Midas Intro Session

Thermal Analysis and Concrete Heat of Hydration

Midas North American Office
Tuesday, Sept 14th, 2021
3:00 PM – 4:00 PM EDT

jsun@midasoft.com
450 7th Ave Suite 2505, New York, NY, 10123, US

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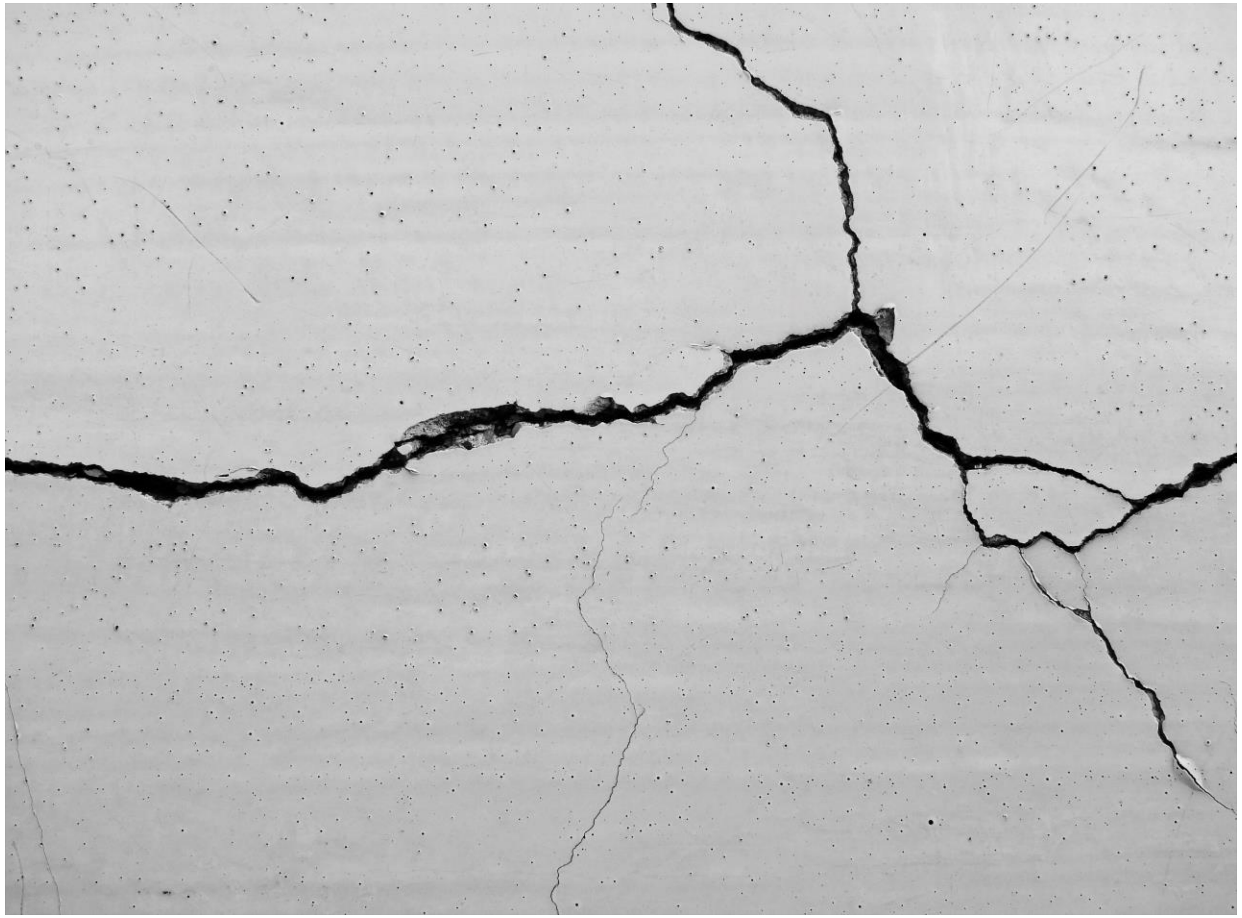
- Concrete Crack Analysis
- Static Analysis
- Construction Stage Analysis
- Reinforcement Analysis
- Buckling Analysis
- Eigenvalue Analysis
- Response Spectrum Analysis
- Time History Analysis(Linear/Nonlinear)
- Static Contact Analysis
- Interface Nonlinearity Analysis
- Nonlinear Analysis(Material/Geometric)
- Heat of Hydration Analysis
- Heat Transfer Analysis
- Slope Stability Analysis
- Seepage Analysis
- Consolidation Analysis
- Coupled Analysis(Fully/Semi)

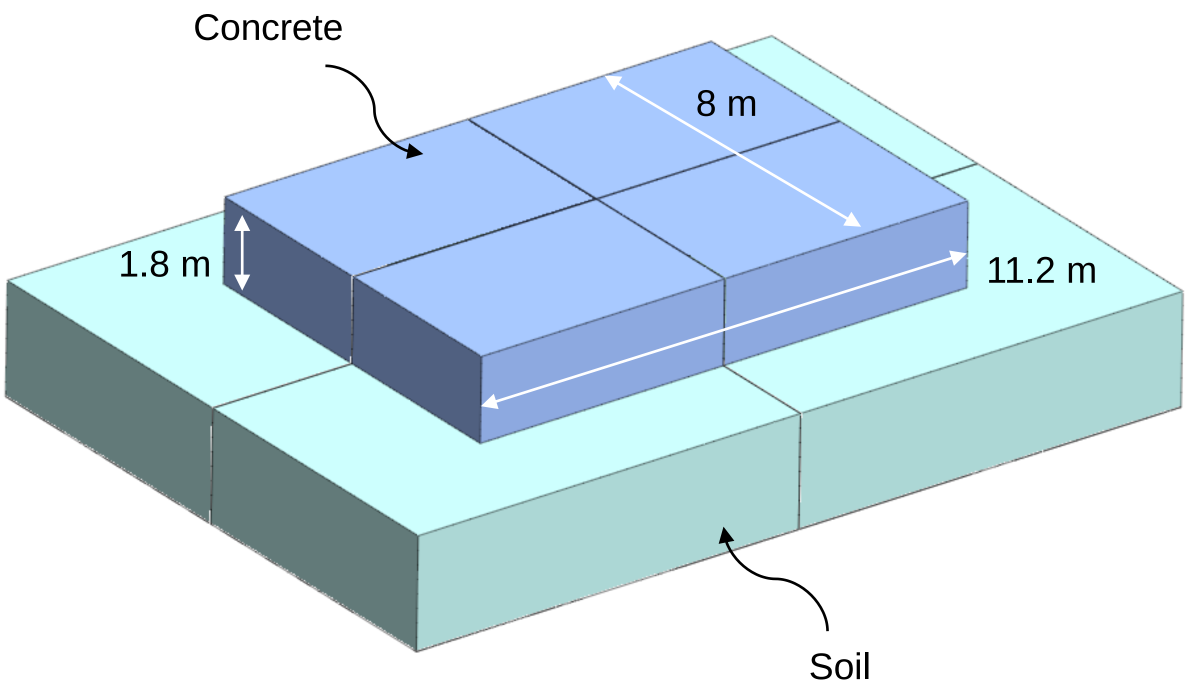
Heat of Hydration



- Heat of hydration is the heat generated during the exothermic reaction between cement and water.
- Thermal stresses due to heat of hydration in a mass concrete structure may cause detrimental cracking and consequent reduction in mechanical properties.
- Mass concrete structures requiring heat of hydration analysis depend on their dimensions, structural types, cement types and construction conditions.
- In practice, heat of hydration analyses are normally carried out for slabs or mats larger than 800~1000 mm in thickness and walls confined at bottom larger than about 500 mm in thickness.

Heat of Hydration Analysis and Cracking

- Heat of hydration analysis is largely classified into heat transfer and thermal stress analyses.
- Heat transfer analysis involves conduction, convection, heat source, etc.
- Thermal stress analysis involves changes in the modulus of elasticity, creep and shrinkage, which are influenced by temperature, curing conditions, maturities, etc.
- Surface cracking may develop initially due to the temperature difference between the surface and the center.
- Through-cracks can also develop as a result of contraction restrained by external boundary conditions in the cooling process of high heat of hydration.



Conduction

- The process by which heat passes through solids from a high temperature zone to a low temperature zone

$$Q_x = q_x A = -kA\frac{\partial T}{\partial x} \tag{11.1}$$

where,

Q_x	: Rate of heat transfer in X-direction
q_x	: Heat flux
A	: Area
k	: Thermal conductivity
$\frac{\partial T}{\partial x}$	: Temperature gradient

Convection

- The process by which heat travels through air. Heat is transmitted between the atmosphere and the surface of the solid.
- The convection coefficient is defined to simply calculate the heat transfer between the solid and the atmosphere.

$$q = h_c(T - T_\infty) \quad \text{: Heat flux on a solid}$$

Heat Source

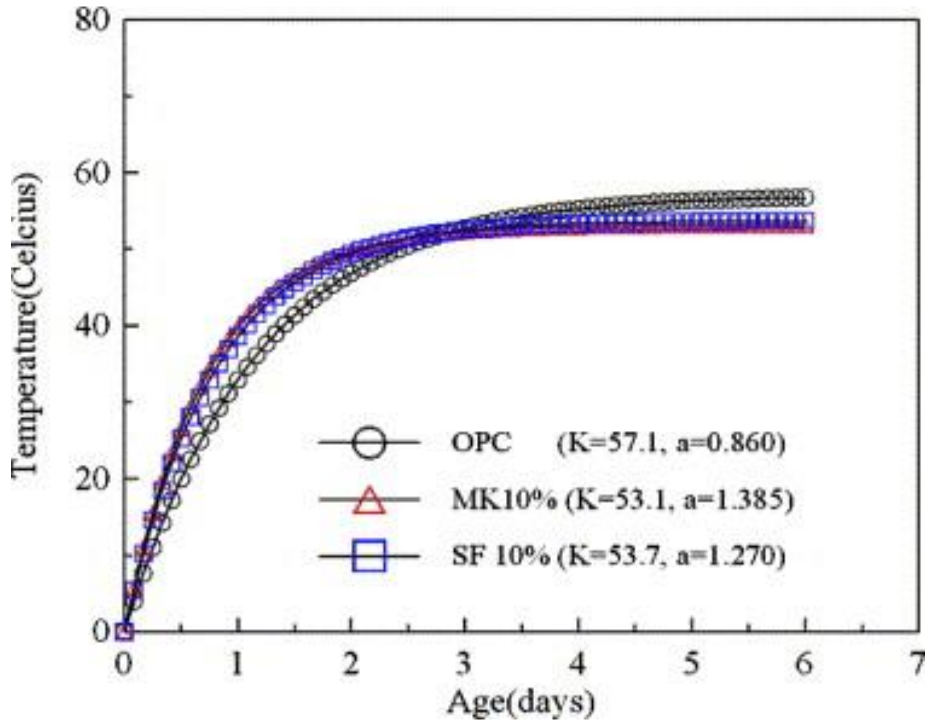
- The amount of heat generated by the hydration process in mass concrete
- Internal heat generation per unit time and volume (W/m3)

Adiabatic temperature rise

$$T = K(1 - e^{-\alpha t})$$

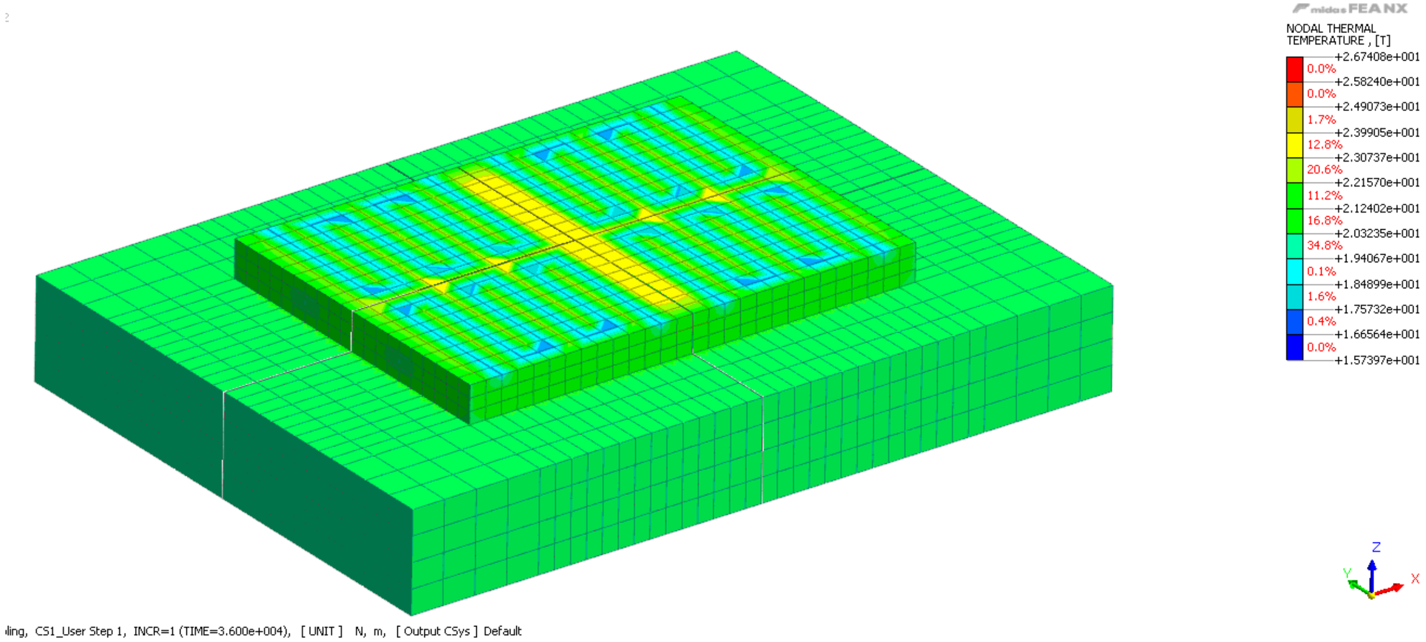
K = Maximum Adiabatic Temp. Rise (Temperature Unit)

α = Reactive Velocity Coefficient (1/sec)



Pipe Cooling

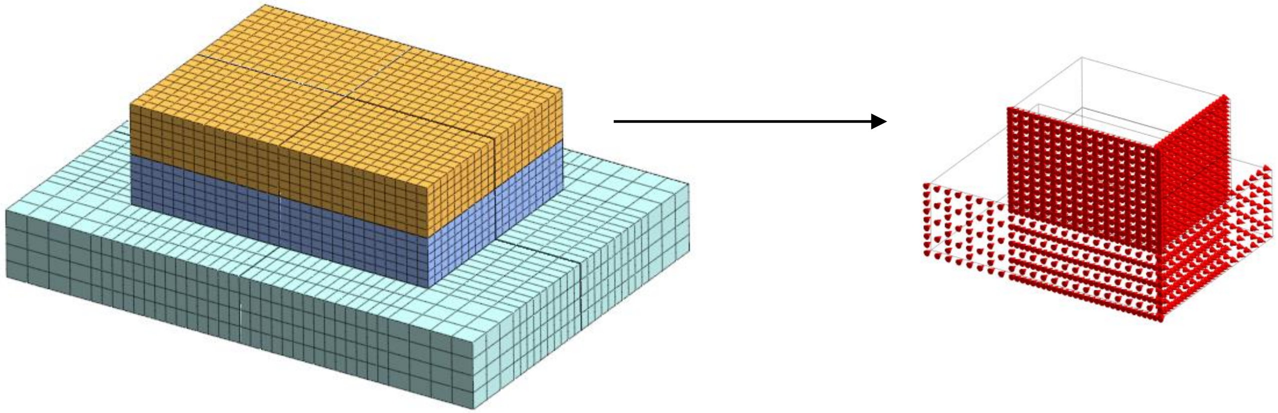
- The pipes are used to reduce the temperature rise from heat of hydration by passing a lower temperature fluid through the pipes.

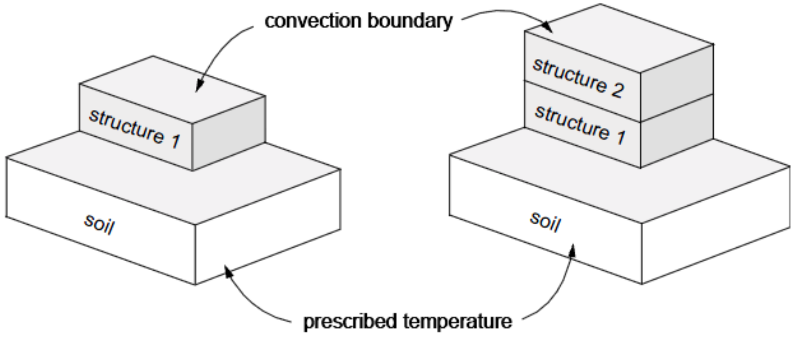


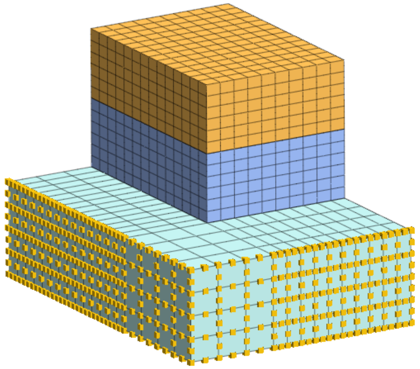
Initial, Ambient, and Prescribed Temperature

- Initial temperature is an average temperature of water, cement and aggregates at the time of concrete casting, which becomes the initial condition for analysis.
- Ambient temperature represents the curing temperature, which may be defined as a constant value, sine function or time-dependent function.
- A prescribed temperature represents a boundary condition for a heat transfer analysis and always remains a constant temperature.
- In a symmetrical model, the plane of symmetry is considered an adiabatic boundary condition.

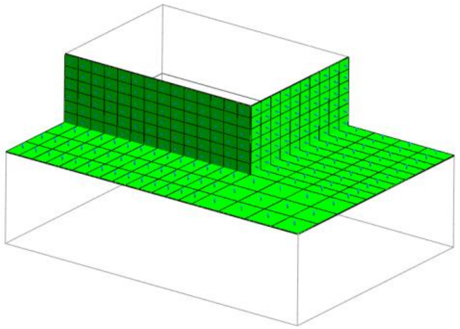
Symmetry B.C.







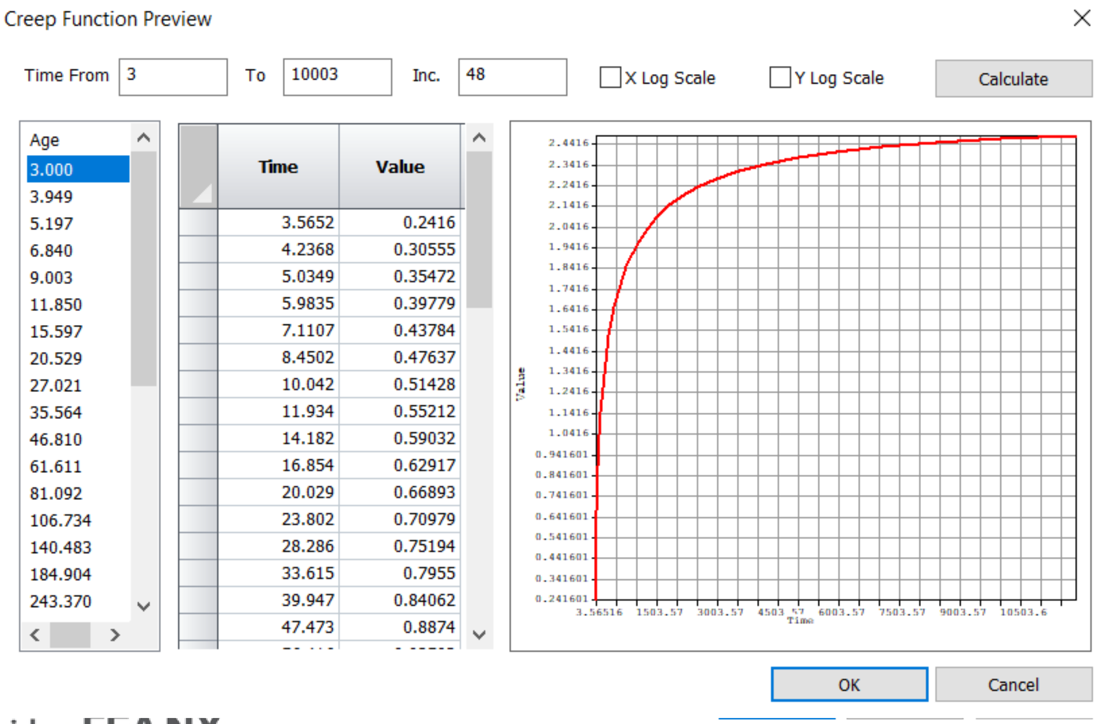
Prescribed Temperature

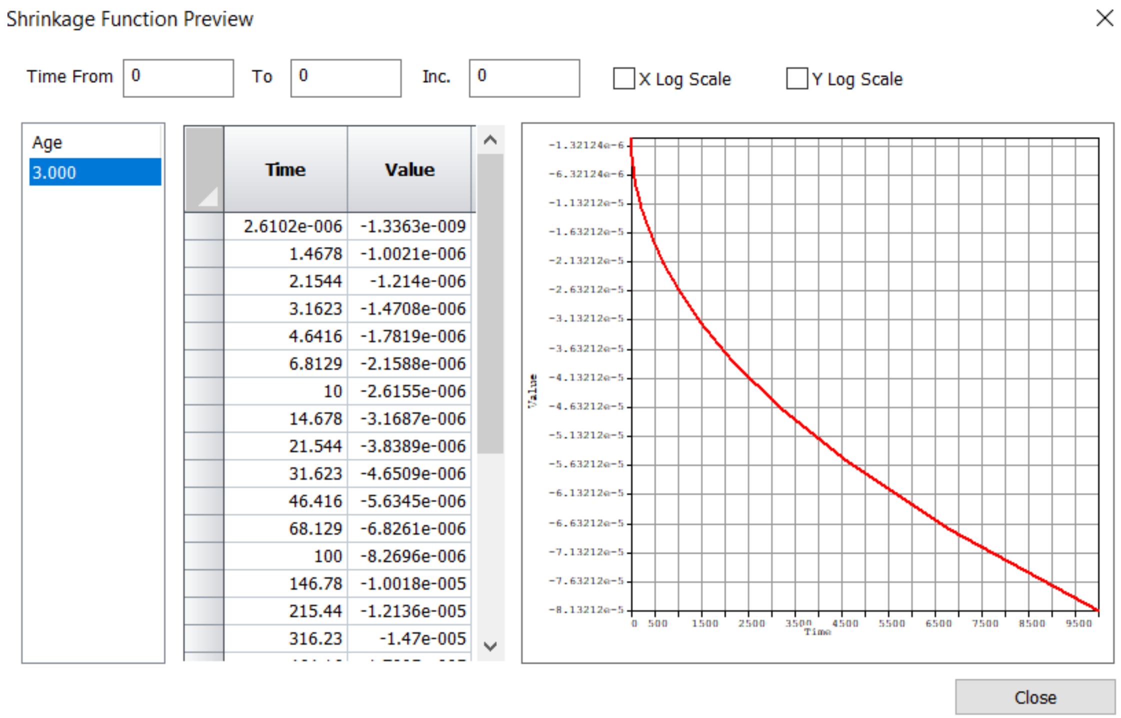


Convection Plane with Ambient Temperature

Thermal Stress Analysis

- the results of heat transfer analysis
- changes in material properties due to changes in time and temperature
- time-dependent shrinkage
- time and stress-dependent creep





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