Numerical modeling software for advanced geotechnical analyses of soil, rock, groundwater, and ground support in two dimensions.
FLAC 8.0

FLAC (Fast Lagrangian Analysis of Continua) is numerical modeling software for advanced geotechnical analysis of soil, rock, groundwater, and ground support in two dimensions. FLAC is used for analysis, testing, and design by geotechnical, civil, and mining engineers. It is designed to accommodate any kind of geotechnical engineering project for continuum analysis.

FLAC utilizes an explicit finite difference formulation that can model complex behaviors not readily suited to implicit finite element method (FEM) programs, such as problems that consist of several stages, large displacements and strains, non-linear material behavior, or unstable systems (even cases of yield/failure over large areas, or total collapse).

The main components of the Graphical User Interface (GUI) are the: ① Project Tree, ② Resources Pane, ③ Modeling Stages, ④ Stage Tools, and ⑤ View Toolbar.
LICENSES

STANDARD LICENSE
A standard license is designed for flexible, perpetual, single-user program use. A standard license will allow up to two instances of FLAC to be run simultaneously on a single computer. However, there is no limit to the number of instances that may be open, permitting you to set up new simulations or analyze existing model results. The program is secured with a key that must be connected to a computer to allow the program to solve/cycle. The security key may be moved between computers and users as needed. This option is ideal for an individual or for multiple users within the same office sharing the software.

NETWORK LICENSE
A network license will cycle a number of FLAC instances equal to the number of seats purchased for the license. In this configuration, the security key and server management software are installed on a server while the FLAC program is installed on end-user computers. The program may be installed on as many computers as needed. This license is ideal for a centralized IT administered organization.

LEASE LICENSE
Both the standard and network licenses can be leased monthly at a prorated cost.

ACADEMIC LICENSE
Academic discounts for non-commercial standard and network licenses are available to qualified institutions. Itasca also invites students and professors to ask about the Itasca Education Program (IEP) and Itasca Teaching Program (ITP).
APPLICATIONS

Use FLAC for stability, remediation, and other geotechnical and groundwater analyses in civil, mining, oil & gas, and power generation engineering fields. The following examples are highlighted, but through scripting and custom constitutive models the possibilities are virtually limitless.

CIVIL
- Slopes
- Tunneling
- Shafts
- Caverns
- Excavations
- Foundations
- Earth retaining structures
- Embankments
- Rockfill and concrete dams
- Harbor structures
- Dewatering and water flow
- Pavement and subgrade
- Waste disposal

MINING
- Open pit slopes and benches
- Dewatering and water flow
- Tailings dams
- Underground stopes, shafts, tunnels, caverns, and passes
- Room and pillar mining
- Waste rock piles
- Blasting and rock bursts
- Ground subsidence
- Backfill design
- Solution mining
- Longwall mining

OIL & GAS
- Conventional and unconventional
- Well completions
- Enhanced recovery
- Fluid injection
- Hydraulic fracturing
- Wellbore optimization
- Casings
- Borehole breakout
- Sanding
- Fault movement and integrity
- Compaction and subsidence
- Salt caverns
- Reservoir-scale modeling
- Cap rock integrity
- Microseisms

POWER GENERATION
- Engineered geothermal systems
- Hydroelectric dams
- Nuclear waste isolation
- Hydro/thermal plants
- Hydroelectric power houses
- CO₂ sequestration
- Wind turbine foundations
- Engineered barriers
- Cap rock integrity
FLAC cohesion plot showing dog-ear shaped borehole breakouts in an oil-saturated, low-permeability sandstone with a confining pressure of 40 MPa.

Large-strain model of a shallow, circular tunnel in soft ground. Contours of vertical displacement and displacement vectors are shown. With large-strain, the plot is based on updated coordinates calculated each solution cycle.

Dynamic model of an earth dam showing contours of shear strength increment and displacement vectors.
FLAC offers large-strain simulation of continua using interfaces that simulate faults, joints, or boundaries, driven by an explicit solution scheme that can model unstable physical processes.

It offers 17 built-in material models, groundwater flow, coupled mechanical-flow calculation, inclusion of structural elements, plotting statistical distribution of any property, optional automatic remeshing during solution, and a built-in scripting language (FISH) to customize or automate virtually all aspects of program operation, including user-defined properties and other variables.

The program can be configured using optional modules that extend the capabilities of the base program (see the Options section for more information).

The program interface offers a fully integrated development environment that includes project management facilities, built-in libraries of materials, pre-defined meshes, movies, extensive plotting capabilities, and run-time monitoring of results.

GENERAL
- Large-strain simulation of continua
- Explicit solution scheme
- Extensive solution controls and options
- Multi-physics modeling
- Histories of model properties and results allow for comparison to actual monitoring and instrumentation data
- Built-in scripting language (FISH)
- Multi-threaded solutions with no CPU locks or additional cost
- Built-in project management tools
- All operations can be implemented via the GUI, written commands, and/or FISH scripting
- Coupled hydro-mechanical-thermal effects

GRIDS and GEOMETRY
- Visual model geometry creation and manipulation tools
- Library of pre-built geometries
- Import grid geometry from CAD or table data
- Automatic grid re-meshing tools
- Export extruded FLAC3D models
MATERIALS and CONSTITUTIVE MODELS

• Built-in material properties database
• Option to add user-defined models via C++
• Specify property statistical distributions
• Groundwater fluid flow analyses are included
• Includes 17 standard, built-in material models:
  • Null (for construction sequence and excavation)
  • Elastic, isotropic
  • Elastic, transversely isotropic
  • Drucker-Prager
  • Mohr-Coulomb
  • Ubiquitous-joint (UBJ)
  • Caniso
  • Strain hardening/softening
  • Bilinear strain hardening/softening UBJ
  • Double yield
  • Modified Cam-clay
  • Hoek-Brown
  • Modified Hoek-Brown
  • Cysoil soil
  • Simplified Cap-yield soil
  • Plastic Hardening (PH)
  • Swelling

BOUNDARIES and CONDITIONS

• Displacement and stress boundaries
• Artificial boundaries
• Structural elements include: beams, liners, cables, piles, rockbolts, strips, support members, and shells
• Water table for effective stresses
• Interfaces allow inclusion of faults, joints, and boundaries that permit slip, separation, and closure

SOLUTIONS

• Project tree and clone model tools make for easy construction sequencing and parametric analysis at any construction phase
• Rapid batch processing outside of the GUI using data files
• Groundwater flow calculations are included as standard
• Coupled calculations between standard (mechanical and fluid flow) and options (thermal, creep, C++ UDM, and dynamic)
• Mechanical and fluid flow calculations are multithreaded
• FLAC/Slope is included for simple and fast factor-of-safety analysis of soil and rock slopes and earth dams
FACTOR OF SAFETY ANALYSIS
• Automatic, fast solutions using the shear strength reduction (SSR) method
• Includes groundwater, structural support elements, and material strength properties for zones and interfaces – regions may also be excluded
• Mohr-Coulomb, Ubiquitous-joint, and Hoek-Brown constitutive models
• Associated plastic flow rule can be enabled
• Now includes automatic safety map contouring to indicate the distribution of factors of safety throughout the model

FISH SCRIPTING
FISH is a scripting language embedded within FLAC that enables the user to define new variables and functions. These functions may be used to extend FLAC’s usefulness or add user defined features (e.g., servo-control boundaries may be applied to a numerical test, unusual property distributions specified, and parameter studies automated).

POST PROCESSING
• Multiple graphical output formats (PNG, JPG, BMP, EMF, DXF, and PS)
• Copy plots to the clipboard to directly paste into reports or slides
• Easily export history results to spreadsheet-compatible CSV files
• Export tables, histories, and model variable data to ASCII files
• Extensive visual plotting facilities
• Automatically export a series of PNG images at regular cycling intervals for any plot in order to generate videos (third party software required)
FLAC models multiple failure mechanisms as they evolve naturally. In this example, a slope is reinforced with a sheet pile wall (SPW), shown in red. A factor of safety less than 1.0 is determined due to (a) global deep-seated shear failure, (b) an active wedge behind the SPW, and (c) the bearing capacity of the lower-most slope toe. The bending moments of the SPW are also shown in black.
WHY CHOOSE FLAC?

POWERFUL
- Numerical stability with large displacements, including collapse
- Very large models (64-bit)
- 17 built-in material behaviors
- Automatic factor-of-safety analysis
- Groundwater flow, creep, thermal, and dynamic modes
- Coupled solutions
- Accommodate complex materials and pore pressure distributions
- Assess service limit state criteria
- Deep scripting with FISH and user-defined constitutive models using C++

PROVEN
- Tested against analytical solutions
- Used by Itasca’s own consulting engineers and scientists
- A large repository of worked examples and validations with hundreds of articles and papers
- Used worldwide by industry, universities, and government agencies

EFFICIENT
- Multi-core processing
- Optimized solution calculations
- Customize material behaviors efficiently using optional C++ User-Defined Models (UDM)

RELIABLE
- Realistic physical solutions
- Natural evolution of failure
- Transparent methodology with all equations and algorithms fully documented
- Built-in constitutive models are open-source; no black boxes
- Strong software support led by an experienced team of engineers, scientists, and software developers
- Extensive manuals and documentation
- Automated update notification

FLEXIBLE
- General by design
- Access to almost all internal variables via the embedded FISH scripting language
- CAD interoperability
- Import/export data as ASCII
- Human-readable data files
- Users may write their own constitutive models, and may modify, or add to, most of the built-in algorithms using the optional C++ UDM
- Standard License is portable between computers and users
- Network licenses are available
- Leases licenses are available

ECONOMICAL
- No CPU limits
- No annual maintenance fee
- Academic discount
- Two instances of FLAC can be run on a single computer with a Standard License
NEW in FLAC 8.0

FLAC 8.0 offers a number of new and enhanced features that enable users to construct larger models and solve these models more easily and faster than ever. Additions to the user interface make working with FLAC easier and simpler.

64-BIT VERSION
FLAC models can now be substantially larger with more zones, nodes, and structural elements.

FASTER GROUNDWATER FLOW
FLAC now utilizes multi-threaded fluid-flow solutions, taking advantage of multi-core CPUs for faster calculations. Flow models can now be solved faster using a simplified uncoupled fluid-mechanical scheme (e.g., changes of the phreatic surface) and coupled-undrained and -drained simulations.

SAFETY MAPPING
The automatic, built-in factor-of-safety (FoS) contouring logic, using the shear strength reduction (SSR) method, has been expanded in FLAC. Now multiple local stability states can be evaluated and plotted on a single “safety map.”

BOUNDARY RELAXATION
The automatic boundary relaxation feature is used to slowly and systematically reduce forces along boundaries, as specified by the user. This can be used to simulate the 3D effect of advancing tunnels and is useful when modeling excavations in weak materials under high stresses by minimizing inertial effects. A ground reaction curve (GRC) can be recorded for each excavation.

NEW MATERIAL MODELS
• Plastic Hardening Model (PH)
• Mohr-Coulomb Swell Model (Swell)
• Anisotropic Ubiquitous Elastic Model (Canisotropic)
• Updated Cap-Yield Model (CYSoil)
• Ubiquitous Viscoplastic Creep Model (Cupow); creep option only
The seismic wizard facilitates the preprocessing of signals/waveforms used for dynamic analyses. Import ground motion data, apply filters and baseline corrections. Export processed data as FLAC history or table files.

An unsupported advancing tunnel simulation is simple to set-up using the new APPLY relax command, including recording the Ground Reaction Curve (GRC). In this example, the tunnel is brought to a relaxation factor of 0.2 prior to the installation of ground support. Contours of vertical displacement are also shown.
**AXISYMMETRIC SHELLS**

FLAC three-dimensional axisymmetric shell structures now allow for the calculation of in-plane and out-of-plane quantities (e.g., hoop stress resultants, hoop moments). FLAC shells may be used to model a variety of axisymmetric geometries, such as shaft lining support, pressure vessels, circular plates, etc.

**SEISMIC WIZARD for DYNAMIC ANALYSIS**

The new FLAC seismic wizard tool is designed to guide users and facilitate the preprocessing and correction of input signals for use in dynamic analyses. Users can import ground motion data (velocity or acceleration), filter high-frequency components with a specified cut-off frequency, apply a baseline correction, and export the processed data as a FLAC history or FLAC table file.

**UPDATED PLOT CONTOURING**

Five new contour ramps have been added as continuous-coloring schemes for contour plotting. There are now no color limits in FLAC for contours plots.

**GRAPHICAL USER INTERFACE**

- Model property dialogs now provide basic and advanced input
- Mechanical, fluid flow, and thermal boundary conditions are now easier to apply across attached grids
- Plot history data is accessible for export by right-clicking on the plot window (View data); the data can be saved in CSV format
- Mouse position identified by x, y coordinates and zone i, j numbers can be displayed at the bottom left corner of the FLAC main window
- The font size in the Record pane and the plot legend can be adjusted (CTRL + mouse scroll)
- The DOS console window can now be hidden or visible

**AND MORE ...**

- The SOLVE elastic command now works with most plasticity constitutive models
- The length and angle of structural elements can be specified
- Multiple histories can be exported to a file with data written either vertically or horizontally
- Liner moment-thrust and shear-thrust diagrams can be plotted
- FISH line statements can now contain up to 200 characters
- New FISH Library function can automatically vary the slope angle iteratively to reach a given factor of safety
OPTIONS

Options in FLAC are sold separately from the code license, allowing users to augment the program’s functionality according to their analysis needs.

DYNAMIC OPTION
The dynamic analysis option permits two-dimensional, plane-strain, plane-stress, or axisymmetric, fully dynamic analysis with FLAC. This formulation can be coupled to the structural element model (soil-structure interaction), to the groundwater flow model (liquefaction), and to the optional thermal model.

CREEP OPTION
This FLAC option can be used to simulate the behavior of materials that exhibit creep (i.e., time-dependent material behavior). Eight creep models are included: viscoelastic, two-component power-law, WIPP, PWIPP, Burgers, Mohr-Coulomb power law, CWIPP (crushed-salt), and a new power-law viscoplastic creep with ubiquitous joints.

TWO-PHASE FLUID FLOW OPTION
The two-phase flow option in FLAC allows numerical modeling of the flow of two immiscible fluids through porous media. The formulation applies to problems in which a fluid displaces another, and simultaneous flow of the two fluids takes place in the porous medium with no mass transfer between them.

THERMAL OPTION
The thermal analysis option in FLAC incorporates both the conduction (transient heat conduction and the development of thermally induced displacements and stresses) and advection (transport of heat by convection; it can simulate temperature-dependent fluid density and thermal advection in the fluid) models.

C++ USER Defined Constitutive Model Option
With this option, new constitutive models can be created for use in FLAC. The model is written in C++, compiled as a DLL file, and loaded as needed. This option allows users to create models that exhibit customized material behavior.
Dynamic model of a pulse wave – originating from a tunnel, traveling through the surrounding elastic rock – shown as total displacement. Quiet boundaries have been applied to the sides and bottom of the model, allowing the wave to dissipate over time, while the wave reflects off the free surface boundary.

Horizontal section showing a freeze wall developing around a shaft after (a) 5 days and (b) 20 days. Adiabatic (no flux) boundaries are indicated with blue lines.
Multiple tunnels in a biaxial stress field with x-displacement contours shown.