the actual performance of various buildings over the last 15 years.

1.2.5 Moisture penetration

The possibility of moisture being transmitted to the inside face of the wall depends on a number of factors including the workmanship and the physical characteristics of the concrete masonry units. One overriding factor appears to be the width of the wall between flanges. Moisture which penetrates into the cross-rib can dry out before it reaches the inner leaf provided there is adequate ventilation within the voids and the width of the wall is sufficient to allow this process to take place. Furthermore, the function of some buildings is such that occasional penetration can be tolerated.

In many cases when the diaphragm wall forms the external envelope of a building, the overall thickness of the wall will be sufficient to prevent moisture penetration. However, in some severe exposure areas and/or when the possibility of damp penetration to the inner face is particularly critical it is recommended that a vertical damp-proof membrane be provided at the junction of the cross-rib with the external flange. Alternatively, the external face may be rendered. In very severe exposure areas both these measures may be required.

Retaining walls are a special case where moisture penetration is either not critical or is overcome, for example, by providing a damp-proof membrane covering the inner or outer wall surface.

1.2.6 Movement joints

Movement joints are required at the appropriate centres, in accordance with the normal recommendations for concrete masonry given in CP 121 and manufacturers' technical publications. Joints to accommodate shrinkage movement of the concrete masonry are usually necessary and may be achieved by providing double cross-ribs, one either side of each joint, as in Figure 6.

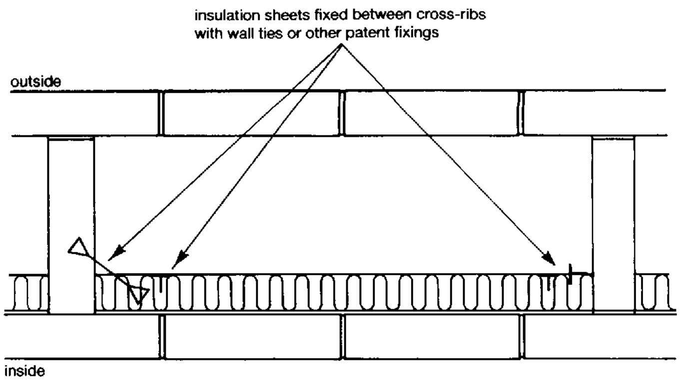

Figure 5: Improved thermal insulation using quilts or insulation boards fixed to the inner leaf

Such joints should also be provided near to a corner to allow the wall at this location to hinge at the base. It is not usually necessary for the joints in the masonry to extend through the concrete capping beam, if provided.

1.2.7 Openings in walls

Large openings for access, windows, service entries, etc., can create high local loading conditions from both horizontal wind loading and increased axial loads at lintel bearings. The opening can be accommodated by providing a beam or lintel to carry the vertical load and by using extra or thicker cross-ribs on each side of the openings to carry the increased lateral load, as in Figure 7. Double cross-ribs are preferred at openings through which vehicles are likely to pass; the outer cross-rib is often considered to be non-structural, using the inner cross-rib for the lintel support. Vertical damp-proof membranes should be provided at external openings in diaphragm walls. The use of lintel blocks or bond beam blocks, commonly available from numerous concrete block manufacturers, to span openings in diaphragm walls, may be considered. Bed-joint reinforcement may be included around wall openings to minimize the effects of shrinkage and thermal movement.

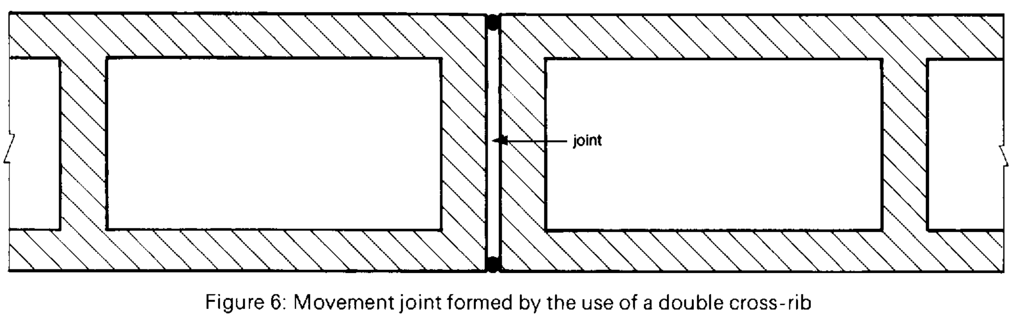

Figure 6: Movement joint formed by the use of a double cross-rib

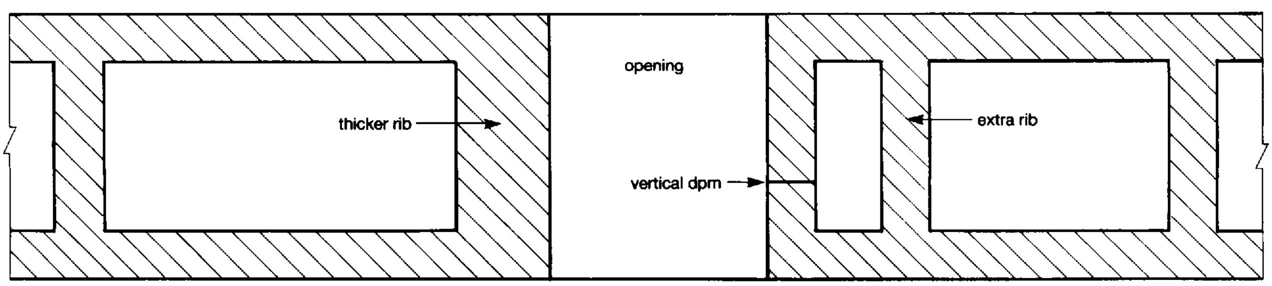

Figure 7: Arrangement of cross-ribs at an opening in a diaphragm wall

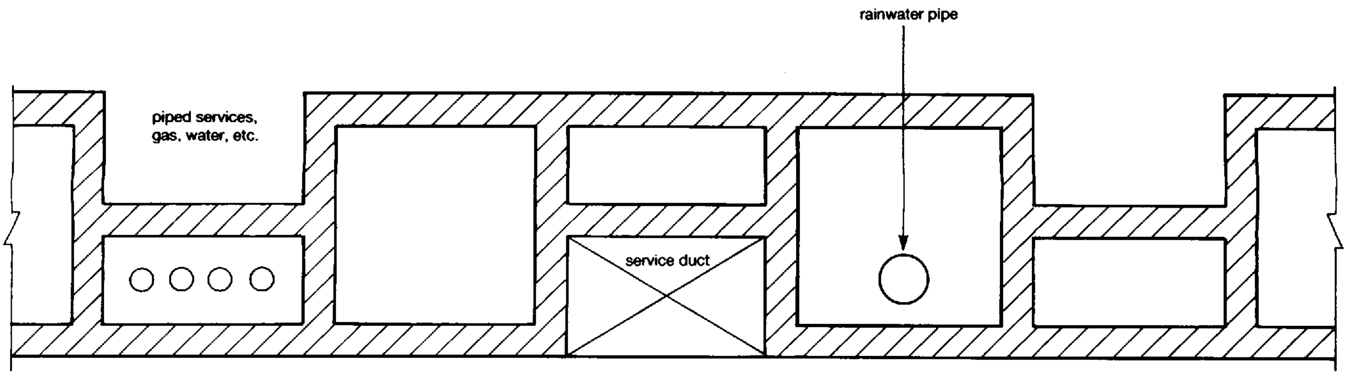

Figure 8: Provision for service ducts

1.2.8 Services

The large vertical voids within diaphragm walls are useful to accommodate certain services. The size and location of access openings may cause high local stressing in the concrete masonry and these must be considered in the design. Service ducts can be positioned within the voids as shown in Figure 8. Such ducts should, of course, be ventilated when housing gas pipes.

1.2.9 Foundations

The load from a wall in a tall single-storey building is transferred to the foundations as a uniformly distributed load combined with the applied bending moment and not as a point load as is the case with framed construction. Thus the ground contact pressures are sufficiently low for a normal concrete strip footing to be adequate (see Figure 9). This must, of course, be checked by considering the relevant soil properties. The designer should include in the foundation design a check on the effect of the applied moment at the base of the diaphragm wall. The calculation of the magnitude of this moment is discussed later in this design guide and in the worked examples.

1.3 Construction

1.3.1 Damp-proof courses and membranes

Horizontal damp-proof courses should be chosen which give the necessary shear resistance to prevent sliding and which do not squeeze out under load. In situations where vertical damp-proof membranes between leaf and cross-ribs are considered necessary, an unbonded diaphragm wall construction should be used. It is essential that the vertical damp-proof membrane does not prevent or inhibit the tying of the cross-ribs to the leaves. In practice, brush-applied types of damp-proof membrane and metal shear ties have proved to be a successful combination. Fully-filled, flush mortar joints are necessary for the effective application of a brush-applied damp-proof membrane treatment. The durability of the shear ties should be consistent with the design life of the structure.

Vertical damp-proof membranes should, as stated earlier, be provided at door and window openings and it is recommended that a double cross-rib be provided to accommodate this, as in Figure 7.

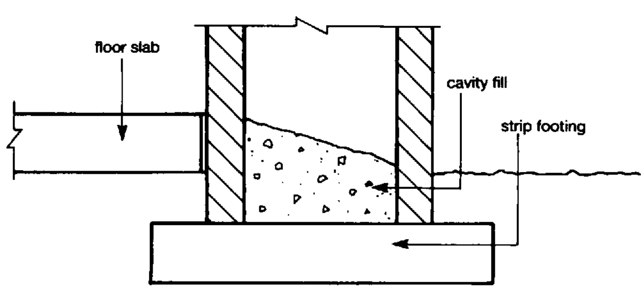

Figure 9: Concrete strip footings are normally adequate for diaphragm walls

1.3.2 Temporary propping

The diaphragm wall, like most other walls, is often in its most critical state during construction, before the roof has been constructed and fixed, particularly if the design is based on roof propping action. The contractor must take the usual precautions for temporary restraint such as the use of scaffolding to prop the walls to ensure that they remain stable, or by other means. Better workmanship is achieved by working from scaffolding on both sides of the diaphragm wall rather than working overhand from one side. The double scaffold system is usually all that is necessary to provide adequate temporary propping to the walls, but this should be checked by structural calculation.

1.3.3 Void cleaning

It is equally important in diaphragm wall construction, as in conventional cavity work, to maintain high standards of workmanship to ensure satisfactory performance of the wall. The voids should be clean, but elaborate cleaning out methods are not usually necessary with diaphragm wall construction owing to the larger voids employed.

1.4 Economics

Economy is generally the most cogent reason for adopting any particular building method. In the authors' experience this has always been the prime factor for adopting the diaphragm wall method of construction. Considerable evidence has shown that, for the more sophisticated type of structure, such as sports halls, theatres and swimming pools, the diaphragm wall is the most economic.

Recently, for basic industrial structures, this building method has provided the most cost-effective solutions. Experience has shown that diaphragm wall projects can produce a considerable saving of time, both in the pre-contract period and during the on-site construction. This is largely because the design, estimating and