

A 1.0 m strip of wall is analyzed (see Fig. 3-8) and the section effective in resisting bending is shown in Fig. 3-9,  $x-x$  being the axis of bending.

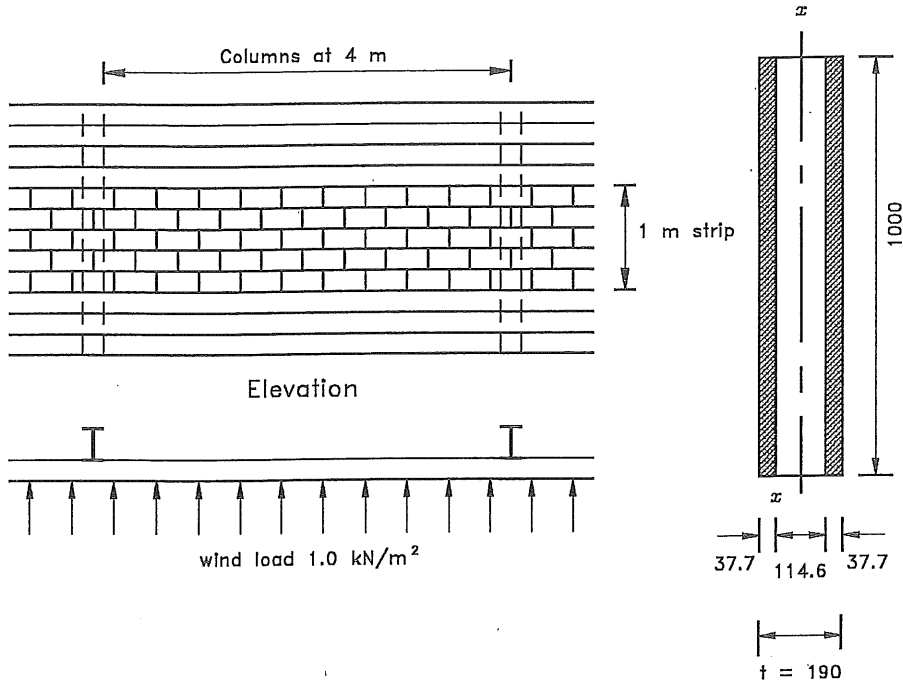


Fig. 3-8 Wall of Example 3-5

Fig. 3-9 Effective Section

For a 1.0 m strip

Recalling that the load factor  $\alpha_L = 1.5$  for wind, then the factored wind is

$$w_f = \alpha_L P = 1.5 \times 1.0 \text{ kN/m}^2 \times 1 \text{ m} = 1.5 \text{ kN/m};$$

span  $L = 4.0 \text{ m}$

Assuming simple spans, the moment is found as

$$M_x = \frac{w_f L^2}{8} = \frac{1.5(4.0)^2}{8} = 3.0 \text{ kN-m} = 3.0(10)^6 \text{ N-mm}$$

$$I_x = \frac{1000(190)^3}{12} - \frac{1000(114.6)^3}{12} = 446.2(10)^6 \text{ mm}^4$$

$$S_x = 2I_x/t = \frac{2(446.2)(10)^6}{190} = 4.70(10)^6 \text{ mm}^3$$

Therefore the bending stress is

$$f = M_x / S_x = \frac{3.0(10)^6}{4.70(10)^6} = 0.64 \text{ MPa} \quad \text{Ans.}$$

Note that since the wind can act in any direction, the wind stresses in the wall are  $= \pm 0.64 \text{ MPa}$ . From Table 6, S304.1, the limiting flexural tensile strength for this wall is  $f_t = 0.9 \text{ MPa}$  and the factored tensile strength is  $\phi_m f_t = 0.55(0.9) = 0.50 \text{ MPa}$ . Therefore the spacing of the columns should be reduced.

**EXAMPLE 3-6** The free-standing 200 mm concrete block wall shown in Fig. 3-10 is unreinforced and ungrouted. If Type S mortar has been used and if the mean mortar bed width for the block is 37.7 mm, what wind pressure  $p$ , in  $\text{kN/m}^2$ , will produce limiting tensile stresses in the wall: (a) neglecting the self weight of the wall, and (b) including the self weight of the wall?

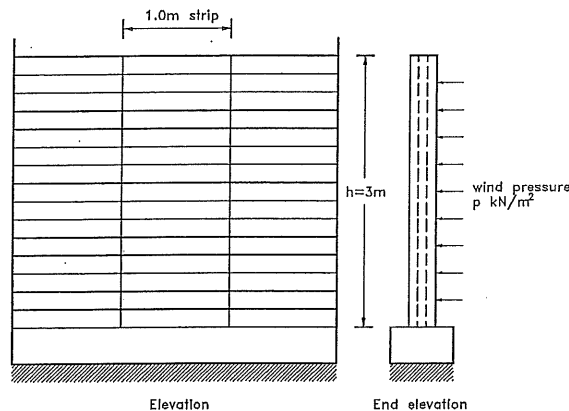


Fig.3-10 Wall analyzed in Example 3-6

- Note**
1. The Notes on Table 6 of S304.1 limits the tensile strength  $f_t$  for free-standing cantilever walls to 0.1 MPa.
  2. The unit weight of solid concrete masonry may be taken as  $21.0 \text{ kN/m}^3$  and the blocks may be assumed to be 50% solid.

Since the wall is acting as a vertical cantilever, tensile stresses produced by the wind will be normal to the bed joints. The limiting tensile stress is  $\phi_m f_t = 0.55(0.1) = 0.055 \text{ MPa}$ .

For a 1.0 m strip

The effective section will be the same as that shown in Fig. 3-9.

$$A_e = 2(37.7)(1000) = 75.4(10)^3 \text{ mm}^2$$

$$S_x = 4.70(10)^6 \text{ mm}^3 \text{ (from Example 3-5)}$$

The maximum moment occurs at the base of the wall and is

$$M_x = 1/2 \alpha_1 p h^2 = 1/2 (1.5) p (3)^2 = 6.75p \text{ kN-m}$$

where  $p$  = wind pressure in kN/m<sup>2</sup>

The flexural stress is found as

$$f = M_x / S_x = \frac{6.75(10)^6 p}{4.70(10)^6} = 1.436p \text{ MPa}$$

a) *Neglecting wall self weight:*

The tensile stress  $f_t$  should be less than 0.055 MPa, or

$$f_t = 1.436p \leq 0.055 \text{ MPa}$$

or

$$p = 0.038 \text{ kN/m}^2$$

Ans.

b) *Including wall self weight*

The self weight of a 1.0 m strip at the base of the wall, that is, at the critical section, is found as

$$P = \alpha_D [\text{unit weight}(\text{percent solid})(\text{thickness})(\text{height})]$$

Since the dead load resists overturning,  $\alpha_D = 0.85$

$$= 0.85(21.0)(0.5)(0.19)(3.0) = 5.09 \text{ kN} = 5.09(10)^3 \text{ N}$$

From Equation (3-5), considering tensile stresses as positive, the tensile stress is found as

$$f_t = -P/A_e + M_x/S_x \leq 0.055 \text{ MPa}$$

that is,

$$f_t = \frac{-5.09(10)^3}{75.4(10)^3} + 1.436p \leq 0.055 \text{ MPa}$$

Solution of this equation gives the maximum value of the wind pressure as

$$p_{(\max)} = 0.086 \text{ kN/m}^2$$

Ans.

Note that although the self weight of the wall enhances its resistance to wind load, the pressure it can safely sustain is not very great, a more likely value being  $1.0 \text{ kN/m}^2$ . In practice, the wall of Example 3-6 would be reinforced with vertical bars extending from the foundation.

### 3-4 FLEXURE OF SINGLY-REINFORCED SECTIONS

When the loading is such that flexural tensile stresses in masonry exceed their prescribed limit, or where shrinkage cracks or control joints eliminate any tensile resistance, the masonry should be reinforced.

If the limiting tensile stresses,  $f_t$ , for reinforced masonry were the same as those in unreinforced masonry, the corresponding tensile stresses in the reinforcement (being bonded to masonry) would be in the order of  $nf_t$ , or about  $20(0.50) = 10.0 \text{ MPa}$ . This would be an excessive penalty to impose upon a material with a yield stress of  $300 \text{ MPa}$  or more. In the interest of economy, reinforced masonry is allowed to crack so that the reinforcement is utilized efficiently. This, of course, is consistent with practice in reinforced concrete design.

Reinforcement can be used to enhance the flexural resistance of a wall, such as that shown in Fig. 3-6, through the provision of vertical bars in grouted cores, as shown in Figs. 1-2 and 1-4, or to span openings, as shown in Fig. 1-3. Furthermore, if the span and the loading are considerable, the beam can be more than one course in depth, as shown in Fig. 3-11.

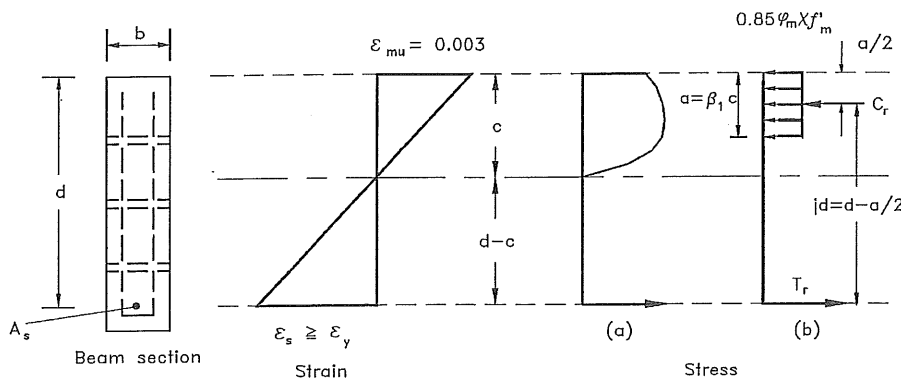


Fig. 3-11 Masonry Beam Reinforced for Tension Only

The bottom course of multi-course beams is constructed from lintel or bond beam units (see Fig. 2-4) in which the longitudinal bars are placed, and subsequent