moisture content at all stages of their existence. Typical values are shown in Table 13.1.

13.2.2 Thermal movements

Thermal movements depend on the coefficient of expansion of the material and the range of temperature experienced by the building element. Values of the coefficient of expansion are indicated in Table 13.1 but estimation of the temperature range is complicated depending as it does on other thermal properties such as absorptivity and capacity and incident solar radiation. The temperature range experienced in a heavy exterior wall in the UK has been given as -20 °C to +65°C but there are likely to be wide variations according to colour, orientation and other factors.

13.2.3 Strains resulting from applied loads

Elastic and creep movements resulting from load application may be a factor in high-rise buildings if there is a possibility of (differential movement between a concrete or steel frame and masonry cladding or infill. Relevant values of elastic modulus and creep coefficients are quoted in Chapter 4.

13.2.4 Foundation movements

Foundation movements are a common cause of cracking in masonry walls and are most often experienced in buildings constructed on clay soils which are affected by volume changes consequent on fluctuation in soil moisture content. Soil settlement on infilled sites and as a result of mining operations is also a cause of damage to masonry walls in certain areas. Where such problems are foreseen at the design stage suitable

Table 13.1 Moisture and thermal movement indices for masonry materials, concrete and steel

Material	*Reversible moisture movement* (%)	*Irreversible moisture movement* (%)	*Coefficient of thermal expansion* ($10^{-6}/°C$)
Clay brickwork	0.02	+ 0.02–0.07	4–8
Calcium silicate brickwork	0.01–0.05	– 0.01–0.04	8–14
Concrete brick- or blockwork	0.02–0.04	– 0.02–0.06	7–14
Aerated, autoclaved blockwork	0.02–0.03	– 0.05–0.09	8
Dense aggregate concrete	0.02–0.10	– 0.03–0.08	10–14
Steel	–	–	12

precautions can be taken in relation to the design of the foundations, the most elementary of which is to ensure that the foundation level is at least 1m below the ground surface. More elaborate measures are of course required to cope with weak soils or mining subsidence.

13.2.5 Chemical reactions in materials

Masonry materials are generally very stable and chemical attack in service is exceptional. However, trouble can be experienced as the result of sulphate attack on mortar and on concrete blocks and from the corrosion of wall ties or other steel components embedded in the masonry.

Sulphate solution attacks a constituent of cement in mortar or concrete resulting in its expansion and disintegration of the masonry. The soluble salts may originate in ground water or in clay bricks but attack will only occur if the masonry is continuously wet. The necessary precaution lies in the selection of masonry materials, or if ground water is the problem, in the use of a sulphate-resistant cement below damp-proof course level.

13.3 HORIZONTAL MOVEMENTS IN MASONRY WALLS

Masonry in a building will rarely be free to expand or contract without restraint but, as a first step towards appreciating the magnitude of movements resulting from moisture and thermal effects, it is possible to deduce from the values given in Table 13.1 the theoretical maximum change in length of a wall under assumed thermal and moisture variations. Thus the maximum moisture movement in clay brick masonry could be an expansion of 1mm in 1m. The thermal expansion under a temperature rise of 45°C could be 0.3mm so that the maximum combined expansion would be 1.3 mm per metre. Aerated concrete blockwork on the other hand shrinks by up to 1.2 mm per metre and has about the same coefficient of thermal expansion as clay masonry so that maximum movement would be associated with a fall in temperature.

Walls are not, in practical situations, free to expand or contract without restraint but these figures serve to indicate that the potential movements are quite large. If movement is suppressed, very large forces can be set up, sufficient to cause cracking or even more serious damage. Provision for horizontal movement is made by the selection of suitable materials, the subdivision of long lengths of wall by vertical movement joints and by the avoidance of details which restrain movement and give rise to cracking.

The spacing of vertical movement joints is decided on the basis of empirical rules rather than by calculation. Such joints are filled with a