3DEC™ VERSION 5.0
Advanced, Three Dimensional Discrete Element Modeling
for Geotechnical Analysis of Rock, Blocky Structures and Structural Support
Introduction

3DEC is numerical modeling software for advanced geotechnical analysis of soil, rock, blocky structures and structural support in three dimensions. 3DEC simulates the response of discontinuous media (such as jointed rock or masonry structures) that are subject to either static or dynamic loading.

Discontinuous medium is modeled as an assemblage of polyhedra blocks which may be rigid or made deformable through zoning. Fractures are treated as boundary conditions between blocks. Motion along discontinuities is governed by linear and nonlinear force-displacement relations for movements in both the normal and shear directions.

Hydraulic and seismic analyses were modeled for a dam. Free-field meshes provided the lateral dynamic boundary conditions.

Ancient temple undergoing a simulated earthquake using the dynamic option.

Slope failures caused by interaction of large-scale structures.

Displacement contours are shown.
3DEC is an accurate and efficient geotechnical analysis tool, using an explicit solution scheme that gives stable solutions to unstable processes. 3DEC can model large surface and underground excavations and masonry structures.

### Features

- Single-precision, double-precision, 32-bit and 64-bit versions all come standard.
- Automatic mesh generation in fully deformable blocks.
- Automatic time-step calculation.
- FISH, Itasca’s built-in scripting language, provides powerful user-control to parameterize, analyze and control nearly every aspect of the simulation.
- UDM or user-defined models (optional).
- Explicit time-marching solution that provides realistic path dependent post-peak failure behavior in joints and plastic zones.
- Beam and cable structural elements (and liners, optionally), with general coupling to blocks, are included.
- Nodal Mixed Discretization to provide more accurate solutions for certain plasticity analyses.
- Automatic Factor of Safety (FOS) calculation based on the Shear Strength Reduction (SSR) method for Mohr-Coulomb and Hoek-Brown materials.
- Extensive, fast interactive menu-based 3D OpenGL onscreen graphics.
- Interactive mouse provides point-and-click control of model views as well as the ability to measure and query plot views.
- Built-in text editor provides command syntax error checking and context sensitive help.
- Tunnel region generator.
- Statistical joint-set generator.
- Effective stress calculations are performed using pore-pressure gradients.
- Mechanical models can be fully coupled with both joint fluid flow and thermal (optional) models.
- Null blocks can be specified to simulate excavation and backfill simulation without deleting the block.
- DXF import for visualization.
- Motion absorbing boundaries and wave input for fully dynamic (optional) response.
- “Infinite domain” models can be simulated using inner/outer region coupling.

### Standard Material Models

- Elastic
- Anisotropic
- Mohr-Coulomb
- Hoek-Brown*
- Ubiquitous joints
- Bilinear plasticity
- Strain-softening
- Visco-plastic creep
- Visco-elastic creep

*Both Hoek-Brown and modified Hoek-Brown constitutive models are included.

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The 3DEC graphic user interface has been updated and can be customized.

Discrete fractures of limited extent can be created within a model by defining different intact and joint properties along through-going cuts.

3DEC now features a probabilistic Discrete Fracture Network (DFN) generator. DFNs also can be imported and exported.
Vastly Improved Performance

- Overall model construction and run-times are much faster now due to more rapid block cutting and deletion processes combined with faster calculation cycling (for both small- and large-strain) on multi-threaded computers. A 3DEC timing test* (shown, in part, below) demonstrated a 16x overall performance improvement.

User-Interface Additions

- Projects permit files and plots to be combined.
- Command-level UNDO: A complete record of all commands used to create a model is recorded in the model save file.
- Interface panes can be adjusted and customized.
- Context sensitive HTML help is now available.
- Additional methods of filtering objects: If connected to interfaces, if on model surface, filter by object extent instead of centroid, etc.

* Performance factor is based on a model consisting of 40,000 blocks and 800,000 zones generated with 31,000 construction cuts, 7380 fractures and 3,560 block deletions. The model was run for 10,000 steps using a 2.9 GHz i7 3520M computer processor with 4 cores was used. Results will vary from problem to problem.
Enhanced FISH

- Many improvements have been added to FISH, Itasca’s powerful built-in scripting language that permits users to control, monitor, parameterize and customize most aspects of a model.
- EXTRA variables and GROUPS have been added for blocks, zones, gridpoints and contacts; input to FISH functions, command in-line FISH, ELSE IF, EXIT LOOP, APPEND of ASCII files and fluid-flow functions are just some of the new features.

To enhance and simplify model interpretation, new model-result plotting tools include zone plotting, isosurface contouring and surface painting.

Pore pressure plot of jointed rock undergoing hydraulic fracturing. The model DFN can be seen in the circular insert.

New Results Interpretation Tools

- Zone plotting.
- Joint-surface property plotting.
- 3D isosurface contouring of zone and gridpoint data.
- Model results can be painted (contoured) now onto geometry surfaces imported from DXF or STL formats.
- Voxel plotting.

Other New Features Include

- New “WALL” block type. Calculations for wall motion and wall-to-wall contacts are skipped, speeding up model runs.
- The Modified Hoek-Brown constitutive model is now compatible with factor of safety calculations.
- Projects can be Packed and Unpacked to more readily share or archive your work.

Many new plot items are now available.

- Joint structure
- Block structure
- Displacement and velocity vectors and contours
- Zone stresses
- Joint plane displacements and stresses
- Structural element displacements and stresses
- Fluid flow apertures and velocities
OPTIONAL MODULES

Options in 3DEC are sold separately from the software license. These options provide rich, powerful additions to the base software allowing users to augment the program’s functionality according to their analysis needs.

Dynamic
Models the full dynamic response of a system in the time domain. Capabilities include: specification of velocity or stress-wave input, quiet boundaries, free-field conditions and damping (mass- and stiffness-proportional Rayleigh). Problems such as seismic loading, explosive loading, seismic release of energy and flow of particles may be simulated.

Thermal
Effects of heat sources embedded in a material are modeled with this option. Both numerical and analytical formulas are included. Point heat sources may be placed individually, in lines, or in grids, to represent point, line or plane sources of heating. The analytic formula yields rapid calculations. Mechanical and fluid coupling is supported in the numerical formula. Inhomogeneous and anisotropic mechanical properties are supported.

Structural Elements (Liners)
This option adds the ability to model tunnel liners and external structures (such as dams, bridges, walls, buildings, etc.). The tunnel liner logic automatically places equally spaced triangular-shaped plates on the inside surface of an excavation or tunnel. External structures can be modeled using finite elements that are attached to the 3DEC model.

UDM
User-defined constitutive models (UDM) can be written in C++ and compiled as DLL files that can be loaded as required. A Visual C++ Version 2010 compiler is used to compile the DLL files. This permits exchange of constitutive models among users. Models may be shared with other Itasca software products that contain this feature (FLAC, FLAC3D and UDEC).

KUBRIX® Geo Block Generator
An optional software tool, KUBRIX® Geo can seamlessly generate 3D blocks ready for import into 3DEC. This unique automatic grid generator can create complex 3DEC models for the efficient generation of multi-scale, boundary-fitted models. The blocks produced conform to material, group or region boundaries with fractures being converted to joints or contact surfaces in 3DEC.

For more information:
www.itascacg.com/kubrixgeo/index.php

▲ An open pit created using KUBRIX Geo. A section though the model reveals its block structure
**SUMMARY**

**Suggested System Minimums**
- Windows XP, Windows Vista, Windows 7 and Windows 8; 10 GB free space on hard drive; 2 GB RAM; Graphics card with OpenGL 1.3 or higher; 1GHz or better processor.

**Standard License Includes**

**Support**
- Free: Software updates and support information via website; free direct support for software installation and general software operation. Free admission to a regularly scheduled training course for one person.
- Fee-based: Engineering consulting or model generation support is available.

**Sales**
- Locations of Itasca offices and agents throughout the world, including a locator to determine the user’s 3DEC sales office/agent, are available from the Itasca website: www.itascacg.com/software/sales.php

**Supplemental Software Available**
- User Defined Models (UDM), Dynamic Analysis, Thermal Analysis and Structural Liners.

*These options are included at an additional cost.