4.10.2 BASIS OF DESIGN OF COMPRESSION MEMBERS

When the ratio of the effective length to the least lateral dimension is less than 15, the design of prestressed concrete compression members should conform with the requirements that the computed stresses in the concrete and in the steel should not exceed the permissible stresses given in Clause 4.2 for normal combinations of loading during transfer, handling and construction and under working loads.

When a compression member is subjected to a combination of axial loading and bending due to dead and live loads and the stress in the concrete due to axial loading is less than 25% of the maximum stress in the concrete due to bending under this loading, then the permissible compressive stress in the concrete may be taken as that given for bending in Clause 4.2.2(1). When the ratio of stress due to axial loading to maximum stress due to bending is greater than 1/4, the permissible compressive stress in the concrete should be that given for direct compression in Clause 4.2.2(1).

Computation of the stresses in the materials should be based on the assumptions given in Clause 4.9.3.

When the ratio of the effective length of the least lateral dimension is greater than 15, the stability of the compression member should be considered. For guidance, the reduction coefficients for the permissible loads on long columns given in Section 3 may be used.

No recommendations are made for the calculation of the ultimate strength of compression members, but the disposition of the tendons and of any additional steel reinforcement should be favourable to the development of an adequate margin of security against failure.

4.10.3 REINFORCEMENT IN COMPRESSION MEMBERS

The provision of reinforcement in compression members should, in general, conform with the recommendations given for beams in Clause 4.9.7. In addition where a compression member has longitudinal reinforcement, it should also have transverse or helical reinforcement so disposed as to provide all necessary restraint against the buckling of each of the longitudinal reinforcements. Every bar in a column near the face should be properly linked. The ends of such transverse reinforcement should be properly anchored.

The pitch of transverse reinforcement should be not more than the least of the three following distances:

(1) The least lateral dimension of the members;

(2) 12 times the diameter of the smallest longitudinal reinforcement in the member;

(3) 300 mm.

Where, however, the longitudinal reinforcement is provided only for the purpose of holding the prestressing steel in position and the diameter of such reinforcement does not exceed 10 mm nominal links will in general be satisfactory.

4.11 *OTHER STRUCTURES*

4.11.1 STATICALLY INDETERMINATE STRUCTURES

In calculations for working loads of systems which are statically indeterminate account should be taken not only of the applied and dead loads, but also of the strains in the structure caused by the application of the prestress and also of the subsequent creep and shrinkage in the concrete after prestressing: this is particularly important when restraints are added during or after the initial prestressing.

4.11.2 SPECIAL STRUCTURES

Some special structures cannot easily be analysed as regards the stresses in the members during transfer, handling and construction and under working loads, or as regards their ultimate strength. The strength requirements of this Code may be deemed to be satisfied for such structures if it can be established by test that they behave satisfactorily as working loads and have an adequate ultimate strength. For beams and other members in bending, the ultimate strength should be shown to satisfy the second requirement of Clause 4.9.1.

5. DESIGN AND DETAILING: PRECAST CONCRETE

5.1 *GENERAL*

5.1.1 SCOPE

The Section is concerned with the additional considerations which arise in design and detailing when precast concrete members or precast concrete components are incorporated into a structure. It does not cover the use of plain concrete for walls, large panels, composite construction or when a structure in its entirety is of precast concrete construction.

5.1.2 BASIS OF DESIGN

The design philosophy set out in Section 2 applies equally to precast and in-situ construction and therefore, in general, the recommended methods of design and detailing given in Section 3 for reinforced concrete and those for prestressed concrete given in Section 4 apply also to precast concrete construction. Clauses in Section 3 and 4 which do not apply are either specifically worded for in-situ construction or are modified by this section.

5.1.3 HANDLING STRESSES

Precast units should be designed to resist without permanent damage all stresses induced by handling, storage, transport and erection. When necessary the positions of lifting and supporting points should be specified. Consultation at the design stage with those responsible for handling is an advantage. The design should take account of the effect of snatch-lifting and placing on to supports.

5.1.4 CONNECTIONS AND JOINTS

The design of connections is of fundamental importance in precast concrete construction and must be carefully considered. The overall stability of the structure as well as the compatibility of the design and details of parts and components should be ascertained. Joints to allow for movements due to shrinkage, thermal effects and possible differential settlement of foundations are of as great importance in precast as in-situ construction. The number and spacing of such joints should be determined at an early stage in the design. In the design of beam and slab ends on corbels and nibs particular care should be taken to provide overlap and anchorage of all reinforcement adjacent ot the contact faces, full regard being paid to constructional tolerances.

5.2 *BEARINGS FOR PRECAST CONCRETE MEMBERS*

5.2.1 CONCRETE CORBELS

A corbel is a short cantilever beam in which the principal load is applied such that the distance between the line of action of the load and the face of the supporting member is less than 0.6d and the depth at the outer edge of the bearing is not less than 1/2 of the depth at the face of the supporting member.

The depth at the face of the supporting member should be determined from shear conditions in accordance with Clause 3.2.7(1).

The main tension reinforcement in a corbel should be designed and the strength of the corbel checked, on the assumption that it behaves as a simple strut and tie system. The reinforcement so obtained should be not less than 0.4% of the section at the face of the supporting member and should be adequately anchored. At the front face of the corbel, the reinforcement should be anchored either by welding to a transverse bar of equal strength or by bending back the bars to form a loop; in the latter case, the bearing area of the load should not project beyond the straight portion of the bars forming the main tension reinforcement.

When the corbel is designed to resist a stated horizontal force, additional reinforcement should be provided to transmit this force in its entirety; the reinforcement should be welded to the bearing plate and should be adequately anchored within the supporting member.

Shear reinforcement should be provided in the form of horizontal links distributed in the upper 2/3 of the effective depth of the corbel at the column face; this reinforcement should not be less than 1/2 of the area of the main tension reinforcement and should be adequately anchored.

5.2.2 CONTINUOUS CONCRETE NIBS

Where continuous nib less than 300 mm deep provides a bearing as on a boot lintel, the nib should normally be designed as a short cantilever slab in accordance with the following provisions and definitions:

(1) the projection of the nib should be sufficient to provide an adequate width of bearing for the type of member to be supported see Clause 5.2.3. The reinforcement in the nib and any reinforcement in the supported member should have a minimum nominal overlap on plan of 60 mm;

(2) The line of action of the load should be assumed to occur at the outer edge of the loaded area, i.e. at the front edge of the nib, at the beginning of the chambered edge, or at the outer edge of the bearing pad as appropriate;

(3) The maximum bending moment in the nib should be taken as the product of the load supported and the distance from its line of action to the nearest vertical leg of the links (see (6)) in the beam. The tension reinforcement in the nib should not be less than that required by Clause 3.2.1(3) and should be adequately anchored;

(4) the tension reinforcement should extend as near to the front face of the nib as considerations of adequate cover will allow and be anchored there, either by welding to a transverse bar of equal strength or by bending the bars through 180° to form loops in the horizontal or vertical plane. Vertical loops should be of bar size not greater than 12 mm;

(5) the shear resistance of the nib should be checked in accordance with Clause 3.2.7.

(6) links capable of transmitting, in addition to any other forces which they resist, the load from the nib to the compression zone of the main beam should be provided in the main beam.

5.2.3 WIDTH OF BEARINGS FOR PRECAST CONCRETE UNITS

The width of bearing of precast units should be sufficient to ensure proper anchorage of tension reinforcement see Clause 3.1.10. Precast concrete units should have a bearing of at least 100 mm on masonry or brickwork supports and of at least 75 mm on steel or concrete; this bearing may be reduced by taking into account relevant factors such as tolerances, loading, span, height of support and the provision of continuity reinforcement. Nevertheless, when reduced bearings are used, the minimum anchorage lengths of reinforcement required by 3.1.10 must be provided and precautions must be taken to ensure that collapse of the unit cannot occur due to accidental displacement during erection.

5.2.4 BEARING STRESSES

The contact surfaces should not contain excessive irregularities and when adequate intermediate padding is not provided, the compressive stress in the contact area should not normally exceed 0.25 u_w under the working loads. When the members are made of concretes of different strength, the lower concrete strength is applicable. Higher bearing stresses may be used where suitable measures are taken to prevent splitting or spalling of the concrete at the interface, such as the provision of well-defined bearing areas and additional binding reinforcement in the ends of the members. Stresses in excess of 0.5 u_w due to working loads, should only be used where justified by tests. Direct bearing connections should not be used for column/column or wall/wall connections either with or without flexible padding.

5.2.5 HORIZONTAL FORCES OR ROTATING IN BEARING

The presence of horizontal forces at a bearing can reduce the load-carrying capacity of the supporting member considerably by causing pre-mature splitting or shearing. These forces may be due to creep, shrinkage and temperature effects or result from misalignment, lack of plumb or other causes. When they are likely to be significant, these forces should be allowed for in designing and detailing the connection by providing either:

(1) sliding bearings; or

(2) suitable lateral reinforcement in the top of the supporting member; and

(3) continuity reinforcement to tie together the ends of the supported members.

Where owing to large spans or other reasons, large rotations are likely to occur at the end supports of flexural members, suitable bearings capable of accommodating these rotations should be used.

5.3 *JOINTS BETWEEN PRECAST CONCRETE MEMBERS*

5.3.1 GENERAL

The critical sections of members close to joints should be designed to resist the worst combinations of shear, axial force and bending caused by the vertical and horizontal forces. When the design of the precast members is based on the assumption that the joint between them is not capable of transmitting moment, suitable precautions should be taken to ensure that if any cracking develops it will not be unsightly and will not excessively reduce the member's resistance to shear or axial force.

Where a space is left between two or more precast concrete units, which is to be filled later with in-situ concrete or mortar, the space should be large enough for the filling material to be placed easily and compacted sufficiently to completely fill the gap, without the need for abnormally high standards of workmanship or supervision. The assembly instructions should contain definite information as to the stage during construction when the gap should be filled.

The majority of joints will incorporate a structural connection and this should be considered in the design of the joint.

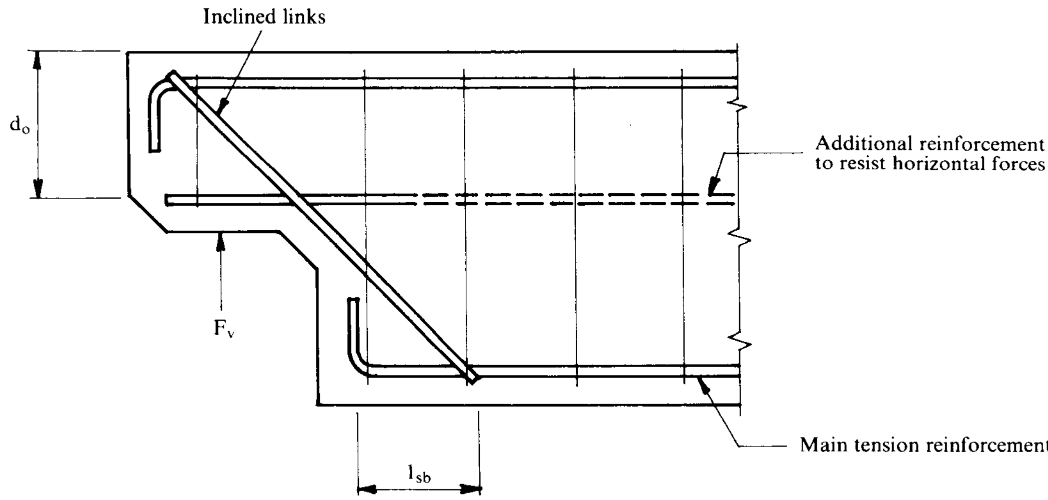
5.3.2 HALVING JOINT

For the type of joint shown in Fig. 5.1, the maximum vertical working load, F_v, should not exceed that given by equation:

$$F_v = 2p_vbd_o$$

Where b is the breadth of the beam,
p_v is the permissible shear stress (see Table 3.1);
d_o is the depth to additional reinforcement to resist horizontal forces.

When determining the value of F_v consideration should be given to the method of erection and the forces involved.



Note. This figure is diagrammatic.

Fig. 5.1 Halving joint

The joint should be reinforced by inclined links so that the vertical component of force in the link is equal to F_v, as given in equation:

$F_v = A_{sv}p_{sv} \cos 45°$ for link at 45°

Where A_{sv} is the cross-sectional area of the inclined links;
p_{sv} is the permissible stress of the inclined links.

The links must intersect the line of action of Fv.

In the compression face of the beam the links should be anchored in accordance with Clause 3.1.10. In the tension face of the beam, the horizontal component, F_h, which for 45° links is equal to F_v, should be transferred to the main reinforcement. If the main reinforcement is continued straight on without hooks or bends the links may be considered anchored if:

$$\frac{F_h}{2\,\Sigma o\; l_{sb}} < \text{Pba (see Table 3.1)}$$

Where Σo is the perimeter of the main reinforcement;
l_{sb} is the length of the straight reinforcement beyond the intersection with the link.

If the main reinforcement is hooked or bent vertically, the inclined links should be anchored by bending them parallel to the main reinforcement; in this case, or if inclined links are replaced by bent-up bars, the bearing stress inside the bends should not exceed the value given in Clause 3.1.10(6).

If there is a possibility of a horizontal load being applied to the joint, horizontal links should be provided to carry the load as shown in Fig. 5.1; such links should also be provided if there is a possibility of the inclined links being displaced so that they do not intersect the line of action of F_v. The joint may alternatively be reinforced with vertical links, designed in accordance with Clause 3.2.7 provided the links are adequately anchored.

5.3.3 SIDE JOINT

When a secondary member is supported within the span of a primary beam, attention should be paid, in designing the connection between them, to the conditions during construction as well as those due to the design working loads. The possibility of torsion should be considered. When the joint is formed when the secondary beam penetrating into a pocket formed in the side of the primary beam, the reduced section of the latter should be used in design for conditions before the grout in the pocket has reached its characteristic strength, unless the main beam is propped during construction.

The recommendations of Clause 5.2.1 and 5.2.2 apply where the joint is formed outside the limits of the normal cross-section of the main beam.