粗晶大理岩单轴压缩力学特性的静态加载速率效应及能量机制试验研究

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EXPERIMENTAL INVESTIGATIONS ON STATIC LOADING RATE EFFECTS ON MECHANICAL PROPERTIES AND ENERGY MECHANISM OF COARSE CRYSTAL GRAIN MARBLE UNDER UNIAXIAL COMPRESSION

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摘要 加载速率对岩石力学性质具有重要影响，影响的程度与岩石本身的微结构和加、卸载应力路径及状态等密切相关。基于静态加载速率范围内的9个不同等级应变率下粗晶大理岩单轴压缩试验，研究加载应变率对岩石的应力－应变曲线、破坏形态、强度、弹性模量及变形模量与应变能耗散及释放的影响规律，探讨岩石损伤演化的能量机制。根据总体积应变及裂纹体积应变与起裂及扩容应力的相关性，确定各应变率下岩石起裂及临界扩容应力。加载应变率大约以1×10－3 s－1为分界点，小于该值时应力－应变曲线峰值点附近仍存在一定的塑性屈服或流动段，超过该值后表现为“折线”型。随着加载应变率的增加，岩样破裂模式由张剪型逐渐过渡到张性劈裂甚至劈裂弹射。一般而言，起裂及临界扩容应力和峰值应力均随加载速率增大而增大，且起裂及临界扩容应力越接近峰值强度，但当应变率为1×10－4～1×10－3 s－1时，上述值均出现一个相对低值区间，这与粗晶大理岩的微结构特征相关。起裂应力、临界扩容应力、弹性模量及变形模量均与峰值强度线性相关。单轴压缩下峰前能量耗散量越多，强度越高，峰后可释放弹性应变能和释放速率越大，岩石的张性贯通破裂特性愈强，破裂块数越多。能量耗散使岩石损伤而强度丧失，而能量释放使岩石宏观破裂面贯通而整体破坏。

关键词： 岩石力学 单轴压缩 加载应变率 损伤演化 能量释放与耗散

Abstract： Loading rate has an important influence on rock mechanical properties. The influence degree is closely related to the microstructure of rock，loading and unloading paths and states，etc.. Based on the uniaxial compression tests of coarse crystal grain marble with nine strain rate levels in range of static loading rate，the influences of loading strain rate on stress-strain curve，failure pattern，strength，elastic modulus，deformation modulus and strain energy dissipation and release of the marble are investigated；and the energy mechanism of rock damage evolution is discussed. The initial cracking stress and critical dilatancy stress of rock specimens under different loading rates can be obtained by the relations of total volumetric strain and crack volumetric strain with initial cracking stress and critical dilatancy stress. The loading strain rate of about 1×10－3 s－1 is the dividing point. When the strain rate is less than the value，a certain plastic yield or flowing section near the peak of stress-strain curve is still present；but when the strain rate is more than the value，the fold line type near the peak of stress-strain curve is present. The fracture pattern of rock specimen changes from tension-shear to tensile rip and even rip-ejection with the increase of loading strain rate. Generally，the initial cracking stress，critical dilatancy stress，and uniaxial compressive strength increase with the loading strain rate；and the initial cracking stress and critical dilatancy stress are more closer to the peak strength. But when the loading strain rate is 1×10－4－1×10－3 s－1，a relative low value area is present for all values mentioned above，which is related to the microstructure of coarse crystal grain marble. The correlations between the initial cracking stress，critical dilatancy stress，elastic modulus and deformation modulus and the uniaxial compressive strength are linear. Under uniaxial compression，the more the energy dissipation before peak strength is，the higher the strength is；and the more the energy release after the peak strength is，the stronger the tensile through fracture characteristic is，and the more the fractured blocks are. The energy dissipation makes rock damage and the strength loss；and the energy release makes the macrofracture surface be run-through，inducing integral damage.

Keywords： rock mechanics uniaxial compression loading strain rate damage evolution energy release and dissipation

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