Numerical Simulation Study of Anti-Large Deformation Bolt Structure

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Abstract. In order to study the mechanics of the anti-deformation hemp anchor rod, and numerical simulation was carried out with ANSYS fmitengen software, the mechanics characteristics of a single spiral anchor and a hemp anchor rod under different spiral rings were compared and analyzed. The results show that for a single screw anchor, the number of spiral turns has a greater effect on the stretch elongation rate of the anchor test piece, and the more spiral turns, the greater the elongation when the anchor is destroyed, and the structural deformation of the anchor rod force is greater, which is the main reason for the increase of the elongation with the increase of the number of spiral rings. The hemp anchor is affected by the number and spacing of spiral rings, and does not produce yield stage and destruction stage when stretching, which indicates that the hemp anchor has better ability to resist shearing and deformation. In engineering applications, the ability of hemp anchor rod to resist large deformation of surrounding rock can be effectively improved, the effect of roadway support can be ensured, and the research results provide theoretical basis for the application and parameter design of hemp anchor.

1. Introduction

With the development of coal mining to the deep, the amount of perimeter rock deformation is large and has obvious time effect, the shear carrying capacity provided by the traditional pull-concentrated anchor anchor solid can not balance the deformation pressure generated by the surrounding rock after the roadway excavation, and the superiority of its support can not be reflected in the deep laneway [1-4]. In order to adapt to the characteristics of perimeter rock deformation under the complex conditions of coal mines in China, reduce the stress concentration of anchor end, improve the limit carrying capacity of anchor solids, enhance the anti-shear deformation ability of anchor solids, adapt to large deformation of surrounding rocks, improve the effect of anchor support, develop anchor support new products, new materials, new technology, etc. are the main methods to solve geotechnical problems.

Pressure dispersion anchor can effectively solve the problem of stress concentration and improve its carrying capacity, which has become a hot spot to solve geotechnical problems. He Jinfang [5] compared and studied the extreme anti-pull carrying capacity of different anchors and their anchoring performance by conducting indoor model test and field in situ testing and simplifying theoretical analysis of the carrying performance of the pull-down composite anchor rod; Based on the experiment [6], the displacement field and shear strain field of the pressure-dispersed anchor rod applied by the pull-load load are analyzed from the fine-grained level, and the fine-view mechanics parameter change law of the pressure-dispersed anchor is simulated by using the particle flow software. Jia Jinqing [7] et al. By analyzing the force of the pressure-dispersed pre-stress anchor anchor segment, the analysis of shear
stress and shaft force distribution of this type of anchor is deduced, and on this basis, the force performance of the pressure-dispersed anchor and the pressure-concentrated anchor is compared.

At the same time, domestic scholars have done a lot of research to improve the performance of anchor material, anchor system destruction mode and new anchor research and development. Among them, the injection slurry tray anchor rod [8], flexible anchor bar [9], the sac expansion anchor rod [10], the anti-flush anchor rod [11], frictional large deformation anchor rod [12] and other new anchor rods [13]. The emergence of energy absorption-seismic [14-16] anchor rod is an effective solution to a large number of practical construction problems, for anchor rod research and development has accumulated a lot of experience;

2. Ansys Numerical Simulation Analysis of the Hemp Anchor Bar

In order to study the structural mechanics characteristics of the new hemp anchor, the new anchor numerical model was tested by Using State Structural Structural, a static analysis module inside ANSYS Workbench, a single-axis stretching test was carried out, and the numerical model size of the hemp anchor rod was 1000mm x 20mm, using load loading method (anchor theoretical limit value is about 80kN), load increment of $\Delta_1=10$ KN (first 4 steps), $\Delta_2=5$ KN (last 8 steps), a total of 12 loading steps. The material parameters are shown in table 1.

### Table 1. Material attribute parameters of bolt.

| Material density/kg/m-3 | Elastic modulus /GPa | Poisson | Yield strength/MPa | Extreme strength/MPa |
|------------------------|----------------------|---------|---------------------|----------------------|
| 7850                   | 200                  | 0.325   | 350                 | 516                 |

2.2. Twist Anchor Control Variable Simulation Scheme

Because the new pull-dispersed hemp anchor rod to be simulated is a combination of two anchor rods by means of spiral winding, there are two main reasons for the impact on the mechanics of the anchor rod: first, the number of spiral windings (pitch); In order to simulate the single variable principle of numerical simulation, the single and double helixes are simulated separately, and different turns and different winding spacing are simulated. Because of the optimization of the structure, the models established by this simulation are smooth rod parts, regardless of the horizontal effect of the real anchor rod.

3. Numerical Simulation Analysis of a Single Anchor Rod

3.1. A Single Screw Anchor Finitex Model

For a single screw anchor, the length of the anchor bar set in this paper is 1,000 mm, the diameter is set to 20 mm, the number of spiral turns is set to 0 (no spiral number is set), 1, 2, 3, 4, 5, 6, 7, 8, winding clearance is 1, 2, 4 mm, respectively. To establish an anchor bar model under different parameters, the model is shown in figure 1.
3.2. The Distribution of Load Displacement of Anchor Rods Under Different Spiral Spacing

This section mainly analyzes the distribution law of load displacement of anchor rods under different helix spacing. Figure 2 shows the load displacement curve of the anchor rod at different spacings under the conditions of 2, 4, 6, 8 revolutions.

![Figure 2. Load displacement curve of bolt at different spacing.](image)

In order to better compare the distribution law of anchor load displacement curve under different spiral spacing, the anchor load displacement curve with the number of spiral rings of 2, 4, 6, 8 is selected for analysis. As can be seen from figure 2, the overall trend of the load displacement curve of the anchor bar does not change greatly by changing the helix spacing, and when the number of anchor bars is small, the load displacement curve of the anchor bar under different spiral spacing also overlaps partially.

In order to compare more intuitively the mechanics of the anchor before yield damage, when the load value is 80 kN, the displacement value of the anchor bar is corresponding and the displacement change is plotted as follows.

![Figure 3. Comparison of displacement under the influence of different spacing.](image)

As can be seen from figure 3, when the number of spirals of the anchor bar is the same, the displacement of the anchor bar increases with the increase of the spiral spacing of the anchor rod, and the spacing and displacement are linear. When the number of spiral circles is biased for several hours, the slope of the straight line between displacement and spacing is also small, and when the number of spiral circles increases, the slope of the straight line increases. Overall, the anchor screw spacing has less effect on the anchor lever stretch displacement.

4. Double Hemp Anchor Numerical Simulation Analysis

4.1. Two-Root Hemp Anchor Finite Part Model

For the hemp anchor, it is proposed to set the length of the two anchor bars to 1,000 mm diameter of 14 mm, the number of turns set to 0 (no spiral), 2, 3, 4, 5, 6, 7, 8, winding clearance is 1, 2, 4 mm. The schematic diagram of twist anchor is shown in figure 4.
4.2. The Distribution Law of Load Displacement of The Hemp Anchor Rod Under Different Spiral Spacing

This section mainly analyzes the distribution law of load displacement of the hemp anchor rod under different spiral spacing. The figure below shows the load displacement curve of the anchor rod at different spacings under the conditions of 2, 4, 6, 8 spirals. Load-displacement distribution diagram is shown in figure 5.

![Figure 4](image1.png)

**Figure 4.** Numerical simulation model and stress distribution diagram.

In order to better compare the distribution law of the load displacement of the hemp anchor rod at different helix spacing, the load displacement curve of the hemp anchor rod with the number of spiral rings of 2, 4, 6 and 8 was selected for analysis. As can be seen from the figure above, the overall trend of the load displacement curve of the anchor bar does not change much by changing the spiral spacing, and when the number of anchor bars is small, the load displacement curve of the anchor bar under different spiral spacing also overlaps partially. In order to compare more intuitively the mechanics of the anchor before yield damage, when the load value is 80 kN, the displacement value of the anchor bar is corresponding and the displacement change is plotted as follows.

![Figure 5](image2.png)

**Figure 5.** Load displacement curve of double bolt at different spacing.

As can be seen from figure 6, when the number of spiral turns of the anchor bar is consistent, the displacement of the anchor rod increases with the increase of the spiral spacing of the anchor rod, and the spacing and displacement are linear. When the number of spirals of the hemp anchor bar is small, the slope of the straight line between displacement and spacing is also small, and when the number of spirals increases, the slope of the straight line increases relative to the anchor bar with a smaller number of turns. Overall, the anchor screw spacing has less effect on the anchor lever stretch displacement.
5. Conclusion

In order to verify the mechanics of the new anti-large deformed hemp anchor, the optimal structural size of the hemp anchor is inferred by an ANSYS finite element software simulation analysis and comparison with the test results. The following conclusions are drawn from indoor tests and numerical simulations:

(1) In finite-unit analysis, some of the hemp anchor deformation stage did not see the yield stage and destruction stage, reflecting the hemp anchor rod carrying capacity, strong shear resistance, used in coal mine laneway surrounding rock support, to maintain the relative stability of the roadway surrounding rock during the use cycle. In the process of supporting the load, the strength, carrying capacity and stretch of the anchor rod will gradually adapt to the increase of load, and further improve the stability of the surrounding rock.

(2) After comparing and analyzing the optimization results with a single anchor rod, according to the optimal parameters of a single anchor rod in laps of 5 laps, it is inferred that for the two anchor bars, in order to obtain the optimal parameters, the number of spirals should be set to 5 and the spacing is 2. The corresponding single lap length is 200 mm when the number of spiral turns is 5, i.e. the pitch is 200 mm. According to the parameters of this simulation result, the model of the hemp anchor rod of the indoor experiment is designed.

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