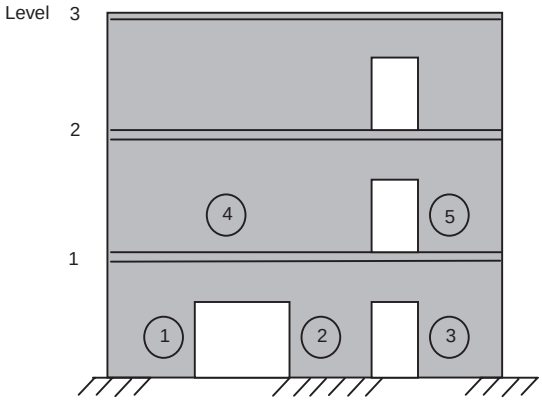
Design Example 22 Vertical Irregularity Type 5a/5b – Concrete Wall §12.3.2.2

PROBLEM STATEMENT

A concrete bearing-wall building has the shear wall configuration shown in Figure 22-1. All walls in this direction are identical, and the individual piers have the shear contribution given below. V_n is the nominal shear strength calculated in accordance with ACI 318.



PIER	V_n
1	20 kips
2	30
3	10
4	80
5	10

Figure 22-1.

DETERMINE THE FOLLOWING:

1. If a Type 5a or Type 5b vertical irregularity (discontinuity in lateral strength—weak-story) exists.

1. Determine if a Type 5a or Type 5b Vertical Irregularity Exists §12.3.2.2

A Type 5a weak-story discontinuity in capacity exists when the story strength is less than 80 percent of that in the story above. The story strength is the total strength of all seismic-force-resisting elements sharing the story shear for the direction under consideration. Since all the walls in this direction are identical, it is adequate to perform this analysis on just one of the walls.

Using the values of V_n given for each pier, the story strengths are

First-story strength = 20 + 30 + 10 = 60 kips

Second-story strength = 80 + 10 = 90 kips

Check if first-story strength is less than 80 percent of that of the second story.

60 kips < 0.8(90) = 72 kips

Therefore, a weak story condition exists.

Check if first-story strength is less than 65 percent of that of the second story (irregularity Type 5b).

60 kips < 0.65(90 kips) = 58.5 kips

60 kips > 58.5 kips

Therefore, the lower story is not an extreme weak story, irregularity Type 5b, but is a vertical irregularity Type 5a - weak story.

Commentary

This irregularity check is to detect any concentration of inelastic behavior in one supporting story that can lead to the loss of vertical load capacity. Elements subject to this check are the shear wall piers (where the shear contribution is the lower of either the shear at development of the flexural strength, or the shear strength), bracing members and their connections, and frame columns.

Frame columns with weak column-strong beam conditions have a shear contribution equal to that developed when the top and bottom of the column are at flexural capacity. Where there is a strong column-weak beam condition, the column shear resistance contribution should be the shear corresponding to the development of the adjoining beam yield hinges and the column base connection capacity. In any case, the column shear contribution shall not exceed the column shear capacity.

An extreme weak story is prohibited (under Section 12.3.3.2) for structures more than two stories or 30 feet in height unless the weak story is capable of resisting a total seismic force equal to Ω_0 times the design force prescribed in Section 12.8. Per Section 12.3.3.1, either weak-story condition is prohibited in SDC E and F. Vertical irregularity Type 5b is not permitted in structures assigned to SDC D.

It is assumed in this example that shear governs the strength of the wall and the system. If the walls had a taller aspect ratio and the walls became flexurally governed, then the walls' moment strengths should be used for checking this irregularity. In this case, both the 1.2D and 0.9D axial load cases should be considered.

In this example, the weak story could be mitigated by providing additional shear reinforcing in the first floor walls so long as the upper bound strength limits in ACI are not reached.