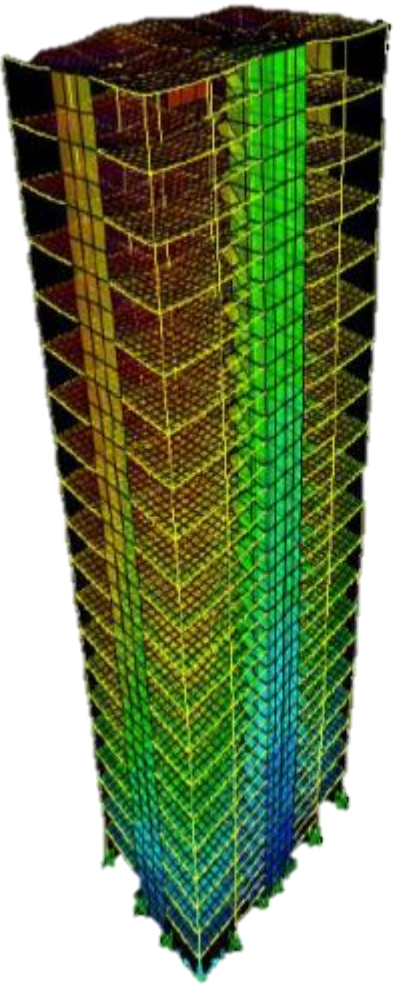
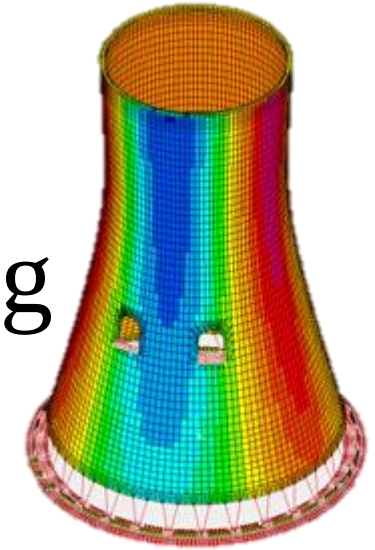
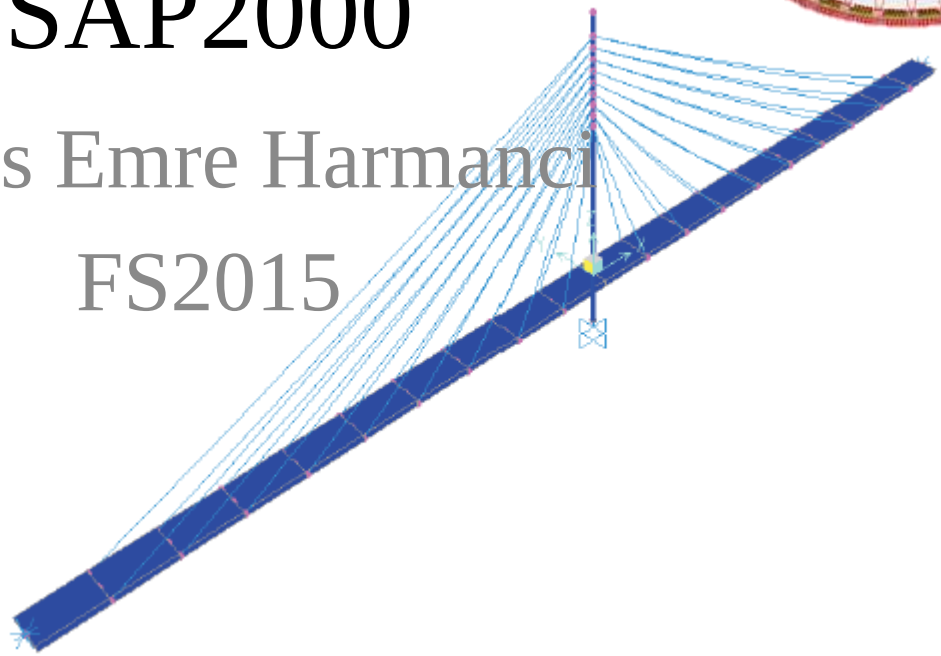
ETH Eidgenössische Technische Hochschule Zürich



Introduction to Modelling with SAP2000





Yunus Emre Harmanci

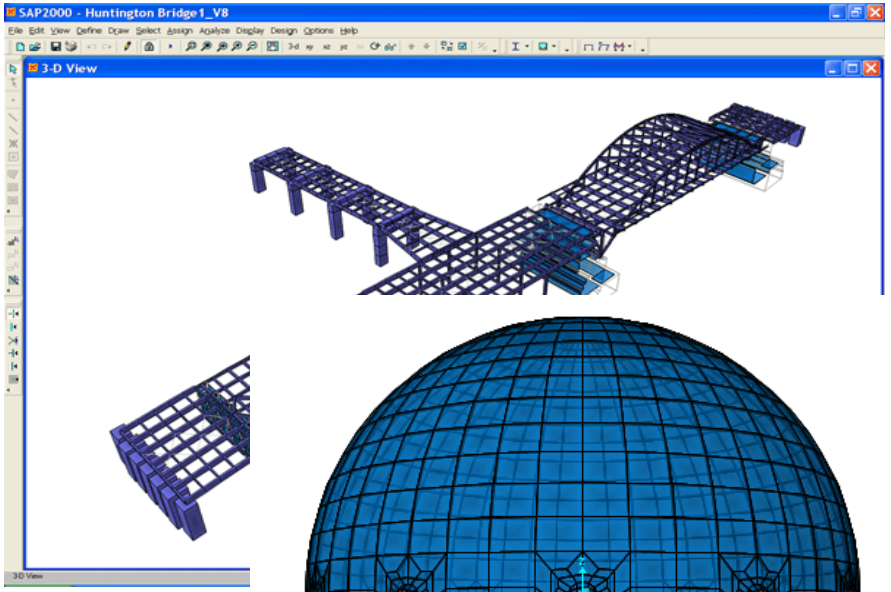
FS2015

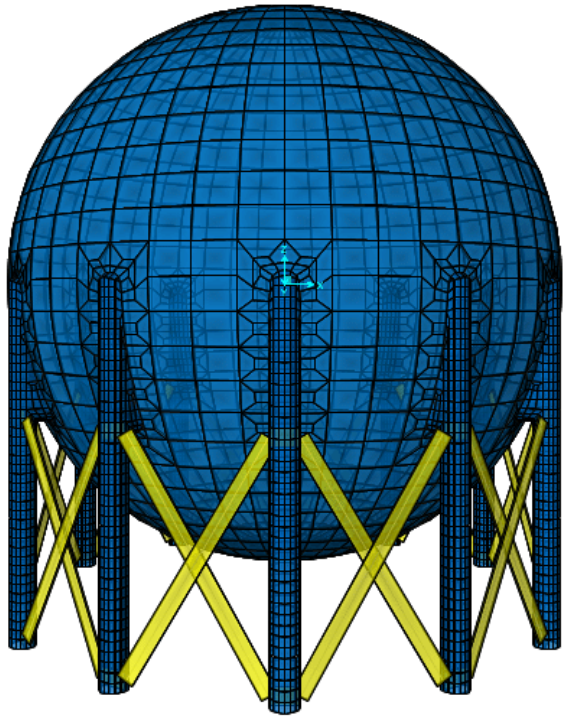
Overview

- Key Features of SAP2000
- Modelling of Elements
- Analysis Capabilities
- Viewing Results
- Tutorial Example: Static and Dynamic Analysis of a 3D Truss Frame
- Further Reading/Tutorials
- Q&A

Key Features

- Powerful and Integrated Structural Analysis and Design Software
- Fully Interactive Graphical Interface for quickly creating models
- Frame, Shell, Solid and Non-linear Link Elements



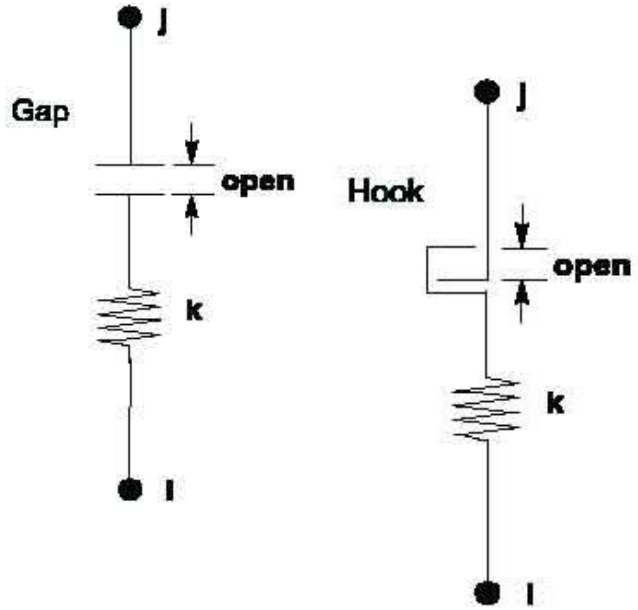


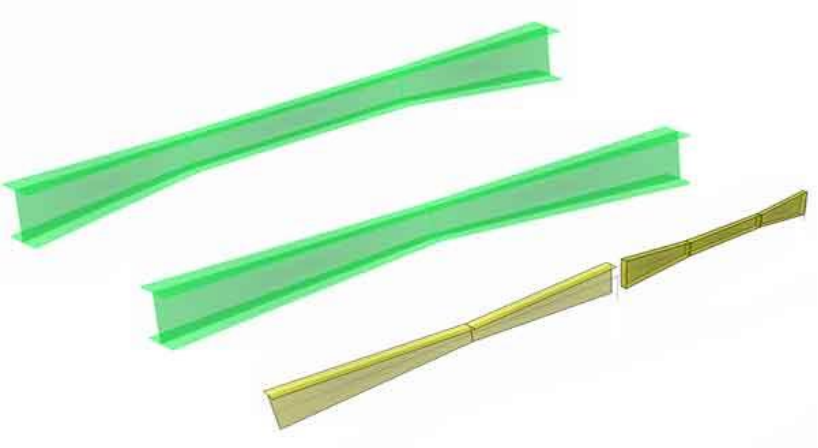
Key Features

- Extensive Analysis Options including Linear-Static, Linear-Dynamic, Nonlinear-Dynamic
- Automated design of Concrete and Steel Members to various International Codes
- Fully formatted, customized reporting
- DXF Import and Export Link to AutoCAD

Modelling of Elements

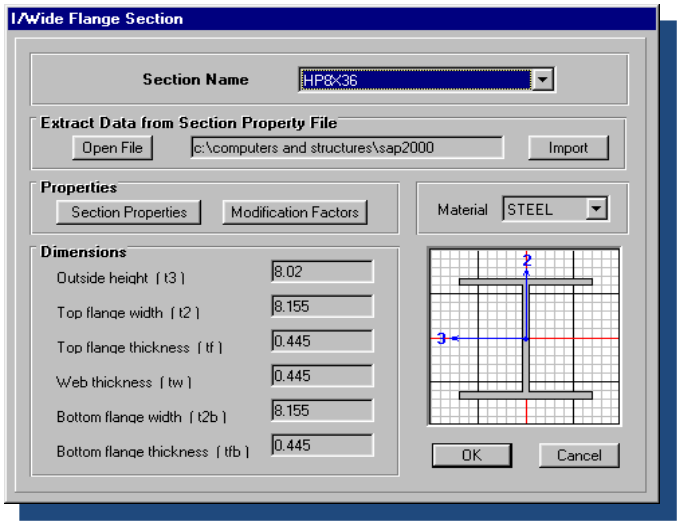
- Simple Frame Elements for
  - Beam, Column
  - Truss, Bracing, etc.
- Non-Linear Link Element for
  - Hook, Gap, Damper
  - Base Isolators
  - Friction
- Plastic Hinge Element

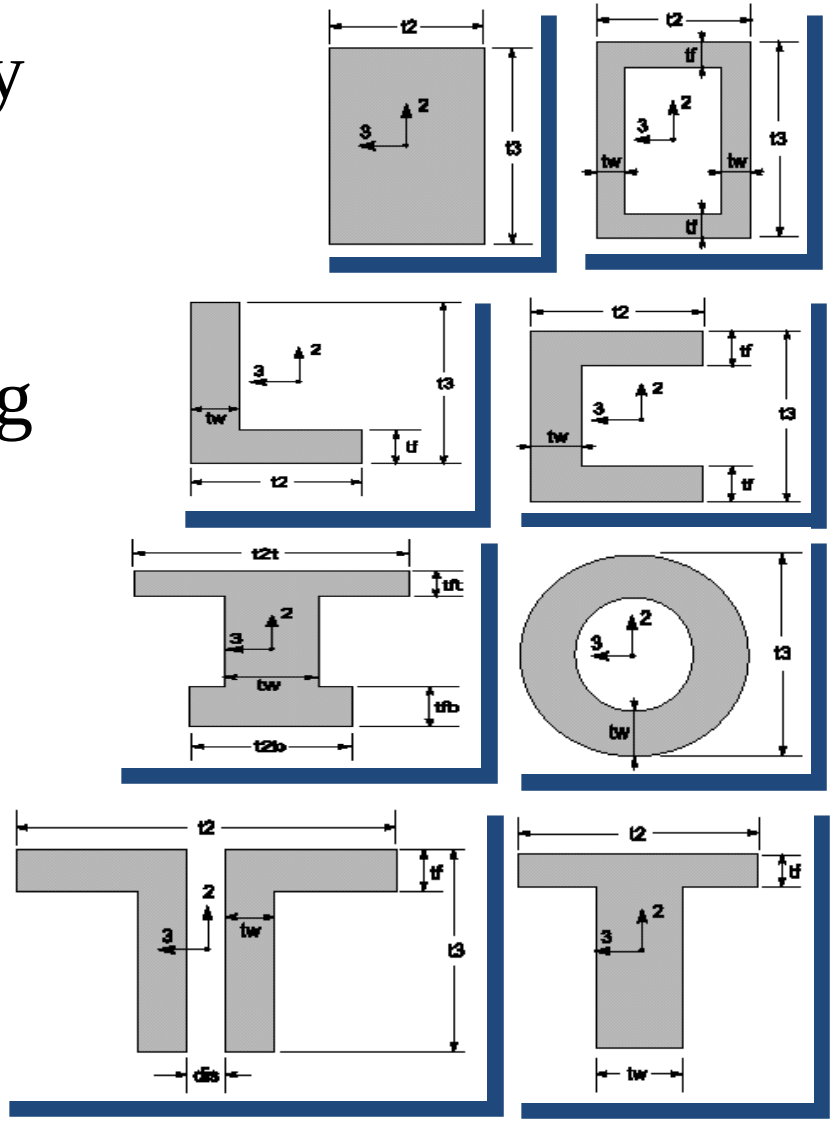




Modelling of Elements

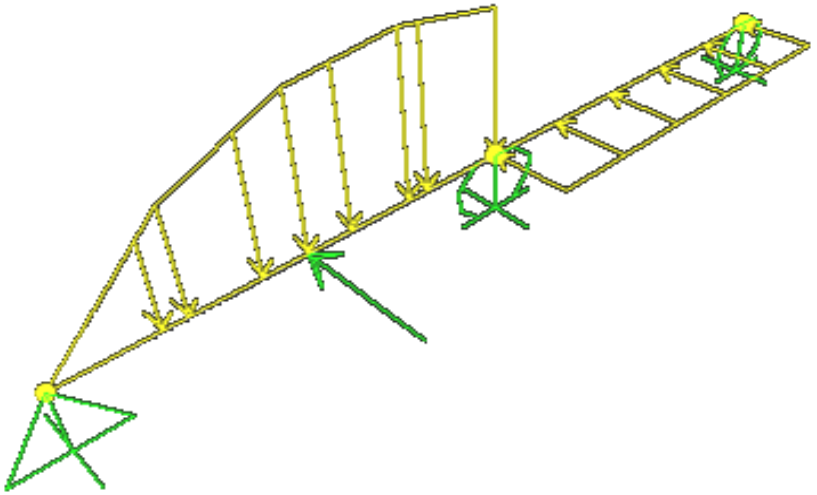
- Automatic section property calculation for standard shapes
- Built-in steel sections for several Standards including AISC, CISC, EN, BS etc.

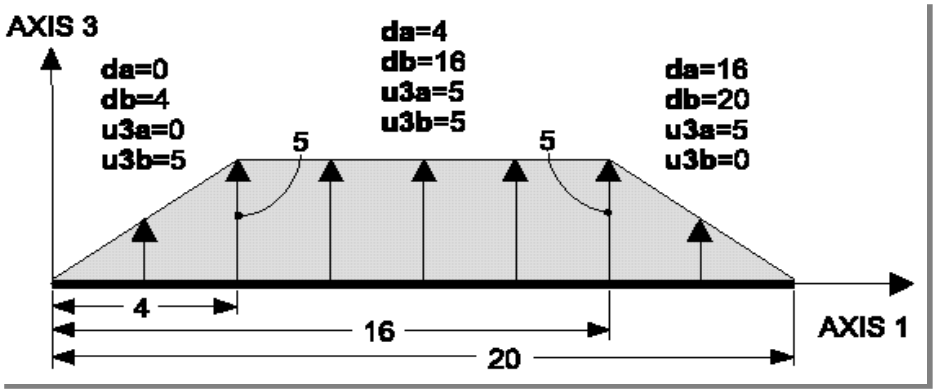




Modelling of Elements

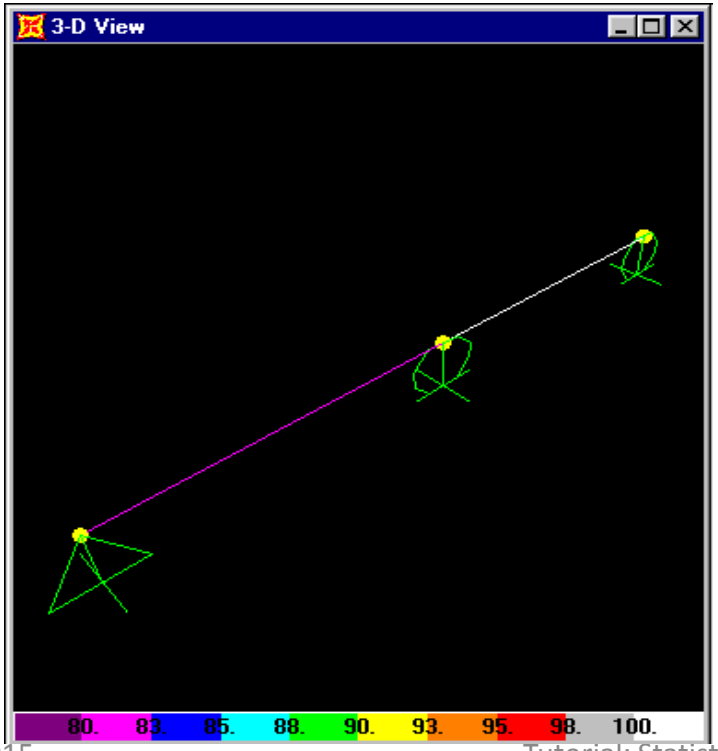
- Gravity Load
- Point Load
- Uniform Load
- Trapezoidal Load
- Prestress
- Temperature Variation

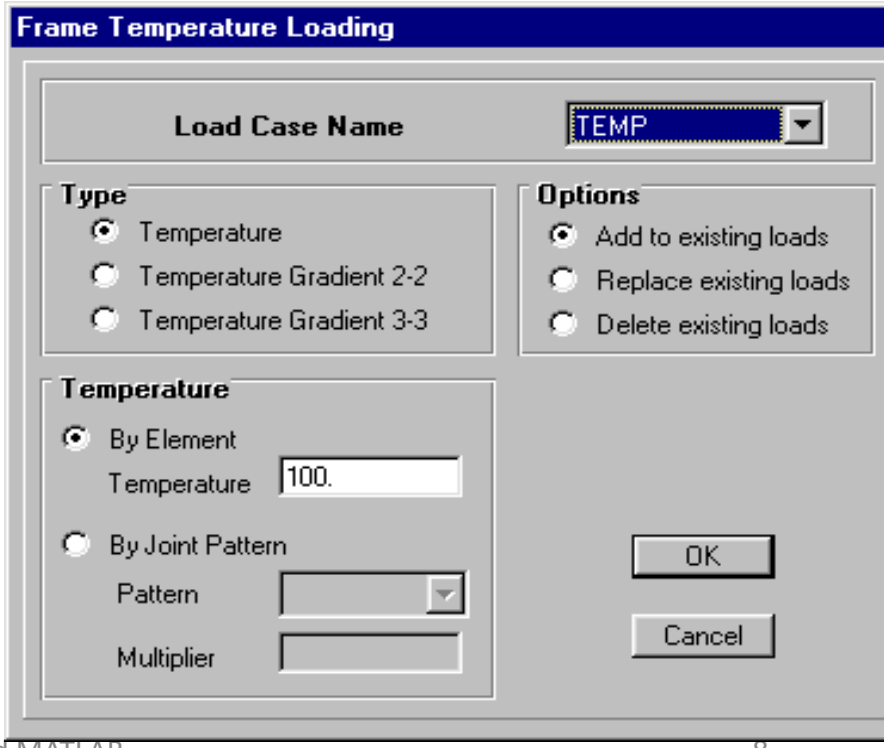




Modelling of Elements

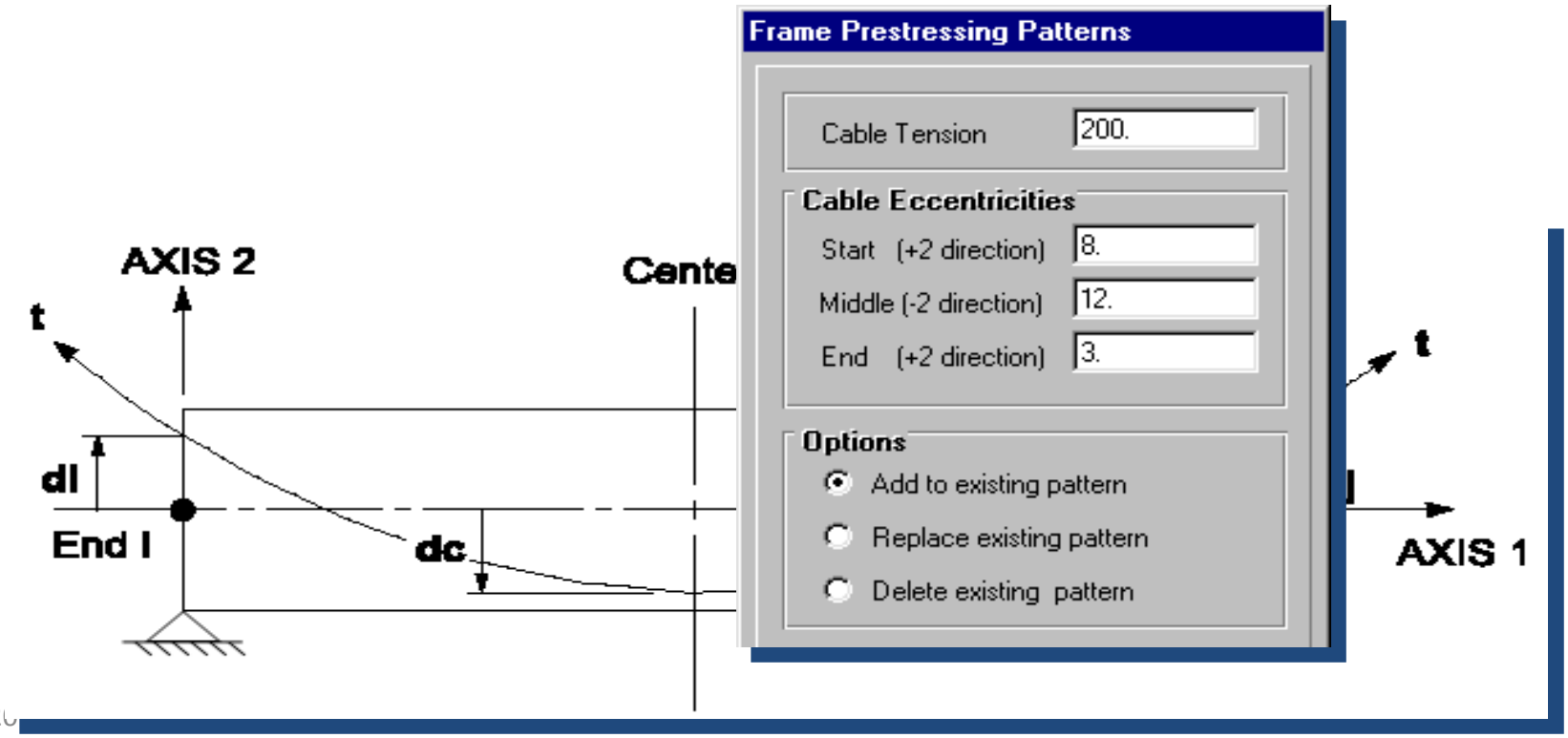
- Applied to Element Section in any direction
- Applied to Nodes and Groups





Modelling of Elements

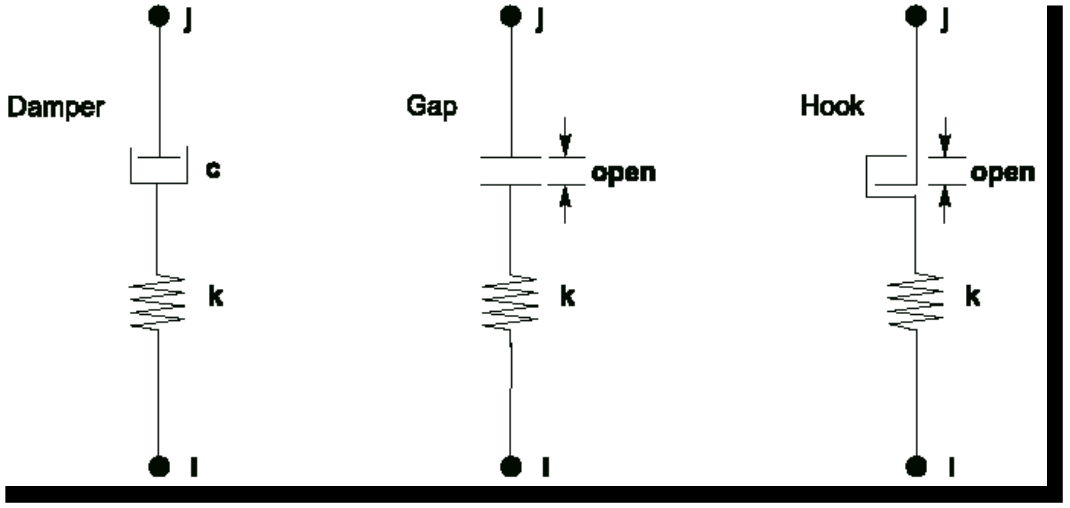
- Load due to Prestress can be applied to Frame Elements as Cables in Patterns and Load Cases



Modelling of Elements

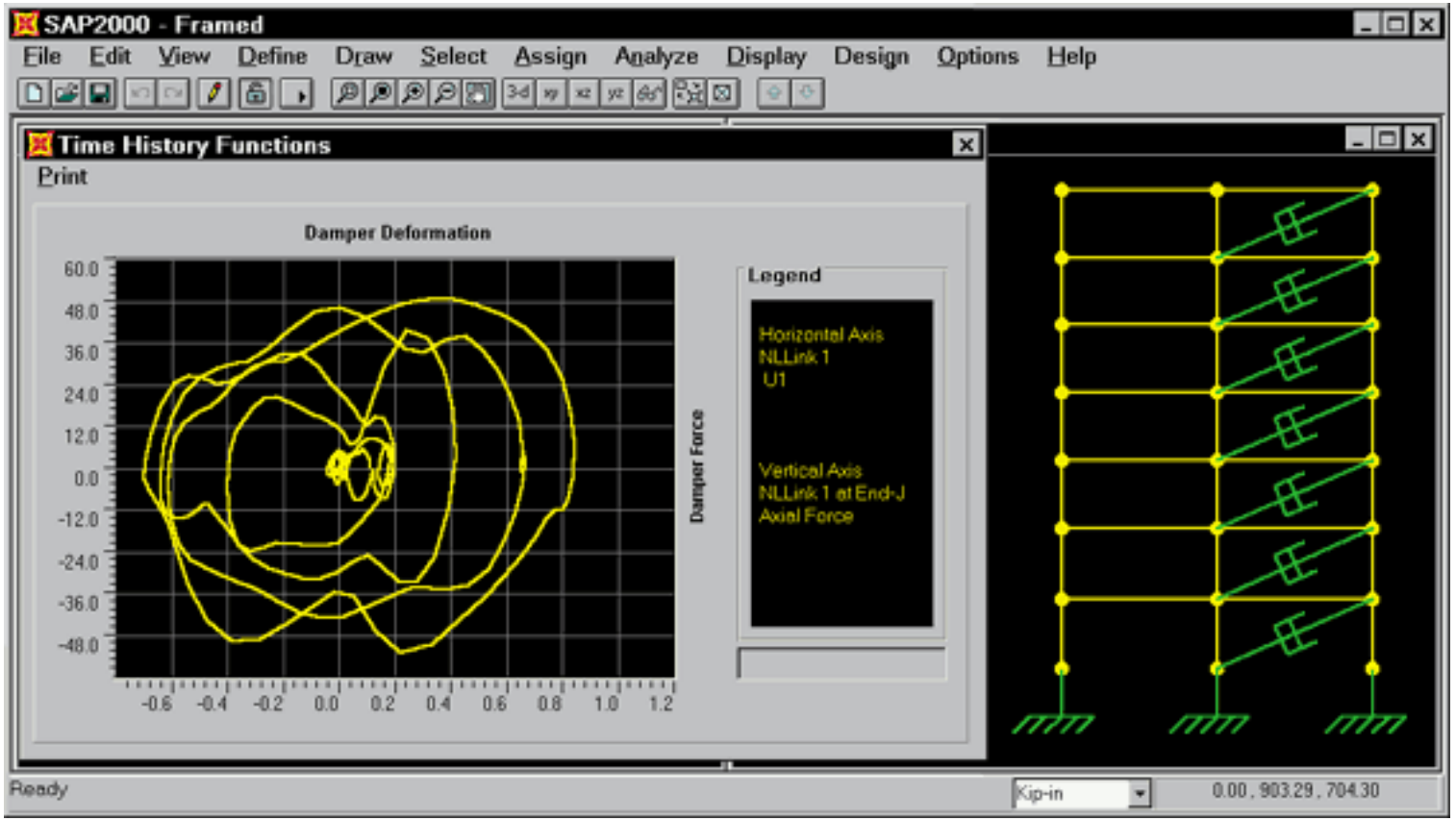
Non-Linear Link Element

- For use with the dynamic time history analysis option
- Link may be placed between any two joints or from joint to ground
- Viscous damper with nonlinear exponent on velocity
- Gap (compression only)
- Hook (tension only)



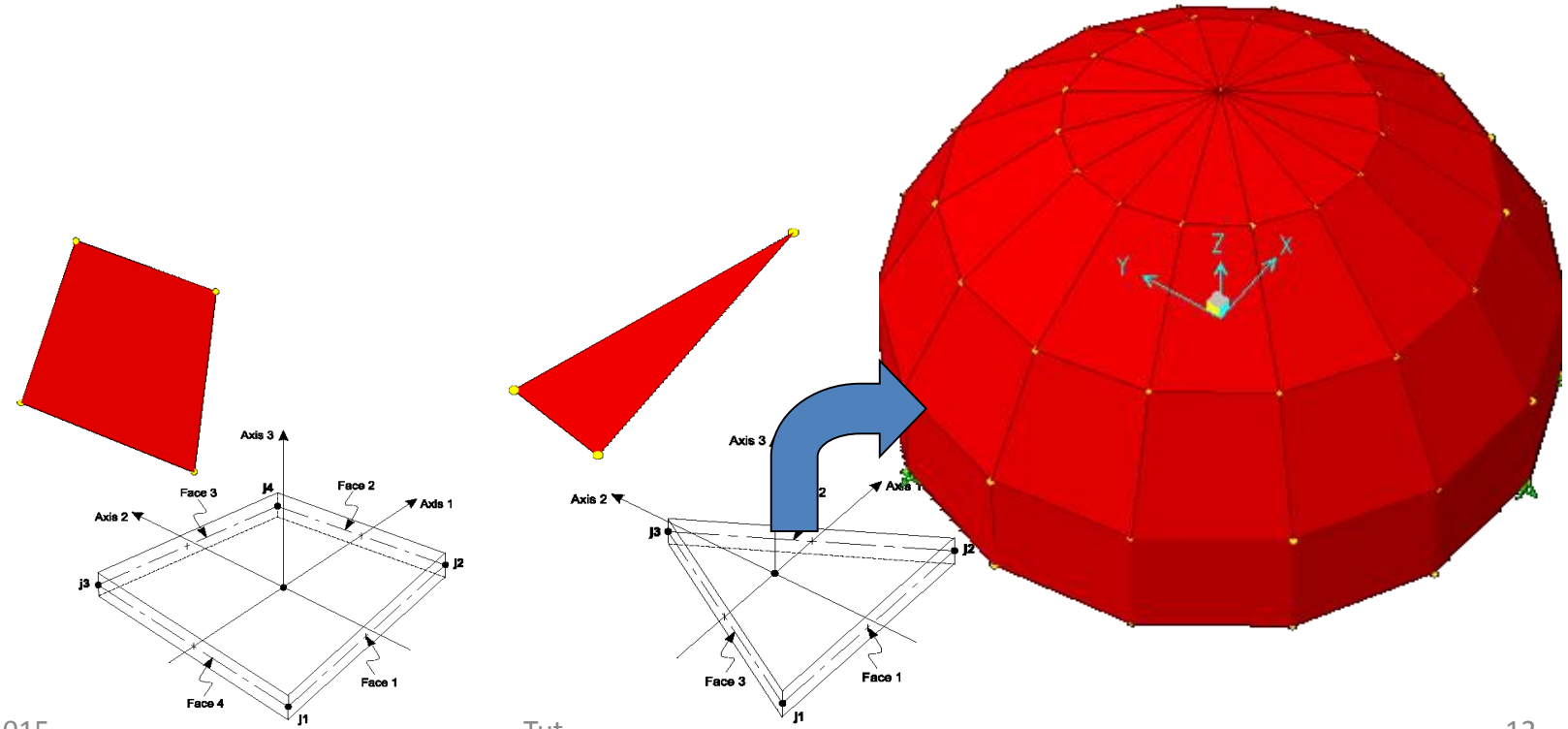
Modelling of Elements

- Force versus deformation plots of nonlinear systems for energy dissipation studies



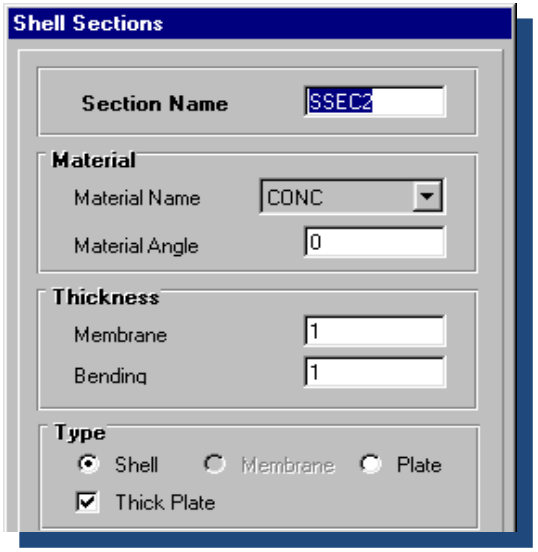
Modelling of Elements

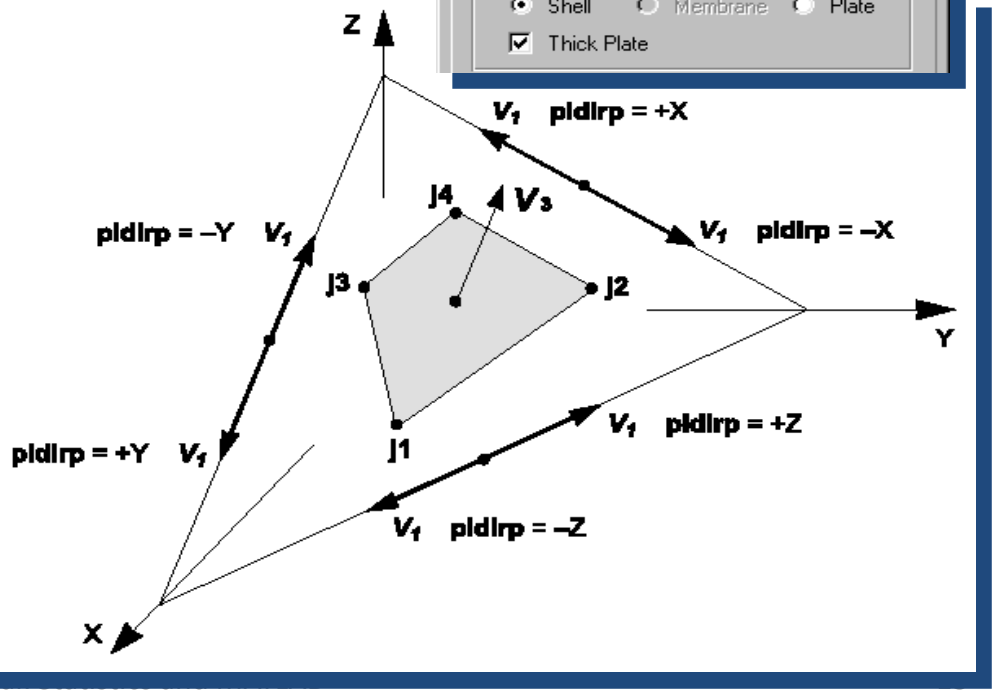
- General quadrilateral or triangular element
- Isotropic, Orthotropic and Anisotropy material



Modelling of Elements

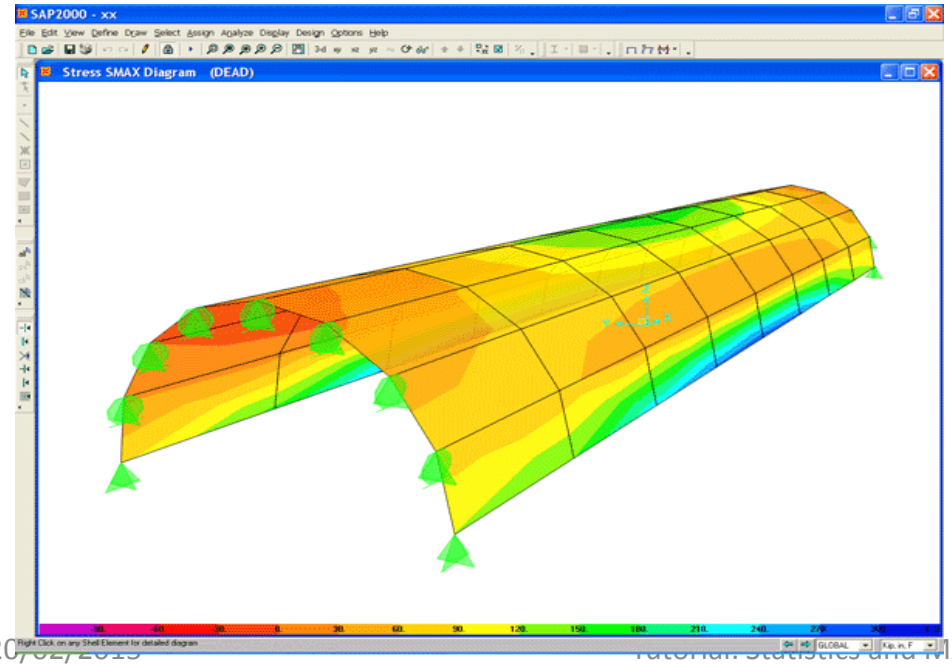
- Six degrees of freedom per joint
- Shell, plate or membrane action
- Thick shell option

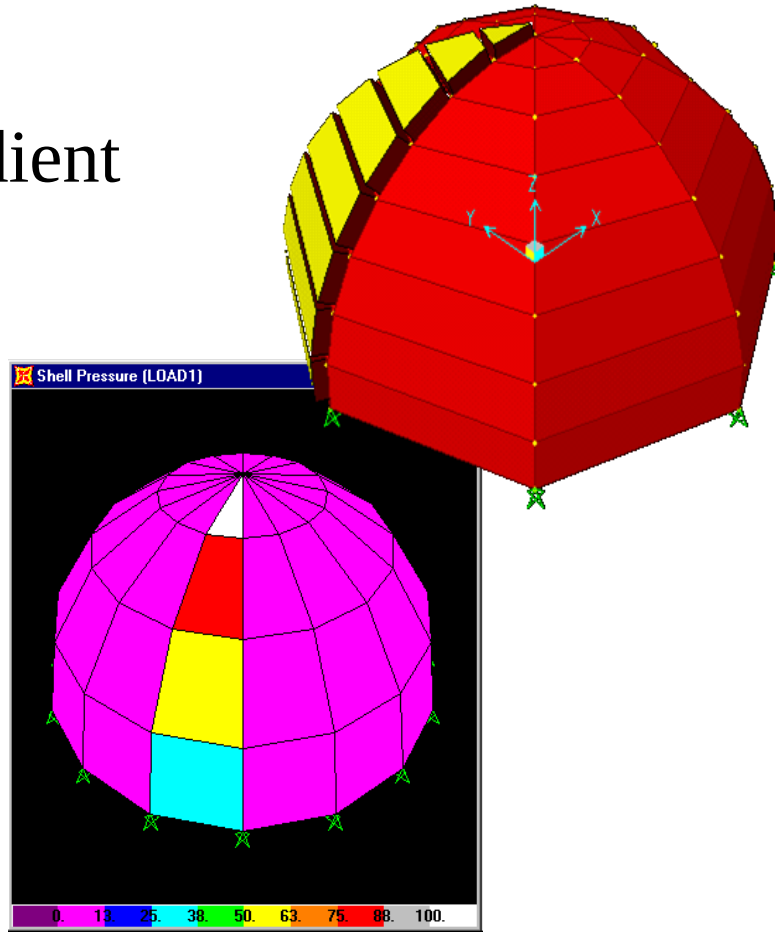




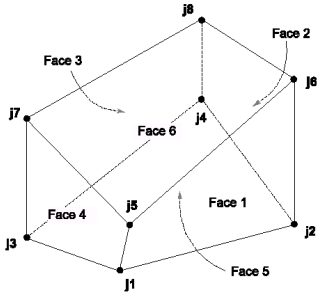
Modelling of Elements

- Gravity and uniform loading
- Pressure loading
- Temperature and thermal gradient loading



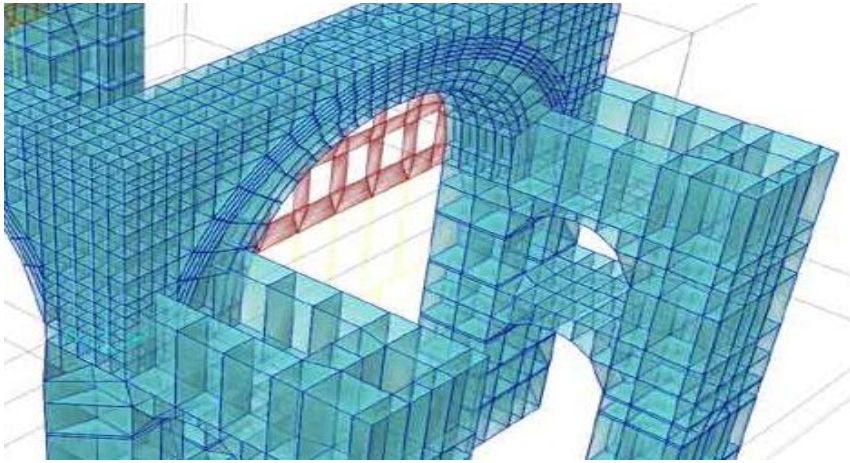


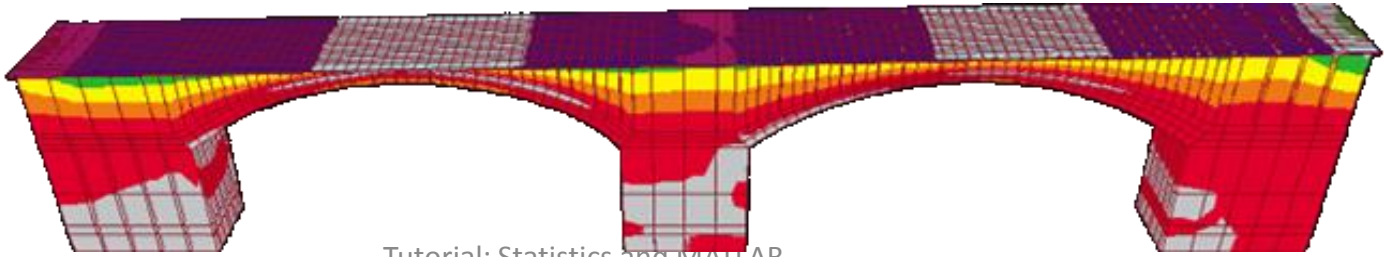
Statistics: Overview



Solid Elements

- Three dimensional 8 node brick element
- Anistropic material
- Gravity, thermal, surface pressure and pressure gradient loading

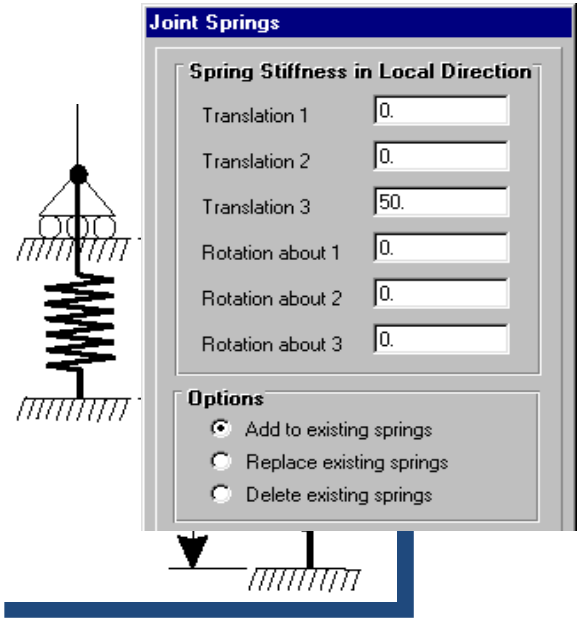


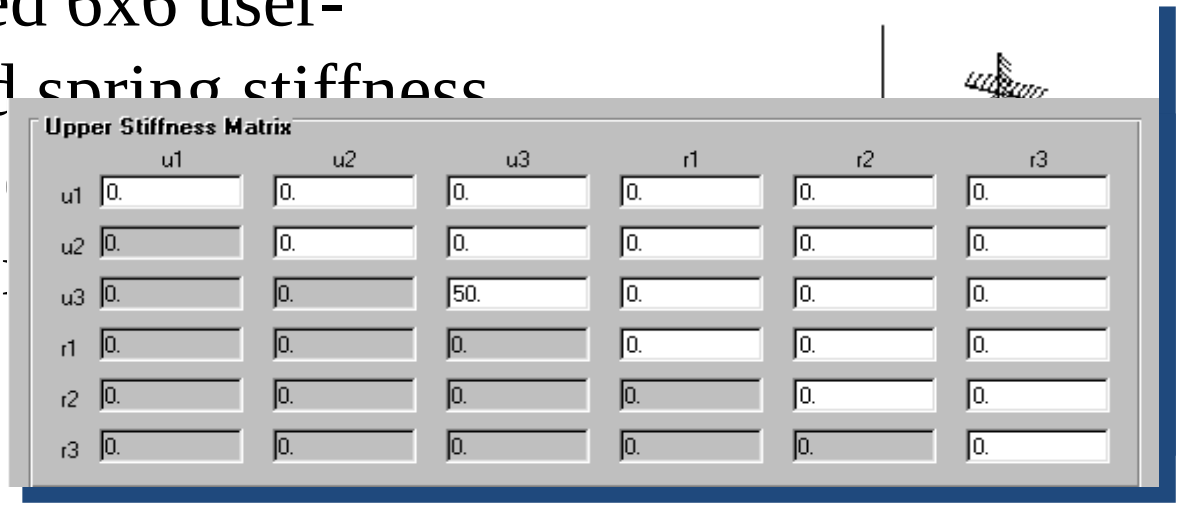


Modelling of Elements

Joint restraints

- General Spring Connection
- Global and skewed springs
- Coupled 6x6 user-defined spring stiffness option (modeli

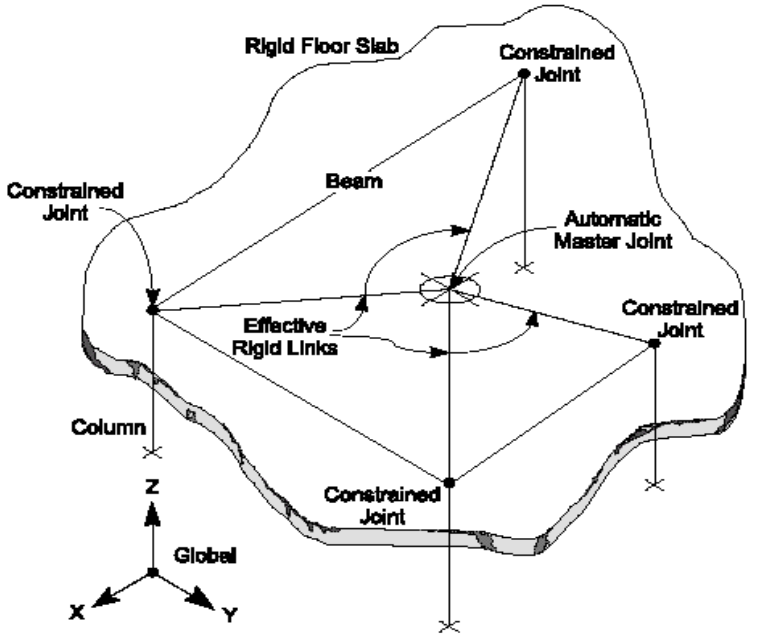


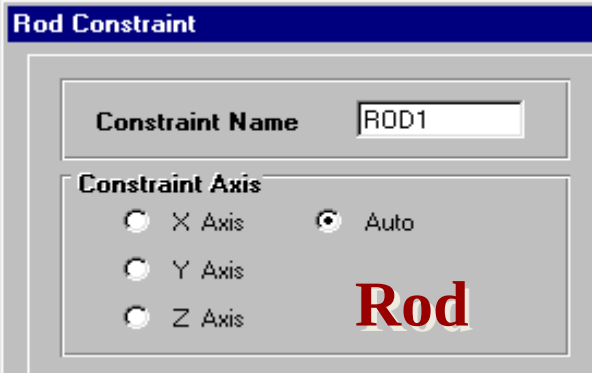


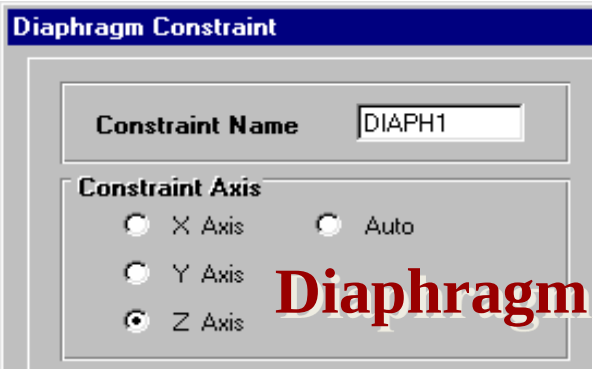
Modelling of Elements

Joint constraints

- Generalized joint constraint optic
  rigid bodies, diaphragms, rods ar



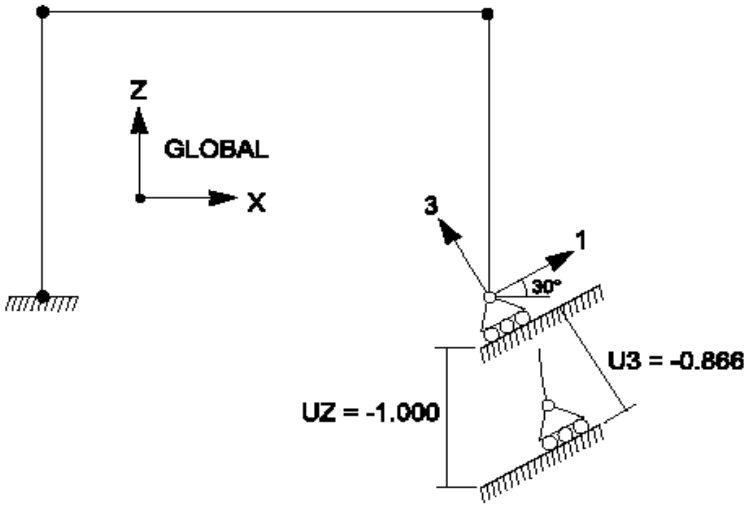


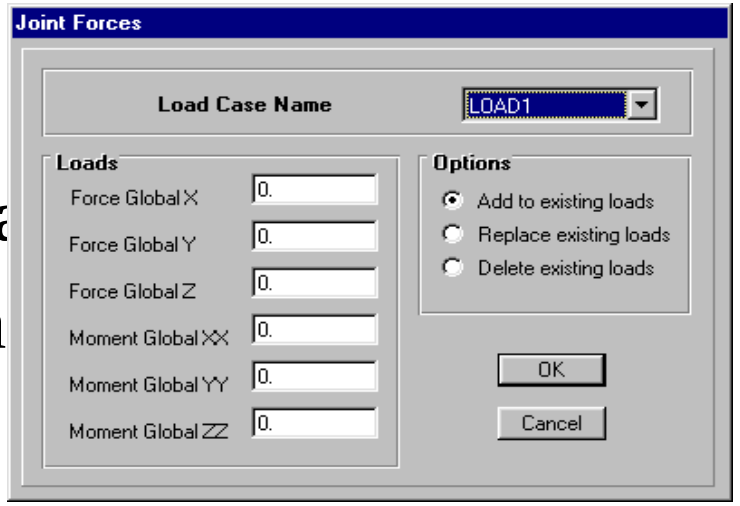


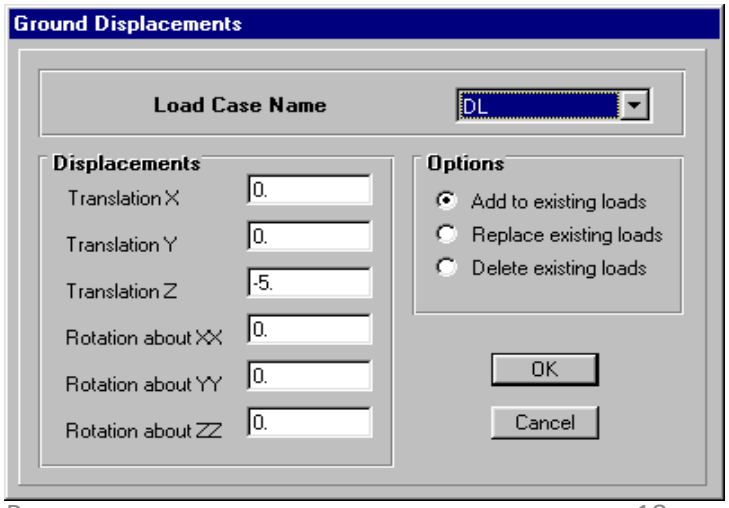
Modelling of Elements

Joint Loads and Displacements

- Applied force and applied displ
- Inclined Supports and joint loca





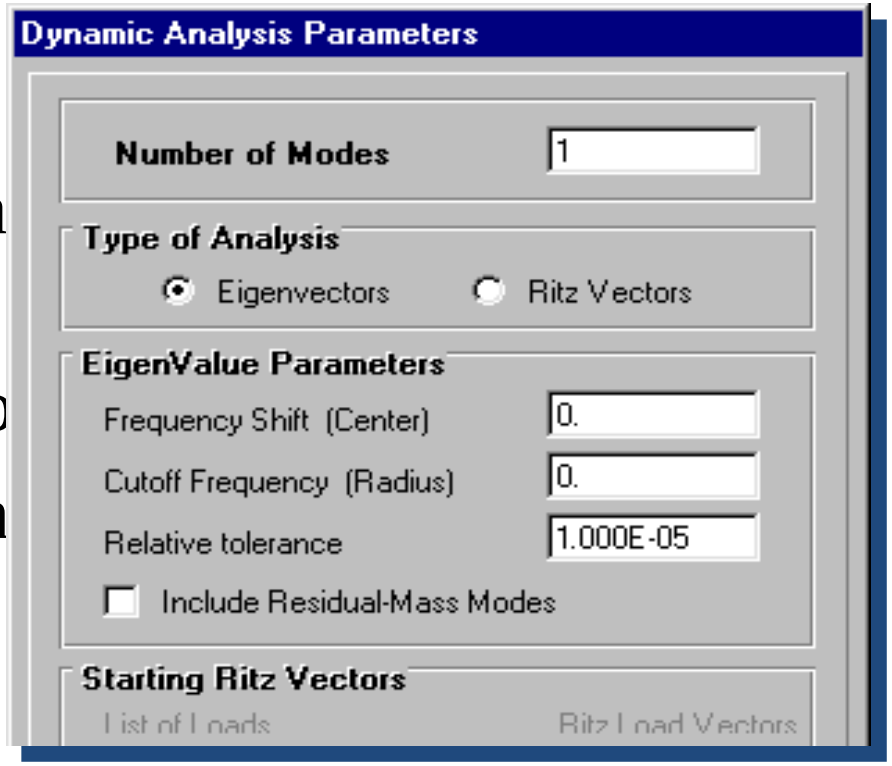


Analysis Options

- Static and/or dynamic response spectrum analysis
- P-delta analysis with either static or dynamic analysis
- Blocked active column equation solver
- Automated fast profile optimization
- Non-linear Pushover Analysis

Analysis Options

- Modal Analysis
- Eigenvalue analysis with a iteration algorithm
- Ritz analysis for fast predo
- Harmonic Steady-State An

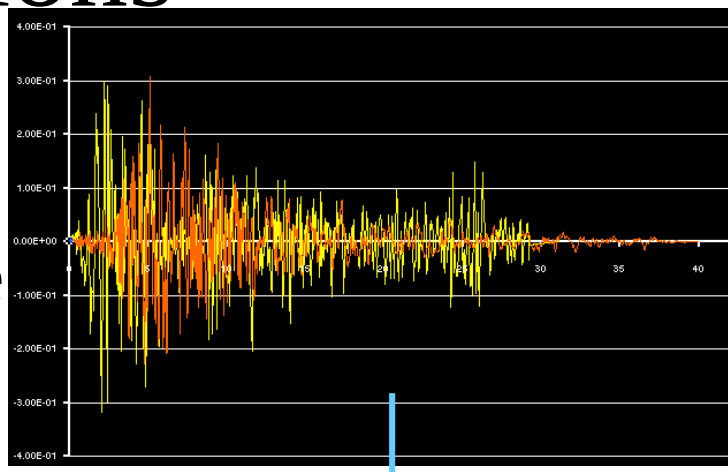


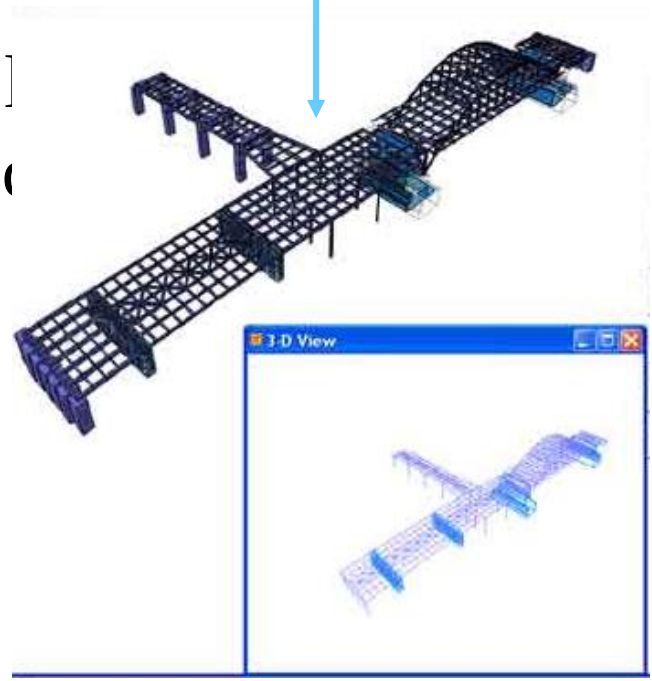
$$Ku(t) + M\ddot{u}(t) = r(t) = p\cos(\varpi\ t) \qquad [K - \Omega^2 M]\Phi = 0$$

Analysis Options

Time History Analysis

- Ground acceleration and Multiple
- Sequential history cases
- Time history Windows AVI file
- Results can be combined with other l
  enveloping or step by step steel and c

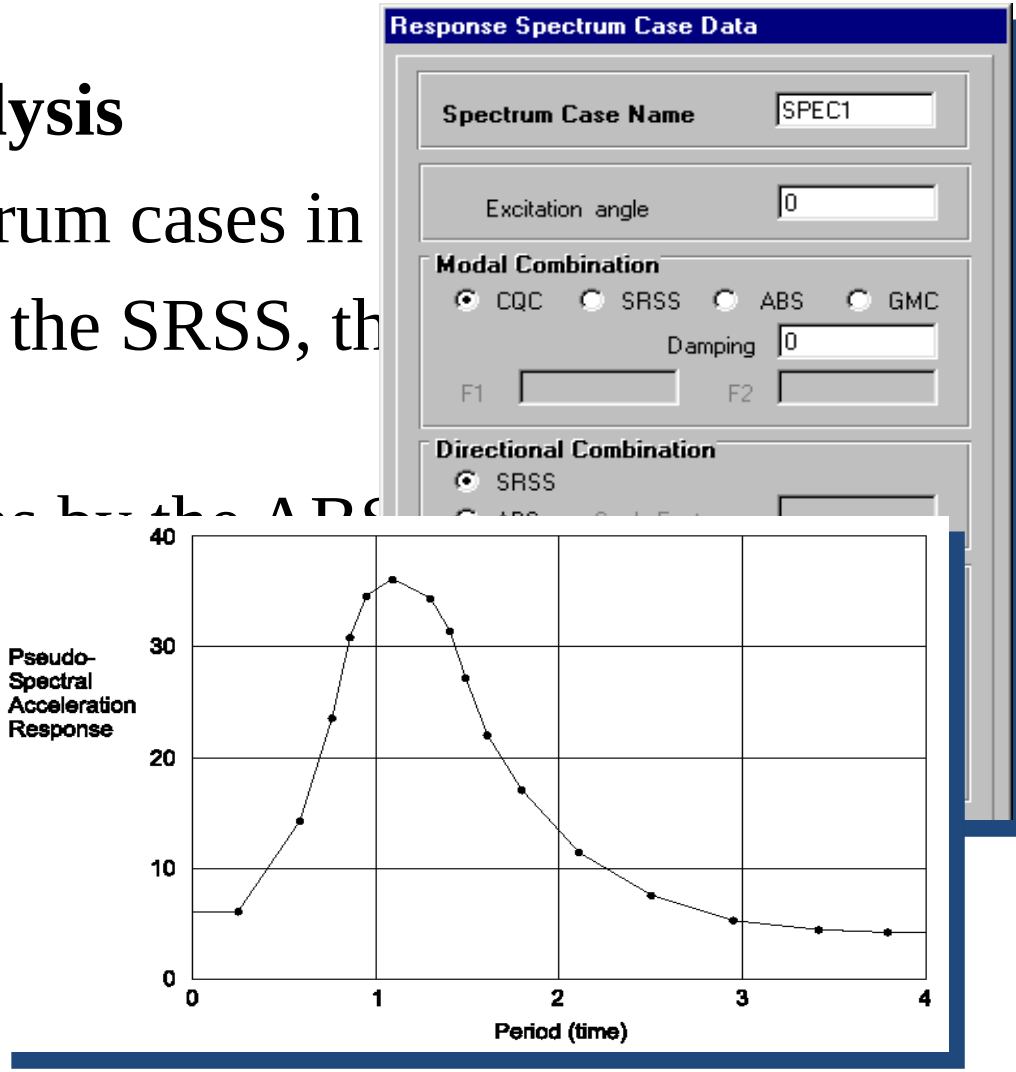




Analysis Options

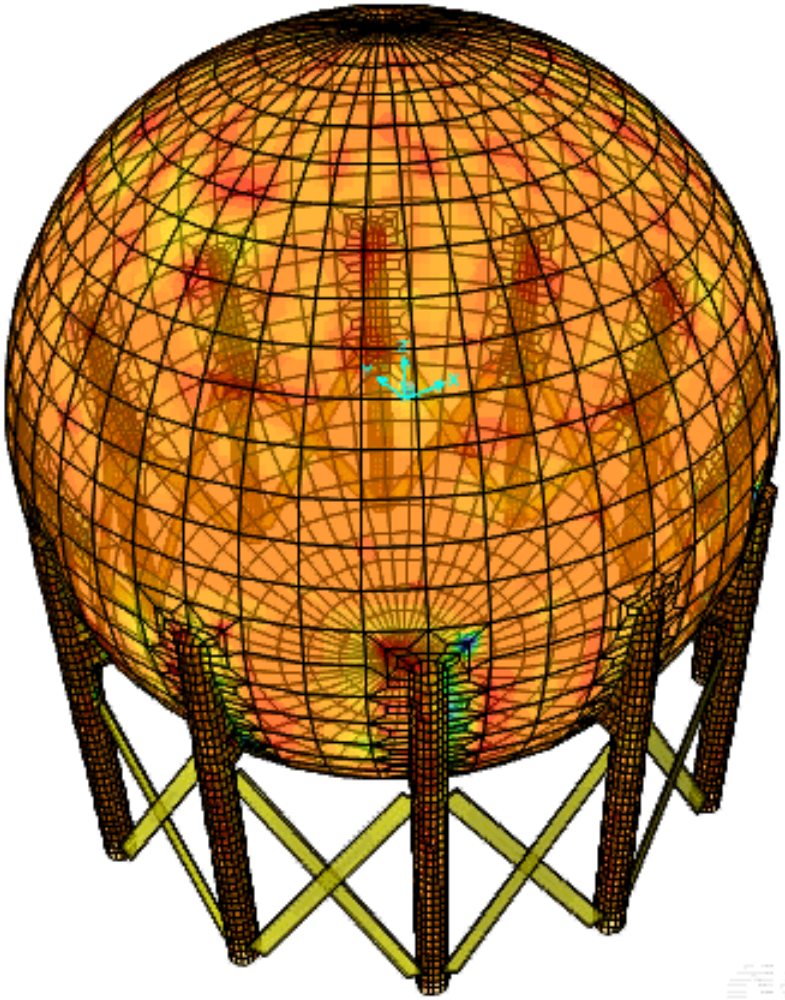
Response Spectrum Analysis

- Multiple response spectrum cases in
- Modal combinations by the SRSS, th
  GMC (Gupta) method
- Directional combinations by the AB
  method



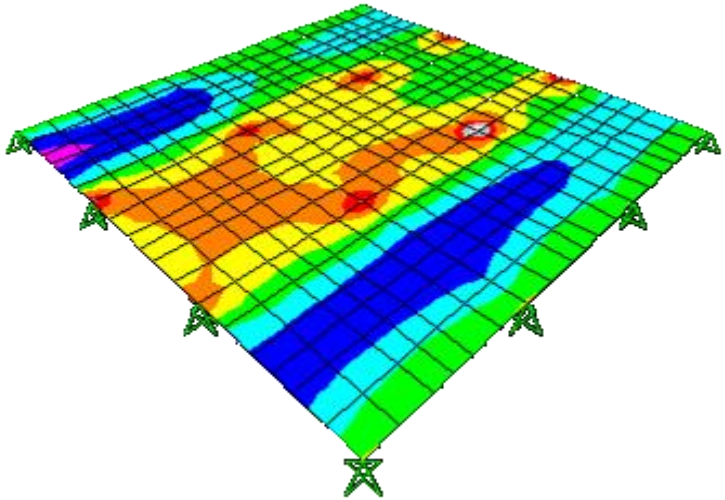
Viewing Results

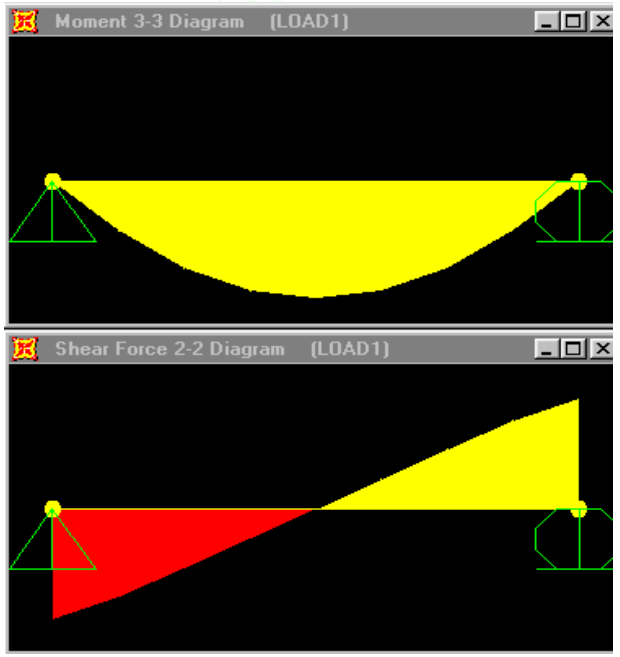
- 3D perspective graphica
  and deformed structural
- Static deformed shapes a
- Static and dynamic load



Viewing Results

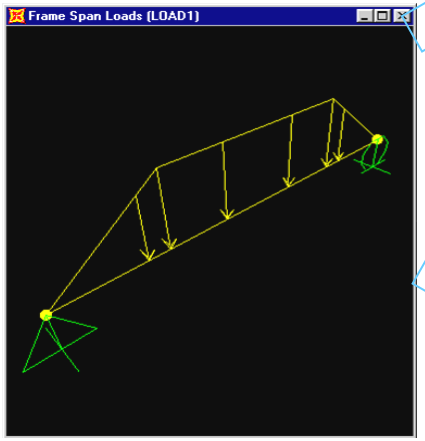
- View Loading diagrams
- Bending moment and shear force diagrams
- Stress contours

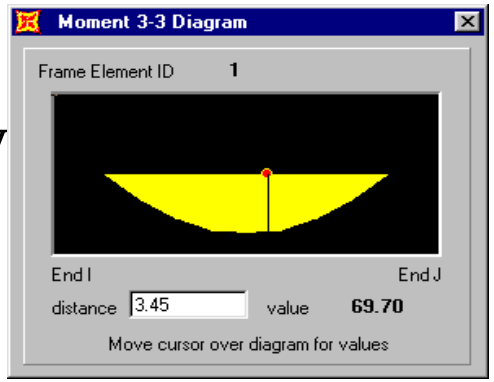


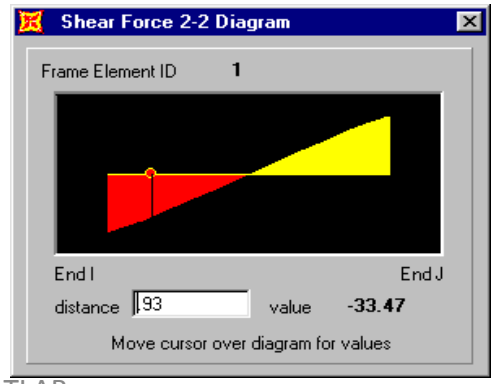


Viewing Results

- Instantaneous graphical and tabulated output details for specific joint or element with right button click
- Multiple windows display parameters





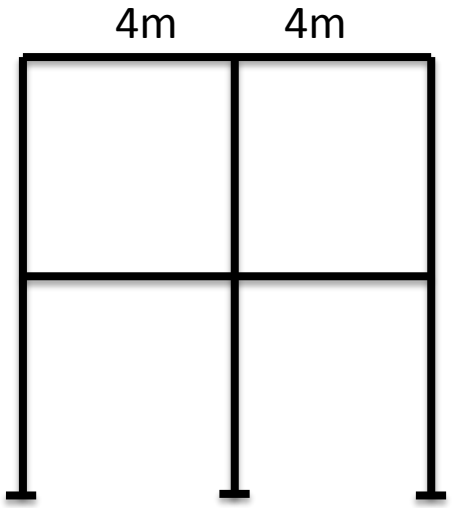


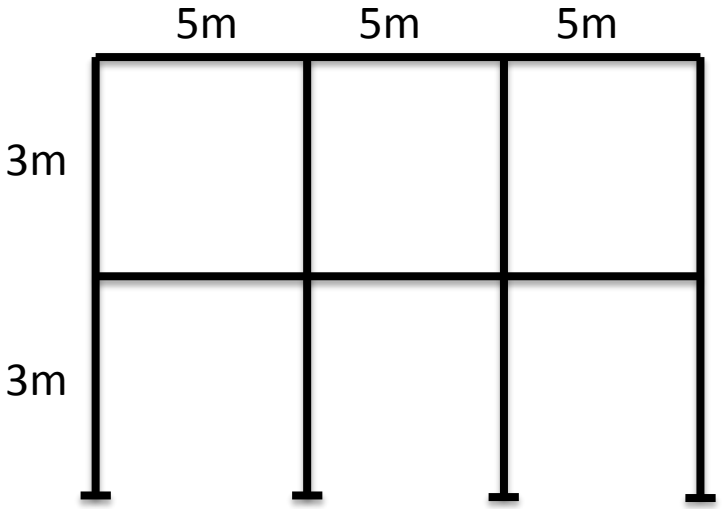
Tutorial Example: Static and Dynamic Analysis of a 3D Truss Frame

Tutorial Example

- 3D RC-Frame (C30/37) with slabs.
- 3x2 spans, 2 storeys
- Dimensions:
  - Span in x-dir= 5m; y-dir= 4m; storey height = 3m
  - Beams: h=50; w = 30 cm
  - Columns: w1 = w2 = 60 cm
  - Slabs: t = 20cm
- Loads: Self weight, live load, SLS (Factors= 1)

Tutorial Example





Further Reading

- http://www.csiamerica.com/products/sap2000/watch-and-learn
- http://ocw.mit.edu/courses/civil-and-environmental-engineering/1-051-structural-engineering-design-fall-2003/projects/SAP2000_Tutorial2.pdf
- http://www.grad.hr/csi/web___manuals/01%20%20%20SapStart.pdf.
- http://ctgttp.edu.free.fr/TRUNGWEB/Bai%20Giang/Bai%20giang%20va%20Vi%20du%20SAP/SAPWEB01.pdf

Q&A