Analyzing with P-Delta

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What?

Why?

When?

How?

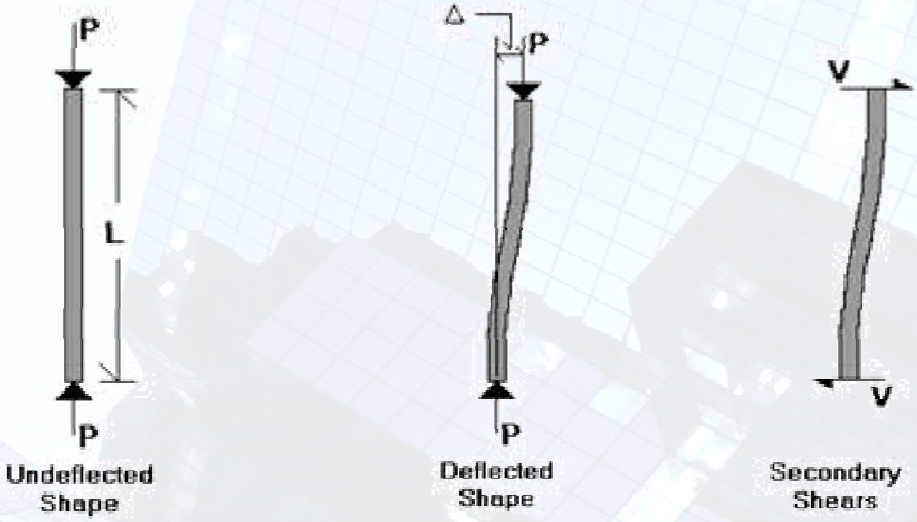
P-Delta?

Definition:

Destabilizing moment equal to the force of gravity multiplied by the horizontal displacement a structure undergoes as a result of a lateral displacement.

P (Force of Gravity) x **Delta** (Horizontal Displacement)

What is P-Delta Effect?



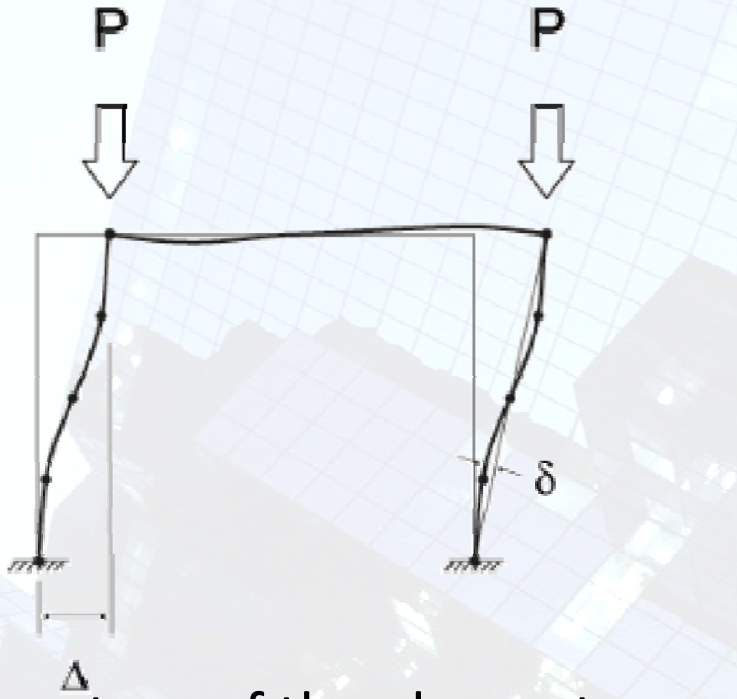
Step 1: Model deflects Δ

Step 2: Secondary shear force (V) calculated $P*\Delta = V*L \longrightarrow V = \frac{P*\Delta}{L}$

Step 3: Model is re-solved with V applied

Step 4: Iterate until the model converges

What is P-Delta in RISA?



P- δ Little P-Delta : curvature of the element

<u>RISA Implementation:</u>

Add Intermediate Joints to the element

What is little P-Delta?

P-Delta Required by Code

- AISC 13th & 14th Edition- Design for Stability → Direct Analysis Method

  Second Order Analysis (P- Δ, P- δ)

- ACI 2008 & ACI 2012

  Nonlinear Second Order Analysis (10.10.3)

  Elastic Second Order Analysis (10.10.4)

  Moment Magnification (10.10.5)

- Foreign Codes (CSA, etc.)

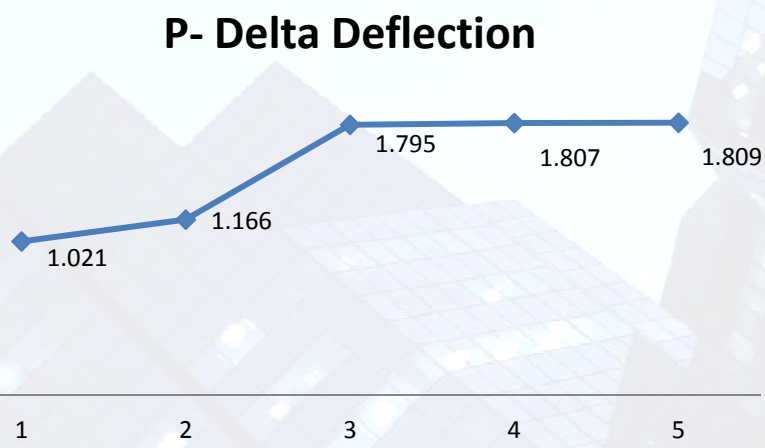
Why?

1. Design Gravity Systems
   No P-Delta

2. Design Lateral System
   P-Delta?

3. Final Design
   P-Delta

When?



Little P-Delta:

Deflection: 1.226in

3% Increase

Strong Axis Bending		% Change
	Deflection	
1st Iteration:	1.021in	
2nd Iteration:	1.166in	14.20%
3rd Iteration:	1.186in	53.95%
4th Iteration:	1.189in	0.67%
5th Iteration:	1.19in	0.11%

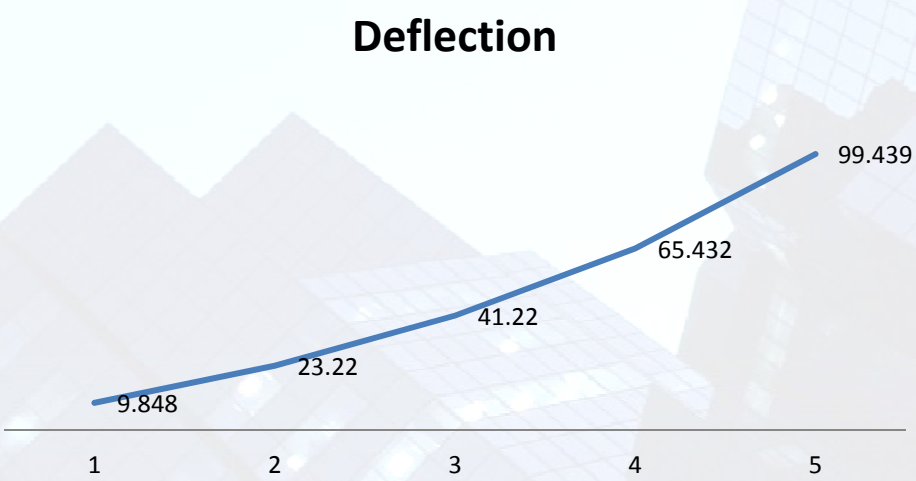
AISC 14th Edition:

Final Deflection: 2.342in

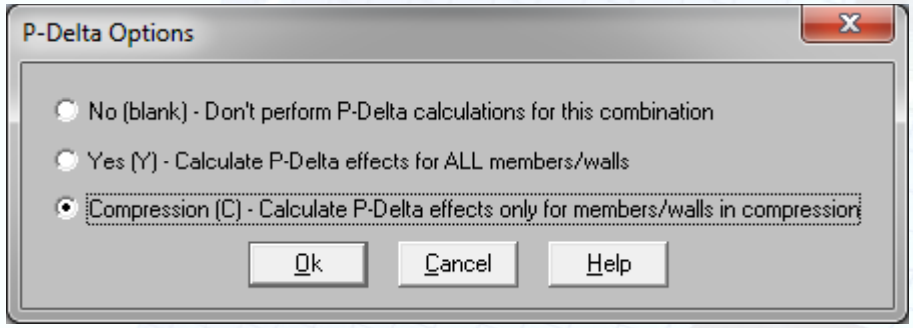
96% Increase

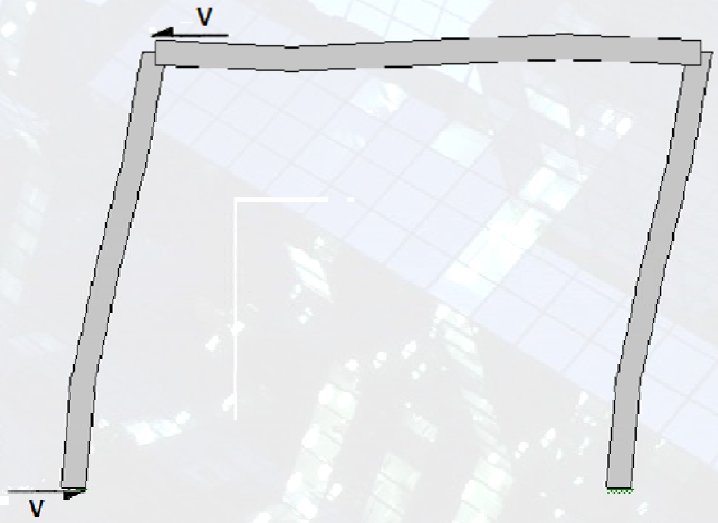
P-Delta Example

Let's Try the Weak Axis:



Weak Axis Bending		% Change
	Deflection	
1st Iteration:	9.848in	
2nd Iteration:	23.22in	135.78%
3rd Iteration:	41.22in	77.52%
4th Iteration:	65.432in	58.74%
5th Iteration:	99.439in	51.97%





The P-Delta effect → increases the flexural stiffness of members in tension

Compression Only

How do we get past a P-Delta Divergence?

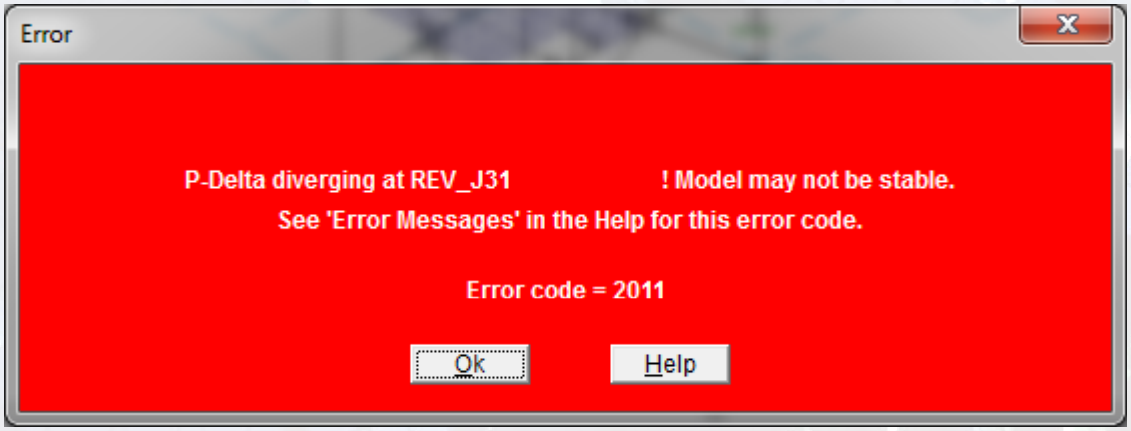
1. Turn off P-Delta
2. Run the model
3. Review Deflection
4. Review Design Results

How?

- **Instabilities**
- **Inadequately sized members**
- **Tension/Compression Only Members**
- **Stiffness Adjustment (Direct Analysis method)**
- **Model Errors**

Common P-Delta Problems

Let’s review some examples!



Common P-Delta Problems

Questions?

Please let us know if you have questions.

We will answer as many questions as time permits during the webinar.

Once the webinar is closed, we will post all Q&A's to our website: www.risa.com

For further information, contact us at: webinar@risatech.com

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