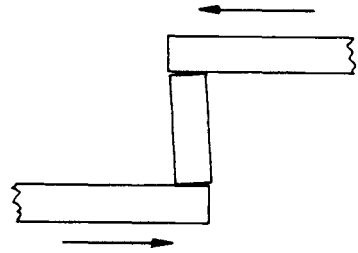
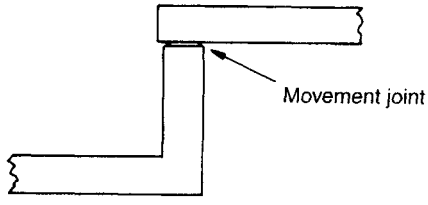
compressible sealant and their spacing will depend on the masonry material. An upper limit of 15 m is appropriate in clay brickwork, 9 m in calcium silicate brickwork and 6 m in concrete blockwork. Their width in millimetres should be about 30% more than their spacing in metres. Location in the building will depend on features of the building such as intersecting walls and openings. It should be noted that the type of mortar used has an important influence on the ability of masonry to accommodate movement: thus a stone masonry wall in weak lime mortar can be of very great length without showing signs of cracking. Brickwork built in strong cement mortar, on the other hand, will have a very much lower tolerance of movement and the provision of movement joints will be essential.

Certain details, such as short returns (Fig. 13.1) are particularly vulnerable to damage by moisture and thermal expansion. Similar damage can result from shrinkage in calcium silicate brickwork or concrete blockwork. Parapet walls are exposed to potentially extreme variations of temperature and moisture and their design for movement therefore requires special care. A considerable amount of guidance on these points is provided in BS 5628: Part 3.



(a) Cracking at a short return due to masonry expansion



(b) Cracking avoided by insertion of a movement joint

Fig. 13.1 Cracking at a short return in brick masonry.

13.4 VERTICAL MOVEMENTS IN MASONRY WALLS

Vertical movements in masonry are of the same order as horizontal movements but stress-related movements in multi-storey walls will be of greater significance. Vertical movements are of primary importance in the design of cavity walls and masonry cladding to reinforced concrete or steel-framed buildings. This is because the outer leaf of masonry will generally have different characteristics to those of the inner leaf or structure and will be subjected to different environmental conditions. This will result in differential movements between the outer leaf and the inner wall which could lead to loosening of wall ties or fixtures between them or in certain circumstances to serious damage to the masonry cladding.

To avoid problems from this cause, BS 5628: Part 1 states that the outer leaf of an external cavity wall should be supported at intervals of not more than three storeys or 9m (12m in a four-storey building). Alternatively, the relative movement between the inner wall and the outer leaf may be calculated and suitable ties and details provided to allow such movement to take place.

The approximate calculation of vertical movements in a multi-storey, non-loadbearing masonry wall may be illustrated by the following example, using hypothetical values of masonry properties. Height of wall=24m. Number of storeys=8.

- *Moisture movements.* Irreversible shrinkage of masonry, 0.00525%. Shrinkage in height of wall, 0.0000525×24×10=1.26mm. Reversible moisture movement from dry to saturated state, ±0.04%. Moisture movement taking place depends on moisture content at time of construction. Assuming 50% saturation at this stage reversible movement may be

$$0.5\times0.0004\times24\times10^{3}=+4.8\text{mm}.$$

Table 13.2 Elastic and creep deformations

Storey	*Average stress* (kN/m^2)	*Strain* ($\times 10^{-6}$)	*Compression in storey* (mm)	*Cumulative compression* (mm)	*Creep compression* (mm)
8	56.1	26.7	0.08	5.12	7.68
7	168.4	80.2	0.24	5.04	7.56
6	280.7	133.7	0.40	4.80	7.20
5	393.0	187.1	0.56	4.40	6.60
4	505.3	240.6	0.72	3.84	5.76
3	617.5	294.0	0.88	3.12	4.68
2	729.8	347.5	1.04	2.24	3.36
1	842.2	401.0	1.20	1.20	1.8