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ORIGINAL PAPER

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USAGE OF CABLE BOLTS FOR GATEROAD MAINTENANCE IN SOFT ROCKS

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ABSTRACT

Purpose	This paper analyses the effectiveness of gateroad reinforcing by means of cable bolts under weak rock conditions. In the worldwide mining industry the method of gateroad support reinforcement using cable bolts is considered to be effective. The experimental application of cable bolts was performed in gateroad #165 of the "Stepova" mine, Western Donbass, Ukraine, and required instrumental control of "support-rock mass" system conditions.
Methods	Obtaining absolute displacement of "support-rock mass" system elements and extensometer anchors by means of levelling in order to improve the method of observation.
Results	The peculiarities of geomechanical behaviour of rock mass in the roof of gateroads is investigated. It has been established that the application of cable bolts allows for a reduction in the vertical convergence of the gateroad, both in front of and behind the longwall face.
Practical implications	Advantages of cable bolts instead of end-face support and props in case of a high advance rate of the longwall face are shown.
Originality/ value	1. There are no regulations and state standards in regard to cable bolt installation parameters in the mines of Ukraine, consequently the usage of cable bolts for gateroad maintenance required preliminary testing under geological conditions at the Western Donbass mines with soft enclosing rocks. 2. Combining levelling with observations using extensometers allowed for the detection of the rock layers' uniform sagging zone in the roof of the gateroad.

Keywords
gateroad, soft rock, cable bolt, vertical convergency, abutment pressure, levelling, multiple-position borehole extensometers

1. INTRODUCTION

The current economic environment which the coal industry of Ukraine is experiencing requires increasing volumes of production whilst reducing the operating costs of mines.

Issues arise in the gateroad contour longwall which provides ventilation and transportation of rock mass and materials. The excessive impact of abutment pressure manifestations on the support of gateroads leads to cross-section losses and to further reduction of coal mining efficiency. This is particularly evident in conditions of weak strata.

One example of the aforementioned condition is the geological condition of the Western Donbass coal mines. The mines are characterized by soft enclosing rocks (with a uniaxial compressive strength of less than 30 MPa), thin (0,6–1,2 m) lightly pitching coal ($\alpha < 5°$), and a depth of 200 m to 600 m. Coal extraction is carried out by longwall mining with caving.

According to Standart (2007), in soft rocks (UCS < 30 MPa), it is not recommended to maintain gateroads behind the longwall face. Nevertheless research was carried out for these conditions and technology for gateroad maintenance was developed under advance rates of the longwall face of up to 100 m/month (Instruktsiya, 1994, p. 2). Thus there is a plan that support of gateroad should be reinforced in the area of abutment pressure ahead of the longwall (area 1, Fig. 1), at the T-junction (area 2, Fig. 1) and behind the longwall face (area 3, Fig. 1).

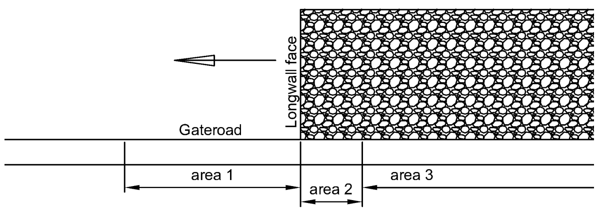

Fig. 1. Areas of longwall influence on the gateroad

The reinforcement of the gateroad support ahead of the longwall face (area 1) by means of props (wooden, hydraulic or friction) is recommended. The usage of face-end support is believed to mechanize the process of intersectional supporting (area 2), improve safety and productivity (Shirokov, Lider, & Petrov, 1987, pp. 4, 15). This type of "classic" system of gateroad support reinforcement in areas 1–2 is characteristic for the longwall mines of Ukraine (Fig. 2).

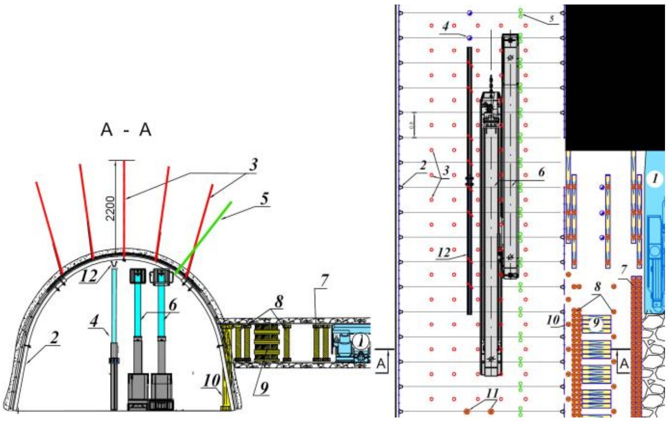

Fig. 2. The "classic" support and reinforcement pattern of the gateroad #163 at intersection with #161 longwall: 1 – longwall set of equipment; 2 – steel arch support KShPU-17,7; 3 – rock bolts; 4 – hydraulic props installed 20 m in front of the longwall face and under the horsehead; 5 – rock bolts connected to the top section of arch support; 6 – face-end supports; elements of roadside pack: 7 – breaker row; 8 – breaker props; 9 – chock; 10 – wooden prop between the roof of the seam and the floor of the gateroad; 11 – wooden props installed under each arch; 12 – steel horsehead

However, it is ineffective in cases of high advance rate of the longwall face (more than 100 m/month) because of the high labor input of the works, time spent on operations near the face-end, and the cluttering of the gateroad.

A system of gateroad support reinforcement by means of cable bolts installed before the beginning of abutment pressure influence in areas 1–2 is considered to be effective. This system excludes the usage of props in area 1 and face-end support at the intersection (area 2). Experience of cable bolts application has been accumulated abroad (Razumov, Grechishkin, Samok, & Pozolotin, 2011; Tadolini & McDonnell, 2010). There are no regulations and state standards with regard to the cable bolt installation parameters in Ukrainian mines. That is why, the usage of cable bolts required preliminary testing and geomechanical substantiation under the geological conditions that exist in the Western Donbass mines with rocks with a UCS of less than 25 MPa (Khalymendyk, 2011).

This article is dedicated to the effectiveness of the experimental method of gateroad #165 reinforcing at T-junction and in front of #163 longwall face at the "Stepova" mine, which included the application of cable bolts instead of face-end support and props.

2. GEOLOGICAL AND TECHNICAL CONDITIONS

The gateroad was driven from the roadways at a level of 300 m down the dip of the coal seam C_6 to a level of 490 m, with an average inclination of 4° (Fig. 3). Coal seam C_6 is fractured, simply structured and has no cohesion with the enclosing rocks. The extracting seam thickness is 1.04 m. Enclosing rocks are interstratified siltstones and mudstones with a UCS of up to 25 MPa and weak cohesion.

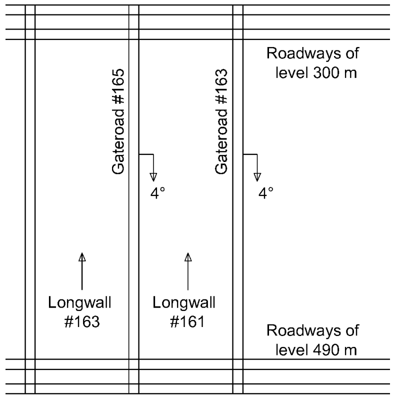

Fig. 3. Principle scheme of mine workings at C_6 seam

Gateroad #165 was arched with KShPU-17,7, with spacing 0,7 m (Fig. 4). The roof of the gateroad was bolted on the depth of 2.2 m with 5 bolts in a row. Load-bearing capacity of bolts was 275 kN, untensioned, resin-grouted using resin-cartridges of a total length of 1.5 m.

Maintenance of the gateroad #165 in the area of abutment pressure and at the intersection with the longwall (areas 1, 2, Fig. 1) was performed by two rows of cable bolts with a load bearing capacity of 210 kN (Fig. 4, No 4). The density of the cable bolt setup was 0.3 pcs/m^2.

Two wooden props were installed under each steel arch and a roadside pack was erected behind the face of the longwall (Fig. 4, No 7–11).

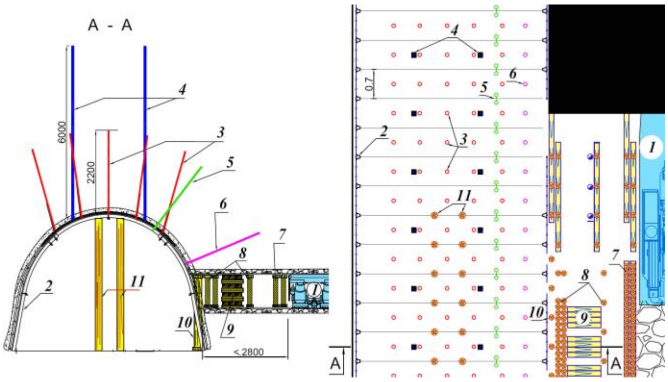

Fig. 4. Support and reinforcement pattern of the gateroad #165 at intersection with #163 longwall: 1 – longwall set of equipment; 2 – steel arch support KShPU-17,7; 3 – rock bolts; 4 – cable bolts, length 6.0 m, paired installation, spacing 1.4 m; 5 – rock bolts connected to the top section of arch support; 6 – rock bolt for strengthening of the roof above the roadside pack; elements of roadside pack: 7 – breaker row; 8 – breaker props; 9 – chock; 10 – wooden prop between roof of the seam and floor of the gateroad; 11 – wooden props installed under each steel arch

3. RESEARCH TECHNIQUE

The measurement of the deformation of the support elements and rock mass ("support-rock mass" system) i.e. roof, floor, rock layers in the roof, elements of arch support, are possible with the use of wall-embedded marks (Fig. 5) (Prusek, 2010; Metodicheskiye ukazaniya, 1973; Novikov & Shestopalov, 2012).