# DIAPHRAGM DESIGN OF FLOOR SLABS FOR EARTHQUAKE FORCES

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Floor slabs, in addition to gravity are designed to distribute the story shear from the seismic effects among the supporting lateral force resisting members of the floor. In the general case, the design requirements consist of eight items. These are shown schematically in Fig. 1. Checks marked 2 through 6 are based on the code specified strength combination. Adequacy of a slab to qualify as seismic diaphragm, marked as check 1 in the figure, is by prescription. The item marked 8 is for deformation compatibility. In the general case, this is handled through code-recommended detailing. The remainder items are strength checks for adequacy of rebar and prestressing, if any.

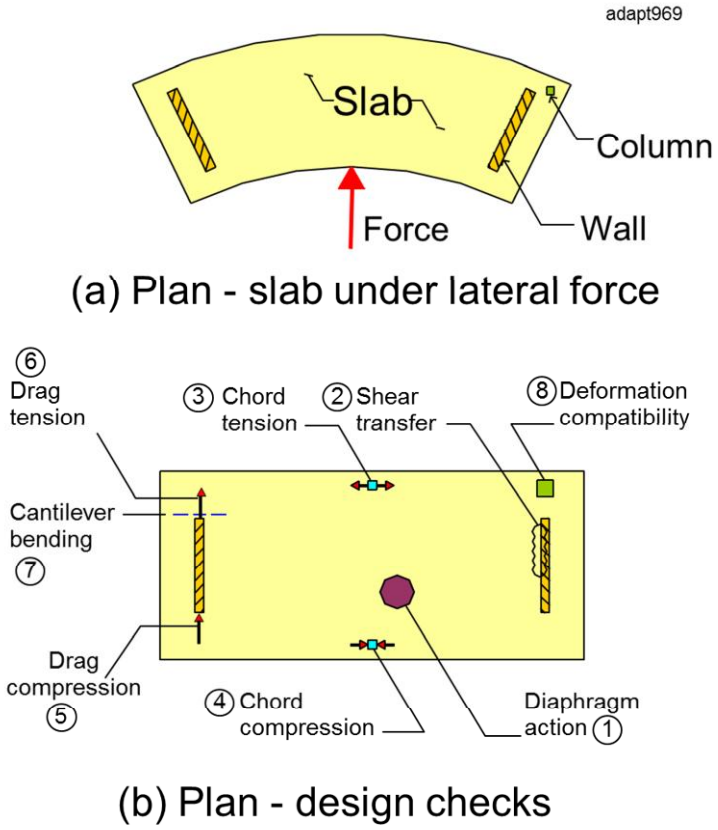



FIGURE 1 Identification of Eight Checks Generally Applicable to Diaphragm Design (P990)

Traditionally, before the advent of comprehensive and inclusive analysis and design software, two of the strength checks, namely requirements for “chord” and “drag” reinforcement were singled out for special consideration (Fig. 2). The possibility of development of tension in the slab resulting from the chord or drag forces was investigated. Tension reinforcement was provided, where required.

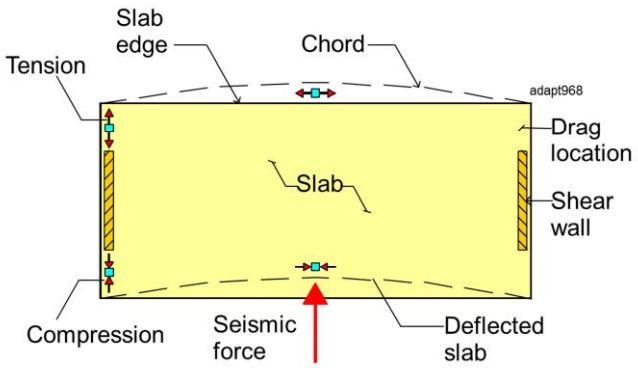



FIGURE 2 General Definition of Drag and Chord Conditions
Demonstration of chord and drag definition resulting from the action of seismic force (P995).

The following explains the current practice, and compares it with the traditional approach for the separate treatment of chord and drag reinforcement

Using ACI 318-14, the recommended load combinations in the presence of seismic forces are:

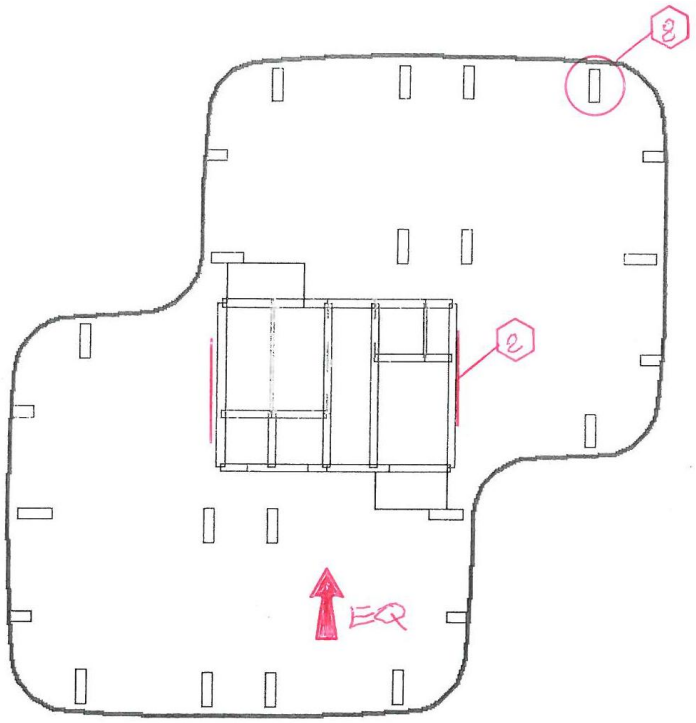
U1 =1.2D + 1.6L + 1.0HYP
U2 =1.2D + 1.0E + 0.5L[1] + 1.0HYP
U3 = 0.9D + 1.0E + 1.0HYP
U4 = 1.4D + 1.0HYP

Where,

E = seismic force; and
HYP = hyperstatic force from prestressing.

When the design of a floor is based on using the above load combinations, the effect of the seismic force (E) is implicit and accounted for in the strength design of the floor for gravity. The “drag” and “chord,” where needed, will be automatically provided for in the strength consideration of the floor. In this case, the seismic design of the floor will be limited to the checks 2 and 8 as identified in the example shown in Fig. 3.

[1] For (a) garages; (b) areas of public assembly; and (c) where LL is greater than 100 psf, the load factor for live load shall be 1.00




FIUGRE 3 Plan; Identification of typical locations and the type of the required strength check for the comprehensive strength load combination U1 =1.2D + 1.0E + 0.5L + 1.0HYP. Numbers relate to the type of strength check required as shown in Fig. 1. Check marked 2 is for the transfer of shear from the slab to the shear wall. Item marked 8 is check for deformation compatibility between the slab and column support for the calculated lateral drift.

If the design follows the traditional scheme, when comprehensive analysis and design software are not used, or due to other restrictions, the design is based on the separate treatment of gravity and seismic loads. The following load combinations apply, followed by seismic design of the floor as a separate step.

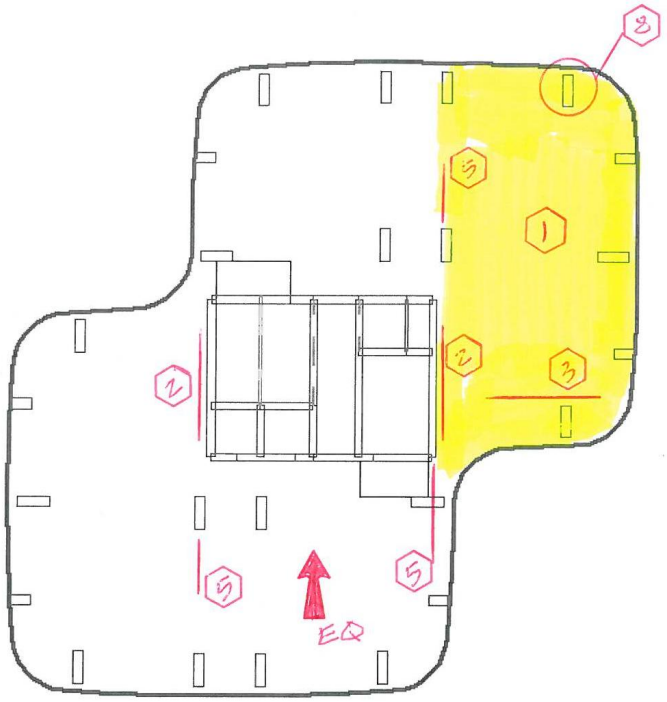
Load combinations for gravity design

U1 = 1.2D + 1.6L + 1.0HYP
U2 = 1.4D + 1.0HYP

The initial design is completed using the gravity loads, using the above combinations. Next, the design is re-done for the following seismic load combination.

U3 = 1.0E

The demand values obtained from the load combination U3 are checked for the 8 items listed in Fig, 1. The reinforcement required is ADDED to the reinforcement obtained for the gravity load combinations separately. In a typical example the traditional application of design checks for “chord, drag and shear transfer” are shown in the example of Fig. 4 for the region highlighted.




FIUGRE 4 Plan; Identification of typical locations and the type of the required strength check for the load combination that includes the seismic actions only, namely U = 1.0E  Numbers relate to the type of strength check required.

From the forgoing, it is apparent that a more efficient design will be obtained if the comprehensive option  is used, where the load combination includes both the gravity and seismic forces.