

Triaxial Hopkinson Bar Technique and Deep Rock Dynamics

Abstract: Dynamic disasters induced by deep complex high-stress and strong disturbances present a scientific challenge for deep resource development and strategic infrastructure construction. The development of three-dimensional dynamic techniques and theories for deep rock masses is crucial for efficient construction and safe operation in major engineering projects such as deep resource extraction, scientific laboratories, nuclear waste disposal, and tunnel transportation. This report provides a detailed introduction to the development of a Triaxial Hopkinson Bar (Tri-HB) system, which achieves coupling of three-directional static pre-stress and dynamic loading to capture the dynamic mechanical response of rock under multi-confining pressures and a wide range of strain rates. Based on the triaxial Hopkinson bar system, experimental methods for dynamic tension, shear, and compression of rock under uniaxial, biaxial, and triaxial stress states using the same cubic specimen are proposed. These methods explore the strain rate effect and confining pressure effect on the dynamic failure of rock. By combining high-speed photography, three-dimensional digital image correlation (3D-DIC), synchrotron-based micro-CT (μ CT), and SEM observation techniques, the multi-scale damage and failure mechanisms of rock under dynamic loading are studied. The research findings reveal the mechanisms of dynamic damage, fracture, and catastrophic evolution in rock under different static-dynamic loading combinations, providing experimental and theoretical foundations for the prevention and control of dynamic disasters in deep Earth.

Keywords: Triaxial Hopkinson Bar; Rock Dynamics; Strain Rate Effect; Confining Pressure Effect