Comprehensive assessment of excavation damaged zone (EDZ) based on analysis of geophysical method in rock mass

Hoang Dinh Phuc[1,*], Bui Anh Thang[1]

[1] *Faculty of Civil Engineering, Hanoi University of Mining and Geology, Vietnam*

ABSTRACT

It is inevitable that excavation at deep underground powerhouse in high in-situ stresses induced damages to the surrounding rocks. As a result, reasonable determination of the excavation damage zone (EDZ) is critical to the design, construction and safe operation of the underground powerhouse. This study divides EDZ into excavation highly damaged zone (EHDZ), excavation slightly damaged zone (ESDZ) and undamaged zone (UDZ) so as to better capture the evolving characteristics of the surrounding rocks at deep underground powerhouse with high in-situ ground stresses. With the utilization of acoustic detection, this study introduces the damage factor D to quantitatively distinguish the EDZ. Borehole camera is also employed to observe the characteristics of fissure development within the surrounding rocks. The observed damage characteristics of the surrounding rocks are then compared against the acoustic detection results, showing favorable agreement. Based on the actual engineering practice, this study puts forward the discriminating standard for the EDZ at deep underground powerhouse in high in-situ stresses during construction. Hopefully, this study could provide some basis for the evaluation of degree of damage of the surrounding rocks as well as the informational design and construction at underground powerhouse with similar conditions.

Keywords: Rock mechanics; Excavation damage zone (EDZ); Acoustic detection; Borehole camera imaging; Damage factor

1. Introduction

Construction of the large hydropower stations in valley regions gives rise to a series of problems, such as deep burial depth and long span of the underground powerhouse. In addition, increasingly serious problems such as the damage of surrounding rocks during excavation have also captured more and more attention from the engineers and scholars in China and abroad.

As a complex geologic body, rock mass are usually subject to complicated stresses. It is known to us all that in situ rock mass are subject to three-dimensional stresses. The excavation of underground powerhouse disturbs the stress balance and alters the stress regime. Also, the excavation of underground powerhouse affects the mechanical properties and water-physical properties of the surrounding rocks. The effect is mainly manifested in aspects such as a great amount of fissures generated within the rock mass, rapid fissure development and fissure coalescence. As a result, permeability coefficient of the rock mass is increased, creating channels for water intrusion. Therefore, it is of great engineering significance and theoretical value to study the EDZ at deep underground openings in high in-situ ground stresses during construction and its implications for support parameters optimization, safe construction and evaluation of engineering stability and safety.

A significant number of studies at China and abroad have been carried out regarding EDZ partition and zonal support during excavation of underground openings. With consideration of the research results at home and abroad, Li et al, 2013 systematically analyzed and summarized EDZ at underground openings from aspects such as EDZ concept, field test, laboratory test, theoretical analysis and numerical calculation. Xu et al, 2014 divided EDZ into excavation highly damaged zone (EHDZ) and excavation slightly damaged zone (ESDZ) and introduced damage factor to quantitatively distinguish the EDZ based on the rationale of acoustic detection. Zhang et al, 2007 combined the damage evaluation based on plastic strain within the plastic zone with the partition of the EDZ and put forward the new concept of failure approach index (FAI), thus quantitatively evaluating the stability of rock mass in different sections of the surrounding rocks. Dai et al, 2015 utilized multiple monitoring methods to investigate the forming and evolving mechanism of the EDZ at the underground powerhouse of Houziyan hydropower station. Liu et

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