equal to 1/10 the span, whichever is smaller. If the effective flange width exceeds 1/10 the span, some longitudinal reinforcement shall be provided in the outer portions of the flange.

10.6.7 – If the depth of a web exceeds 3 ft, longitudinal reinforcement having a total area equal to at least 10 percent of the area of the flexural tension reinforcement shall be placed near the side faces of the web and distributed in the zone of flexural tension with a spacing not more than the web width, nor 12 in. Such reinforcement may be included in strength computations only if a strain compatibility analysis is made to determine stresses in the individual bars or wires.

10.7 – Deep flexural members

10.7.1 – Flexural members with overall depth to clear span ratios greater than 2/5 for continuous spans, or 4/5 for simple spans, shall be designed as deep flexural members taking into account nonlinear distribution of strain and lateral buckling.

10.7.2 – Design of deep flexural members for shear effects shall be in accordance with Section 11.8.

10.7.3 – Minimum flexural tension reinforcement shall conform to Section 10.5.

10.7.4 – Minimum horizontal and vertical reinforcement in the side faces of deep flexural members shall be the greater of the requirements of Sections 11.8.8 and 11.8.9 or Sections 14.2.10 and 14.2.11.

10.8 – Design dimensions for compression members

10.8.1 – Isolated compression member with multiple spirals

Outer limits of the effective cross section of a compression member with two or more interlocking spirals shall be taken at a distance outside the extreme limits of the spirals equal to the minimum concrete cover required by Section 7.7.

10.8.2 – Compression member built monolithically with wall

Outer limits of the effective cross section of a spirally reinforced compression member built monolithically with a concrete wall or pier shall be taken either as a circle at least 1½ in. outside the spiral, or as a square or rectangle, with sides at least 1½ in. outside the spiral.

10.8.3 – Equivalent circular compression member

In lieu of using full gross area for design, a compression member with a square, octagonal, or other shaped cross section may be considered as a circular section with a diameter equal to the least lateral dimension of the actual shape. Gross area considered, required percentage of reinforcement, and design strength shall be based on that circular section.

10.8.4 – Limits of section

For a compression member with a larger cross section than required by considerations of loading, a reduced effective area A_g not less than one-half the total area may be used to determine minimum reinforcement and design strength.

10.9 – Limits for reinforcement of compression members

10.9.1 – Area of longitudinal reinforcement for noncomposite compression members shall not be less than 0.01 nor more than 0.08 times gross area A_g of section.

10.9.2 – Minimum number of longitudinal reinforcing bars in compression members shall be 6 for bars in a circular arrangement and 4 for bars in a rectangular arrangement.

10.9.3 – Ratio of spiral reinforcement ρ_s shall not be less than the value given by

$$\rho_s = 0.45\left(\frac{A_g}{A_c} - 1\right)\frac{f'_c}{f_y} \qquad (10\text{-}5)$$

where f_y is the specified yield strength of spiral reinforcement but not more than 60,000 psi.

10.10 – Slenderness effects in compression members

10.10.1 – Design of compression members shall be based on forces and moments determined from analysis of the structure. Such analysis shall take into account influence of axial loads and variable moment of inertia on member stiffness and fixed-end moments, effect of deflections on moments and forces, and the effects of duration of loads.

10.10.2 – In lieu of the procedure prescribed in Section 10.10.1, slenderness effects in compression members may be evaluated in accordance with the approximate procedure presented in Section 10.11.

10.10.3 – The detailed requirements of Section 10.11 need not be applied if slenderness effects in compression members are evaluated in accordance with Section 10.10.1.

10.11 – Approximate evaluation of slenderness effects

10.11.1 – Unsupported length of compression members

10.11.1.1 – Unsupported length ℓ_u of a compression member shall be taken as the clear distance between floor slabs, beams, or other members capable of providing lateral support for that compression member.

10.11.1.2 – Where column capitals or haunches are present, unsupported length shall be measured to the lower extremity of capital or haunch in the plane considered.

10.11.2 – Effective length of compression members

10.11.2.1 – For compression members braced against sidesway, effective length factor k shall be taken as 1.0, unless analysis shows that a lower value may be used.

10.11.2.2 – For compression members not braced against sidesway, effective length factor k shall be determined with due consideration of cracking and reinforcement on relative stiffness, and shall be greater than 1.0.

10.11.3 – Radius of gyration

Radius of gyration r may be taken equal to 0.30 times the overall dimension in the direction stability is being considered for rectangular compression members, and 0.25 times the diameter for circular compression members. For other shapes, r may be computed for the gross concrete section.

10.11.4 – Consideration of slenderness effects

10.11.4.1 – For compression members braced against sidesway, effects of slenderness may be neglected when $k\ell_u/r$ is less than $34 - 12\,M_1/M_2$.

10.11.4.2 – For compression members not braced against sidesway, effects of slenderness may be neglected when $k\ell_u/r$ is less than 22.

10.11.4.3 – For all compression members with $k\ell_u/r$ greater than 100, an analysis as defined in Section 10.10.1 shall be made.

10.11.5 – Moment magnification

10.11.5.1 – Compression members shall be designed using the factored axial load P_u from a conventional frame analysis and a magnified factored moment M_c defined by

$$M_c = \delta M_2 \qquad (10\text{-}6)$$

where

$$\delta = \frac{C_m}{1 - (P_u/\phi P_c)} \geq 1.0 \qquad (10\text{-}7)$$

and

$$P_c = \frac{\pi^2 EI}{(k\ell_u)^2} \qquad (10\text{-}8)$$

10.11.5.2 – In lieu of a more accurate calculation, EI in Eq. (10-8) may be taken either as

$$EI = \frac{(E_c I_g/5) + E_s I_{se}}{1 + \beta_d} \qquad (10\text{-}9)$$

or conservatively

$$EI = \frac{E_c I_g/2.5}{1 + \beta_d} \qquad (10\text{-}10)$$

10.11.5.3 – In Eq. (10-7), for members braced against sidesway and without transverse loads between supports C_m may be taken as

$$C_m = 0.6 + 0.4\frac{M_1}{M_2} \qquad (10\text{-}11)$$

but not less than 0.4.

For all other cases, C_m shall be taken as 1.0.

10.11.5.4 – If computations show that there is no moment at both ends of a compression member or that computed end eccentricities are less than $(0.6 + 0.03h)$ in., M_2 in Eq. (10-6) shall be based on a minimum eccentricity of $(0.6 + 0.03h)$ in. about each principal axis separately. Ratio M_1/M_2 in Eq. (10-11) shall be determined by either of the following:

(a) When computed end eccentricities are less than $(0.6 + 0.03h)$ in., computed end moments may be used to evaluate M_1/M_2 in Eq. (10-11).

(b) If computations show that there is essentially no moment at both ends of a compression member, the ratio M_1/M_2 shall be taken equal to one.

10.11.6 – Moment magnifier δ for unbraced frames

10.11.6.1 – In frames not braced against sidesway, the value of δ shall be computed for an entire story assuming all columns to be loaded.

10.11.6.2 – In Eq. (10-7), P_u and P_c shall be replaced by the summations ΣP_u and ΣP_c for all columns in a story.

10.11.6.3 – For design of each column within a story, δ shall be taken as the larger of the values computed for the entire story according to Section 10.11.6.2 or as computed for the individual column assuming column ends to be braced against sidesway.

10.11.6.4 – In frames not braced against sidesway, flexural members shall be designed for the total magnified end moments of the compression members at the joint.

10.11.7 – Moment magnifier δ for biaxial bending

For compression members subject to bending about both principal axes, moment about each axis shall be magnified by δ, computed from corresponding conditions of restraint about that axis.

10.12 – Axially loaded members supporting slab system

Axially loaded members supporting a slab system included within the scope of Section 13.1 shall be designed as provided in Chapter 10 and in accordance with the additional requirements of Chapter 13.

10.13 – Transmission of column loads through floor system

When the specified compressive strength of concrete in a column is greater than 1.4 times that specified for a floor system, transmission of load through the floor system shall be provided by one of the following.

10.13.1 – Concrete of strength specified for the column shall be placed in the floor about the column for an area 4 times the column area. Column concrete shall be well integrated into floor concrete, and shall be placed in accordance with Sections 6.4.5 and 6.4.6.

10.13.2 – Strength of a column through a floor system shall be based on the lower value of concrete strength with vertical dowels and spirals as required.

10.13.3 – For columns laterally supported on four sides by beams of approximately equal depth or by slabs, strength of the column may be based on an assumed concrete strength in the column joint equal to 75 percent of column concrete strength plus 35 percent of floor concrete strength.

10.14 – Composite compression members

10.14.1 – Composite compression members shall include all such members reinforced longitudinally with structural steel shapes, pipe, or tubing with or without longitudinal bars.

10.14.2 – Strength of a composite member shall be computed for the same limiting conditions applicable to ordinary reinforced concrete members.

10.14.3 – Any axial load strength assigned to concrete of a composite member shall be transferred to the concrete by members or brackets in direct bearing on the composite member concrete.

10.14.4 – All axial load strength not assigned to concrete of a composite member shall be developed by direct connection to the structural steel shape, pipe, or tube.

10.14.5 – For evaluation of slenderness effects, radius of gyration of a composite section shall not be greater than the value given by

$$r = \sqrt{\frac{(E_c I_g/5) + E_s I_t}{(E_c A_g/5) + E_s A_t}} \qquad (10\text{-}12)$$

For computing P_c in Eq. (10-8), EI of the composite section shall not be greater than

$$EI = \frac{(E_c I_g/5) + E_s I_t}{1 + \beta_d} \qquad (10\text{-}13)$$

10.14.6 – Structural steel encased concrete core

10.14.6.1 – For a composite member with concrete core encased by structural steel, thickness of the steel encasement shall not be less than

$$b\sqrt{\frac{f_y}{3E_s}}, \text{ for each face of width } b$$

nor

$$h\sqrt{\frac{f_y}{8E_s}}, \text{ for circular sections of diameter } h$$

10.14.6.2 – Longitudinal bars located within the encased concrete core may be considered in computing A_t and I_t.

10.14.7 – Spiral reinforcement around structural steel core

A composite member with spirally reinforced concrete around a structural steel core shall conform to the following.

10.14.7.1 – Specified compressive strength of concrete f'_c shall not be less than 2500 psi.

10.14.7.2 – Design yield strength of structural steel core shall be the specified minimum yield strength for grade of structural steel used but not to exceed 50,000 psi.

10.14.7.3 – Spiral reinforcement shall conform to Section 10.9.3.

10.14.7.4 – Longitudinal bars located within the spiral shall not be less than 0.01 nor more than 0.08 times net area of concrete section.

10.14.7.5 – Longitudinal bars located within the spiral may be considered in computing A_t and I_t.

10.14.8 – Tie reinforcement around structural steel core

A composite member with laterally tied concrete around a structural steel core shall conform to the following.

10.14.8.1 – Specified compressive strength of concrete f'_c shall not be less than 2500 psi.

10.14.8.2 – Design yield strength of structural steel core shall be the specified minimum yield strength for grade of structural steel used but not to exceed 50,000 psi.

10.14.8.3 – Lateral ties shall extend completely around the structural steel core.

10.14.8.4 – Lateral ties shall be at least #5 bars, or smaller bars with a diameter not less than 1/50 times the greatest side dimension of the composite member, but not smaller than #3. Welded wire fabric of equivalent area may be used.

10.14.8.5 – Vertical spacing of lateral ties shall not exceed 16 longitudinal bar diameters, 48 tie bar diameters, or 1/2 times the least side dimension of the composite member.

10.14.8.6 – Longitudinal bars located within the ties shall not be less than 0.01 nor more than 0.08 times net area of concrete section.

10.14.8.7 – A longitudinal bar shall be located at every corner of a rectangular cross section, with other longitudinal bars spaced not farther apart than 1/2 the least side dimension of the composite member.

10.14.8.8 – Longitudinal bars located within the ties may be considered in computing A_t for strength but not in computing I_t for evaluation of slenderness effects.

10.15 – Special provisions for walls

10.15.1 – Walls may be designed by provisions of Chapter 10 with limitations and exceptions of Section 10.15, or by provisions of Chapter 14.

10.15.2 – Minimum ratio of vertical reinforcement area to gross concrete area shall be:

(a) 0.0012 for deformed bars not larger than #5 with a specified yield strength not less than 60,000 psi, or

(b) 0.0015 for other deformed bars, or

(c) 0.0012 for welded wire fabric (smooth or deformed) not larger than W31 or D31.

10.15.3 – Vertical reinforcement shall not be spaced farther apart than 3 times the wall thickness, nor 18 in.

10.15.4 – Vertical reinforcement need not be enclosed by lateral ties if vertical reinforcement area is not greater than 0.01 times gross concrete area, or where vertical reinforcement is not required as compression reinforcement.

10.15.5 – Minimum ratio of horizontal reinforcement area to gross concrete area shall be:

(a) 0.0020 for deformed bars not larger than #5 with a specified yield strength not less than 60,000 psi, or

(b) 0.0025 for other deformed bars, or

(c) 0.0020 for welded wire fabric (smooth or deformed) not larger than W31 or D31.

10.15.6 – Horizontal reinforcement shall not be spaced farther apart than 3 times the wall thickness, nor 18 in.

10.16 – Bearing strength

10.16.1 – Design bearing strength on concrete shall not exceed $\phi(0.85 f'_c A_1)$, except as follows.

10.16.1.1 – When the supporting surface is wider on all sides than the loaded area, design bearing strength on the loaded area may be multiplied by $\sqrt{A_2/A_1}$, but not more than 2.

10.16.1.2 – When the supporting surface is sloped or stepped, A_2 may be taken as the area of the lower base of the largest frustum of a right pyramid or cone contained wholly within the support and having for its upper base the loaded area, and having side slopes of 1 vertical to 2 horizontal.

10.16.2 – Section 10.16 does not apply to post-tensioning anchorages.