

(b) Concrete not exposed to weather or in contact with ground:

Slabs, walls, joists:	
#14 and #18 bars . . . . .	1 1/4
#11 bar and smaller . . . . .	5/8
Beams, columns:	
Primary reinforcement . . $d_b$	but not less than 5/8 and need not exceed 1 1/2
Ties, stirrups, spirals . . . . .	3/8
Shells, folded plate members:	
#6 bar and larger . . . . .	5/8
#5 bar, W31 or D31 wire, and smaller . . . . .	3/8

**7.7.3 – Prestressed concrete**

**7.7.3.1** – The following minimum concrete cover shall be provided for prestressed and nonprestressed reinforcement, ducts, and end fittings, except as provided in Sections 7.7.3.2 and 7.7.3.3:

	Minimum cover, in.
(a) Concrete cast against and permanently exposed to earth . . . . .	3
(b) Concrete exposed to earth or weather:	
Wall panels, slabs, joists . . .	1
Other members . . . . .	1 1/2
(c) Concrete not exposed to weather or in contact with ground:	
Slabs, walls, joists . . . . .	3/4
Beams, columns:	
Primary reinforcement . . . .	1 1/2
Ties, stirrups, spirals . . . . .	1
Shells, folded plate members:	
#5 bar, W31 or D31 wire, and smaller . . . . .	3/8
Other reinforcement . . . . $d_b$	but not less than 3/4

**7.7.3.2** – For prestressed concrete members exposed to earth, weather, or corrosive environments, minimum concrete cover shall be increased 50 percent if the tensile stress of Section 18.4.2(b) is exceeded.

**7.7.3.3** – For prestressed concrete members manufactured under plant control conditions,

minimum concrete cover for nonprestressed reinforcement shall be as required in Section 7.7.2.

**7.7.4** – For bundled bars, minimum concrete cover shall be equal to the equivalent diameter of the bundle, but need not be greater than 2 in.; except for concrete cast against and permanently exposed to earth, minimum cover shall be 3 in.

**7.7.5** – In corrosive environments or other severe exposure conditions, amount of concrete protection shall be suitably increased, and denseness and nonporosity of protecting concrete shall be considered, or other protection shall be provided.

**7.7.6** – Exposed reinforcement, inserts, and plates intended for bonding with future extensions shall be protected from corrosion.

**7.7.7** – When the general building code (of which this code forms a part) requires a thickness of cover for fire protection greater than the minimum concrete cover specified in Section 7.7, such greater thicknesses shall be used.

**7.8 – Special reinforcing details for columns**

**7.8.1 – Offset bars**

Offset bent longitudinal bars shall conform to the following:

**7.8.1.1** – Slope of inclined portion of an offset bar with axis of column shall not exceed 1 in 6.

**7.8.1.2** – Portions of bar above and below an offset shall be parallel to axis of column.

**7.8.1.3** – Horizontal support at offset bends shall be provided by lateral ties, spirals, or parts of the floor construction. Horizontal support provided shall be designed to resist 1 1/2 times the horizontal component of the computed force in the inclined portion of an offset bar. Lateral ties or spirals, if used, shall be placed not more than 6 in. from points of bend.

**7.8.1.4** – Offset bars shall be bent before placement in the forms. See Section 7.3.

**7.8.1.5** – Where a column face is offset 3 in. or greater, longitudinal bars shall not be offset bent. Separate dowels, lap spliced with the longitudinal bars adjacent to the offset column faces, shall be provided. Lap splices shall conform to Section 12.18.

**7.8.2 – Steel cores**

Load transfer in structural steel cores of composite compression members shall be provided by the following:

**7.8.2.1** – Ends of structural steel cores shall be accurately finished to bear at end bearing splices,

with positive provision for alignment of one core above the other in concentric contact.

**7.8.2.2** – At end bearing splices, bearing shall be considered effective to transfer not more than 50 percent of the total compressive stress in the steel core.

**7.8.2.3** – Transfer of stress between column base and footing shall be designed in accordance with Section 15.8.

**7.8.2.4** – Base of structural steel section shall be designed to transfer the total load from the entire composite member to the footing; or, the base may be designed to transfer the load from the steel core only, provided ample concrete section is available for transfer of the portion of the total load carried by the reinforced concrete section to the footing by compression in the concrete and by reinforcement.

## **7.9 – Connections**

**7.9.1** – At connections of principal framing elements (such as beams and columns), enclosure shall be provided for splices of continuing reinforcement and for end anchorage of reinforcement terminating in such connections.

**7.9.2** – Enclosure at connections may consist of external concrete or internal closed ties, spirals, or stirrups.

## **7.10 – Lateral reinforcement for compression members**

**7.10.1** – Lateral reinforcement for compression members shall conform to the provisions of Sections 7.10.4 and 7.10.5 and, where shear or torsion reinforcement is required, shall also conform to provisions of Chapter 11.

**7.10.2** – Lateral reinforcement requirements for composite compression members shall conform to Section 10.14. Lateral reinforcement requirements for prestressing tendons shall conform to Section 18.11.

**7.10.3** – Lateral reinforcement requirements of Sections 7.10, 10.14, and 18.11 may be waived where tests and structural analysis show adequate strength and feasibility of construction.

### **7.10.4 – Spirals**

Spiral reinforcement for compression members shall conform to Section 10.9.3 and to the following:

**7.10.4.1** – Spirals shall consist of evenly spaced continuous bar or wire of such size and so assembled to permit handling and placing without distortion from designed dimensions.

**7.10.4.2** – For cast-in-place construction, size of spirals shall not be less than 3/8 in. diameter.

**7.10.4.3** – Clear spacing between spirals shall not exceed 3 in., nor be less than 1 in. See also Section 3.3.3.

**7.10.4.4** – Anchorage of spiral reinforcement shall be provided by 1½ extra turns of spiral bar or wire at each end of a spiral unit.

**7.10.4.5** – Splices in spiral reinforcement shall be lap splices of 48d, but not less than 12 in., or welded.

**7.10.4.6** – Spirals shall extend from top of footing or slab in any story to level of lowest horizontal reinforcement in members supported above.

**7.10.4.7** – Where beams or brackets do not frame into all sides of a column, ties shall extend above termination of spiral to bottom of slab or drop panel.

**7.10.4.8** – In columns with capitals, spirals shall extend to a level at which the diameter or width of capital is 2 times that of the column.

**7.10.4.9** – Spirals shall be held firmly in place and true to line by vertical spacers.

**7.10.4.10** – For spiral bar or wire smaller than 5/8 in. diameter, a minimum of two spacers shall be used for spirals less than 20 in. in diameter, three spacers for spirals 20 to 30 in. in diameter, and four spacers for spirals greater than 30 in. in diameter.

**7.10.4.11** – For spiral bar or wire 5/8 in. diameter or larger, a minimum of three spacers shall be used for spirals 24 in. or less in diameter, and four spacers for spirals greater than 24 in. in diameter.

### **7.10.5 – Ties**

Tie reinforcement for compression members shall conform to the following:

**7.10.5.1** – All nonprestressed bars shall be enclosed by lateral ties, at least #3 in size for longitudinal bars #10 or smaller, and at least #4 in size for #11, #14, #18, and bundled longitudinal bars. Deformed wire or welded wire fabric of equivalent area may be used.

**7.10.5.2** – Vertical spacing of ties shall not exceed 16 longitudinal bar diameters, 48 tie bar or wire diameters, or least dimension of the compression member.

**7.10.5.3** – Ties shall be arranged such that every corner and alternate longitudinal bar shall have lateral support provided by the corner of a tie with an included angle of not more than 135 deg and no bar shall be farther than 6 in. clear on each side along the tie from such a laterally supported bar.

Where longitudinal bars are located around the perimeter of a circle, a complete circular tie may be used.

**7.10.5.4** – Ties shall be located vertically not more than half a tie spacing above the top of footing or slab in any story, and shall be spaced as provided herein to not more than half a tie spacing below the lowest horizontal reinforcement in slab or drop panel above.

**7.10.5.5** – Where beams or brackets frame into all sides of a column, ties may be terminated not more than 3 in. below the lowest reinforcement in such beams or brackets.

### **7.11 – Lateral reinforcement for flexural members**

**7.11.1** – Compression reinforcement in beams shall be enclosed by ties or stirrups satisfying the size and spacing limitations in Section 7.10.5 or by welded wire fabric of equivalent area. Such ties or stirrups shall be provided throughout the distance where compression reinforcement is required.

**7.11.2** – Lateral reinforcement for flexural framing members subject to stress reversals or to torsion at supports shall consist of closed ties, closed stirrups, or spirals extending around the flexural reinforcement.

**7.11.3** – Closed ties or stirrups may be formed in one piece by overlapping standard stirrup or tie end hooks around a longitudinal bar, or formed in one or two pieces lap spliced with a Class C splice (lap of  $1.7l_d$ ), or anchored in accordance with Section 12.14.

### **7.12 – Shrinkage and temperature reinforcement**

**7.12.1** – Reinforcement for shrinkage and temperature stresses normal to flexural reinforcement shall be provided in structural floor and roof slabs where the flexural reinforcement extends in one direction only.

**7.12.2** – Area of shrinkage and temperature reinforcement shall provide at least the following ratios of reinforcement area to gross concrete area, but not less than 0.0014:

Slabs where Grade 40 or 50 deformed bars are used . . . . . 0.0020

Slabs where Grade 60 deformed bars or welded wire fabric (smooth or deformed) are used . . . . . 0.0018

Slabs where reinforcement with yield strength exceeding 60,000 psi measured at a yield strain of 0.35 percent is used . . . . .  $\frac{0.0018 \times 60,000}{f_y}$

**7.12.3** – Shrinkage and temperature reinforcement shall not be spaced farther apart than 5 times the slab thickness, nor 18 in.

**7.12.4** – At all sections where required, reinforcement for shrinkage and temperature stresses shall develop the specified yield strength  $f_y$  in tension in accordance with Section 12.1 or 12.16.