1. Increase width of rib
2. Reduce spacing of ribs
3. Provide solid concrete at supports
4. Provide shear reinforcement only if none of the above is possible.

For ribbed and coffered flat slabs, solid areas should be provided at columns, and the punching shear stress should be checked in a similar manner to the shear around columns in solid flat slabs.

4.2.6.4 Beam strips in ribbed and coffered slabs

Beam strips may be used to support ribbed and coffered slabs. The slabs should be designed as continuous, and the beam strips should be designed as beams spanning between the columns. The shear around the columns should be checked in a similar manner to the shear around columns in solid flat slabs.

4.2.7 Notes on the use of precast floors

Use of precast or semi-precast construction in an otherwise *in situ* reinforced concrete building is not uncommon. There are various proprietary precast and prestressed concrete floors on the market. Precast floors can be designed to act compositely with an *in situ* structural topping, although the precast element can carry loads without reliance on the topping. Design using proprietary products should be carried out closely in conjunction with the particular manufacturer. The notes below may be helpful to the designer:

1. The use of a structural topping should be considered but particularly to reduce the risk of cracking in the screed and finishes:
   (a) when floors are required to resist heavy concentrated loads such as those due to storage racking and heavy machinery
   (b) when resistance to moving loads such as forklift trucks is required
   or to provide diaphragm action when a floor is used which would otherwise have insufficient capacity for transmitting in-plane shear. When used a structural topping should always incorporate light fabric reinforcement
2. In selecting a floor, fire rating, durability and acoustic insulation need to be considered as well as structural strength
3. Precast components should be detailed to ensure a minimum bearing when constructed of 75mm on concrete beams and walls, but in cases where this bearing cannot be achieved reference should be made to BS 8110 for more detailed guidance. Mechanical anchorage at the ends should be considered. The design should cater for the tying requirements for accidental loading (see subsection 4.11)
4. Precast floor units, particularly those that are prestressed, have cambers that should be allowed for in the thickness of finishes. When two adjoining units have different spans, any differential camber could also be critical, and this has to be allowed for in the applied finishes (both top and bottom)
5. A ceiling to mask steps between adjoining units may be necessary
6. Holes required for services need to be planned
7. An *in situ* make-up strip should be provided to take up the tolerances between precast units and *in situ* construction.

4.3 Structural frames

4.3.1 Division into sub-frames

The moments, loads and shear forces to be used in the design of individual columns and beams of a frame supporting vertical loads only may be derived from an elastic analysis of a series of sub-frames. Each sub-frame may be taken to consist of the beams at one level, together with the columns above and below. The ends of the columns remote from the beams may generally be assumed to be fixed unless the assumption of a pinned end is clearly more reasonable. Normally a maximum of only five beam spans need be considered at a time. For larger buildings, several overlapping sub-frames should be used. Other than for end spans of a frame, sub-frames should be arranged so that there is at least one beam span beyond that beam for which bending moments and shear forces are sought.

The relative stiffness of members may be based on the concrete section ignoring reinforcement.

For the purpose of calculating the stiffness of flanged beams the flange width of T-beams should be taken as 0.14 times the effective span plus the web width and for L-beams 0.07 times the effective span plus the web width. If the actual flange width is less, this should be used.

4.3.2 Elastic analysis

The loading to be considered in the analyses should be that which provides the greater values of moments and shears for the following two cases:

all spans with maximum ultimate load ($1.4G_k + 1.6Q_k$)

alternate spans with maximum ultimate load and all other spans with minimum ultimate loads ($1.0G_k$).

The elastic bending moments should now be calculated.

4.3.3 Redistribution of moments

The moments obtained from the elastic analysis of the frames may be redistributed up to a maximum of 30% to produce members that are convenient to detail and construct. 'Whether to redistribute and by how much to redistribute are thus matters of engineering judgment, not analysis'[8]. Normally 15% redistribution could be taken as a reasonable limit.

The criteria to be observed are:

(a) Equilibrium must be maintained for each load case
(b) The design redistributed moment at any section should not be less than 70% of the elastic moment
(c) The design moment for the columns should be the greater of the redistributed moment or the elastic moment prior to redistribution.

A simple procedure may be adopted that will satisfy the above criteria:

1. **Alternate spans loaded**
   Move the moment diagram of the loaded span up or down by the percentage redistribution required; do not move moment diagram of the unloaded span (see Fig. 10).
2. **All spans loaded**
   Move the moment diagram of the loaded spans up or down by the percentage redistribution required.

4.3.4 Design shear forces

Shear calculations at the ultimate limit state may be based on the shear forces compatible with the bending moments arising from the load combinations noted in clause 4.3.2 and any redistribution carried out in accordance with clause 4.3.3.