods, but also by means of an experimental-analytical method, i.e., using analytical methods of investigation on the basis of experimental data (BjiaceHKO, 1995).

The new method of mining geomechanics of computer experimental-analytical simulation of the geomechanical state of a rock mass is developed during the mining of a coal seam.

Analytical solutions to problems of rock mechanics are performed using experimental measurement results or calculated values of adjoining rock shifts as boundary conditions. The advantages of such an approach are in the use of real manifestations of geomechanical states under certain mining conditions and in the opportunity to overcome difficulties in the solution of spatial problems.

General solutions to spatial problems of the strained-deformed state of the rock mass İn the vicinity of the face have been obtained on the basis of formulated statements under boundary conditions in the form of set surfaces of shifts. {Jalevsky & Vlasenko, 1998).

The method, algorithms and the programs of the accounts make it possible to:

- display the spatial design scheme of the task for any technological scheme of the mining and dynamics of the development of coal face works with the help of units of wall advance and front of operations;
- automate both the construction of the design scheme of the task, and account for the spatial stressed and deformed state of a rock mass and processing of the account results;
- present visually with the help of standard programs the machine profiles the obtained results as (Fig. 4) spatial pictures, maps of isolines, and orthographic épures of the surface offsets and stresses, and temporary profiles of changes in offsets and stresses during the development of a seam.

The advantages of the developed computer method of simulation have not been obtained previously in mining geomechanics, either in simulation by analytical methods (for example, the method of boundary integral equations, finite element methods, etc.), or in physical simulation (for example, with the help of equivalent or photo-elastic materials).

In Figure 5, the modelling results of the rock pressure manifestations are shown. They were modelled for schemes of seam working with the use of a narrow-web cutter-loader and a cutter-loader at broken front lines of works. The pictures of rock roof shifts (roof subsidence) (Figure 5a, c), calculated over them the pictures of abutment roof pressure on a coal seam and the reaction support within the goaf (Figure 5b, d), give the opportunity to understand and compare rock mass geomechanical states for different schemes of working at one-type formation of deformation processes in roofs.

The accounts of the stressed-deformed status of rock massif in the vicinity of systems of mine workings in a coal seam were carried out at the rectilinear and non-rectilinear forms of the front of working faces, essentially the spatial schemes of the complex configuration of the workings. It has made it possible to begin the creation of a directory of geomechanical status and conditions for basic elements of new and traditional technological schemes of coal seam mining.

4 CONCLUSIONS

The use of kinematic theory, experimental analytical methods of determination of the geomechanical state and geographical information systems enable a system of dynamic computer modelling of geomechanical processes within the rock mass to be worked out.

Dynamic computer modelling of geomechanical processes m the mine information monitoring system is designed to calculate the geomechanical conditions within panels during planning arid development as well as during mining, i.e., to enable long-term prediction, in-line control and short-terra prediction of rock pressure manifestations.

Such a monitoring system can be used as a basic part of the system in order to facilitate scientifically proven technical and technological solutions in seam working.

REFERENCES

Jalevsky V.D.. Vlasenko B.V. 1998. Geomechanical e\alution of method lor long room mining of coal scams *APCOM'9H 27-ih international Symposium on Computet Application* in the Minimi Industries. Paper* presented at the 'APCOM'9ft' confèrent, organized h\ the Institution of Mining and Metiilhrgy ami help in London, United Kingdom from 19 to 23 April, 199H* 429-440

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