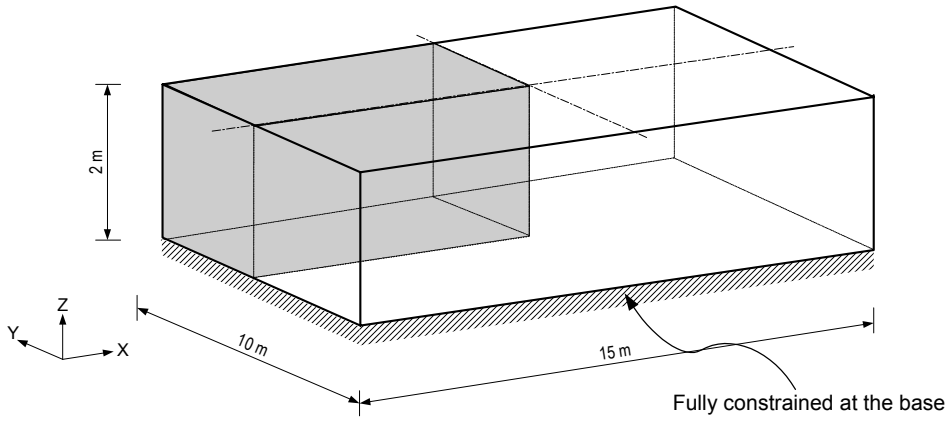
Hydration-1

Title

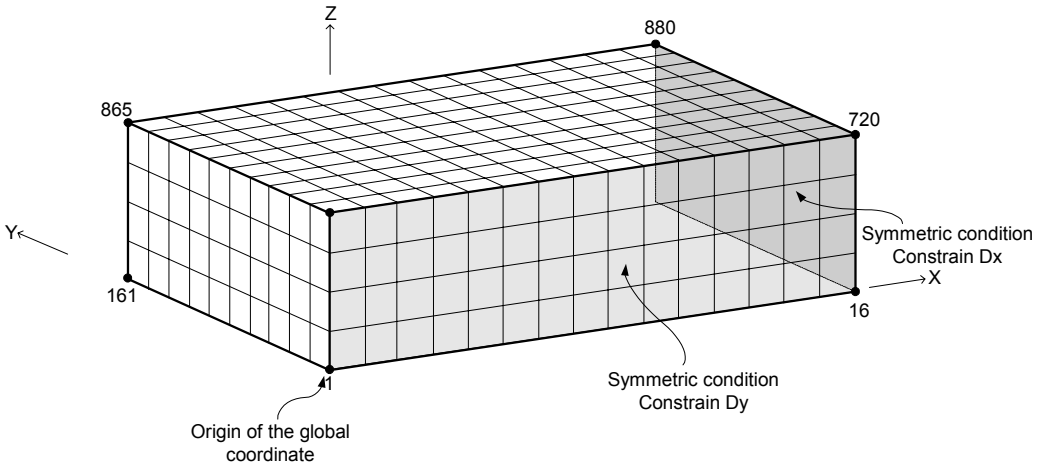
Heat of hydration analysis of a quarter of a rectangular model

Description

Given is a mass footing concrete constrained at the base. The footing dimensions are 10m wide × 15m long × 2m thick. Using the symmetry, a 1/4 model will be used to represent the total mass for a heat of hydration analysis. We will examine the time variant temperatures and stresses at the surface and center.



(a) Total model for heat of hydration analysis



(b) Quarter model

Structural geometry and analysis model

Model

Analysis Type

3-D Heat of hydration analysis

Unit System

m, kN

Dimension

5m wide×7.5m long×2m high (no. of elements 10×15×4)

Element

Solid element

Material

Specific heat : 106713 J/kN °C

Density : 22.56 kN/m^3

Heat conductivity : 9627.8 J/m hr °C

28day concrete compressive strength : 23536 kN/m^2 ($f_{ck}(t) = \frac{t}{4 + 0.85t} f_{ck}(28)$)

Coefficients for cement classification : a=4.0 b=0.85

28day modulus of elasticity: 2.2751e+007 kN/m^2 ($E_c(t) = 4800 \times 10^{3/2} \sqrt{f_{ck}(t)}$)

Boundary Condition

Fully constrained at the base

Symmetric boundary condition : adiabatic condition without heat transfer

Heat of hydration Analysis Data

Heat transfer boundary condition : base temperature constrained at 20℃

Rate of heat flow : Q = 50, r = 1.0

Surface convection boundary

Convection coefficient s: 12 kcal/m^2 hr℃

Ambient temperature : 20℃

Concrete cast temperature : 20℃

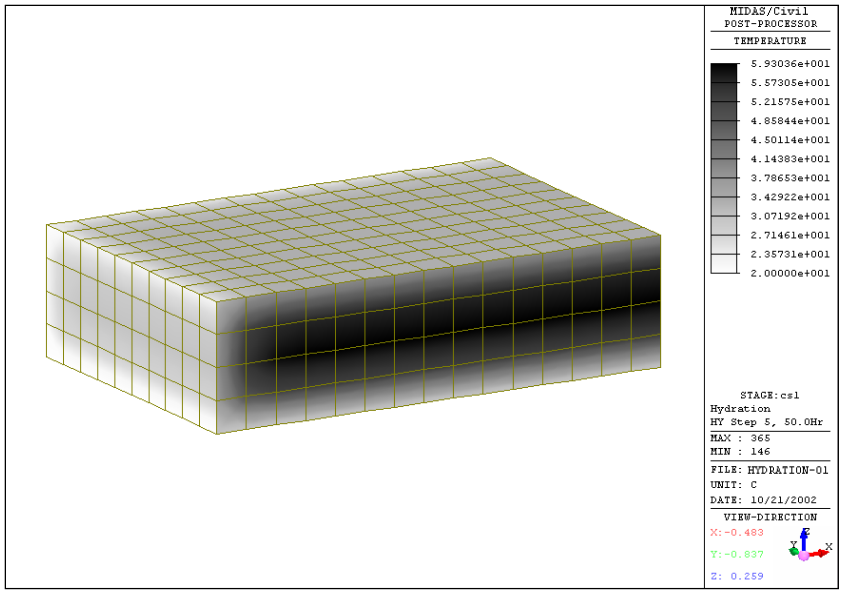
Thermal expansion coefficient : 1E-5

Poisson's ratio : 0.2

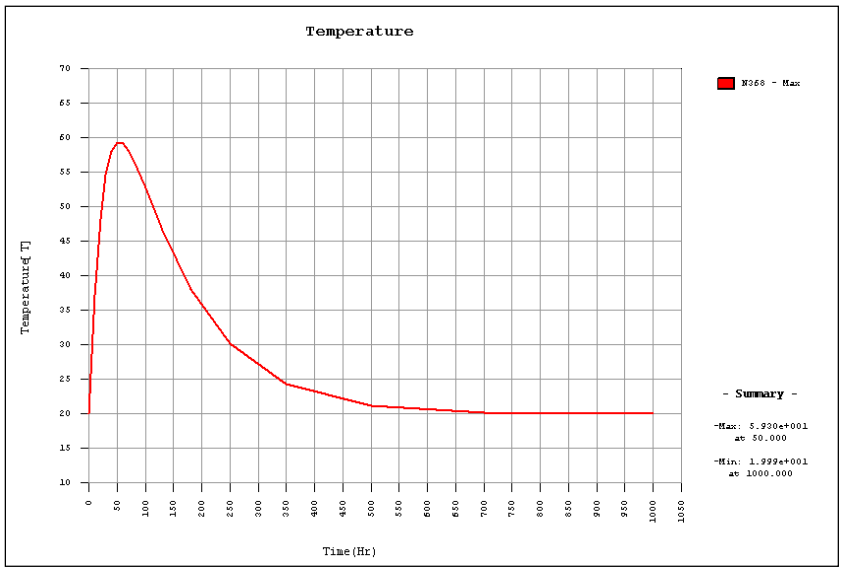
Analysis time intervals (hours) : 10@8, 20, 30, 50, 70, 100, 150, 200, 300

Results

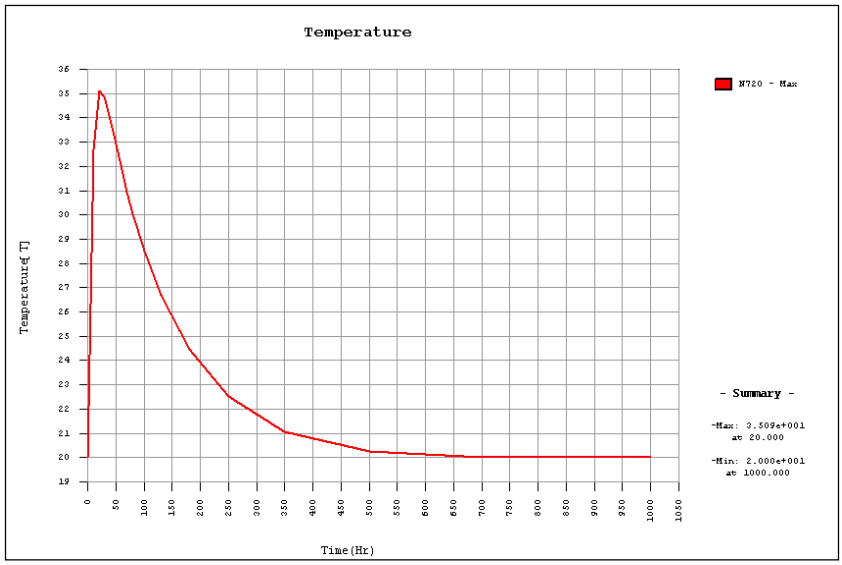
Temperature



Temperature distribution at the time of the max. temperature (Step: 5, 50 hours)

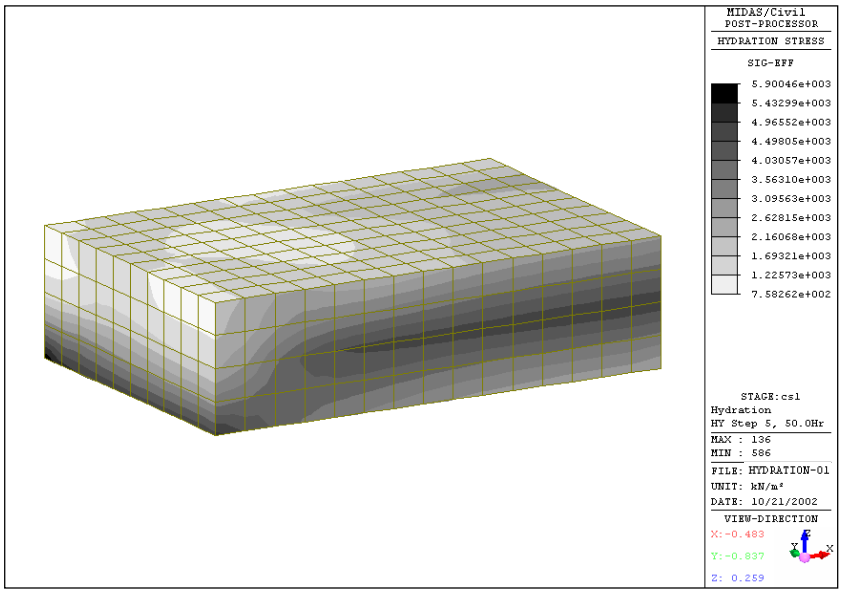


Temperature time history curve at the center (Node 368)

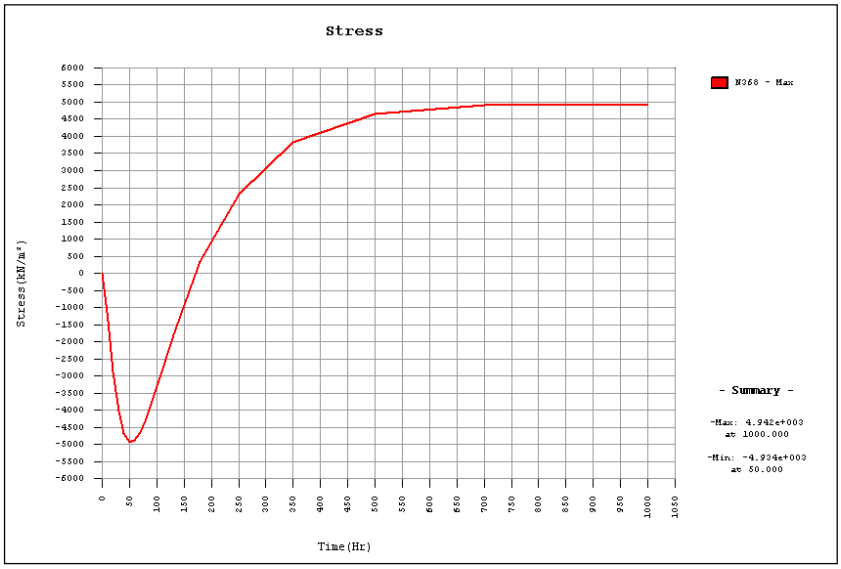


Temperature time history curve at the surface (Node 720)

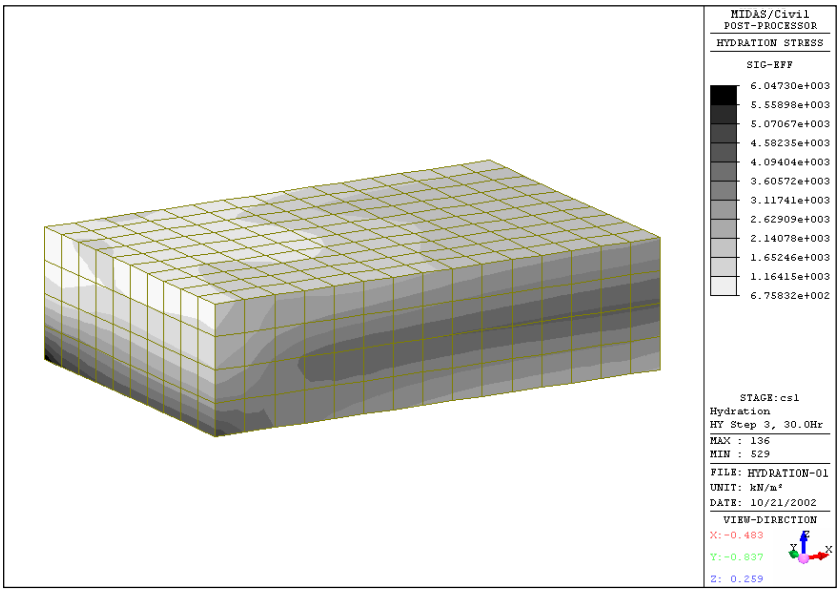
Stress



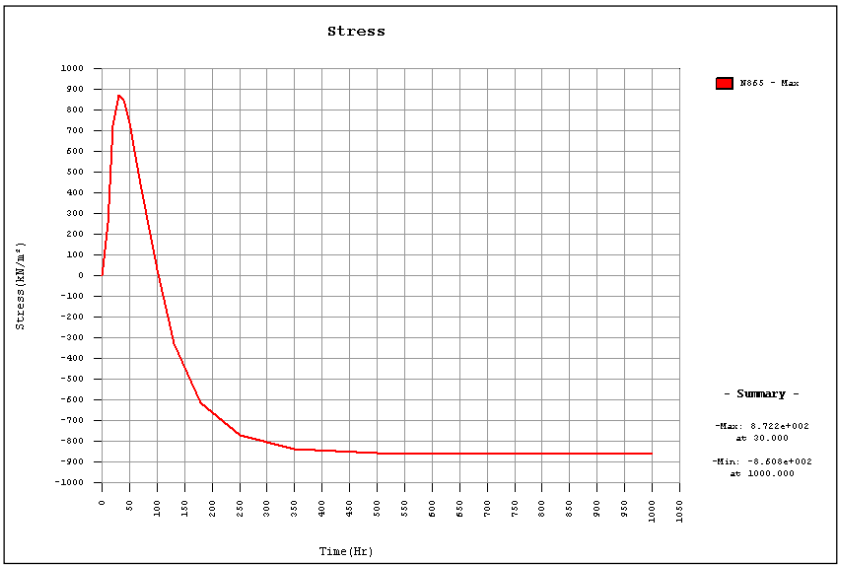
Stress distribution when the stress at the center reaches the highest



Stress time history curve at the center (Node 368)



Stress distribution when the stress at the surface reaches the highest

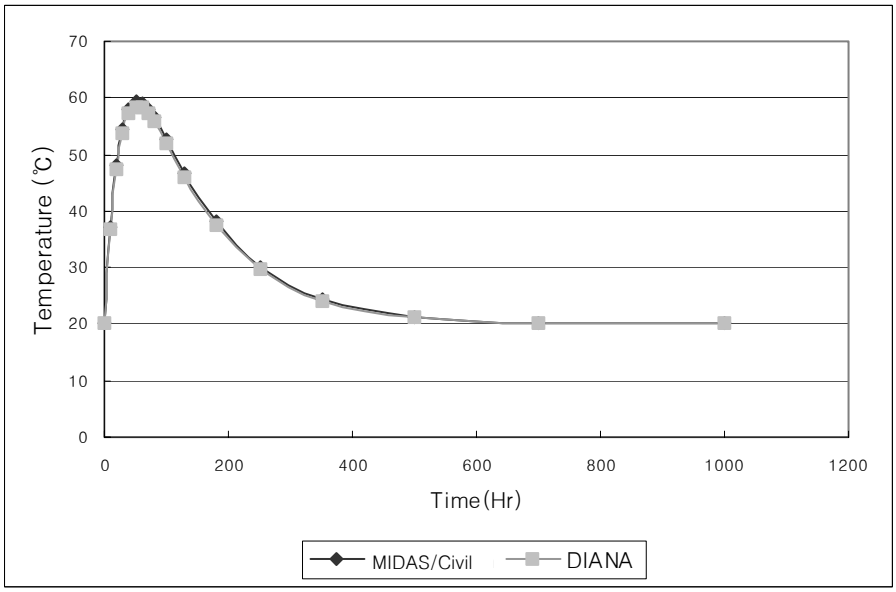


Stress time history curve at the surface (Node 865)

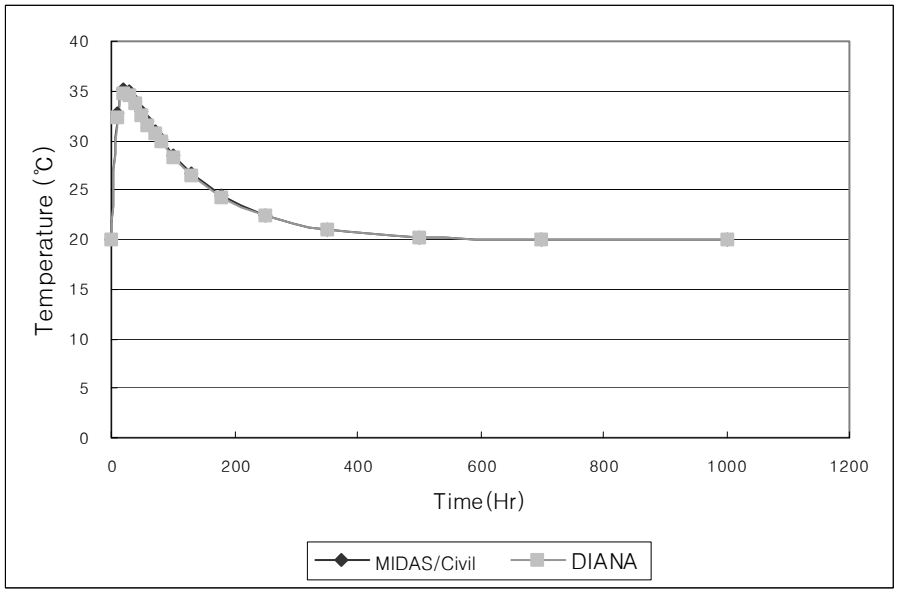
Comparison of Results

Nodal Temperature

Location	Node 368 (Center)		Node 720 (Surface)	
Time (hours)	MIDAS/Civil (°C)	DIANA (°C)	MIDAS/Civil (°C)	DIANA (°C)
0	20	20	20	20
10	37.2	36.8	32.7	32.4
20	48.1	47.5	35.1	34.8
30	54.6	53.9	34.9	34.5
40	58	57.2	33.9	33.7
50	59.3	58.5	32.9	32.6
60	59.2	58.3	31.9	31.6
70	58.1	57.3	30.9	30.7
80	56.5	55.8	30.1	29.8
100	52.6	51.9	28.5	28.3
130	46.5	45.8	26.7	26.5
180	38	37.4	24.5	24.3
250	30.2	29.8	22.5	22.4
350	24.3	24.2	21.1	21.1
500	21.1	21.1	20.3	20.3
700	20.1	20.2	20	20
1000	20	20	20	20



Temperature time history curve at the center (Node 368)



Temperature time history curve at the surface (Node 720)

Reference

"DIANA", Release 7, TNO Building and Construction Research, 1998.