

STRUCTURAL WALL REINFORCEMENT DESIGN CONSIDERATIONS

Structural walls are frequently designed with out of plane loads and two curtain of reinforcement. spWall has an option for design of walls with two curtains of reinforcement as well as one curtain of reinforcement to accommodate various needed wall thicknesses.

For each plate element, the required areas of reinforcement A_{sx} and A_{sy} are computed based on the average moments per element and are output along with design forces and governing ultimate load combination. In both horizontal and vertical directions, the reported reinforcement is the total required area of steel per unit length. Half of the reported value applies to each curtain in models with two curtain layout.

If the area of vertical reinforcement required for a plate element is greater than one percent of the gross area of the concrete section (0.5 percent for CSA A23.3-04), the program indicates that ties are required for bars in compression. If the program reports that ties are required for a single curtain design, switching to two curtain design should be considered by the user.

The general considerations for design of wall elements in spWall are as follow:

- spWall calculates the required reinforcement only for the ultimate load combinations.
- For walls with two curtain of reinforcement, spWall considers contribution of both layers in calculation of required reinforcement.
- In cases where the load is not reversible from wind or seismic (i.e. only one layer of steel is subjected to maximum stress like in a retaining wall) the design may be conservative and the user can use a single layer option to optimize the design.
- The plate design criteria section of the inputs provides options for minimum and maximum reinforcement ratios (A_s/A_g) and location of reinforcement centroid with respect to the face of the wall for each curtain.
- One curtain is not permitted for wall thicker than 10 inches by default unless the box is checked to allow this condition (Chk-1) in cases where the user deems suitable.
- spWall permits the user to override the default code minimum reinforcement ratios for investigation of as built wall by invoking the check box for (Chk-2)

- spWall calculate the required reinforcement for all ultimate load combinations and reports the greatest value and the corresponding load combination. In the following example the required vertical reinforcement for element “1” is $1.46\text{in}^2/\text{ft}$ and the related load combination is “U1”.

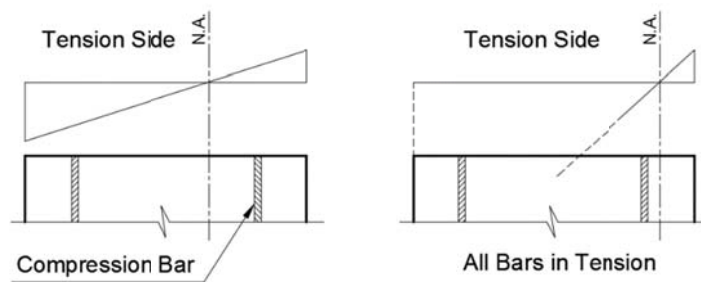
Total required area of steel (A_s): in^2/ft
 Bending moment (M_u): k-ft/ft, axial force (N_u): klf

Elem	Curtains	Direction	M_u (x/y)	N_u (x/y)	Ld_combo	A_s (x/y)	ro(%)	Tie
1	2	Horizontal	-6.4702e+000	-2.9779e+000	U1	2.45e-001	0.20	
		Vertical	-3.5001e+001	-2.6503e+001	U1	1.46e+000	1.22	

- In instances where the required area of vertical reinforcement for a plate element is greater than one percent (0.5 percent for CSA A23.3-04), spWall will examine the location of the neutral axis and indicates that ties are required for bars in compression by placing a star in the Tie column.

Elem	Curtains	Direction	Mu (x/y)	Nu (x/y)	Ld_combo	As (x/y)	ro(%)	Tie
1	2	Horizontal	-6.4702e+000	-2.9779e+000	U1	2.45e-001	0.20	
		Vertical	-3.5001e+001	-2.6503e+001	U1	1.46e+000	1.22	*

Note:
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* - Ties required for vertical reinforcement in compression



- The load combination which calls for “Ties required” flag is not necessarily the same load combination from which the greatest required reinforcement is reported.

Conclusions

spWall users who have designed walls with a total required area of steel greater than 1% of the gross area of the concrete section have to contend with the confinement requirements of ACI 318, 14.3.6. This provision indicates that “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”.

The proper consideration of this condition as provided by spWall is important to ensure the successful performance of compression reinforcement in the wall section.