

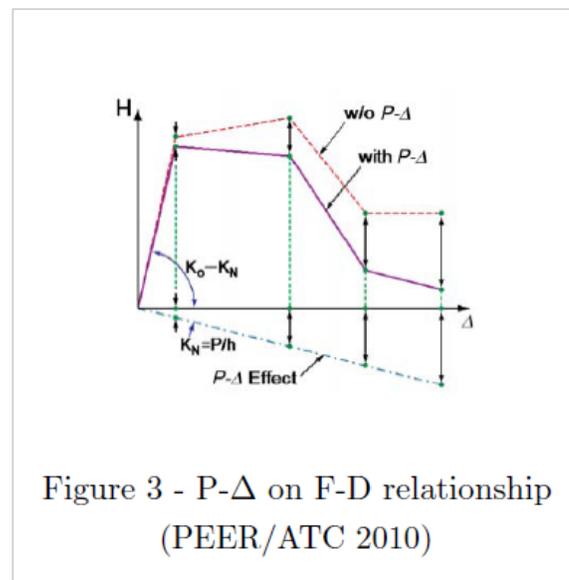
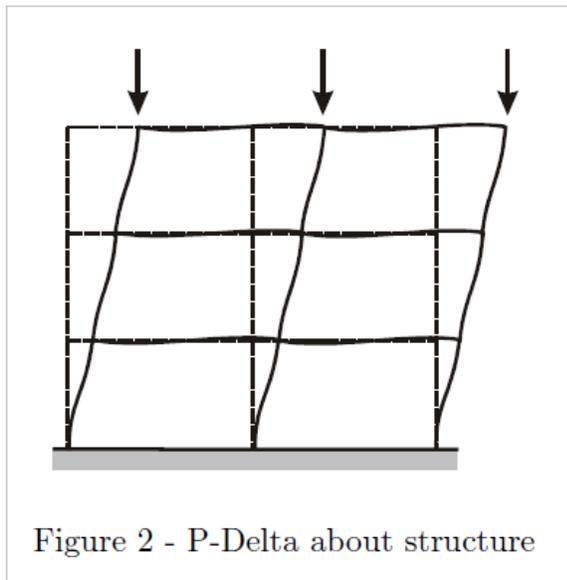
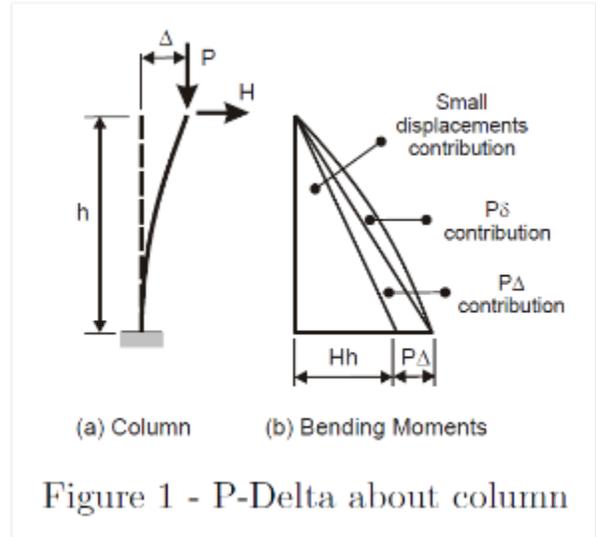
# P-Delta effect

**P-Delta effect**, also known as geometric nonlinearity, involves the equilibrium and compatibility relationships of a structural system loaded about its deflected configuration. Of particular concern is the application of gravity load on laterally displaced multi-story building structures. This condition magnifies story drift and certain mechanical behaviors while reducing deformation capacity.

P-Delta effect typically involves large external forces upon relatively small displacements. If deformations become sufficiently large as to break from linear compatibility relationships, then Large-Displacement and Large-Deformation analyses become necessary. The two sources of P-Delta effect are illustrated in Figure 1, and described as follows:

- P- effect**, or P-"small-delta", is associated with local deformation relative to the element chord between end nodes. Typically, P- only becomes significant at unreasonably large displacement values, or in especially slender columns. So long as a structure adheres to the slenderness requirements pertinent to earthquake engineering, it is not advisable to model P-, since it may significantly increase computational time without providing the benefit of useful information. An easier way to capture this behavior is to subdivide critical elements into multiple segments, transferring behavior into P- effect (Powell 2006).
- P- effect**, or P-"big-delta", is associated with displacements relative to member ends. Unlike P-, this type of P-Delta effect *is* critical to nonlinear modeling and analysis. As indicated intuitively by Figure 2, gravity loading *wi* //influence structural response under significant lateral displacement. P- may contribute to loss of lateral resistance, ratcheting of residual deformations, and dynamic instability (Deierlein et al. 2010). As shown in Figure 3, effective lateral stiffness decreases, reducing strength capacity in all phases of the force-deformation relationship (PEER/ATC 2010). To consider P- effect directly, gravity load should be present during nonlinear analysis. Application will cause minimal increase to computational time, and will remain accurate for drift levels up to 10% (Powell 2006).

The [Types of P-Delta analysis](#) article further explains the difference between P- and P-.



## Articles

## Test Problems

Title	Description	Program
<a href="#">Interpreting buckling analysis results for different initial conditions</a>	Buckling analysis may begin with either zero initial conditions or the stiffness taken from the end of a nonlinear load case. This test problem compares the associated output.	SAP2000

## See Also

- [Buckling](#) section

## References

- Powell, G. H. (2010). *Modeling for Structural Analysis: Behavior and Basics* (1st ed.). Berkeley, CA: Computers and Structures, Inc. Available for purchase on the CSI Products >  
page
- Deierlein, G. G., Reinhorn, A. M., and Willford, M. R. (2010). *Nonlinear Structural Analysis For Seismic Design*, NEHRP Seismic Design Technical Brief No. 4., NIST GCR 10-917-5. Gaithersburg, MD: National Institute of Standards and Technology.
- PEER/ATC (2010). *Modeling and acceptance criteria for seismic design and analysis of tall buildings*, PEER/ATC 72-1 Report. Redwood City, CA: Applied Technology Council.