Three-Dimensional Simulation Analysis of Surrounding Rock Pressure Characteristics in the Tunnel Excavation with ANSYS

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Keywords: ANSYS, Tunnel Excavation, Surrounding Rock Pressure Characteristics, Three-Dimensional Simulation.

Abstract: Tunnel excavation is quite a complex engineering, which requires professional and accurate measures of geology and surrounding rock pressure analysis. Thus, it will ensure the quality and safety of engineering. However, traditional simulation technology will not analyze surrounding characteristics in the tunnel excavation deeply and thoroughly. Therefore, three-dimensional simulation analysis of surrounding rock pressure characteristics in the tunnel excavation is conducted based on ANSYS. It solves relevant technological problems in the tunnel excavation and ensures the quality and safety of engineering.

1   INTRODUCTION

With problems of strong geological dependence, difficult excavation process and complex force analysis, tunnel engineering is one of the relatively complex types in civil engineering. To improve engineering efficiency, quality and safety, the developing technologies set technological foundation for traditional tunnel excavation. It is the same with three-dimensional simulation technologies. Thus, fewer technological problems occur in the engineering, which improves engineering quality and safety to some extent. However, some shortcomings still exist in the traditional three-dimensional simulation technologies, including poor visual effects and incomplete functions. The problems are all needed to be solved. Therefore, surrounding rock pressure characteristics in tunnel excavation are emphasized in the work based on the three-dimensional simulation software ANSYS.

2   ADVANTAGES ANALYSIS AND TECHNOLOGICAL THEORIES OF ANSYS

ANSYS, with application and development worldwide, is large common finite element analysis software developed by America. Its largest advantage is that it can share simple and important data with multiple computer assisting design ports through software. Thus, ANSYS is applied in wide fields including engineering, railway, petrochemical industry and aerospace. Meanwhile, many research institutes regard it as standard teaching software considering its simple and easy operations and strong functions.

2.1   Advantage Analysis of ANSYS

ANSYS has many technological advantages, which are mainly shown in the technological research and application fields. ANSYS allows users to conduct deeper researches in some physics fields to solve problems easily. The advantages of ANSYS are studied with the following analysis.

Firstly, ANSYS is applied in academic fields, including fields of fluid, thermodynamics, electromagnetics, system simulation and data management. Therefore, ANSYS is of vital influence to push forward the fields above.

Secondly, ANSYS is so flexible that it can meet different needs of both companies and individuals. The needs include complex analysis and calculation, as well as simple desktop treatment and multinuclear parallel calculation. Thus, ANSYS not only satisfies requirements of high expansion, but also caters to different customers.

Thirdly, ANSYS is flexible enough to realize the efficient work transfixion. It is different from popular data processing system and software in database and data processing. However, it is greatly applied and awarded due to its strong openness and adaptability.

2.2 Technical Theory Analysis of ANSYS

ANSYS is widely applied for its obvious advantages. How does the technical theory of ANSYS come true? As ANSYS is closely connected with its technical structure and theory, the discussion on technical theories is emphasized.

ANSYS can conduct finite element calculation in variety ways. The finite element structure includes structure, power, electromagnetics and collision, which explain why ANSYS is widely applied in the industry.

ANSYS can be divided into three main parts in theory.

2.2.1 Pre-processing Module of ANSYS

Pre-processing module is used for image grid processing. In the module, ANSYS provides strong data modeling and meshing functions. Therefore, it is convenient for users to build finite model easily.

2.2.2 Analysis Calculation Module of ANSYS

The analysis calculation module is the core part of ANSYS. Therefore, the structuring and analyzing will all be conducted in this part, including linear, non-linear and field analysis.

2.2.3 Post-processing Module of ANSYS

Post-processing module reprocesses analyzing and calculating results of images and grids, including colors, data gradients and vectors. Besides, particle streams can be exported in images and curves with post-processing unit.

3 ANALYSIS OF SURROUNDING ROCK PRESSURE CHARACTERISTICS IN THE TUNNEL EXCAVATION

The tunnel excavation is the key of engineering as it is complex in techniques. Meanwhile, the surrounding rock pressure analysis and solving has always been the difficulties. Therefore, the main technical treatment is to solve quality and efficient problems through analyzing surrounding rock pressure characteristics.

3.1 Physical Characteristics of Surrounding Rock Pressure

The most important thing in analyzing tunnel excavation is to solve problems of surrounding rock pressure. Therefore, the discussion on surrounding rock pressure comes first. Thus, concepts of surrounding rock pressure need to be clarified.

Surrounding rock pressure refers to the strength arising from shape changes of rocks and supporting in the space. Therefore, rock force and surrounding rock deformation resistance arising from earth stress can be regarded as surrounding rock pressure. The pressure functions on the supporting, thus it causes some damages. Generally speaking, surrounding rock pressure arises from the supporting. However, pressure without supporting will also cause surrounding rock pressure. Narrowly speaking, surrounding rock pressure refers to forces on supporting.

3.2 Understanding and Influencing Factors of Surrounding Rock Pressure

Excavation has always been an important engineering since ancient times. Especially, grounding transportation cannot cater to people's needs due to fundamental demands of modern society. Therefore, the railway and tunnel gives transportation more definitions. However, people begin to realize the surrounding rock pressure and pay more attention to it when caves and tunnels collapse and distort.

Thus, what measures should be taken considering surrounding rock pressure? To solve the problem, factors influencing surrounding rock pressure need to be clarified. Generally, factors include the following aspects:

Firstly, tunnel shapes, sizes, grounding structure nearby and supporting are all the direct factors influencing tunnel surrounding rock pressure. Thus, the factors are directly connected with the formation and future effects of surrounding rock pressure.

Secondly, construction of tunnel excavation has large influences on surrounding rock pressure. In the excavation, rocks used to be relatively static. However, rocks are all influenced by each other nearby. Thus, the whole integrity is stable. After the excavation, surrounding stress environments change with missing rocks. Thus, surrounding rock pressure comes out. Besides, measurements of initial stress are very important in the study of surrounding rock pressure.

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Thirdly, direct influencing factors of balancing force; when initial stress and environments are damaged, forces need to be balanced. Thus, surrounding rock pressure come out and find new balancing point in the stressing process. All the deformation and damages are the visual influencing factors of surrounding rock factors.

4 ANSYS THREE-DIMENSIONAL SIMULATION ANALYSIS OF SURROUNDING ROCK PRESSURE CHARACTERISTICS IN THE TUNNEL EXCAVATION

Pre-calculation and analysis is found necessary in solving problems of surrounding rock pressure through the analysis of ANSYS and pressure forming factors. Thus, how the torque will change in the excavation to influence the stability of tunnel? With the help of three-dimensional simulation software, pre-analysis of surrounding rock pressure is conducted in the tunnel excavation.

4.1 Effects and Results of ANSYS

ANSYS is multi-functioning software based on data processing techniques. In the tunnel excavation, pre-analysis can be done in ANSYS. Meanwhile, the largest characteristic of ANSYS is that it allows users to realize complex functions with easy operations. Besides, ANSYS realizes early estimates to ensure complete operation with targets. In all, ANSYS is deeply applied in tunnel excavation and awarded good results with years' analysis.

Three-dimensional simulation technique of ANSYS realizes pre judgment and simulation of tunnel excavation. Thus, workers' efficiencies and safety are protected. Besides, in the post maintaining, ANSYS can also be used in simulation to give early warnings to tunnel. In all, ANSYS is very efficient, especially in the excavation of railway and tunnel.

4.2 Realization of Surrounding Rock Pressure with Three-Dimensional Simulation

Geological environment, characteristics and excavation ways are input with ANSYS. After pre-processing, the information is calculated and simulated. Then, the information is output to the analyzing and calculation module, which deals with information with data modeling. Finally, information is transferred to post-processing unit, which shows information with images and curves. Thus, users and researchers can conduct three-dimensional simulation by changing data. By changing original data, ANSYS shows the corresponding surrounding rock pressure with post-processing module when sizes of tunnel change in excavation. Besides, early warning of dangers and crisis is available when operation errors and mistakes occur. Furthermore, the distortion and damages of tunnel with changing rock pressure can be simulated with ANSYS. Above all, stress analysis of tunnel excavation can be clearly shown in expected results with three-dimensional simulation of ANSYS.

5 CONCLUSIONS

The theory and simulation characteristics of ANSYS were analyzed in the work. Besides, surrounding rock pressure characteristics in the tunnel excavation were also discussed. The pre-simulation based on ANSYS was meant to explain the outcome of tunnel excavation. Thus, three-dimensional simulation analysis dealt with surrounding rock pressure with targets. Meanwhile, detailed, professional and reliable plans ensured quality and safety of engineering after solving hidden crisis. The application of ANSYS was based on its strong functions and easy operations. Furthermore, ANSYS got better results of force analysis in the three-dimensional simulation analysis.

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