

Summarization of Soft Rock Collapse Mechanism under Unloading Condition

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Abstract

At present, China's underground tunnels, subway projects have been continuously developed, but there has also been a lot of security risks, the deformation and failure of tunnel rock is one of the most common phenomena. Through consulting related literature information, in this paper we briefly introduce some definitions and types of deformation of surrounding rock, and summarizes the domestic and foreign research on deformation and failure of surrounding rock in tunnel and other underground engineering, so that we master from the soft rock deformation and deformation of the evolution mechanism and control the development of deformation methods.

Keywords

Underground Engineering, Surrounding Rock, Deformation and Failure Mechanism.

1. Introduction

With the continuous development of China's economy, tunnels, subways, underground tunnels and other underground works have also been rapid development. According to incomplete statistics, by the end of 2015, China's total length of the railway tunnel has been built more than 7000km, the total number of highway tunnels is more than 3000km. Up to now, the total length of the national rail transit line is more than 4000km, which requires the construction of the tunnel line accounted for a large proportion, in addition to the western development of the railway, highway tunnels, subway, underground utilities, West-East Gas Transmission, hydropower projects and other underground works. China plans to build 5,000 tunnels by 2020, the total length of more than 9000m. In achieving remarkable results at the same time, we also bear the challenge, because the underground engineering is often in a complex environment, the rock in these specific circumstances prone to deformation, and even induce geological disasters, to the tunnel and other related underground engineering design and construction of a series of problems. How to do well in the complex terrain environment like underground tunnel construction work is related to the overall economic development, especially in many areas of poor rock stability, but also need us to invest a lot of energy to do the research work.

This paper summarizes the domestic and foreign research on the deformation and failure of surrounding rock in tunnel and other underground engineering, from which the damage of deformation and damage of the surrounding rock is well known, and the relevant research and shortcomings of scholars at home and abroad. So that we can continue to study on this basis.

2. Brief Introduction to Deformation of Weak Surrounding Rock in Tunnel

2.1 Tunnel Weak Rock Section Headings

Weak surrounding rock generally refers to the weak rock, bearing capacity is low, joint development of fractures, broken rock structure, engineering geological features are:

(1) Rock mass broken loose, poor cohesive force: generally soil, rock body of the weathering layer, crushing zone composed of crushed rock, due to structural fragmentation, poor bond between the rock, after the excavation of the cavern, Only the friction between the particles and weak cementing

operation arch, such rock is extremely unstable, especially in the shallow-prone areas prone to collapse roof.

(2) Low strength of the surrounding rock, easy to water softening: generally shale, mudstone, schist and other soft rock as the representative of the bottom, due to low strength, poor stability, easy to weathering exposure, water softened, especially deep Plastic deformation is liable to occur under high stress.

(3) The rock mass structure is weak and slippery. It mainly exists in the massive rock mass which is seriously affected by the cutting of the structural plane. Due to the low strength of the bond strength of the structural plane, the surrounding rock mass is easy to produce along the structural plane after excavation Relaxation, slip and fall and other deformation and damage phenomena.

2.2 Deformation of weak surrounding rock

2.2.1 Deformation Definition of Weak Surrounding Rock

Terzaghi first proposed the concept of extruded and expansive rocks in 1946, that is, extruded rock is rock that has no apparent volume change after the tunnel has been excavated (excavation profile); expansive rock is defined as And the geologic characteristics, deformation characteristics and strength characteristics of the surrounding rocks are analyzed [1].

The engineering geologic properties of weak surrounding rock determine its deformation characteristics in tunnel engineering, mainly as the change of its mechanical behavior, that is, the difference of self-stability after excavation, the characteristics of "self-stabilization time is short, easy to collapse"[2]. The large deformation of surrounding rock mass of tunnel can be defined as: a kind of plastic deformation and damage of tunnel and underground engineering with progressive and obvious time effect, which is different from rockburst movement brittle failure, and different from the rock loosening The deformation is very complicated and the stability is very different from that of the general wall rock [3]. Because of the tunnel excavation, the surrounding rock of the previously supported tunnel was removed and the wall of the tunnel was empty. The surrounding rock stress was re-adjusted, and the surrounding rock and the tunnel wall were deformed in the direction of tunnel clearance.

2.2.2 Deformation Classification of Weak Wall Rock

Generally, the large deformation of surrounding rock is divided into two categories according to the formation mechanism, mainly from the calculation method to distinguish [4]: First, the stress re-distribution of excavation is more than the strength of the surrounding rock and plasticization occurs. If the deformation of the medium is slow, it belongs to the extrusion (if the deformation is immediate, is rockburst); the second is that some minerals and rocks in the water reaction and expansion. The presence of water and certain (expansive) minerals is necessary for swell deformation. The deformation and failure of surrounding rock in tunnel and underground engineering are mainly rockburst, collapse and large deformation. Rockburst is a kind of brittle failure of hard rock under high ground stress. Collapse and dropout are the local deformation and deformation of wall rock under certain structure control [5]; while the large deformation of surrounding rock is another kind of underground rock Deformation failure mode, is the plastic deformation of surrounding rock mass, and has a progressive expansion and significant time effect. The deformation of the surrounding rock can be divided into three parts, namely, the front deformation of the front face, the extrusion of the face and the deformation of the rear face of the face, which are simultaneously occurred. The tunnel deformation of weak surrounding rock is large, the deformation duration is long, the influence range of front and rear deformation is large, and the deformation speed is the deformation characteristic of soft surrounding rock tunnel.

Most people have mentioned in accordance with different controlled conditions for large deformation of the type of division: the control by the rock mass of large deformation, controlled by the structure of the surrounding rock deformation and large deformation by artificial mining disturbances of the three types of large deformation [6-9]:

(1) controlled by lithology of surrounding rock

Weak surrounding rock, including weak mud shale and sandy mudstone, marl, and with the expansion of soft rock, this type of surrounding rock often retains the original structure of the rock mass, under high stress state, the rock mass has flow or plastic deformation, when the groundwater is involved, the rock mass softens and flows, when the rock mass contains the expansive minerals, expansion deformation occurs. According to the developmental characteristics of the structural plane in soft rock, it is divided into homogeneous type, lamellar type, interbedded type and expansive weak rock. The deformation and failure mechanism of the soft rock is shear failure, and the deformation and failure mode of the surrounding rock is shear deformation and plastic flow caused by bending deformation.

(2) controlled by rock mass structure

The deformation of the rock mass is obviously controlled by the stress environment of surrounding rock, and it has high strength and stability when the tunnel is in high confining pressure before excavation. When the confining pressure decreases and the stress difference of surrounding rock increases, the structural plane is open or slippery, and the strength and modulus of the surrounding rock are reduced, which shows remarkable structural rheology. According to the formation mechanism of rock mass structure, it can be divided into structural reconstruction and superficial metamorphism. According to the degree of transformation, can be further divided into block-like structure, fragmentary structure and debris-like structural type.

(3) controlled by artificial excavation disturbance

The failure mechanism of this kind of surrounding rock is shearing and sliding failure. It occurs in relatively thick sedimentary rocks, including two kinds of failure modes: sliding along the layer and shearing of intact rock. This form of damage occurred in the affected area by artificial disturbance, rock mass movement led to large deformation of the surrounding rock tunnel, such as the Dazhou City, Sichuan Province Papeng Highway Tieshan tunnel goaf deformation and Xiaoliu Railway Mazi Tunnel. The deformation of coal mined-out section is a typical example of this type of large deformation. As a result of artificial disturbance, that is, the formation of coal mining gob deformation, leading to the tunnel through the mined-out area of its lining structure deformation and fracture. This type of structure can be divided into inclined and horizontal form according to the relationship between the strata direction of goaf and the tunnel.

In the survey and design stage, it is preliminary to predict the possible large deformation of surrounding rock of tunnel and underground engineering, which is often different from engineering practice. The construction practice of partridge mountain highway tunnel proved that the prediction and prediction of large deformation of surrounding rock is carried out by applying the aforesaid forecasting and forecasting system, which provides effective service for reasonable supporting of large deformation section of tunnels and enriches the surrounding rock of tunnel and underground engineering large deformation of the study.

3. Study on Deformation Mechanism and Control Technique of Weak Surrounding Rock in Tunnel

3.1 Study on Deformation Mechanism of Surrounding Rock

Chen Jianping professor convergence of surrounding rock deformation mechanism should include plastic wedge, flow deformation, expansion of surrounding rock, capacity, deflection in five aspects, the swelling can occur in the excavation of the surrounding rock has a high strength, deformation occurs mainly in the tunnel operation a few years later, the deformation is generally expressed as a drum, and the vault and the wall is generally intact status[10]. According to the characteristics of deformation and failure of surrounding rock, characteristic mineral, mechanical function and characteristics, the deformation and failure mechanism of soft rock is divided into the chemical properties of the deep soft rock itself molecular structure, and force source, and the cavity structure and rock body structure of the combination of characteristics of the three aspects, the deep soft rock

(depth greater than 500m) is classified into three classes according to the mechanical mechanism of deformation: the physico-chemical expansion type, the stress expansion type and the structural deformation class [6].

Li Yonglin and Jiang Yun et al according to the actual engineering analysis proposed tunnel large deformation mechanism of the surrounding rock can be broadly summarized as the following aspects:(1) Plastic flow of soft rock, (2) Swelling deformation of soft rock, (3) Bending deformation of plate beam, (4) Plastic wedge , (5) Structural rheology, (6) Progressive loose extension, (7) Different loose extension, (8) Inclined settlement deformation, (8) Vertical settlement deformation [11].

Chen Jianji et metamorphic soft rock deformation and failure of tunnel based on the actual engineering analysis put forward the tunnel deformation and failure mechanism of the place. They suggest that different soft rocks exhibit different mechanisms of deformation in their specific geomechanical environment. The deformation and failure of soft rock tunnel is the result of plastic flow and deformation of rock mass, such as "biasing" materialized expansion "rheology" stress expansion and so on [12]

3.2 Mechanical Properties of Soft Rock and its Calculating Method

The reason why the soft rock can produce significant plastic deformation, because the soft rock in the shale composition (clay minerals) and structural plane control of the soft rock engineering mechanical properties. In general, soft rock has plasticity, swelling, disintegration, dispersibility, rheology, thixotropy and ion exchange [1].

At present, the mathematic analytic method has been widely used in engineering calculation [30-31], but it can not overcome the difficulty of the complexity of mountain tunnel construction and the unique nature of crossing the surrounding rock conditions, which promote the numerical simulation method application in tunnel construction. With the development of computer equipment and geotechnical constitutive relations, the computational method has entered the era of numerical analysis represented by finite element. Finite element method based on numerical analysis, which can deal with all kinds of nonlinear problems flexibly simulate the complex construction process in geotechnical engineering and become the most widely used numerical analysis method in geotechnical engineering. Based on the elastic-plastic mechanics theory, the elastic-plastic mechanics equation is established to calculate the stress and strain field of rock and soil under certain environment. According to the failure criterion of rock and soil, the stress and strain state of each corresponding part of rock mass is judged. So as to judge the stability state of the surrounding rock structure.

3.3 Study on Control Technology of Surrounding Rock Deformation

Zhang Wei suggested that the influence of the construction site on the deformation of surrounding rock can not be ignored, and he summed up the construction experience according to the investigation in the actual project: before the tunnel excavation, the geological condition of the tunnel area should be understood in detail. Especially after the tunnel excavation, the stability of the surrounding rocks should be analyzed and classified correctly. The classification of tunnel rock is complicated, mostly based on the basis of engineering practice, to master the information summarized statistical analysis, and then through quantitative and qualitative analysis, combined with the data model and calculated. To make construction of the tunnel smooth, we must first ensure the stability of the surrounding rock. Therefore, the factors that affect the stability of the tunnel surrounding rock should be as comprehensive as possible in place. In addition, the construction method is also influential. In the same kind of rock mass, the ordinary blasting method is used to construct and control the blasting method. The mining method and the shield method or the roadheader construction are adopted. Large section excavation and small section excavation, The impact on the stability of the tunnel are not the same [13].

Zhao Yong in his doctoral dissertation mentioned excavation method and supporting measures are two aspects of surrounding rock deformation control, excavation makes the release of stress in the surrounding rock, support is to control the stress release method, supporting structure and the surrounding rock Stability is the goal of deformation control[1]. The principle of controlling surrounding rock deformation is based on the temporal and spatial distribution law of surrounding rock deformation, adopting reasonable excavation method and supporting measures to control the front face, the face face and the rear face deformation, so that the deformation of surrounding rock is controlled by deformation to maintain long-term stability of the surrounding rock and tunnel structures. That is, the use of advanced support, to control the face of the front of the deformation and vault subsidence: the use of hand surface support, to control the extrusion face deformation; to strengthen the initial support, control excavation rear face deformation; supporting measures to control the stability of the face and arch support the initial displacement of the arch; the use of secondary lining, a reasonable reserve structure to protect the safety reserves to control the residual deformation of the tunnel is completed. The design principle, design flow and design parameters of support structure of soft surrounding rock tunnel are put forward.

4. Conclusion

Soft rock tunnel deformation and control technology, involving the theoretical research, survey, design, construction and construction management and other issues, to improve the soft rock tunnel construction technology level, also need to further strengthen the following aspects:

- (1) To further strengthen the study of the theory of the weak rock tunnel deformation control, according to the requirements of the engineering, the deformation control standards for targeted, makes the control of the deformation of the tunnel in weak rock more refinement, standardization and mechanization.
- (2) Improve the construction technology. Due to the creep characteristics of the weak surrounding rock, the deformation lasted for a long time, if the construction speed is slow, supporting the formation of closed a long time, it is prone to large deformation or even excessive relaxation and landslides. Therefore, the rapid construction is to improve the stability of soft rock tunnel stability of the basic requirements, but also weak rock tunnel construction principles.
- (3) Improve the accuracy of predicting the deformation of weak surrounding rock. The complexity of surrounding rock structure and the diversity of its deformation mechanism make it difficult to accurately calculate and predict the deformation of surrounding rock. Therefore, it is necessary to study the characteristics of surrounding rock and its deformation characteristics , More effective means to calculate the deformation of the surrounding rock is the next step in the direction of research.

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