ConcreteWorks

IHEEP Conference

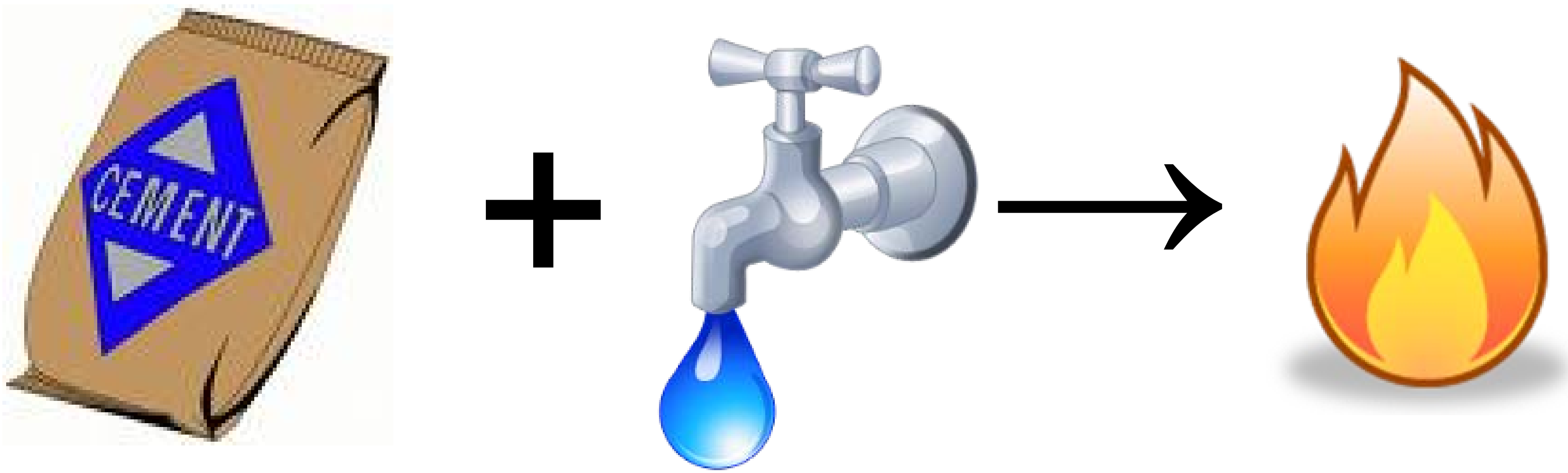
September 29, 2009

San Antonio, TX

Outline

- Concrete and early-age heat generation
- Heat Prediction Methods
- ConcreteWorks

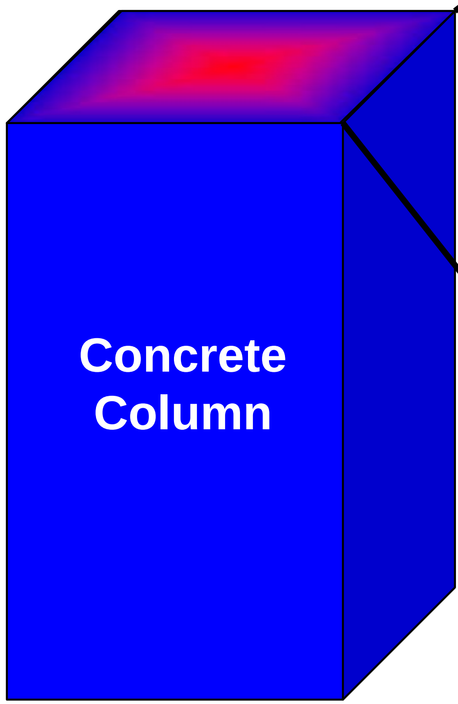
Early Age Curing Temperature:
A Blessing and a Curse

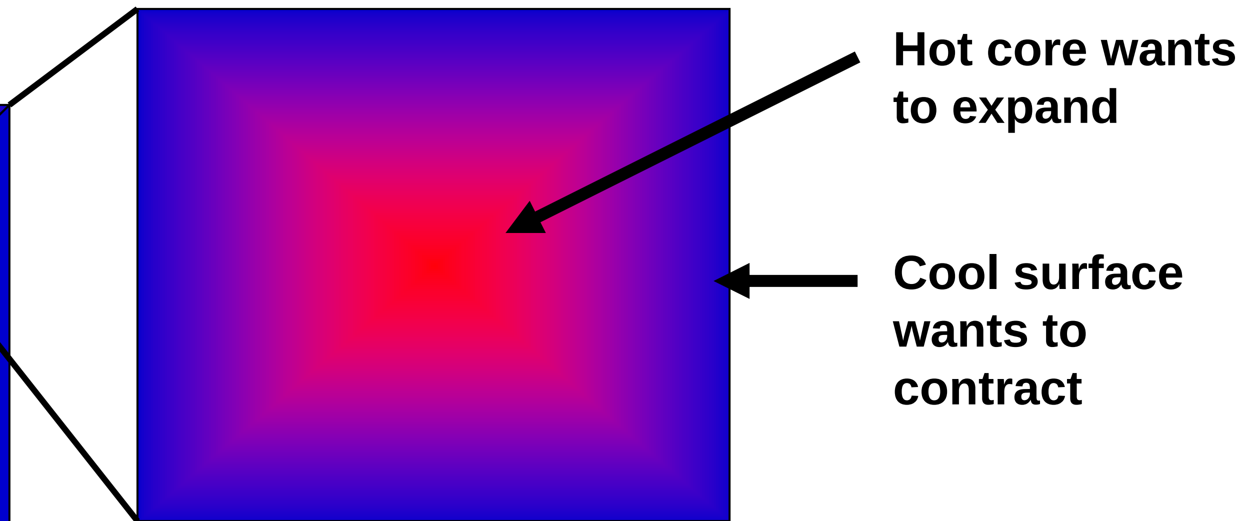


- Heat generated increases the rate of the reaction and rate of strength gain
- Too much heat too early can cause problems especially in large sections

Thermal Cracking

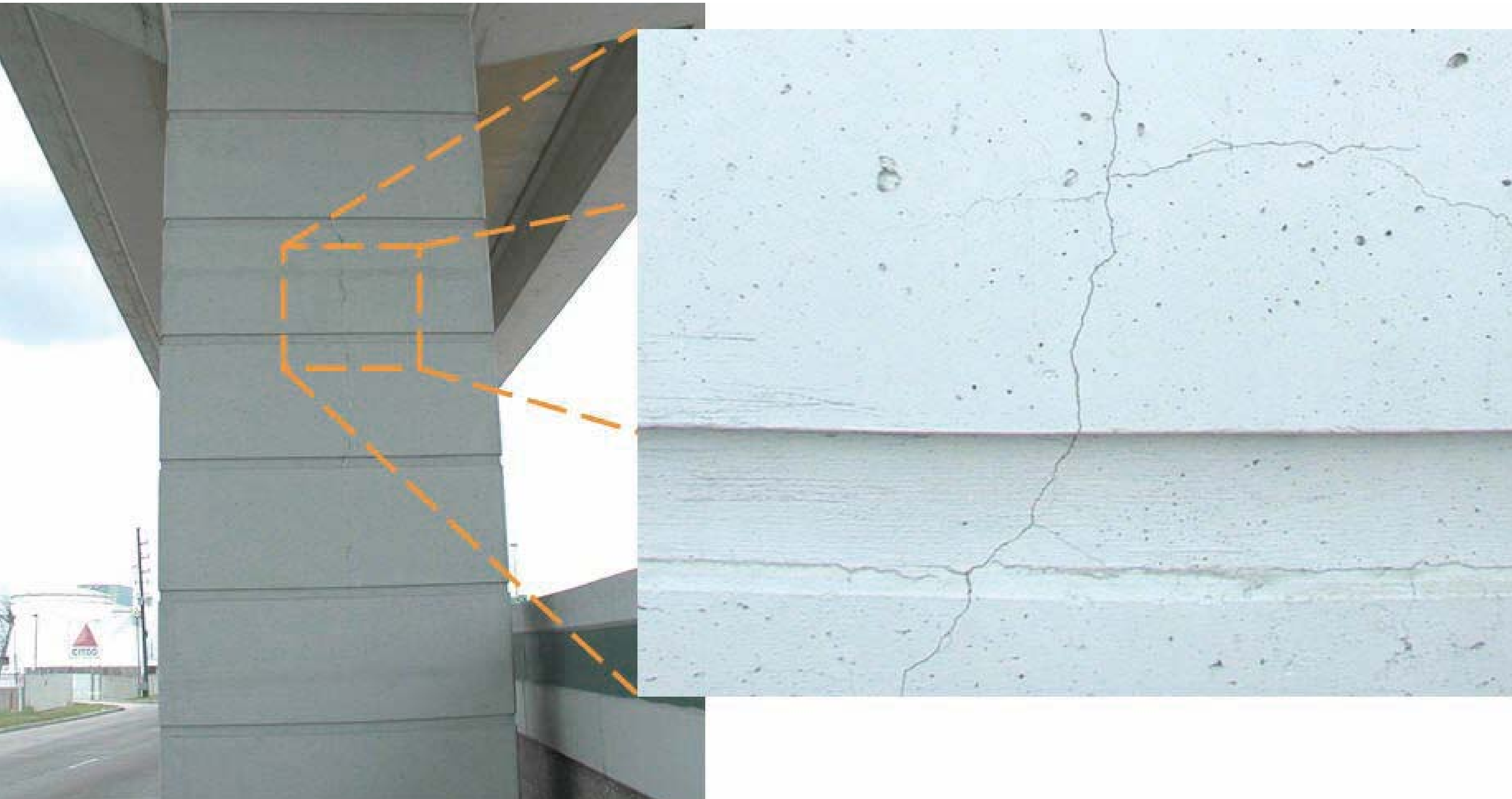
- Cracking that results from having large differences between core temperature and surface temperature





- This condition sets up stress gradients which cause cracking
- Minimizing the temperature gradients reduces the potential for cracking to occur

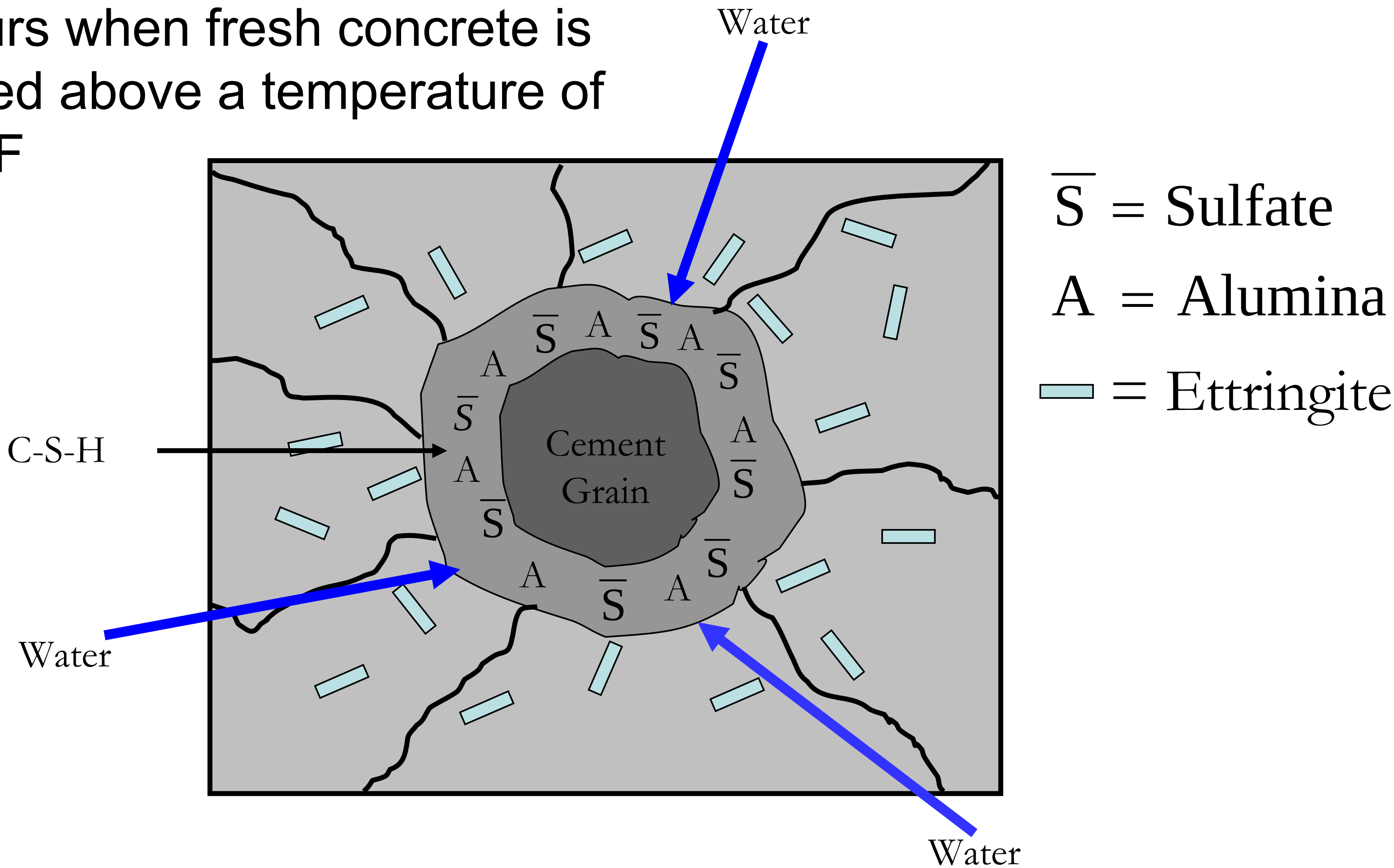
Thermal Cracking



Premature Concrete Deterioration

"Delayed Ettringite Formation"

Occurs when fresh concrete is heated above a temperature of 158°F



Premature Concrete Deterioration

"Delayed Ettringite Formation"

Heat Prediction Methods

Methods for Predicting Heat Generation

- PCA Method
  - Calculates ~10°F temperature rise for every 100lb of cement
  - Assumes a least dimension of 6ft
  - Does not calculate time to maximum temperature
  - No temperature differential calculation
  - Does not account for differences in cement composition
  - Adjustments for SCM's (fly ash , slag, etc.) are crude at best

Methods for Predicting Heat Generation

- ACI 207.2R "Graphical Method"
  - Uses charts and equations based on empirical data
  - Assumptions for boundary conditions
  - Cement fineness based on test method rarely used anymore
  - Generally underestimates maximum temperature
  - Poor prediction of time to maximum temperature

Methods for Predicting Heat Generation

- Schimdt’s Method
  - Developed in the1920’s as a simplified finite difference method
  - Little guidance for boundary conditions and difficult to model
  - Adjustments for SCM’s are crude
  - Method can be complicated and should be performed by an experienced engineer

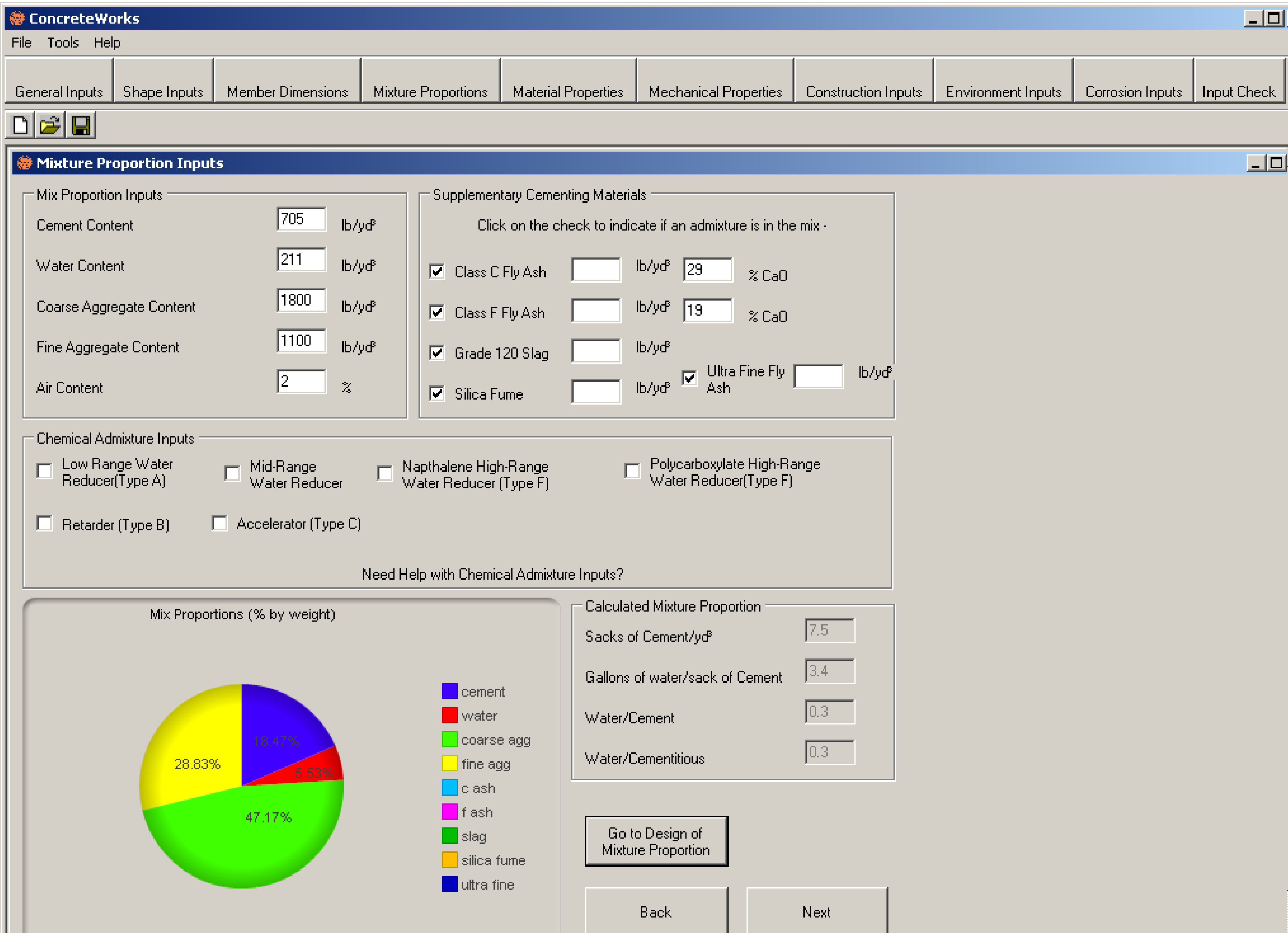
ConcreteWorks

What is ConcreteWorks?

- Software package that was a result of project 0-4563 “Prediction Model for Concrete Behavior” UT @ Austin
- Program is capable of predicting heat generated during early ages of concrete
- Other features
  - Mixture Proportioning
  - Cracking Probability
  - Chloride Concentration Prediction

Member Type		Initial Chloride Profile Input for Existing Structures	Chloride Service Life	Thermal Cracking Probability	Temperature Prediction
Mass Concrete	Rectangular Column		X	X	X
	Rectangular Footing		X	X	X
	Partially Submerged Rectangular Footing		X	X	X
	Rectangular Bent Cap		X	X	X
	T-Shaped Bent Cap		X		X
	Circular Column		X		X
	Drilled Shaft		X		X
Precast Concrete Members	Box Beam (Type 5B40)				X
	Type IV I-Beam				X
	U40 Beam				X
	U54 Beam				X
Bridge Deck Types	Pre-cast 1/2 Depth Panels	X	X		X
	Permanent Metal Decking	X	X		X
	Removable Forms	X	X		X
	User-Defined	X	X		X
Pavements	User-Selected Layers				X

Mix Design Proportioning



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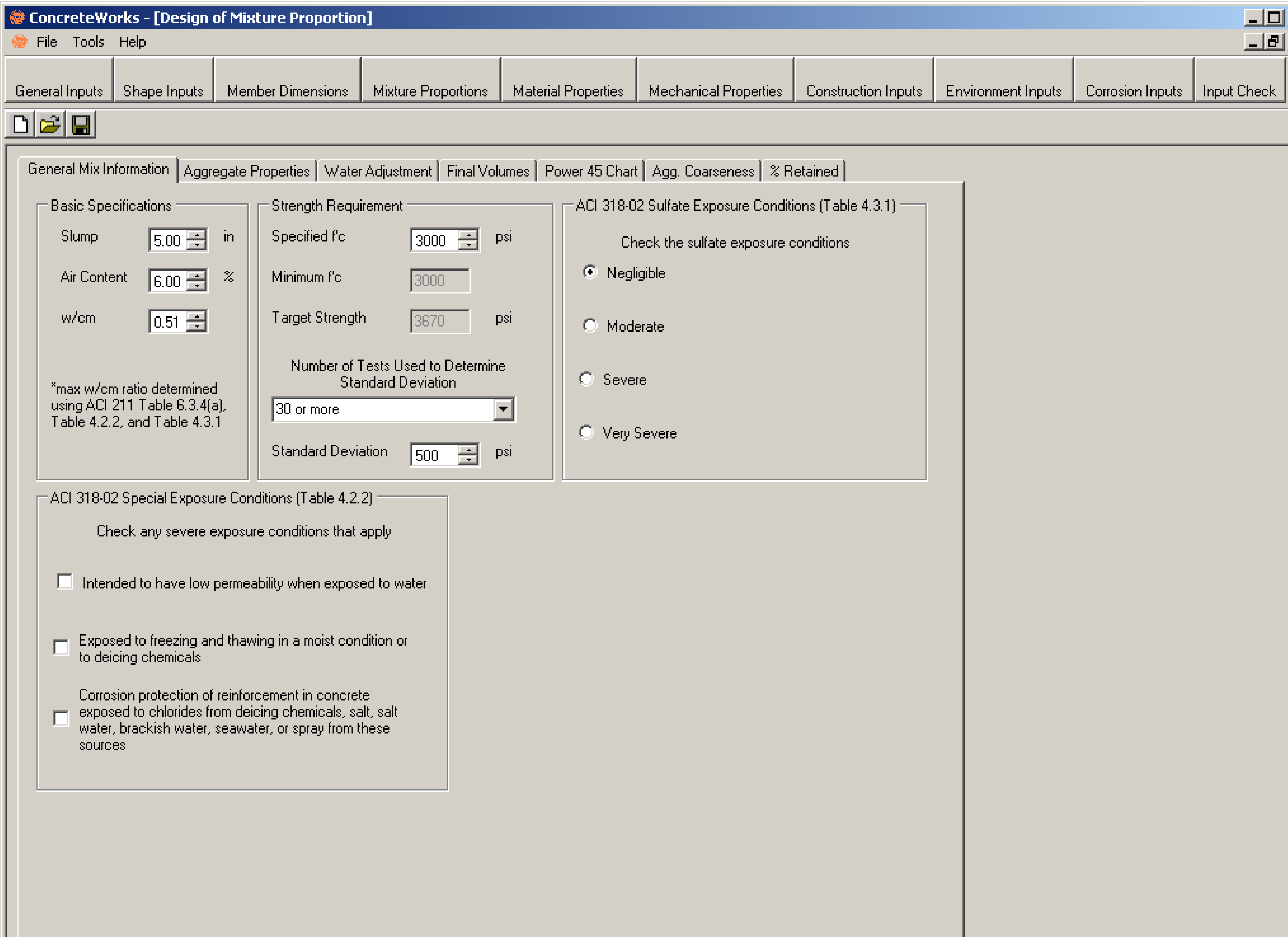
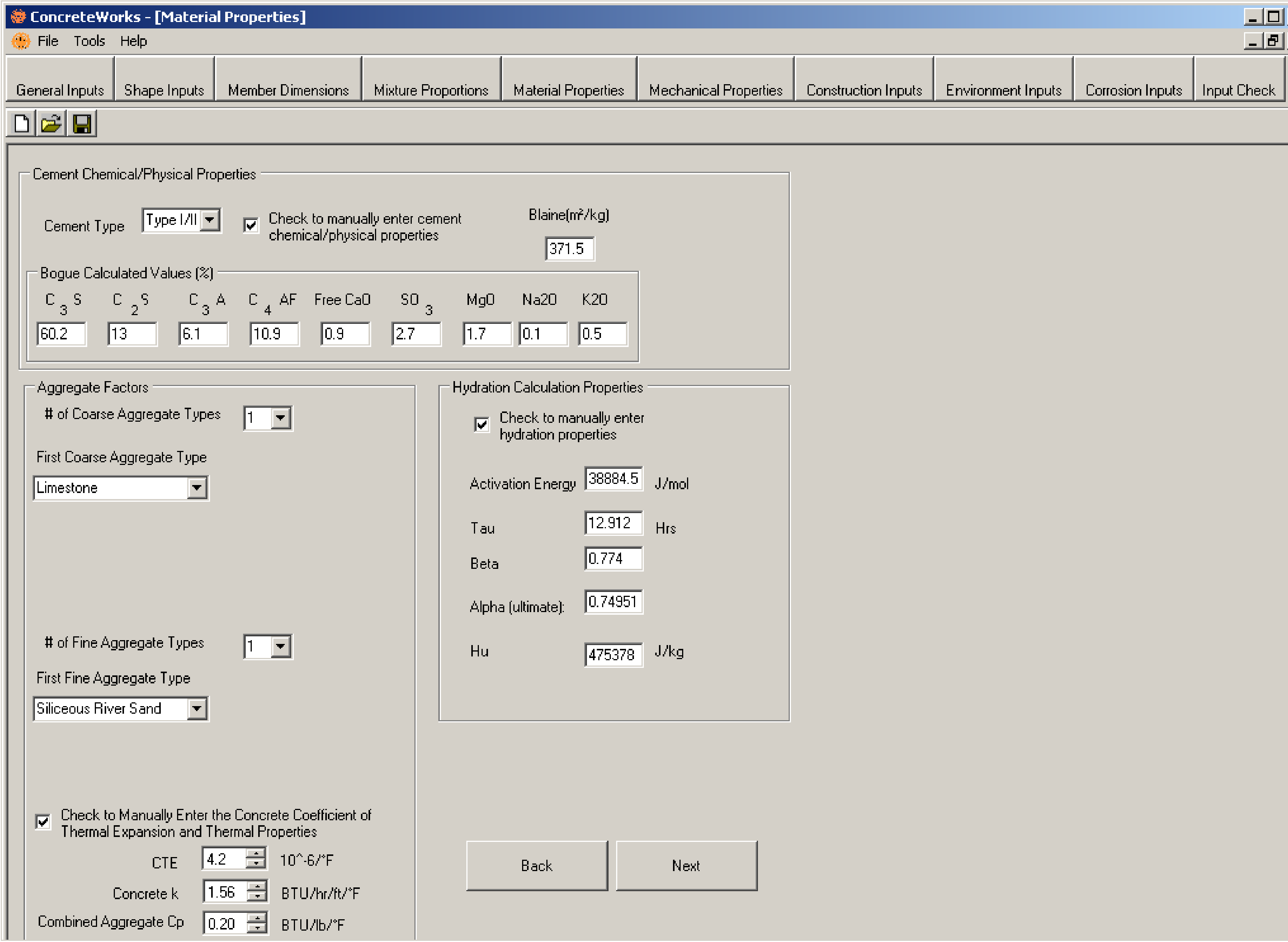
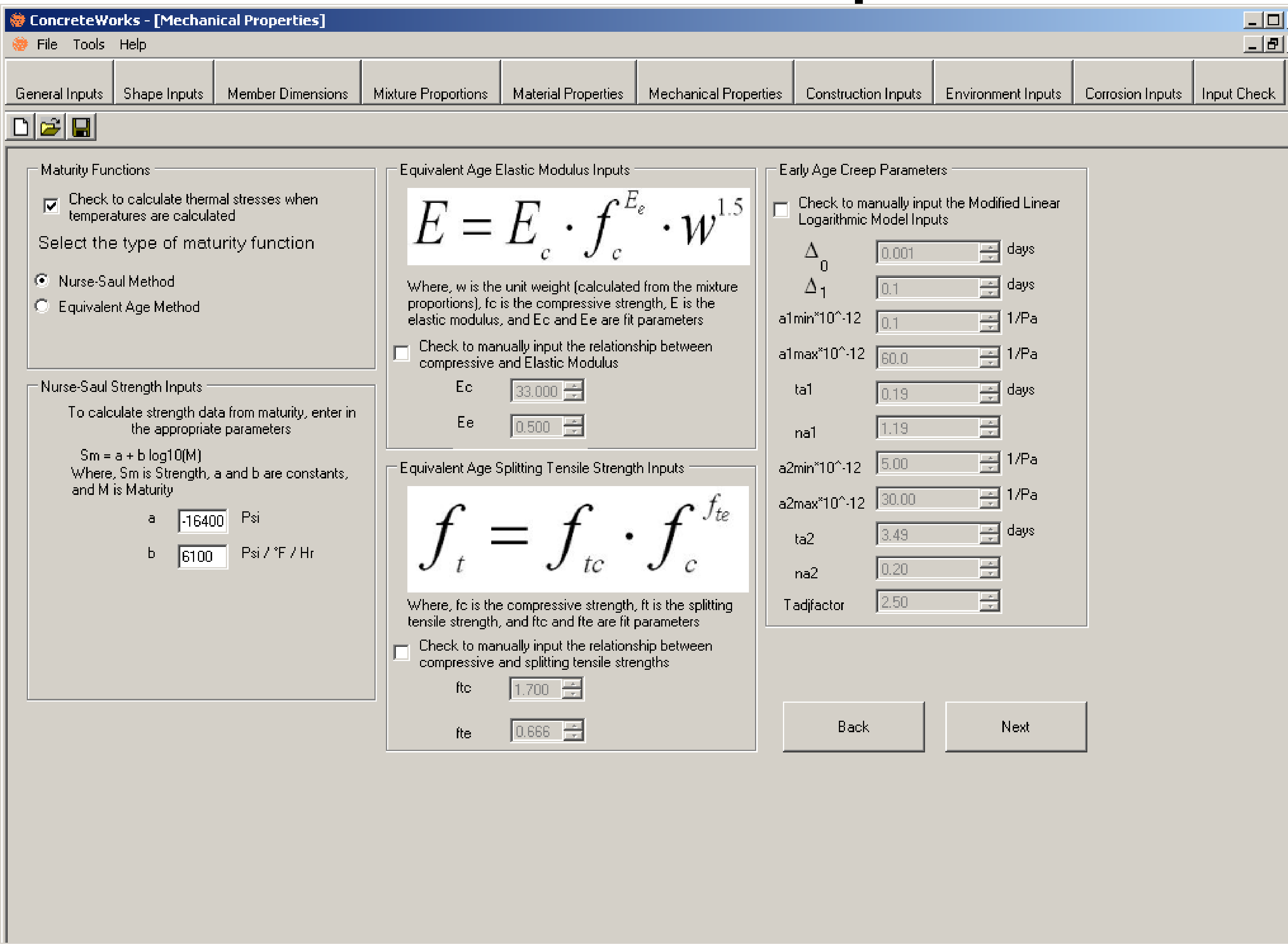


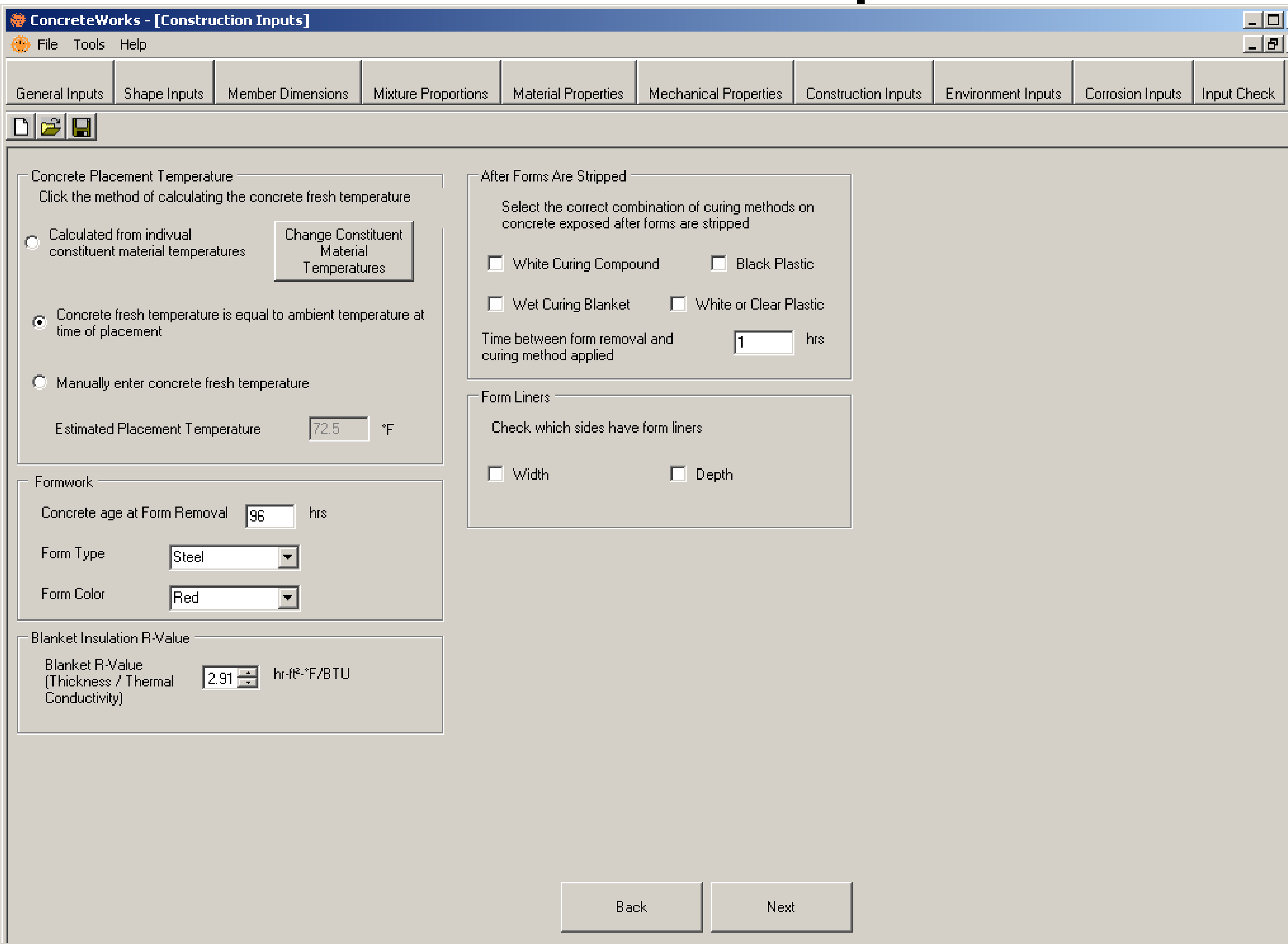
Material Properties



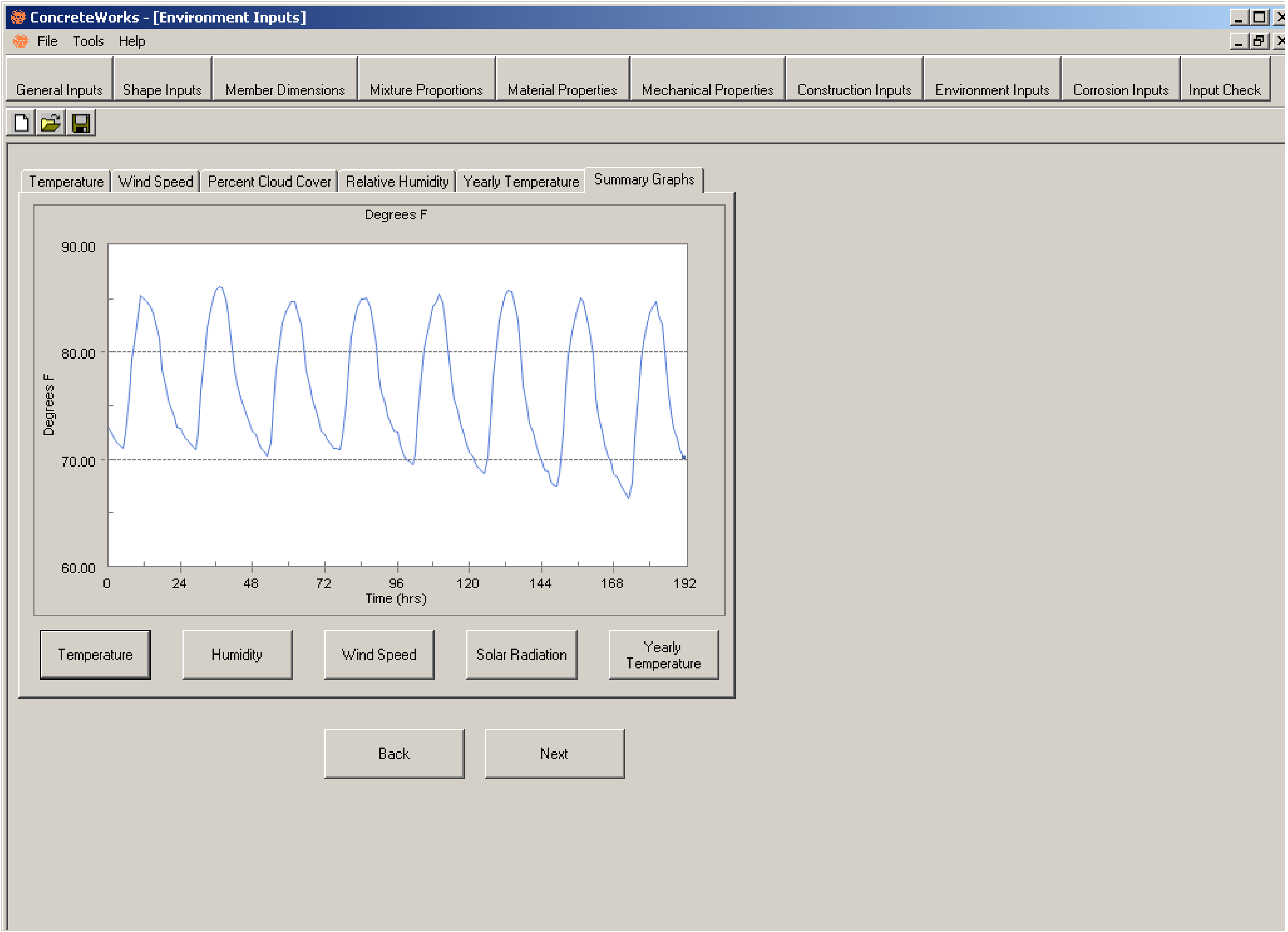
Mechanical Properties



Construction Inputs



Environmental Inputs



ConcreteWorks - [Input Check]

File Tools Help

General Inputs | Shape Inputs | Member Dimensions | Mixture Proportions | Material Properties | Mechanical Properties | Construction Inputs | Environment Inputs | Corrosion Inputs | Input Check

Parameter	Value	Units
General Inputs		
Project Location	Houston	
Unit System	English	
Chloride Units	Percent of Concrete	
Life Cycle Analysis Duration	75	Years
Analysis Duration	7	days
Concrete placement time	7	am
Concrete placement date	9/15/2009	
Member Inputs		
Shape Choice	Rect. column	
Member width	10	ft
Member depth	10	ft
Mixture Proportions		
Cement Content	705	lb/yd^3
Water Content	217	lb/yd^3
Coarse Aggregate Content	1800	lb/yd^3
Fine Aggregate Content	1100	lb/yd^3
Air Content	2	%
Material Properties		
Cement Type	I/II	
Cement Chemistry Values	Default	
Hydration Parameter Values	Default	
Coarse Agg. type	Limestone	
Fine Agg. type	Siliceous River Sand	
Coarse Agg. type	Limestone	
Fine Agg. type	Siliceous River Sand	
Mechanical Properties		
Maturity Method	Nurse-Saul	

Parameter	Value	Units
Environment Inputs Summary		
Ave. Daily Max Temp.	85.7	°F
Ave. Daily Min Temp.	70.5	°F
Ave. Max Daily Solar Radiation	665.3	W/m^2
Ave. Max Daily Wind Speed	10.9	m/s
Ave. Max Relative Humidity	91.6	%
Ave. Min Relative Humidity	58.2	%
Construction Inputs		
Concrete Fresh Temperature	72.7	°F
Blanket R-Value	2.91	°F
Forms are stripped after	96	hrs
Form Color	Red	
Form Type	Steel	
No Cure Method Chosen		
Corrosion Inputs		
Steel Type	Black Steel	
Steel Cover	2	
Dref	65.9	x 10^...
m	0.26	
No Barrier Method Selected		
Exposure Class	Urban Road	

Default values are indicated by green

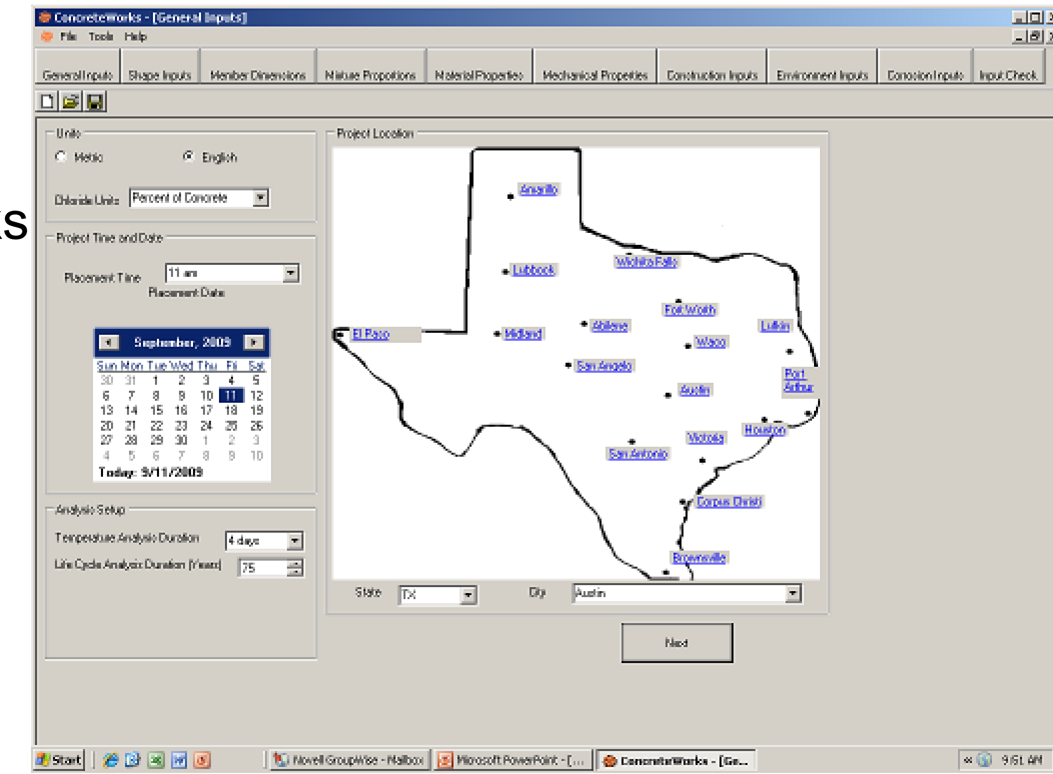
Questionable input values are indicated by red

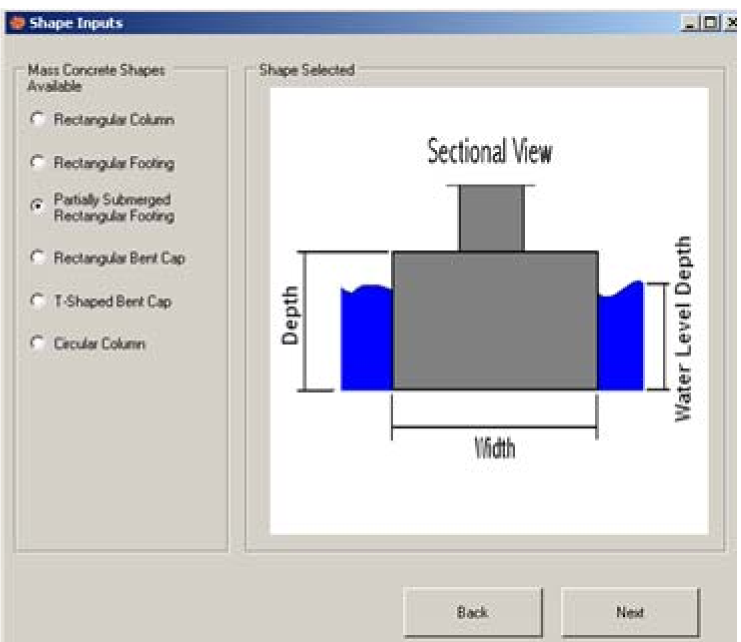
Back

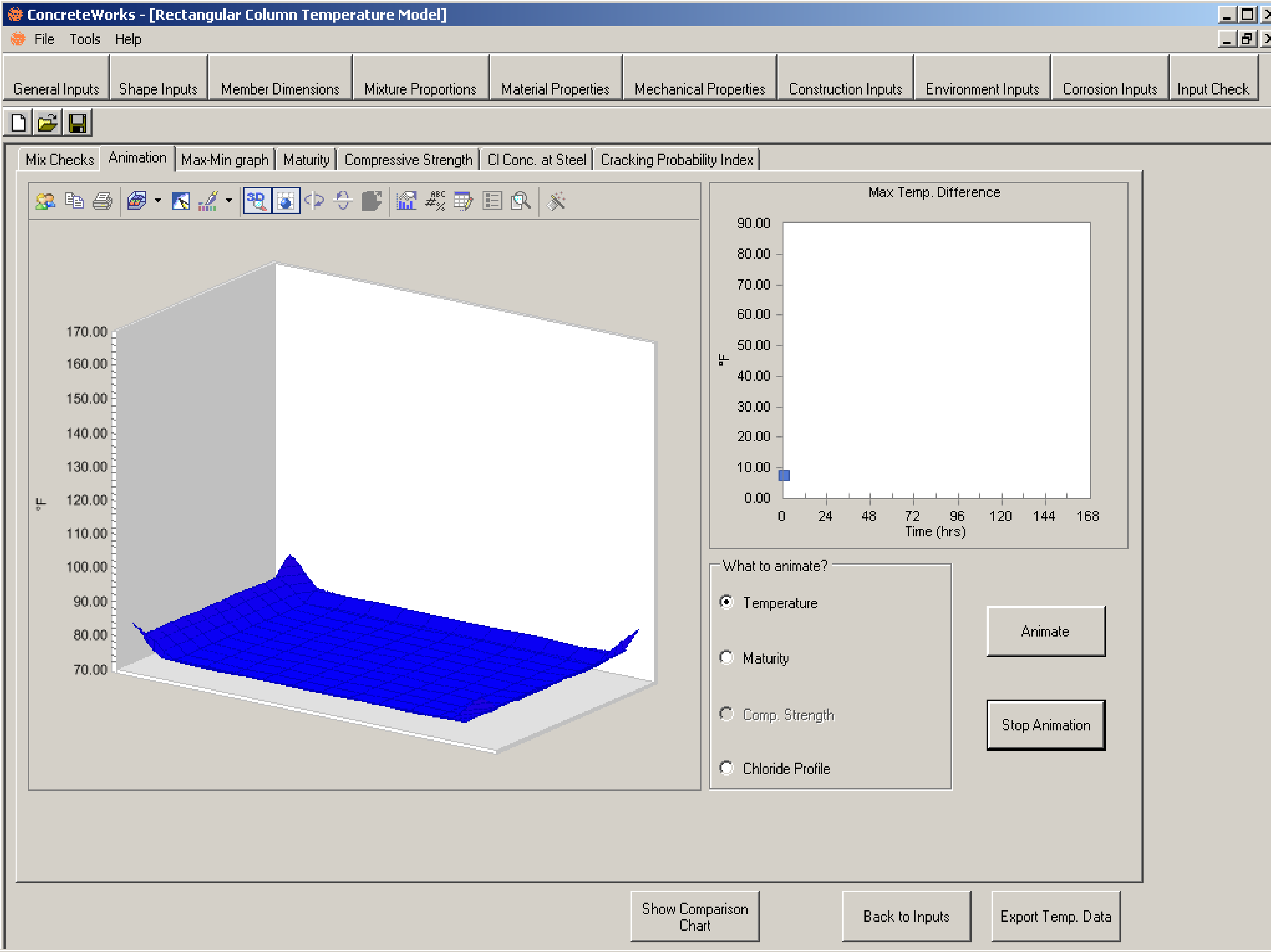
Calculate Temperatures

Temperature Predictions

- Temperature Predictions for Various Section Shapes and Location around the State
  - Mass Concrete Sections
  - Pavement & Bridge Decks
  - Precast Bridge Girders



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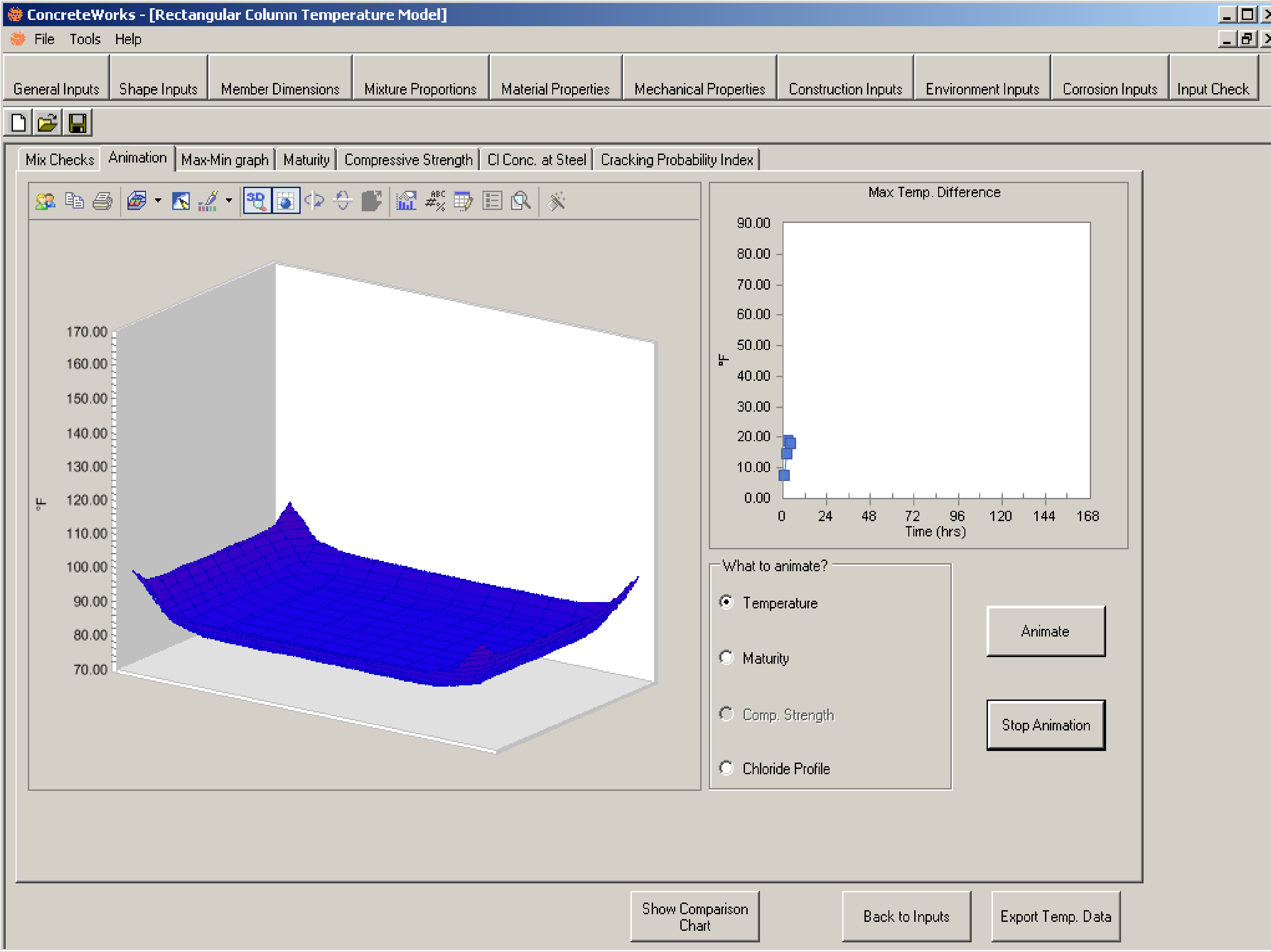
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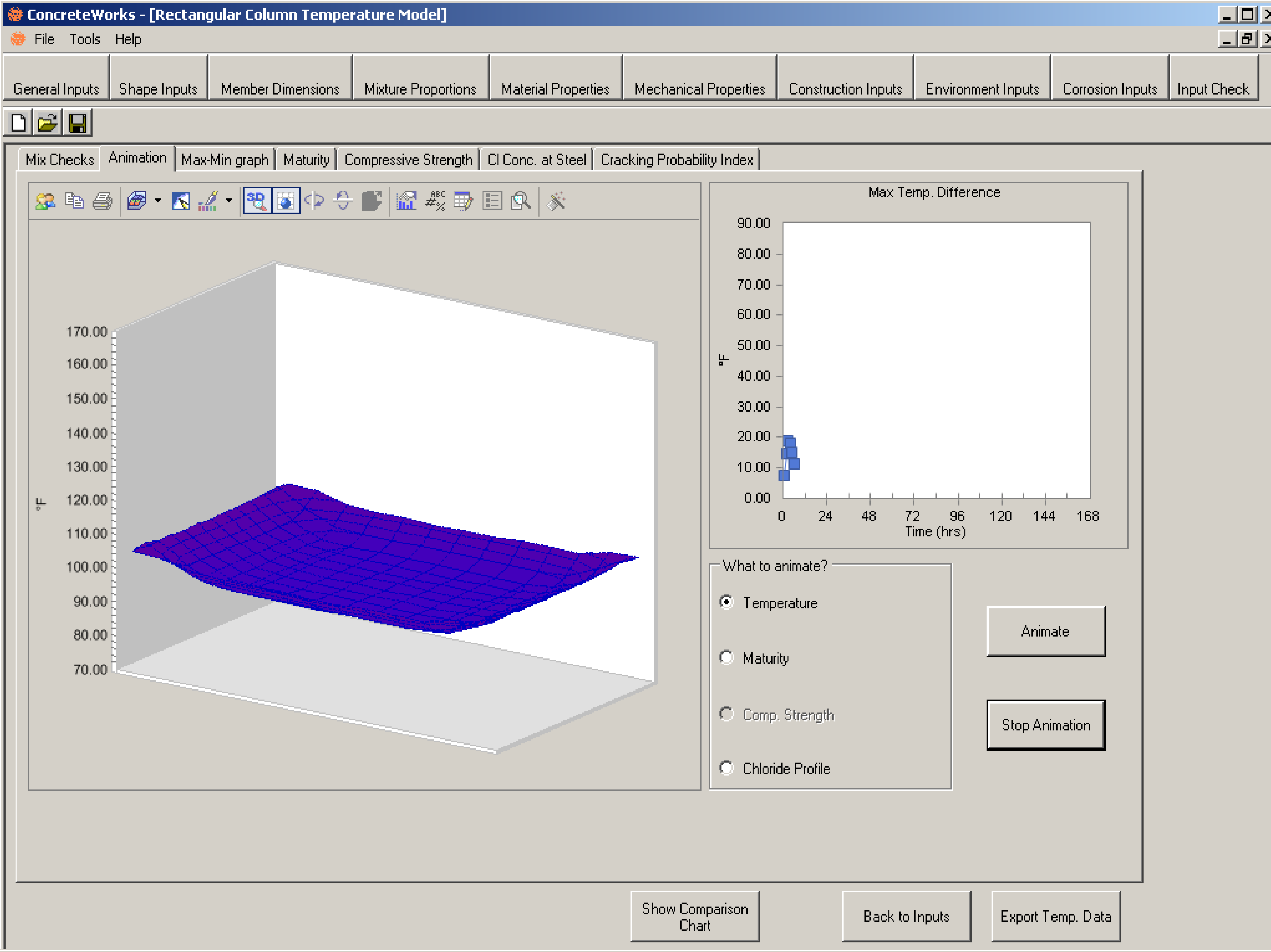
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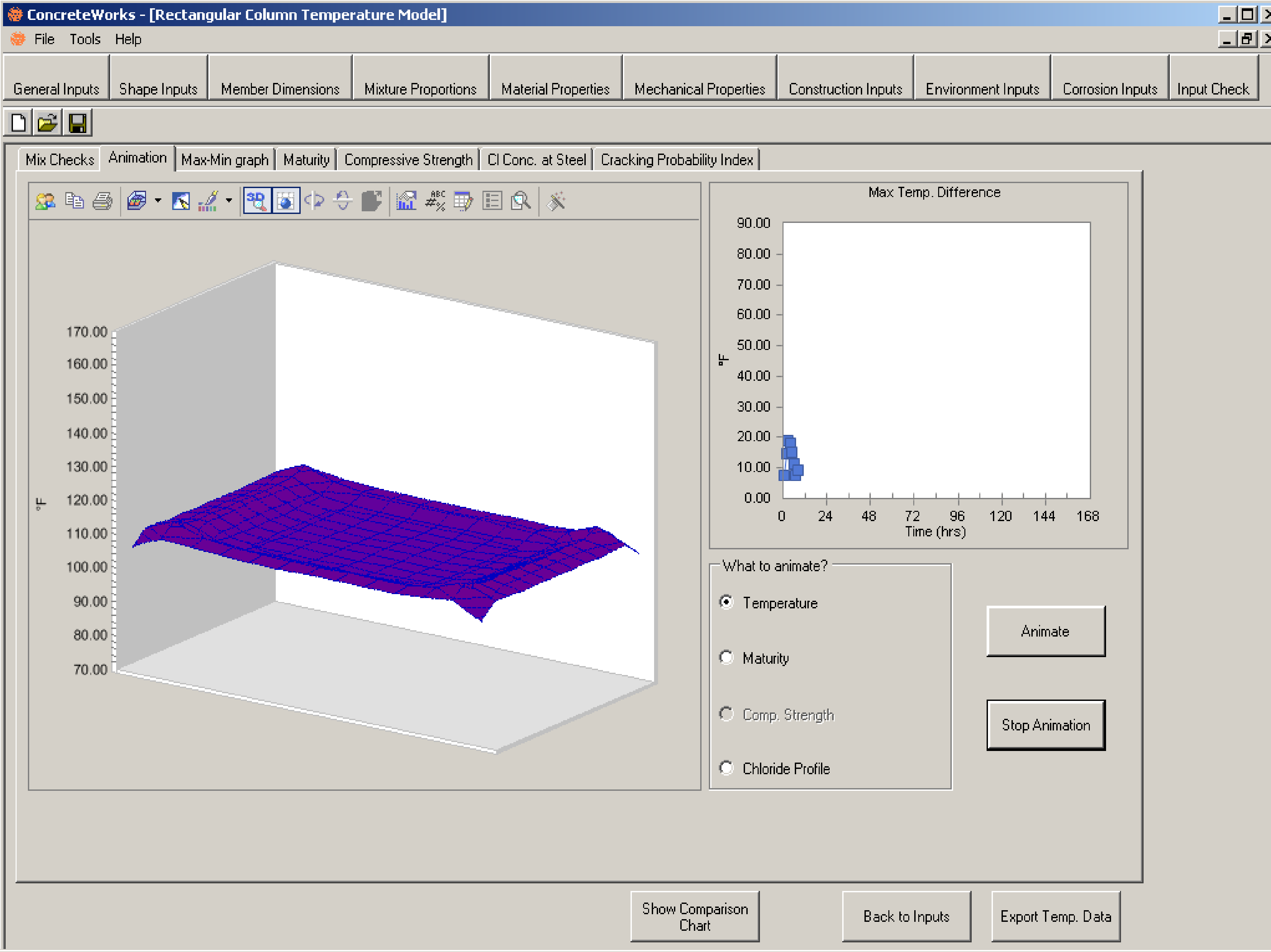
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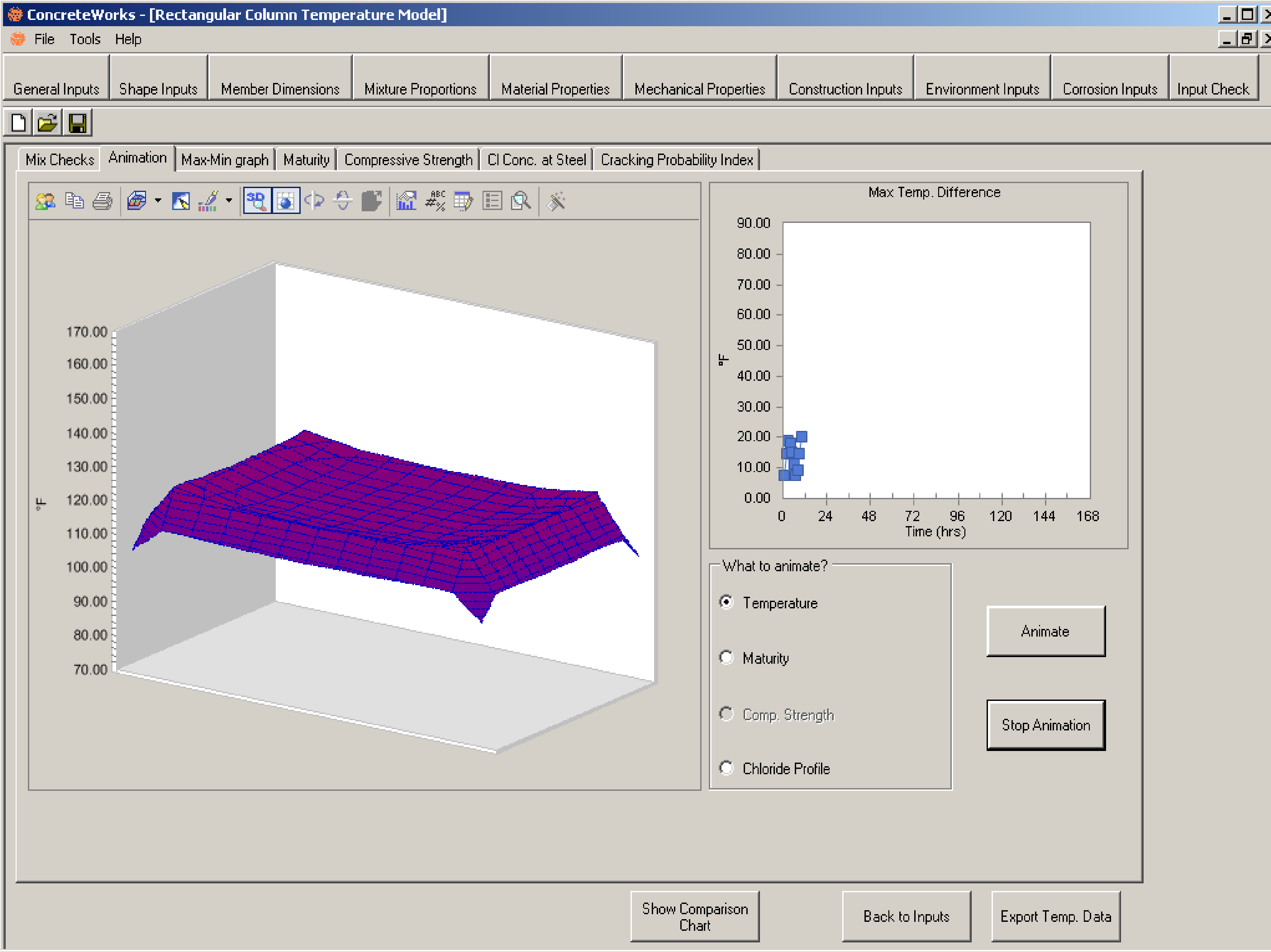
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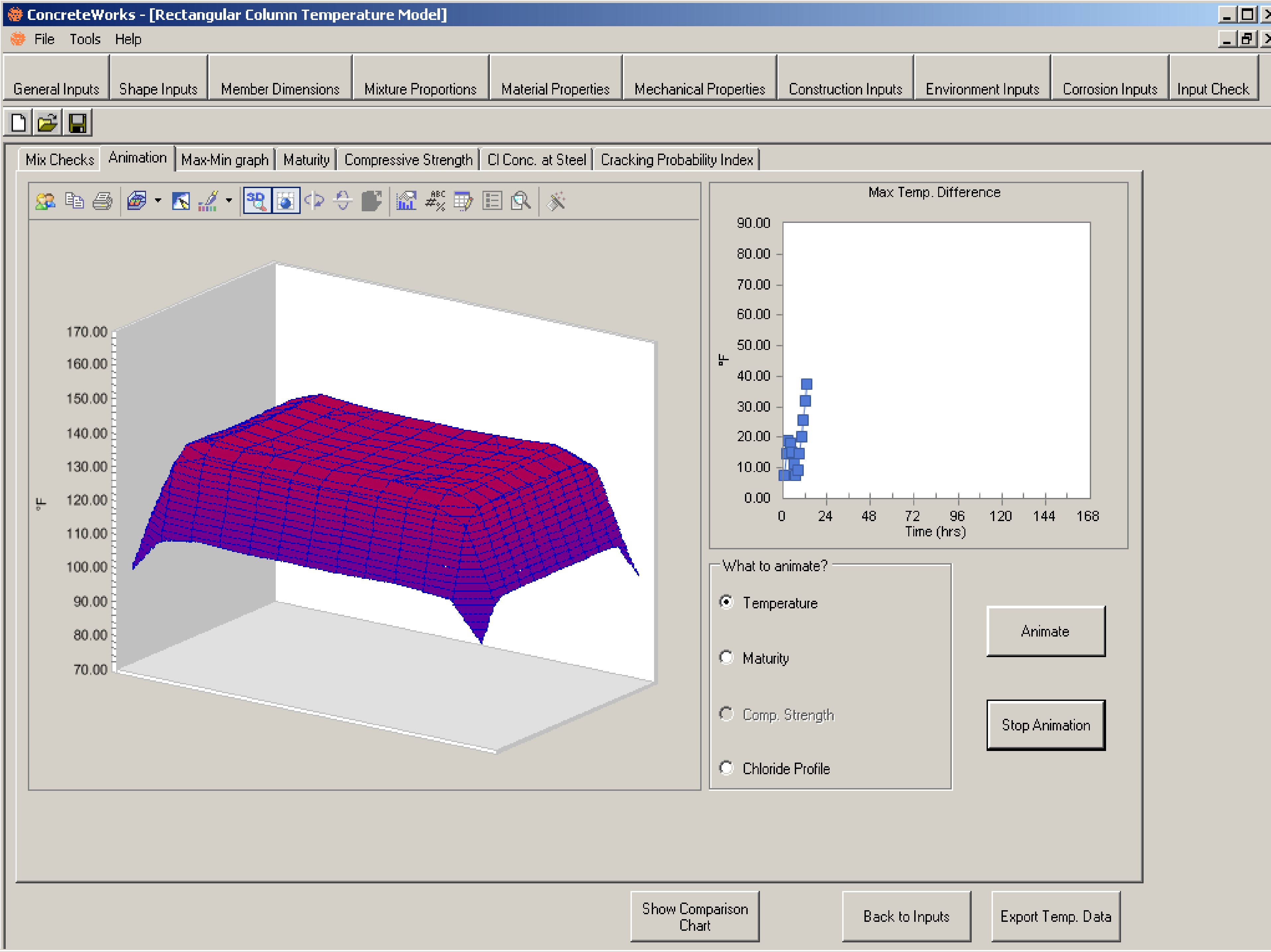
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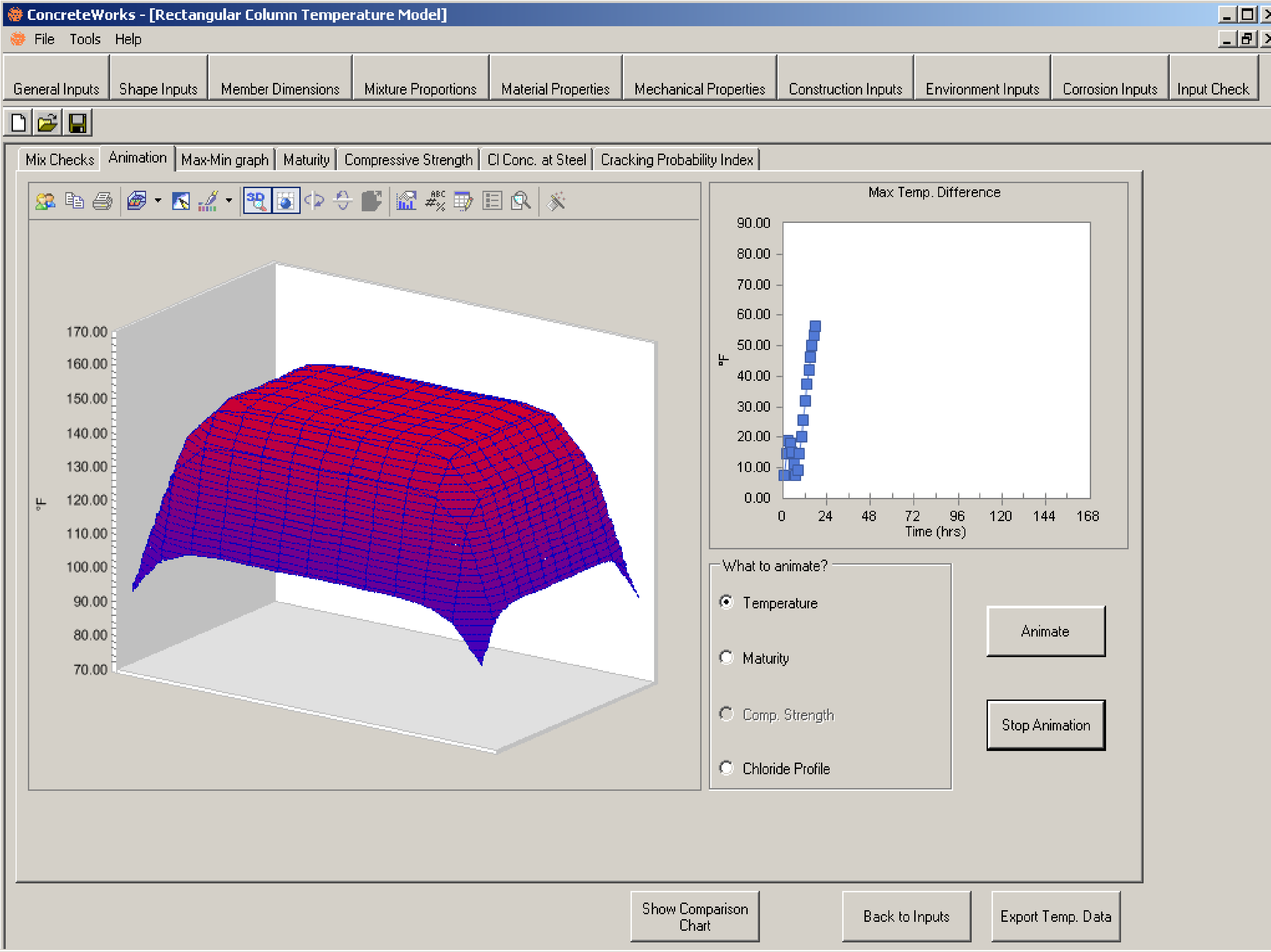
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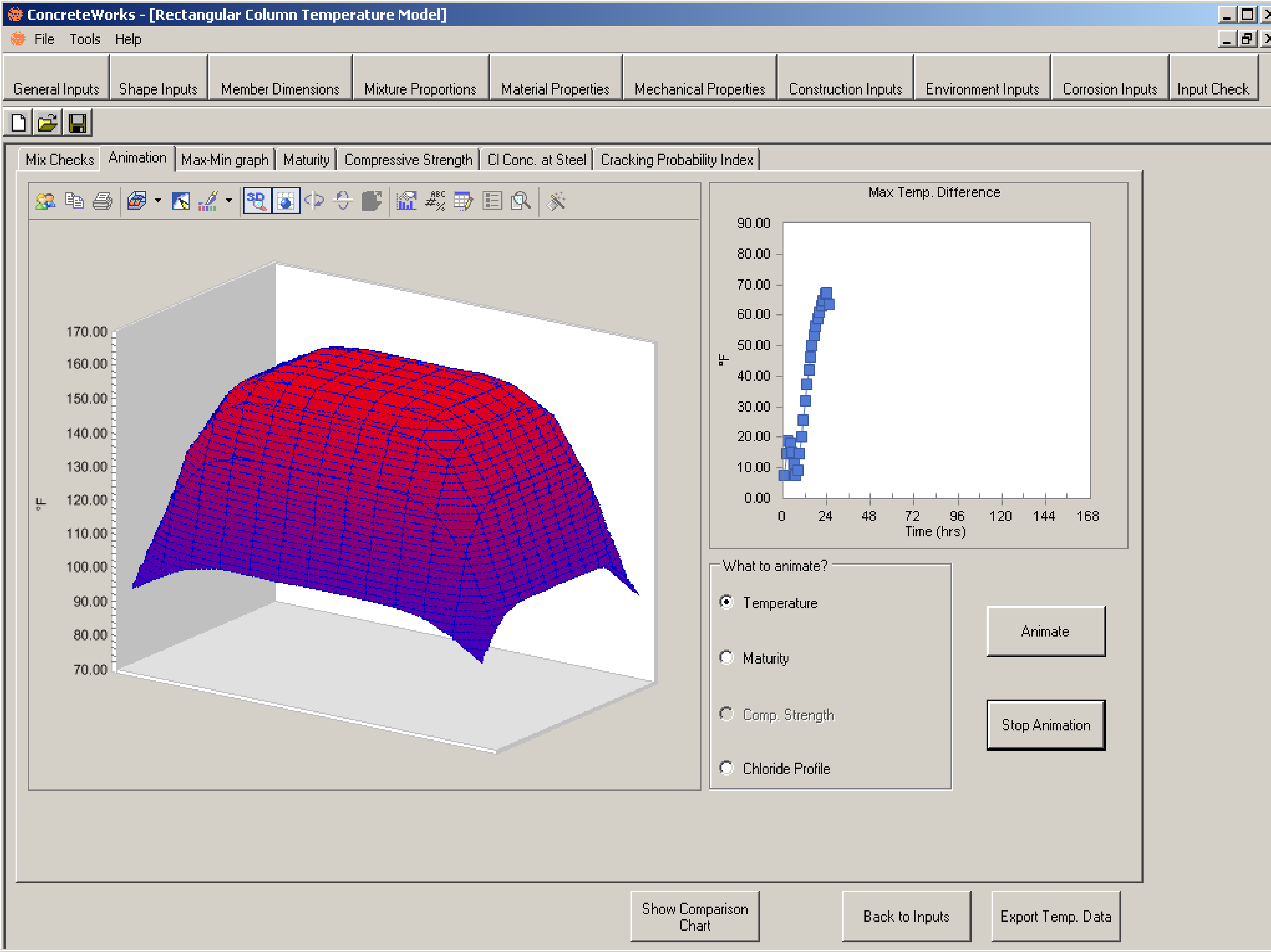
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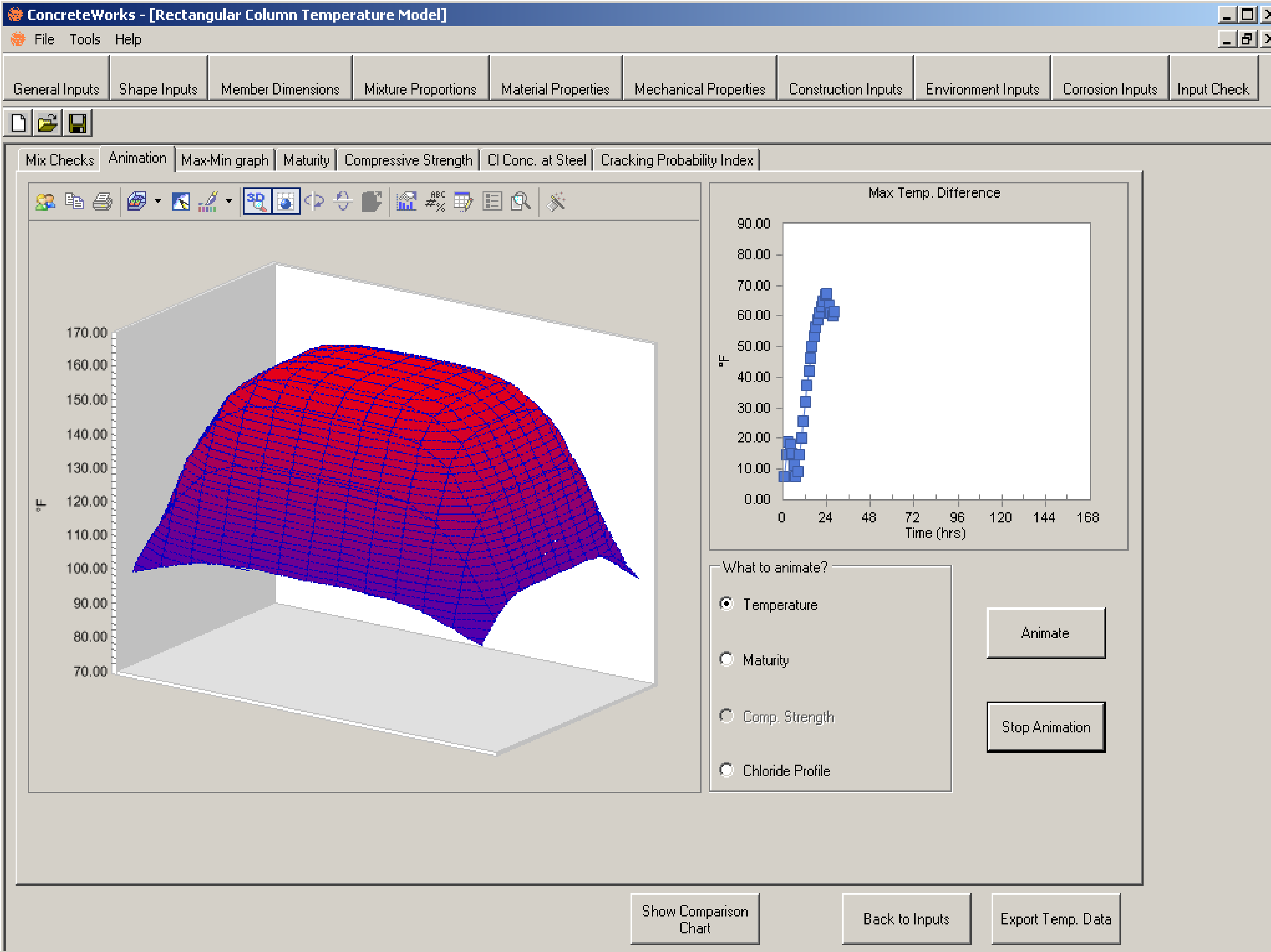
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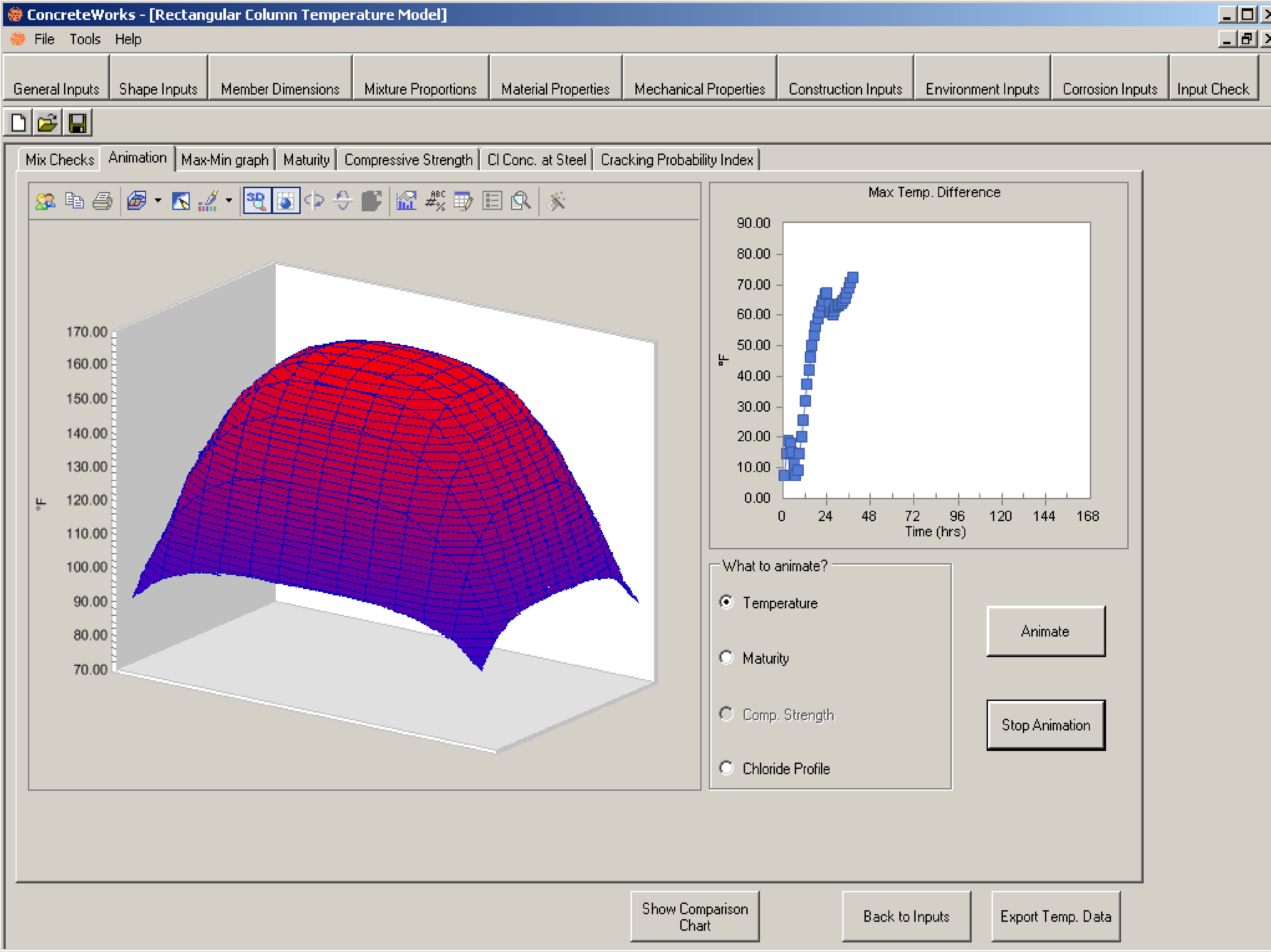
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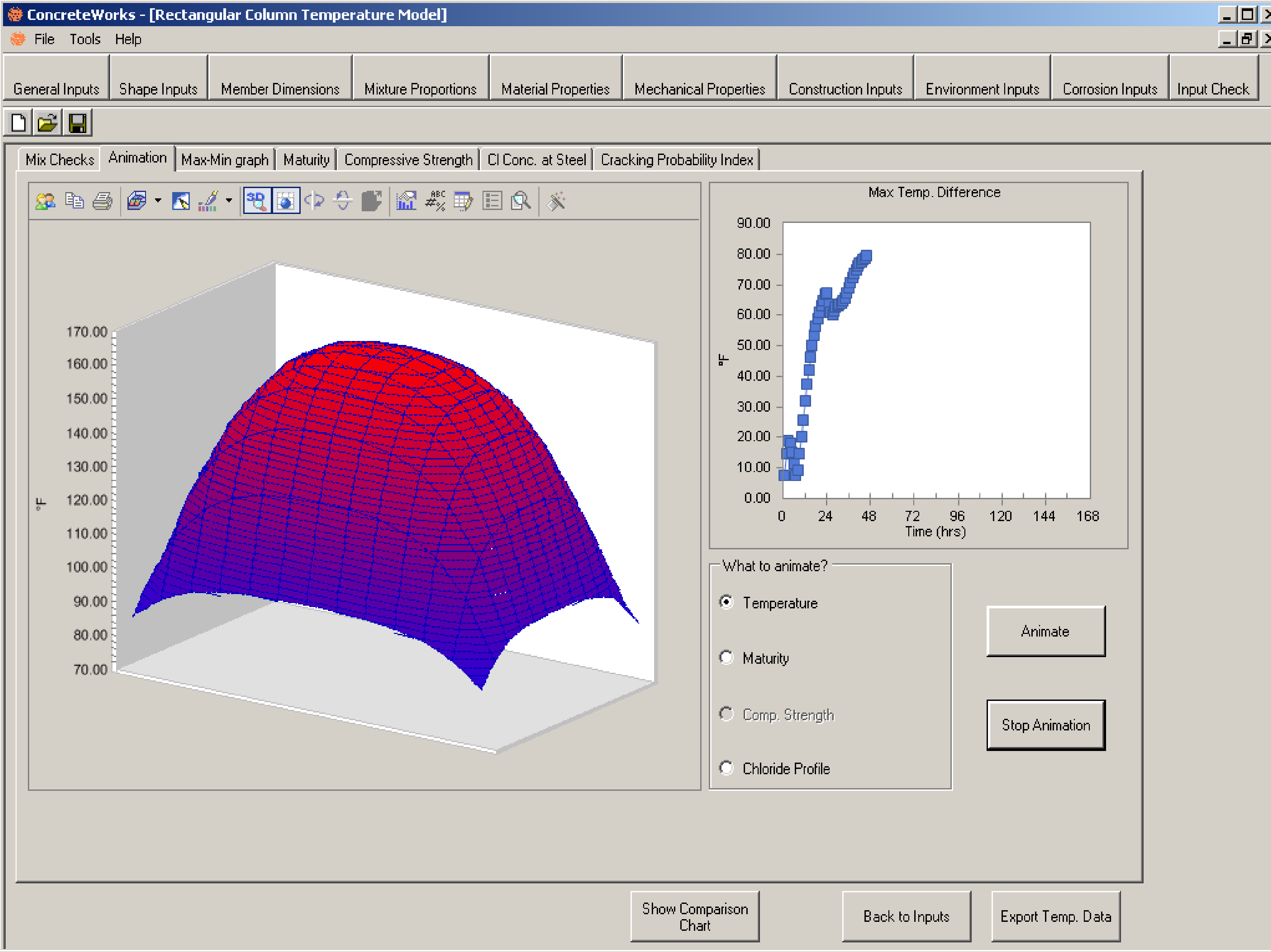
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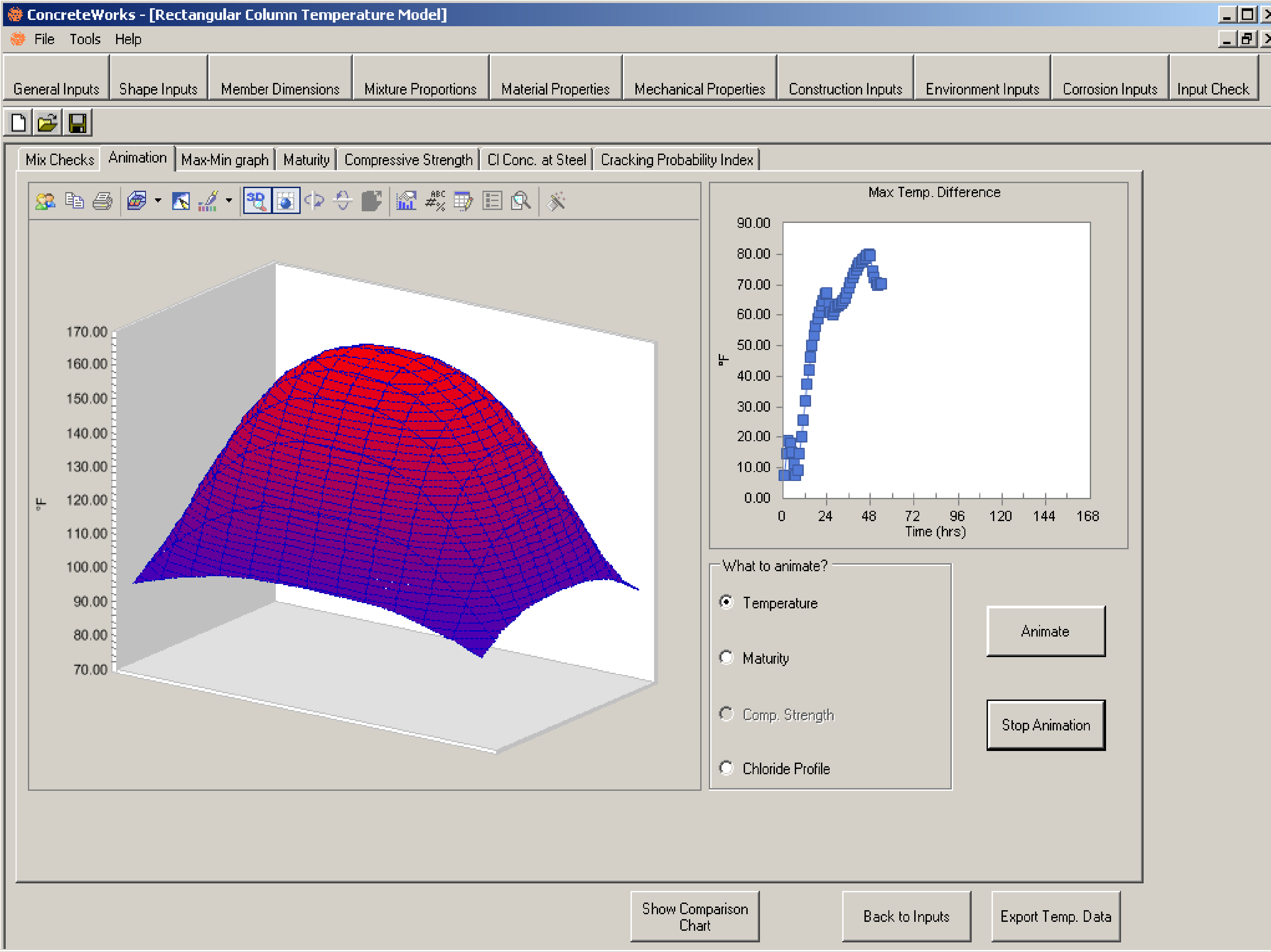
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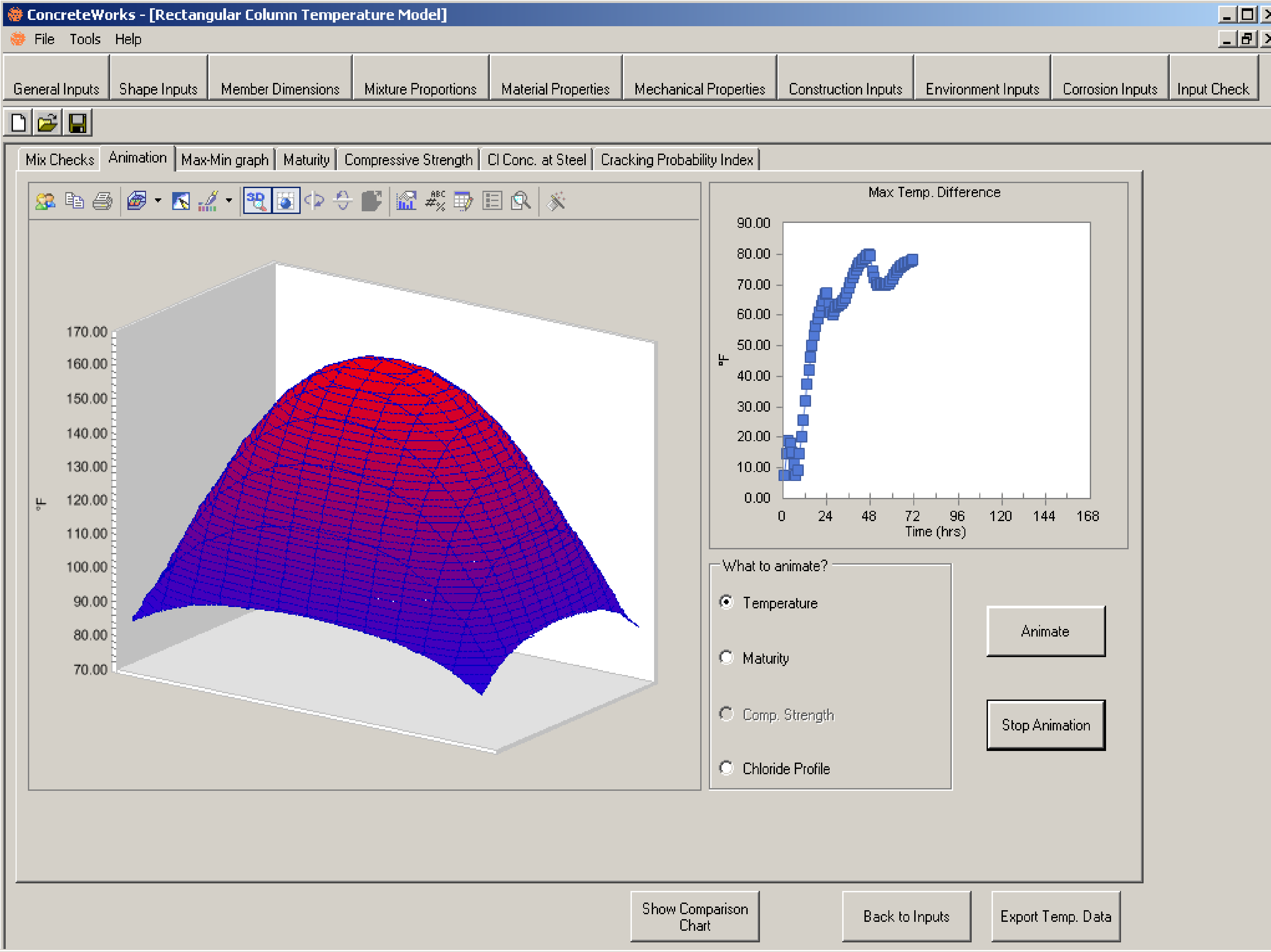
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Max Temp. Difference
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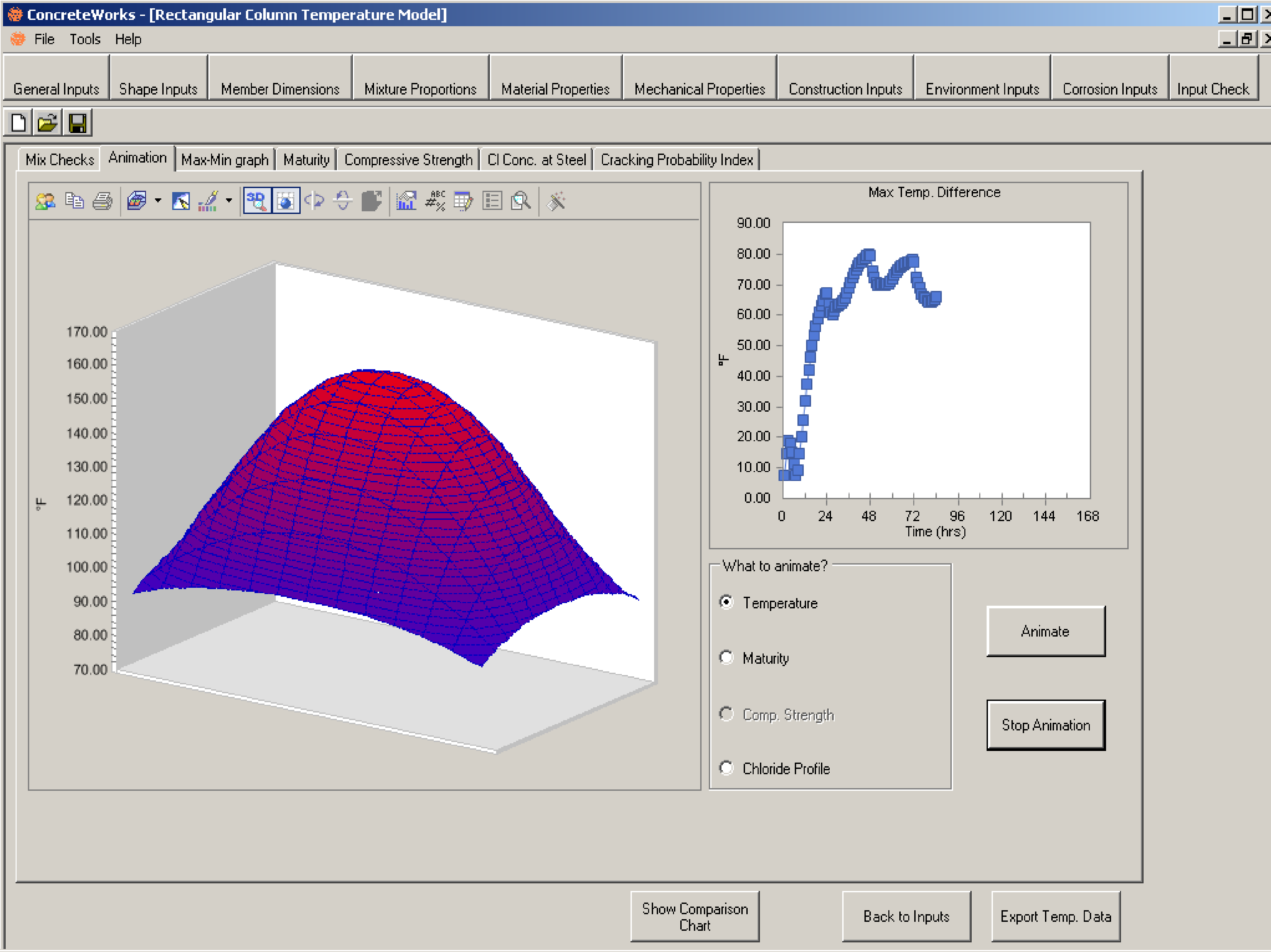
72
96
120
144
168
Time (hrs)
What to animate?
Temperature
Maturity
Comp. Strength
Chloride Profile
Animate
Stop Animation
Show Comparison Chart
Back to Inputs
Export Temp. Data


ConcreteWorks - [Rectangular Column Temperature Model]
File
Tools
Help
General Inputs
Shape Inputs
Member Dimensions
Mixture Proportions
Material Properties
Mechanical Properties
Construction Inputs
Environment Inputs
Corrosion Inputs
Input Check
Mix Checks
Animation
Max-Min graph
Maturity
Compressive Strength
Cl Conc. at Steel
Cracking Probability Index
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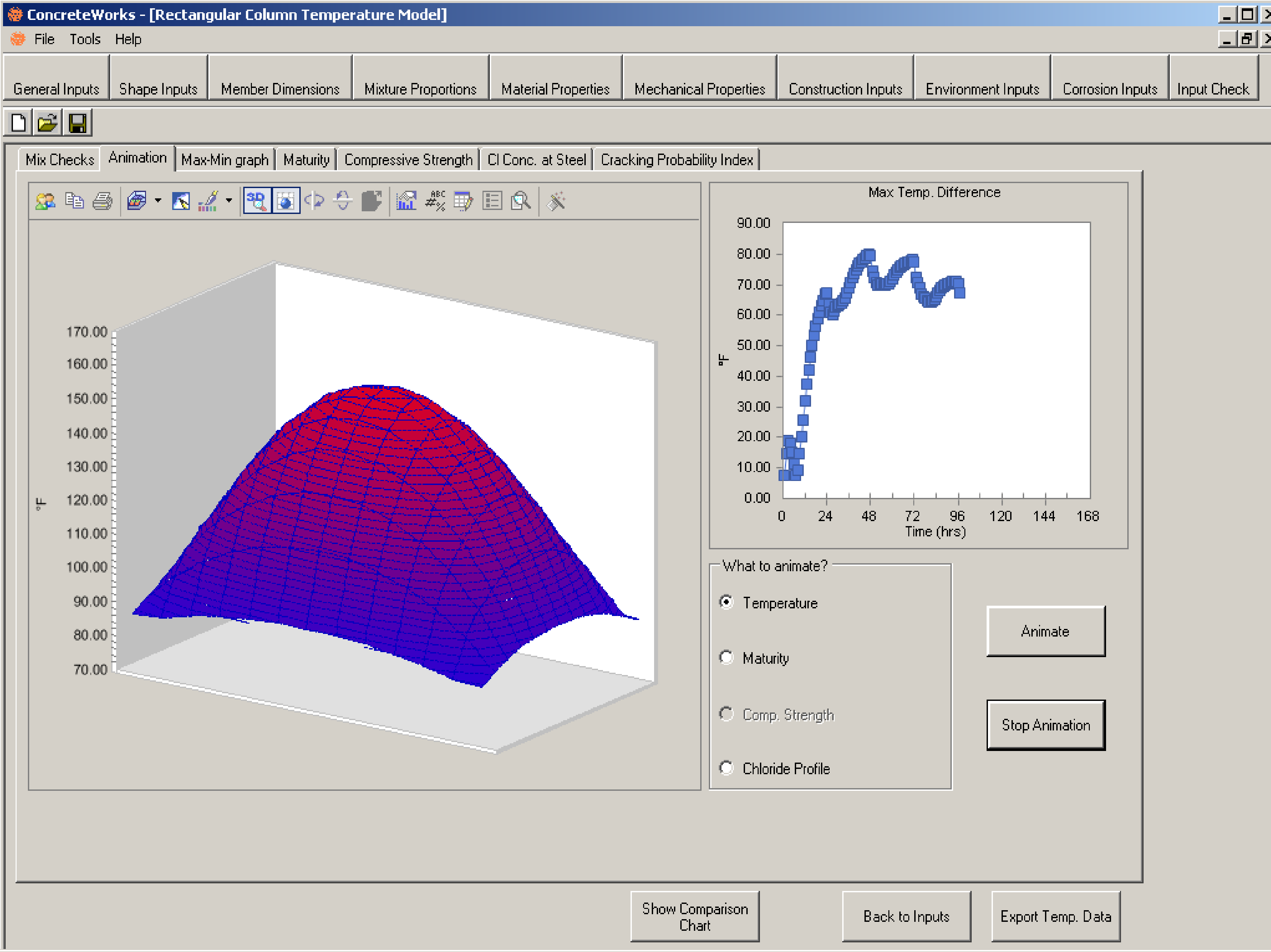
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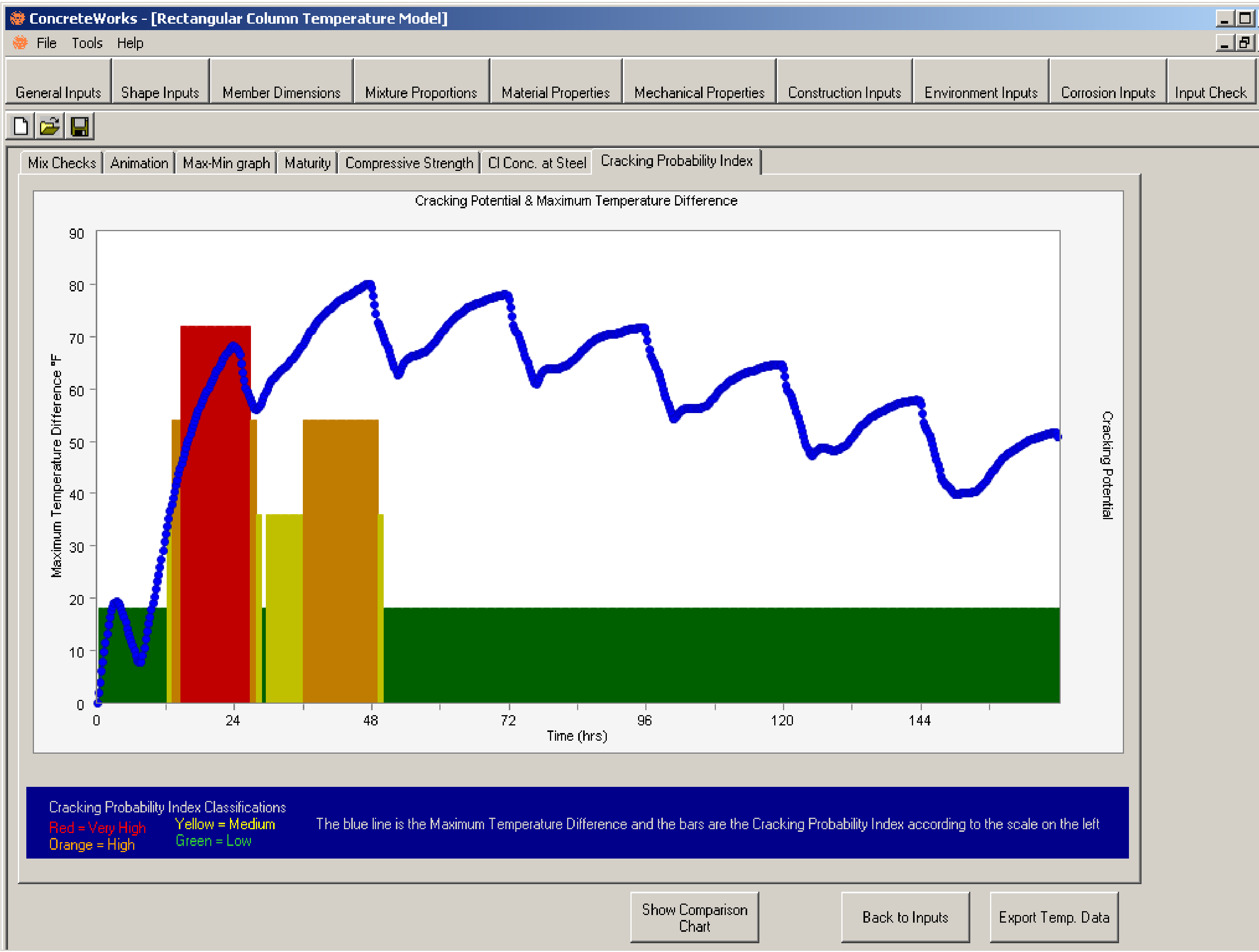
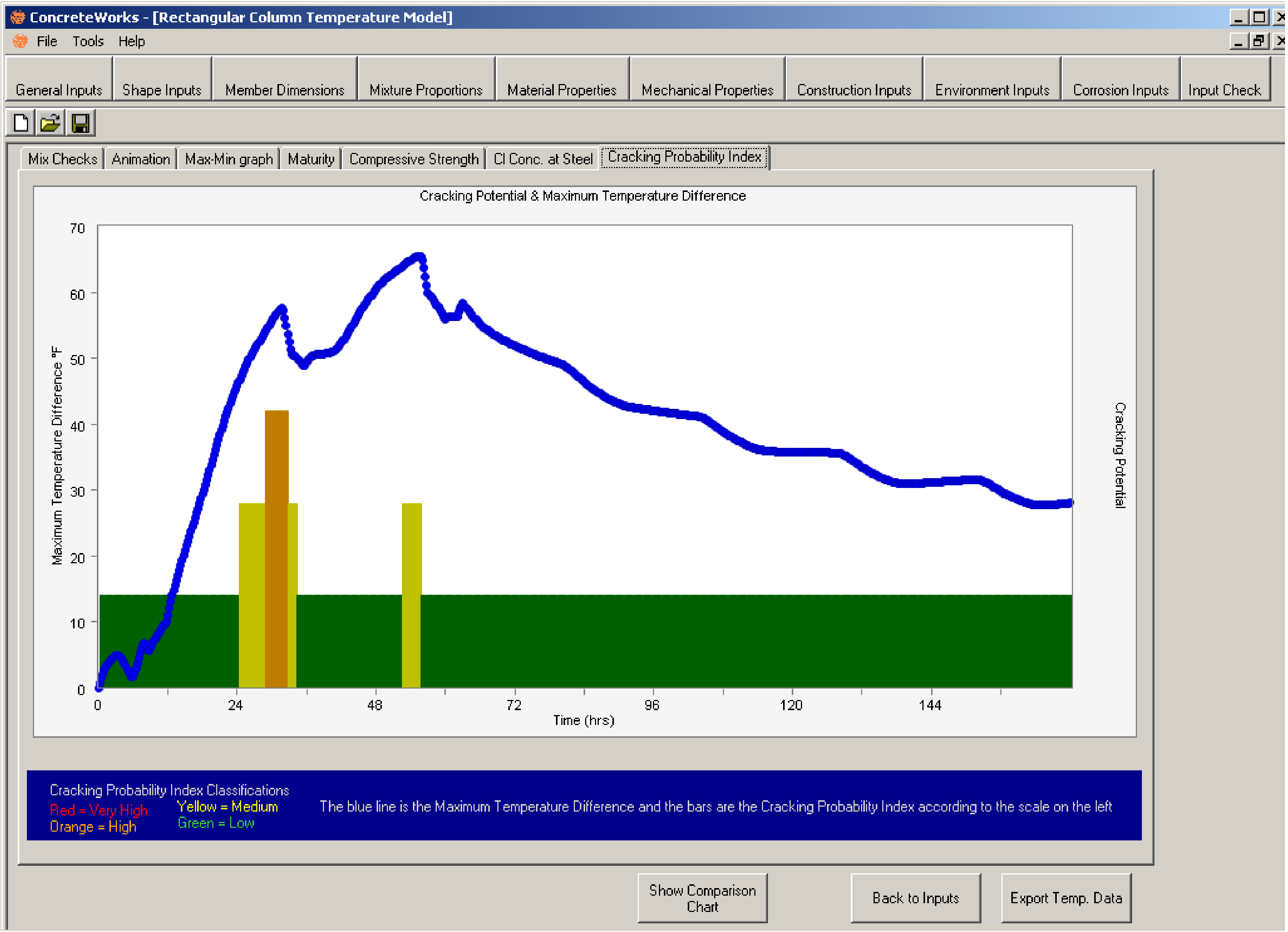
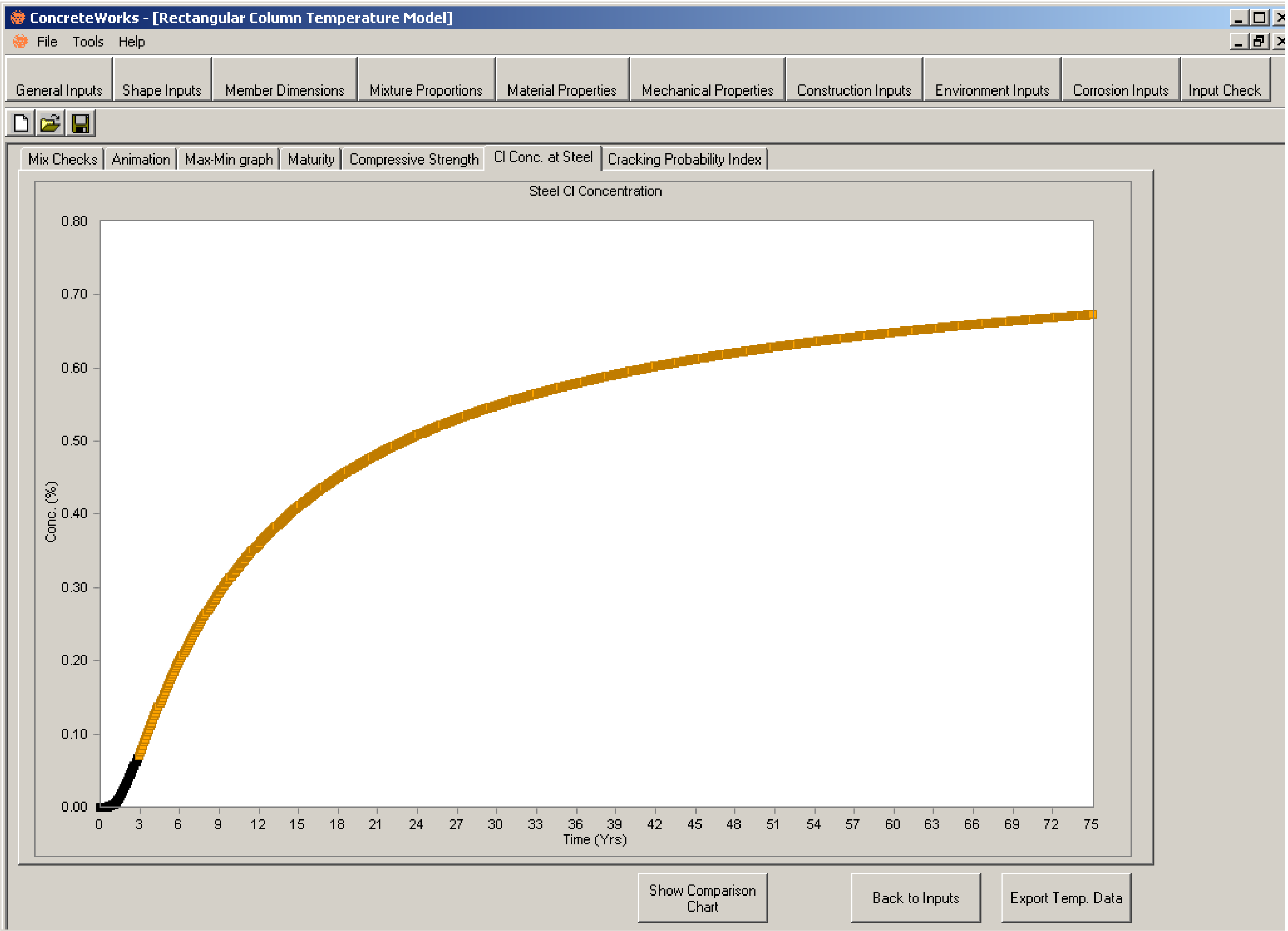
Thermal Cracking Probability



Thermal Cracking Probability



Chloride Prediction



Where do I get ConcreteWorks?

- TxDOT Employees
  - Contact your IRA
- Non-TxDOT Employee
  - www.texasconcreteworks.com
  - Site hosted and managed by UT-CMRG

What's Next?

- Training program for TxDOT and Contractors currently being developed
- Research on crack probability for bridge decks is ongoing

Acknowledgements

- University of Texas @ Austin – CMRG
  - Dr. Kyle Riding
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  - Dr. Kevin Folliard
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Thank You