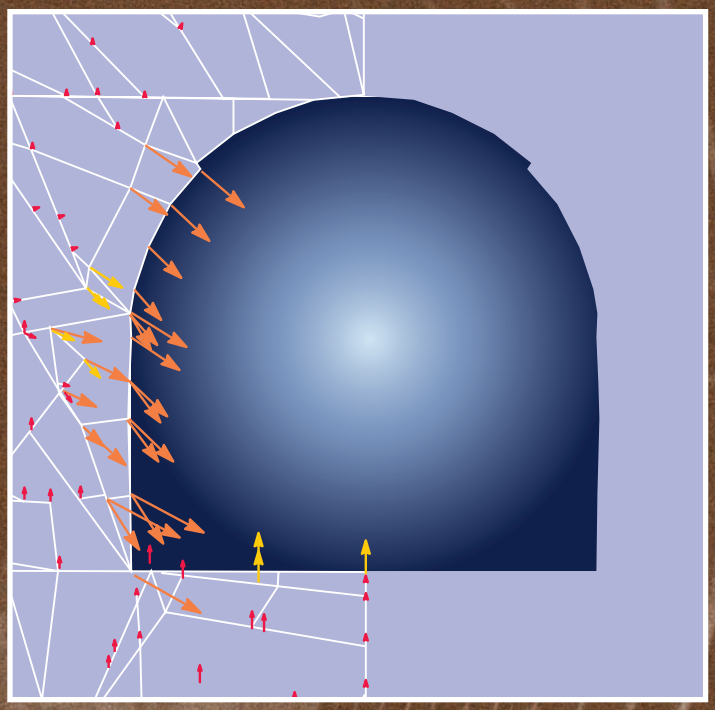
Geotechnical & Mining Engineering Services



Southwest Research Institute®
San Antonio, Texas

s an independent, nonprofit research and development organization, Southwest Research Institute (SwRI®) uses a multidisciplinary, integrated approach to solving complex problems in science and applied technology.

SwRI provides effective solutions to a broad range of geotechnical and mining engineering problems. Experienced staff members use state-of-the-art computer, laboratory, and field study equipment to solve diverse scientific and engineering problems related to surface and underground structure stability.

The Institute has developed an international reputation for its expertise in the following technologies:

- Physical and earth sciences
- Material sciences and engineering
- Hazard and risk assessment
- Environmental science and engineering
- Regulatory interpretation, implementation, and compliance demonstration

The Institute's comprehensive services address geotechnical and mining industry needs in areas such as:

- Numerical modeling
- Site investigations
- Laboratory testing
- Reliability analyses
- Borehole stability assessment

About the Cover Inset:

Numerical simulations are used to calculate stresses and displacements resulting from a combination of in situ *stresses and thermal loads.*

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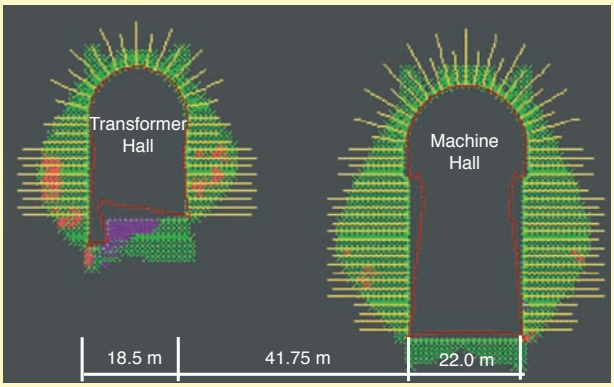
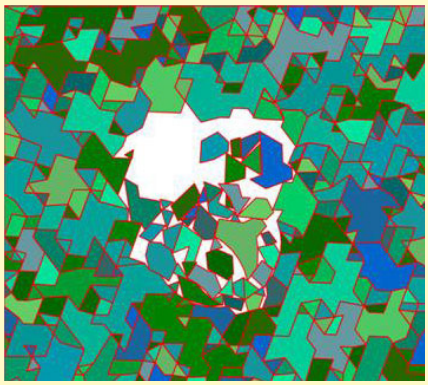
Numerical Modeling

The Institute develops and applies numerical modeling to solve a variety of geotechnical and mining engineering problems. Staff members have also modified available numerical codes to meet client needs in:

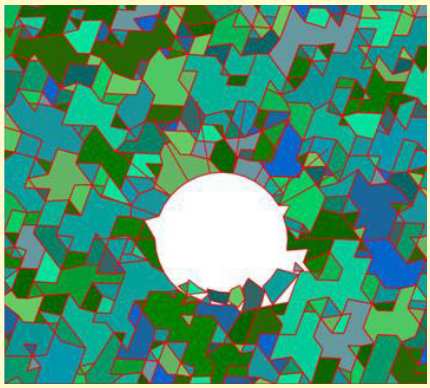
- Underground and surface structural stability assessment (for example, longwall chain and yield pillars and entry; multiple seam mining optimization; and surface slope) using continuum, discontinuum, and particle flow methods
- Earthquake and rockburst stability determination
- Support system design and analysis including rock bolts, lining, and shotcrete
- Rock- and soil-structure interaction
- Earthquake ground response analysis
- Failure zone and progression estimation



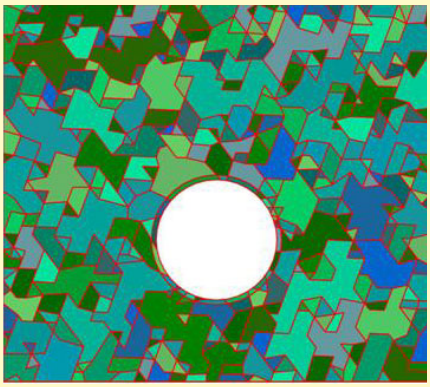
SwRI staff have experience applying numerical modeling to the design analysis of Transformer Hall and Machine Hall in an underground cavern.



Unsupported underground excavations may be unstable when subjected to mine seismic events or high stresses.



Underground excavations may be stabilized using rockbolts.



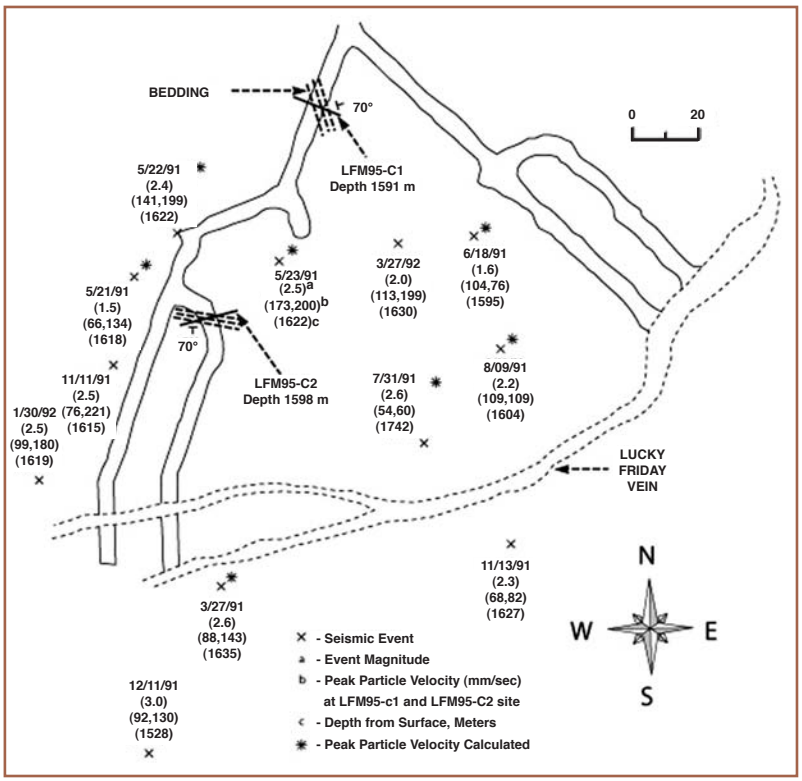
Underground excavations may also be stabilized using shotcrete.

SwRI engineers assess the effectiveness of ground supports under complex ground conditions using numerical models.

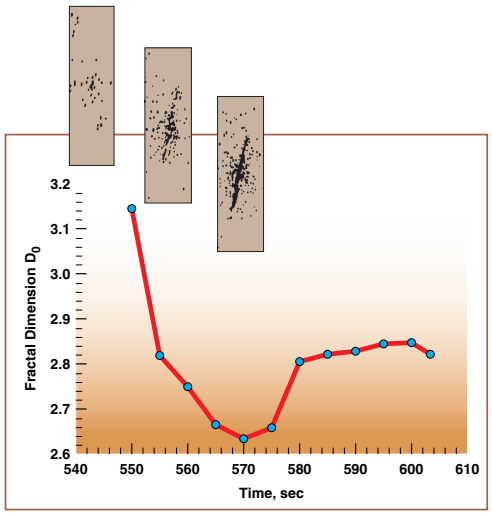
Site Investigation

The Institute conducts comprehensive field studies to characterize sites and evaluate effects of mining-induced seismicity on underground excavation stability. SwRI field experience includes a wide range of investigations and assessments, including the following:

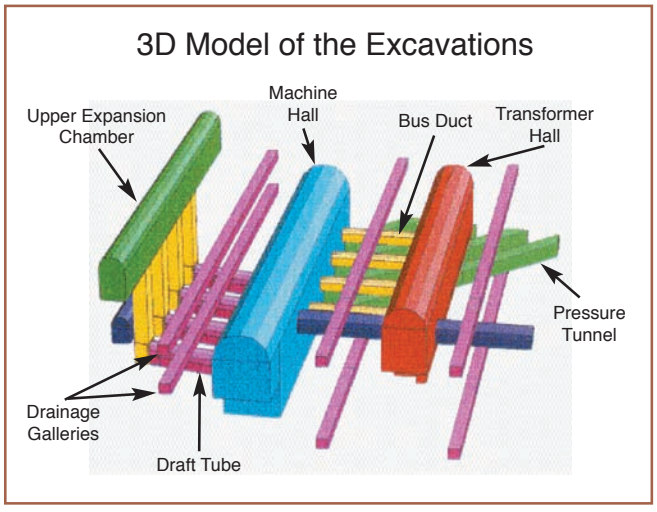
- Instability prediction and monitoring under earthquake loads
- Underground pillar and entry stress and deformation measurements
- Support systems (including rock bolt, lining, shotcrete, and soil nailings) design and effectiveness assessment
- Rockburst and mine seismicity monitoring and investigation
- Damage zone estimation, monitoring, and propagation assessments
- Slope stability monitoring and assessment under gravity, hydrological, and earthquake loads
- Surface subsidence measurements and assessments
- Soil and rock mass classification and characterization
- Rock fracture geometry surveying and fracture network simulation
- Blasting-induced structural damage assessment
- Hydrological response assessment



SwRI engineers monitored mining-induced seismicity greater than magnitude 1.5 on the Richter scale at a deep undergound mine.



SwRI engineers are developing a methodology for early warning of rockburst potential.



Institute staff members extensively instrumented sites to aid the design of an underground hydropower facility.

Laboratory Testing

To understand rock and soil behavior under a variety of conditions, SwRI engineers determine physical and mechanical properties through a battery of laboratory tests. These test results contribute to the design, structural modeling, and stability assessments of mines, shafts, tunnels, and various underground storage structures. Using methods approved by the American Society for Testing and Materials and the International Society for Rock Mechanics, SwRI performs laboratory tests on rock specimens and joints, soils and granular materials, and scale models of openings in jointed rock masses. Laboratory testing services include:

- Direct shear tests of large rock fractures and soil specimens
- Small-scale physical model tests of underground and surface structures under static and dynamic loads
- Specialized laboratory tests, including damage assessment of underground excavations under repetitive seismic loads
- Shear and creep tests
- Uniaxial and triaxial compression tests for rock strength, modulus, shear wave velocity, and compressive wave velocity measurements
- Surface profile measurement and roughness characterization

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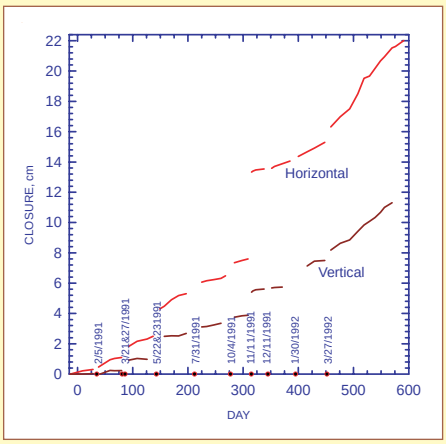
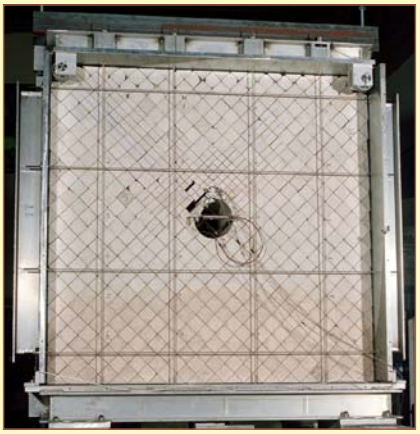
SwRI engineers studied the effects of mine seismicity on the stability of underground excavations.



SwRI-conducted field investigations to show the stepwise closure of an underground excavation as a result of mine seismicity.



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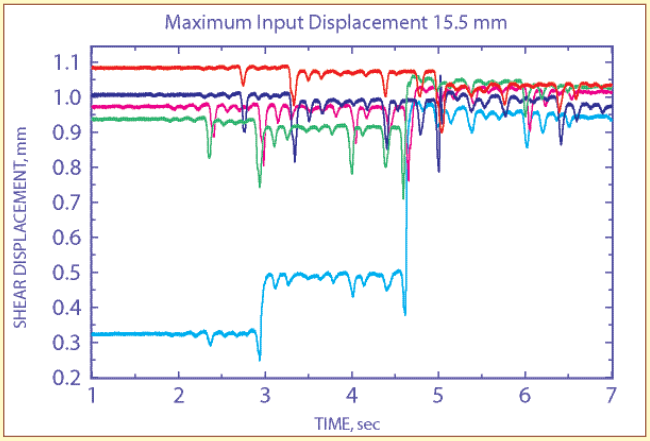
An Institute laboratory experiment measured the deformation around an underground excavation subject to an earthquake ground motion.



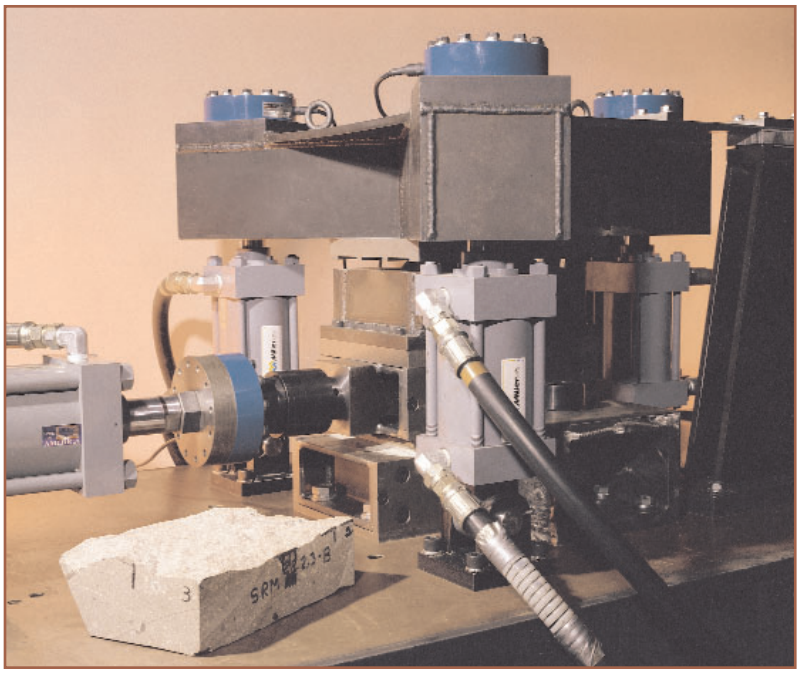
Engineers investigated the effects of mine seismicity using standard and customized tests.

SwRI has extensive laboratory testing capabilities to evaluate potential problems in the field.

Laboratory Facilities

As an internationally recognized multidisciplinary research and development organization, SwRI has extensive laboratory facilities. The Institute has innovative and state-of-the-art facilities for performing a variety of geotechnical and geological evaluations including:

- Environmentally controlled scale-model evaluation
- Rock sample preparation and physical testing
- Rock strength, modulus, and shear and compressive wave velocity measurements



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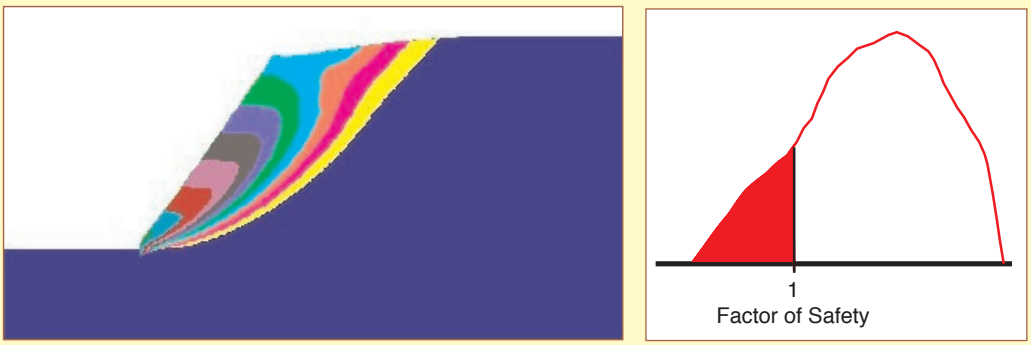
Experienced SwRI engineers design and build specialized test equipment, such as this device for large-scale dynamic shear tests of natural rock fractures under earthquake loads.

A triaxial test cell enables engineers to determine a rock matrix failure envelope under various environments including pore-pressure and heated conditions. The test cell also measures the shear and compressive wave velocities of rocks undergoing progressive damage.

Reliability Analyses

The Institute conducts comprehensive reliability analyses on a variety of geological and support structures, including

- Soil and rock slope
- Tunnel reliability
- Support systems

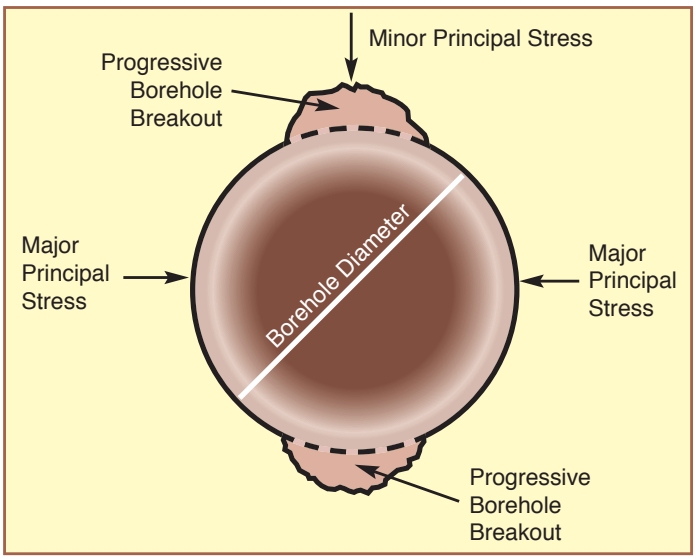


Institute engineers assess the reliability of a slope considering uncertainties related to slope geometry, material and fracture properties, and watertable location.

Borehole Stability Assessment

The oil and gas industry is striving to reduce drilling-related costs and downtime and to enhance well production by controlling potential borehole stability and sanding problems. SwRI engineers conduct numerical analyses to identify potential borehole failure mechanisms and to provide cost-effective solutions. SwRI provides a variety of drilling and borehole-related service support including:

- Borehole stability estimation considering presence of weak zones, fractures, and variation of material properties
- Mud weight estimation while drilling
- Potential caving analysis
- Drill performance estimation
- Potential sand formation
- Material properties investigation
- Wave propagation analysis



Using advanced numerical modeling, SwRI engineers assess potential borehole breakout mechanism and recommend methods of preventing or reducing the severity of breakouts.

Southwest Research Institute is an independent, nonprofit, applied engineering and physical sciences research and development organization using multidisciplinary approaches to problem solving. The Institute occupies more than 1,200 acres and provides nearly two million square feet of laboratories, test facilities, workshops, and offices for more than 3,000 employees who perform contract work for industry and government.

We welcome your inquiries.
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