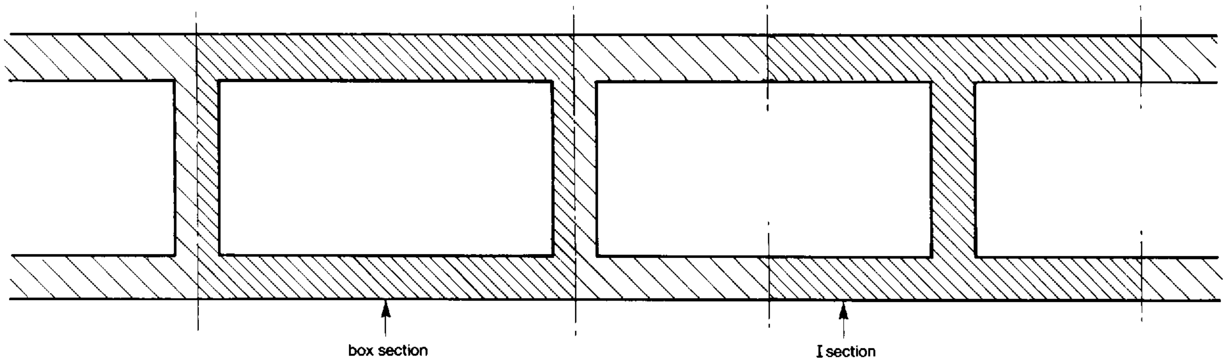

Figure 1: Box sections and I sections formed by diaphragm walls

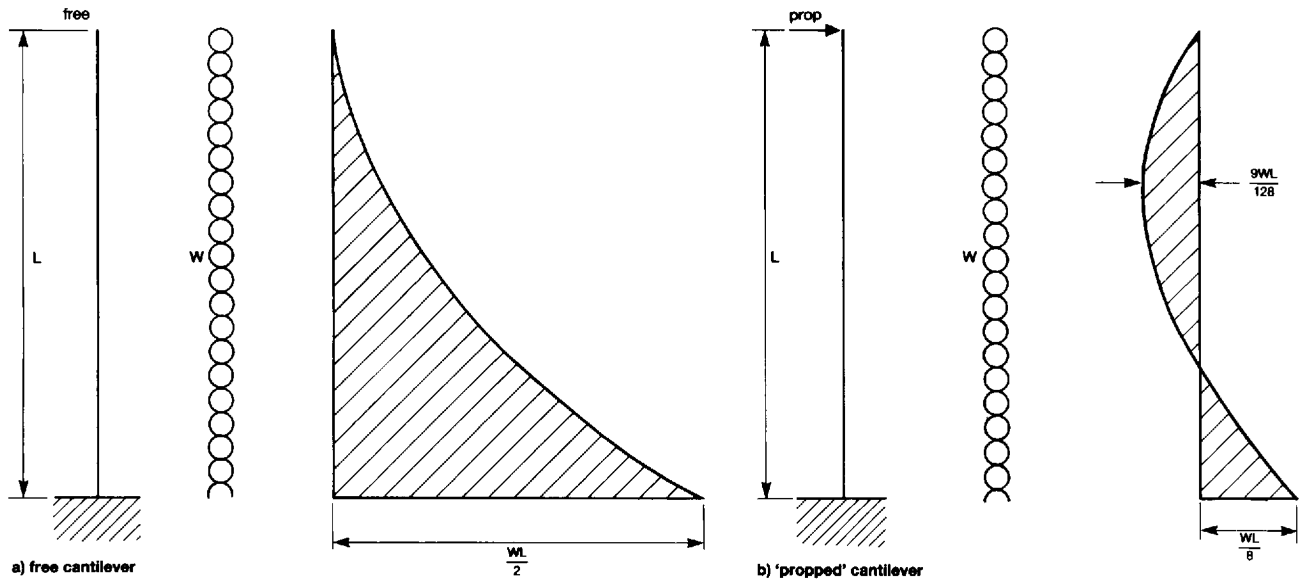

Figure 2: Bending moment diagrams for free cantilever and propped cantilever diaphragm walls

bending stresses, and are stiffened by the cross-ribs which act as webs to resist the shear forces. The distance between flanges is designed to suit the individual requirements of each project, taking account of unit size and bonding, and should be kept to a minimum to save on space and cost. The spacing of cross-ribs is determined from a number of factors including the need for the flange to span horizontally between them. The spacing and thickness of the cross-ribs are also subject to shear resistance requirements.

1.2.2 Wall/roof interaction

The concrete masonry is in this context no longer mere cladding to steel columns but part of the structure. It must resist both lateral load from the wind and vertical load from the roof. The vertical load is unlikely to be significant since both the self weight (of lightweight roofs) and the superimposed loads are generally low. The critical load in the case of tall single-storey buildings is usually the lateral load due to wind. The wall can act as a vertical free cantilever or as a propped cantilever as shown in Figure 2. The bending moment at the base of the propped cantilever is shown to be only a quarter of that for a free cantilever. In order to obtain the maximum economy in the overall cost of the structure, the roof of a diaphragm wall structure should be used, wherever possible, to prop or tie the tops of the walls. The resulting horizontal reactions can be transferred through the roof structure to the gable or other transverse walls which then act as shear walls in resisting these forces.

Often the decking material itself, if suitably stiff and fixed, can be used as a plate in conjunction with the main roof beams. But where this is not the case, a horizontal wind girder may be formed utilizing the concrete capping beam as described below. The insertion of light diagonal bracing between the capping beam and perhaps a purlin acting as the other boom is often all that is necessary.

The roof deck can be of a variety of materials and supported in many ways. Depending on the spans involved, the most economic roof may be steel beams or girders spaced at centres to suit the most economical arrangement. On very long spans, a steel space deck may prove to be economic in providing the necessary support and can be designed to act as a plate to transfer the propping loads to the transverse walls. Timber decking on glued laminated timber beams has also been used in which the decking has proved adequate in providing the horizontal plate to prop the top of the wall.

Precast, prestressed concrete purlins supporting woodwool decking may be economic but this type of roof is likely to require a secondary bracing system to provide the horizontal plate action.

A reinforced concrete capping beam can be used at the

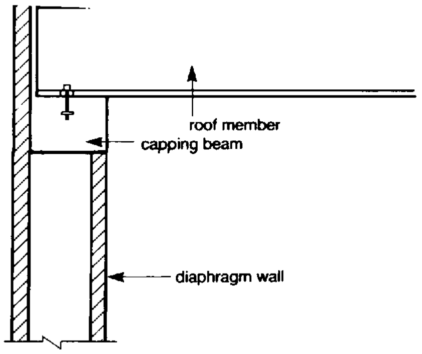

Figure 3: Capping beam to transmit horizontal forces from the wall to the roof in the propped cantilever system

top of the diaphragm wall to transfer the propping forces into the roof deck. It can also serve as a counterweight to overcome uplift forces from wind suction acting on lightweight decking and the same capping beam may also be used as the boom member of the roof plate.

The capping beam may be constructed either in in situ concrete or by precasting the beam in bay lengths, using suitable connections to transfer the forces at the joints. The design of these beams should provide for the horizontal forces which must be transferred from the wall to the roof structure, but this is outside the scope of this guide. The precast beams may be cast and supplied by the block manufacturer and can be used as the seating and fixing for the roof structure, as shown in Figure 3. Generally the more successful and popular method of construction is that of precasting. This overcomes the problem of keeping the facing masonry clean, avoids possible formwork difficulties and reduces the on-site construction time. If in situ beams are used the shuttering can be retrieved by leaving one of the wall leaves down a couple of courses and building up later. Alternatively, permanent formwork can be used.

1.2.3 Appearance and bonding

The wall/roof junction of the building can be treated in a variety of ways, for example as illustrated in Figure 3. It is also unnecessary for the diaphragm wall to be designed with flat faces on each side, for example a fluted arrangement can be neatly incorporated in the structure as shown in Figure 4. The treatment of the face of the wall and its junction with the roof gives scope for a wide variety of interesting external and internal elevations.

It is possible to use either bonded joints, between the cross-ribs and leaves, or butt joints, with designed shear ties. The choice is often governed by cost and appearance.

In concrete masonry diaphragm walls there are a number of points to consider which will generally result in the cross-ribs being tied rather than bonded, e.g:

(a) effect of bonding on the rate of construction;

(b) different sized units such as a concrete brick external leaf and a concrete block internal leaf;

(c) rain and damp penetration which, if the external face is not to be rendered, may require a vertical damp-proof course at the junction of the cross-rib and the leaf (see Section 1.3.1);

(d) differing materials used for internal and external leaves resulting in varying degrees of shrinkage movement or even opposing movements (see below).

An architect may wish to design the building using clay bricks externally and concrete blocks internally. This method of construction should generally be avoided as concrete products tend to shrink and clay products tend to expand with time, causing increased stresses at the interface of the two materials. If combinations of such dissimilar materials cannot be avoided, shear-tied joints should always be used.

1.2.4 Acoustic and thermal properties

Statutory requirements for sound insulation rarely apply to diaphragm wall buildings. There can be occasions where it is desirable to use the walls as a sound barrier and whilst no actual tests have been carried out, experience has shown that diaphragm walls perform well.

Low strength concrete masonry can provide an inherently high level of thermal insulation. However, where this is not adequate, it is a simple matter to improve its performance by fixing insulation boards or quilts to the void face of the inner leaf as shown in Figure 5.

Alternatively, the designer may choose to omit the insulation from within the wall and to 'trade off' against an improved insulation within the roof space. This is a commonly employed design technique within the scope and requirements of the current Building Regulations, Part FF3. Research carried out by the Building Research Establishment confirmed that the dew point will normally occur within the cross-ribs or voids and that condensation or pattern-staining on the inner leaf is very unlikely to occur. This view concurs with observations of

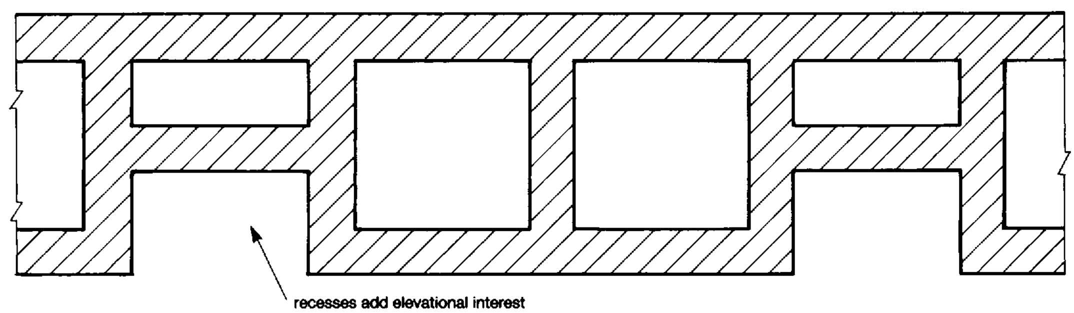

Figure 4: Fluted arrangement to provide visual effect