TWO CASE-STUDIES OF ROOF FALL ACCIDENTS IN COAL ROADWAY: OCCURRENCE MECHANICAL ANALYSIS IN PREVENTIVE MEASURES

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ABSTRACT

Two cases of coal roof fall accidents were described in this paper. Based on analysis of specific support modes and site observation, a mechanical model was set up to locate the causes of the accidents. Then the paper ends with enumeration of preventive measures.

Key words: coal roadways, roof fall accidents, mechanism analyses, mechanical model, preventive measures.

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INTRODUCTION

The yearly coal roadway engineering of our country is more than 10000 kilometers, which makes up of the main passage for underground digging, airiness and transport. Occurrence of roof accidents in coal roadway is common, even holding first in terms of both accident quantity and death number in the latest three years. However, it still hasn't got enough social concern for the lack of society –shocking bad accidents.

In the late of the 20th century, supporting manner of coal roadways began to transform from shelves-support to bolts-support. By far, supporting of most diggings has achieved by the latter, but security and reliability of which are still low. The 3~5% roof fall ratio per 10,000 meters and one death possibility every 30~50 thousands meters cast a big shadow upon collieries' safe production. Special attention should be paid to the fact that roof falls caused by bolts support and shelves support that have different characters. Failure of exact mastering of the disabling rule of bolts support may lead to eruptive and structure stability-losing malignant roof fall accidents.

TWO TYPICAL ROOF FALL ACCIDENTS IN COAL ROADWAYS

Whole collapse of the outer separation layer within bolts-hold region by bolt supporting

The said colliery's coal is 3.4 meters in thickness and its immediate roof is made up of 4.0-meter-thick sandy mud rock while the main roof is 2.5 –meter- thick moderate thin

sandstone. The roadway was driven along the immediate roof. As the roof in good condition, so the support used 2.5 meter-long bolts without anchors. Due to increase of the thickness of the immediate roof, outer part of the bolts-hold region appeared separation layer, and then the whole bolts-hold region collapsed with a bulk of $13\times4.8\times4.5m^3$. The distance between this region and the working face was only 10 meters apart, resulted in a one-death and two-casualties bad accident.

Whole collapse of the outer separation layer within anchors -hold region by combined supporting

Another said colliery dug the roadway along the goaf (with only 1.5 meters wide pillars reserved). Adopted support manner was as follows: the solid side with bolts support, the roof using bolts and anchors combined supports and the goaf side using the I–shaped steels only. Roof fall accident happened only after the roadway was dug about 100 meters long, then the outside of the anchors-hold region appeared separation layer, induced large roof area shearing, as a result, the whole anchors-hold region fell entirely with only a 1.0 meter-distance from the working face, caused 3 deaths in this malignant roof fall accidents.

THE MECHANISM AND ANALYSES BY MECHANICAL MODELS OF THE TWO ROOF FALL ACCIDENTS

The mechanism analyses of the locale observation

Accident one

The roof conditions changed suddenly, but there were no immediate observation and judgment, consequently the support parameters were not adjusted in time.

As to the first accident, if the roof conditions hadn't altered and kept fine all the time, the support manner of this roadway adopted might be ok. However, lack of effective ground pressure observation and no special man to judge abnormal changes such as distortion failed to make any support alteration to the transformed conditions. Then there was not any sign before the accident, and left no room for the workers to escape. From locale observation, separation layer only appeared outside of the bolts-hold region, and the bolts still worked well in the rock, which proved that the bolts had made some stated functions.

Accident two

The location of the roadway itself was unreasonable and the support was invalid actually, so caused the roadway roof to fall extensively.

Supports of coal roadways driven along the goaf always are taken seriously. Even by bolts support, reasonable width of the pillar should be reserved and support intensity should be strengthened, especially that of the goaf side[1]. Roadway location of the second accident was a big fault: the width of the pillar was too narrow thus providing no support force in deed; the workers could see even the bolts of the other side of the pillar. The support

manner of the goaf side also had obvious problem: due to the failure of adopting bolts supporting, I-shaped steels were used instead, whose support intensity was so bad that the pillar side was actually in zero- support state. There was no strange that the roadway roof was sheared and fell with large area at last.

Calculation analyses of the mechanical models

Beam model with both ends fixed

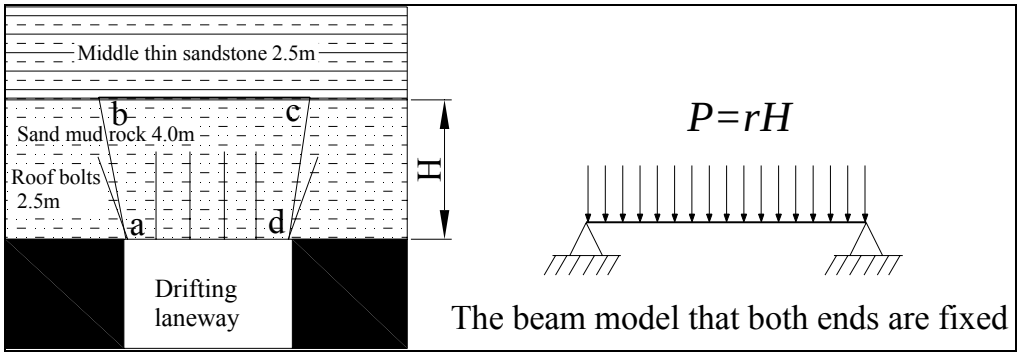

Figure 1.: The mechanics figure of the beam model that both ends are fixed of the first accident.

According to the support of the first accident, if the conditions were stable, the structure of the support manner could be abstracted as the beam model that both ends were fixed [2], as shown in figure 1. The thickness and intensity of the middle thin sandstone above the immediate roof were too high, so it could be seen as the key stratum [3], and the bolts-hold stratum of the bolts support formed as the beam model. If the pre-stress was very high [4], the support ability of the beam structure is F (which is the whole shear ability of the beam structure, MPa), and it could support the wall rock load of the immediate roof P;

$$P=\gamma H \qquad (1)$$

Where as: P stands for the load of wall rock, MPa,
γ means the weight of the rock, kN/m^3,
H implies the thickness of the immediate roof, m.

If the conditions of the roof were no variety, the whole bolts-hold region could support the wall rock stress of immediate roof (the locale did do this), it meant that F was bigger than P, so the roof would not have separation layer and fall, the above wall rock could be supported effectively. Nevertheless, as the thickness of the immediate roof of the locale became higher, i.e. H was bigger than before, the wall rock stress P also became bigger than before, but the bolts-hold region did not have change, and its ability F was not alter either, result in P was bigger than F, moreover no effective support structure to share the redundant stress (P-F), consequently the ABCD region in figure 1 total fell, the bad accident happened.

The cantilever beam model

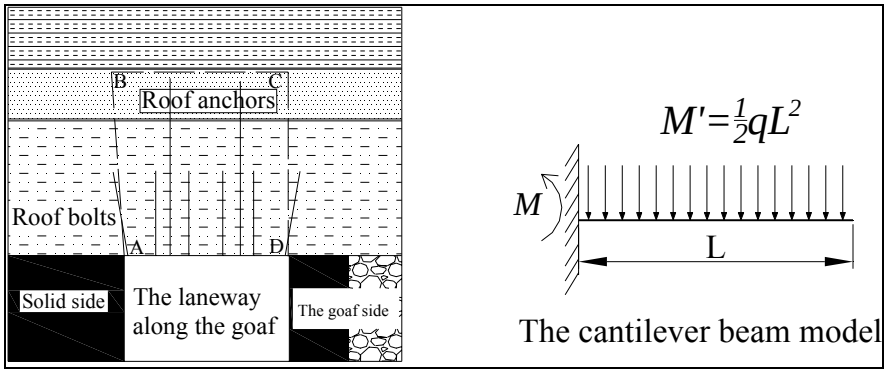

Figure 2.: The mechanics figure of the cantilever beam model of the second accident.

The mechanics model of the second accident could be abstracted as the cantilever beam model [2], which the entity side be treated as the beam's fixed end, and as the goaf side basically in the no support state, so the support structure formed by roof bolts and anchors as the beam liberty end, therefore, the roof shaped the cantilever beam model, as shown in figure 2. It is very difficult to absolutely fix the cantilever beam, that is to say, the beam and the fixed end both have very high toughness, in fact, it is unpractical, even though the toughness is too high, if the moment of loading is a bit higher, the beam would have some movement, and the whole beam will unstable, at last the beam can curve and destroy easily. The moment of the fixed end of beam is M (the highest moment of the cantilever to resist the curve and destroy, kN·m), the moment of roof action on the fixed end is M′,

$$M' = \frac{1}{2} qL^2 \tag{2}$$

Where as: M′ stands for the moment of the equal load formed, kN·m,
q means the equal load on the cantilever beam, kN/m,
L implies the length of the cantilever beam, m.

If the cantilever beam could keep stable, the moment M must be bigger than M′,or else, the cantilever beam would bend and then destroy. After had drifted about 100 meters, outside of the anchors-hold region of the locale roof appeared whole separation layer, however, the goaf side did not have the support ability, so all the load had to be supported by the fixed end of the cantilever beam, when M′was bigger than M, the cantilever beam totally destroyed, so the ABCD region in figure 2 fell wholly, the evil roof fall accident of large area happened in the end.

THE ANALYZED CONCLUSION OF THE TWO ROOF FALL ACCIDENTS

The reasons for the accidents of the two roadways in this paper are all due to rock mass layers detached outside of the anchors-hold regions, the first one is for the outside the bolts-hold region, and the second one for the outside the bolts-anchors-hold region. If the

effective schemes had been actualized then to the two roadways, the roof fall accidents could be avoided absolutely.

(1) The first accident could be refrained successfully if only the workers of that roadway had a clear cognition and determinant to the changed instance of lithology of the roof, and immediately installed some long cables or anchors as the supplied measure in the appropriate position of the roof.
(2) If the design of the second accident had been more perfected and improved, and the intension of goaf side and the whole supports structure were strengthened or the supports were more contraposed, the tragedy would never happen.

PREVENTIVE MEASURES TO ROOF FALL ACCIDENTS IN COAL ROADWAYS [5] [6]

The geological conditions of all the collieries are various and in rapid change, so bolt supporting cannot go for all situations, accessorial supports should be applied to ration the supporting under especially complicated conditions.

(1) Close attention must be paid to any change of the roof, including the lithology, thickness, changing causations and etc.
(2) Immediate correlative measures should be taken to deal with the changes, e.g. intensifying length and density of the bolts and anchors, mending some pillars or spanning steel shelves.
(3) Once any following exceptional instances occur, performing of bolting should be paused to check the reasons: coal-explosion, evident increase of deformation on top-bottom and two sides, violent floor heave, watering roof , more wall rock cranny, abrupt slicing off the two sides, unusual drilling speed and etc.

As a safety issue, the support design must be strict and perfect as possible. Above all, the quality of the working managers is of vital importance. They should be trained to deal with the special conditions in good time and availably. Safety first, speed and benefits second, this is the unchanging rule of supporting.

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