Types of P-Delta analysis

Simply supported beam P-

P- is a local effect associated with axial load on displacement relative to element chord extending between end nodes. Figure 1 illustrates the influence of P- on a simply supported beam. Here, a longitudinal distributed load correlates with elastic bending-stiffness properties $K_E$ to induce vertical displacement. An additional flexural contribution comes from the relationship between this deformed configuration and axial load $P$. The geometric stiffness properties $K_G$ which dictate this relationship are discussed further in Dr. Edward L. Wilson’s text, *Static and Dynamic Analysis of Structures*.

Values for the maximum flexural response which occurs at element midspan are shown in Figure 1:

![Figure 1 - P- applied to a simply supported beam](image)

Cantilevered column P-

Now, when observing P- effect on a cantilevered column, response is shown in Figure 2:
However, columns seldom displace with single curvature. More commonly, especially with multi-story-building analysis and design, columns deform according to a third-order (cubic) displacement pattern under double curvature. As shown in Figure 3, P- effect is much less pronounced because an inflection point intersects the element chord near midspan, previously where displacement from chord was greatest.

Cantilevered column P-

However, what is often of significance, given this loading condition and double-curvature displacement pattern, is P- effect. Although displacement deviates from element chord much less, the lateral displacement associated with story drift is significant. With increasing levels of drift, gravity load has a greater effect on mechanical behavior, as shown in Figure 4. P- effect should be implemented during design, whether static or dynamic, linear or nonlinear.
Figure 4 - P- applied to a cantilevered column

References