10.18686/frim.v2i3.4236

Study on Classification of Close Coal Seams in Hebao Mining Area Based on Layer Spacing

Huiyu Guo

Taian Coal Mine of Jinneng Holding Coal Industry Group, Shanxi, Baode, 036600

Abstract: In order to understand the situation of close coal seam in Baode mining area of Hequ, it is convenient to form the surrounding rock control technology of roadway in close coal seam. Aiming at the inner staggered roadway under the goaf in Hebao mining area, a mechanical model is established, the influence of layer spacing on the inner staggered roadway is analyzed, and a short-distance coal seam classification method based on layer spacing is proposed. The results show that the close distance coal seams in Hebao mining area can be divided into three categories: 0-2m is the close distance coal seam with very small spacing, 2-6m is the close distance coal seam with small spacing, and more than 6m is the close distance coal seam with large spacing.

Keywords: Close coal seam; Layer spacing; Inner alternated roadway; Coal seam classification

Close-distance coal seam mining will encounter [1-4] in many mining areas, and a unified classification method of close-distance coal seam has not yet been formed. Chinese scholars have done a lot of work in close-distance coal seam classification [5-9]. Huang Qingxiang et al. [10] classified the short-distance coal seams into three categories, namely, extremely short-distance coal seams, single-key-layer short-distance coal seams and double-key-layer short-distance coal seams, according to whether the interval between layers can form a key seam in the mining process of the lower coal seam working face. The main coal seams in Hebao mining area are 8# upper layer, 8#, 9#, 10#, 11#, 12# and 13#, etc., which are close-distance coal seams with unequal spacing, and lack of mature close-distance coal seam mining classification methods with similar conditions that can be directly used for reference. Therefore, from the point of view of roadway support, according to the roof deformation and support characteristics of staggered roadway under different interlayer spacing, this paper puts forward a classification method of short-distance coal seams based on interlayer spacing.

1. Engineering mechanics analysis

1.1 Engineering overview

Mining 8# upper coal seam in 18205 working face of Shaping Coal Industry is arranged according to two return air roadway s and one air inlet roadway. Among them, 18205 auxiliary haulage is left as 18207 return air roadway, the net coal pillar between 18205 belt and auxiliary haulage is 20 m, the maximum buried depth of 18205 working face is 180 m, and the width of 18205 working face is 310 m. 8# on the coal seam thickness of 3.5 m or so. The distance between 8# upper layer and 8# lower layer is about 4 m.

The thickness of 11# coal seam in 11102 working face of Taian Coal Industry is 1.43-2.2 m, and the lower spacing of 11102 transportation gateway is 0.75-5.2 m. 12# upper coal seam thickness is 2-2.75 m, 11102 return air gateway lower spacing is 3-13 m, and 12# coal seam thickness is 4.2-5 m.

1.2 Mechanical model of roadway

When the roadway in the lower coal seam is arranged under the stable goaf, the force exerted by the goaf in the upper coal seam on the interlayer strata can be regarded as uniform load. When the roadway in the lower coal seam is staggered, the mechanical model of the roadway in the lower coal seam can be simplified as shown in Figure 1.

By further analysis of the stress and deformation of the roof, the roof can be simplified as a simply supported beam model, with both ends simply supported and the upper part uniformly loaded, and the deflection in the middle part is,

$$W_{\max} = \frac{5qb^4}{384EI} \tag{1}$$

Where, W_{max} is the maximum deflection. q is uniformly distributed load. E is elastic modulus. I is the moment of inertia of the section, $I = \frac{ah_0^3}{12}$. b is the roadway width. a is the unit length of roof. h_0 is the interlayer rock thickness.

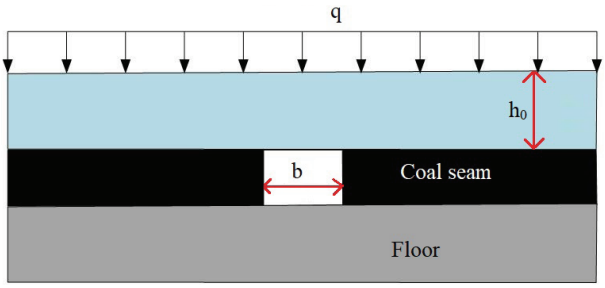


Fig1. Mechanical model of lower coal seam roadway with internal dislocation arrangement

2. Influencing factors of roadway deformation

2.1 Inner staggered roadway under goaf in Shaping coal industry

Using numerical simulation, the subsidence of roadway roof and the approach of two sides are analyzed under the conditions of different layer spacing. Taking the staggered layout under 18205 goaf in Shaping Coal Industry as an example, the subsidence of roadway roof and the approach of two sides are analyzed when the interlayer spacing is 2 m, 4 m, 6 m, 8 m, 12 m and 16 m respectively. The roadway support method is bolt and anchor cable support, with only bolt when the interlayer spacing is 2 m, anchor cable length 4 m when 4 m, and anchor cable length 6 m when the interlayer spacing is more than 6 m. Fig. 2 and fig. 3 are cloud pictures of vertical displacement and horizontal displacement of roadway under different interlayer spacing conditions respectively, and Table 1 is statistical table of roadway deformation under different interlayer spacing conditions.

(a) Layer spacing 2 m

(b) Layer spacing 4 m

(c) Layer spacing 6 m

(d) Layer spacing 8 m

(e) Layer spacing 12 m

(f) Layer spacing 16 m

Fig. 2 Nephogram of vertical displacement of roadway in lower coal seam with different interlayer spacing

(a) Layer spacing 2 m

(b) Layer spacing 4 m

(c) Layer spacing 6 m

(d) Layer spacing 8 m

(e) Layer spacing 12 m

(f) Layer spacing 16 m

Fig. 3 Nephogram of horizontal displacement of roadway in lower coal seam with different interlayer spacing

Table 1 Statistics of deformation of roadway in lower coal seam with different interlayer spacing

Layer spacing/m	2	4	6	8	12	16
Roof subsidence/mm	97	41	35	32	30	29
Displacement of two sides/mm	23	20	18	17	16	16

From Figure 2, Figure 3 and Table 1, it can be seen that in a certain range, with the gradual increase of interlayer spacing, the roof subsidence of the lower coal seam roadway gradually decreases, and the reduction amplitude first increases and then decreases. The approach of the two sides of the roadway decreases gradually, and the deformation reaches the minimum when the interlayer spacing is 16 m. From the simulation results, it can be seen that the roof subsidence decreases greatly when the interlayer spacing increases from 2 m to 4 m, and the roof subsidence changes little when it is greater than 4 m. It can be seen that the thickness of interlayer spacing plays a key role in roof deformation of staggered roadway.

2.2 Inner staggered roadway under goaf in Taian coal industry

Taking the staggered layout under the 11102 goaf of Taian Coal Industry as an example, the deformation and failure characteristics of the roadway roof in the lower coal seam are analyzed when the interlayer spacing is 2 m, 4 m, 6 m and 8 m respectively.

When the spacing between 11# coal seam and 12# coal seam is 2 m, 4 m, 6 m and 8 m in turn, after the excavation of 11# coal face, the roof deformation nephogram and plastic zone distribution map of the lower coal seam roadway are obtained, as shown in Figures 4 and 5 respectively. Table 2 is the statistical table of roof subsidence of roadway in lower coal seam with different interlayer spacing.

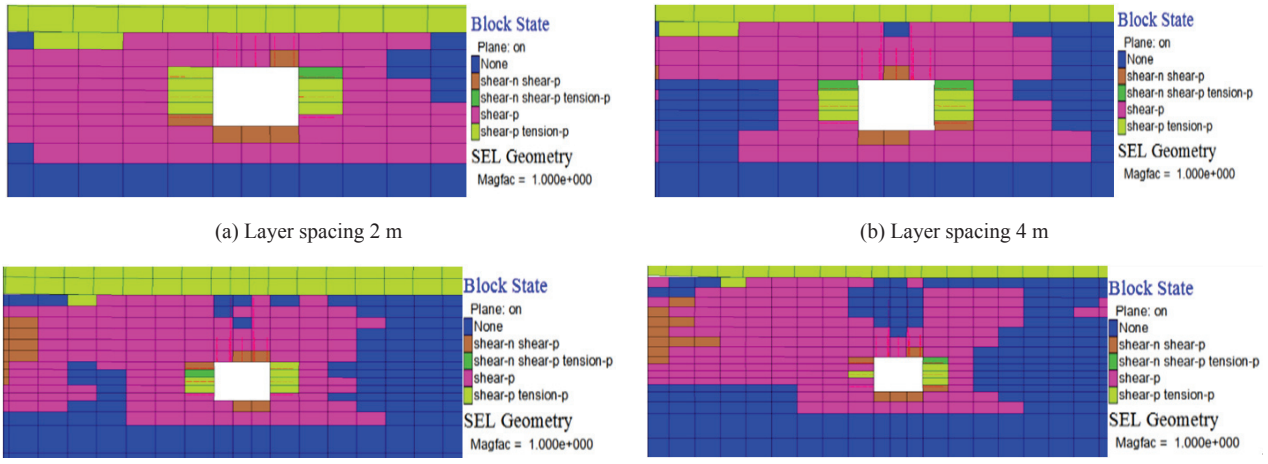
(a) Layer spacing 2 m

(b) Layer spacing 4 m

(c) Layer spacing 6 m

(d) Layer spacing 8 m

Fig. 4 Nephogram of roof deformation of roadway in lower coal seam with different interlayer spacing



(a) Layer spacing 2 m

(b) Layer spacing 4 m

(c) Layer spacing 6 m

(d) Layer spacing 8 m

Fig. 5 Distribution map of plastic zone of roadway roof in lower coal seam with different interlayer spacing

Table 2 Roof Subsidence of Roadway in Lower Coal Seam with Different Layer Spacing

Layer spacing/m	2	4	6	8
Roof subsidence/mm	186	131	127	125

From Figure 4 and Table 2, it can be seen that after the excavation of No.11 coal face, the roof subsidence of the roadway in the lower coal seam shows a decreasing trend with the gradual increase of the spacing between No.11 coal seam and No.12 coal seam within a certain range of interlayer spacing, reaching a maximum of 186 mm when the interlayer spacing is 2 m, and the roof subsidence decreases rapidly after the interlayer spacing is greater than 2 m, and with the further increase of interlayer spacing, the roof subsidence changes little.

From the analysis of Figure 5, it can be seen that after the excavation of 11# coal face, within a certain interval, with the increasing interval between 11# coal and 12# coal seam, the plastic zone of the roadway roof in the lower coal seam gradually decreases. When the interval is less than 6 m, the damage depth of the roadway roof directly penetrates into the goaf in the upper coal seam. It can be seen that the more the interval is, the more serious the roadway roof damage is, and the smaller the damage degree of surrounding rock in the roadway roof is.

Like the staggered roadway under the 18205 goaf of Shaping Coal Industry, the roof subsidence of the staggered roadway under the 11102 goaf of Taian Coal Industry is also directly related to the interlayer spacing. When the interlayer spacing is increased from 2m to 4m, the roof subsidence is greatly reduced, but it does not change much when it is more than 4m. The difference is that because the buried depth of Taian coal industry is greater than that of Shaping coal industry, its roof separation value is also greater than Shaping coal industry.

3. Close-range coal seam classification

The stress state, roof subsidence and deformation of two sides of roadway in close distance coal seam are obviously related to the interlayer spacing, especially the roof support mode of inner alternated roadway is directly related to the interlayer spacing. According to the previous analysis, combined with the choice of roadway support methods at different layer spacing, a classification method of close-range coal seams based on roadway support is proposed, which divides close-range coal seams into three categories, with minimum spacing of 0-2m, small spacing of 2-6 m and large spacing above 6 m.

(1) When the interval between layers is 0-2 m, it is a short-distance coal seam with minimal interval. When an internal dislocation layout is adopted, the thickness of the roof is small, so it is impossible to construct the anchor cable, and the roof is broken after mining, so the stability is poor, and the roadway support is mainly auxiliary support.

(2) When the layer spacing is 2-6 m, it is a short-distance coal seam with small spacing. When an internal dislocation layout is adopted, the roof stability is obviously improved when it is increased from 2 to 4 m. In this type, the anchor can be constructed normally, and different lengths of anchor cables can be selected, but the anchoring force is still difficult to ensure, and passive support methods such as scaffolding are still needed when the roof stability is difficult to determine.

(3) When the interlayer spacing is greater than 6 m, it is a large-spacing close-distance coal seam; Under this condition, the internal dislocation layout is generally selected. When an internal dislocation layout is adopted, the stress under the goaf is obviously reduced, and the

roof stability is better when the interlayer spacing is large, and the anchor bolts and cables can be constructed normally, which can ensure the roof stability.

4. Conclusions

In this paper, by establishing the mechanical model and numerical simulation method of the inner alternated roadway, the influence of the interlayer spacing between two groups of typical short-distance coal seams in Hebao mining area on the inner alternated roadway is studied, and the classification method of short-distance coal seams based on interlayer spacing is put forward, and the conclusions are as follows:

(1) The roof subsidence of the inner alternated roadway under the goaf of Shaping Coal Industry and Taian Coal Industry is directly related to the layer spacing. When the layer spacing increases from 2 to 4 m, the roof subsidence decreases significantly. When the layer spacing is greater than 4 m, the roof subsidence changes little. The roof separation value of the inner alternated roadway under the goaf of Taian Coal Industry is greater than the roof separation value of the inner alternated roadway under the goaf of Shaping Coal Industry.

(2) The interval between layers is 0-2 m, which is the minimum interval close-range coal seam, the interval between layers is 2-6 m, which is the small interval close-range coal seam, and the interval between layers is more than 6m, which is the large interval close-range coal seam.

(3) Auxiliary support is the main support for inner alternated roadway in extremely short-distance coal seam. While constructing anchor cable, passive support methods such as building shed should be adopted for inner alternated roadway in small-distance coal seam. Anchor cable is the main support for inner alternated roadway in large-distance coal seam.

References

[1] Han Shuaijie. Study on Reasonable Layout of Mining Roadway under Goaf of Close Distance Coal Seam Group[J]. Coal Mine Modernization, 2022, 31(02): 1-5.

[2] Teng Fei, Yu Minggao, Han Xuefeng, et al. Study on the mechanism of coal pillar breaking and fracture development under repeated mining in a close seam group[J]. Frontiers in Earth Science, 2023.

[3] Xie Shengrong, Wu Xiaoyu, Chen Dongdong, et al. Failure Mechanism and Control Technology of Thick and Soft Coal Fully Mechanized Caving Roadway under Double Gobs in Close Coal Seams[J]. Shock and Vibration, 2020, 2020.

[4] Wei Zhang, Zhang Dongsheng, Qi Dahong, et al. Floor failure depth of upper coal seam during close coal seams mining and its novel detection method[J]. Energy Exploration & Exploitation, 2018, 36(5): 1265-1278.

[5] Li Xiang. The study of reasonable location of mining roadway in close coal seam[J]. Coal Mine Modernization, 2018, (06): 4-6.

[6] Li Xiaobin, He Fulian, Qin Binbin, et al. Study on classification and support of surrounding rock of mining roadway in extremely close coal seams[J]. Journal of Mining Science and Technology, 2020, 5(03): 325-333.

[7] Hao Binbin, Wang Chunhong. Study on stability classification of coal seam roof in close distance[J]. Coal and Chemical Industry, 2017, 40(01): 21-25, 29.

[8] Zhang Tao, Hao Bingyuan, Qian Hanfei. Classification of surrounding rock stability of coal roadway based on fuzzy clustering comprehensive analysis[J]. China Mining Magazine, 2020, 29(04): 116-119, 125.

[9] Chen Yanjun. Study on the Surrounding Rock Classification and Control Model of Ultra- close Thin Coal Seam [J]. Technology Wind, 2011(12): 106.

[10] Huang Qingxiang, Cao Jian, He Yanpeng, et al. Classification of shallow buried close seams group and support resistance determination [J]. Journal of Mining & Safety Engineering, 2018, 35(06): 1177-1184.