Vertical design shear stress $v_h = VA_1\bar{y}/Ib_r$

V = design shear force = γ_f x characteristic shear force

$A_1 = B_d \times t_f$ and $\bar{y} = d/2 + t_f/2$

Then, $v_h = V \times B_d \times t_f(d/2 + t_f/2)/Ib_r \leqslant f_v/\gamma_{mv}$

Generally, $t_f = b_r$

Therefore $v_h = V \times B_d(d/2 + t_f/2)/I$

Now let $K_1 = B_d(d/2 + t_f/2)/I$ = shear stress coefficient

Then $v_h = VK_1$

Values of K_1 may be calculated for all diaphragm wall profiles and some are given in Tables 1 and 2.

Example:

For the concrete blockwork diaphragm wall reference A considered in Section 2.3:

$K_1 = 0.9/0.0053\ (0.235/2 + 0.10/2)$
$= 28.39\ \mathrm{m}^{-2}$

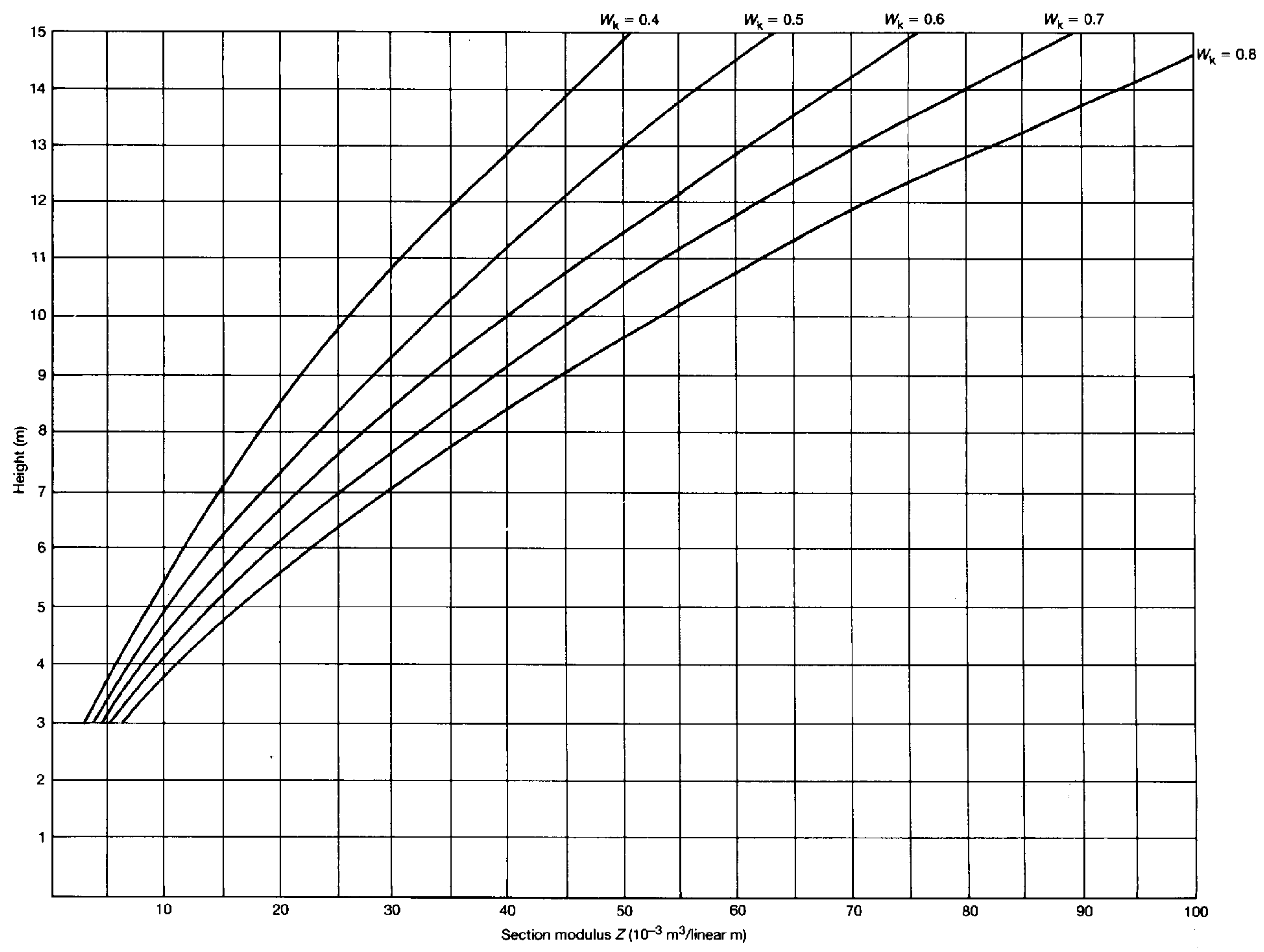
2.5 Vertical loading only

2.5.1 Slenderness ratio

Whilst in most cases of single-storey structures vertical loading is not critical, it is nevertheless advisable to follow where possible the recommendations of BS 5628 on this aspect. Thus it is necessary to assess the slenderness ratio of such walls, and to check that it does not exceed 27.

2.5.2 Effective height

There are difficulties in determining the effective height of diaphragm walls. If a wall is considered as a propped cantilever, it would be reasonable to suggest that the effective height is 0.875 times the actual height. Under the action of wind pressure on the wall and suction on the roof, however, the restraining action of the prop could be reduced and the effective height could be greater than this figure. The assessment of the effective height must therefore be judged by the designer for each individual case.



Note: this trial section graph is based on the loading combination of dead plus wind for which the partial safety factors on loads are taken as 0.9 and 1.4 respectively

Figure 29: Graph to determine Z

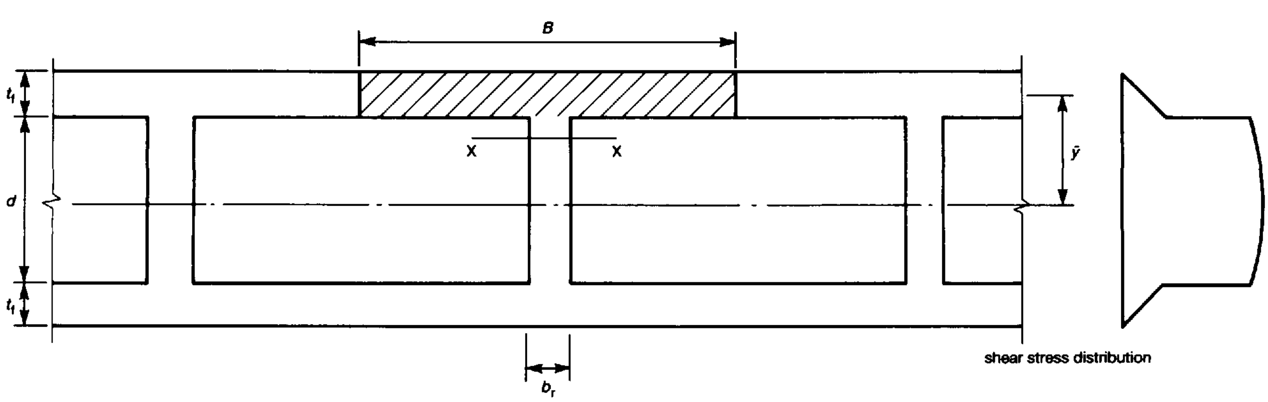


Figure 30: Shear stress at junction of cross-rib and flange

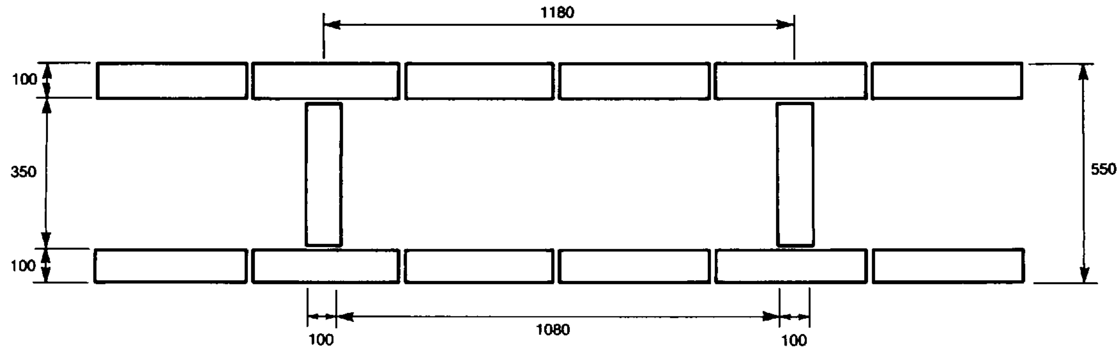


Figure 31: Dimensions used to compare slenderness ratios of a diaphragm wall and a solid wall

2.5.3 Effective thickness

BS 5628 : Part 1 does not provide a satisfactory means of determining the effective thickness of diaphragm walls. It might be considered that the effective thickness should be assessed as two-thirds of the sum of the thicknesses of the two leaves, i.e. the same as a normal cavity wall. This, however, does not take account of the composite box action of the section. In most structural codes slenderness ratio is related to radius of gyration, but in BS 5628 : Part 1 slenderness ratio is defined as the ratio of effective height to effective thickness. This is because this code takes account of only plane solid and cavity walls and the radius of gyration of such walls is directly proportional to their thickness. For geometric walls, such as the diaphragm, this is clearly not the case and it would be preferable if the radius of gyration were to be used for all walls.

For the purposes of this design guide the effective thickness of a diaphragm wall is taken to be the overall thickness. This gives a conservative design solution as explained in the following:

Consider the diaphragm shown in Figure 31 in which the overall thickness is 550 mm, $I = 12.5 \times 10^{-3}$ m^4 and $A = 0.271$ m^2.

Radius of gyration $\sqrt{I/A} = \sqrt{12.5 \times 10^{-3}/0.271}$
$= 0.215$ m

Now consider a solid wall of unit length

$I = 1 \times t^3/12$

$A = 1 \times t$

Radius of gyration $= \sqrt{I/A} = \sqrt{t^3/12t} = t/3.46$

Thus, for the same radius of gyration, the solid wall requires a thickness of

$t = 0.215 \times 3.46$
$= 744$ mm

Hence the diaphragm wall has considerable inbuilt stiffness since 550 mm overall thickness of diaphragm wall has an equivalent slenderness ratio (l/r) to a solid wall of 744 mm thickness, and the rule 'effective thickness of diaphragm wall equals overall thickness' is seen to be on the conservative side.

2.5.4 Eccentricity of vertical loading

The eccentricity of the vertical loading depends upon the means of application of the load.

The majority of diaphragm walls are capped by reinforced concrete ring beams, to which the roofs are bolted. If the roofs were not to deflect, there would be zero slope of the roof members at their connection to the capping beam. Such a theoretical condition does not arise, for the roofs will deflect, even under their self weight. There is then a slope of the roof members at the support, resulting in the roof/wall contact being eccentric. In the extreme case, the contact could be close to the inner face of the inner leaf (Figure 32).