



# **Structural Analysis & Design Software**



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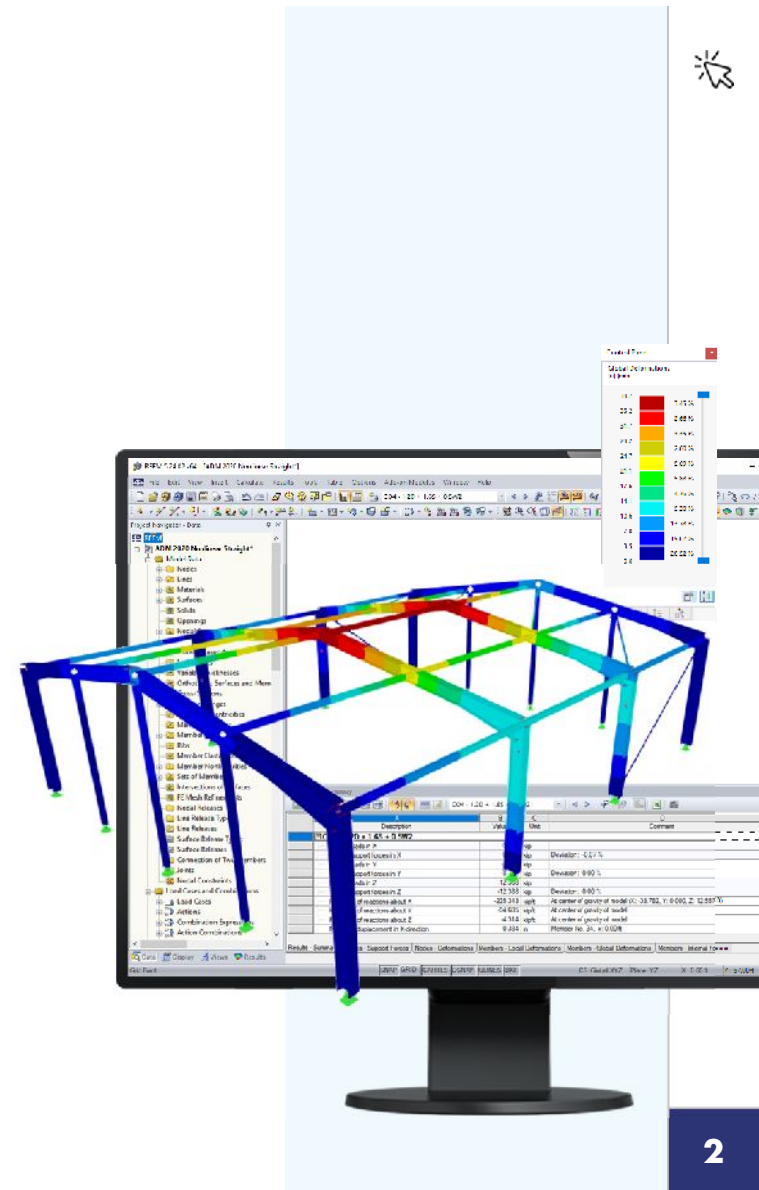
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**Webinar**

# CSA S16:19 Steel Design in RFEM 6



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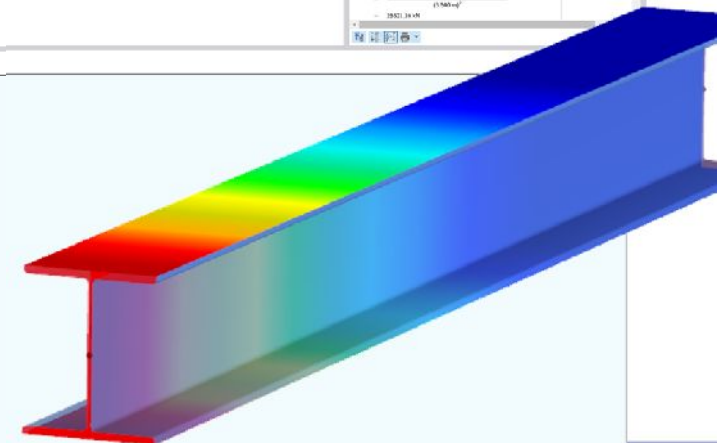
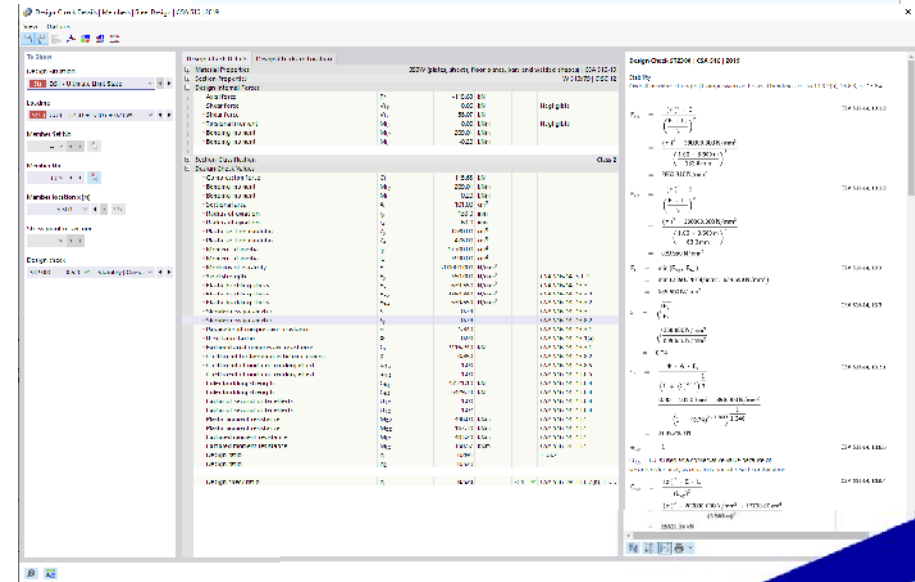


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# Content

- 01 RFEM 6 structure and load review
- 02 Stability Design Add-on instability troubleshooting
- 03 CSA S16:19 Annex O.2 stability requirements
- 04 Steel Design Add-on data input
- 05 Analysis and design results review

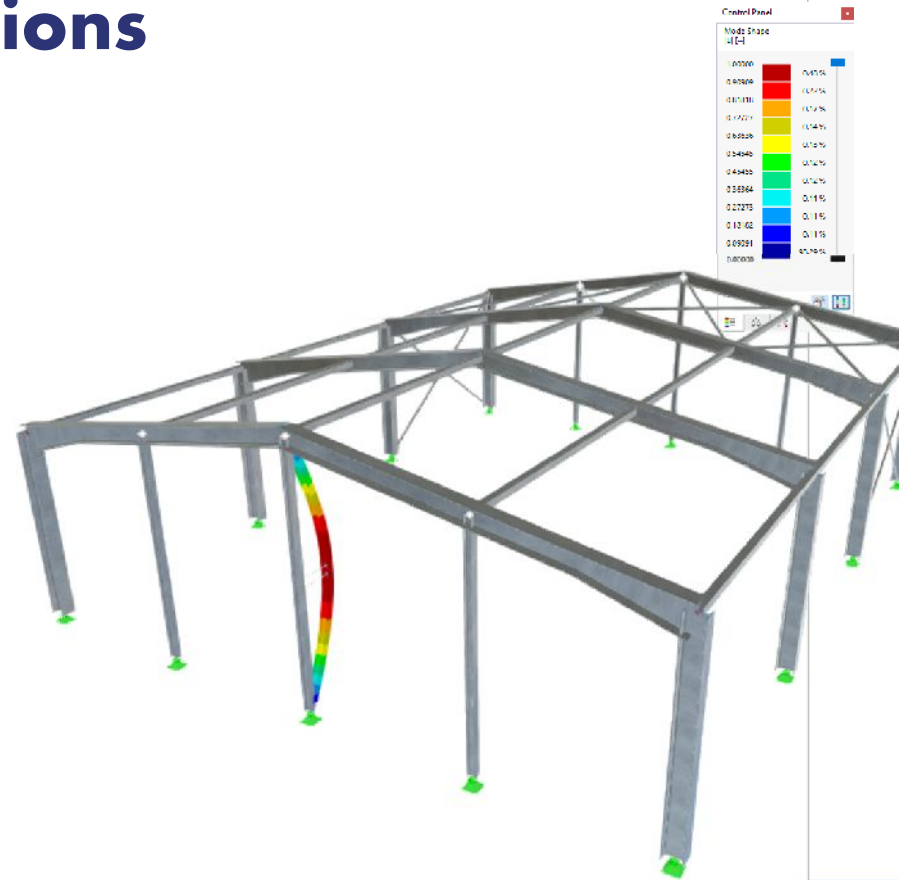




# CSA S16:19 Stability Considerations

## Design for Structure Stability [Clause 8.4]

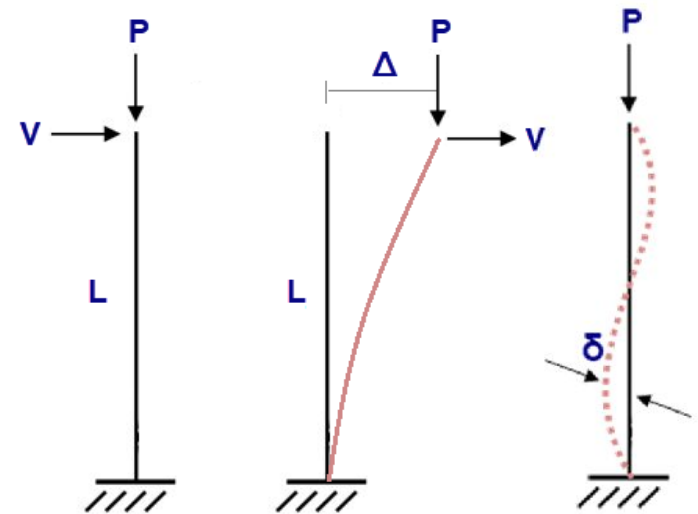
- **Stability requirements [Clause 8.4.1]**
  - Consideration to deformation, P-Delta, P-delta, geometric imperfections, stiffness reduction, uncertainty in strength/stiffness
- **Methods of analysis and design for stability [Clause 8.4.2]**
  - Simplified stability analysis method [Clause 8.4.3]
  - Stability effects in elastic analysis [Clause O.2]



## 8.4.3 Simplified Stability Requirements

### Simplified stability analysis method [Clause 8.4.3]

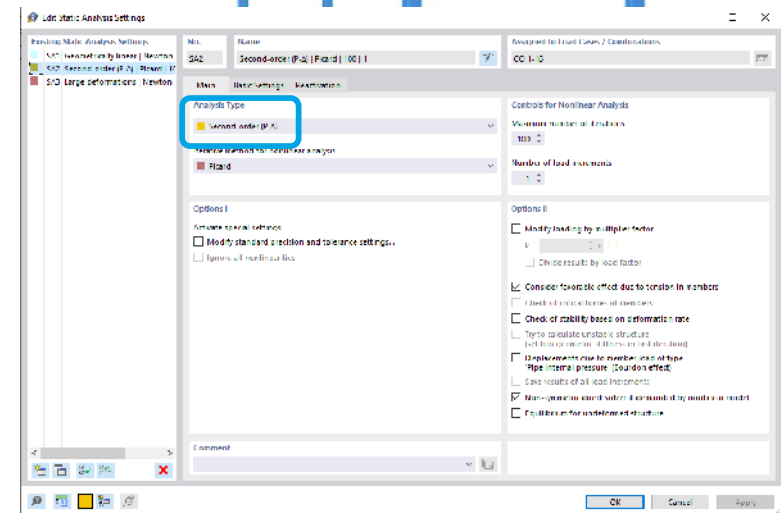
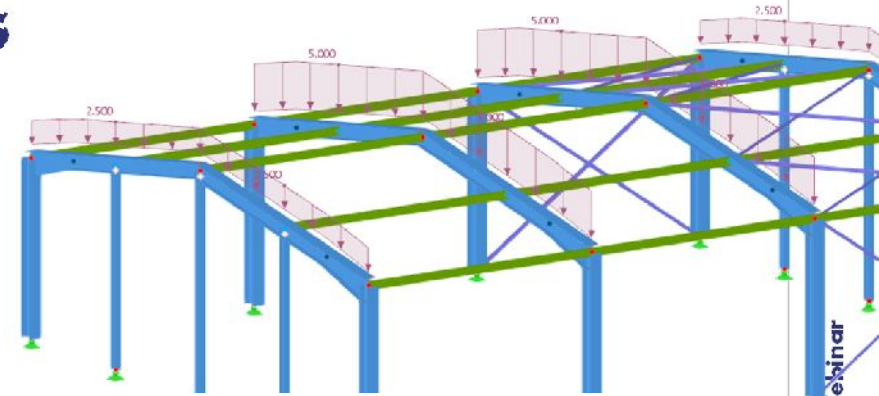
- **P- $\Delta$  effects [Clause 8.4.3.2]**
  - 2<sup>nd</sup> order analysis (RFEM approach) [Clause 8.4.3.2a]
  - $U_2$  amplification factor, axial loads and bending moments from 1<sup>st</sup> order analysis [Clause 8.4.3.2b]
- **Notional Lateral Loads [Clause 8.4.3.3]**
  - 0.005 x factored gravity load
  - Applied independently in 3D structure's orthogonal directions
  - Applied creating greatest destabilizing effect



# O.2 Second-Order Requirements

## Stability effects in elastic analysis [Clause O.2]

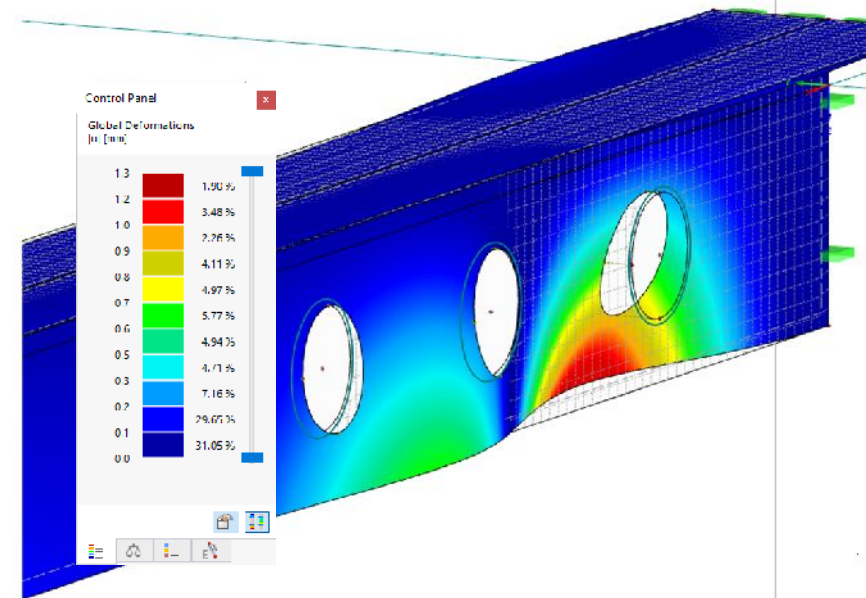
- Geometric nonlinearity (second-order) effects [Clause O.2.2]
  - P-Δ and P-δ effects
  - Conditions to neglect P-δ effects [Clause O.2.2a-d]
  - P-δ included,  $U_1 = 1.0$  (factor to account 2<sup>nd</sup> order effects due to the deformation between member ends) [Clause 13.8.5]
  - [Knowledge Base Article 1759](#)



## O.2 Imperfection Requirements

### Geometric Imperfections [Clause O.2.3]

- Member and local geometric imperfections neglected for elastic analysis
- Global geometric imperfections must be accounted for with listed methods
- Global imperfections can be neglected for lateral load COs [Clause O.2.3.1]
  - Gravity loads primarily supported by vertical elements
  - 1<sup>st</sup> to 2<sup>nd</sup> order story drift ratio with reduced member stiffnesses  $< 1.7$

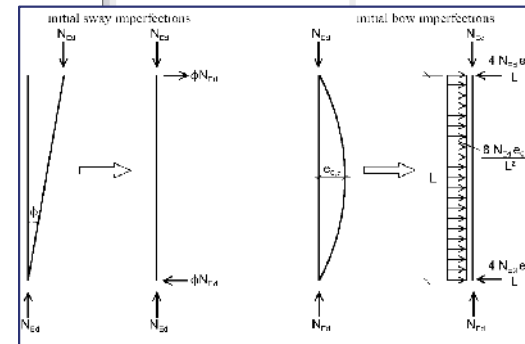
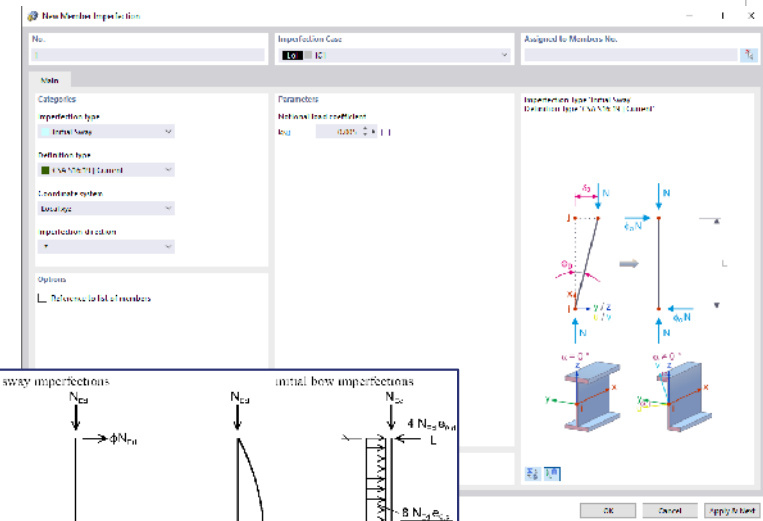






# O.2 Imperfection Requirements (cont'd)

- **Method 1: Direct modeling (Clause O.2.3.2)**
  - Displaced member intersection points (Clause 29.3 and column out-of-plumbness tolerances of 1/500)
  - Difficult and requires multiple different models
  
- **Method 2: Notional lateral loads (Clause O.2.3.3)**
  - 0.002 x factored gravity load
  - Simplified stability analysis method - 0.005 [Clause 8.4.3.3] vs. 0.002 factor
  - Applied in the direction for greatest destabilizing effect

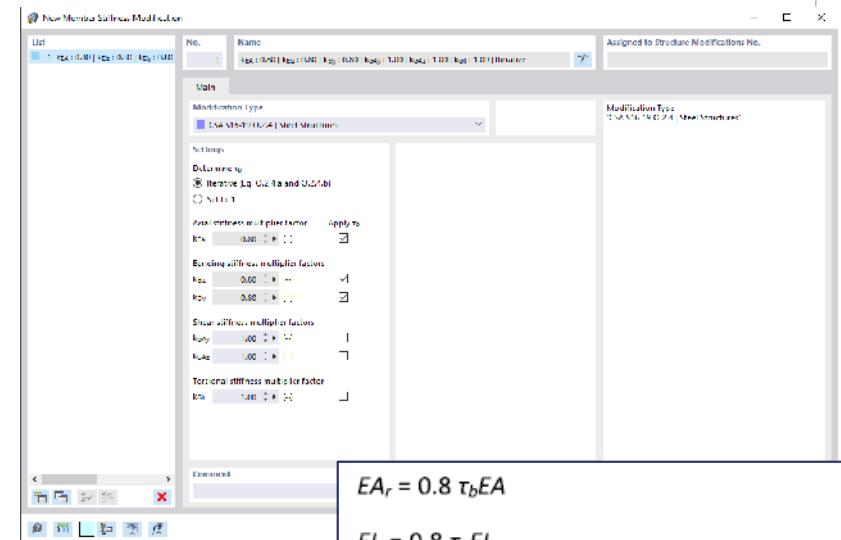




## O.2 Reduced Stiffness Requirements

### Reduced member stiffnesses [Clause O.2.4]

- Account for initial geometric imperfections, inelasticity, uncertainty in strength and stiffness
- Reduced member axial stiffness (EA) and flexural stiffness (EI)
  - 0.8 reduction factor
  - $\tau_b$  dependent on factored axial force ( $C_f$ ) and axial strength ( $C_y$ )
- Recommended application to all members
- Apply to shear stiffness (GA) and torsional stiffness (GJ) when stiffnesses contribute significantly to lateral stability
- Not applicable for serviceability (drifts, deflections, vibrations, periods, etc.)



$$EA_r = 0.8 \tau_b EA$$

$$EI_r = 0.8 \tau_b EI$$

where  $\tau_b$  is given by

a) when  $C_f/C_y < 0.5$ :  $\tau_b = 1.0$ ;

b) when  $C_f/C_y > 0.5$ :  $\tau_b = 4 C_f/C_y (1 - C_f/C_y)$ .

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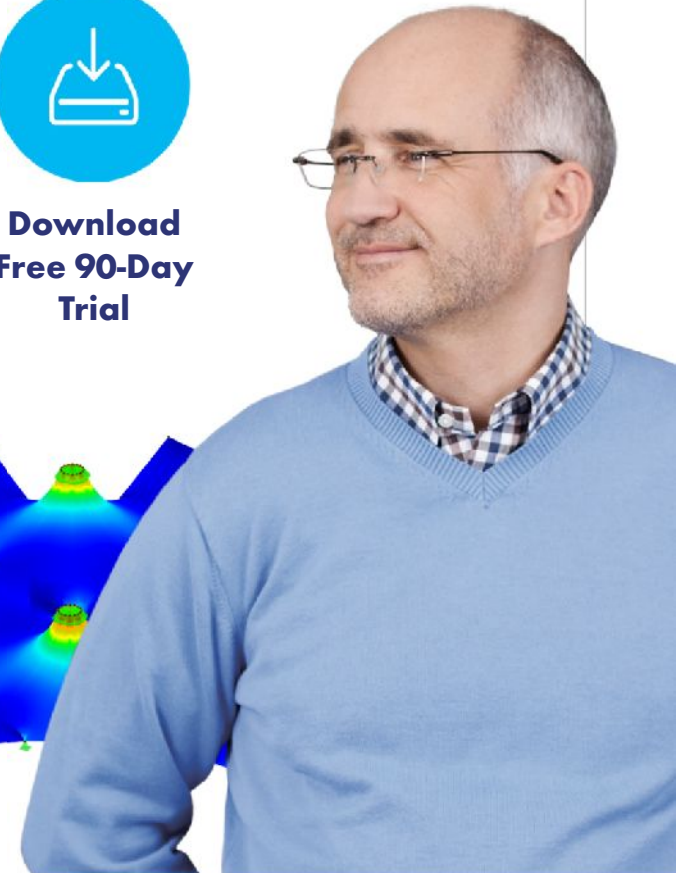
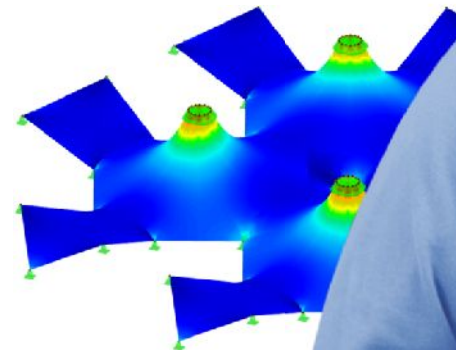
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