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Use of Rock Mechanics in Soft Rock Tunnel

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ABSTRACT

There has always been a symbiotic relationship between rock mechanics and tunnel construction. Rock mechanics plays a very important role in the decision making of soft rock tunnel. It tells us more about the place where the construction is going to take place, the rock content and strength, its characteristics and it influences the method of construction that will be adopted in the construction process.

KEYWORDS: Rock mechanics, soft rock, tunnels, rock mass classification, rock mass rating, soft rock tunnel, Q system

1.0 INTRODUCTION

Recently, a number of countries have seriously lacked land space because of the increase of population density and industrialisation; thus, a number of constructions such as the tunnel, high-speed railway, housing complex, airport and harbour are progressing in special soil areas [1].

Rock mechanics parameters is one of the most important influence factors on mechanical characteristics of tunnel construction as well as the access point for disasters control and structure design [2].

2.0 ROCK MECHANICS

Rock mechanics is a theoretical and applied science of the mechanical behaviour of rock and rock masses. It is that branch of mechanics concerned with the response of rock and rock masses to the force fields of their physical environment [3].

Rock mechanicsis concerned with the application of the principles of engineering mechanics to the design of the rock structures such as tunnels, mining shafts, underground excavations, open pit mines, oil and gas wells, road cuts, waste repositories, and other structures built in or of rock. It also includes the design of reinforcement systems, such as rock bolting patterns.

Rock mechanics provides information of utmost relevance: measurement of initial stress; monitoring stresses developed in the peripheries of openings; measurement of material properties; analysis of stresses, deformations, temperatures and water flow in support of design and interpretation of instrumentation readings especially displacements.

3.0 SOFT ROCKS

Soft rocks, i.e. sandstone and mudstone have the main characteristics such as large deformability, strong dependence of resistance on degree of saturation or temperature, and susceptibility to alteration [4].

Soft rock indicates those engineering rock masses which are acted by the engineering forces of the tunnel and cause large deformation [5].

The deformation of the soft rock tunnel has two significant characteristics. One is that the proportion of advanced displacement in total radial displacement is large. The other is that the face extrusion is large [6].

The prevalent definition emphasizes the softness, weakness and looseness while the definition emphasizes not only the strength of soft rocks but also the level of engineering forces [5].

Soft rock material is easily deformed if disturbed; one of the causes is due to excavation. The most effective actions that can be done are the installation of pre-support (pipe umbrella) before excavation [4].

4.0 TUNNELS

A tunnel is an underground passageway, dug through the surrounding soil/earth/rock and enclosed except for entrance and exit, commonly at each end. A tunnel may be for foot or vehicular road traffic, for rail traffic, or for a canal. A tunnel has also been described as a long, narrow, mostly linear excavated underground opening in which one dimension that is the length greatly exceeds the other two; that is the opening width or height [7].

The construction of tunnels is gaining popularity for transportation and other utilities due to the restrictions in the expansion of the surface infrastructure [8]. Factors like urban development, population growth and limited space have emphasized a considerable growth in tunnel construction for subways, underpasses and urban highways for providing the better services to transportation all around the world [7].

The 21st century is recognized as a century of underground space all around the world. There are a lot of underground roadway projects, moreover, much of them are located in the soft rock tunnel, in which it is likely to be with expansive feature and the deformation of creep is obvious, causing serious problems related to both long term stability and safe operation of soft rock [9].

Many cities in the world are already having or planning to construct tunnels as part of metro projects [8]. In recent years, because of the rapid development of China's highway construction, tunnel construction is rapidly increasing. Many of which need to pass through soft rock tunnel area [10].

5.0 RELATIONSHIP BETWEEN ROCK MECHANICS AND SOFT TUNNEL

For the safe and economical design of tunnels, it is necessary to consider the engineering characteristics such as the strength and joint of rock mass, and the excavation and support system for tunnels should be designed based on those [1].

Early knowledge of rock structure and strength is used in the design tunnel of an openings shape, and excavation method. Systems, like Barton’s Q-system, can be used to rate the relative quality of different rock masses. Rock Mass Rating (RMR) system by Bieniawski and Q system by Barton, Lien and Lunde are the most famous systems among the geological classification systems. Each of them is a kind of geo-mechanical classification based on a series of rock mechanics parameters and geological structure parameters [6]. The Rock Mass Rating (RMR) and the Q-system are commonly used for rock mass classifications for typical tunnels [1]. Although rock-mass rating (RMR) and tunnelling quality index (Q) systems are used in different rock engineering projects as empirical design tools, their application in tunnel design is widely accepted as these systems were developed and updated for this purpose specifically [11].

Engineering underground space such as the construction of tunnels have many facets some of which are unrelated to rock conditions. However, rock mechanics has direct bearing on many of the critical aspects of engineering work for example, planning the location, dimensions, shapes and orientation of chambers, selecting supports, arranging for construction access, engineering blasting and designing instrumentation.

In rock engineering design, the rock mass is considered as a complex natural geological building material and during tunnel construction, ground behaviour is dependent on the ground condition and tunnel related features [11].

Rock conditions have great influence on blast design and results. Designers can not choose rock conditions, but they can study and define the characteristics of existing rock. In many large civil construction and mining projects, information about rock properties is gathered before excavations begin.

A large increase in the use of shallow tunnels in soft rock has been observed, mainly in urban regions, during the last few years. These tunnels have been built for a variety of purposes, such as transportation, water supply and as part of sewerage systems [4].

An important fact in rock mechanics is that having inadequate information for engineering design of structure in rock is a way of life, which is why the empirical rock-mass classification approaches have been established and are still essential for the tunnel construction [11].

CONCLUSION

The main objective of this study is to investigate the role that rock mechanics plays in soft rock tunnel construction. The following conclusions could be drawn from the present study:

- This paper provides valuable information in regards to how rock mechanics has an influence in the construction of tunnels
- Rock mass classification systems such as the Rock Mass Rating (RMR) and tunnelling quality system (Q-system) are used in rock engineering projects as empirical design tools.

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