A COMPARATIVE STUDY ON RIGID CONNECTION DESIGN OF FRAMED MULTI STOREYED STEEL BUILDING BASED ON IS CODE AND AISC

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Abstract - *Connections are crucial to any steel structure, which is vital to form stability to support heavy loads and withstand lateral forces. The major connections in multi storied steel structures are column to beam moment connection, beam to beam shear connection and also the connection of column to the baseplate. Connection design is the most critical and also the time-consuming stage of designing. In this paper a G+2 multi storied steel building for a hotel is analyzed with several loading conditions including dead load, live load, wind load and seismic load using a software and it has been designed for safety and serviceability based on Indian standard codes. The connection design has been done manually based on Indian standard codes and also using a software based on American standard codes. The results obtained from the software and manual calculation are compared.*

Key Words: Steel, design, analysis, foundation, connection design, fin connection, moment connection, IS code, AISC code

1.INTRODUCTION

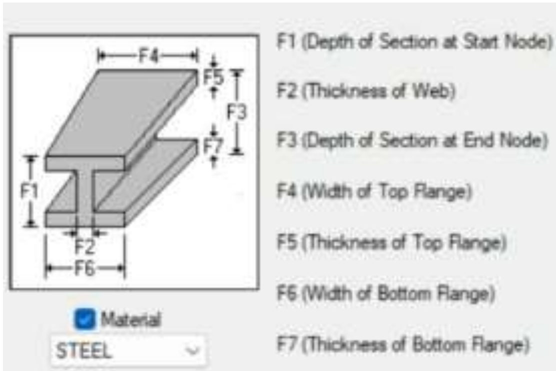
Steel has been used in construction of tall buildings since the 19th Century but nowadays steel has become an option for smaller buildings and even personal residences. Steel has many advantages over concrete, faster method of construction meaning better for business. Because of its increased durability and low maintenance, it is an attractive building material. Thus, understanding steel and learning how to design steel structures will help to prepare for the future industry. In this paper we are analysing and designing a three storied steel hotel building. And a comparative study of software connection design and manual connection. This Design of Steel Structure teaches about design procedures for steel structure members with and connections. This will broaden knowledge of how to design suitable bolt and welded connections for steel structures.

2. OBJECTIVES OF PROJECT

The main objective is to analyze and design the three storied hotel steel building and its foundation, and designing and comparison of the connection using IS Code and AISC

3. MODELLING AND ANALYSIS

Fig -1: Rendered view of building.



Column

- Depth- 450mm
- Flange width- 300mm
- Flange thickness- 16mm
- Web thickness- 10mm

Primary beam

- Depth- 550mm
- Flange width- 225mm
- Flange thickness- 10mm
- Web thickness- 6mm

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 10 | Oct 2023 www.irjet.net p-ISSN: 2395-0072

Secondary beam

- Depth- 275mm
- Flange width- 250mm
- Flange thickness- 8mm
- Web thickness- 5mm

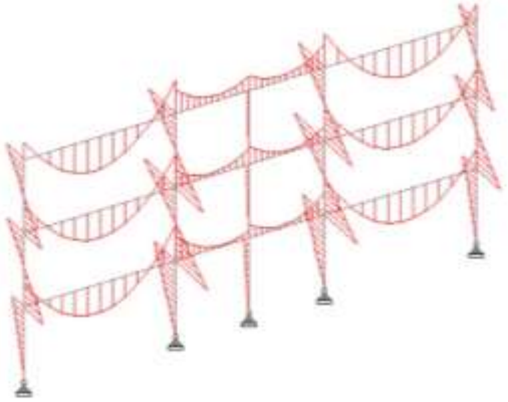


Fig -2: Bending moment diagram

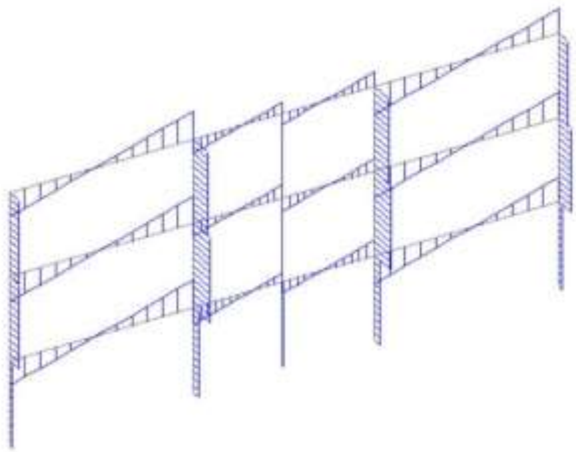


Fig -3: Shear force diagram

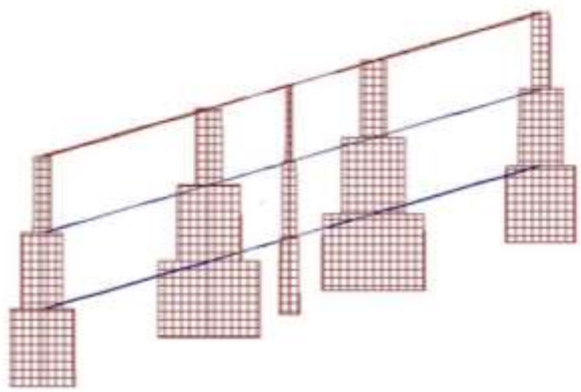


Fig -4: Axial force diagram

4. DESIGNING

4.1 Connection design as per AISC

The connection design as per AISC is carried out using the software IDEASTATICA

Baseplate

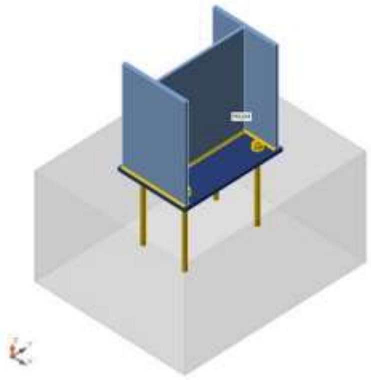


Fig -5: Baseplate connection isometric view

4 number of 20 mm diameter anchor bolt of 4.6 grade with anchor length 400mm is provided to connect a baseplate of size 470×320×20mm to the pedestal. And the column is welded to the baseplate 4.2mm double fillet weld with length of weld 1018mm.

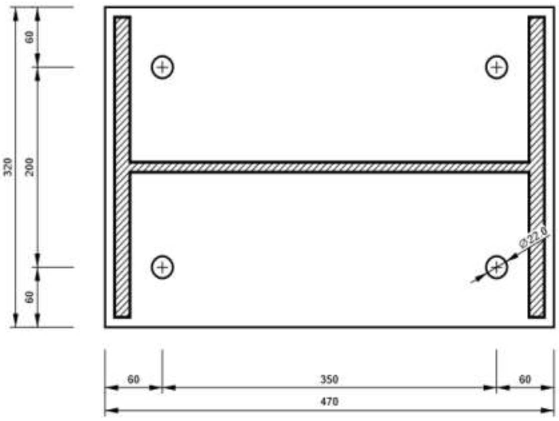


Fig -6: plan of baseplate connection

Moment connection

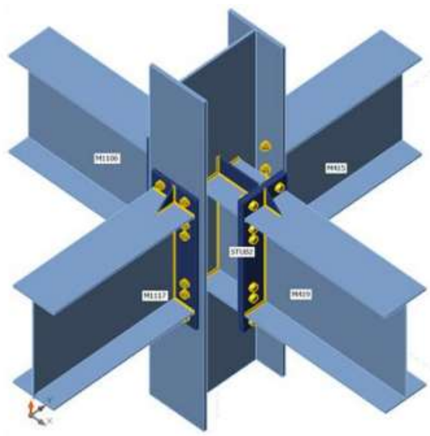


Fig -7: Moment connection

Table -1: Moment connection details

Plate	Type	Throat thickness (mm)	Length (mm)	Bolt
End plate(730×245×16mm)	Double fillet Double fillet	3.5 2.8	900 696	12 no 20mm dia 4.6 grade
Stiffener (90×90×6mm)	Double fillet	2.8	360	
Stiffener (230×90×6mm)	Double fillet	2.8	640	
Stub(730×245×15mm)	Fillet Double fillet	5.7 2.8	450 1060	12 no 20mm dia 4.6 grade

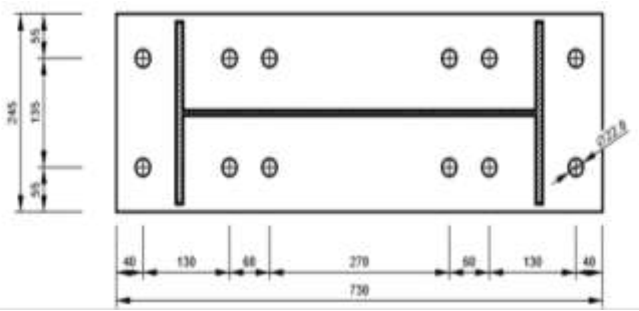


Fig -8: Connection in endplate and stub

Shear connection

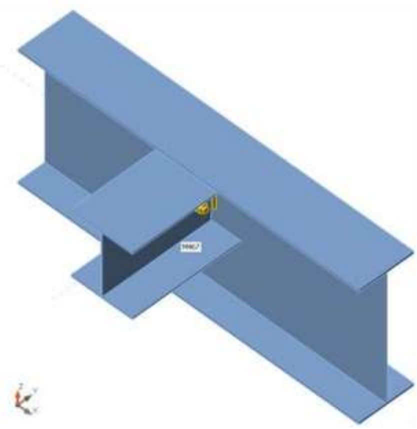


Fig – 9: Shear connection

Table -2: Shear connection details

Plate	Type	Throat thickness (mm)	Length (mm)	Bolt
Fin plate(195×120×12mm)	Double fillet	5.7	195	2 no 20mm dia 4.6 grade
Stiffener(530×109.5×6mm)	Double fillet	2.8	749	

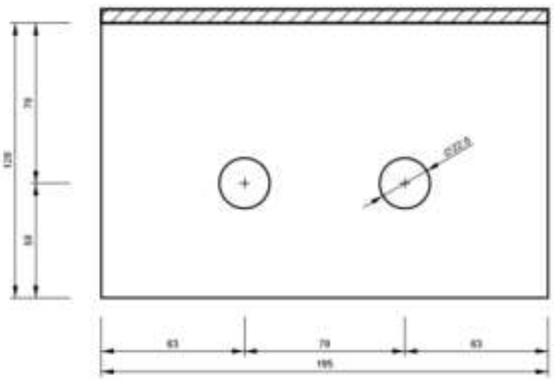


Fig -10: Connection in fin plate

4.2 Connection design as per IS Code

Baseplate

Maximum load = 1378 kN

Column size = 450 x 10 (web)+ 300 x 16 (flange)

Base plate size

i. Depth of section+ 2× thickness of web = 450+ (2 × 10) = 470mm
ii. Width of section + 2 ×thickness of web = 300+ 2× 10= 320 mm

Size of baseplate = 470 × 320 mm

Bearing pressure in concrete

Actual bearing pressure = $\frac{P}{A} = \frac{1378 \times 1000}{470 \times 320}$ = 9.16 N/mm^2

Permissible bearing pressure in concrete = 0.45 × f_{ck} = 0.45 × 25 = 11.25 N/mm^2

Actual bearing pressure is less than permissible limit. Hence assumed baseplate size is ok

Baseplate thickness

Bending moment = $\frac{P(L\times L)}{10}$ = $\frac{9.16\times(450\times450)}{10}$ = 185.5 ×10^3 Nmm

$\frac{M}{I} = \frac{f}{y}$ M = f × $\frac{I}{y}$ = f × Z

M = $\frac{fy}{Y} \times \frac{b\times d\times d}{6} = \frac{fy}{1.1} \times \frac{b\times t\times t}{6}$

6.6 M = f_y ×b × t^2

t = $\sqrt{\frac{6.6M}{fy\times b}} = \sqrt{\frac{6.6\times185.5\times1000}{345\times1}}$ = 60 mm

Provide 4 no of 24mm diameter anchor bolt :-

Anchor capacity

Torsion capacity, T_{dt} = (0.9 f_u× A_m) / Υ_{mb}

= (0.9× 400 × 0.78 × $\pi \times 10^2$) / 1.25

= 70.57 kN

T_{dt} = (f_{yb} × A_{sb}) / Υ_{m0}

= (250 ×$\pi 10^2$)/ 1.1 = 78.54 kN

Torsion capacity of anchor bolt = 70.57 kN

Shear capacity of bolt

V_{dt} = (f_u/√3) × (n_s× A_n) / Υ_{mb}

= (400/√3) × $\pi 10^2$/ 1.25 = 58.04 kN

Large joint effect (B_{ij}) = 58.04 × 0.75 =43.53 kN

Calculation for plate thickness

Bolt tension T_b = T_{nb}/Υ_{mb}

T_{nb} = 0.9xf_{ub}xA_n < f_{yb}xA_{sb}x(Υ_{mb}/ Υ_{m0})

= 0.9x400x (0.78x$\frac{\pi}{4}$x20 ^{2}) < 250 x ($\frac{\pi}{4}$x 20^2) x(1.25/1.1)

= 88.2 kN < 89.25 kN

T_b = 88.2/1.25 = 70.56 kN

Moment M = $\frac{2Tg}{8} = \frac{2\text{x}70.56\text{x}0.1}{8}$ = 1.764 kNm

Thickness of plate, t = $\sqrt{\frac{6.6M}{fy \text{ xb}}} = \sqrt{\frac{6.6\text{x}1.764}{345\text{x}100}}$

= 18.37 mm

Provide baseplate thickness as 20mm

Check for combined shear and tension

From Cl:10.4.6, Pg. no. 77, IS 800-2007

$$\left(\frac{T}{Tdb}\right)^2 + \left(\frac{V}{Vnsb}\right)^{2} < 1$$

Tension in bolts due to moment = $\frac{M}{leveram\ distance}$ = $\frac{185.5\text{x}1000}{450-16}$ = 427.42 kN

Tension in each bolt = $\frac{427.42}{2}$ = 213.7 kN

Shear in each bolt = $\frac{6.8}{4}$ = 1.7 kN

Combined shear and tension = $\left(\frac{70.56}{213.7}\right)^2 + \left(\frac{1.7}{43.53}\right)^2$

= 0.11 < 1 hence safe

Calculation of imbedded length of anchor bolt

Design for stress in limit state method for plain bars in tension

T = τ_{bd}xπxdxL

τ_{bd} = 1.44 N/mm² for M25 grade concrete

Tension in each bolt = 70.56 kN

ie; 70.56x10^3 = 1.4xπx20xL

L = $\frac{70.56\text{x}1000}{1.4\text{x}\pi\text{x}20}$ = 800 mm

Moment connection

Axial force = 58 kn

Shear force Fy = 18.8 kN

Fz = 0 kN `

Moment Mz = 218.85 kNm

Column Section Properties

D = Total Depth = 450 mm

B_f = Flange Width = 300 mm

t_f = Thickness of flange = 16 mm

t_w = Thickness of web = 10 mm

d_w = Clear depth of web (D-2tf) = 418 mm

A_{xb}= Area of section = 137.8 cm2

Beam Section Properties

D_b = Total Depth = 550 mm

B_{fb} = Flange Width = 225 mm

t_{fb} = Thickness of flange = 10 mm

t_{wb} = Thickness of web = 6 mm

d_{wb} = Clear depth of web (D-2tf) = 530 mm

A_{xb}= Area of section = 81.8 cm2

Grade of steel FE410

f_y = Yield stress = 300 N/mm2

f_u = Ultimate Tensile stress = 410 N/mm2

E.D = 40 mm, Gauge g =135 mm, Pitch =60 mm

Bolt Properties Using 20 mm Dia Bolts with 8.8 Grade

Hole Dia Do = 22 mm

f_{yb} = 660 N/mm2, f_u = 830 N/mm2

Net Area of Bolt = 245.044 mm2

Weld thickness for Beam web to Column = 5.7 mm

Weld thicness for Stiffener to Beam = 2.8 mm

Weld thickness for Stiffener to Column = 2.8 mm

End Plate Thickness = 16 mm

1) CHECK FOR TENSION IN TOP OR BOTTOM FLANGE

T = $\frac{M}{D-thickness\ of\ flange}$ = $\frac{218.85\ X\ 1000}{550-10}$ = 405.27 kN

Tension Capacity of the Flange = $\frac{Ag*Fy}{1.1}$ = $\frac{(300\ X\ 16) X\ 300}{1.1}$ = 1309 kN

Hence safe

Shear Capacity of Flange for Fz = $\frac{Av\ X\ Fy}{\sqrt{3}\ X\ 1.1}$ = $\frac{(300\ X\ 16)X300}{\sqrt{3}\ X\ 1.1}$ = 755.804 kN

$\frac{T}{Td} + \frac{V}{Vd} = \frac{405.27}{1309}$ = 0.31

FLANGE IS SAFE

2) EVALUATION OF WELD AT FLANGES AND WEB

a) Determine weld size around flange

Length of weld available in flange = 2 xB_f-t_w = 2 x225 - 6 = 444 mm

From Cl:10.5.7, Pg. no.: 79, IS 800- 2007

Design strength of Shop fillet weld 'f_{wd}'= $\frac{fwn}{(\sqrt{3}\ X\ \gamma mw)}$ =$\frac{410}{(\sqrt{3}\ X\ 1.25)}$ = 189.4 N/mm2

Force per mm length = $\frac{189.4}{444}$ = 0.42 kN/mm

Weld Strength for Size 5.7 double fillet weld = 0.707X5.7 X189.4 = 0.763 kN /mm

WELD SIZE IS OK

Provide 5.7mm fillet weld for the Beam Flange

b) Determine weld size around web

Resultant shear = 18.8 kN

Length of weld available =2D - 4t_f = 2 X 550 – 4 X 16 =1036 mm

Checking the size of weld = 5.7 mm fillet weld

Weld capacity = 0.7x5.7x189.4x1036 = 782.9 kN > 18.8 KN

Therefore, 5.7 mm fillet weld to the Web

3) TO DETERMINE THE SIZE & NUMBER OF BOLTS

REQUIRED

a) Tension capacity of bolt Tb

Tension on each bolt= 405.27/4 = 101.3 KN

From CL:10.3.5, Pg. no.:76, IS 800-2007

Tension capacity of 20 dia 8.8 grade bolts

= (0.9 x f_{ub} x A_n) < (f_{yb} x A_{sb} x (γ_{mb}/ γ_{mo}))

= (0.9x830x245.04) < (660 x314.16 x$\frac{1.15}{1.1}$)

= 183.04 < 216.7 kN SAFE

Design capacity of bolt, T_b = 183.04/1.25 = 146.43 kN

b) Shear capacity of bolt 'V_{dsb}'

Shear force in each bolt= (18.8/8) = 2.35 kN

Shear capacity of bolt 'V_{dsb}' = $\frac{\frac{fu}{\sqrt{3}} \text{ x (Nn x Anb+Ns Asb)}}{\gamma mb}$= ($\frac{410}{\sqrt{3}}$ x (2 x 0.78 x 314.16))/1.25

= 92.8 kN SAFE IN SHEAR

Bearing capacity of bolt 'Vdpb' = 2.5 kb x d x t x fu

=2.5x0.66x20x16x410/ 1.25

= 173.2 kN SAFE

4) CHECK BOLTS SUBJECT TO COMBINED SHEAR & TENSION

$$\left(\frac{T}{Tdb}\right)^2 + \left(\frac{V}{Vnsb}\right)^2 = \left(\frac{101.3}{146.43}\right)^2 + \left(\frac{2.35}{92.8}\right)^2$$

= 0.45

0.45 < 1 HENCE SAFE

5) CHECK END PLATE FOR MOMENT

Distance between bolt centre to flange edge of beam, L_0= 57mm

Tension in each bolt = 101.3 kN

Moment at edge of the flange = tension in bolt x L_0 = 101.3 x 57 = 5.77 kNm

Thk. Of plate, t = $\sqrt{\left(\frac{4xM}{\left(\frac{fy}{1.1}\right)x2L}\right)} = \sqrt{\left(\frac{4x5.77}{\left(\frac{300}{1.1}\right)x2x130}\right)}$ = 18 mm

Therefore, Provide 18 mm thick End plate.

6) GROSS SHEAR CAPACITY OF PLATE

Gross shear area= Perimeter of I section x thickness of endplate

= (40+(2 x130) + 550+ (2 x130) +40) x 18 = 62820 mm2

Design shear strength of end plate = $\frac{\text{gross shear area x}\frac{fy}{\sqrt{3}}}{1.25}$

$$= \frac{62820 \text{ x} \frac{300}{\sqrt{3}}}{1.25} = 8704.6 \text{ kN} > 2.35 \text{ kN}$$

SAFE

7) DESIGN OF STIFFENER PLATE

Tensile force transferred to flanges=2 x101.3= 202.6 kN

B. M. = 202.6 x 10^3x40 = 8.1 x10^6 N.mm

B. M. =8.1x10^6x0.4= 3.24 x 10^6 N.mm

thk. Of plate =6 mm & depth =90 mm

Section modulus of plate= (6 x90^2) / 6 =8100 mm^3

Shear in the Stiffener =81.04 kN

Shear Stress = (81.04 x 10^3)/ (6 x 90) = 150 N/mm2

M/Z = (3.24 x 10^6)/ 8100 = 400 N/mm2 SAFE

a) Check Tension Capacity of the Stiffener

Tension in the Stiffener = 81.04 kN

Tension Capacity = KN SAFE

b) Check weld between stiffener & End Plate

Tension Force in the Stiffener =202.6 x 0.4 =81.04 kN

Weld length available =90 mm

3.5 mm double fillet weld, strength of the stiffener = 0.707 x 3.5 x2 x189.4 x90 = 84.4 kN

3.5 mm double fillet weld between Stiffener & End Plate

SUMMARY

End plate = 730 mm X 245 mm x18 mm

Bolts = 8 Nos 20 mm Dia Bolts

Stiffeners = 6 mm thick stiffeners

Weld = provide 5.7 mm fillet weld for the Beam Flange

Provide 2.8 mm double fillet Weld to Stiffener & Flange

Shear connection

Secondary beam

1) flange = 250 mm ✕ 8 mm

2) web = 259 mm ✕ 5 mm

Shear force acting = 17.72 kN

Assume 2 Nos 20 mm ø (high strength bolt grade 4.6)

Grade of steel = 345 N/mm^2

Force in each bolt (shear) = $\frac{17.72}{2}$ = 8.86 kN

Spacing of bolt (pitch) as code = 2.5 d

Pitch = $2.5 \times 20 = 50$ mm

Provided pitch = 60 mm (from bolt fixing erection considered)

Minimum edge distance = 1.5 d

e = $1.5 \times 20 = 30$ mm

provide edge distance = 40 mm (from bolt fixing erection considered)

connecting plate thickness = 10 mm

welded to web of secondary beam and primary beam to transfer the shear force from secondary to primary beam.

Design strength of bolt

1) Design strength of bolt in bearing based on connecting plate as per IS 4000:1992

Nominal bearing strength V_{dpb} = $1.2 \times d \times t \times f_y$

d = 20 mm t = 10 mm f_y = 345 N/mm²

V_{dpb} = $1.2 \times 20 \times 10 \times 345$ = 82800 N = 82.8 kN

Bearing capacity of bolt = $\frac{V_{dpb}}{\gamma_{mb}} = \frac{82.8}{1.25}$ = 66.24 kN

2) design strength of bolt based on edge distance of bolt hd_e in the direction of the minimum distance towards edge of ply shall not exceed $\frac{e f_y t}{1.4}$ as per IS 4000 :1992

$V_{dpb} = \frac{e f_y t}{1.4}$

e = 40 mm f_y = 345 N/mm² t = 10 mm

$V_{dpb} = \frac{40 \times 345 \times 10}{1.4}$ = 98571.43 N = 98.57 kN

Bearing capacity of bolt = $\frac{V_{dpb}}{\gamma_{mb}} = \frac{98.57}{1.25}$ = 78.86 kN

4) shear capacity of bolt

$$v_{dsb} = \frac{v_{nsb}}{\gamma_{mb}}$$

where $V_{nsb} = \frac{f_u}{\sqrt{3}}(n_n A_{nb} + n_s A_{sb})$

f_u = 400 N/mm² $A_{nb} = 0.78 \times \frac{\Pi \times 20^2}{4}$ n_n = 1

n_s = 0

$= \frac{400}{\sqrt{3}} \times \left(1 \times 0.78 \times \frac{\Pi \times 20^2}{4} + 0\right) =$ 56590.54 N

V_{dsb} $= \frac{56590.54}{1.25}$ = 45272.43 N

= 45.27 kN

Long joint effect (β_{ij}) = 0.75

Shear capacity of bolt = 45.27 × 0.75 = 33.95 kN

5) bearing capacity of bolt

$V_{dpb} = \frac{v_{npb}}{\gamma_{mb}}$

Where V_{npb} = 2.5 K_b d t f_u

d = 20 mm t = 10 mm f_u = 490 N/mm²

e = 40 mm p = 60 mm d_o = 22 mm

k_b is smaller value of $\frac{e}{3d_0}, \frac{p}{3d_0}$ - 0.25, $\frac{f_{ub}}{f_y}$

$\frac{e}{3d_0} = \frac{40}{3 \times 22}$ = 0.60

$\frac{p}{3d_0}$ - 0.25 = $\frac{60}{3 \times 22}$ – 0.25 = 0.65

$\frac{f_{ub}}{f_y} = \frac{400}{490}$ = 0.81

Therefore k_b = 0.60

V_{npb} $= 2.5 \times 0 \cdot 60 \times 20 \times 10 \times 490$ = 147000 N

V_{dpb} $= \frac{147000}{1.25}$ = 117600 N = 117.6 kN

Over size and short slotted hole = 0.70

V_{dpb} = 117.6 × 0.70 = 82.32 kN

Shear capacity of bolt is least of these values

Therefore, shear capacity of bolt = 33.95 kN

Required shear capacity = 17.72 kN

Hence assume 2 Nos of 20 mm ø bolt with 10 mm thick connecting plate.

Weld capacity of connecting plate

Connecting plate thickness = 10 mm

Weld size assume (S) = 6 mm

Effective weld size = 0.7S = $0.7 \times 6 = 4.2\, mm$

Design strength of fillet weld $f_{wd} = \frac{f_{wm}}{\gamma_{mw}}$

$F_{wm} = \frac{f_u}{\sqrt{3}} = \frac{400}{\sqrt{3}} = 230.94$ N/mm²

$F_{wd} = \frac{230.94}{1.25} = 184.75$ N/mm²

Weld length = 190 $\times$ 2 = 380 mm (L_w)

Weld capacity = $f_{wd} \times L_w \times t$ = 184.75 $\times$ 380 $\times$ 4.2 = 294861 N = 294.86 kN

Required weld capacity = 17.72 Kn

5. RESULT AND DISCUSSION

Design of connections are done using software and manually. Considered main connections are beam to beam connection (shear connection), moment connection (beam to column connection) and baseplate to the column connection.

By comparing the manual design and software design of each connections the following results are observed.

Baseplate

• In software design we have obtained size of baseplate as 470×320×20mm, connected with 4 number of anchor bolt of 20mm diameter with anchor length 400mm.

• In manual designing 4 number of anchor bolt of diameter 20mm in anchor length of 800mm is used to connect the baseplate of size 470×320×20mm to the pedestal.

Moment connection

• Column and beams are connected by means of endplate, stub and stiffeners in software design. Endplates are welded to the flanges of beam in major axis and stub to the beams in minor axis. And these are connected to the column by 12 number of 20mm diameter bolt.

• In manual calculation the beams are welded to endplates and connected to column with 8 number of 20mm diameter bolt.

Shear connection

• Primary and secondary beams are connected using fin plates welded to the primary beam and bolted to the secondary beam.

• In software design 5.7mm double fillet weld is provided for connecting the 12 mm fin plate to the web of primary beam and 2 numbers of 20 mm diameter bolt is used for the connection of fin plate to secondary beam.

• In manual design a 10 mm fin plate is connected to the primary beam with 4.2 mm weld and to the secondary beam fin plate relates to 2 numbers of 20 mm diameter bolt

6. CONCLUSIONS

A functionally suitable steel structure considering all the specifications as per IS codes is analyzed and designed. The structure is analyzed with dead load, live load, wind load and seismic load. The design is found to be safe in strength.

Connection designs are done using software and manually. The software and manual designs are then compared. Software designs are done based on AISC code and manual designs are done based on IS codes. There are slight variations in the results may be due to the assumptions and factor of safety in both codes. However manual design procedures are more accurate even if it takes comparatively more time than the software design.

REFERENCES

[1]. Sharma, V., Kumar, R., Singh, H., Ahmad, W., & Pratap, Y. (2017). A Review Study on uses of steel in construction. International Research Journal of Engineering and Technology, 4(4), 1140-1142.

[2]. Madhav, P. V., Ragnesh, R., Kumar, A., Shekar, M. C., & Kumar, B. S. Analysis And Design Of Residential Building Stilt (G+ 4) Using Staad Pro.

[3]. Dhiman, S., Thakur, N., & Sharma, N. K. (2019). A Review on Behaviour of Columns of Steel Framed Structure with Various Steel Sections.

[4]. Meshram, P. K. S., Kumbhare, S., Thakur, S., Mate, D., Moundekar, A., & Waghmare, R. (2019). Seismic Analysis of Building Using Staad-Pro. International Journal of Innovations in Engineering and Science, 4(5), 17-24.

[5]. Verma, A. (2023, February). Dynamic Analysis of Irregular Multi-Storied building using Staad pro. In IOP Conference Series: Earth and Environmental Science (Vol. 1110, No. 1, p. 012039). IOP Publishing.

[6]. Kulkarni, Y. U., Chandak, P. G., Devtale, M. K., & Sayyed, S. S. (2016). Analysis of Various Steel Bracing Systems

using Steel Sections for High Rise Structures. Int. J. Eng. Technol. Manag. Appl. Sci, 4(6), 220-227.

[7]. Topalakati, P., & Kinnagi, P. M. (2014). Parametric Study of Steel Frame Building with and without Steel Plate Shear Wall. Civil and Environmental Research ISSN, 2224-5790.

[8]. Subramanian, N. (2008). Design of steel structures. Oxford University Press.

[9]. Bhavikatti, S. S. (2009). Design of Steel Structures (By Limit State Method asPer Is: 800 2007). IK International Pvt Ltd.

[10]. Murray, T. M., & Sumner, E. A. (2003). Extended end-plate moment connections: Seismic and wind applications. American Institute of Steel Construction.

[11]. Fisher, J. M., & Kloiber, L. A. (2006). Base plate and anchor rod design. American Institute of Steel Construction.

[12]. IS 875:1987 Part 1-2 Indian Standard Code for Practice for Design Loads for Buildings and Structures

[13]. IS 875:2015 Part 3 Indian Standard Code for Practice for Design Loads for Buildings and Structures

[14]. IS 800:2007 Indian Standard code of practice for general construction in steel

[15]. IS 1893:2002 Part 1, criteria for earthquake resistant design of structures.

[16]. IS 1893:2016 Indian code of seismic design of structure.