Bentley
Advancing Infrastructure

PLAXIS® Thermal

Geotechnical Thermal Modeling Software

In many engineering projects, such as the design of pipelines, ground energy storage, roads or building construction in cold regions where heat transfer takes place in the soil, the effect of temperature on the behavior of soil is of critical importance. Highly dependent on water content of the soils, the ground heat transfer is also playing an important role in the overall thermal performance of the infrastructure.

Regardless of the cause, by nature or through man-made interactions, with PLAXIS Thermal geotechnical modeling software geotechnical engineers can analyze and take into consideration the thermal effects on soils as well as deploy innovative artificial ground freezing construction methods.

Reliable Data-Geotechnical Experise-Digital Workflows

The PLAXIS 2D Thermal module is an extension of PLAXIS 2D. It is used to analyze and model the effects of heat flow on the hydraulic and the mechanical behavior of soils and structures in geotechnical design. The implementation supports plane strain and axisymmetric models and the calculation can be performed in steady-state or transient in the framework of either semi- or fully coupled analysis.

The Thermal module offers capabilities that analyze the thermal flow in soil and its implications on groundwater flow and the strains and stresses in the soil. This module broadens the range of geotechnical engineering applications in the tunneling, mining, environmental, and energy sectors.

Powerful Modeling and Analytic Capabilities

The temperature gradient is a main cause for movement of heat and water in soils. Since groundwater flow plays an essential role in the transport of heat in the ground, thermal calculations are normally coupled with groundwater flow calculations, called the thermo-hydraulic coupling. In terms of thermo-mechanical coupling, the change of temperature influences the mechanical behavior of soil, giving rise to thermal expansion or contraction.

Thermo-hydraulic Coupling

Artificial ground freezing is a process that can be used to temporarily stabilize weak ground. As the temperature in the soil decreases due to frozen pipes, an ice wall is formed, making the soil watertight. Dry excavation can then be performed, and permanent stability measures can be provided. The coupling between groundwater flow and thermal flow facilitates analysis on the influence of the velocity of the groundwater on the formation of the ice wall. In addition to groundwater flow boundary conditions, facilitated by the PLAXIS 2D and PlaxFlow modules, thermal flow boundary conditions can be assigned to the model, such as an imposed temperature, a heat flux, or a convective boundary condition. Besides cluster-defined temperature, energy conditions can also be applied to model a heat source or sink on a cluster.

Thermo-mechanical Coupling Analysis

Coupling between thermal loading and mechanical process occurs when the temperature change in soils results in thermal stresses. One of the typical cases encountered in engineering applications is the deformation of a navigable lock due to sunlight absorption when it doesn´t contain water. With PLAXIS 2D Thermal, we can analyze the effects of temperature changes due to weather conditions on the stresses and deformations in the soils by introducing climate boundary conditions. Such boundary conditions can be either constant or time dependent following the linear, harmonic, or user-defined input value function.

Thermo-hydro-mechanical Coupling

With PLAXIS 2D Thermal, the results of semi-coupled steady-state thermo-hydraulic mechanical calculations can be used to analyze the effects of temperature changes on pore pressures, stresses, and deformations. PLAXIS Thermal allows for fully coupled transient thermo-hydromechanical problems in which the time dependent effect of temperature changes on stresses, deformations, and groundwater flow are analyzed simultaneously.

User-friendly Technology

PLAXIS 2D Thermal is fully integrated and interoperable with PLAXIS' 2D suite of geotechnical software solutions to seamlessly manage your project.

PLAXIS 2D Thermal is user-friendly software built around intuitive geotechnical digital workflows for efficient project management. A flexible interface allows for easy geotechnical process management and inputs while the output program allows for powerful reporting and analysis through animation, graphs, and numeric results.

PLAXIS 2D Thermal users can rely on an easy-to-use licensing and user management platform as well as support, educational resources, and product updates from Bentley.

System Requirements

Operating System
Windows 8 Professional 64-bit, Windows 10 Pro 64-bit

Graphics Card
Required: GPU with 256 MB OpenGL 1.3. Bentley recommends avoiding simple onboard graphics chips in favor of a discrete GPU from the Nvidia GeForce or Quadro range with at least 128-bit bus and 1 GB of RAM, or equivalent solution from ATI/AMD

Processor
Required: Dual Core CPU
Recommended: Quad Core CPU

Memory
Recommended for 2D: minimum 4 GB. Large projects may require more

Hard Disk
Minimum 2 GB free space on the partition where the Windows TEMP directory resides, and 2 GB free space on the partition where projects are saved. Large projects might require significantly more space on both partitions. For best performance, ensure that the TEMP directory and the project directory reside on the same partition.

Video
Required: 1024 x 768 pixels, 32-bit color palette
Recommended: 1920 x 1080 pixels, 32-bit color palette

Internet connection
Required for SES licensing

Find out about Bentley at: www.bentley.com

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PLAXIS Thermal At-A-Glance

Modeling and Analysis

- Coupling between thermal flow, groundwater flow and/or deformation
- Unfrozen water content modeling
- Fully coupled flow-deformation analysis, flow only mode
- Safety factor and enhanced safety analysis
- Deformations, displacements, and strains in soil due to temperature change
- Cartesian and principal total or effective stresses due to temperature change
- Deformation in structures and interfaces due to freezing soil expansion
- Sensitivity analysis possible on projects involving temperature
- Stress and strain diagrams
- Temperature or ice saturation vs. time curves
- Resulting forces in (volume) plates, anchors, geogrids, embedded beams rows due to stress rotations in the soil

Thermal Calculations of Realistic Geotechnical Problems

- Flow only mode, with steady state and transient temperature flow
- Fully coupled thermal-flow-deformation

Results

- Initial temperature distribution
- Steady-state temperature distribution
- Time-dependent temperature distribution
- Stress or flow in each stage due to temperature changes
- Vector and contour plots for ice saturation, temperature, heat and vapour flux
- Visualize frost line

Usage

- Thermal expansion of navigable lock
- Freeze pipes in tunnel construction
- Thermal expansion of struts
- Artificial ground freezing
- Frozen ground engineering
- Nuclear waste disposal
- Borehole heat exchangers in aquifer layers
- Pipeline or cable heat dissipation
- Temperature effects on structures

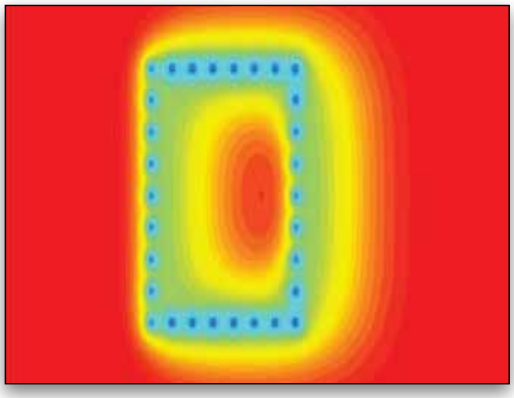

Figure 1: Temperature distribution around freezing pipes.

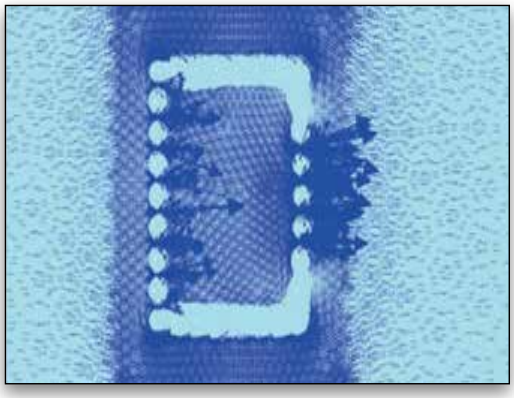

Figure 2: Water flow around freezing pipes.