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Electronic Automation of the AISC 13th Edition

Analysis Methods of Chapter C

Direct Analysis Method (Appendix 7)

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Analysis Methods Of Chapter C

Summary of New Requirements

- Must Account for Geometric Imperfections (Out of Plumbness)
- Must Account for 2nd Order Effects (P- Δ & P- δ)
- Must Include Member Stiffness Reductions Due to Residual Stresses
- Use of K-Values Can Be Eliminated in Most Cases

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Analysis Methods Of Chapter C

Methods Meeting Requirements

1st Order Analysis

Amplified 1st Order Analysis

General 2nd Order Analysis

Direct Analysis Method (Appendix 7)

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Analysis Methods Of Chapter C

1st Order Analysis (Section C2.2b)

- Only Allowed When
 - $P_r \leq 0.5P_y$ (LRFD)
 - $P_r \leq 0.3125P_y$ (ASD)
- Must Include Minimum Notional Load in ALL Load Combinations
 - $N_i = 2.1(\Delta / L)Y_i \geq 0.0042Y_i$
- Must Apply B_1 Amplifier to all Member Moments
 - $B_1 = C_m / (1 - \alpha P_r / P_{e1}) \geq 1$

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Analysis Methods Of Chapter C

Amplified 1st Order Analysis (C2.1b)

- Qualifies as a 2nd Order Analysis

- $M_r = B_1 M_{nt} + B_2 M_{lt}$

- $P_r = P_{nt} + B_2 P_{lt}$

- $B_1 = C_m / (1 - \alpha P_r / P_{e1}) \geq 1$

- $B_2 = 1 / (1 - (\alpha \Sigma P_{nt} / \Sigma P_{e2})) \geq 1$

- + The Additional Requirements of
General 2nd Order Analysis

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Analysis Methods Of Chapter C

General 2nd Order Analysis

Any Method That Accounts for P- Δ & P- δ

Additional Requirements:

1. ASD Analysis Shall Be Carried Out Under 1.6 x Load Combinations (Results Divided by 1.6)
2. Must Include Minimum Notional Load in All Gravity Load Combinations
3. Must Use K-Factors for Moment Frame Columns If (2nd Drift / 1st Drift) > 1.1

Direct Analysis Method

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Direct Analysis Method (Appendix 7)

- Preferred Method in AISC Specification
- No Restrictions on Use
- Must Be Used if $(2^{\text{nd}} \text{ Drift} / 1^{\text{st}} \text{ Drift}) > 1.5$

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Direct Analysis Method

Geometric Imperfections

- Apply Notional Loads = $0.002Y_i$
(Assumes Imperfection = $L / 500$)
- Notional Loads May Be Reduced When Imperfections Are Smaller
- If $(2^{\text{nd}} \text{ Drift} / 1^{\text{st}} \text{ Drift}) < 1.5$, Notional Loads Apply To Gravity Load Combinations Only

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Direct Analysis Method

2nd Order Analysis

- P- Δ (Big Delta) Analysis

Always Required

- P- δ (little delta) Analysis

Can Be Ignored If $\alpha P_r < 0.15 P_{eL}$

Example: W12x65 Column (L = 15')

$$P_{eL} = 4708 \text{ kips}$$

$$\Phi P_n = 746 \text{ kips}$$

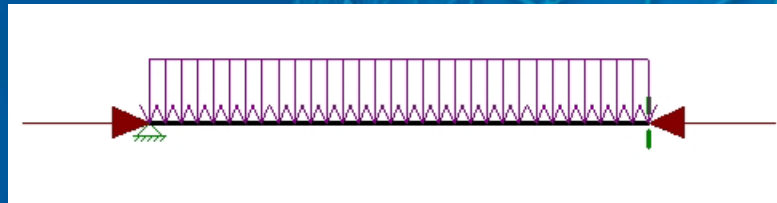
$$P_y = 955 \text{ kips}$$

$$\rightarrow 0.16 P_{eL}$$

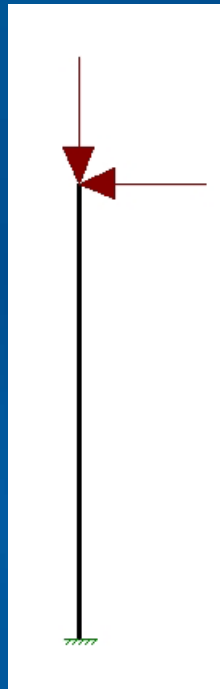
Direct Analysis Method

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AISC “Benchmark” Problems



Case 1

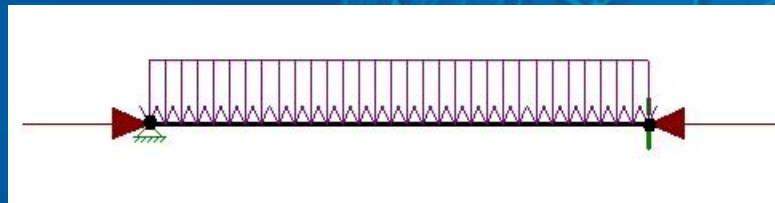


Case 2

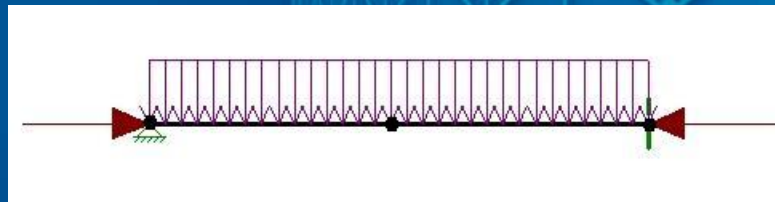
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Direct Analysis Method

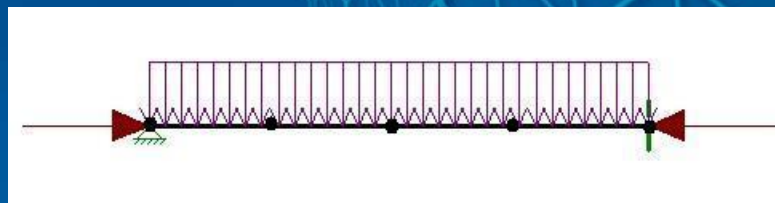
Benchmark – Case 1



Zero Joints



One Joint



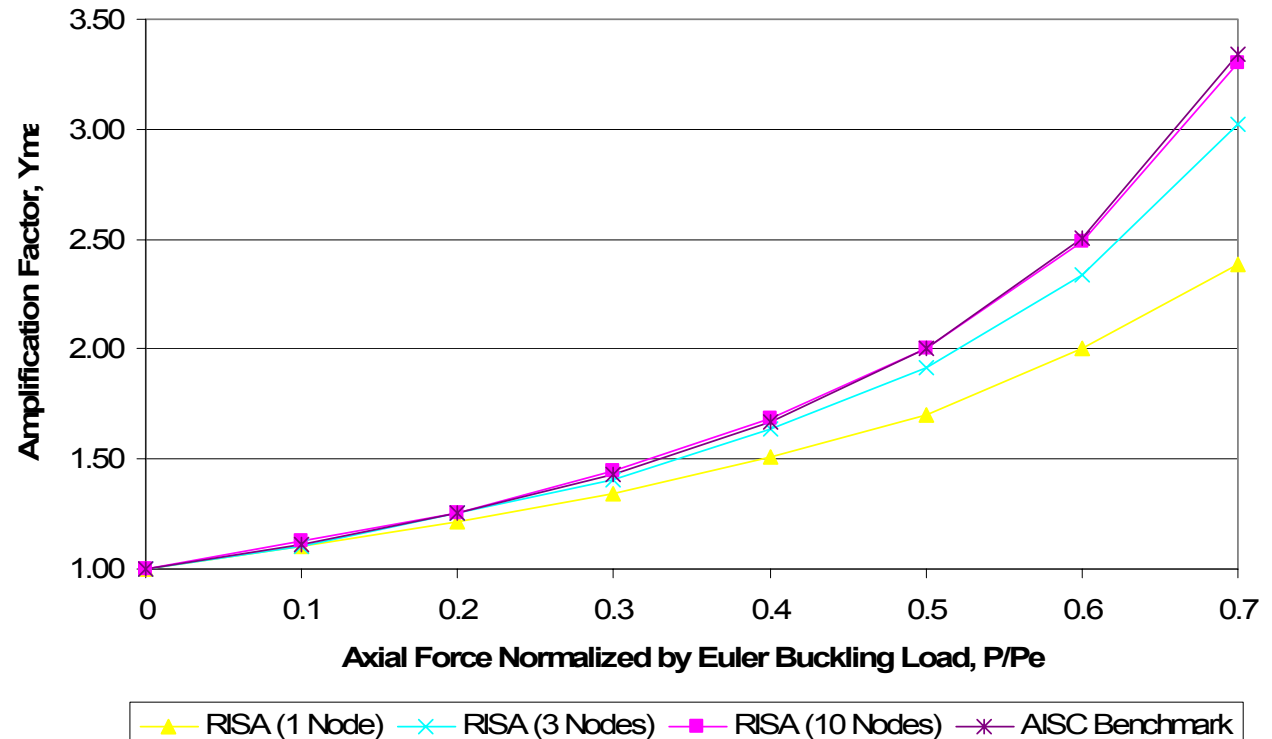
Three Joints

Direct Analysis Method

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Benchmark – Case 1

Case 1: Deflection Amplification

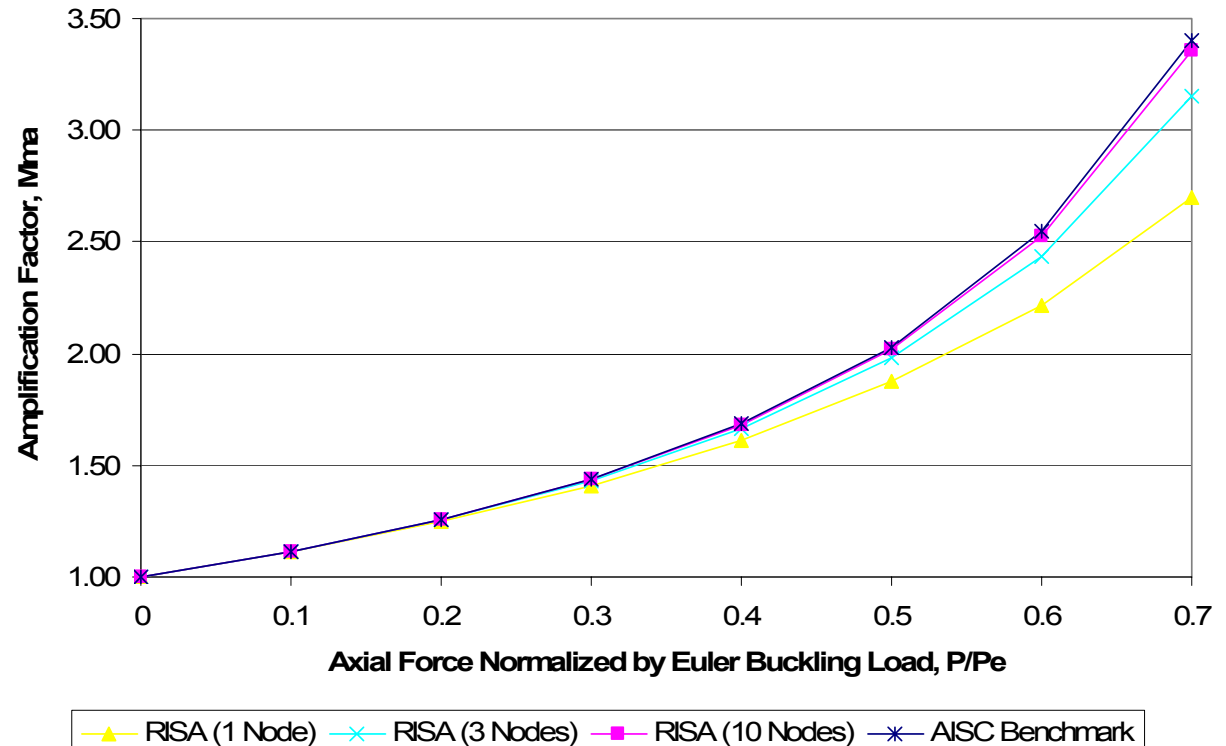


Direct Analysis Method

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Benchmark – Case 1

Case 1: Moment Amplification

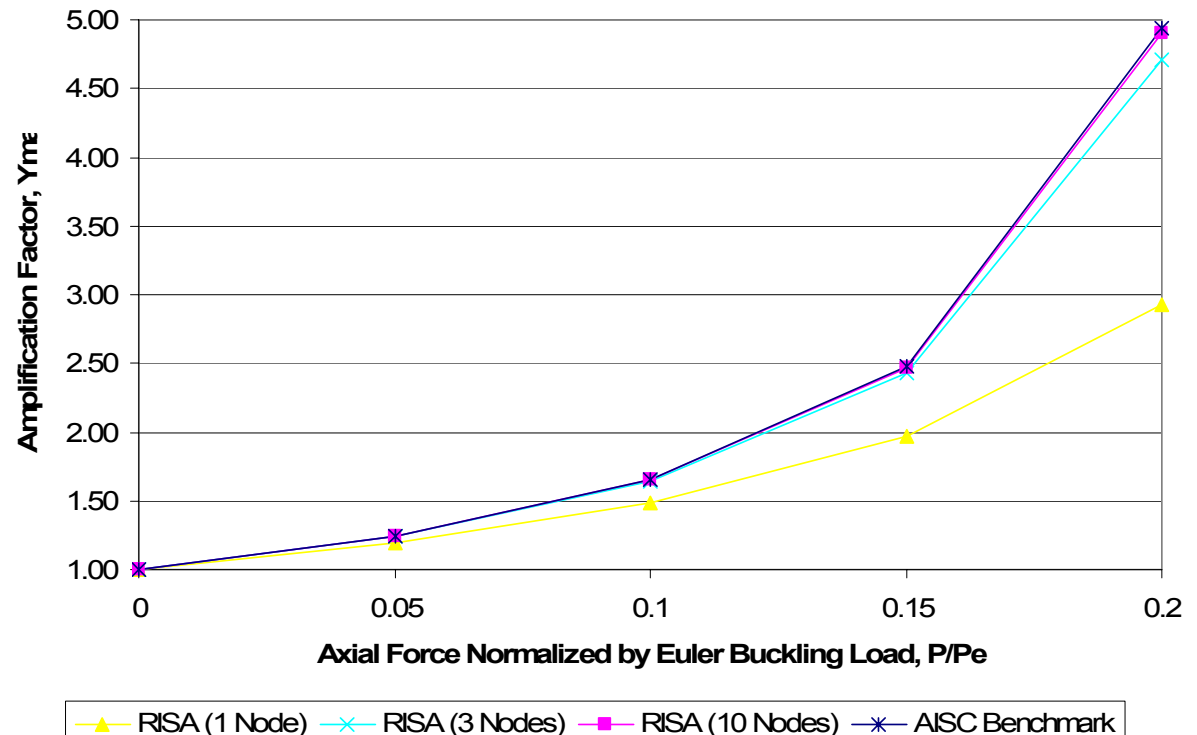


Direct Analysis Method

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Benchmark – Case 2

Case 2: Deflection Amplification

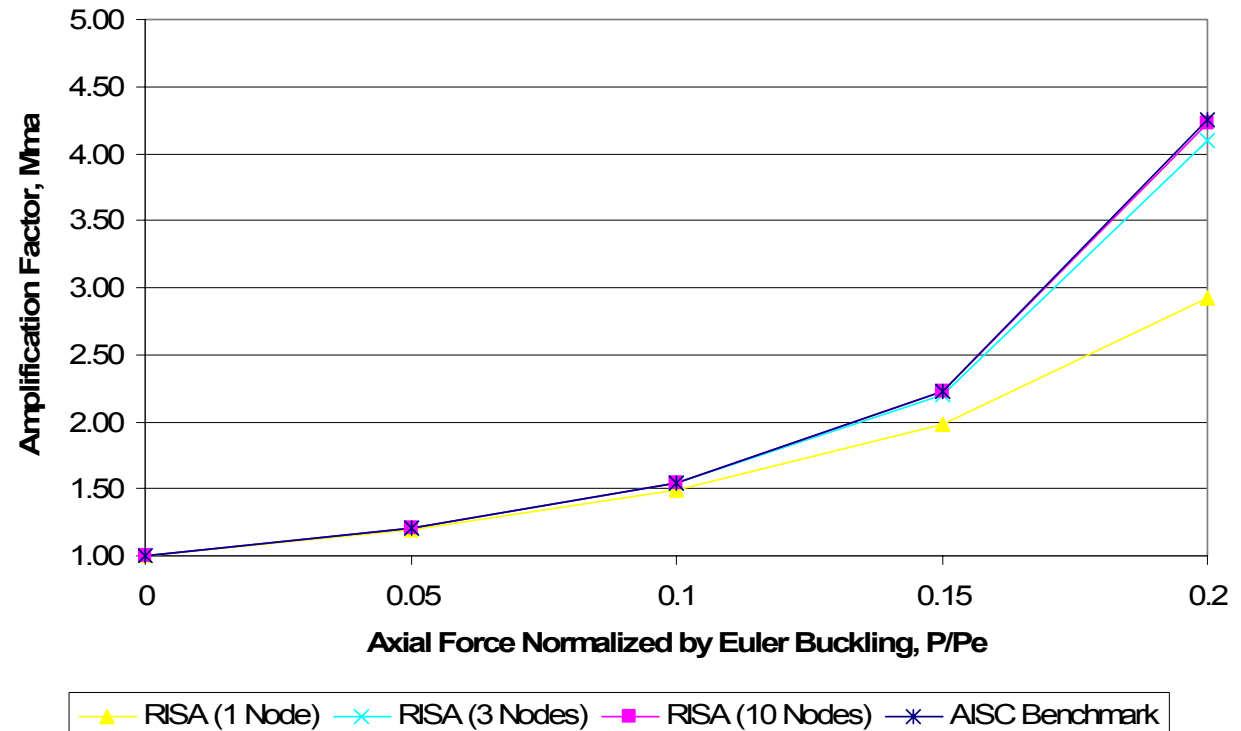


Direct Analysis Method

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Benchmark – Case 2

Case 2: Moment Amplification



Direct Analysis Method

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Material Non-Linearity Effects

Axial Stiffness Reduction

- $0.8EA$ – For Members Whose Axial Stiffness Contributes To Lateral Stability of Structure
 - Columns That Are Part of LFRS
 - Braces That Are Part of LFRS

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Material Non-Linearity Effects

Flexural Stiffness Reduction

- $0.8\tau_b EI$ – For Members Whose Flexural Stiffness Contributes To Lateral Stability of Structure
 - Beams That Are Part of Moment Frames
 - Columns That Are Part of Moment Frames
 - Tau (τ_b) Is Based on Axial Load
- Tau May Be Set to '1.0' If An Additional Notional Load ($0.001Y_i$) Is Included

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Analysis Methods of Chapter C

- 1st Order Analysis
- Amplified 1st Order Analysis
- General 2nd Order Analysis

Direct Analysis Method (Appendix 7)

- Geometric Imperfections (Notional Loads)
- 2nd Order Effects
- Material Non-Linearity

Direct Analysis Method

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RISA's Implementation of D.A.M.

- ✓ Notional Loads
- ✓ P- Δ (Big Delta)
- ✓ P- δ (little delta)
- ✓ Automated Stiffness Adjustments



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