

Flexible vs. rigid diaphragm effect on torsional stiffness of buildings

When considering the [P-delta](#) and [buckling](#) behavior of multi-story buildings, due consideration should be given to modeling the floors as flexible diaphragms when they are connected to walls that carry vertical load. This allows tensile membrane forces to develop within these flexible diaphragms, which may be necessary to balance the compressive forces which result where floors resist the horizontal Poisson expansion of vertically loaded walls. Without this balance between forces, the P-delta effect unrealistically reduces the torsional stiffness of the wall systems, possibly causing excessively large torsional deformations, elongated torsional periods, low buckling factors, or convergence problems for P-delta analyses.

Whether or not this effect is significant depends on the torsional characteristics of the structure, and how much of the vertical load is carried by the walls. For a cruciform or similar shapes with a central core and several wings, or for long and narrow structures, torsional behavior may be affected if a significant portion of the vertical load is carried by walls. For more square or circular shapes, the effect may be minor.

When walls are subjected to vertical compressive loading, horizontal Poisson expansion occurs. In the physical structure, adjoining slabs resist this horizontal expansion, causing compressive horizontal stresses in the walls and tensile stresses in the slabs. The compressive stresses within the walls reduce the torsional stiffness of the structure, whereas the tensile stresses in the slabs balance this effect by increasing the torsional stiffness. However, when diaphragm [constraints](#) are assigned to slabs, these tensile forces do not develop since rigid diaphragms are constrained against in-plane deformation. When wall systems carry gravity load, interconnecting slabs should be modeled as flexible diaphragms such that membrane behavior may balance the compressive effect of horizontal Poisson expansion.

This discussion applies only to [shell](#) objects, since [frame](#) objects, and therefore column systems, do not exhibit Poisson effect. Further, while rigid diaphragms cause a reduction in the torsional stiffness of adjoining wall systems, the effects associated with horizontal Poisson stresses do not affect vertical wall stresses. As a result, diaphragm constraints do not influence the P-delta and buckling effects for lateral modes of the structure. To be more specific, vertical stresses cause P-delta effects for rotation about a horizontal axis, and are unaffected by the presence of a rigid diaphragm. However, horizontal stresses cause P-delta effects for rotation about a vertical axis, and these can be affected by the rigid diaphragm constraint.

See Also

- [Effect of rigid diaphragms on buckling of a cruciform structure](#) article