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Research on Active-passive Joint Support Technology for the Roadway of Thick Coal Seam Mining

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ABSTRACT

The lower trench of 2301 working face of Anyang Main Coking Coal Mine has the problems of large deformation of surrounding rock and high difficulty of maintenance in the process of digging. According to the deformation characteristics of the surrounding rock, a "U-type steel + anchor cable" joint support technology is proposed to control the deformation. In this paper, the main parameters of joint support are studied through numerical simulation, and the effect of perimeter rock control is verified through on-site monitoring. The results show that: within a reasonable range of preload force, the larger the preload force of the anchor cable, the better the effect of controlling the deformation of the surrounding rock; when the bracket row spacing is 600-800mm, the stability of the surrounding rock of the roadway can be ensured; during the roadway excavation, the maximum deformation of the surrounding rock is 40mm, which realizes the control of the stability of the surrounding rock in the roadway of the top coal of the soft and thick coal seam.

KEYWORDS

Thick Seam Roadway, Joint Support, Numerical Simulation, On-Site Monitoring.

1. INTRODUCTION

In recent years, the roadway support technology is centered on active enhancement of the peripheral rock's own bearing capacity, however, when the single active support can not effectively control the large deformation of the roadway peripheral rock, the combination of active and passive support support form combines the advantages of the two forms of support, and plays an important role in controlling the large deformation of the peripheral rock. Qing Shui Li et al [1] based on the analysis of the damage causes of weak and crushed perimeter rock roadway, used high strength steel combined with spray grouting technology to carry out repair and support of weak and crushed perimeter rock roadway, and achieved good results. Zhang Nong et al [2] put forward the support strategy which is mainly based on the active support of anchor rods, anchor cables and grouting, and supplemented by the supplementary support of U-type steel arches. Steel pipe concrete support is a new type of support with strong bearing capacity, low cost, various specifications, and can adapt to a variety of geological conditions [3]. Gao Yanfa et al [4] developed steel pipe concrete supports for mining, which accelerated the promotion and application of steel pipe concrete supports in various types of roadways in coal mines. Xia Fangqian et al [5] studied the role mechanism of flexural reinforcement from theory and indoor experiments to address the problem, and pointed out that improving flexural stiffness is the fundamental way to control the bending deformation of steel pipe concrete. Wang Peng et al[6] proposed the active-passive joint support technology of "I-beam shed + anchor cable + shotcrete + submerged low-pressure grouting" with the engineering background of multi-layer mining of extra-thick coal seams. Zuo Jianping et al [7, 8] used active support such as anchor rods (ropes) to control the deformation of the surrounding rock and enhance the bearing capacity of the surrounding rock, and at the same time, used U-beam steel, steel pipe concrete and other passive support modes with high support resistance, forming a combination of active and passive, all-space synergistic and highly efficient control process.

2. ENGINEERING BACKGROUND

2301 working face lower tunnels, floor elevation of -345m ~ -390m, total footage of 700m, the roadway along the bottom of the coal seam digging, the roadway along the direction of the average inclination of 4 °, the thickness of the top coal 0m ~ 3.8m, the average thickness of 2.0m, the shape of the roadway cross-section for the straight wall semicircular arched, the form of support for the "U-beam steel + anchor rope The support form is "U-beam + anchor cable" joint support, U-beam openings, anchor cable through the U-beam, in the anchor cable through the U-beam part of the injection of concrete. The design of the roadway support program is shown in Figure 1.

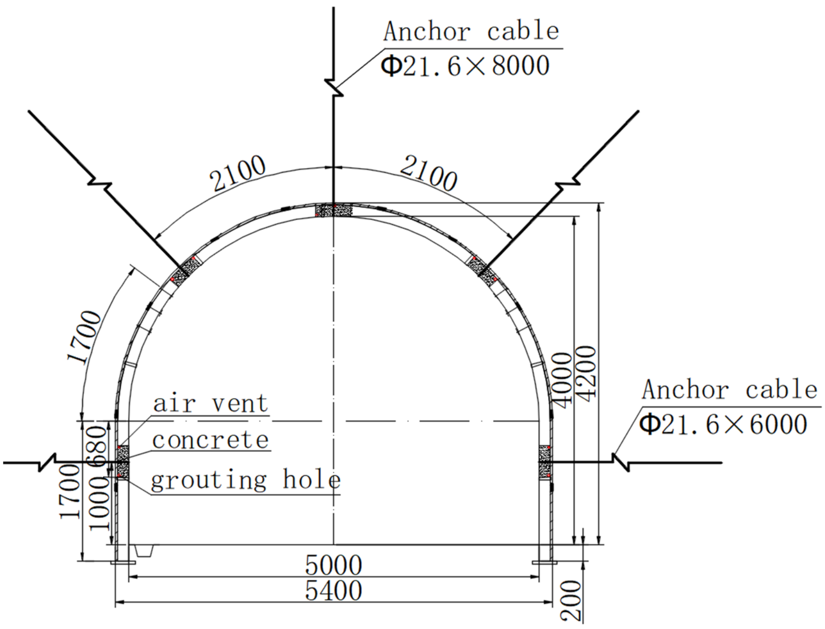
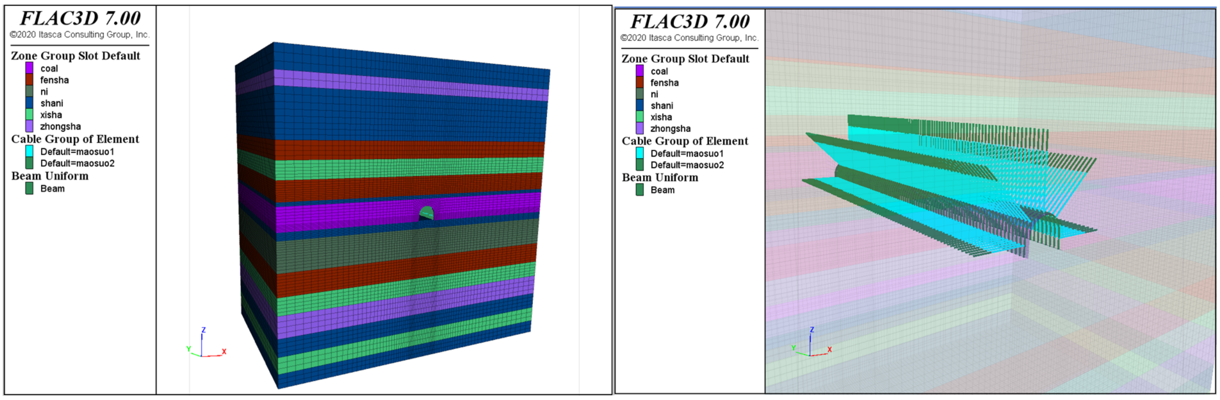


Figure 1. Roadway support section

3. NUMERICAL SIMULATION STUDY ON KEY SUPPORT PARAMETERS OF ROADWAY

The 3D model is built with Flac3D, and the numerical model size is: 100m×50×100mm (length×width×height), and the numerical model diagram is shown in Fig. 2. Normal displacement constraints are applied to all the boundaries of the model in the horizontal direction, and fixed constraints are applied to the lower boundaries of the model.

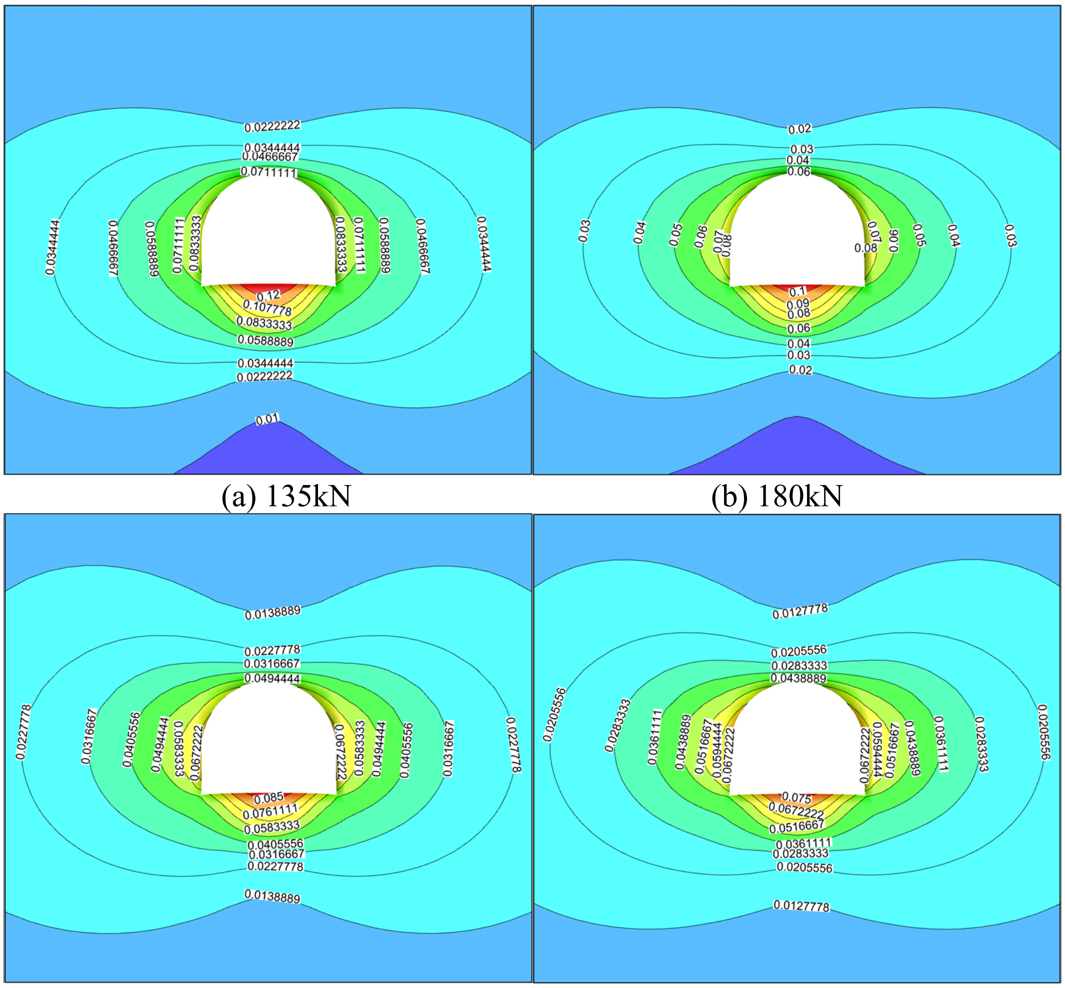


(a) numerical model (b) Support structure diagram

Figure 2. Numerical simulation model of initial support stress field

3.1. Effect of anchor cable preload on perimeter rock deformation

The perimeter rock deformation was simulated when the bracket row spacing was 800mm and the anchor cable preload was 135kN, 180kN, 225kN and 270kN, and the resultant perimeter rock displacement cloud diagrams for each scenario are shown in Fig. 3.



(a) 135kN (b) 180kN

(c) 225kN (d) 270kN

Figure 3. Displacement cloud of different preload anchor cable supported roadway (m)

Taking the deformation of the roadway when the preload force is 135kN as a reference, when the preload force is 180kN, the deformation of the roadway top plate, gang part and bottom plate is reduced by 15%, 3.6% and 20% respectively, with the increase of preload force, the deformation of the roadway peripheral rock is reduced continuously, and finally when the preload force is 270kN, the maximum displacement of the roadway top plate, gang part and bottom plate is reduced by 38%, 16% and 60%, respectively, comparing with that of the initial 135kN. The maximum displacement of the tunnel roof, gang and bottom plate were reduced by 38%, 16% and 60% respectively compared with the initial 135kN, indicating that increasing the preload force of the anchor cable within the range of reasonable preload force of the anchor cable is effective in controlling the deformation of the roadway perimeter rock.

The relationship curve between the maximum deformation of each part of the perimeter rock of the tunnel with different preload force and the preload force is shown in Fig. 4. From the figure, it can be seen that the pre-tensioning force on the deformation of the roadway perimeter rock control effect in the pre-tensioning force is relatively low when the effect is more obvious, with the increase of the pre-tensioning force, its role in the control of the perimeter rock to enhance the gradual decrease, that is, by adjusting the pre-tensioning force of the active support in the form of the control of the perimeter rock is not desirable.

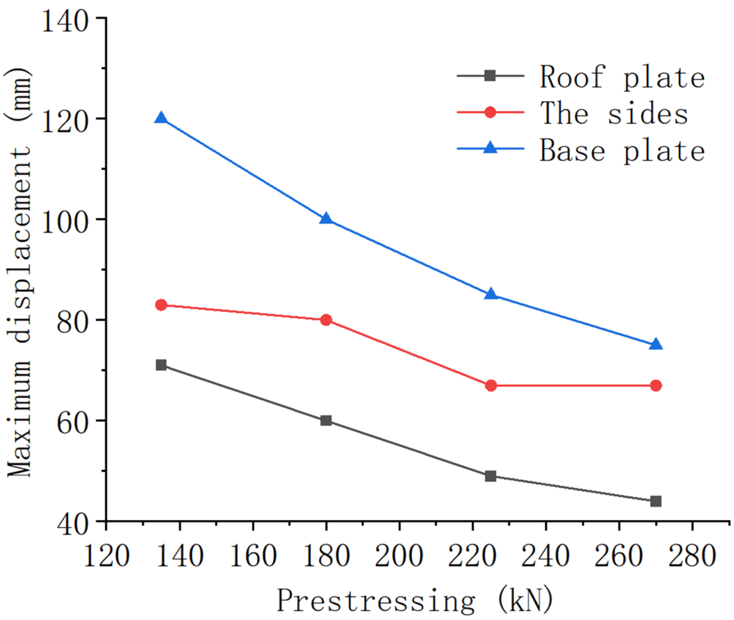
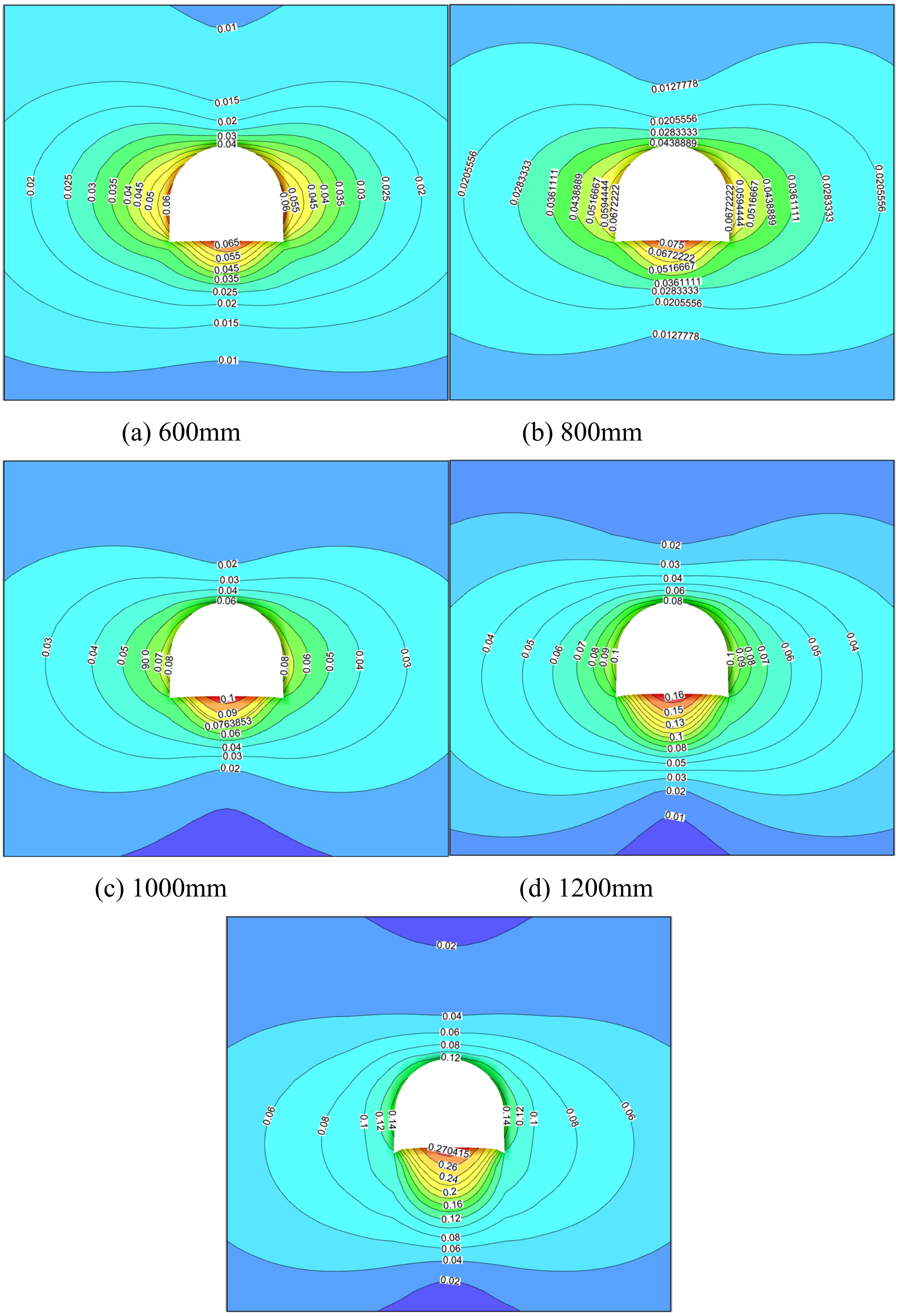


Figure 4. Relationship curve between deformation amount of roadway surrounding rock and preload force

3.2. Effect of brace row spacing on envelope deformation

Different row spacing of the roadway perimeter rock support scheme is simulated, bracket row spacing simulation scheme for 600mm, 800mm, 1000mm, 1200mm and 1400mm, the anchor cable pre-tensioning force are 270kN.

The displacements of the perimeter rock of the roadway with different bracket spacing are shown in Fig. 5.



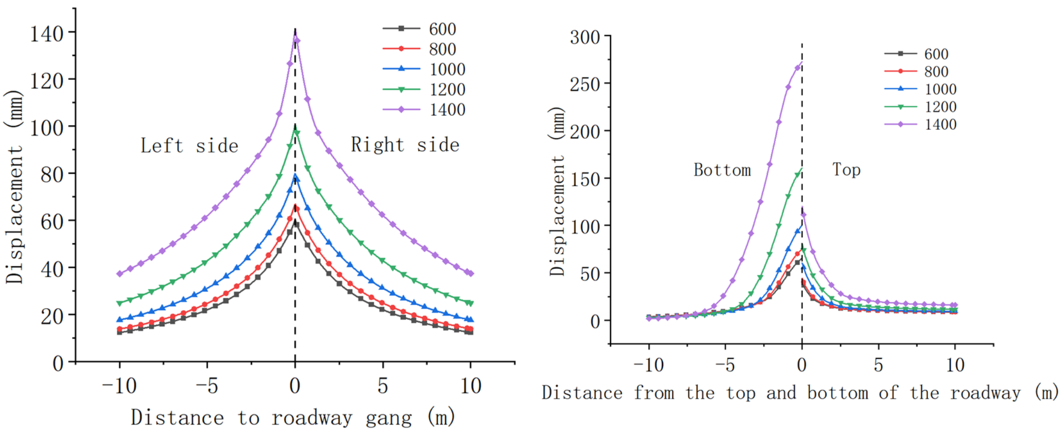
(a) 600mm (b) 800mm

(c) 1000mm (d) 1200mm

(e) 1400mm

Figure 5. Displacement distribution of different bracket row spacing (m)

The relationship curve of the displacement distribution of the two gangs and the top and bottom plates of the roadway perimeter rock at different depths with the distance between the rows of braces is shown in Fig. 6, with the increase of the depth of the perimeter rock, the displacement of each part decreases gradually, and the displacement achieves the maximum value on the surface of the roadway, and the deformation of the perimeter rock increases significantly with the increase of the distance between the rows of braces.



(a) The two sides (b) Top and bottom roof

Figure 6. Curve of displacement of surrounding rock at different depths versus brace row spacing

The maximum deformation of each part of the roadway rock with different bracket spacing is shown in Fig. 7. From the figure, it can be seen that with the increase of brace spacing, the deformation of each part of the roadway peripheral rock increases, in which the bottom plate is not supported, the deformation of the most obvious growth momentum, compared with the brace spacing of 600mm, 800mm, 1000mm, 1200mm, 1400mm corresponding to the displacement of the roadway roof increased by 8%, 50%, 100%, 200%, respectively, and the displacement of gang part increased by 12%, 33%, 67%, 133%, respectively, and the bottom plate deformation increased by 25%, 67%, 133%, respectively. increased by 12%, 33%, 67%, 133%, and bottom plate deformation increased by 25%, 67%, 167%, 350%, respectively.

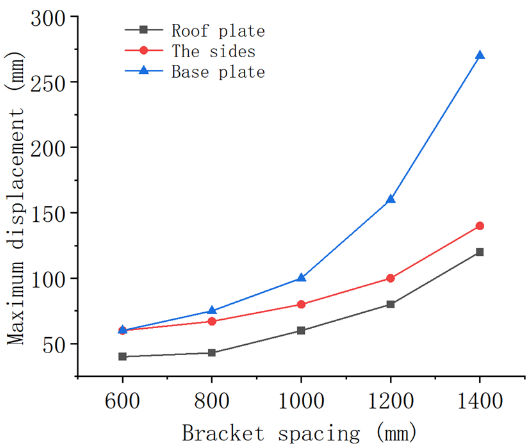


Figure 7. Curve of the relationship between the deformation amount of the roadway perimeter rock and the distance between the rows of braces

The finalized key support parameters of the roadway are: anchor cable pre-tensioning force of 270kN, bracket row spacing of 800mm.

4. ON-SITE MONITORING OF ROADWAY DEFORMATION

The surface displacement of the roadway is recorded by the cross-point method, in the location of the measuring point perpendicular to the direction of the roadway perimeter rock to the interior of the perimeter rock to drill holes with a diameter of 20mm and a depth of 300mm, and then to the drilling hole to hit a stake, the size of the stake for the diameter of 21mm, the length of 300mm. testing method: pull the measuring rope tightly between the C, D, and use a steel tape measure to read out the distance between the A, B points and the measuring rope, the same way to measure the displacement of the C, D, pulling the measuring rope between A, B and use a tape measure to measure the C and D displacement. Similarly, when measuring the displacement of C and D, pull the measuring rope between A and B, and measure the displacement of C and D with a tape measure. The layout of the measuring points of the station is shown in Figure 8.

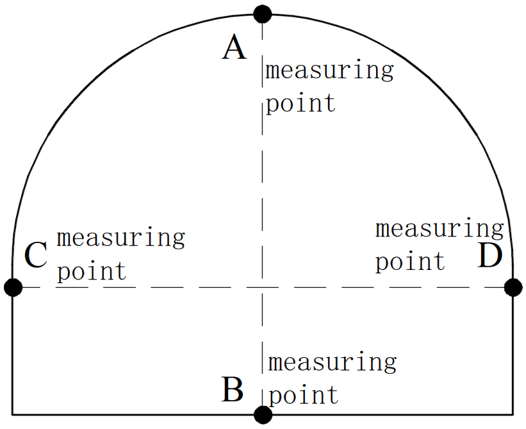


Figure 8. Layout of measurement points within the station

Record the displacement monitoring data and draw the displacement curve of surrounding rock during digging, and the displacement monitoring curve of the top and bottom plates and two gangs of the roadway is shown in Figure 9.

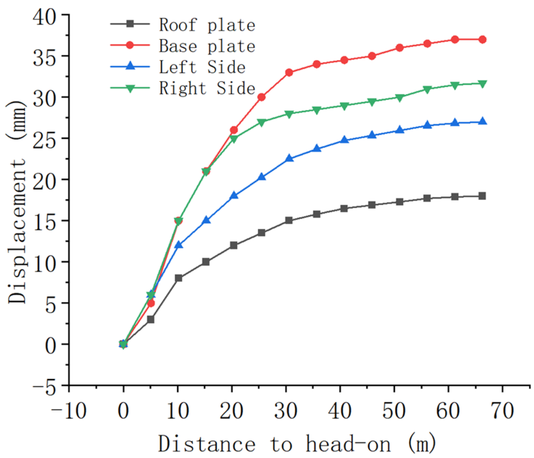


Figure 9. Tunnel surface displacement monitoring curve

On the whole, the bottom drum of the roadway is the most obvious, the top plate is the most stable, and the deformation of the two gangs is more obvious than that of the top plate. There are two main reasons for the obvious bottom drum, one is that there is no support for the bottom plate, and the other is that the higher horizontal stress forms stress concentration near the bottom plate after the excavation of the roadway, and the maximum displacement of the bottom plate is close to 40mm, and the deformation of the top plate is basically below 15mm, which indicates that the top plate is well controlled under the support method. The two gangs are coal body with soft medium, the deformation is more obvious than the top plate, the maximum deformation is near 33mm.

5. CONCLUSION

Firstly, Analyze the effect of different preload force on the deformation of the surrounding rock of the roadway, and the results show that the increase of preload force can effectively improve the control effect of the surrounding rock of the roadway.

Secondly, Analyze the effect of different bracket spacing on the deformation of the peripheral rock in the roadway, and the results show that when the bracket spacing is 600-800mm, the deformation of the peripheral rock can be effectively controlled. When the bracket spacing is 1000mm or greater than 1000mm, the surrounding rock deformation appears to surge, which is not conducive to the control of the stability of the surrounding rock of the roadway.

Thirdly, The distance of roadway excavation that significantly affects the surrounding rock deformation is about 30m, and the roadway deformation gradually tends to be stabilized after the distance of excavation headway exceeds 30m. The bottom drum of the roadway is the most obvious, the top plate is the most stable, the deformation of the two gangs is more obvious than that of the top plate, the maximum displacement of the bottom plate is close to 40mm, the deformation of the top plate is basically below 15mm, and the maximum deformation of the two gangs is near 33mm, and the deformation of the peripheral rock of the roadway is within a reasonable range.

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