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COMPLIANCE TEST OF GROUND SUPPORT DESIGNS AND ESTABLISHED STANDARDS FOR TEMPORARY ROADWAYS IN COAL MINES

I'll condition of temporary roadways in coal mines is one of the reasons for the lower reliability of performance of basic mining subsystems. The practice of rock bolting used to ensure stability of temporary roadways shows that the rock bolting technology needs improvement and calls for the new procedures, regulations and estimation criteria in order to provide conformity between the ground support designs and the ground support standards. The observation data on the condition of walls and support in temporary roadways in coal mines in Kuzbass show that the true condition of the temporary roadways sometimes disagrees with the mine project. These findings can have aggravating effect on the further operation of the temporary roadways in coal mines.

The instrumental monitoring and visual inspection have shown that the increase in the width of a temporary roadway by 15% and more as compared with the mine project can result in emergency situations.

With the aim to enhance coal mine safety and efficiency, rock bolting should be considered as the mine support system at the stage of mine project, and a new regulatory document should be developed to perform observation, monitoring and estimation of the condition of walls and support in temporary roadways.

According to the elaborated and approved regulations, the auditing of the conformity between the support designs and the support standards should be carried out at least once a year.

Key words: *coal mine, temporary roadway, rock bolting, visual observation, instrumental monitoring, temporary roadway condition estimation, System of anchors*

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Introduction

The present-day safety and efficiency of coal mines directly depends on the security of roadways. Total or partial loss of stability even in a small area of a roadway can result in an accident and considerable economic damage.

Widely applied rock bolting has enhanced safety of coal mining. However, accidents associated with instability of roadways yet happen. This is for the first turn connected with the neglect of the pre-estimated geomechanical behavior and variability of ground conditions within the mine life in the modern procedures for calculating rock bolting parameters in roadway support design charts [1–3]. In particular, a key regulatory document — rock bolting design and installation guidelines [4] — lacks predicted data on stress state of rocks based on preliminary modeling of geomechanical processes. The calculation procedures included in the guidelines [4] present stress concentration factors that offer no predictive estimate of rock mass condition as these factors are only valid for the specific and most hazardous areas in a roadway, while reinforcement and support standards may greatly vary along the roadway.

The problem is even more complicated by the inconsistency between the design and actual data on the adjacent rock mass, or by the total absence of the actual data.

Thus, it is required to introduce a new rock bolting design procedure and to develop a technology for rock bolt support and monitoring of roadways in order to reduce the risk of accidents.

As per Article 24 of the Law on Subsoil [5], construction and operation of mineral mines and different-purpose underground structures is only allowed given the safety of life and health of personnel and population in the influence zone of operations connected with the subsoil use.

The new regulatory documents worked out within the latest five years for the persistently deeper level mining of mineral reserves omit criteria to assess concordance of the support designs and support requirements in roadways of coal mines [6, 7].

It is noteworthy that the regulatory documents in force offer no clear regulations for the implementation and control over monitoring and estimation of the integrity of walls and support in roadways with the rock bolting [8, 9]. At the present time the monitoring and inspection of walls and support in roadways is carried out using procedures developed and approved at a regional level [10].

Moreover, the most efficient methods of the adjacent rock mass estimation in roadways using boreholes and video endoscopes with a view to having on-line prediction of rock mass condition are included in none of the effective regulatory documents.

This article describes the case studies of monitoring support condition and auditing the support design conformity with the specifications in terms of roadways in coal mines in Kuzbass.

Examination of roadway walls and rock bolting in longwall 42 in Berezovskaya Mine

By the time of the estimate, conveyor road 42 in Berezovskaya Mine was supported with steel-and-polymer rock bolts ASP20 (rows of 5 bolts 2.4 m long installed across the width of the roadway) with the lattice-like and mesh-like reinforcement by U-sections (No. 10). The roof of the roadway is additionally strengthened with the rope bolts AK01 6 m long installed pair-wise across the width with the separate backup plates 300×300×8 mm [11]. Rock bolts A20V with the strip base plates are driven in the roadway sides.

The observations revealed that the factual height of the roadway in the linear supported section changes from 2.42 to 2.89 m and the actual width — from 5.45 to 5.72 m. In the meanwhile the ground support standard for the roadway under examination states that the height from the side of the footwall is to be 2.1 m, the height from the side of the hanging wall — 3.2 m and the width — 5 m. Furthermore, the standard number of rock bolts to be installed in the roof rocks is 6 bolts per 1 row across the width.

Thus, the height of the roadway is reduced by 0.3 m as against the standard design, while the width is increased by 0.5 m.

The visual inspection of the walls and support in conveyor road 42 displayed local areas with minor events due to rock pressure along the supported section and roof rock falls from 0.2 to 0.4 m. At the intersection of the conveyor road and haulage ramp 4, roof rock fall to 1.3 m deep was detected.

Ventilation road 42 in Berezovskaya Mine by the time of the estimation had steel-and-polymer rock bolting ASP20 (4 bolts 2.4 m long per row across the width) in combination of lattice-like and mesh-like reinforcement by U-sections (No. 10).

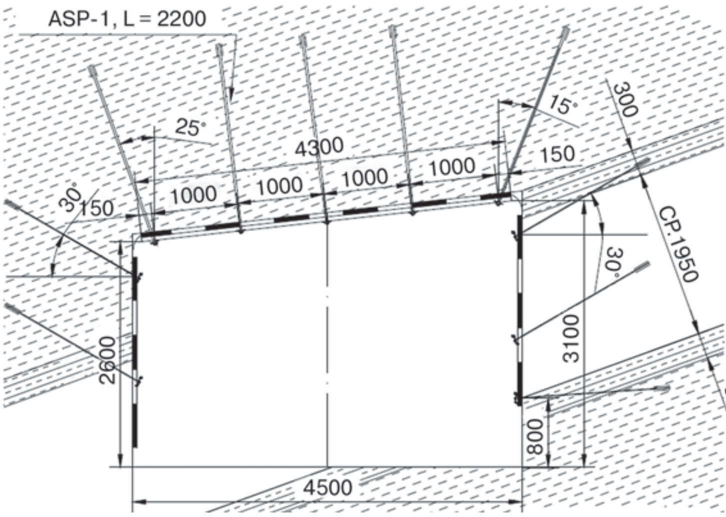

Fig. 1. Ground support standard for ventilation roadway 65, Pervomaiskaya Mine

It is found that the factual height in the linear supported section of the road changes from 2.27 to 3.35 m, the factual width — from 4.02 to 5.78 m and reaches 7.62 m in some areas of the roadway (intersections with manholes). As per the standard support design, the roadway should be 2.35 m high on the side of the footwall, 3 m high on the side of the hanging wall and 4 m wide. The ground support standard for ventilation road 42 provides installation of rock bolts 1.5 m long in the exposed areas of coal bed; in the meanwhile the inspection reveals the absence of reinforcement of the walls along the full length of the roadway. The permanent increase in the width of the roadway as against the ground support standard for the side walls can result in improper performance of the roadway.

Examination of roadway walls and rock bolting in air roadway 65 in Pervomaiskaya Mine

By the time of inspection, ventilation roadway 65 in Pervomaiskaya Mine was supported with the steel-and-polymer rock bolting and reinforced with the prop-and-bar system KMPT (at the junction with brattice 1897 all the way down to the mouth) and with the timber posts (a row on the side of the mined-out area). Across the width of the roadway, the primary support of 5 bolts A20V per row spaced at 0.9 m was added with the secondary meshing.

According to the observations, the factual height and width of the roadway in the linear supported section are 2.3 and 3.8 m, respectively. The support design standard sets the roadway height and width as 2.6–3.1 and 4.5 m, respectively (**Fig. 1**).

Along the observation path, the actual height is reduced upon the average by 0.55 m in some places as compared with the standard design values. The decrease in the width of the roadway reaches 0.7 m.

The visual inspection of the surfaces and support system in ventilation roadway 65 reveals local events due to rock pressure, roof rock falls make from 0.2 to 1.3 m.

In the roadway section 5 m long between the mouth and the junction with brattice 1697, there is a local roof rock fall to a depth of 1.3 m.

The ground support system in the roadway lacks points of continuous displacement control in the roof rocks, which is out of conformity with the regulatory documents.

Examination of conveyor road 560 in Chertinskaya-Koksovaya Mine

Conveyor road 560 is driven in seam 5 with a thickness of 1.94 m, in the influence zone of the residual abutment pressure caused by mining operations in adjacent longwall 561. The mining depth in the supported area is 560–590 m. The ground support standard design is shown in Fig. 2. Conveyor road 560 is secured with a yielding pillar 5–6 m wide on the side of longwall 561 and with a rigid pillar 52 m wide on the opposite side.

From the estimates of the walls and support conditions in conveyor road 560, the factual sizes of the roadway (height and width) disagree with the ground support standard. The actual width along the supported section of the roadway is 5 to 6.25 m, and the actual height in some places is 2.4 to 3.11 m. The actual support system falls short of the ground support standard (**Fig. 2**).

In the roadway, at a distance of 27 m from the junction with the cross with industrial furnace 2, swelling of rocks is detected in the floor with the visible fracture in the middle, the actual height of the roadway is 2.7 m in this area and 2.95 at the edge; the actual width of the roadway is 5.4 m.

In the roadway section 5 long from MT 9094 toward the face, floor swelling is observed in the center of the roadway, and the actual height is 2.4 m in this area and 2.7 m at the right-hand edge.

In the roadway section 5 m off the face, the actual width is 4.99 and the actual height is 3.1 m. The side walls are supported in accordance with the design standard with a lag to 7 m behind the face by bolts 2.8 m long.

The video monitoring of rock mass using holes drilled in the adjacent rocks from temporary roadways in longwall 561 shows that the increased damage zone may be 0.1 to 0. 5 m in size (**Fig. 3**).

From the evidence on roof rock state in Fig. 3, it is possible to draw a conclusion that the borehole monitoring using

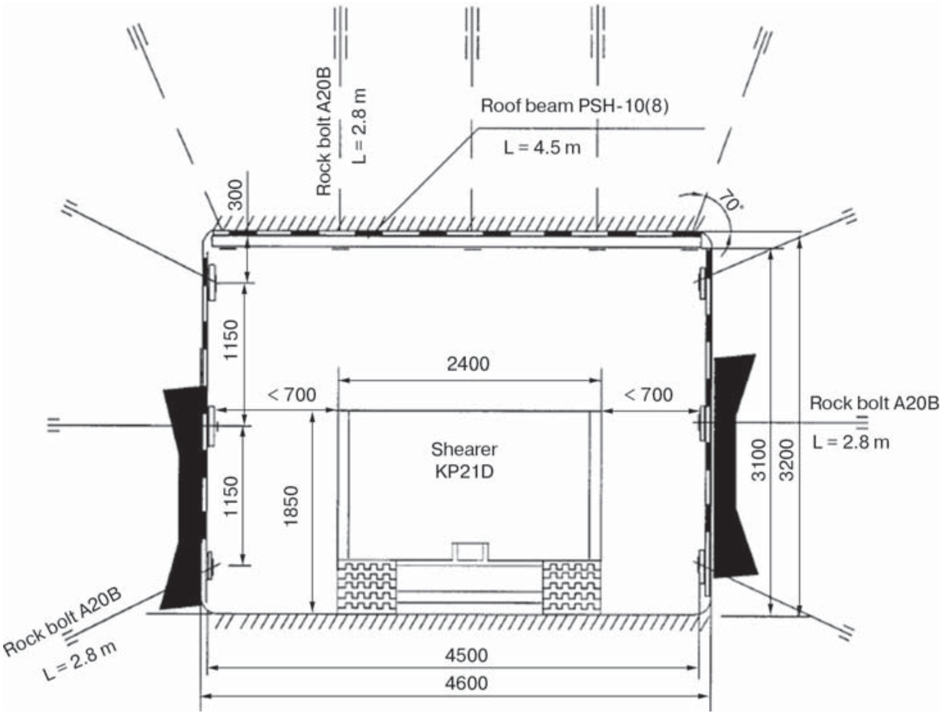

Fig. 2. Ground support standard for conveyor road 560, Chertinskaya-Koksovaya Mine

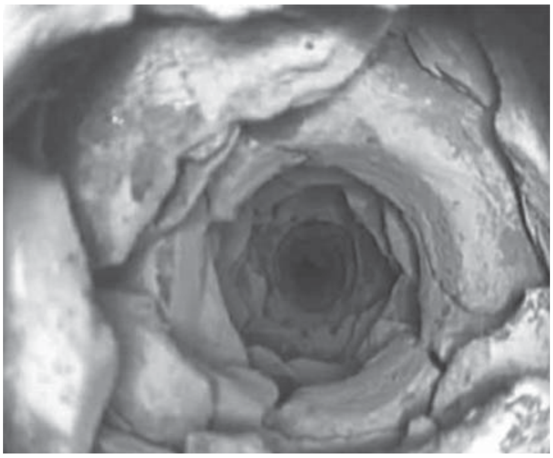

Fig. 3. Roof rock condition at a distance of 0.15 m from the boundary of conveyor road 561 in Chertinskaya-Koksovaya Mine

video endoscopes enables efficient diagnosis of the enclosing rock mass condition and the obtained information can be used in the justification of rock bolting support design [12, 13], or for the evaluation of the support design in temporary roadways at the stage of planning. Yet, the borehole videoimage endoscopy procedure is not included in the technical standard documentation.

On the whole, conveyor road 560 is estimated to be in proper condition.

Conclusions

Based on the analysis of the practical experience, monitoring data and compliance test results for ground support systems in coal mines and the requirements of the current regulatory documents, it can be concluded that:

1. One of the main factors that can cause instability in temporary roadways is the mismatch between the roadway design parameters (geometrical sizes of height and width), ground support standards (support spacing, density, etc.) and the actual data.

2. The practice shows that the increase in the width of a temporary roadway as against the design parameters by 15 % and more can result in emergencies or accidents and considerable material loss during the roadway operation.

3. The reduced support density and ill-timed reinforcement in wet stratifiable rocks in the abutment pressure zones also can end with an emergency situation.

4. Mine planning and ground support standard development aimed to improve stability of temporary roadways should consider a mine support System of anchors, composed of all level rock bolts and their elements (base plates, grouting methods and kinds) to be selected based on the predictive geomechanical modeling data and the instrumental borehole observations of the adjacent rock mass, and the secondary support represented by reinforcement meshing and lacing to secure strength of underground openings for the design life time [14].

5. The basic techniques of instrumental estimation and monitoring of walls and support conditions in temporary roadways aimed to ensure quality justification of rock bolting designs for stability of temporary roadways in operation and in project may be added with the method of borehole videoimage endoscopy.

6. The enhancement of safety and efficiency of coal mining needs a new regulatory document to rule the practice of observation, monitoring and estimation of the condition of walls and support systems in temporary roadways.

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STUDIES OF TOTAL HARMFUL GAS FLOWS ON THE GROUND SURFACE FROM SPONTANEOUS MINE FIRES IN KUZBASS*

The statistical analysis of air pollutant emission from stationary sources is carried out at large industrial centers in Kuzbass over the period from 2006 to 2015. The data on the active spontaneous fires in Kuzbass mines are reviewed. Emissions of harmful gases are studied using the land-based gas survey method. The total gas flow rate on the ground surface is evaluated. Based on the studies and calculations, the extra total toxic emission from active mine fires is determined.

Key words: *spontaneous fire, harmful gases, self-ignition processes, land-based gas survey, mined-out area, mine field, specific gas flow rate*
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Introduction

Practice shows that fires in mines are one of the main causes of accidents with casualties, material damage and environmental pollution. Among the mine fires, a special place belongs to spontaneous fires as a consequence of spontaneous ignition of coal accumulated in mined-out areas [1–3].

Spontaneous firing is sourced by coal accumulations and access of oxygen to oxidizing surface of broken coal. Coal accumulations may result from actual mining and form in coal bed damage areas. Rock pressure contributes to coal failure and accumulation at pillars left in mined-out areas. The outbreak and seats of such fires are difficult to reveal.

Underground fires greatly complicate production as fire fighting often ends with the loss of coal, roadways and expensive cutting-and-loading machinery. Spontaneous fires cause grave economic damage connected with fire extinguishing activities, reconstruction of damaged roadways and accident management.

Spontaneous firing is also accompanied by generation of large quantities of toxic gases propagating in mines and releasing from the ground surface. The gases releasing from the ground surface after spontaneous firing are mostly methane, carbon oxide, hydrogen, radon, etc. Around the combustion sources, moisture content of rocks drops, and convective air flows are formed, which contributes to the increase in dust escape in the atmosphere. The toxic gases and dust propagate over long distances from mining allotments and often at concentrations higher than maximum permissible limits set for the zones of working and residency [4, 5].

Such emissions are not always recordable. For example, mine accidents with fires and explosions result in major blowouts of toxic substances in the atmosphere. The suddenness of the events impedes the control and statistical recording of the blowouts. In the meanwhile, such blowouts are the considerable components in the general structure of the air pollutant emission.

The aim of this research is estimation of harmful gas flow rates from the ground surface above mines owing to spontaneous firing.

Theory

The issues of early detection of self-combustion have been studied by many researchers, in particular, by V. A. Skritsky, V. G. Igishev, N. I. Lindenau and V. A. Portol. The works [6–10] describe different methods to detect spontaneous fires at early stage. One of efficient self-combustion seat localization techniques is the control of tracer gases flowing from the ground surface [11–13]. Combustion gases (CH_4, CO, H_2) flow from mines and form a gas anomaly in the near-surface layer, this gas anomaly can be used in

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