EFFECTIVE AREA FOR MASONRY

M.A. Hatzinikolas
H. Morstead

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Introduction

The purpose of this technical note is to call attention to the variations in the load resisting areas of masonry. External loads applied to masonry result in two basic types of stresses, namely:

a) normal stresses

b) shearing stresses

Normal stresses basically result from vertical loads and/or bending moments. Shearing stresses are commonly the result of lateral loads.

The level of stress, either normal or shearing, is a function of the applied loads and the effective area. The effective area, in turn, is influenced by the type of construction and the type of masonry units used.

As a result of the testing procedures used in evaluating strength of masonry, the allowable stresses for plain masonry as given in Table 5 of the C.S.A. Standard S-304-1977 "Masonry Design and Construction for Buildings"

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are based on the net cross-sectional area for compressive stresses resulting from axial loads, and on the net section for all other types of stresses.

The allowable stresses (f_m) for reinforced masonry are given on Tables 6 and 7 of the above-mentioned document, and they are based on the net cross-sectional area.

The compressive strength (f_m') as given in the C.S.A. Standard S-304 "Masonry Design and Construction for Buildings", is based on the net cross-sectional area. The shear strength is based on the net section for plain masonry and the net cross-sectional area for reinforced masonry.

The two very important parameters in masonry design, - Net Cross-Sectional Area and Net Section, - are defined as follows:

- <u>Net cross-sectional area</u> -- Average net cross-sectional area of the masonry unit plus the grouted area.
- <u>Net section</u> -- Minimum cross-section of the member under consideration. Usually, the mortar bedded area plus the grouted area.

Effective Area for Axial Compressive Stress Calculations

This area considers the net cross-sectional area.

Figure a shows a partially grouted concrete masonry wall. The effective area (shaded) consists of the net section of the masonry units plus the grouted cores.

The Canadian Masonry Code[1] allows the use of the same net cross-sectional area for running bond and stack bond types of construction. (In running bond vertical joints are in alignment in every second course, whereas in stack bond the vertical joints are alignment in every course.) As a result the two walls shown schemati-cally in Figure 1 have the same effective area for resisting axial compressive stresses, although the net section for the two walls is not the same. (This aspect is examined in the following section.)

The effective area for walls consisting of two core concrete block units is given in Table 1. This area is to be used for evaluation of the allowable vertical load only. Note that this table is valid for running bond, stack bond, fully bedded or face shell bedding types of construction.

The values listed in Table 1 have been arrived at as follows:

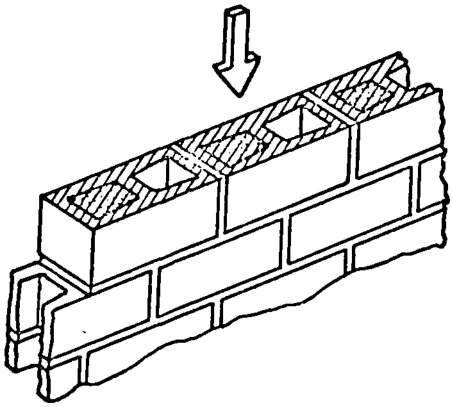
-- Consider the wall shown in Figure la and in particular the two full blocks shown on top of the wall. The wall is an 8 in. block grouted at 16 in. on centre. The net cross-sectional area of this wall portion is:

$$2(16.0 \times 2 \times 1.25) + 2(5.125 \times 1.25 \times 3)$$

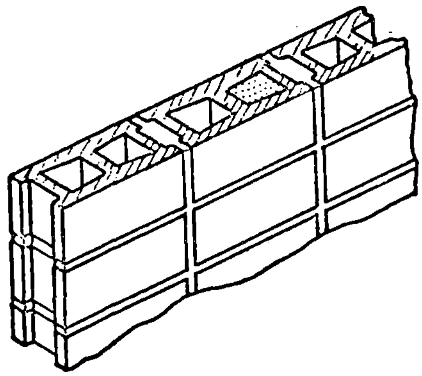
$$+ 2(5.125 \times 6.125) \simeq 185.6 \text{ in.}^2$$

TABLE 1 Effective Area for Resisting Axial Compressive Stresses

Nominal Wall Thickness		6 in.	8 in.	10 in.	12 in.
		Net Cross-Sectional Area in^2/in			
Solid Grouted		5.6	7.6	9.6	11.6
	16 in. O.C.	4.5	5.8	7.2	8.5
	24 in. O.C.	4.1	5.2	6.3	7.5
	32 in. O.C.	3.9	4.9	5.9	7.0
	40 in. O.C.	3.8	4.7	5.7	6.7
	48 in. O.C.	3.7	4.6	5.6	6.5
No Grout in Wall		3.4	4.0	4.8	5.5



(a) Effective area for compressive stress calculations in running bond type of construction.



(b) Effective area for compressive stress calculations in stack bond type of construction

FIGURE 1 Effective Area for Compressive Stress Calculations

The net cross-sectional area per inch of this wall is:

$$\frac{185.6 \text{ in.}^2}{32} = \frac{5.8 \text{ in.}^2}{\text{in.}}$$

In the above calculations the face shell and the web thicknesses of the masonry units were taken to be 1.25 in.

Effective Area for Flexural Stress Calculation

a) Plain Masonry

Flexural stresses are resisted by the net section, that is, by the mortar and the grouted cores (where applicable).

In the case of two core blocks this area is the face shell only if running bond type of construction is used. For stack bond the flexural stresses are resisted by the net cross-sectional area. This discrepancy arises because of the misalignment of the webs in running bond, whereas in stack bond the webs line up, thus increasing the area resisting bending stresses (stack bond fully bedded type of construction.) Plate 1 illustrates the concept of web misalignment.

b) Reinforced Walls

The flexural stresses in reinforced load bearing masonry are resisted by the net cross-sectional area.

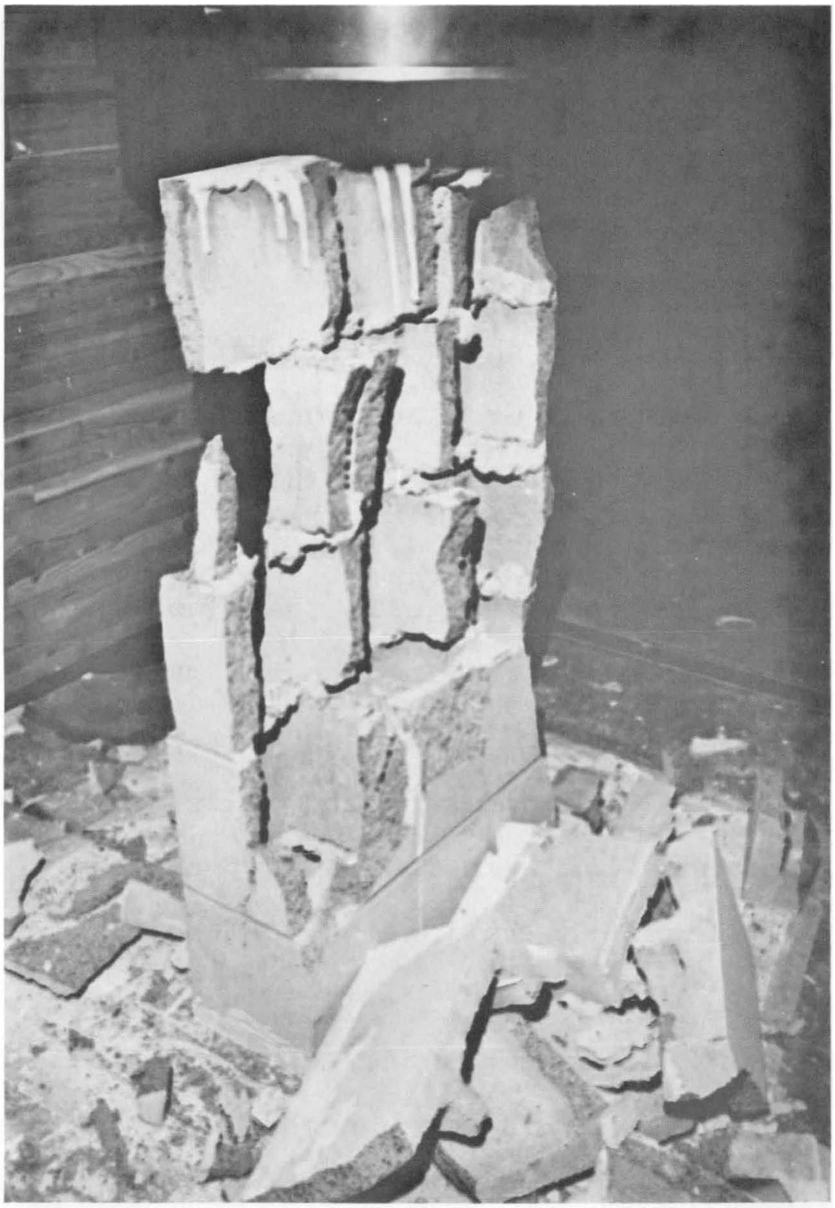


PLATE 1 Web Misalignment in Running Bond Construction

A designer who is conscious about "necking" in a, load path will instinctively regard this as a discrepancy and inconsistent to the design approach. In this case, however, the effect of .the "weak link" has, in the opinion of the writers, already been included in the conservative allowable stress values in C. S.A. - S-304.

For flexurai calculation, the following limitations are set by the Canadian Code.

Where a masonry shear wall intercepts a loadbearing masonry wall to form T or I sections the effective flange shall not exceed one-sixth of the total wall height above any cross-section of the wall, and its overhanging width, on either side of the shear wall shall not exceed six times the thickness of the intercepted wall. C.C.I.7.5 S-304[1], the ACI Standard "Building Code Requirements for Concrete Masonry Structures"[2] recommends that the total thickness of the flange in T or I sections, is to be taken as 1/6 times the wall height of the intersected wall.

Figure 2 illustrates the ACI recommendation for intercepting shear wails for a number of conditions.

For flexural calculation it should be noted that the tensile forces in reinforced masonry are resisted only by the tensile reinforcement, and that tensile stresses parallel to bed joints are not permitted in stack pattern masonry unless adequate reinforcement is provided.

(Articles 4.8.1.c and 4.s.1.2, C.S.A. S-304).

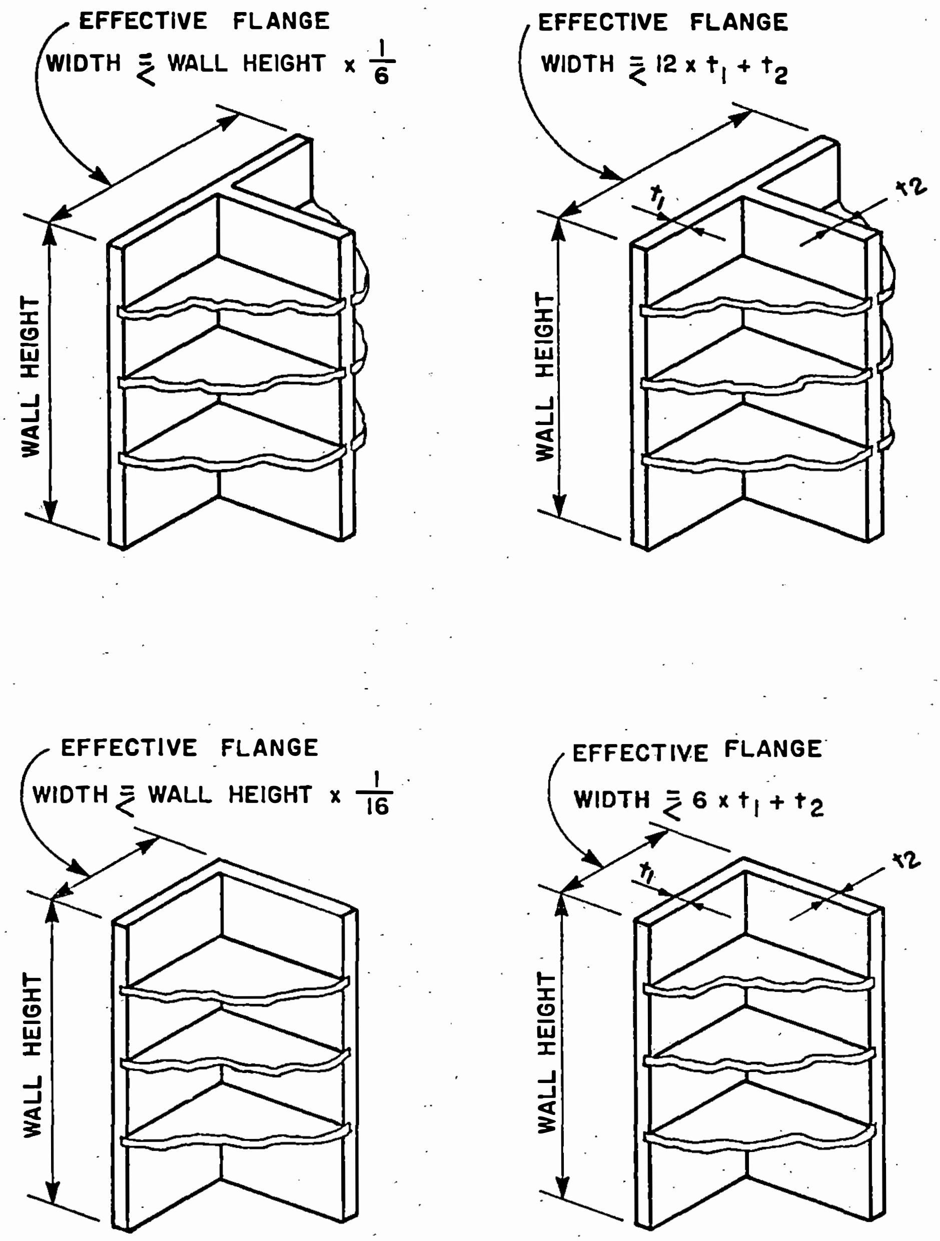


FIGURE 2 Intersecting Shear Walls

In computing flexural stresses in walls where reinforcement occurs, the effective width shall be not greater than four times the wall thickness (4.8.2.4 c.s.A. S-304-1977).

The Canadian Masonry Code does not differentiate between running bond and stack bond patterns in establish-ing the effective width.

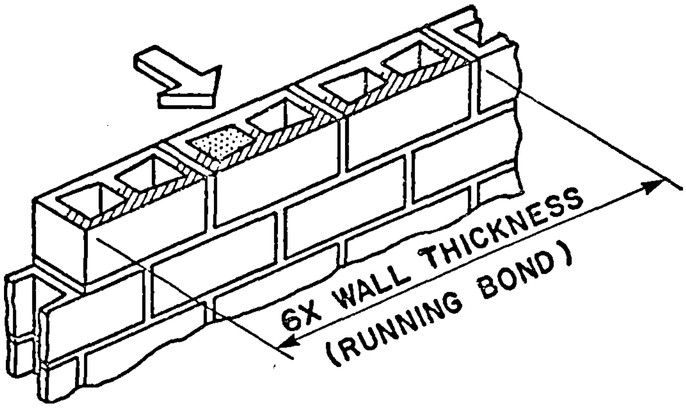
The ACI Code recommends the use of effective width equal to 6 times the wall thickness for running bond, and 3 times the wall thickness for stack bond. The value recommended by C.S.A. Standard S-304 - 1977 is within the two values suggested by ACI. Figure 3 illustrates the ACI recommendations.

Effective Area for Shear Stress Calculations

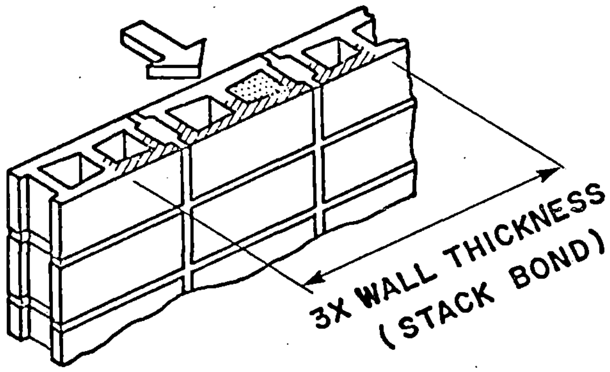
a) Plain Masonry

Shearing stresses in plain masonry are resisted by the net section, that is, by the mortar bedded area and the area of grouted cores. As a result the effective area is influenced by the type of construction. The effective area for shear calculation is given in Tables 2 and 3 for 6 in., 8 in., 10 in. and 12 in. two core concrete blocks.

Table 2 is applicable to running bond type of construction and Table 3 is applicable to stack bond construction and fully mortar bed types of construction.



(a) Effective area for flexural stress calculations in grouted core running bond masonry construction.



(b) Effective area for flexural stress calculations in grouted core stack bond masonry construction.

FIGURE 3 Effective Area for Flexural Stresses in Grouted Core Construction

TABLE 2 Net Section for Shear Calculations in Running Bond Type of Construction

(2 Core Concrete Block Units)

Nominal Wall Thickness		6 in.	8 in.	10 in.	12 in.
		Net Section $in.^2/in.$			
Solid Grouted		5.60	7.60	9.6	11.60
	16 in. O.C.	3.20	5.00	5.2	6.40
	24 in. O.C.	2.80	3.80	4.5	5.30
	32 in. O.C.	3.60	3.45	4.1	4.70
	40 in. O.C.	2.45	3.25	3.9	4.40
	48 in. O.C.	2.40	3.15	3.7	4.15
No Grout in Wall		2.0	2.5	3.0	3.0

TABLE 3 **Net Area for Shear Calculations, For Stack Bond Type of Construction (2 Core Concrete Block Units, Full Mortar Bedding)**

		Net Section in.^{2}/in.			
Nominal Wall Thickness		6 in.	8 in.	10 in.	12 in.
		Net Cross-Sectional Area in.^{2}/in.			
Solid Grouted		5.6	7.6	9.6	11.6
	16 in. O.C.	4.5	5.8	7.2	8.5
	24 in. O.C.	4.1	5.2	6.3	7.5
	32 in. O.C.	3.9	4.9	5.9	7.0
	40 in. O.C.	3.8	4.7	5.7	6.7
	48 in. O.C.	3.7	4.6	5.6	6.5
No Grout in Wall		3.4	4.0	4.8	5.5

It should be noted that for stack bond type of construction the effective area for shear calculations is the same as the effective area for axial stress calculations, that is, the net cross-sectional area. Note that there is no difference in effective areas for running and stack bond and face shell mortar bedding.

b) Reinforced Masonry

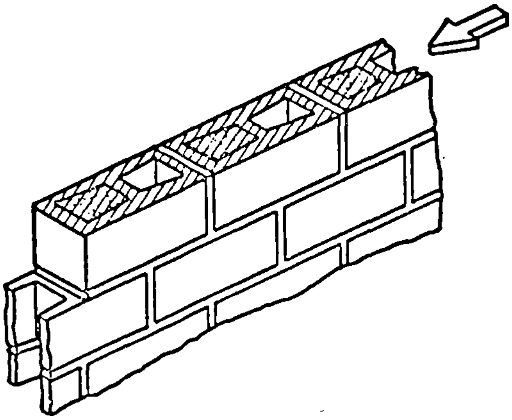
In calculating the shearing stresses for reinforced masonry structural elements, the resisting area according to C.S.A. S-304 "Masonry Design and Construction for Buildings" is the net cross-sectional area.

However, the maximum shearing stress is limited to 50 psi, (for shear walls of reinforced concrete block construction). If this value is exceeded the total shear shall be taken by the reinforcement and shall not exceed 150 psi for flexural member and 75 for shear walls.

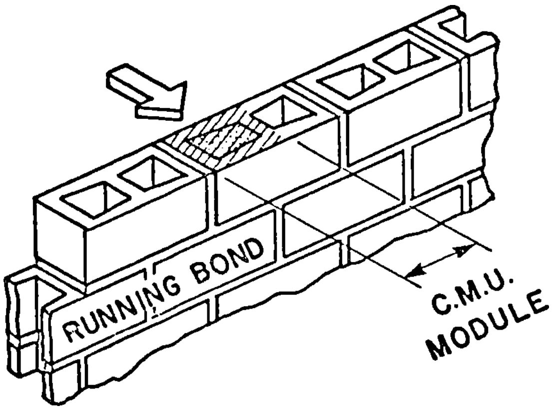
For shear calculations in reinforced shear walls the effective areas are the same as those given in Table 1.

It should be noted that only walls in the direction of the lateral force are effective in resisting the resulting shearing stresses.

In grouted core construction shear is resisted by the grouted core plus the surrounding mortared area and the cross webs. Figure 4 shows the effective area for shear stress in grouted core construction.



(a) Effective area for shear along the wall in grouted masonry. (ACI recommendation)



(b) Effective area for shear perpendicular to the wall in grouted masonry. (ACI recommendation)

FIGURE 4 Effective Area for Shear Calculations in Grouted Masonry

REFERENCES

1. C.S.A. Standard S-304-1977, "Masonry Design and Construction for Buildings", Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ontario, Canada, May 1977.

2. Building Code Requirements for Concrete Masonry Structures, Title No. 75-42 reported by ACI Committee S31, ACI Journal, August 1978.