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深埋隧道围岩损伤破坏模式的数值试验研究

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摘要 深部岩体具有内禀特性。在开挖过程中，由于应力重分布导致围岩损伤破坏，传统岩体力学未能有效揭示其破坏机制。随着细观损伤岩体力学的发展，采用损伤观点解决深埋隧道围岩破坏问题逐渐显示出其优越性，但目前仅在均质性假设的基础上对应力状态和破坏判据进行研究，缺乏对其破坏全过程的相关研究。采用RFPA2D软件对通渝隧道二叠系栖霞组岩性为石灰岩且埋深超过1 000 m的K22+029断面在开挖过程中围岩的渐进破坏过程进行模拟，使用EMS－2型工程多波地震仪实测围岩破坏前、后波速的变化，定量模拟计算围岩损伤度的变化，揭示深埋隧道围岩破坏过程的损伤演化特性及损伤破裂过程中声发射、剪应力及岩体纵波波速等因素的变化特性，得出深埋硬岩隧道以拉剪型破坏为主，围岩破坏顺序依次为拱顶开裂→左、右拱肩裂纹扩展→左、右拱肩围岩深部裂纹；损伤过程中声发射事件数与围岩损伤程度近似成正比关系；损伤围岩表现出明显的非线性特性和损伤局部化特征。所得结论对于隧道施工支护具有指导意义，也为揭示深埋隧道围岩破坏机制进行有益的尝试。

关键词 隧道工程；深埋隧道；围岩破坏模式；细观损伤力学

分类号

RESEARCH ON NUMERICAL TESTS ON DAMAGE-FAILURE MODE OF SURROUNDING ROCK IN DEEP-BURIED TUNNEL

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Abstract

Because of complex tectonic boundary condition and high stress environment in deep rock mass，surrounding rock has intrinsic characteristics，which will damage caused by stress redistribution in excavation of deep-buried tunnel. The traditional rock mechanics has been always focused on the stress state and failure criteria under the hypothesis of rock homogeneous，the total rock mass failure process is not considered yet. With the development of meso-damage rock mechanics，the method of damage mechanics has been proved to be better than the traditional theories. But relevant researches are not available at present. Based on the numerical test on damage property of tunnel surrounding rock in an excavation section K22+029 by using the software RFPA2D(two-dimensional rock failure process analysis system)，which was developed according to meso-damage mechanics of rock mass，the total failure process of surrounding rock in deep-buried tunnel is simulated，the failure mode，acoustic emission(AE) map and shear strength map in the failure process are shown quantitively；and the damage index is also achieved by velocity test with EMS–2 engineering multi-poly seismic system. It is found that the hard rock mass in deep-buried tunnel is fractured firstly at the roof，then at the spandrel；and finally the fracture extends to the deep layer. Damaged surrounding rock shows obvious characteristics of nonlinearity and localization. The possible failure mode and the relationship between AE amounts and damage variable of surrounding rock in deep-buried tunnel can be obtained from the analysis by using meso-damage mechanics. It is shown from in-situ test results by engineering multi-poly seismic system that the attenuation of longitudinal wave accords with the change of damage variable in tunnel surrounding rock. The conclusions have great application values

for tunnel construction and supports. What¢s more， these are also beneficial tries for the study on failure mechanism of deep rock mass.

Key words tunnelling engineering；deep-buried tunnel；failure mode of surrounding rock；meso-damage mechanics

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