

Rock Stress Measurement in Manhattan, New York

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Abstract

Knowledge of the structural geology and the state of stress in the ground are critical requirements for efficient design of underground excavations. The methods of establishing the structural geology for major infrastructure projects in New York City were presented to the LIAG conference in 2004 but the state of stress was an elusive property at that time. It can be reasoned that there are sources of tectonic stress in Manhattan – it is the location of repeated tectonic activity and quaternary loading and unloading as testified by the complex metamorphic relics and glacial paleo-surface. However, there are only a few anecdotes of manifested high stresses during construction and none at the shallow depth of typical transportation projects.

This paradox was examined initially by theoretical analysis and numerical modeling, which confirmed that the magnitude and orientation of in situ stress is a critical influence on the stability and cost of excavating large underground openings in the rock of the type required for the new transit network for the City. If the state of stress is large compared to the strength of the rock mass it will fail or deform to an unacceptable degree. Also, certain stress conditions enhance the strength of the rock by locking the fractures and faults together. Both of these scenarios can be controlled by design and construction methods if the magnitude and orientation of the principal stresses are known.

The method of borehole hydrofracture was used to measure the in situ stress and the orientation was determined by impression packer. The measurements were compared to other data from Manhattan. The results show that the horizontal stress in Manhattan is very high compared to the vertical or overburden stress. However, the magnitude of the stress would be expected to cause significant movement of the ground that would be more than observable but commonplace during construction. A parallel study of the shape and condition of fractures in Manhattan rocks revealed these to be very complex shapes with multi-scale irregularity. It is possible that the lack of observed behavior normally associated with such high stresses is attributed to this tortuosity and roughness of the fractures.