(c) **External column or wall ties**

External columns and loadbearing walls should be tied to the floor structure. Corner columns should be tied in both directions. Provided that the clear floor-to-ceiling height does not exceed 2.5m, the tie force for each column and for each metre length of wall is 1.0 F_t. For floor-to-ceiling heights greater than 2.5m, the tie forces should be increased *pro rata,* up to a maximum of 2.0 F_t. The tie force should in no case be assumed less than 3% of the total design ultimate load carried by the column or wall. This reinforcement should be fully anchored in both vertical and horizontal elements.

(d) **Vertical ties**

Vertical ties should be present in each column and loadbearing wall. They should be capable of resisting a tensile force equal to the maximum total design ultimate load received by the column or wall from any one floor or roof.

Where effectively continuous vertical ties cannot be provided (e.g. in some precast construction), the effect of each column or loadbearing wall being removed in turn should be considered in accordance with the provisions of BS 8110, Part 2.[1]

4.12 Detailing

4.12.1 General

Certain aspects of reinforcement detailing may influence the design. The most common of these are outlined below.

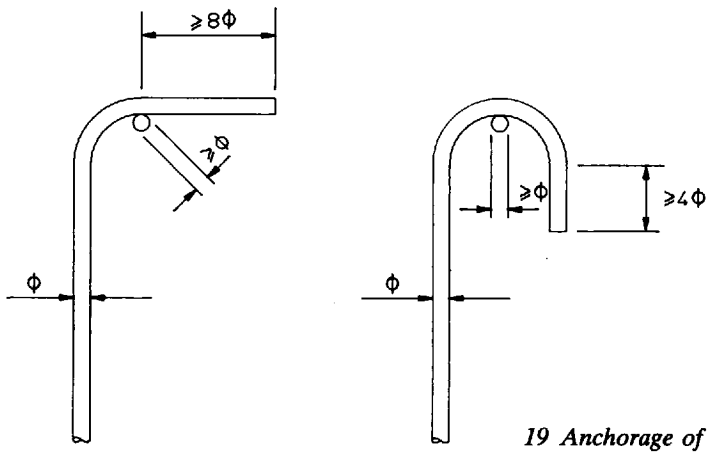
4.12.2 Bond and anchorage

Local bond stress may be ignored, provided that the force in the bar can be developed by the appropriate anchorage length (see Table 40).

A link may be considered fully anchored if it is detailed in accordance with Fig. 19.

4.12.3 Laps and splices

Laps and splices should generally be positioned away from zones of high stress and should preferably be staggered. When bars in tension are lapped the length should be at least equal to the design tension anchorage length necessary to develop the required



19 Anchorage of links

stress in the reinforcement. Lap lengths for unequal size bars (or wires in fabric) may be based on the smaller bar. The following provisions also apply:

(a) Where a lap occurs at the top of a section as cast and the minimum cover is less than twice the size of the lapped reinforcement, the lap length should be multiplied by a factor of 1.4

(b) Where a lap occurs at the corner of a section and the minimum cover to either face is less than twice the size of the lapped reinforcement or where the clear distance between adjacent laps is less than 75mm or six times the size of the lapped reinforcement, whichever is the greater, the lap length should be multiplied by a factor of 1.4

(c) In cases where both conditions *(a)* and *(b)* apply, the lap length should be multiplied by a factor of 2.0.

Where bars in compression are lapped the length should be at least 25% greater than the compression anchorage length necessary to develop the required stress in the reinforcement. Lap lengths for unequal size bars (or wires in fabric) may be based on the smaller bar.

Values for lap length are given in Table 40 as multiples of bar size.

Table 40 Ultimate anchorage bond lengths and lap lengths as multiples of bar size

f_{cu}, N/mm^2	25			30			40 and over		
Reinforcement type	250	460*	Fabric†	250	460*	Fabric†	250	460*	Fabric†
Tension anchorage and lap lengths	39	41	31	36	37	29	31	32	25
1.4 × tension lap	55	57	44	50	52	40	43	45	35
2.0 × tension lap	78	81	62	71	74	57	62	64	49
Compression anchorage length	32	32	25	29	29	23	25	26	20
Compression lap length	39	40	31	36	37	29	31	32	25

Note: These lengths have been calculated assuming the reinforcement is acting at its design strength ($0.87f_y$). If the reinforcement acts at a lower stress the length may be reduced proportionately. The minimum lap length for bar reinforcement should not be less than 15 times the bar size or 300mm, whichever is the greater, and for fabric reinforcement should not be less than 250mm.

*deformed bars type 2
†welded fabric complying with BS4483.[12]

Mechanical splices may be used in lieu of laps in order to reduce congestion of reinforcement. For further information specialist literature should be consulted.

4.12.4 Hooks, bends and bearings

The minimum radii to which reinforcement may be bent may govern certain aspects of design, e.g. depths of bearings and choice of bar size for a given thickness of slab. Table 41[13] gives these dimensions, together with effective anchorage lengths for bends and hooks.