AD 535: Horizontal lateral loading on internal load-bearing walls in residential buildings

There are two sources of horizontal lateral loading on internal walls in residential buildings that should be considered in their design. These are loads caused by:

- Building occupants (e.g. crowd loads)
- Differential internal air pressure.

These loads should be considered as a leading or accompanying variable actions in combinations determined in accordance with BS EN 1990[1] e.g. using expression 6.10 or expressions 6.10a and 6.10b.

Horizontal loads caused by building occupants

Values of horizontal loads acting on internal walls due to building occupants are defined in Table NA.8 of the UK National Annex to BS EN 1991-1-1:2002[2]. These values should be used in place of those given in Table 6.12 of BS EN 1991-1-1:2002[3]. The loads are specified for categories and sub-categories of loaded areas based on their specific use. Some examples are given in Table 1.

Category	Specific use	Sub-category	Description	Characteristic load (q_k)
A	Areas for domestic and residential activities	(i)	All areas within or serving exclusively one dwelling including stairs, landings etc.	0.36 kN/m
		(ii)	Residential areas not covered by (i).	0.74 kN/m

Table 1: Examples of horizontal loads on internal walls due to building occupants
Note: For full definitions and descriptions see Table NA.8 of the UK National Annex to BS EN 1991-1-1:2002.

The characteristic horizontal load acting on walls (q_k) should be applied as a line load at a height of 1.20 m above the floor level.

BSi published document PD 6688-1-1:2011[4] specifies values for uniformly distributed and concentrated loads applicable to infills for walls and parapets in Table 2. These are specifically for the infill panels within a wall or parapet acting as a barrier (e.g. glass panel) and should not be used for the design of the primary elements of the wall or parapet. The loads given in Table NA.8 of the UK National Annex to BS EN 1991-1-1:2002 and those given in Table 2 of PD 6688-1-1:2011 are not additive and should be considered as three separate load cases.

Horizontal loads caused by differential internal air pressures

Horizontal loads caused by differential internal air pressures lead to a bending moment on the walls that act in combination with the applied vertical loads. Additional moments due to eccentricity of vertical loads from unequal floor spans or unequal loading should also be considered in the design.

Guidance given in SCI publication P394[5] states that for multi-storey buildings the internal wind pressure coefficient (c_{pi}) is "commonly taken as the more onerous of +0.2 and −0.3". This approach is adopted on the basis that the probability of a dominant opening occurring during a severe storm is considered negligible. Adopting the more onerous case for c_{pi} of +0.2 and −0.3 in adjoining compartments results in an overall pressure coefficient for the internal walls of 0.5.

Clause 2.6.1.2 and Table 16 of the now withdrawn BS 6399-2[6] state that for buildings in which the four façade walls are equally permeable, the internal pressure coefficient may be taken as -0.3. It is also states that the maximum net pressure across internal walls should be taken as 0.5.

Modern residential buildings are designed with high levels of airtightness for effective thermal insulation and therefore their external walls are relatively impermeable. Internal separating or compartment walls in multi-occupancy residential type buildings are also likely to be of low permeability which can lead to significant differences in pressures on either side of these walls.

The value of c_{pi} can be estimated by iterative calculation of balancing the inward and outward flow through the various faces, as described in Section 6.2.1 of P394 and Appendix C of SCI-P286. The flow balance is sensitive to the relative permeability of walls and therefore to variations in build quality. Designers may therefore judge it prudent to use values +0.2 and −0.3 and an overall pressure coefficient 0.5 in preference to a more refined calculation. Further guidance on pressures on internal walls and an example of the iterative airflow calculation is provided in BRE Digest 346 Part 8[7].

SCI has conducted a limited number of airflow calculations for a building with a regular arrangement of units positioned either side of a central corridor. Calculations were conducted for various wall permeabilities and the resulting overall pressure coefficients varied from zero to 0.5 depending on the wall permeabilities used. Wall permeabilities based on guidance given in References [8] and [9] were used.

The balance of airflow does not occur instantly. The size effect factor C_a of the standard method in BS 6399-2 accounts for the non-simultaneous action of gusts across an external surface and for the response of internal pressures. As suggested in Reference 8, the size effect factor C_a may be used to account for the response time of the balance of airflow and reduce the resultant internal pressures. Values of the size effect factor are given in Figure 4 of BS 6399-2 and are dependent on the site exposure and the diagonal dimension a. For exposure category B and a diagonal dimension a of 40 m, the size effect factor is 0.85.

Using load combinations given in BS EN 1990 expression 6.10 or expressions 6.10a and 6.10b requires variable actions to be assigned as leading or accompanying.

When the imposed floor loading is taken as the leading variable action and the internal wind pressure is taken as the accompanying variable action, there is an additional factor ($\psi_{0,i}$) of 0.5 to be applied to the wind as the accompanying variable action. When the internal wind pressure is taken as the leading variable action there is no additional partial factor to be applied to the wind.

In many cases, for loadbearing light steel frame walls in multi-storey buildings the critical design case will be when imposed floor loading is taken as the leading variable action and the internal wind pressure is taken as the accompanying variable action.

In the absence of a detailed airflow calculation, it is recommended that an overall pressure coefficient of 0.5 is used for the internal loadbearing walls of residential buildings. The factors discussed above can be used to reduce the design actions of the internal wind pressure.

For double leaf light steel framed walls, the lateral loading due to differential air pressures on either side of the wall can be assumed to be resisted equally by each leaf of the wall.

For internal walls within a dwelling it is not necessary to carry out airflow calculations to determine the air pressure on each side of the wall as there will be significant air leakage between rooms due to gaps around doors and in many cases doors being open.

Large windows or doors (which would be classified as dominant openings) being open during high winds should be treated as an accidental load combination which has lower partial factors applied to the loads.

Contact: **Andrew Way**
Telephone: **01344 636555**
Email: **advisory@steel-sci.com**

[1] BS EN 1990. *Eurocode - Basis of structural design*. BSI, 2010.
[2] BS EN 1991-1-1:2002 UK NA. *UK National Annex to Eurocode 1. Actions on structures - General actions. Densities, self-weight, imposed loads for buildings*. BSI, 2019.
[3] BS EN 1991-1-1:2002. *Eurocode 1. Actions on structures - General actions. Densities, self-weight, imposed loads for buildings*. BSI, 2002
[4] PD 6688-1-1:2011. *Recommendations for the design of structures to BS EN 1991-1-1*. BSI, 2011.
[5] SCI P394 - *Wind actions to BS EN 1991-1-4*. SCI, 2014.
[6] BS 6399-2:1997. *Loading for buildings - Code of practice for wind loads*. BSI, 2010.
[7] BRE Digest 346 Part 8. *The assessment of wind loads. Part 8: internal pressures*. BRE, 1990.
[8] *Wind loading: a practical guide to BS 6399-2*. N. Cook. Thomas Telford, 1999
[9] BS EN 1991-1-4:2005+A1:2010 UK NA. *UK National Annex to Eurocode 1. Actions on structures - General actions - Wind actions*. BSI, 2008.