# 3

# Masonry properties

## 3.1 GENERAL

Structural design in masonry requires a clear understanding of the behaviour of the composite unit-mortar material under various stress conditions. Primarily, masonry walls are vertical loadbearing elements in which resistance to compressive stress is the predominating factor in design. However, walls are frequently required to resist horizontal shear forces or lateral pressure from wind and therefore the strength of masonry in shear and in tension must also be considered.

Current values for the design strength of masonry have been derived on an empirical basis from tests on piers, walls and small specimens. Whilst this has resulted in safe designs, it gives very little insight into the behaviour of the material under stress so that more detailed discussion on masonry strength is required.

## 3.2 COMPRESSIVE STRENGTH

### 3.2.1 Factors affecting compressive strength

The factors set out in Table 3.1 are of importance in determining the compressive strength of masonry.

**Table 3.1** Factors affecting masonry strength

| *Unit characteristics* | *Mortar characteristics* | *Masonry* |
|---|---|---|
| Strength | Strength: | Bond |
| Type and geometry: | mix | Direction of stressing |
| solid | water/cement ratio | Local stress raisers |
| perforated | water retentivity | |
| hollow | Deformation characteristics | |
| height/thickness ratio | relative to unit | |
| absorption characteristics | | |

### 3.2.2 Unit/mortar/masonry strength relationship

A number of important points have been derived from compression tests on masonry and associated standard tests on materials. These include, first, that masonry loaded in uniform compression will fail either by the development of tension cracks parallel to the axis of loading or by a kind of shear failure along certain lines of weakness, the mode of failure depending on whether the mortar is weak or strong relative to the units. Secondly, it is observed that the strength of masonry in compression is smaller than the nominal compressive strength of the units as given by a standard compressive test. On the other hand, the masonry strength may greatly exceed the cube crushing strength of the mortar used in it. Finally, it has been shown that the compressive strength of masonry varies roughly as the square root of the nominal unit crushing strength and as the third or fourth root of the mortar cube strength.

From these observations it may be inferred that:

1. The secondary tensile stresses which cause the splitting type of failure result from the restrained deformation of the mortar in the bed joints of the masonry.
2. The apparent crushing strength of the unit in a standard test is not a direct measure of the strength of the unit in the masonry, since the mode of failure is different in the two situations.
3. Mortar withstands higher compressive stresses in a brickwork bed joint because of the lateral restraint on its deformation from the unit.

Various theories for the compressive strength of masonry have been proposed based on equation of the lateral strains in the unit and mortar at their interface and an assumed limiting tensile strain in the unit. Other theories have been based on measurement of biaxial and triaxial strength tests on materials. But in both approaches the difficulties of determining the necessary materials properties have precluded their practical use, and for design purposes reliance continues to be placed on empirical relationships between unit, mortar and masonry strengths. Such relationships are illustrated in Fig. 3.1 and are incorporated in codes of practice, as set out in Chapter 4 for BS 5628 and Eurocode 6.

### 3.2.3 Some effects of unit characteristics

The apparent strength of a unit of given material increases with decrease in height because of the restraining effect of the testing machine platens on the lateral deformation of the unit. Also, in masonry the units have to resist the tensile forces resulting from restraint of the lateral strains in the mortar. Thus for given materials and joint thickness, the greater the height of the unit the greater the resistance to these forces and the greater