

**Subject:**

171205 - 3 - RE: ACI 318 - Code Interpretation (Walls)

**Attachments:**[2003j\\_Oct\\_When a column becomes a wall AND Lateral ties for columns less 1 percent.pdf](#)

ACI publishes codes, specifications, and reports for the concrete user. This message is in response to your technical question/inquiry.

Your question is actually a two-part question. Attached file is an FAQ regarding the 2002 version of the code, but the analysis stands.

First, if you have reinforcement in excess of 1%, you are required to tie the reinforcement in the wall (essentially, you build a column at the end of the wall). There are a couple of reasons for this. The obvious one is the compression reinforcement issue, buckling of the longitudinal bars. Even if you are not counting on the bars for compression, the wall is likely going to see said compression – which could theoretically cause buckling if the outside surface of the concrete spalls off at some point in the loading process. The less obvious is actually something that has been discovered in all of the wall testing for seismic design requirements. What they have found is that the transverse reinforcement helps with controlling the size of the horizontal cracks that will occur in a wall during an earthquake or other high-load event such as a hurricane. Without the lateral tie spacing, the first crack that appears near the base of the wall will simply get bigger. With the lateral tie spacing, the tendency is to have many more smaller cracks form instead of that one large crack. When you are getting to 1% or more longitudinal reinforcement in a wall, you are seeing some substantial loading – perhaps not special seismic loading, but substantial nonetheless.

Second, with regard to the tall basement walls. If you follow the normal design process of chapter 11 in ACI 318-14, yes, you would need to tie the reinforcement in your wall if you exceeded 1%. Note that 1% steel is a substantial amount of reinforcement in a wall for out-of-plane bending. If you run into this issue, there are a couple of options that you may wish to consider. If the space is available, you may find that thickening the wall to reduce the required reinforcement may be more cost effective than adding ties. Another option that may be appropriate (you would need to determine if your situation meets the limitations of the method) is the alternative method for out-of-plane slender wall analysis (section 11.8 of ACI 318-14).

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Sincerely,  
Technical Staff

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Good afternoon,

I was hoping you might be able to provide some input on ACI 318-14 Section 11.7.4 or ACI 318-11 Section 14.3.6

In instances where reinforcement in excess of 1% is provided at wall ends for tension due to overturning, the way I am reading the code section, I am required to tie it because it exceeds 1% even if I don't count it for compression.

As an example, if you had an 8" thick wall with one curtain of steel of #5@12" with additional end reinforcement of 3#6@4", would you potentially be violating the requirement of not tying steel > 1%?

As an extension, if you had a 12" wall with 2 curtains of reinforcement with say 4#9 at the ends @ 12" apart, the same would apply. Are there exceptions in ACI 318 that would preclude needing to tie these 4#9 bars at a wall end it can be shown that the #9 bars are not counted in the compression block?

Another example would be a tall basement wall with 1% reinforcement (sum of bars on both faces), would you be required to tie the reinforcement?

Would appreciate a clarity on whether the code intends vertical reinforcement more than 1% to be tied even if they are not used in compression calculations.

**Q.** Is there an aspect ratio at which a "column" becomes a "wall?" In designing a relatively tall axial compressive member, I am confused whether it would be appropriate to use the slenderness criteria for columns versus walls.

**A.** In ACI 318-02 (and previous versions), the design of walls as compression members is governed by the same requirements as columns. Let me give you a little background before pointing to the corresponding Code requirements.

In general, reinforced concrete design approaches can be divided into geometrical and behavioral. The former approach sets dimensional limits for both types of elements (walls and columns); the latter makes no distinction between them when the structural behavior is similar but introduces different requirements where no commonality is observed.

ACI 318 chose the behavioral approach. That is why the flexural design procedures, including the slenderness evaluation, are the same for walls and columns. Shear design procedures are different because the shear behavior of columns is more similar to that of beams, while in walls it varies for out-of-plane effects—similar to slabs—and in-plane effects where the depth-to-height ratio affects the behavior.

This is why there is a section especially for walls in Chapter 11 of ACI 318. Based on this, the ACI Code traditionally has made a distinction only when warranted. Therefore, as a rule, walls can be treated as columns for design purposes unless there is a specific requirement that introduces a difference for wall design, as mentioned for shear.

From the flexural design perspective, the main difference is in minimum allowable steel ratios for vertical reinforcement: 1% for columns and ratios as low as 0.12% for walls in certain circumstances; and the use of completely different reinforcement schemes for horizontal reinforcement: ties or spiral for columns and one-or-two layers of horizontal bars for walls. Therefore,

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the main difference—besides shear design—between columns and walls in ACI 318, rests with the reinforcement schemes and required reinforcement ratios.

One of the main functions of transverse reinforcement in columns is to inhibit the possibility of buckling of the vertical bar when subjected to high compression stresses due to the axial load and moment. In most wall design situations, the order of magnitude of the stresses is much lower, making the possibility of vertical bar buckling remote. Notwithstanding, ACI 318 draws a very definite line with respect to this possibility in Section 14.3.6:

**14.3.6—Vertical reinforcement need not be enclosed by lateral ties if vertical reinforcement area is not greater than 0.01 times gross concrete area, or where vertical reinforcement is not required as compression reinforcement.**

This section states the difference between a wall and a column. A wall with a reinforcement ratio greater than 1%, or having the possibility of compression yielding of the vertical reinforcement, must have ties as in a column.

The Code permits the use of an empirical design method (Section 14.5) for walls that are subjected to small moments about a horizontal axis parallel to the length of the wall (out-of-plane effects). The Code also includes an alternative design method for slender walls (Section 14.8) that is intended for precast wall panels (tilt-up).

Equation (10-7) in Section 10.12.2 gives a limit for ignoring the slenderness effects. It doesn't mean that you cannot design and build a compression member with a larger slenderness ratio if you follow the appropriate requirements of the Code. Section 10.11.5 sets a slenderness limit of 100 for the use of the Moment Magnifier method, but if the designer meets the requirements of 10.10.1, the use of a larger slenderness ratio is feasible, although probably unwise.

By limiting the thickness-to-height ratio, Section 14.5.3.1 essentially gives a maximum slenderness ratio for bearing walls designed by the empirical method. As mentioned before, however, the empirical design method is intended only for out-of-plane small moments that don't introduce tension stresses anywhere in the wall section. If you backtrack one section in the Code to Section 14.4, you will find that it refers to the same requirements as those for columns. Therefore, in reality, the slenderness ratio limits for walls and columns under ACI 318-02 are the same.

—Answer by Luis E. Garcia, Purdue University, West Lafayette, IN