failure to occur:

$$R^* - S^* \leqslant 0 \tag{1.1}$$

where $R^* = R_k / \gamma_m$ is the design strength of the structure, and $S^* = f(\gamma_f Q_k)$ the design loading effects. Here γ_m and γ_f are *partial safety factors;* R_k and Q_k are *characteristic values* of resistance and load actions, generally chosen such that 95% of samples representing R_k will exceed this value and 95% of the applied forces will be less than Q_k.

The probability of failure is then:

$$\mathrm{P}\,[R^* - S^* \leqslant 0] = p \tag{1.2}$$

If a value of p, say 10^{-6}, is prescribed it is possible to calculate values of the partial safety factors, γ_m and γ_f, in the limit state equation which would be consistent with this probability of failure. In order to do this, however, it is necessary to define the load effects and structural resistance in statistical terms, which in practice is rarely possible. The partial safety factors, therefore, cannot be calculated in a precise way and have to be determined on the basis of construction experience and laboratory testing against a background of statistical theory. The application of the limit state approach as exemplified by the British Code of Practice BS 5628 and Eurocode 6 (EC 6) is discussed in Chapter 4.

1.4 FOUNDATIONS

Building structures in loadbearing masonry are characteristically stiff in the vertical direction and have a limited tolerance for differential movement of foundations. Studies of existing buildings have suggested that the maximum relative deflection (i.e. the ratio of deflection to the length of the deflected part) in the walls of multi-storeyed loadbearing brickwork buildings should not exceed 0.0003 in sand or hard clay and 0.0004 in soft clay. These figures apply to walls whose length exceeds three times their height. It has also been suggested that the maximum average settlement of a brickwork building should not exceed 150 mm. These figures are, however, purely indicative, and a great deal depends on the rate of settlement as well as on the characteristics of the masonry. Settlement calculations by normal soil mechanics techniques will indicate whether these limits are likely to be exceeded. Where problems have arisen, the cause has usually been associated with particular types of clay soils which are subject to excessive shrinkage in periods of dry weather. In these soils the foundations should be at a depth of not less than 1 m in order to avoid moisture fluctuations.

High-rise masonry buildings are usually built on a reinforced concrete raft of about 600mm thickness. The wall system stiffens the raft and helps to ensure uniform ground pressures, whilst the limitation on floor spans which applies to such structures has the effect of minimizing the amount of reinforcement required in the foundation slab. Under exceptionally good soil conditions it may be possible to use spread footings, whilst very unfavourable conditions may necessitate piling with ground beams.

1.5 REINFORCED AND PRESTRESSED MASONRY

The preceding paragraphs in this chapter have been concerned with the use of unreinforced masonry. As masonry has relatively low strength in tension, this imposes certain restrictions on its field of application. Concrete is, of course, also a brittle material but this limitation is overcome by the introduction of reinforcing steel or by prestressing. The corresponding use of these techniques in masonry construction is not new but, until recently, has not been widely adopted. This was partly due to the absence of a satisfactory code of practice, but such codes are now available so that more extensive use of reinforced and prestressed masonry may be expected in future.

By the adoption of reinforced or prestressed construction the scope of masonry can be considerably extended. An example is the use of prestressed masonry walls of cellular or fin construction for sports halls and similar buildings where the requirement is for walls some 10 m in height supporting a long span roof. Other examples include the use of easily constructed, reinforced masonry retaining walls and the reinforcement of laterally loaded walls to resist wind or seismic forces.

In appropriate cases, reinforced masonry will have the advantage over concrete construction of eliminating expensive shuttering and of producing exposed walls of attractive appearance without additional expense.

Reinforcement can be introduced in masonry elements in several ways. The most obvious is by placing bars in the bed joints or collar joints, but the diameter of bars which can be used in this way is limited. A second possibility is to form pockets in the masonry by suitable bonding patterns or by using specially shaped units. The steel is embedded in these pockets either in mortar or in small aggregate concrete (referred to in the USA as 'grout'). The third method, suitable for walls or beams, is to place the steel in the cavity formed by two leaves (or wythes) of brickwork which is subsequently filled with small aggregate concrete. This is known as grouted cavity construction. Elements built in this way can be used either to resist in-plane loading, as beams or shear walls, or as walls under lateral loading. In seismic situations it is possible to bond grouted cavity walls to floor slabs to give continuity to the structure. Finally, reinforcement can be accommodated in hollow block