4 General principles of limit-state design for masonry walls and columns

4.1 Loadings

This *Manual* adopts limit-state principles and the partial factor format of BS5628-1[1]. The loads to be used in calculations are therefore:

(a) characteristic dead load, G_k: the weight of the structure complete with finishes, fixtures and fixed partitions (BS648[30] and BS6399-1[31])

(b) characteristic imposed load, Q_k: (BS6399-1 and -3[32] and the appropriate Building Regulations[33])

(c) characteristic wind load, W_k: (BS6399-2[34])

(d) at the ultimate limit state the building should be capable of resisting a uniformly distributed horizontal load equal to:
- 1.5% of the total characteristic dead load above any level (refer to 5.3.1)

(e) for the design of structural members affording horizontal or vertical lateral support to the masonry elements, including the elements transmitting this force to the members providing stability to the whole structure, the sum of:
- the simple static reaction arising from the total design horizontal forces applied at the lateral support, and
- 2.5% of the total vertical design load, applied as a horizontal force at the lateral support.

The horizontal force produced by (d) should be distributed between the strongpoints providing overall lateral stability, according to their stiffnesses. The strongpoints do not need to be designed to resist the horizontal force produced by (e).

The design loads are obtained by multiplying the characteristic loads by the appropriate partial safety factor, γ_f, from Table 8. The 'adverse' and 'beneficial' factors should be used so as to produce the most onerous condition.

Table 8 Partial safety factors for loads, γ_f (Excluding accidental damage)

Load combination	Load type				
	dead G_k		imposed Q_k		wind W_k
	adverse	beneficial	adverse	beneficial	
1. Dead and imposed	1.4	0.9	1.6	0	–
2. Dead and wind	1.4	0.9	–	–	1.4[a]
3. Dead, wind and imposed	1.2	–	1.2	–	1.2

Note

a For infill panels subject to lateral wind loading only, a factor of 1.2 may be used where removal of the wall will in no way affect the stability of the remaining structure.

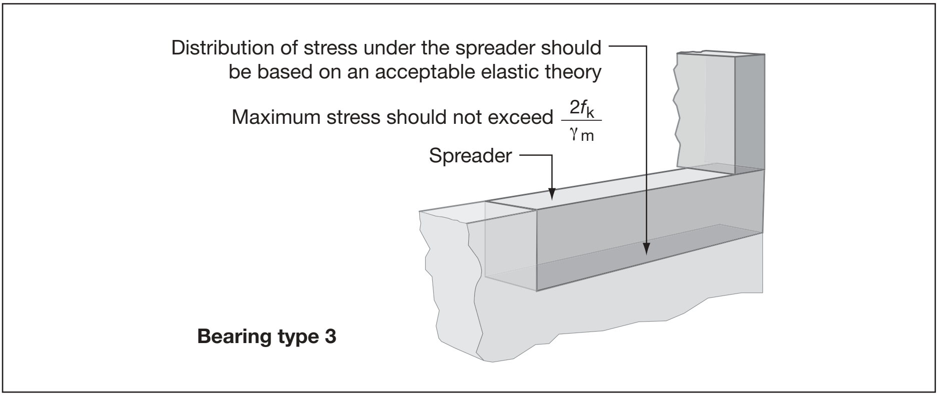
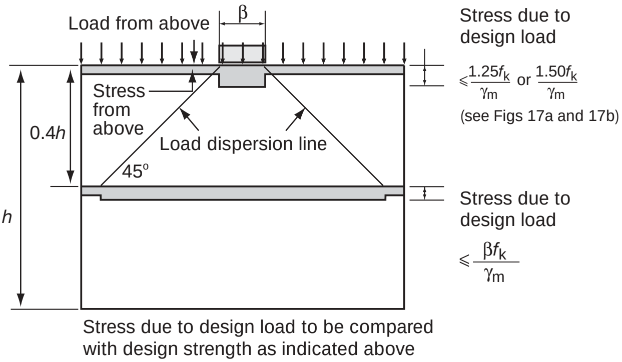


Fig. 17c Concentrated loads: bearing type 3

a Load distribution for bearing types 1 and 2



b Load distribution for bearing type 3

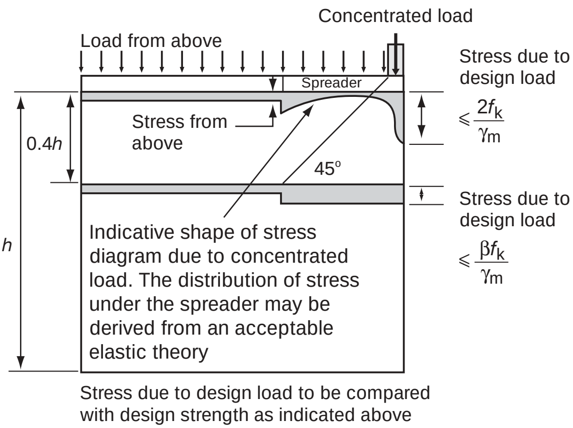


Fig. 18 Concentrated loads: load distribution

5 Design of loadbearing masonry

5.1 Load combinations

Load combinations for masonry design, excluding accidental damage, are given in Table 8. Strongpoints, if constructed from masonry, need to be checked for all three load combinations. Other elements should be checked for either load combinations 1 or 2. Usually masonry elements supporting large vertical loads (e.g. walls in the lower storeys of a multistorey building) need to be checked for load combination 1 only. For masonry elements supporting small vertical loads, load combination 2 will usually be critical (e.g. walls in the top storey of a multistorey building, or walls in a single storey building).

5.2 Design procedure

The normal design procedure for loadbearing masonry is:

(a) consider overall stability and check that strongpoints are sufficient to resist horizontal loading and that floors and roof can act as horizontal diaphragms to transfer lateral loads into strongpoints
(b) consider robustness (see section 2.7)
(c) determine minimum requirements of unit quality and mortar strength for durability (see chapter 3)
(d) determine requirements for minimum thicknesses of members for fire (see section 3.5)
(e) check the architect's requirements for such matters as thermal value, sound transmission, aesthetics, durability, dpcs and partitions
(f) select worst-case loading situations for design (e.g. most heavily loaded; minimum vertical load and maximum lateral wind load; wind uplift possibly inducing tension), checking that points of lateral support and any anchorages assumed in the calculations can be achieved in practice, together with the effects of any dpcs (particularly narrow piers between windows), services perforations and joints.
(g) make calculations
(h) prepare details and specifications, and include provision for movement both of walling elements and of the overall building.

5.3 Walls and piers subject to vertical load

The design of vertical loadbearing masonry is based on consideration of slenderness and buckling. The end restraint conditions of the masonry elements are therefore important.

5.3.1 Lateral supports

A lateral support may be provided along either a horizontal or a vertical line, depending on whether the slenderness ratio is based on a vertical or horizontal dimension.

Horizontal or vertical supports

Vertical lateral supports, (e.g. buttressing walls) and horizontal lateral supports (e.g. floors or roofs acting as horizontal girders) should be capable of transmitting, to those elements of construction that provide lateral stability to the structure as a whole (termed 'strongpoints'), the sum of the following design lateral forces:

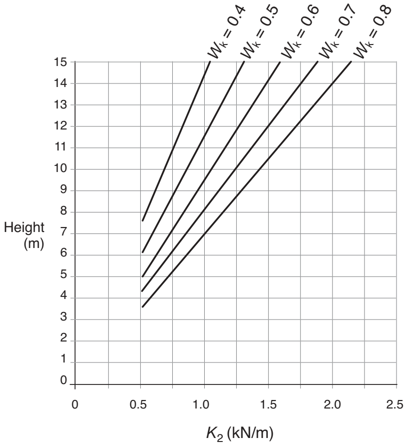


Fig. 30 Diaphragm wall trial section: condition (i)

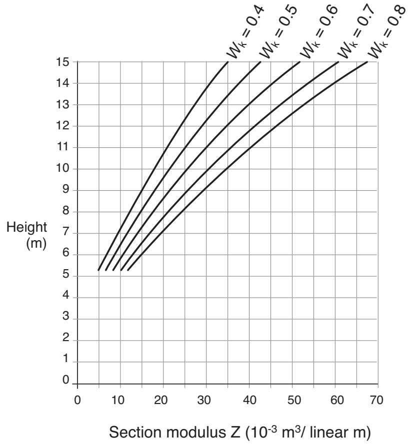


Fig. 31 Diaphragm wall trial section: condition (ii)

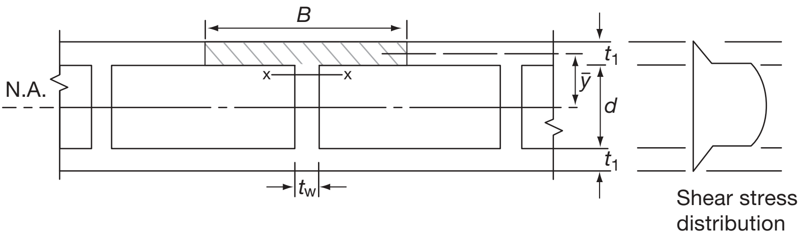


Fig. 32 Diaphragm wall - shear analysis

The vertical shear resistance at the interface of the cross-rib and flange is provided either by the bonded masonry for which characteristic shear strengths are given in subsection 4.3.3 or by metal shear connectors, the size and spacing of which should be calculated:

$$ru = \frac{12 t_w S_v}{0.87\ f_y}$$

where

- r is the width of connector
- u is the thickness of connector
- t_w is the width of masonry section in vertical shear
- S is the vertical spacing of connectors
- v is the design vertical shear stress on masonry section (as calculated above)
- f_y is the characteristic tensile strength of connector