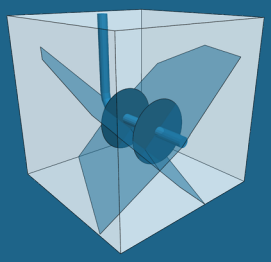


XSite™ VERSION 3.0

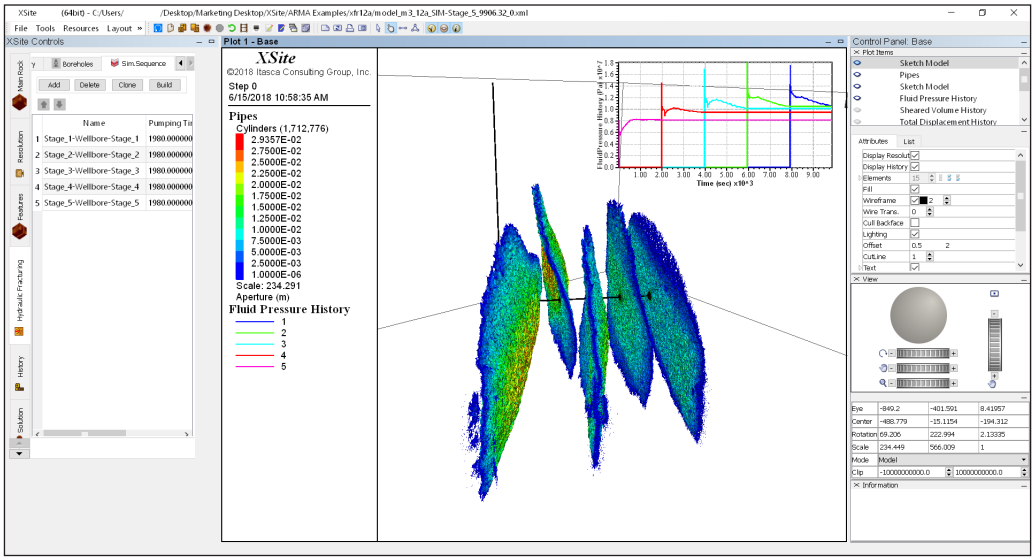
Hydraulic Fracture Simulation of 3D Fracture Networks

ABOUT *XSite*

XSite is a powerful three-dimensional hydraulic fracturing numerical simulation software based on the Synthetic Rock Mass (SRM) and Lattice methods. *XSite* is capable of modeling multiple wellbores with multiple stages and clusters, including open-hole completions and perforation tunnels. The software resolves general hydraulic fracture interaction, including propagation in naturally fractured reservoirs with deterministically or stochastically generated discrete fracture networks (DFNs). The models conduct fully coupled hydro-mechanical simulations. Fluid flow is simulated as fracture flow within the joint networks and as matrix flow within the intact rock. Proppant transport and placement logic is included. Proppant affects fracture closure and fracture conductivity. General pumping schedules can be simulated with switching injected Newtonian or power-law fluids. The borehole flow is coupled with the rest of the model to determine distribution of fluid between multiple clusters. Synthetic microseismicity can be tracked and recorded.

SPECIAL-PURPOSE SOFTWARE

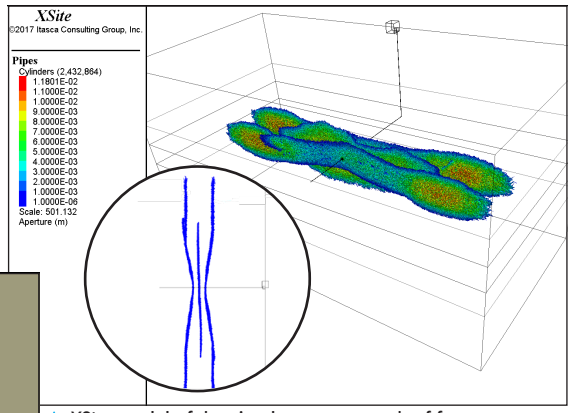
- The user interface is easy to use with no commands or scripting needed
- Extendable library of rock and fluid types; no numerical calibration necessary
- Easy definition of geology (layers and structures), including importing geological geometries from DXF files
- Easy definition of multiple wellbores, stages, and clusters, including importing geometry from DXF files
- Easy definition of injection rates and schedules
- Easy post-processing with many plot types
- Model state can be saved at any stage and restarted later
- Models can be run interactively and in batch mode
- Export results in many formats, including formats that can be read by reservoir simulators



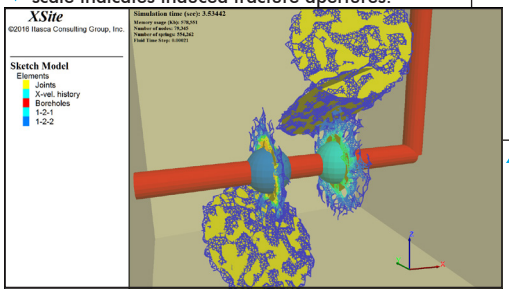
XSite has a user interface designed to ease model creation, execution, and post-processing. Commands or scripting not required.

FEATURES

- No assumptions regarding the fracture shape or trajectory
- Fracture propagation in inhomogeneous and naturally fractured rock masses
- Interactions between hydraulic fractures, joints, and between stages and wells (including the stress shadow effect and hydraulic connectivity) are accounted for
- In situ stresses may be specified
- Arbitrary number of wellbores and injection points
- Monitoring of synthetic microseismicity
- Non-steady fluid flow within joints and the intact rock
- Proppant transport and placement



XSite model of clusters along a well near discrete joints interacting with induced fractures. Color scale indicates induced fracture apertures.



XSite model of the simultaneous growth of fractures from three perforation clusters within one stage, located in a multi-layer formation, showing stress interference between the fractures. The plot shows fracture aperture. The insert (plan-view) shows the non-planar geometry resulting from the interaction between the fractures.

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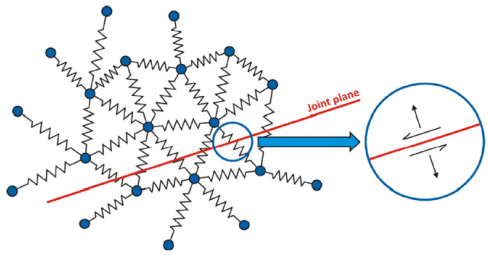
Consulting Group, Inc.

www.itascacg.com/xsite

THE LATTICE METHOD

- Based on the Distinct Element Method (DEM), with particles and contacts replaced by nodes and springs, respectively
- Nodes with masses are arranged quasi-randomly, connected by normal and shear springs, which can fail in brittle manner (i.e., micro-cracks)
- Micro-cracks may coalesce to form macro fractures with a propagation criterion based on the fracture toughness
- Spring elastic/strength parameters calibrated automatically from fracture toughness and unconfined compressive and tensile strengths
- Pre-existing joints represented by the smooth-joint model that accurately predicts slip and opening/closing of joints
- Thousands of pre-existing joints (DFN) can be included
- Uses an explicit solution scheme, which is well-suited for simulation of highly nonlinear behavior, such as fracture slip and the opening/closing of joints.



SYNTHETIC ROCK MASS (SRM)

- A mechanics-based approach representing the dominant mechanisms of deformation and damage of fractured reservoirs
- Explicitly defines a discrete fracture network (DFN) within a modeled rock matrix
- Both the intact rock and the joints can be mechanically characterized by standard laboratory tests
- Not necessary to rely on empirical relations to estimate the rock mass properties and to account for the size effect (i.e., from the tested sample size to the scale of interest in the model)

HYDRO-MECHANICAL COUPLING AND FLOW

- Fluid flow and mechanical simulations can be done separately or coupled
- The fluid flow is approximated by a flow through a network of pipes that connect fluid elements, located at the centers of either broken springs or springs intersected by pre-existing joints
- The flow pipe network is dynamic and automatically updated by connecting newly formed micro-cracks to the existing flow network
- Non-steady fluid flow is modeled within the joint network and intact rock, maintaining continuity of fluid mass and pressures between joints and the rock matrix
- Effective stress calculations are carried out
- Fracture permeability depends on aperture, or on the deformation of the solid model
- Fluid pressure affects both deformation and the strength of the solid model
- The deformation of the solid model affects the fluid pressures (i.e., fluid pressure changes under undrained conditions)
- Includes logic for simulation of proppant transport and placement
- Newtonian and power-law fluid flow available
- Non-Darcy effects and pressure drop at perforation clusters are possible
- Represents leakoff explicitly, as flow into DFN and porous medium flow into rock matrix, or as Carter leakoff

APPLICATIONS INCLUDE

- Reservoir-scale, multi-well, multi-stage field stimulation by multiple fracture propagation with application to both petroleum and Engineered Geothermal System (EGS) operations
- Near-wellbore models to simulate fracture initiation
- Proppant transport and placement
- Prediction of microseismicity
- Rock mass preconditioning for mining operations

THERMAL ANALYSIS

- Heat conduction (and thermo-mechanical effects) in the rock and heat exchange with the fluid in fractures can be simulated
- Approximated heat advection by injected fluid

MICROSEISMICS

- Synthetic microseismicity is generated as the fractures slip or propagate, providing a method for model calibration with field observations

PROVEN

- Verified by comparison with analytical and semi-analytical solutions of different problems that involve important aspects of hydro-mechanical coupling during hydraulic fracture propagation
- Used by Itasca for consulting projects
- Used by industry, including BP America and Aramco Research Center
- Used by universities, including University of North Dakota, University of Pittsburgh, University of Utah, Tongji University, and Ecole Polytechnique Federale De Lausanne

LICENSING

Itasca is pleased to offer *XSite* as an annual license for industry, and a discounted annual academic license for recognized research institutions.

XSite can be run on both Windows and Linux operating systems. The Linux version has the same functionalities and efficiency as the Windows version, but can be used in High Performance Computing (HPC) centers (i.e., large number of the fastest currently available machines) and includes automatic execution of parametric studies (e.g., sensitivity studies and Fracture Network Engineering).

TRY A DEMO

Itasca is pleased to offer a fully-functional, free one-month demo version of *XSite* on request. For further information, or to make a request for a demo, please contact us at:

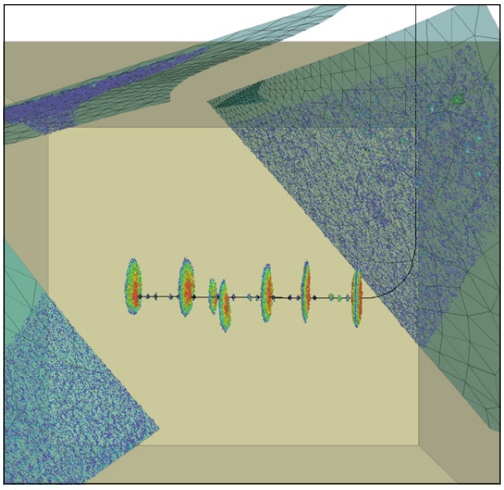
xsite@itascacg.com

ORDER SOFTWARE

For more information or to request an *XSite* software quotation, please contact our sales team:

+1 (612) 371-4711

software@itascacg.com



▲ Fallon FORGE EGS site *XSite* model showing geometry of hydraulic fractures and contours of aperture.