CHAPTER 14

APPENDIX (Important clauses of IS 800 : 2007)

SUMMARY OF CODE

Following are the clauses of IS 800 : 2007 that are associated with General Design Requirement.

Clause	Code Provision
3.2.1	Loads to be considered in design are: 1. Dead load 2. Imposed load 3. Wind load 4. Earthquake load 5. Erection load 6. Accident load 7. Secondary effect due to contraction or expansion.
3.7	It classifies any steel section into 4 classes. (a) Class 1 (Plastic) (b) Class 2 (Compact) (c) Class 3 (Semi-compact) (d) Class 4 (Slender)
4.3.6	To analyse a frame subjected to gravity loads, considering the sway stability of the frame notional horizontal forces equal to 0.5% of factored dead load plus vertical imposed load is applied at that level. These loads should not be combined with other lateral loads such as wind and EQ.
5.3.2	Characteristic Action (Loads) are the values of the different actions that are not expected to be exceeded with more than 5% probability during the life of the structure.
Table 4	Give the Load Factor for various load combination (study this table)
Table 5	Gives partial safety factor for materials, γ_m

Sl.	Definition	Partial Safety Factor	
(i)	Resistance, governed by yielding γ_{m0}	1.1	
(ii)	Resistance to buckling, γ_{m0}	1.1	
(iii)	Resistance, governed by ultimate stress γ_{m1}	1.25	
(iv)	Resistance of connection	Shop	Field
	(a) Bolt Friction Type, γ_{mf}	1.25	1.25
	(b) Bolt Bearing Type, γ_{mb}	1.25	1.25
	(c) Rivets, γ_{mr}	1.25	1.25
	(d) Welds γ_{mw}	1.25	1.50

Clause	Code Provision
Table 6	This table gives the deflection limits for various type of structures (study this table).

Following are the clauses of IS 1800 : 2007 that associated with Design of Connection.

Clause	Code Provision
Table 19	Gives the clearances for fastener holes (Hence hole diameter) (study this table).
10.2.2	Minimum spacing between centre of fastemes shall not be less than 2.5 times the nominal diameter of the fastemes.
10.2.3.1	c/c distance between any two adjacent fasteners shall not be more than 32t or 300 mm whichever is less, where t is thickness of the thinner plate.
102.3.2	c/c distance between any two adjacent fasteners in a line lying in the direction of stress shall not exceed 16t or 200 mm, whichever is less in tension member and 12t or 200 mm whichever is less in compression member; where t is the thickness of the thinner plate. In the case of compression members wherein forces are transferred through butting faces this distance shall not exceed 4.5 times the diameter of the fasteners for a distance equal to 1.5 times the width of the member from the butting face.
10.2.3.3	The distance between any two consecutive fasteners in a line adjacent and parallel to an edge of an outside plate shall not exceed 100 mm plus 4t or 200 mm; whichever is less; both in compression and tension members, where t is the thickness of the thinner outside plate.
102.3.4	When fasteners are staggered at equal intervals and gauge does not exceeds 75 mm, the spacing specified in 10.2.3.2 and 10.2.3.3 between c/c fasteners may be increased by 50% subjected to the maximum spacing in 10.2.3.1.
10.2.4.1	The edge distance is the distance at right angles to the direction at right angles to the direction of stress from the centre of the hole to the adjacent edge. The end distance is the distance in the direction of stress from the centre of a hole to the end of the element.
10.2.4.2	The minimum edge and end distance from the centre of any hole to the nearest edge of a plate shall not be less than 1.7 times the hole diameter in case of sheared or hand flame cut edges; and 1.5 times the hole diameter in case of rolled, machine flame cut, sawn and planed edges.
10.2.4.3	The maximum edge distance to the nearest line of fasteners from and edge of any unstiffened part should not exceed 12tε, where $\varepsilon = \sqrt{250/f_y}$ and 't' is the thickness of the thinner outer plate. This would not apply to fasteners interconnecting the components of back to back tension members. Where the members are exposed to corrosive influences, the maximum edge distance shall not exceed 40 mm plus 4t, where t is thickness of the thinner connected plate.
10.2.5.1	In case of members covered under 10.2.4.3 when the maximum distance between centres of two adjacent fasteners as specified in 10.2.4.3 is exceeded, tacking fasteners not subjected to calculated stress shall be used.
10.2.5.2	Tacking fasteners shall have spacing in a line not exceeding 32 times the thickness of the thinner outside plate or 300 mm whichever is less. Where the plate are exposed to the weather, the spacing in line shall not exceed 16 times the thickness of the thinner outside plate or 200 mm, whichever is less. In both cases, the distance between the lines of fasteners shall not be greater than the respective pitches.
10.3.1.1	Since threads can occur in the shear plane of a bolt, the effective area for resisting shear shall be taken as the net tensile area, A_s of the bolts. It should be taken at the root of the thread. Approx. $A_s = 0.78 \times \frac{\pi}{4} \times d^2$; d = Nominal diameter i.e., dia. of shank.

Clause	Code Provision
10.3.3	Shear Capacity of a bolt is given by $$V_{dsb} = \frac{f_u}{\sqrt{3}\,\gamma_{mb}}(n_n A_{nb} + n_s A_{sb})$$ where f_u = ultimate tensile strength of Bolt n_n = number of shear planes with thread intercepting the shear plane n_s = number of shear planes without threads intercepting the shear plane $A_{sb} = \frac{\pi}{4}d^2$, $A_{nb} = 0.78\frac{\pi}{4}d^2$, d = nominal Bolt diameter
10.3.1	When the length of the joint, l_j exceeds 15 d in the direction of the load, the Nominal shear capacity shall be reduced by the factor $$\beta_{lj} = 1.075 - 0.005\frac{l_j}{d}$$ $$0.75 \le \beta_{lj} \le 1.1$$ Where d = Nominal bolt diameter.
10.3.3.2	When the grip length, l_g (equal to the total thickness of the connected plate) exceeds 5 times the diameter of the bolt, the design shear capacity shall be reduced by a factor $\beta_{lg}\left(\frac{8}{3 + l_g/d}\right) \le \beta_{lj}$ (given in 10.3.3.1). The grip length of shall in no case be greater than 8d.
10.3.3.3	The design shear capacity of bolts carrying shear through a packing plate in excess of 6 mm shall be decreased by a factor, $\beta_{pk} = (1 - 0.0125\, t_{pk})$. Where, t_{pk} = thickness of thicker packing in mm.
10.3.4	Bearing capacity of a Bolt is $$V_{dpb} = \frac{2.5 K_b d t f_u}{\gamma_{mb}}$$ Where K_b is smaller of $\left(\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0\right)$ e, p = end and pitch distance d_0 = diameter of the hole f_{ub}, f_u = ultimate tensile stress of the bolt and the ultimate tensile stress of the plate respectively. d = nominal diameter of Bolt. t = summation of the thicknesses of the connected plates experiencing bearing stress in the same direction or if the bolts are countersunk, the thickness of the plate minus one half of the depth of counter sunking.
10.3.5	Design Tensile Capacity of the Bolt is $$T_{db} = \frac{0.9 f_{ub} A_{nb}}{\gamma_{mb}} < \frac{f_{yb} A_{sb}}{\gamma_{m0}}$$ where, f_{ub} = ultimate tensile stress of bolt f_{yb} = yield stress of Bolt A_{nb} = N_{et} tensile area of the Bolt calculated at root of the thread = 0.78 × A_{sb} A_{sb} = Shank area of the Bolt

Clause	Code Provision

10.3.6

Bolt subjected to combined shear and Tension shall satisfy

$$\left(\frac{V_{sb}}{V_{db}}\right)^2 + \left(\frac{T_b}{T_{db}}\right) \leq 1.0$$

10.4.3

Design shear capacity of a bolt as governed by slip for friction type connection is

$$V_{dsf} = \frac{\mu_f n_e K_h f_0}{\gamma_{mf}}$$

where μ_f = Coefficient of friction as specified in Table 20 (study table 20 for detail)

n_e = Number of effective interfaces offering frictional resistance to slip.

K_h = 1.0 for fastness in clearance hole, 085 for fastness in oversiozed and short slotted holes and for fasteners in long slotted holes loaded perpendicular to the slots. 0.70 for fasteners in long slotted holes loaded parallel to the slot.

γ_{mf} = 1.1 (if slip resistance is designed at service load)

f_0 = Minimum bolt tension (prof load) at installation.

10.4.7

It deals with the calculation of prying force in case of Tension in HSFG Bolts. According to it, praying force (Q) is given by

$$Q = \frac{l_v}{2l_e}\left[T_0 - \frac{\beta_\eta f_0 b_e t^4}{27 l_e l_v^2}\right]$$

where l_v = Distance from the bolt centreline to the toe of the fillet weld or to half the root radius for a rolled section.

l_e = Distance between prying force and bolt centreline and is the minimum of either the end distance or the value given by

$$l_e = 1.1t\sqrt{\frac{\beta f_0}{f_y}}$$

β = 2.0 for non pre-tensioned bolt and 100 for pre-tensioned bolt

η = 1.5

b_e = effective width of flange per pair of bolts

f_0 = proof stress is consistent unit

10.5.1.1

Fillet welds terminating at the ends or sides of parts should be returned continuously around the corners for a distance of not less than twice the size of the weld, unless it is impractical to do so.

10.5.1.3

A single fillet weld should not be subjected to moment about the longitudinal axis.

10.5.2.1

The size of normal fillets shall be taken as the minimum weld leg size. For deep penetration welds, where the depth of penetration beyond the root run is a minimum of 2.4 mm the size of the fillet should be taken as the minimum leg size plus 2.4 mm.

10.5.2.2

For Fillet weld made by sami-automatic or automatic processes, where the depth of penetration is considerably in excess of 2.4 mm, the size shall be taken considering actual depth of penetration subject to the agreement between the purchaser and the contractor.

Clause	Code Provision

10.5.2.3

The size of fillet weld shall not be less than 3 mm. The minimum size of the first run or a single run fillet weld shall be as is given below to avoid cracking in the absence of preheating.

S.No.	Thickness of Thicker Part (mm)	Minimum size (mm)
(i)	upto 10	3
(ii)	10 to 20	5
(iii)	20 to 32	6
(iv)	32 to 50	8 for first run, 10 for min. size of weld

10.5.2.4

The size of the butt weld shall be specified by effective throat thickness.

10.5.3.1

The effective throat thickness of a fillet weld shall not be less than 3 mm and shall generally not exceed 0.7t or 1.0t under special circumstances, where t is the thickness of the thinner plate of elements being welded.

10.5.3.2

For the purpose of stress calculation in fillet welds joining faces inclined to each other the effective throat thickness shall be taken as K times the fillet weld size, where K is a constant.

Angle between Fusion Faces	60-90°	91-100°	101-106°	107-113°	114-120°
Constant	0.70	0.65	0.60	0.55	0.50

10.5.3.3

The effective throat thickness of a complete penetration butt weld shall be taken as the thickness of the thinner part joined and that of an incomplete penetration butt weld shall be taken as the minimum thickness of the weld metal common to the parts joined, excluding reinforcements.

10.5.4.1

The effective length of fillet weld shall be taken as only that length which is of the specified size and required throat thickness. In practice the actual length of weld is made of the effective length of weld plus two times the weld size, but not less than 4 times the weld size.

10.5.4.2

The effective length of butt weld shall be taken as the length of the continuous full size weld, but not less than four times the weld size.

10.5.5.1

Unless otherwise specified, the intermittent fillet welding shall have an effective length not less than 4 times the weld size, with a minimum of 40 mm.

10.5.5.2

The clear spacing between the effective length of intermittent weld shall not exceeds 12 and 16 times the thickness of thinner plate joined, for compression and tension joints respectively, and in no case more than 200 mm.

10.5.5.3

The intermittent welds shall not be used in positions subjected to dynamic, repetitive and alternating stresses.

10.5.7.1.1

Design strength of a fillet weld, f_{wd} shall be based on its throat area.

$$f_{wd} = \frac{f_u}{\sqrt{3}\,\gamma_{mw}}$$

f_u = smaller of the ultimate stress of weld or parent metal.

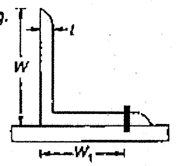
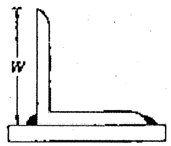
Clause	Code Provision
10.5.7.3	When the length of welded joint, l_j of a splice or end connection in a compression or tension element is greater than $150 t_t$ the design capacity of the weld f_{wd} shall be reduced by a factor of $$\beta_{lw} = 1.2 - \frac{0.2 l_j}{150 t_t} \le 1.0$$ where, l_j = length of the joint in the direction of the force transfer, t_t = throat size of the weld.
10.5.8.1	Where a fillet weld is applied to the square edge of a part, the specified size of the weld should generally be at least 1.5 mm less than the edge thickness in order to avoid washing down of the arris.
10.5.8.2	Where the fillet weld is applied to the rounded toe of a rolled section, the specified size of the weld should generally not exceed 3/4 of the thickness of the section of the toe.
10.5.8.5	End fillet weld, normal to the direction of force shall be unequal size with the throat thickness not less than 0.5 t, where t is the thickness of the part. The difference in thickness of the welds shall be negotiated at a uniform slope.
10.5.9	Stress on weld due to individual forces (Axial/Shear) is given by $$f_a \text{ or } q = \frac{P}{t_t l_w}$$ t_t = effective throat thickness P = force (Axial/shear) l_w = effective length of weld
10.5.10.1.1	Fillet weld when subjected to combination of normal and shear stress, the equivalent stress f_e shall satisfy $$f_e = \sqrt{f_a^2 + 3q^2} \le \frac{f_u}{\sqrt{3}\,\gamma_{mw}}$$ f_a = axial stress q = shear stress
10.5.10.1.2	Check for the combination of stresses need not be done for (a) side fillet welds joining cover plate and flange plates (b) fillet welds where sum of normal and shear stress does not exceed f_{wd}.
10.5.10.2.1	Check for combination of stresses in butt weld need not be carried out provided that: (a) butt weld are axially loaded (b) in single and double bevel welds, the sum of the normal and shear stresses does not exceeds the design normal stress and the shear stress does not exceeds 50% of the design shear stress.
10.5.2.2	Where bearing stress f_{br} is combined with bending stress (tensile or compression) f_b and shear stress, q under the most unfavourable conditions of loading in butt welds, the equivalent stress f_e as obtained from the following formula, shall not exceed the value allowed fo parent metal $$f_e = \sqrt{f_b^2 + f_{br}^2 + f_b f_{br} + 3q^2}$$

Clause	Code Provision
10.7	Minimum forces for which the following connection shall be designed.

Connection type	Design Force
Connection in Rigid construction	0.5 times the member design moment capacity
Connection to beam in simple construction	Minimum of shear capacity 0.15 × member design 40 kN
Connection at the ends of tensile or compression members	0.3 times the member design capacity
Splices in member subjected to tension	0.3 times the members design capacity in tension
Splices in member subjected to Axial Compression	For ends prepared for full contact. The fasteners shall be sufficient to carry 0.15 times the member design capacity in axial compression otherwise designed for 0.3 times the design capacity.
Splicse in Flexural Member	A bending moment of 0.3 times the member design capacity in bending.

Clause	Code Provision
10.12.1	Lug angles connecting outstanding leg of a channel shaped member, shall as far as possible be disposed symmetrically with respect to the section of the member.
10.12.2	In the case of angle members, the lug angles and their connections to the gusset or other supporting member shall be capable of developing a strength not less than 20% in excess of the force in the outstanding leg of the member and the attachment of the lug angle to the main angle shall be capable of developing a strength of not less than 40% in excess of the force in the outstanding leg of the angle
10.12.3	In the case of channel member and the like, the lug angle and their connection to the gusset or other supporting member shall be capable of developing a strength not less than 10% in excess of the force not accounted for by the direct connection of the member and the attachment of the lug angles to the member shall be capable of developing 20% in excess of that force.
10.12.5	The effective connection of the lug angle shall as far as possible terminate at the end of the member connected and the fastening of the lug angle to the main member shall preferably start in advance of the direct connection of the member to the gusset or other supporting member.

Following are the clauses of IS 800 : 2007 that are associated with Design of Tension Member.

Clause	Code Provision
6.2	It gives the design strength due to yielding of gross section $T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$ A_g = gross are of cross-section f_y = yield stress of material. $\gamma_{m0} = 1.1$
6.3	f_y = yield stress of material $V_{m0} = 1.1$
6.31	It gives the design strength due to rupture of critical section $T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ $\gamma_{m1} = 1.25$, f_u = ultimate stress of material A_n = Net effective area of the member = $\left[b - n.d_0 + \sum_i \frac{p_{si}^2}{4g_i}\right]t$
6.32	Design strength of threaded rod in tension is given by $T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}}$ A_n = net root area at the threaded section
6.33	It gives the design rupture strength of single angles connected through one leg. $T_{dn} = \frac{0.9 A_{nc} f_u}{\gamma_{m1}} + \frac{\beta A_{g0} f_y}{\gamma_{m0}}$ where, $\beta = 1.4 - 0.076\left(\frac{W}{t}\right)\left(\frac{f_y}{f_u}\right)\left(\frac{b_s}{L_c}\right)$ $\leq \frac{0.9 f_u \gamma_{m0}}{f_y \gamma_{m1}} \geq 0.7$  $b_s = W + W_1 - t$ where w = outstand leg width b_s = shear leg width L_c = Length of the end connection, that is distance between the outermost bolts in the end joint measured along the load direction or length of weld along the load direction  $b_s = W$
6.4	Give the block shear strength (a) For Bolted Connection $T_{db} = \left[\frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}\right]$ $T_{db} = \left[\frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}\right]$ smaller of the two

Following are the clauses of IS 800 : 2007 that are associated with Design of Compression Member.

Clause	Code Provision
7.1.2.1	Gives the design compressive stress $f_{cd} = \frac{\chi f_y}{\gamma_{m0}} \leq \frac{f_y}{\gamma_{m0}}$ χ = stress reduction factor, for different buckling class, slenderness ratio and yield stress. $= \frac{1}{\left[\phi + \left(\phi^2 - \lambda^2\right)^{1/2}\right]}$ $\lambda = \sqrt{\frac{f_y}{f_{cc}}} = \sqrt{\frac{f_y\left(\frac{KL}{r}\right)^2}{\pi^2 E}}$ $\phi = 0.5\left[1 + \alpha(\lambda - 0.2) + \lambda^2\right]$ α = Imperfection factor based on buckling class. Buckling Class: a, b, c, d α: 0.21, 0.34, 0.49, 0.76
Table 11	Gives the effective length of prismatic columns.
Table 10	Gives the classification of section under different Buckling class (a, b, c, d)
7.3.2	According to it the gross sectional area shall be taken as the effective cross-sectional area for all compression member except those which are classified as class 4 (slender) section. For such section effective section area is calculated either by following the provisions of IS 801 to account for the post-local buckling strength or by deducting width of the compression plate element in excess of the semi-compact (class-3) limit.
7.3.4.1	Splices should be located as close to the point of inflection as possible. Otherwise their capacity should be adequate to carry the magnified moments.
7.4.1	The maximum bearing pressure under a column base should not exceed the bearing strength equal to $0.6 f_{ck}$, where f_{ck} is the smaller of characteristics cube strength of concrete or bedding material.
7.4.3.1	The minimum thickness, t_s of rectangular slab bases, supporting columns under axial compression shall be $t_s = \sqrt{\frac{2.5W\left(a^2 - 0.3b^2\right)\gamma_{m0}}{f_y}} > t_f$ where. w = uniform pressure from below on the slab base under the factored load axial compression. a, b = larger and smaller projection respectively beyond, the rectangle circumscribing the column. t = flange thickness of compression member.
7.6.1.5	The effective slenderness ratio of laced column shall be taken as 1.05 times the actual maximum slenderness ratio, in order to account for shear deformation.
7.6.2	The minimum width of the lacing bar shall be three times the nominal diameter of the end bolts.

Clause	Code Provision
7.6.2	The minimum width of the lacing bar shall be three times the nominal diameter of the end bolts.
7.6.3	The thickness of the flat lacing bar shall not be less than 1/40th of its effective length for single lacing and 1/60th for double lacings.
7.6.4	Lacing bars shall be inclined at an angle not less than 40° nor more than 70° to the axis of the built up member.
7.6.5	The maximum spacing of lacing bars shall be such that the maximum slenderness ratio of the components of the main member between consecutive lacing connections is not greater than 50 or 70 times the most unfavourable slenderness ratio of the member as a whole, whichever is less.
7.6.6.1	The lacing shall be proportional to resist a total transverse shear V_t at any point in the member, equal to at least 2.5% of the axial force in the member and shall be divided equally among the transverse lacing systems in parallel planes.
7.6.6.3	The slenderness ratio KL/r, of the lacing bars shall not exceed 145. In bolted/riveted connection In single lacing K = 1.0 For double lacing K = 0.7 For welded construction K = 0.7
7.7.1.4	The effective slenderness ratio of battened columns shall be taken as 1.1 times the actual slenderness ratio.
7.7.2.1	Battens shall be designed to carry the bending moment and shear force arising from transverses shear force V_t equal to 2.5% of the total axial force on the whole compression member, divided equally between parallel planes of battens. Shear to be resisted $V_b = \frac{V_t C}{NS}$ Moment to be resisted $M = \frac{V_t C}{2N}$ where, C = distance between c/c of battens longitudinally N = number of parallel planes of battens S = minimum transverse distance between the centroid of the rivet/bolt group/welding connecting batten to the main member.
7.7.2.3	When plates are used for battens, the end battens shall have an effective depth, longitudinally not less than the perpendicular distance between centroids of the main members. The intermediate battens shall have an effective depth of not less than 3/4th of this distance but in no case effective depth of any batten be less than twice the width of one member in the plane of the battens. The thickness of battens or the tie plates shall not be less than 1/50th of the distance between the innermost connecting line of rivets bolts or welds perpendicular to the main member.
7.7.3	The spacing of battens shall be such that the slenderness ratio of any component over that distance shall not be more than 50 nor shall be greater the 0.7 times the slenderness ratio of the member as a whole about the axis parallel to the battens.
7.8.1	Compression members composed of two angles, channels or tees back to back in contact or separated by a small distance shall be connected together by riveting bolting or welding so that the ratio of most unfavourable slenderness ratio of each member between the intermediate connections is not greater than 40 or 0.6 times the most unfavourable slenderness ratio as a whole.