CVL 342 Steel Design

Minor 1

07/02/2018

Q1. Draw the following stress strain diagram with important points and values. 10

a) M20, M40, M80 Concrete in one diagram

b) Steel as in your Experimental Lab along with High strength steel with max load of 800 MPa. Define yield strength, peak strength and proof stress.

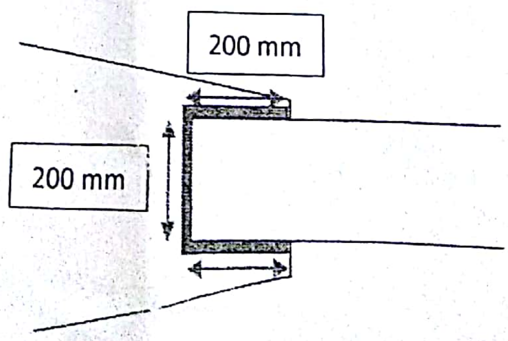
Q2. Explain the process of design of a structure for Dead load, live load, earthquake load and wind load. How are members designed after that? 10

Q3. Explain different between Normal Bolt, Rivet and High strength Friction Grip Bolt. Which two are used for fatigue resistance design with one application? 10

Q4. Two plates on 140 mm width 12 mm thickness Yield strength 250 MPa and Ultimate strength of 410 MPa are connected with Lap joint with bolt of grade 4.6 Fub = 400 MPa in rectangular arrangements with n x m number of bolts (regular pattern only). Design and Draw proper diagram. 20

Last Digit of Roll No	Bolt Dia Q 4
1,4,7,0	16 mm
2,5,8	18 mm
3,6,9	20 mm

Q5. A plate of Yield strength 250 MPa and Ultimate strength of 410 of 10mm thickness as shown in figure is connected to the gusset plate with weld size 6 mm of Fu 410 MPa (check min and max size allowed) with Site welding. Design for maximum allowable strength using slot joint in addition to weld shown by the shaded area. 20



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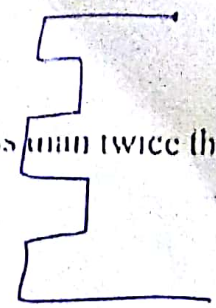


6.10.4 Slot or Plug Welds

Longitudinal fillet welds in slots should be considered as having the same strength as ordinary longitudinal fillet weld. In addition, the following points should be considered (IS 816 : 1969).

should not be less

(a) Width or diameter of the weld should be less than three times the thickness or 25 mm, whichever is greater.

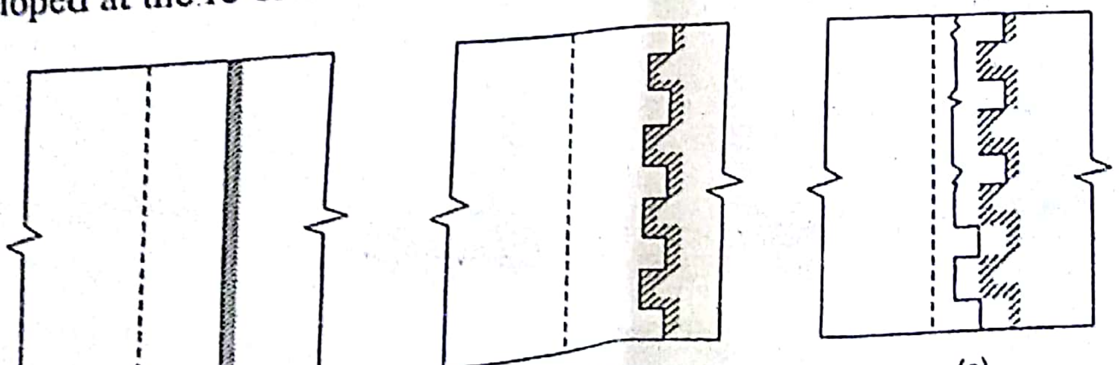
(b) Corners at the enclosed ends or slots should be rounded with a radius not less than 1.5 times the thickness or 12 mm, whichever is greater.

(c) The distance between the edge of the part and the edge of the slot or hole or between adjacent slots or holes, should be not less than twice the thickness and not less than 25 mm for holes.

2t

(d) A combination of plug weld and other types of welds is permissible and the strength of the joint is the sum of the individual capacities of the welds.

Slots if provided should be set back behind the beginning of the welds on the edges of the plate to ensure that the effective area of the plate is not reduced and that the deposition of slots does not lead to serious stress concentration. Thus, the joint shown in Fig. 6.44(b), may appear to have higher strength than the one in Fig. 6.44(a); however it fails at a smaller load due to the high stress concentration developed at the re-entrant angles of the notches.



(a) (b) (c)

Fig. 6.44 Wrong method of increasing length of fillet welds by means of square slots
(a) Joint with fillet weld
(b) Joint with slot and fillet weld
(c) Failure of the joint shown in (b)

Scanned by CamScanner

>3m square 1.5

6. **Effective length of a fillet weld = (actual length −2s) ≥ 4s**
7. **Length of end returns should not be less than 2s (Figure 2.8).**
8. **In lap connections, the minimum length of the weld should not be less than 4 times the thickness of the thinner part joined or 40 mm – whichever is more. If only side fillets are used, the length of the weld on either edge should not be less than the transverse spacing between the welds.**
9. **The throat thickness of the end fillet weld, normal to direction of force, should not be less than 0.5t where t is the thickness of the part.**
10. **For intermittent fillet welds,**

 effective length (wl) ≥ 4s or 40 mm, whichever is greater
 clear spacing (uwl) ≤ 12t (for compression)
 ≤ 16t (for tension)
 ≤ 200 mm

 where t is thickness of thinner part joined.
11. Design shear strength of a fillet weld, $f_{wd} = f_{wn}/\gamma_{mw}$ (2.2)

 where f_{wn} = nominal shear strength of fillet weld

 $= \dfrac{f_u}{\sqrt{3}}$, f_u being the ultimate strength of the weld or the parent metal

 γ_{mw} = partial safety factor
 = 1.25 for shop welding
 = 1.5 for site welding

Bolted Connection

V_{nsb} = the nominal shear capacity of a bolt

$$= \frac{f_{ub}}{\sqrt{3}}(n_n A_{nb} + n_s A_{sb})$$

where

f_{ub} = the ultimate tensile strength of the bolt
n_n = the number of shear planes within the threading of a bolt
n_s = the number of shear planes within the shank of a bolt
A_{sb} = the sectional area of the shank of a bolt (Table 2.2)
A_{nb} = the net shear area of a bolt (Table 2.2)
γ_{mb} = the partial safety factor for bolts = 1.25

2.4.2.2 Bearing Capacity of a Bolt

The design strength of a bolt in bearing V_{dpb} is given by

$$V_{dpb} = V_{npb}/\gamma_{mb}$$

where V_{npb} = the nominal bearing strength of a bolt

$$= 2.5 k_b\, d t f_u$$

k_b is the smallest of $\dfrac{e}{3d_0}, \left(\dfrac{p}{3d_0} - 0.25\right), \dfrac{f_{ub}}{f_u}, 1.0$

e = end distance
p = pitch
d_0 = diameter of the hole
f_{ub} = ultimate tensile strength of the bolt
f_u = ultimate tensile strength of the plates
d = nominal diameter of the bolt
t = least thickness of connection parts or plates

6. Effective length of a fillet weld = (actual length $-2s$) $\geq 4s$
7. Length of end returns should not be less than $2s$ (Figure 2.8).
8. In lap connections, the minimum length of the weld should not be less than 4 times the thickness of the thinner part joined or 40 mm – whichever is more. If only side fillets are used, the length of the weld on either edge should not be less than the transverse spacing between the welds.
9. The throat thickness of the end fillet weld, normal to direction of force, should not be less than $0.5t$ where t is the thickness of the part.
10. For intermittent fillet welds,

effective length (wl) $\geq 4s$ or 40 mm, whichever is greater
clear spacing (uwl) $\leq 12t$ (for compression)
$\leq 16t$ (for tension)
≤ 200 mm

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where f_{wn} = nominal shear strength of fillet weld

$= \frac{f_u}{\sqrt{3}}$, f_u being the ultimate strength of the weld or the parent metal

γ_{mw} = partial safety factor
= 1.25 for shop welding
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$$= 2.5 k_b d t f_u$$

k_b is the smallest of $\frac{e}{3d_0}, \left(\frac{p}{3d_0} - 0.25\right), \frac{f_{ub}}{f_u}, 1.0$

e = end distance
p = pitch
d_0 = diameter of the hole
f_{ub} = ultimate tensile strength of the bolt
f_u = ultimate tensile strength of the plates
d = nominal diameter of the bolt
t = least thickness of connection parts or plates

Sectional area of shank (A_{sb}) and net [illegible] (A_{nb}) of bolts

Bolt designation	M12	M14	M16	M18	M20	M22	M24	M27	M30	M33	M36	M39
Nominal diameter, d in mm	12	14	16	18	20	22	24	27	30	33	36	39
A_{sb} (mm^2)	113	154	201	255	314	380	453	573	707	855	1018	1195
A_{nb} (mm^2)	84	115	157	192	245	303	353	459	561	694	817	976

$A_{sb} = \pi d^2/4$; Values of A_{nb} are from IS 1367 (Part 3):2002

2.4.2.3 Tension Capacity of Plate

The design strength of a plate in tension due to rupture at the net section

$$T_{dn} = 0.9\, A_n f_u / \gamma_{m1} \tag{2.5}$$

A_n = the net sectional area of the plates
f_u = the ultimate tensile strength of the plates
γ_{m1} = the partial safety factor = 1.25

2.4.2.4 Design Strength Due to Block Shear

The block shear strength T_{db} of the bolted connection is the least of

$$T_{db} = \frac{A_{vg} f_y}{\gamma_{m0}\sqrt{3}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}} \quad \text{or} \quad T_{db} = \frac{0.9 A_{vn} f_u}{\gamma_{m1}\sqrt{3}} + \frac{A_{tg} f_y}{\gamma_{m0}} \tag{2.6}$$

where
A_{vg}, A_{vn} are the minimum gross and net areas in the shear along the bolt line parallel to the line of action of force, respectively (along 1–2–3 and 4–5–6 in Figure 2.16).
A_{tg}, A_{tn} are the minimum gross and net areas in tension from the bolt hole to the edge of a plate or between bolt holes, perpendicular to the line of action of the force, respectively (along 3–4 in Figure 2.16).
f_u, f_y are the ultimate and yield strengths of the material of the plates, respectively.

2.4.2.5 Tension Capacity of a Bolt

The design strength of a bolt in tension T_{db} is the least of

(i) the design strength of the bolt due to the yielding of the gross section (i.e., the shank)

$$T_{dbg} = f_{yb} A_{sb} / \gamma_{m0} \tag{2.7}$$

(ii) the design strength of the bolt due to the rupture at the net section, (i.e., at the root of the threads)

$$T_{dbn} = 0.9 f_{ub} A_{nb} / \gamma_{mb} \tag{2.8}$$

where f_{ub} = the ultimate tensile strength of the bolt material
f_{yb} = the yield strength of the bolt material
A_{nb} = the net tensile stress area (Table 2.2)
A_{sb} = the sectional area of the shank of the bolt (Table 2.2)

2.4.2.6 Bolt Subjected to Combined Shear and Tension

A bolt subjected to shear and tension simultaneously should satisfy the condition

$$\left(\frac{V_{sb}}{V_{db}}\right)^2 + \left(\frac{T_b}{T_{db}}\right)^2 \le 1.0 \tag{2.9}$$

2.4.2.7 Other Specifications

1. The diameter of the hole should be the nominal diameter of the bolt plus the clearance as given below.

The nominal diameter of the bolt (mm) :	12 – 14	16 – 24	>24
The standard clearance (mm) :	1.0	2.0	3.0

2. The minimum pitch: The distance between the centres of the bolts in the direction of stress should not be less than 2.5 times the nominal diameter of the bolt.
3. The maximum pitch:
   (i) $32t$ or 300 mm, whichever is less for the bolts in members including the tacking bolts,
   (ii) $16t$ or 200 mm, whichever is less for the bolts in tension members,
   (iii) $12t$ or 200 mm, whichever is less for the bolts in compression members where t is the thickness of the thinner plate.
4. The edge and end distances:
   (i) The minimum edge and end distances from the centre of any hole to the nearest edge of a plate should not be less than 1.7 times the hole diameter for sheared or hand-flame cut edges; and 1.5 times the hole diameter for rolled, machine-flame cut, sawn and planed edges.
   (ii) The maximum edge distance from the centre of the hole to the nearest edge should not exceed $12t\varepsilon$, where $\varepsilon = \left(\frac{250}{f_y}\right)^{1/2}$ and t is the thickness of the thinner outer plate.
5. Tacking bolts:
   These are the additional bolts provided other than strength consideration. They are usually provided to inter-connect two or more members. The maximum pitch of these bolts should be $32t$ or 300 mm, whichever is less, where t is the thickness of the thinner plate. If the members are exposed to weather, the pitch should not exceed 16 times the thickness of the outside plate or 200 mm, whichever is less.

2.4.3.1.2 *Slip Resistance*

The design frictional force produced by a bolt at the interfaces of the connecting parts is given by

$$V_{dsf} = V_{nsf}/\gamma_{mf} \quad (2.10)$$

where V_{nsf} = the nominal frictional capacity produced by a bolt

$$= \mu_f\, n_e\, K_h\, F_0$$

in which

μ_f = the coefficient of friction or slip factor which depends on the treatment of interfaces (refer Table 20 of IS 800:2007). For sand blasted interfaces, $\mu_f = 0.48$

n_e = the number of effective interfaces offering frictional resistance

K_h = 1.0 for standard clearance

γ_{mf} = 1.10 for slip resistance designed at a service load

= 1.25 for slip resistance designed at the ultimate load

F_0 = the minimum bolt tension (proof load) = $A_{nb} f_0$

A_{nb} = the net tensile stress area of the bolt (Table 2.2)

f_0 = the proof stress = $0.7 f_{ub}$

f_{ub} = the ultimate tensile strength of the bolt material

If the holes are staggered at close pitch (Figure 3.4(b)), the net effective area is obtained multiplying the net effective width b_e with the thickness t of the plate or flat. The net effective width b_e is obtained using the following expression.

$$b_e = b - nd_0 + n_1 \frac{p^2}{4g} \quad ($$

where p = staggered pitch

g = gauge

n = number of holes

n_1 = number of inclined lines between the holes

d_0 = diameter of the hole

For example, in Figure 3.4(b), $n = 4$ and $n_1 = 3$.

Again, the net sectional area of the flat, $A_n = b_e\, t$.