FEA of structures with insulation damage in fire

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FEA of structures with insulation damage in fire

- Topics
  - Motivation
  - Physics
  - Procedures
  - Test Case
  - Future Work

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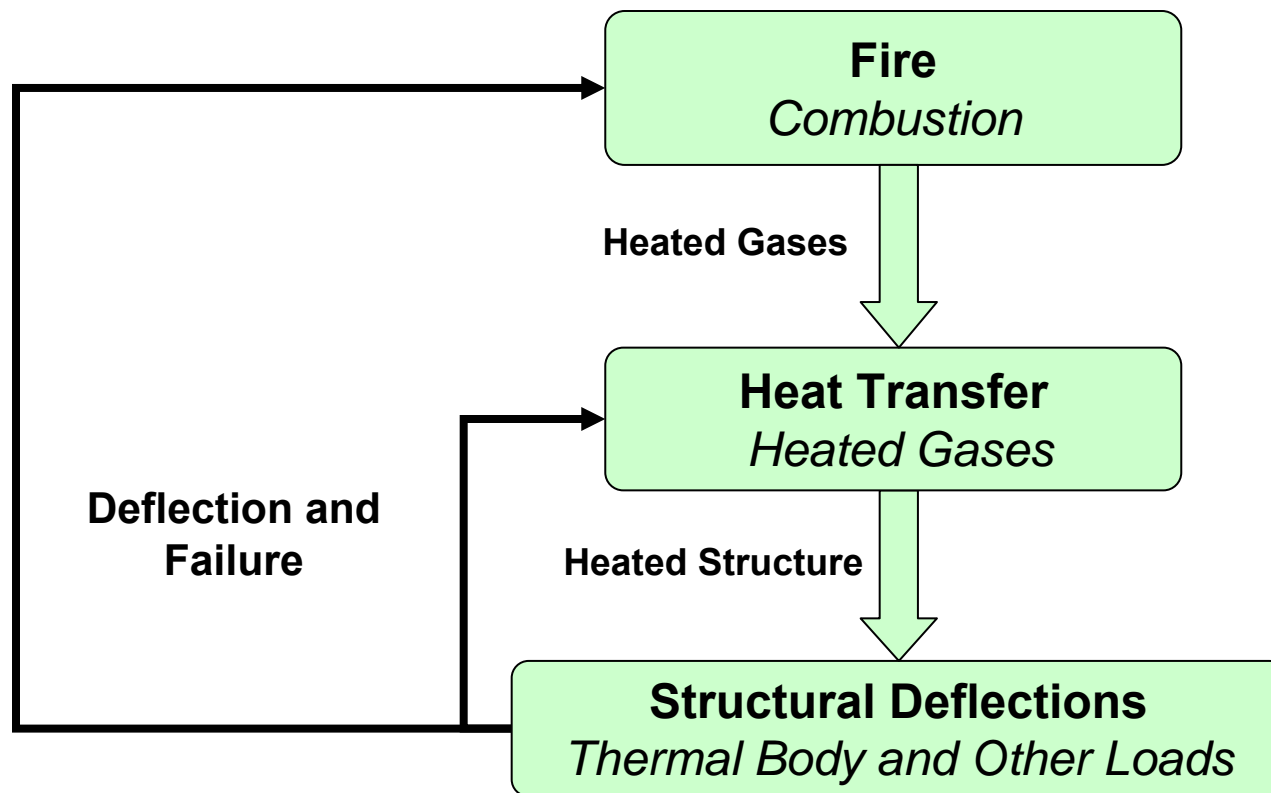
- ## Motivation – WTC Disaster

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- ## Motivation
  - ### WTC destruction
    - Need to treat fire as a structural load
    - Analyze complex structures under fire all the way to collapse
    - National Construction Safety Team recommended enhancing capabilities of available computational software to study the effect of fire on buildings and the design of fire protection systems
  - ### Interface limited to compatible elements
  - ### Intense fire of long duration requires modeling damage and collapse
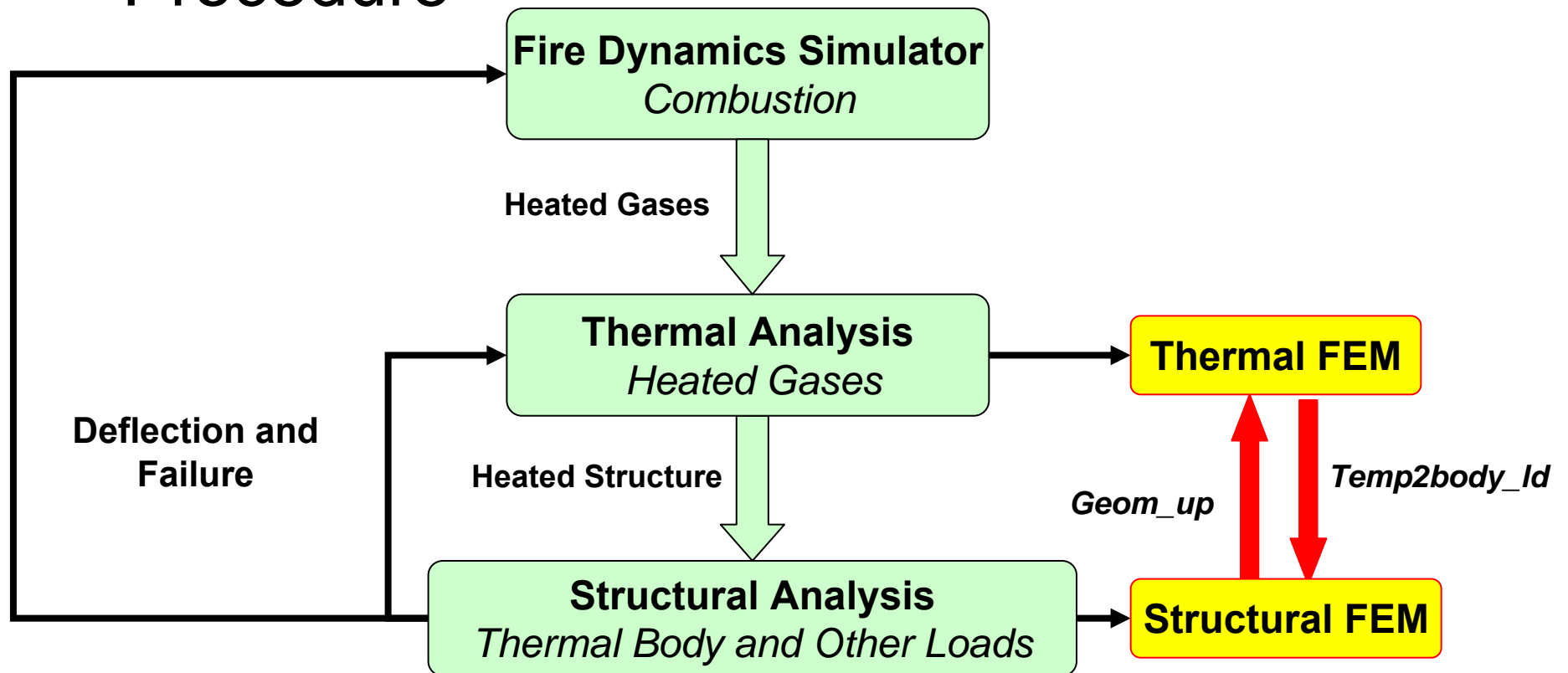
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- Physics: Fire-Structure Interaction

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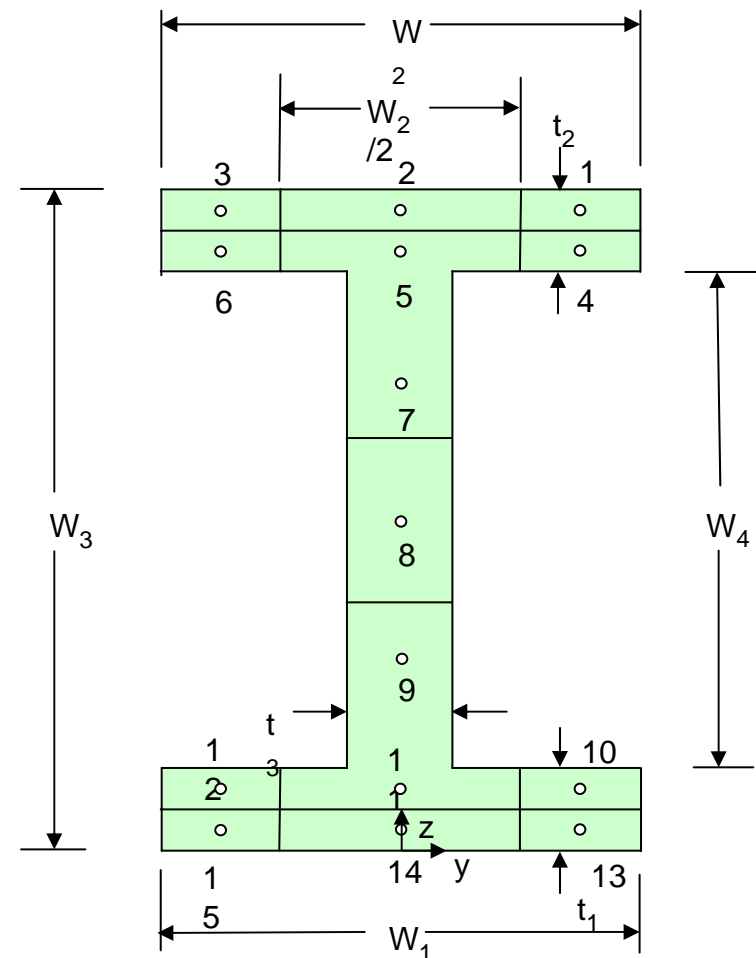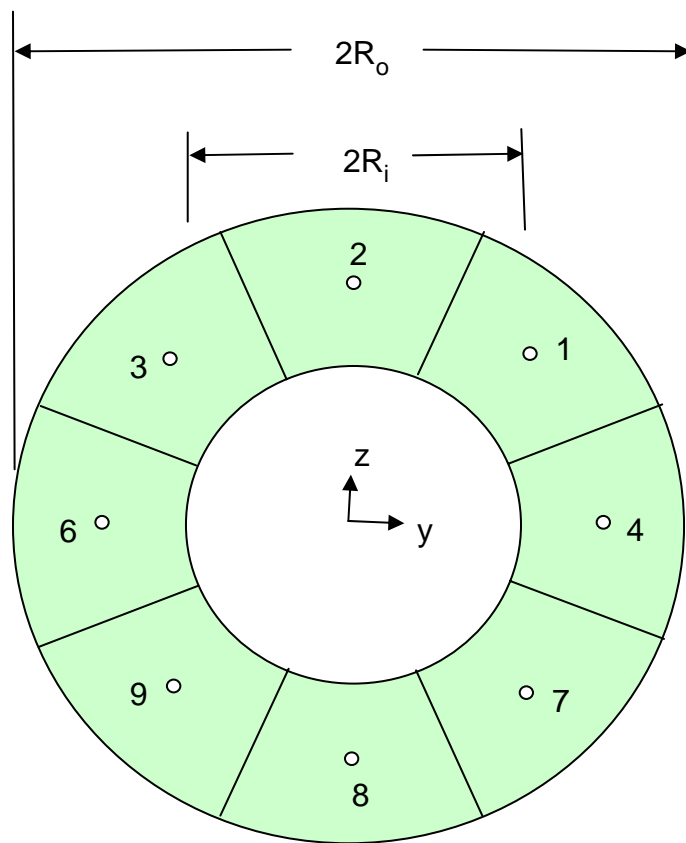
- Procedure

Fire Dynamics Simulator
Combustion

Heated Gases

Thermal Analysis
Heated Gases

Thermal FEM

Heated Structure

Deflection and Failure

Geom_up   *Temp2body_ld*

Structural Analysis
Thermal Body and Other Loads

Structural FEM

FEA of structures with insulation damage in fire

- ## Temp2Body_Id
  - Same Global CSYS
  - Transfer Nodes
  - Temperature Mapping
  - Gradient Calculation and Body Load Definition
  - Use Area-Weighted Averages
- ## Geom_up
  - Maps Deflections and Strains from Structural onto Thermal Model Domain
  - For Deflections use the Kinematics Relationship

    $$U = u + r \times d$$
  - Interpolates Strains from Selected Cross Section Cell Nodes of Structural onto Thermal Model Domain
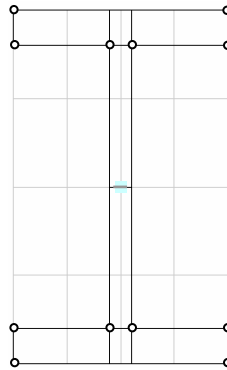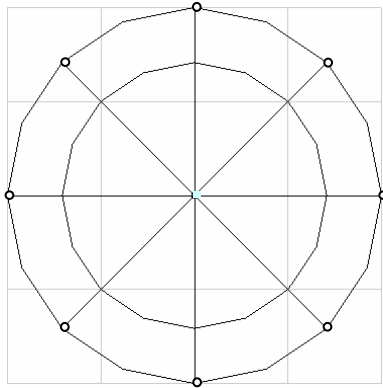
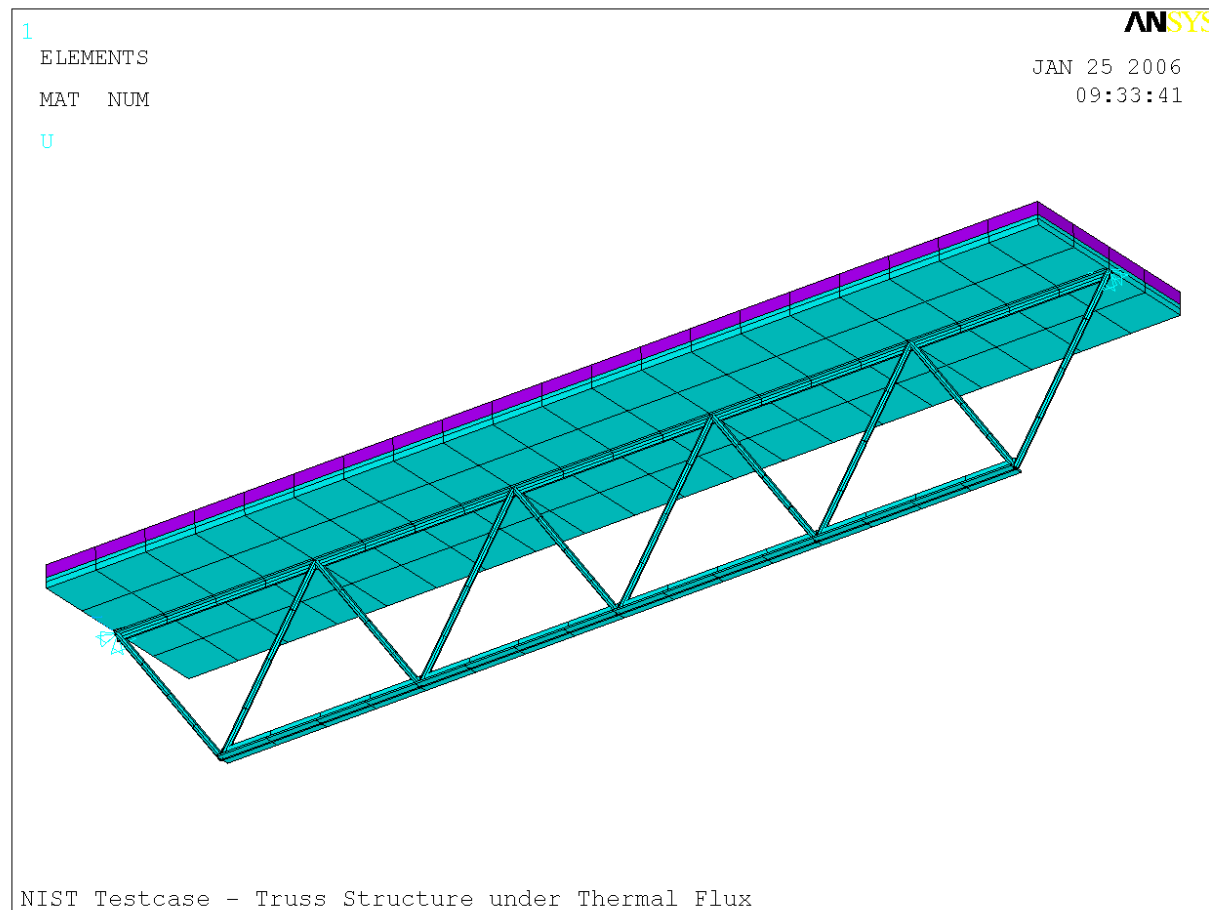# Temp2Body_Id Transfer Nodes

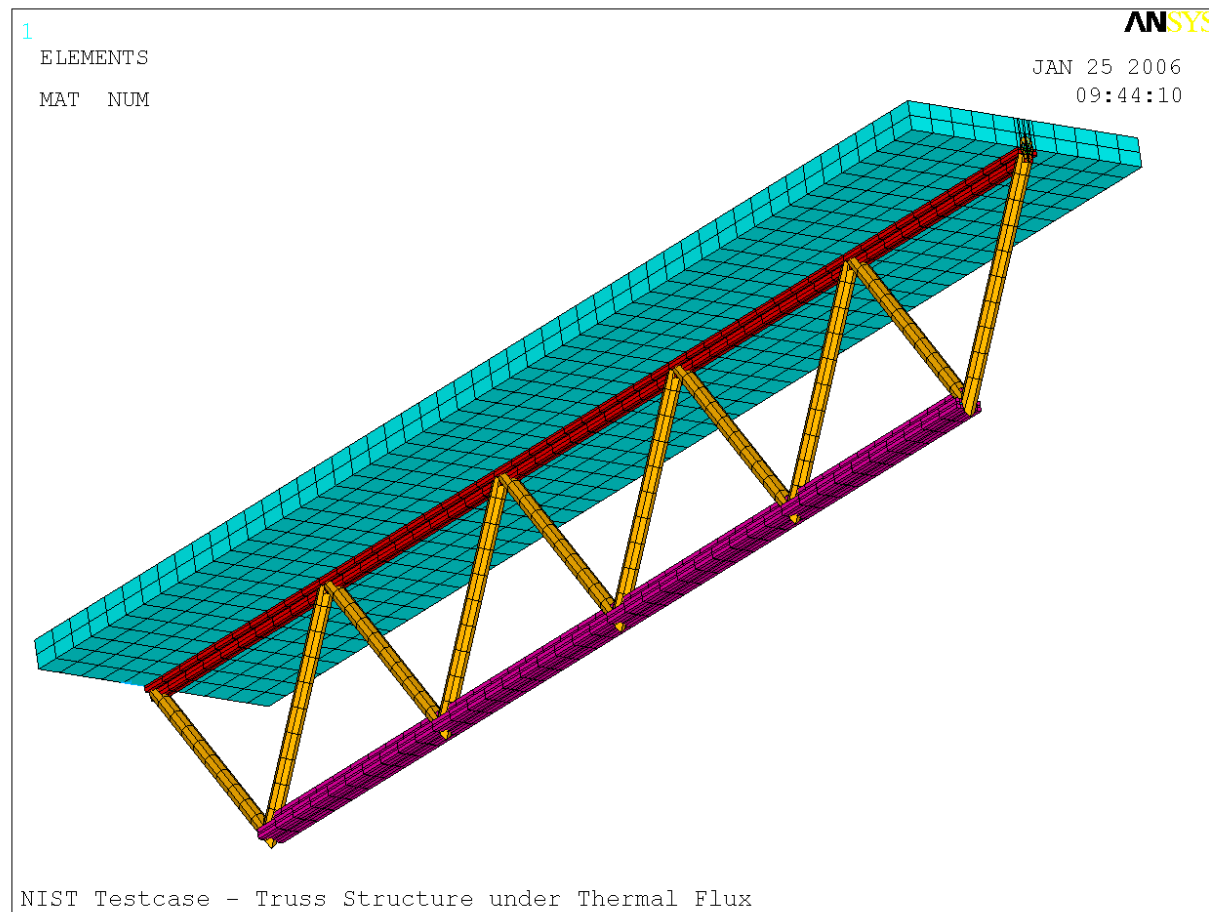- Temperature transfer nodes

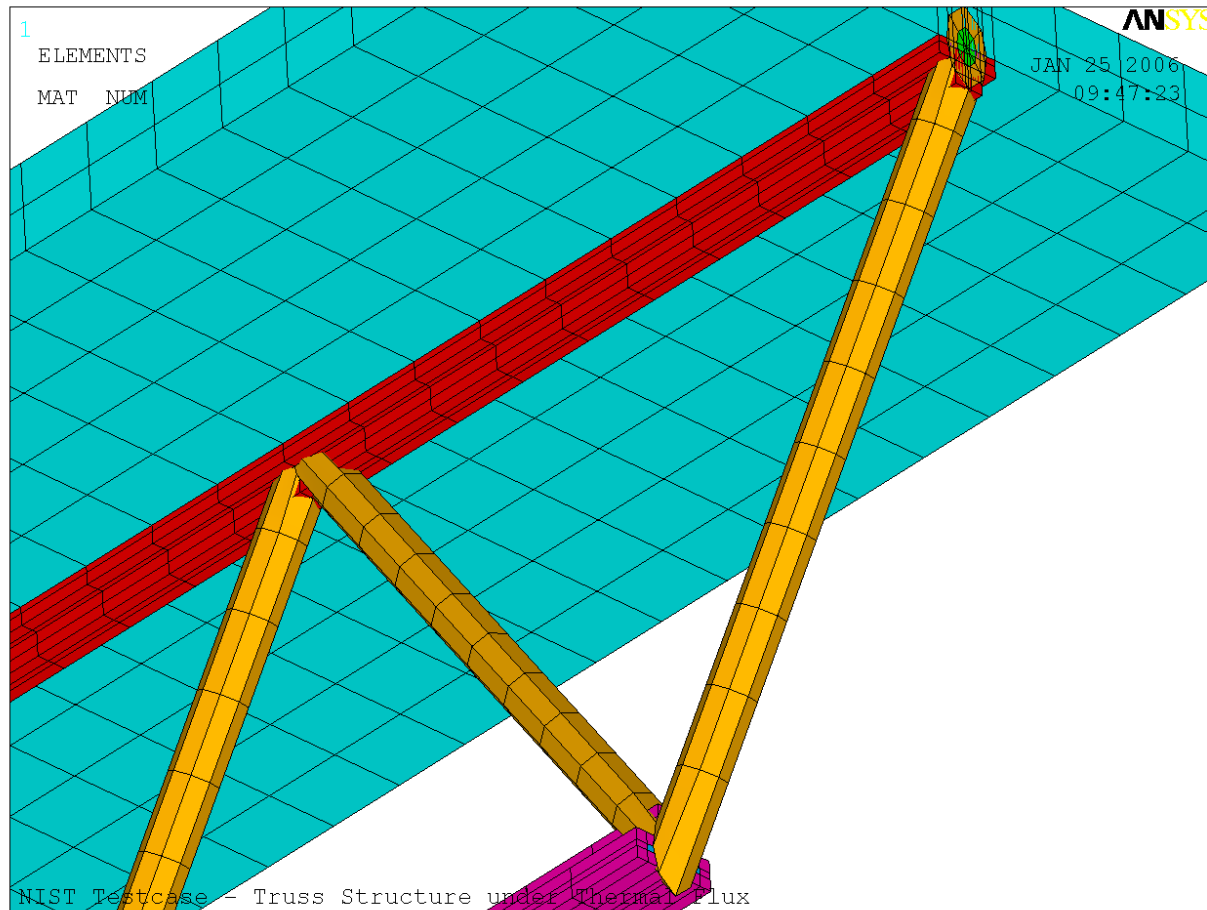# Common cross sections

- Cells and strain transfer nodes

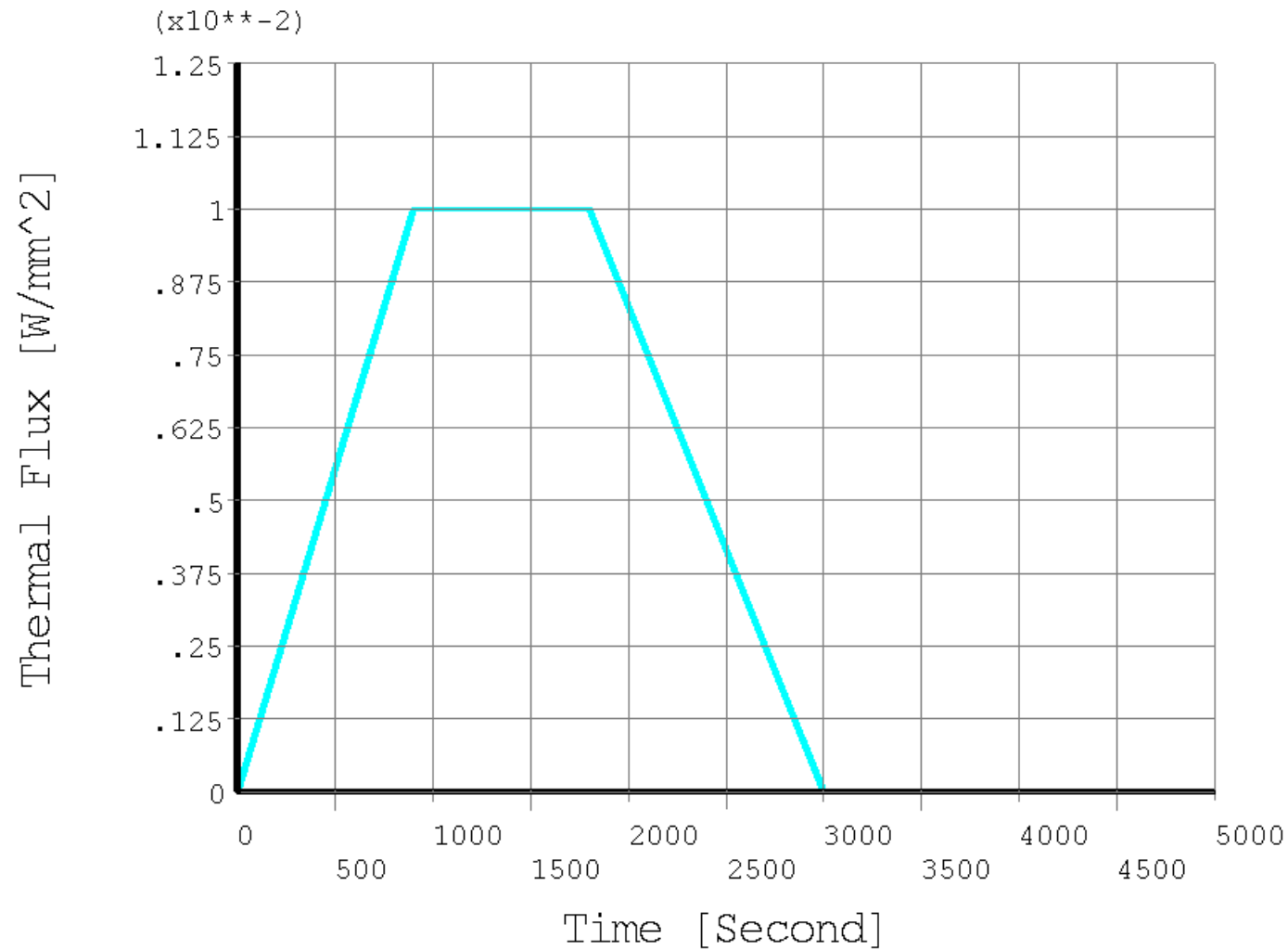# Test Case - Floor Slab Supported by an Open Web Structural FEM – Beam and Shell Elements

Test Case - Floor Slab Supported by an Open Web
Thermal FEM – Solid Elements

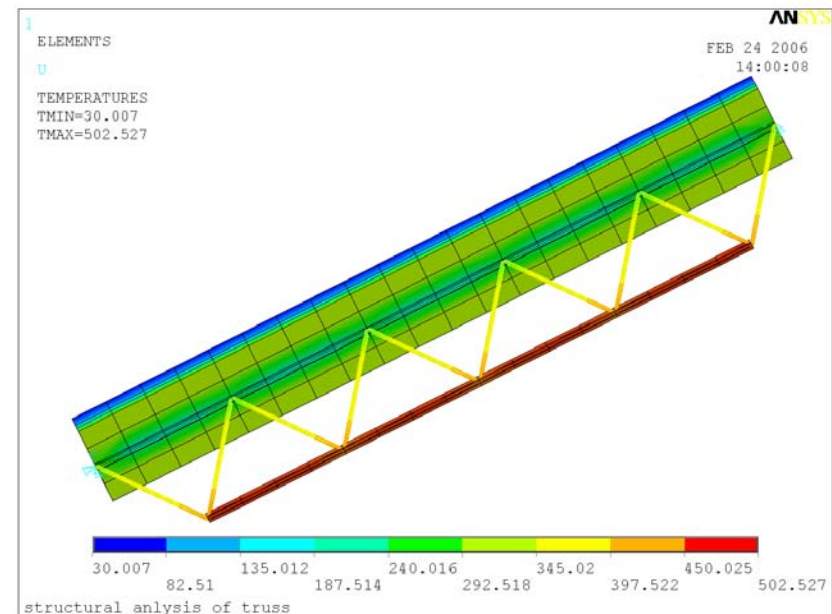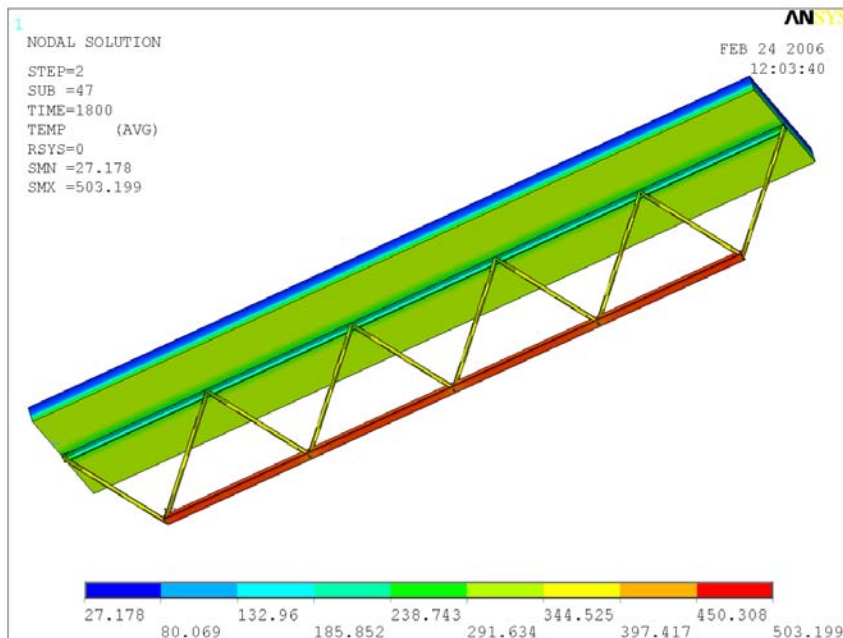# Test Case - Floor Slab Supported by an Open Web Thermal FEM – Insulation Details
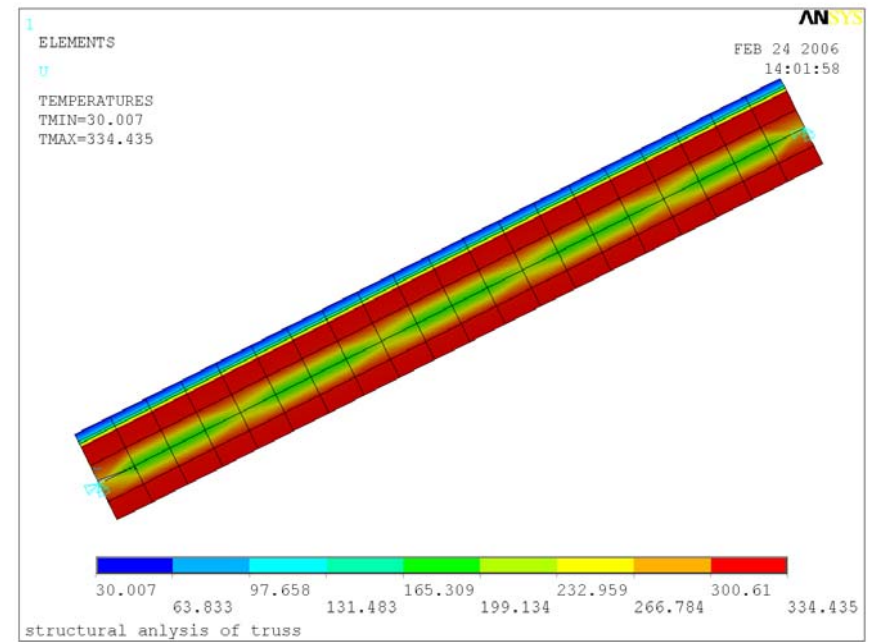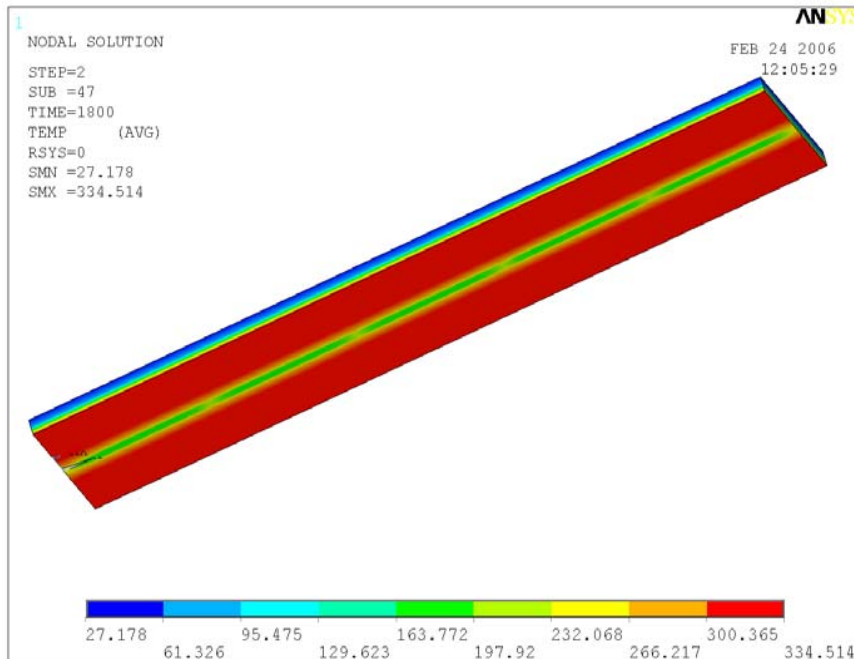
Thermal Finite Element Model – Thermal Flux

Test Case - Floor Slab Supported by an Open Web Thermal and Structural FEM

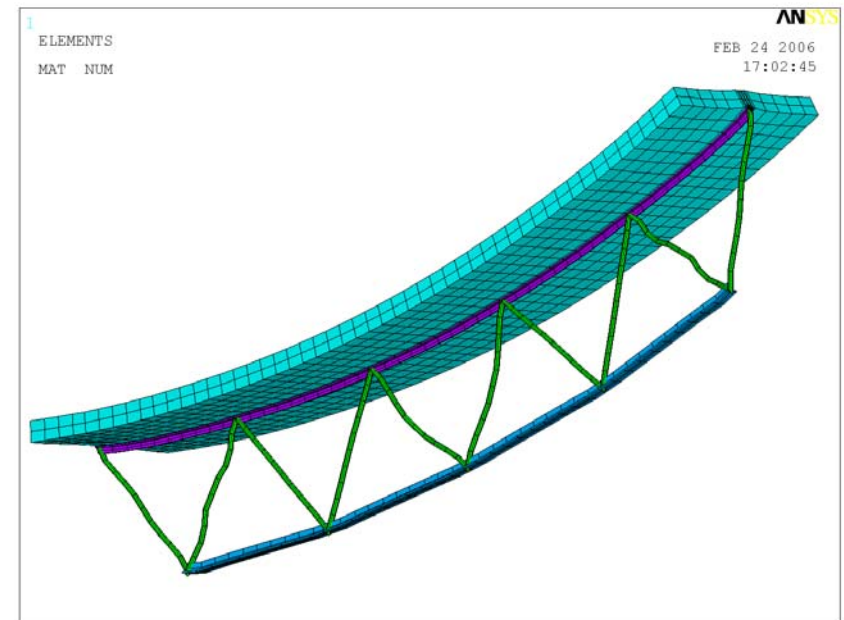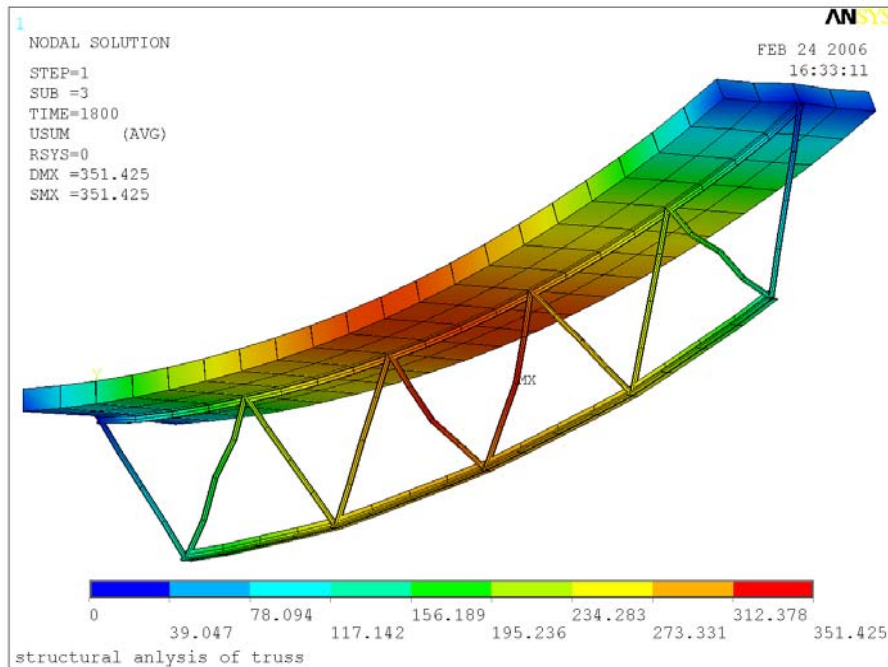- Temperature Solution and Thermal Body Load

Test Case - Floor Slab Supported by an Open Web Thermal and Structural FEM

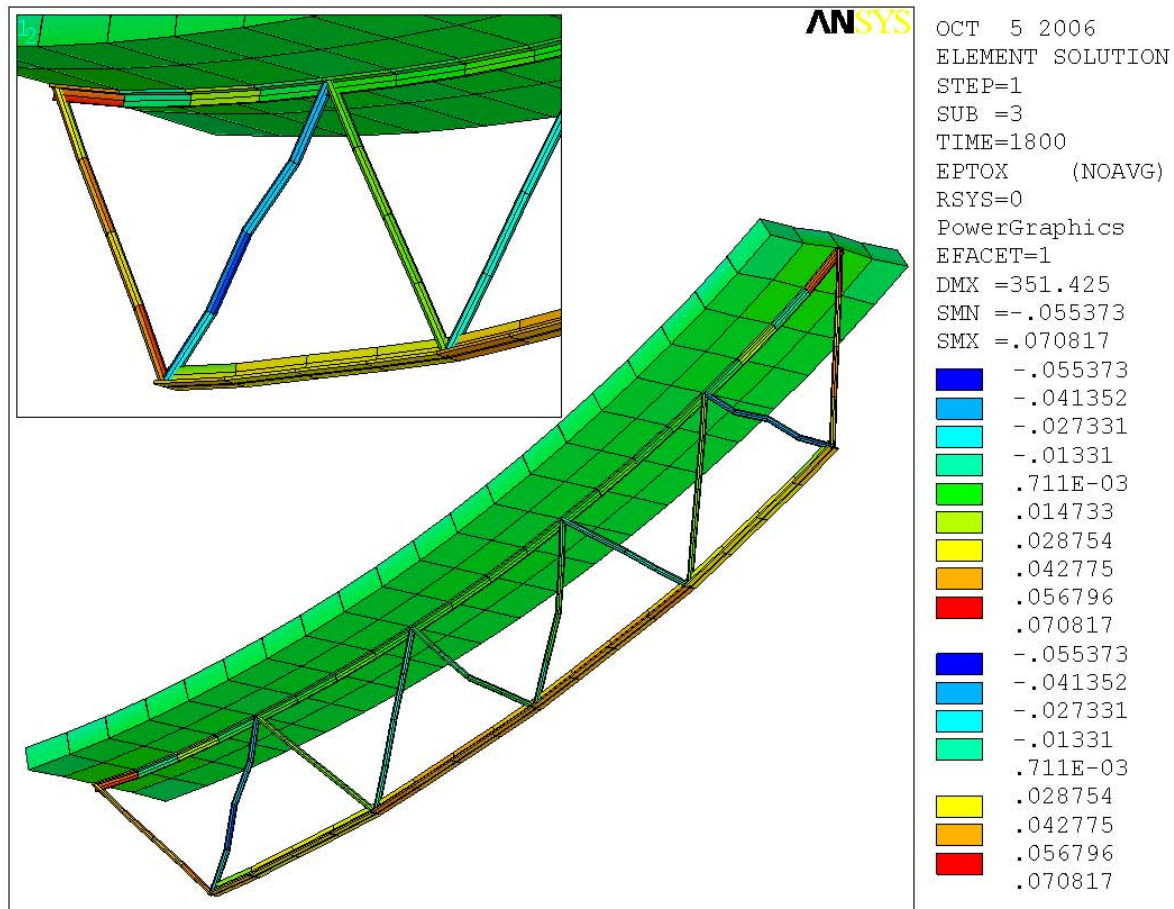## Temperature Solution and Thermal Body Loads - Slab

Test Case - Floor Slab Supported by an Open Web Structural and Thermal FEM
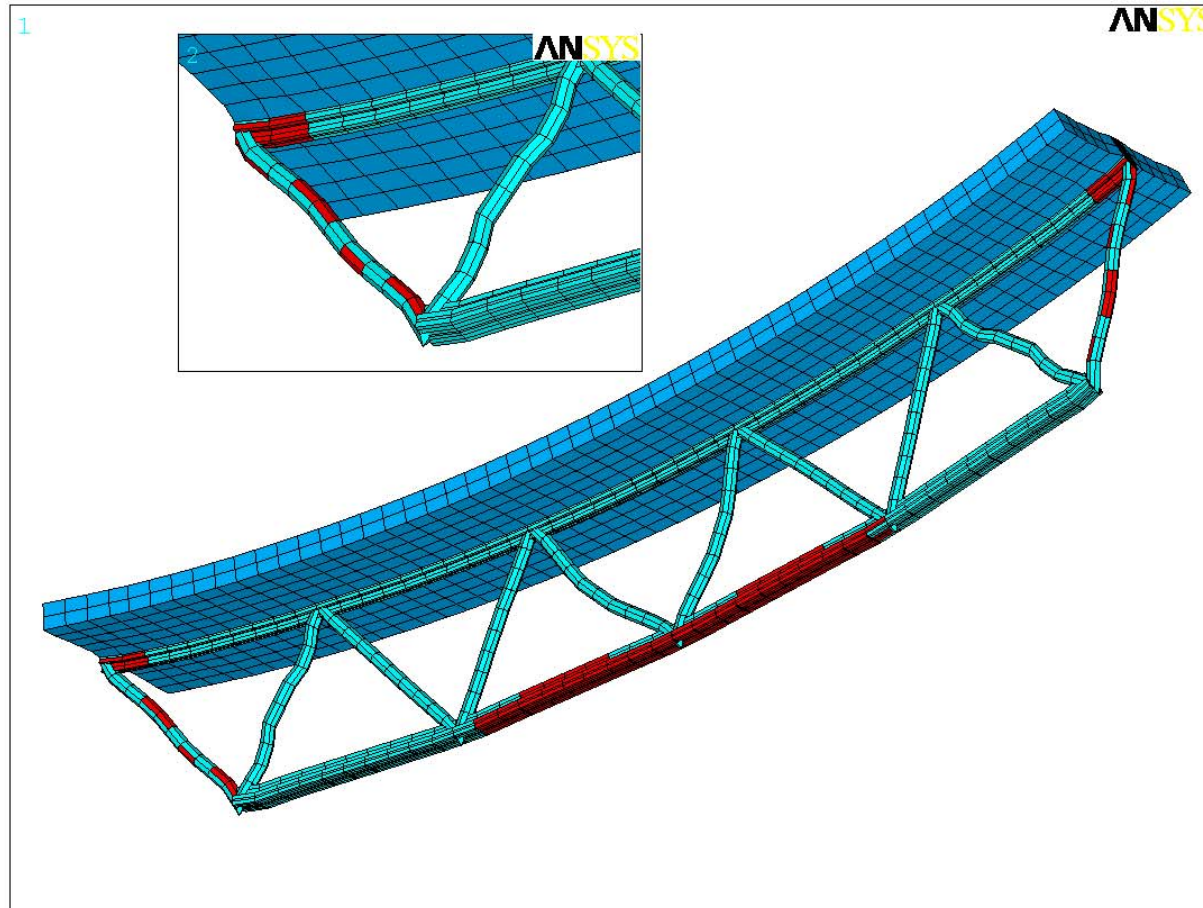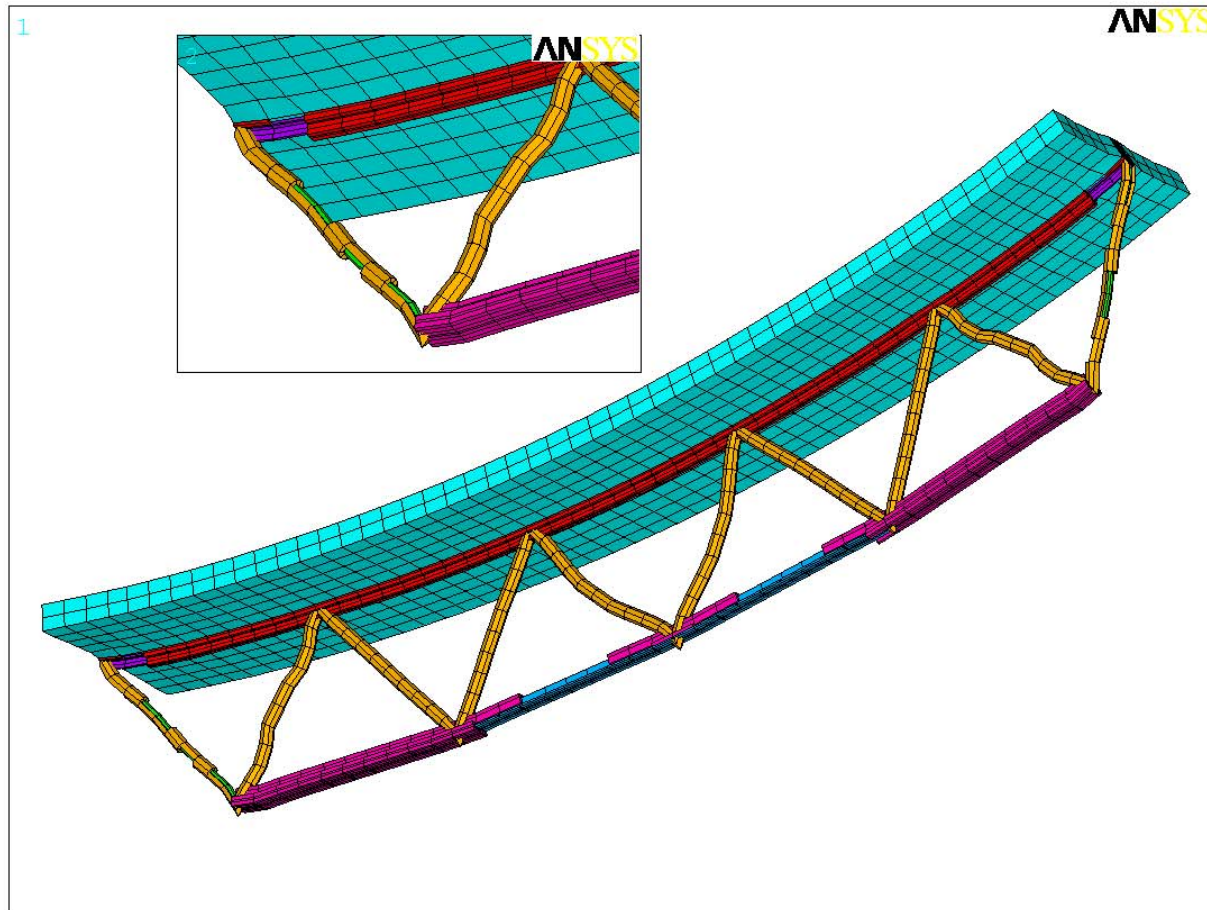
- Deflected and Updated Shapes

Structural strains ε_{xx} at 1800 s

Failed Insulation of Thermal Model (Red)

Failed Insulation of Thermal Model (Removed)

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- Future Work
  - Better failure criteria for insulation (experiments)
  - Predicting structural failure: computational criteria