

CODE

12.4.2.4 Calculation of diaphragm in-plane design moments, shears, and axial forces shall be consistent with requirements of equilibrium and with design boundary conditions. It shall be permitted to calculate design moments, shears, and axial forces in accordance with one of (a) through (e):

- (a) A rigid diaphragm model if the diaphragm can be idealized as rigid
- (b) A flexible diaphragm model if the diaphragm can be idealized as flexible
- (c) A bounding analysis in which the design values are the envelope of values obtained by assuming upper bound and lower bound in-plane stiffnesses for the diaphragm in two or more separate analyses
- (d) A finite element model considering diaphragm flexibility
- (e) A strut-and-tie model in accordance with 23.2

12.5—Design strength**12.5.1 General**

12.5.1.1 For each applicable factored load combination, design strengths of diaphragms and connections shall satisfy $\phi S_n \geq U$. Interaction between load effects shall be considered.

12.5.1.2 ϕ shall be determined in accordance with 21.2.

COMMENTARY

R12.4.2.4 The rigid diaphragm model is widely used for diaphragms that are entirely cast-in-place and for diaphragms that comprise a cast-in-place topping slab on precast elements, provided flexible conditions are not created by a long span, by a large aspect ratio, or by diaphragm irregularity. For more flexible diaphragms, a bounding analysis is sometimes done in which the diaphragm is analyzed as a stiff or rigid element on flexible supports and as a flexible diaphragm on rigid supports, with the design values taken as the envelope of values from the two analyses. Finite element models can be suitable for any diaphragm, but are especially useful for irregularly shaped diaphragms and diaphragms resisting large transfer forces. Stiffness should be adjusted to account for expected concrete cracking under design loads. For jointed precast concrete diaphragms that rely on mechanical connectors, it may be necessary to include the joints and connectors in the finite element model. Strut-and-tie models may be used for diaphragm design. The strut-and-tie models should include considerations of force reversals that may occur under design load combinations.

R12.5—Design strength**R12.5.1 General**

R12.5.1.1 Design actions commonly include in-plane moment, with or without axial force; in-plane shear; and axial compression and tension in collectors and other elements acting as struts or ties. Some diaphragm configurations may result in additional types of design actions. For example, a diaphragm vertical step can result in out-of-plane bending, torsion, or both. The diaphragm is required to be designed for such actions where they occur in elements that are part of the load path.

Nominal strengths are prescribed in Chapter 22 for a diaphragm idealized as a beam or solid element resisting in-plane moment, axial force, and shear; and in Chapter 23 for a diaphragm or diaphragm segment idealized as a strut-and-tie system. Collectors and struts around openings can be designed as compression members subjected to axial force using provisions of 10.5.2 with the strength reduction factor for compression-controlled members in 21.2.2. For axial tension in such members, nominal tensile strength is $A_s f_y$, and the strength reduction factor is 0.90 as required for tension-controlled members in 21.2.2.

Diaphragms are designed under load combinations of 5.3. Where a diaphragm or part of a diaphragm is subjected to multiple load effects, the interaction of the load effects is to be considered. A common example is where a collector is built within a beam or slab that also resists gravity loads, in which case the element is designed for combined moment and axial force. Another example is where a connection is subjected to simultaneous tension and shear.