Be4Cast

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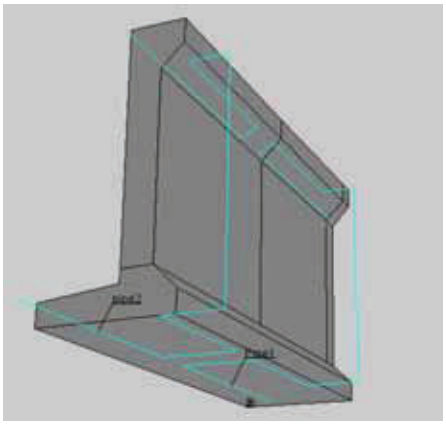
Purpose

Be4Cast is an advanced software package for simulating temperature evolution and stress development in concrete structures during early-ages. The software allows modeling different construction methods for a given structure in order to arrive at an optimal solution for reducing the risk of early-age cracking due to thermal gradients and thermal shrinkage. **Be4Cast** is based on heat transfer in 3-dimensions, which permits more accurate simulation of heat transfer in a structural element of any shape.

It is important to control the early-age hardening process of concrete. Inappropriate construction methods can cause:

- Freezing before the concrete is strong enough to resist expansion stresses
- Rapid evaporation leading to a weak cover layer
- High temperature gradients leading to crack formation
- Reduction in long-term strength due to high early-age temperatures
- Delayed ettringite formation due to high curing temperature
- Inadequate strength at formwork removal, prestressing, or loading

In all cases, the concrete structure may be damaged permanently and the durability, functionality, and appearance will be substantially reduced. On the other hand, it is also important to avoid using costly preventive measures that may unnecessary. By running simulations of alternative schemes before start-up of a project, engineers can arrive at economical solutions for reducing the risk of early-age damage.



Model of construction scheme in which the thick upper part of the wall is cooled by water circulating through the previously cast foundation

The **Be4Cast** computer program is useful for:

- Contractors, in planning construction methods to meet specification requirements and economic limitations.
- Consultants, during the design phase where it is possible to check feasibility of planned construction activities.
- Precast concrete producers, for optimizing production schedules

Because **Be4Cast** is based on the finite-element method and modeling is in 3D, a wide range of problems can be solved. The computer-program is menu-driven and simple to use. Extensive knowledge of the finite-element method is not required. The information needed to run an analysis includes description of the construction method, thermal boundary conditions, and properties of the concrete that will be used. A mouse click starts the calculations, and various graphical outputs are available to check if the results are reasonable.

Construction Method

Volumes corresponding to different placements are defined geometrically. Time of placement and the placement temperature are defined. Volumes are prismatic with arbitrary polygonal cross sections.

Materials

The following properties define the hardening concrete:

- Heat of hydration versus maturity
- Thermal conductivity
- Heat capacity
- Density
- Cement content
- Activation energy
- Tensile strength vs. maturity
- Compressive strength vs. maturity
- E-modulus vs. maturity
- Poisson's ratio vs. maturity
- Coefficient of thermal expansion
- Autogenous shrinkage
- Creep function

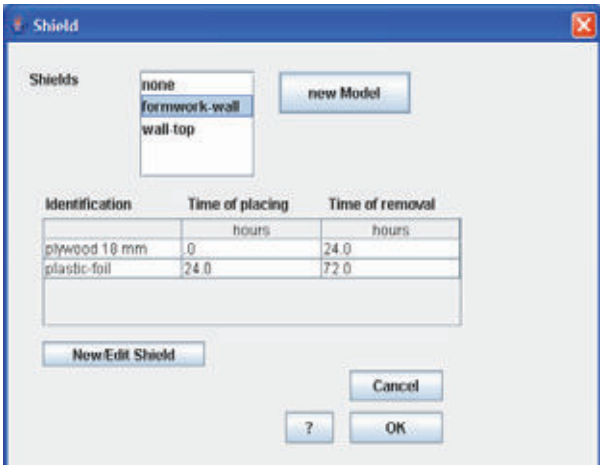
Material properties can be imported from and exported to libraries. Thus the same material can be used in different analyses. The software includes ready-to-use default material properties.

Thermal Boundaries

The following conditions can be assigned to surfaces:

- Temperature related to convection
- Wind-speed
- Thermal shields: user defined formwork, insulation, etc.
- Heat flux
- Temperature related to radiation
- Transmission coefficient related to radiation

All boundary conditions are functions of time. Internal heating or cooling can be modeled by specifying heating cables and cooling pipes (open circuits, closed circuits, and cooling plants can be specified). Thermal barriers can be imported from and exported to libraries, which allows the same materials to be used in different jobs. The software includes several ready-to-use thermal barriers.



Example of **Be4Cast** *input screen to describe formwork and curing procedures*

Displacement Boundaries and External Loads

The structure can be provided with displacement boundary conditions to model external restraints. Displacement boundary conditions are also used to specify planes of symmetry for reducing analysis run time. If insufficient displacement boundary conditions are supplied by the user, the software automatically provides boundary conditions so that the structure is statically determinate.

Calculation Method

The analyses (thermal and stress) in **Be4Cast** are performed by means of the finite-element method. The structure is meshed into tetrahedrons. The variation of temperature and stress within elements is assumed to be parabolic.

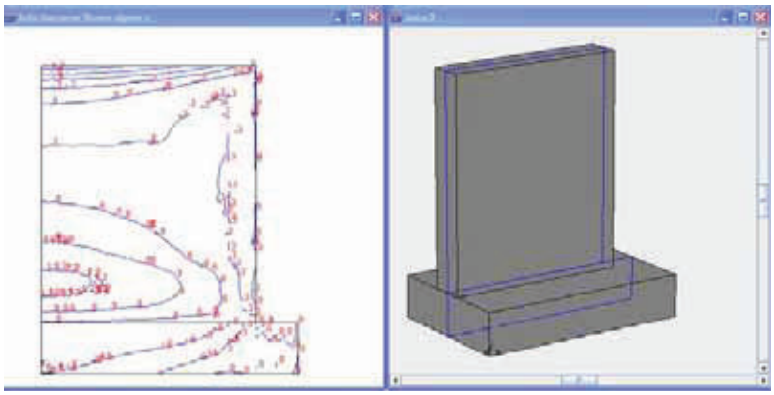
Results

The results from a **Be4Cast** analysis include the following parameters:

- Temperatures
- Maturities
- Tensile and compressive strengths
- Stresses, principal stresses, and tensile stress-strength ratio

Variations of given results within the structure are presented as contour plots at user-defined cross sections (as shown to the right).

Variations of given results with time are presented as graphs of minimum and maximum values, average values, or values at user-defined points.



Contours of longitudinal stress component at section shown on right. Half length-model is shown due to symmetry.

Cross sections with extreme values of the parameters can be located automatically.

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