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锦屏水电站大理岩在高应力条件下的卸荷力学特性研究

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摘要 结合锦屏水电站深埋引水隧洞开挖工程，选取该区域典型大理岩，并以隧洞围岩实际应力环境为基础，开展卸围压破坏试验以及卸围压多级破坏试验。研究成果表明，锦屏大理岩在高应力条件下的卸荷力学性质主要表现为：(1) 相同初始应力条件下，岩石达到卸荷破坏所需应力变化量比轴向压缩破坏时小，卸荷更容易导致岩石破坏；(2) 岩石卸荷开始后侧向变形明显加快，且表现出显著扩容，如果忽略卸荷前岩样变形，则体积变形几乎按照侧向变形的规律增大；(3) 卸围压过程中，泊松比近似按照多项式关系增长。变形模量初始变化不显著，屈服前微量围压减少引起变形模量急剧减小；(4) 卸荷条件下抗剪强度参数c值比加载条件下低14%，而j 值比加载条件下高23%。这些结论揭示高应力条件下大理岩的卸荷力学特性，为深埋引水隧洞开挖稳定分析提供可靠依据。

关键词 岩石力学；深埋隧洞；大理岩；卸荷破坏；力学特性；试验研究
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STUDY ON MARBLE UNLOADING MECHANICAL PROPERTIES OF JINPING HYDROPOWER STATION UNDER HIGH GEOSTRESS CONDITIONS

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Abstract
The Jinping Hydropower Station is a large-scale national key project，of which the diversion tunnels are deep-buried. Especially the tunnels are located in a high geostress area；so it is of significance to study the variation laws of unloading mechanical properties under high geostress conditions. To simulate the tunnel excavation unloading effect，a series of triaxial unloading tests and a special designed multiple failure state unloading tests are carried out. The results show that under high geostress conditions，the unloading properties of marble specimens are as follows. (1) Under same initial stress conditions，stress needed in axial compression failure is more than that in confined unloading failure. Confining pressure reduction is prone to cause rock failure. (2) From the very beginning of unloading，the lateral deformation increases remarkably；and dilatancy presents prominently. Moreover，if the deformation caused by initial axial compression is disregarded，the

volumetric deformation increasing is dominated by lateral deformation. (3) During the unloading stage，the relationship between Poisson¢s ratio rises up；and the confining pressure could be well described by biquadrate. The deformation modulus declines indistinctly at first，while as failure approaching，even little confining declination would cause large decreases. (4) Shear strength parameter c under unloading conditions is 14% lower than that under conventional compression conditions；while j is greater than that about 23%. These conclusions reveal the unloading properties of marble under high geostress conditions and offer important references for stability analysis of deep-buried tunnels.
Key words rock mechanics；deep-buried tunnels；marble；unloading failure；mechanical properties；experimental study

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