FOSSEE Spring Semester Long Internship 2026 Report

on

Design verifications of steel connections in Osdag and SOR in Excel

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Chapter 1

Introduction to ICT Initiatives

1.1 Introduction

1.1.1 National Mission in Education through ICT

The National Mission on Education through ICT (NMEICT) is a scheme under the Department of Higher Education, Ministry of Education, Government of India. It aims to leverage the potential of ICT to enhance teaching and learning in Higher Education Institutions in anytime-anywhere mode.

The mission aligns with the three cardinal principles of the Education Policy—access, equity, and quality—by:

- Providing connectivity and affordable access devices for learners and institutions.
- Generating high-quality e-content free of cost.

NMEICT seeks to bridge the digital divide by empowering learners and teachers in urban and rural areas, fostering inclusiveness in the knowledge economy.
Key focus areas include:

- Development of e-learning pedagogies and virtual laboratories.
- Online testing, certification, and mentorship through accessible platforms like EduSAT and DTH.
- Training and empowering teachers to adopt ICT-based teaching methods.

For further details, visit the official website: www.nmeict.ac.in.

1.1.2 ICT Initiatives of MoE

The Ministry of Education (MOE) has launched several ICT initiatives aimed at students, researchers, and institutions. The table below summarizes the key details:

Table 1.1: Summary of ICT Initiatives by the Ministry of Education

No.	For Students/Researchers (Resource)	For Institutions
	Audio-Video e-content	
1	**SWAYAM**: Earn credit via online courses	Develop and host courses; accept credits
2	**SWAYAMPRABHA**: Access 24x7 TV programs	Enable SWAYAMPRABHA viewing facilities
3	**National Digital Library**: Access e-content in multiple disciplines	List e-content; form NDL Clubs
4	**e-PG Pathshala**: Access free books and e-content	Host e-books
5	**Shodhganga**: Access Indian research theses	List institutional theses
6	**e-ShodhSindhu**: Access full-text e-resources	Access e-resources for institutions
	Hands-on Learning	
7	**e-Yantra**: Hands-on embedded systems training	Create e-Yantra labs with IIT Bombay
8	**FOSSEE**: Volunteer for open-source software	Run labs with open-source software
9	**Spoken Tutorial**: Learn IT skills via tutorials	Provide self-learning IT content
10	**Virtual Labs**: Perform online experiments	Develop curriculum-based experiments
	E-Governance	
11	**SAMARTH ERP**: Manage student lifecycle digitally	Enable institutional e-governance
	Tracking and Research Tools	
12	**VIDWAN**: Register and access experts	Monitor faculty research outcomes
13	**Shodh Shuddhi**: Ensure plagiarism-free work	Improve research quality and reputation
14	**Academic Bank of Credits**: Store and transfer credits	Facilitate credit redemption

1.1.3 FOSSEE Project

The FOSSEE (Free/Libre and Open-Source Software for Education) project promotes the use of FLOSS tools in academia and research. It is part of the National Mission on Education through Information and Communication Technology (NMEICT), Ministry of Education (MOE), Government of India.

1.1.4 Projects and Activities

The FOSSEE Project supports the use of various FLOSS tools to enhance education and research. Key activities include:

- **Textbook Companion:** Porting solved examples from textbooks using FLOSS.
- **Lab Migration:** Facilitating the migration of proprietary labs to FLOSS alternatives.
- **Niche Software Activities:** Specialized activities to promote niche software tools.
- **Forums:** Providing a collaborative space for users.
- **Workshops and Conferences:** Organizing events to train and inform users.

1.1.5 Fellowships

FOSSEE offers various internship and fellowship opportunities for students:

- Winter Internship
- Summer Fellowship
- Semester-Long Internship

Students from any degree and academic stage can apply for these internships. Selection is based on the completion of screening tasks involving programming, scientific computing, or data collection that benefit the FLOSS community. These tasks are designed to be completed within a week.

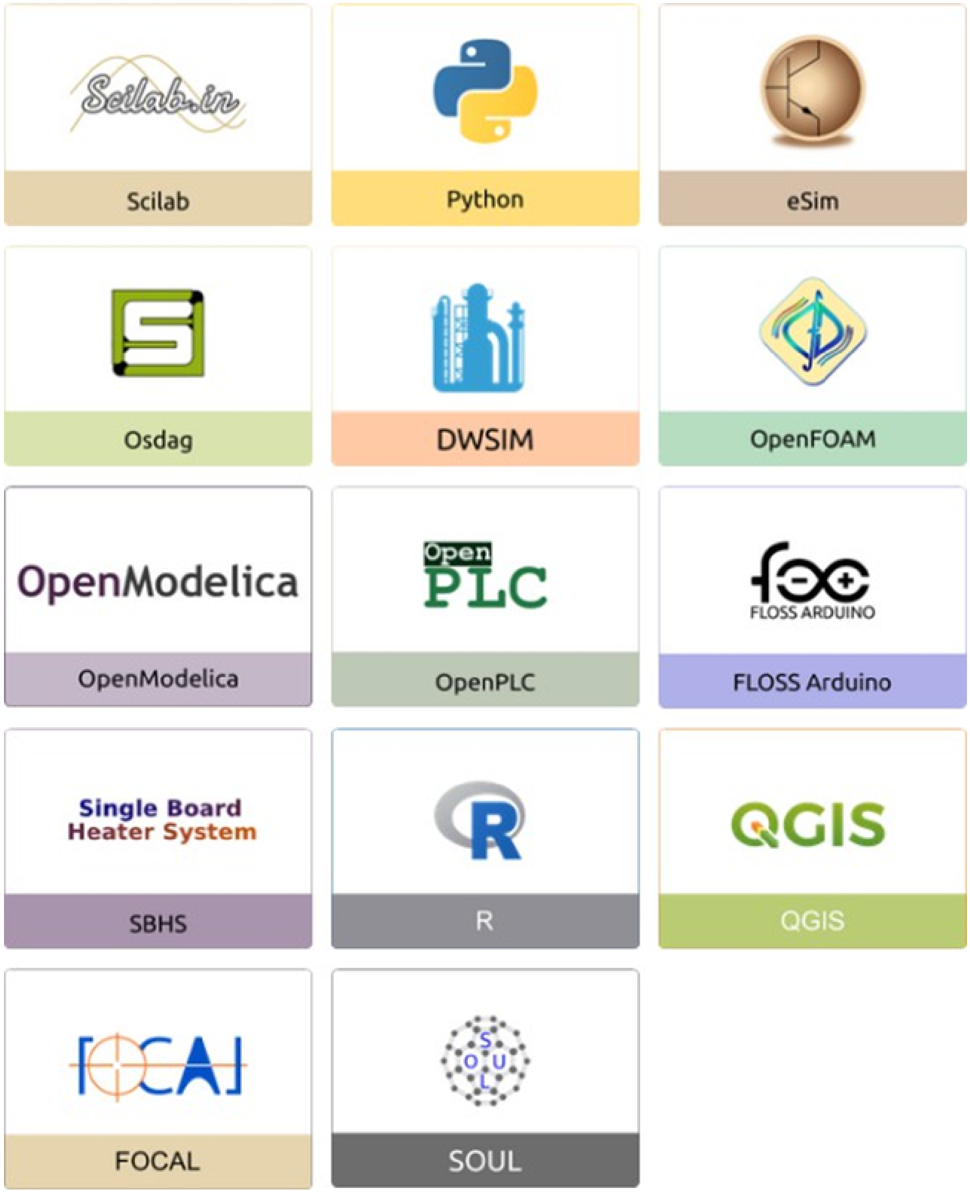

Figure 1.1: FOSSEE Projects and Activities

1.2 What is Osdag?

Open steel design and graphics (Osdag) is an open-source software developed under the aegis of the FOSSEE project, IIT Bombay. Osdag provides various features such as:

- An interactive window displaying a 3D CAD model, which provides a clear visualization of the designed component.
- Creation of 3D CAD models that can be imported to generic CAD software.
- User-friendly input and output docks, with text-validated fields grouped according to the design flow.

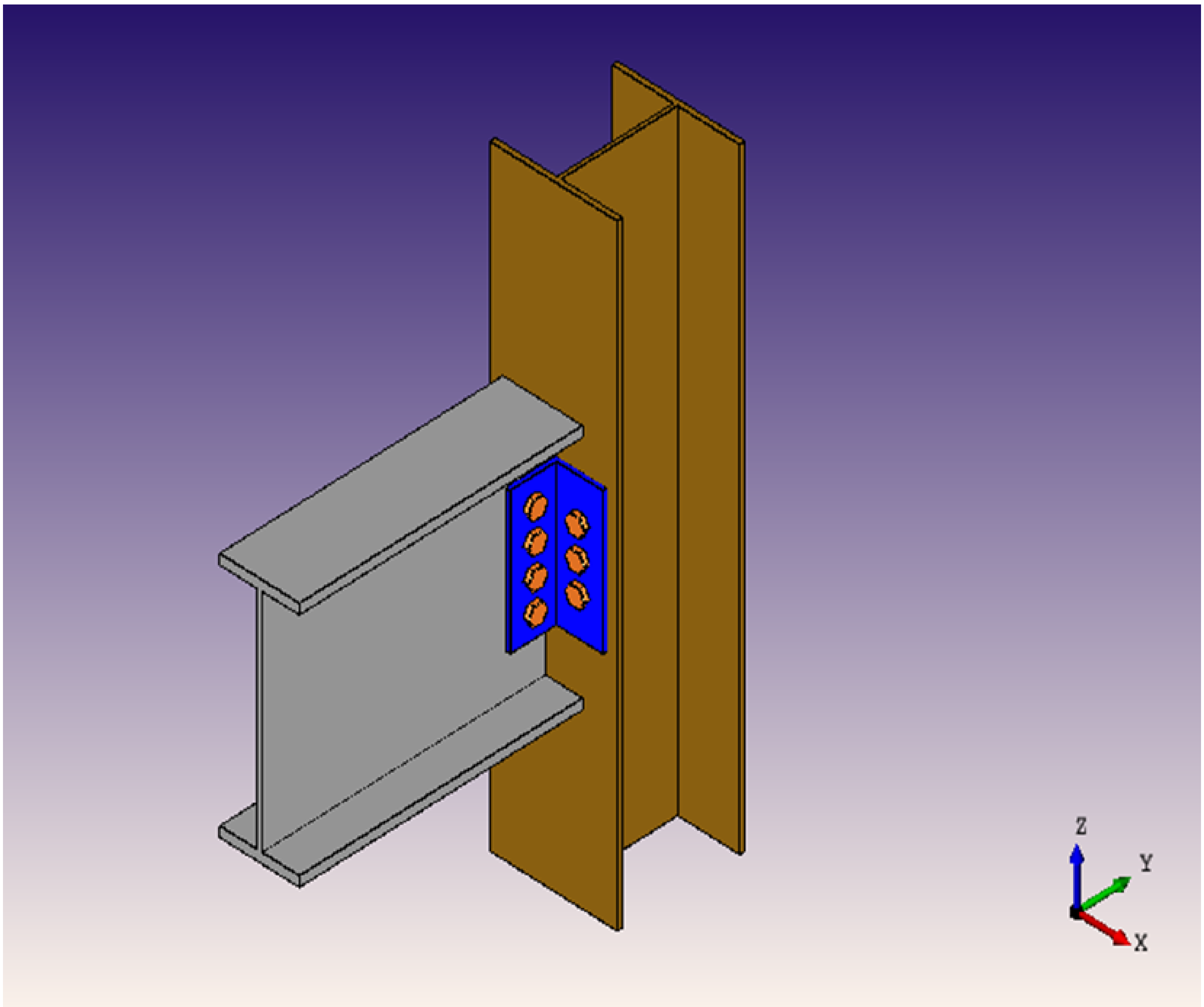

Figure 1.2: 3D CAD Model Visualization (Reference: OSDAG)

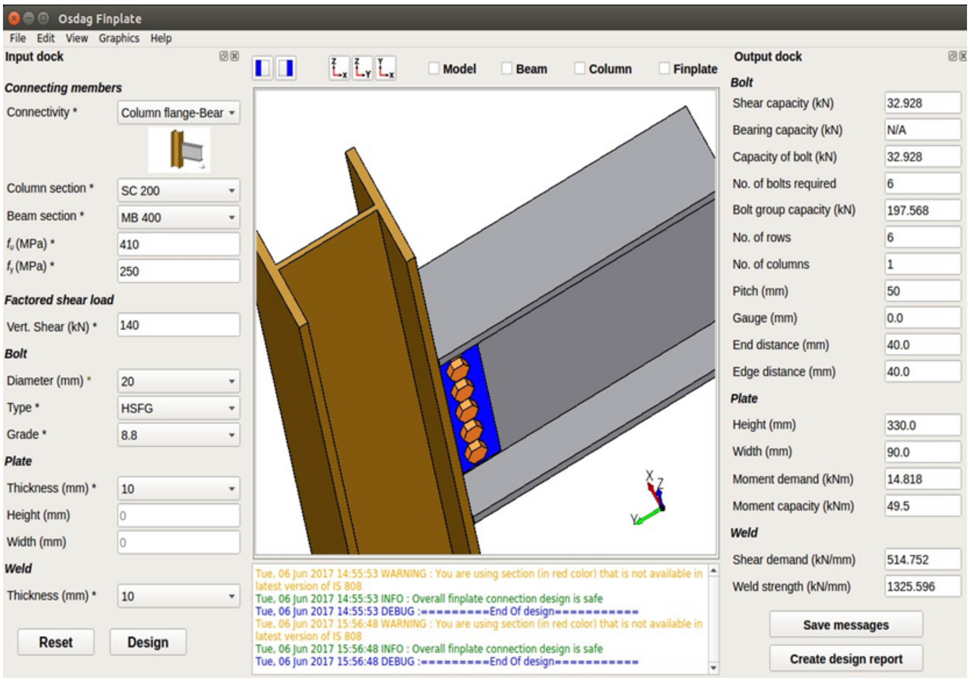

Figure 1.3: User-friendly input and output docks (Reference: Osdag)

- A text window for message display, that also suggests necessary changes if a trial design is found unsafe.

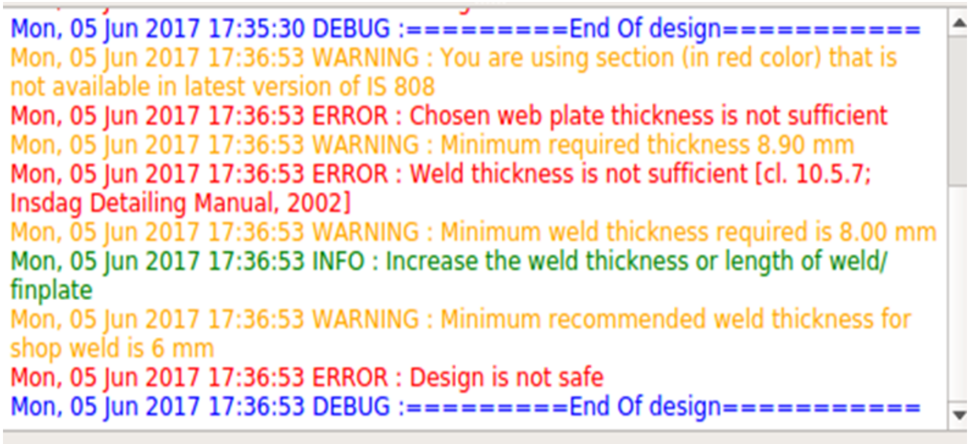

Figure 1.4: Message display window with saftey suggestions

- Creation of a professional design report showing all necessary checks, design calculations as per IS 800:2007, and standard views of the designed component.

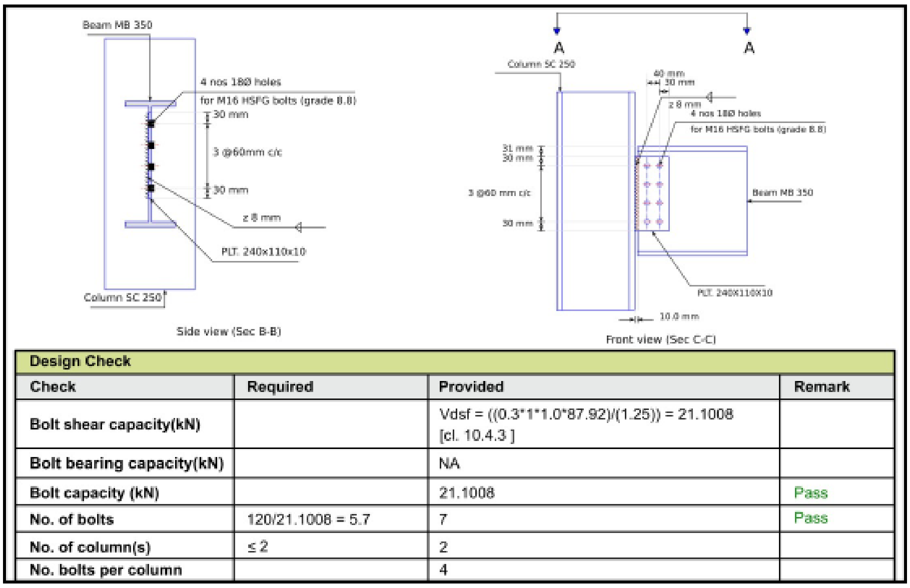

Figure 1.5: 2D Vector Images (Reference: OSDAG)

Design Check Table (Representative)

Check	**Required**	**Provided**	**Remark**
Bolt shear capacity (kN)		$V_{dsf} = \frac{0.3\times1\times1.0\times87.92}{1.25} = 21.1008$	
Bolt bearing capacity		NA	
Bolt capacity (kN)		21.1008	Pass
No. of bolts	$120/21.1008 = 5.7$	7	Pass
No. of column(s)	≤ 2	2	
No. of bolts per column		4	

- Selection of design preferences, considering different construction and detailing aspects, using a design preference toolbox.

1.3 Who can use it?

- **Students:** OSDAG can be effectively used by undergraduate and postgraduate students of civil engineering.
- **Academicians:** The software is suitable for faculty members for classroom demonstrations and academic projects.
- **Professionals:** Practicing structural engineers and design consultants can use OSDAG for professional design work.

1.3.1 Osdag GUI

The Osdag GUI is designed to be user-friendly and interactive. It consists of:

- **Input Dock:** Collects and validates user inputs.

- **Output Dock:** Displays design results after validation.
- **CAD Window:** Displays the 3D CAD model, where users can pan, zoom, and rotate the design.
- **Message Log:** Shows errors, warnings, and suggestions based on design checks.

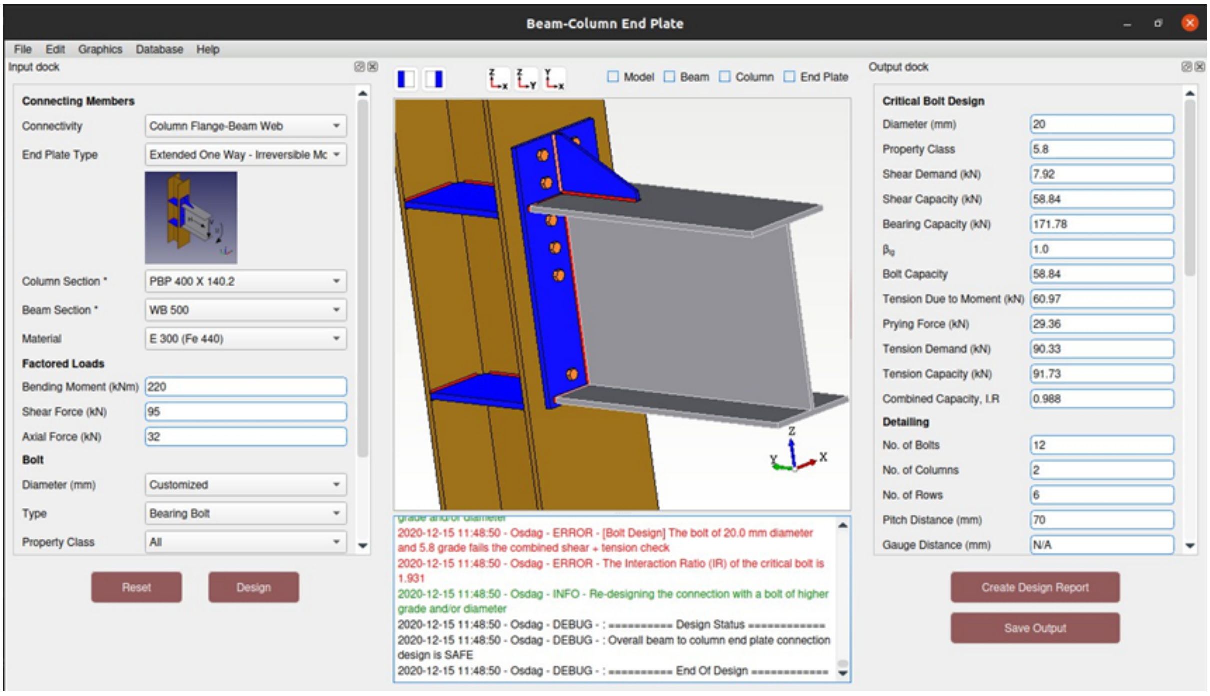

Figure 1.6: Osdag GUI Interface

1.3.2 Features

- **CAD Model:** The 3D CAD model is color-coded and can be saved in multiple formats such as IGS, STL, and STEP.
- **Design Preferences:** Customizes the design process, with advanced users able to set preferences for bolts, welds, and detailing.
- **Design Report:** Creates a detailed report in PDF format, summarizing all checks, calculations, and design details, including any discrepancies.

For more details, visit the official OSDAG website.

Chapter 2

Screening Task

2.1 Problem Statement

Steel connections play a vital role in the safe and efficient transfer of forces between structural members in steel structures. Proper design of connections ensures structural stability, strength, ductility, and serviceability. In modern structural engineering practices, software tools like OSDAG are widely used to perform design checks in accordance with IS 800:2007.

1.Beam-to-Beam Cover Plate Bolted Connection: A beam-to-beam cover plate bolted moment connection is to be designed for a factored bending moment of 25 kN·m and a shear force of 15 kN. The beams used are MB 250 sections made of E 250 grade steel (Fe 410).Standard bearing bolts are used with normal clearance holes, and the connection is not exposed to corrosive conditions.Design the cover plate bolted connection and check the adequacy of bolts and plates as per IS 800:2007. Clearly state all assumptions and design checks carried out.

2.Column-to-Column End Plate Connection The connection is required to transfer a factored bending moment of 165 kN·m, a factored shear force of 25 kN, and a factored axial compressive force of 8 kN. Both the columns are of rolled steel section HB 300, made of steel grade E 250 (Fe 410 W). The bolts used shall be bearing type, non-pre-tensioned, with standard bolt holes. Assume the members are not exposed to a corrosive environment and edge preparation is by shearing or hand flame cutting. Design the end plate and bolts, and check the connection for moment, shear, and axial force in accordance with IS 800:2007.

3.Column-to-Column Cover Plate Bolted Connection: A column-to-column cover plate bolted moment connection is required to transfer a bending moment of 20 kN·m, shear force of 10 kN, and axial force of 5 kN. The columns are HB 400 sections made of E 250 steel. Bearing type bolts (non-pre-tensioned) with a slip factor of 0.3 are used. Design the bolted cover plate connection and verify its safety against moment, shear, and axial force in accordance with IS 800:2007.

4.Column-to-Column Cover Plate Welded Connection: Two HB 450 steel columns are connected using a column-to-column cover plate welded moment connection. The connection is subjected to a bending moment of 10 kN·m and a shear force of 10 kN. Fillet welds are provided, and the material used is E 250 (Fe 410) steel. Design the welded cover plate connection and check the weld strength and plate adequacy as per relevant provisions of IS 800:2007.

5.Beam-to-Column End Plate Connection: A beam-to-column extended end plate moment connection is to be designed for a bending moment of 5 kN·m and a shear force of 5 kN. The beam section is MB 250, and the column section is HB 450, both made of E 250 grade steel. Bolted connections with standard clearance holes are used. Design the end plate connection, including bolt arrangement and plate thickness, and check the connection for moment and shear as per IS 800:2007.

2.2 Task Done

Sample Calculation: Beam-to-Beam Cover Plate Bolted Connection

2.2.1 Given Data

- Beam-Beam Cover Plate Bolted Connection
- Bending moment (kN/m) = 25
- Shear Force (kN/m) = 15
- Ultimate Strength, f_u (MPa) = 410
- Yield Strength, f_y (MPa) = 250

From IS 800:2007, and Steel Table

Property	**Value**
Mass, m (kg/m)	37.3
Area, A (cm^2)	47.55
Depth of Section, D (mm)	250
Width of Flange, b_f (mm)	125
Thickness (flange), t_f (mm)	12.5
Thickness (Web), t_w (mm)	6.9
Radius of Gyration, r_z	10.39
Radius of Gyration, r_y	2.65
Plastic Modulus, Z_{py} (cm^3)	89.7
Plastic Modulus, Z_{pz} (cm^3)	465.71
Section modulus, Z_{xx} (cm^3)	410.5
Section modulus, Z_{xy} (cm^3)	53.5
Shape Factor	1.1345
Moment of Inertia, I_{xx} (cm^4)	5131.6
Moment of Inertia, I_{yy} (cm^4)	334.5
Radius at root, r_1 (mm)	13.0
Radius at toe, r_2 (mm)	[Not specified]
Flange Slope	98

Section Classification

$$\epsilon = \sqrt{\frac{250}{250}} = 1$$

$$\text{Outstand of flange, } b = \frac{b_f}{2} = 62.5 \text{ mm}$$

$$\text{Depth of web, } d = (250 - 2(12.5 + 13.0)) = 199 \text{ mm}$$

$$\frac{b}{t_f} = \frac{62.5}{12.5} = 5 < 9.4\epsilon$$

$$\frac{d}{t_w} = \frac{199}{6.9} = 28.84 < 84\epsilon$$

Hence, Section is **Plastic**.

Calculate Axial, Shear & Moment Capacity

Axial tensile capacity member (kN):

$$t_{dg} = \frac{A_g f_y}{\gamma_{m0}} = 1080.68 \text{ kN}$$

Design shear strength of section:

$$v_{dy} = \frac{A_g f_y}{\sqrt{3}\gamma_{m0}} = 226.347 \text{ kN}$$

Given shear force, $v_y = 15$ kN.
Allowable shear capacity, $v_d = 0.6 v_{dy} = 135.81$ kN.
Required Shear = 15 kN.
Low Shear limit = 122.23 kN.
Hence, $15 < 122.23$ kN.
Therefore, members are under low shear.

Check for Design Bending Strength

Therefore, Section is plastic, $\beta_b = 1$.

$$M_d = \frac{\beta_b Z_{pz} f_y}{\gamma_{m0}} = 105.843 \text{ kNm}$$

And, for cantilever beam: To avoid irreversible deformation under serviceability loads

$$M_d < \frac{1.5 Z_{xx} f_y}{\gamma_{m0}} \implies M_d < 139.94 \text{ kNm}$$

The design bending strength of section, M_{dz} = Minimum of (M_d & deformation criteria).

$$M_{dz} = 105.843 \text{ kNm}$$

Hence, Design moment = 254 kNm.
Design bending strength = 105.843 kNm.

2.2.2 Load Considerations

Interaction Ratio Check

$$\text{I.R axial} = \frac{P_x}{T_{dg}} = \frac{N}{N_d} = 0$$
$$\text{I.R moment} = \frac{M_z}{M_{dz}} = 0.2361$$

From IS 800:2007, clause 9.3.1:

$$\frac{P_x}{T_{dg}} + \frac{M_z}{M_{dz}} \leq 1.0$$

$$\text{Sum I.R} = 0 + 0.2362 = 0.2362$$

If I.R axial < 0.3 and I.R moment < 0.5:

$$P_{x,min} = 0.3T_{dg} = 324.204 \text{ kN}$$

$$M_{z,min} = 0.5M_{dz} = 52.15 \text{ kNm}$$

This means, Assume 30% axial capacity and Assume 50% bending capacity.
If Sum I.R ≤ 1.0 and I.R moment < 0.5:
If $(0.5 - \text{I.R moments}) < (1 - \text{sum I.R})$:

$$0.5 - 0.2638 < 0.7638$$

Then,

$$M_{z,min} = 0.5M_{dz} = 52.9215 \text{ kNm}$$
$$P_{x,min} = P_x = 324.204 \text{ kN}$$

If Sum I.R ≤ 1.0 and I.R axial < 0.3:
If $(0.3 - \text{I.R axial}) < (1 - 0.2362)$:

$$0.3 < 0.7638$$

$$P_{x,min} = 0.3T_{dg} = 324.204 \text{ kN}$$

Final applied load used:

$$P_u = \text{maximum of } (P_x, P_{x,min}) = 324.204 \text{ kN}$$

2.2.3 Final Design Loads

Applied SF, $V_y = 15.0$ kN
Minimum SF, $V_{y,\text{min}} = (0.15V_{dy}$ or 40 kN$)$
$V_{y,\text{min}} = 33.952$ kN
Design S.F, $V_u = \max(V_y, V_{y,\text{min}}) = 33.952$ kN
Applied moment, $M_z = 250$ kNm
Design moment, $M_m = \max(M_{z,\text{min}}, M_z) = 52.9215$ kNm

2.2.4 Force Distribution (Web and Flange)

for Web

$$
\begin{aligned}
&\text{Web area, } A_w = (D - 2t_f)t_w = 1552.5 \text{ mm}^2 \\
&\text{Axial force in web, } P_w = \frac{f_{11} A_w}{A} = 105.852 \text{ kN} \\
&\text{Section modulus of web, } Z_w = 87300\ 5 \text{ mm}^3 \\
&\text{Moment in web, } M_w = \frac{M_u Z_w}{Z} = 9.92 \text{ kNm}
\end{aligned}
$$

for Flange

$$
\begin{aligned}
&\text{Area of flange, } A_f = t_f b_f = 1562.5 \text{ mm}^2 \\
&\text{Axial force in flange, } P_f = \frac{P_u A_f}{A} = 106.534 \text{ kN} \\
&\text{Moment in flange, } M_f = M_u - M_w = 43.0015 \text{ kNm} \\
&\text{Flange force, } F_f = \frac{M_f \times 1000}{D - T} + P_f = 287.593 \text{ kN}
\end{aligned}
$$

2.2.5 Flange Bolt Design

Bolt Parameters:

- Diameter (mm) = 8, 10, 12, 14, 18 ...
- Designed as per IS 800:2007
- Property Class = 3.6, 4.6, 4.8, 5.6, 5.8, 6.8 ... (Optimized = 6.8)
- $f_{ub} = 600 \text{ N/mm}^2$ and $f_{yb} = 480 \text{ N/mm}^2$

Bolt Calculations:

$$
\begin{aligned}
&v_{dy} = \frac{A_{gfy}}{\sqrt{3}\gamma_{m0}} \times A_{nb} \\
&V_{db\ 10} = 11.707 \\
&A_{nb} = 0.78\frac{\pi}{4} \times 10^2 = 61.26 \text{ mm}^2 \\
&d_0 = 10 + 2 = 12 \text{ mm}
\end{aligned}
$$

Minimum Flange Plate

$$
\begin{aligned}
&\text{Thickness, } t = 12.5 \text{ mm} \\
&\text{Provided } t \geq \sqrt{\frac{6MY_0}{f_y}} = 12.397 \text{ mm} \cong 12.5 \text{ cm (approx.)} \\
&\text{Provided: 14 mm as for more resistance (SP-16)}
\end{aligned}
$$

Number of Bolts Column:

$$n = \frac{\frac{p}{2}t\frac{M}{D}}{\frac{0.9F_{nb}A_{nb}}{Y_{mb}}} = 10.86 \cong 12$$

12 bolts column on each flange $\therefore$ 24 numbers of bolt columns

$M = t_b \times e = 582.208$ kNm

$n_c = 12$

Bolt Arrangement

- Number of rows: Total bolts per flange = 6 rows
- In the design (OSDAG), $n_r = 2$ (as 2 rows along the depth direction per side)

Pitch Distance:

$p_{\text{minimum}} = 2.5d = 25$ mm

$p_{\text{maximum}} = 32t$ or 300 mm = 400 or 300 (whichever is less)

Provided $p_{\text{maximum}} = 300$ mm

Gauge Distance:

Minimum gauge distance = $2.5d = 25$ mm

Provided gauge$_{\text{minimum}} = 0$ (as only one bolt line is there)

Maximum gauge distance = $32t$ or 300 mm = 300 mm

Provided gauge$_{\text{maximum}} = 0$

End and Edge Distances

$e_{\text{minimum}} = 1.7d_0 = 17$ mm

Provide, $e = 20$ mm

$e_{\text{maximum}} = 12t\epsilon$

$e_1 = 12 \times 14 \times 1 = 168$ mm

$e_2 = 12 \times 12.5 \times 1 = 150$ mm

$e_{\text{max}} = \min(e_1, e_2) = 150$ mm

$e_{\text{minimum}} < e_{\text{provided}} < e_{\text{maximum}}$ (Check OK)

Minimum edge distance: $e_{\text{minimum}} = 1.7d_0 = 17$ mm. Provided = 23.02 mm.

Bolt Strength Checks

Shear Capacity:

$$v_{dsb} = \frac{A_{nb}f_{ub}}{\sqrt{3}\gamma_{mb}} = 16.98 \text{ kN}$$

Bearing Strength:

$$v_{dpb} = \frac{2.5k_b d t f_u}{\gamma_{mb}}$$

$$k_b = \min\left(\frac{e}{3d_0}, \frac{p}{3d_0} - 0.25, \frac{f_{ub}}{f_u}, 1.0\right)$$

$k_b = 0.584$

$v_{dpb} = 59.86$ kN

Final Bolt Capacity:

$$\text{Bolt capacity} = \min(v_{dpb}, v_{dsb})$$
$$v_{dsb} = 16.98 \text{ kN}$$

Reduction Factors

Long Joints ($l_j \geq 15d$):

$$L = ((n_c \text{ or } n_r) - 1) \times p$$
$$l_c = (1 - 1) \times 25 = 25 \text{ mm}$$
$$l_r = (22 - 1) \times 25 = 275 \text{ mm}$$
$$\text{Now, } l_j = 275 \text{ mm} \quad (\text{Check: } l_j \geq 15d)$$
$$\text{Reduced shear capacity, } v_{rd} = \beta_{lj} v_{db}$$
$$\beta_{lj} = 1.075 - \frac{l_j}{200d} = 0.9375$$
$$v_{rd} = 0.9375 \times 16.98 = 15.91875 \text{ kN}$$

Large Grip Length ($l_g > 5d$):

- Reduced shear capacity $= \beta_{lg} v_{dv}$

Reduction Factors and Capacity Check

$$\beta_{lg} = \frac{8d}{3d + l_g}$$
$$l_g = (t_{\text{provided plate}} + t_{\text{member}}) = 14 + 12.5 = 26.5 \text{ mm}$$
$$\text{Now, } \beta_{l_g} = 1.0$$
$$\text{Now, } v_{rd} = v_{db} = 16.98 \text{ kN}$$

2.2.6 Check for Capacity

$$\text{Required, } v_{rd} = 2 \times \frac{\sqrt{{v_u}^2 + M^2}}{n} = 11.97 \text{ kN}$$
$$\text{Provided, } v_{rd} = 15.91875 \text{ kN}$$
$$\text{Hence, Design is SAFE}$$

Web Bolt Design

Bolt Parameters:

- $D = 10$ mm
- $f_u = 600$ N/mm^2
- Grade $= 6.8$
- $f_y = 480$ N/mm^2

Web Plate Thickness

Required, $t_{rd} = 6.5$ mm

2.2.7 Spacing Requirements

Pitch Distance:

$$\text{Minimum Pitch distance, } p_{\text{min}} = 2.5d = 25 \text{ mm}$$
$$\text{Pitch provided, } p_{\text{provided}} = 25 \text{ mn}$$
$$\text{Maximum pitch, } p_{\text{max}} = (32t \text{ or } 3000 \text{ mm}) = 220.8 \text{ mm}$$

Gauge Distance:

$$\text{Minimum gauge distance, } g_{\text{min}} = 25 \text{ mm}$$
$$\text{Provided gauge distance, } g_{\text{provided}} = 25 \text{ mm}$$
$$\text{Maximum gauge distance, } g_{\text{max}} = 220.8 \text{ mm}$$

End Distance:

$$\text{Minimum end distance (mm), } e_{\text{min}} = 1.7d_0 = 17 \text{ mm}$$
$$\text{Provided end distance, } e_{\text{provided}} = 20 \text{ mm}$$
$$\text{Maximum end distance, } e_{\text{max}} = 12t\epsilon = 82.8 \text{ mm}$$

Bolt Strength Calculations

$$\text{Shear strength of bolt, } \nu_{dsu} = \frac{f_{ub}(n_n A_{nb} + n_s A_{nb})}{\sqrt{3}\gamma_{mb}} = 33.954 \text{ kN}$$
$$\text{Bearing strength of bolts, } v_{dpb} = \frac{2.5 \times k_b \times d \times t \times f_u}{y_{mb}}$$
$$k_b = 0.584$$
$$v_{dpb} = 33.042 \text{ kN}$$
$$\therefore \text{Strength of bolt} = 33.042 \text{ kN}$$

2.2.8 Dimensional Checks

Flange Plate Dimension

$$\text{Minimum flange plate width (mm)} = \text{Beam width} = 125 \text{ mm}$$
$$\text{Let, } B_{\text{provided}} = B_{\text{reqd}} = 125 \text{ mm}$$
$$\text{Minimum flange plate length (mm)} = 2 \times \left[2e_{\text{min}} + \left\{\left(\frac{n_c}{2} - 1\right) \times p_{\text{min}}\right\} \frac{3}{2}\right]$$
$$L_{\text{reqd}} = 621 \text{ mm}$$
$$L_{\text{provided}} = 633 \text{ mm}$$
$$L_{\text{reqd}} < L_{\text{provided}} \text{ (pass)}$$

Minimum Flange Thickness

$$t_{\text{reqd}} = 12.5 \text{ mm}$$
$$\text{But for providing, } t_{\text{provided}} = 14 \text{ mm}$$

Plate Area Check

Plate Area, $A_p = 1.05 \times (\text{connected member area}) = 1640.625 \text{ mm}^2$
Provided area, $A_{pp} = B_f \times t_{f \text{ provided}} = 1750 \text{ mm}^2$
$A_{pp} > A_p$ (pass)

Web Plate Checks

Minimum web plate height, $h_{\text{reqd}} = 0.6 \times (d_0 - 2t_c - 2r_r) = 119.4 \text{ mm}$
Web plate height provided, $h_{\text{provided}} = 199 \text{ mm} \cong 190 \text{ mm}$
Minimum web plate width, $b_{\text{reqd}} = 2e + ((\frac{A_r}{2} - 1) \times p) \times \text{gap} = 121 \text{ mm}$
$b_{\text{provided}} = 133 \text{ mm}$
$\therefore b_{\text{reqd}} < b_{\text{provided}}$ (pass)
Minimum web plate thickness, $t_{\text{reqd}} = 3.45 \text{ mn}$
$t_{\text{provided}} = 8 \text{ mm}$

Web Plate Area

Area required, $A_{\text{vrequired}} = 1.05 \times (\text{connected member area}) = 1630.12 \text{ mm}^2$
Area provided, $A_{p \text{ provided}} = 190 \times 8 \times 2 = 3040 \text{ mm}^2$
required $A_p <$ provided (pass)

Member Capacity Check

Design strength to tension (yielding), $T_{dg} = \dfrac{A_g f_y}{y_{m0}} = 355.114 \text{ kN}$

Design strength due to rupture, $T_{dx} = \dfrac{0.9 A_u f_u}{y_m} = 387.45 \text{ kN}$

$$\therefore T_{db1} = \left[\frac{A_{vg} f_u}{\{\sqrt{3} y_{m0}\}} + \frac{0.9 A_u f_u}{y_{m1}}\right]$$

$$\text{And } T_{db2} = \left[\frac{A_{\nu g} f_u}{\gamma_{m1}} + \frac{0.9 A_u f_u}{\{\sqrt{3} \gamma_{m0}\}}\right]$$

$T_{db} = \min(T_{db1}, T_{db2}) = 897.75 \text{ kN}$
Flange force $= 287$ kN
$T_d = 355.114$ kN

Similarly for web:

$$T_{dg} = 352.841 \text{ kN}$$
$$T_{dx} = 375.72 \text{ kN}$$

*Bolts Force Parameters

$$\text{Length available, } l_n = g(n_r - 1) = 150$$
$$y_{\max} = l_n/2 = 75 \text{ mm}$$
$$x_{\max} = p(\frac{n_c}{2} - 1)/2 = 12.5 \text{ mm}$$

Moment and Bolt Force Calculations

Moment Demand:

$$M_d = (V_u \times e_{cc} + M_w) = 10.96 \text{ kNm}$$

Bolt Force:

$$v_{bv} = V_u/(n_r \times (n_c/2)) = 2.18 \text{ kN}$$
$$t_{mh} = \frac{M_d \times y_{\max}}{{r_i}^2} = 22.11 \text{ kN}$$
$$t_{mv} = \frac{M_d \times x_{\max}}{{r_l}^2} = 3.68 \text{ kN}$$
$$a_{bh} = \frac{A_n}{((n_r/2) \times n_c)} = 7.56 \text{ kN}$$
$$v_{res} = \sqrt{(v_{bv} + t_{mv})^2 + (t_{mh} + a_{bh})^2} = 30.24 \text{ kN}$$

2.2.9 Reduction Factors (Re-check)

Long Joint Reduction Factor

Required:

- If $l_j \geq 15d$, then $v_{rd} = \beta_{lj} v_{db}$
- If $l_j < 15d$, then $v_{rd} = v_{db}$

Provided:

$$l = ((n_r \text{ or } n_c) - 1) \times (p \text{ or } g)$$
$$l_r = 25 \text{ mm}$$
$$l_c = 150 \text{ mm}$$
$$\text{Since, } l = 15d$$
$$\text{Then, } v_{rd} = \beta_{lj} v_{db} = 33.042 \text{ kN}$$

Large Grip Length Reduction Factor

Required Values:

- If $l_g \geq 5d$, then $v_{rd} = \beta_{lj} v_{db}$
- If $l_g < 5d$, then $v_{rd} = v_{db}$
- $l_g \leq 8d$
- Where, $l_g = \Sigma(t_{ep} + t_{\text{member}})$
- $\beta_{lg} = 8d/(3d + l_g)$
- But $\beta_{lg} \leq \beta_{lj}$

Provide Values:

$$l_g = \Sigma(t_{ep} + t_{\text{member}}) = 22.9$$
$$5d = 50.0$$
$$8d = 80.0$$
$$\text{Since, } l_g < 5d; \quad \beta_{lg} = 1.0$$

Capacity Check

$$\text{Required: } 30.24 \text{ kN}$$
$$\text{Provided capacity, } v_{rd} = \beta_{lj}\beta_{lg}v_{db} = 33.042 \text{ kN}$$

2.2.10 Final Dimension Checks

Flange Plate Dimension Check

Outside Dimensions

Minimum Flange Plate Width (mm) = Minimum flange plate height = beam width = 125
Provided: 125

Minimum Flange Plate Length (mm) $= 2 \times [2e_{\min} + \{(\frac{n_c}{2} - 1) \times p_{\min}\}] + \text{gap}/2$

Required: 621.0 mm
Provided: 633 mm

Plate Area Check

$$\text{Required: Plate area } \geq 1.05 \text{ connected member area} = 1640.62 \text{ mm}^2$$
$$\text{Provided: Plate area } = B_{fp} \times t_{ifp} = 1750 \text{ mm}^2$$

Web Plate Dimension Check

Height and Width

Minimum Web plate height (mm)
Required: $0.6 \times (d_b - 2t_f - 2r_r) = 119.4$
Provided: 190
Minimum web plate width (mm)
Required: $2 \times [2e_{\min} + \{(\frac{n_c}{2} - 1) \times p_{\min}\}] + \text{gap}/2 = 121$
Provided: 133.0

Thickness and Area

Minimum web plate thickness (mm)
Required: $t/2 = 3.45$
Provided: $t_{wp} = 8.0$
Plate check area (mm^2)
Required: Plate area ≥ 1.05 connected member area $= 1630.12$
Provided: $2 \times t_{wp} \times w_{wp} = 3040.0$

2.2.11 Member Tension and Shear Checks

Flange Tension Capacity

Yielding Capacity:

$$T_{dg} = \frac{A_{vg} f_u}{\gamma_{m0}}$$
$$A_g = It = 125.0 \times 12.5$$
$$T_{dg} = 355.11$$

(There is error in design report file)

Rupture Capacity:

$$T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}} = 387.45 \text{ kN}$$

Flange Block Shear Capacity:

$$T_{db1} = \left[\frac{A_{vg} f_u}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}\right]$$
$$T_{db2} = \left[\frac{A_{vg} f_u}{\gamma_{m1}} + \frac{0.9 A_u f_u}{\sqrt{3}\gamma_{m0}}\right]$$
$$T_{db} = \min(T_{db1}, T_{db2}) = 897.75 \text{ kN}$$

Flange Tension Capacity Summary:

Required: $f_f = 287.24$ kN
Provided, $T_d = \min(T_{dg}, T_{dn}, T_{db}) = 355.11$ kN

Web Tension Capacity

Web Tension Yielding Capacity:

$$T_{dg} = \frac{A_{vg} f_u}{\gamma_{m0}}$$
$$A_g = l \times t = 225 \times 6.9$$
$$T_{dg} = 315.72 \text{ kN}$$

Web Tension Rupture Capacity:

$$T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}} = 315.72 \text{ kN}$$

Web Block Shear Capacity:

$$T_{db1} = \left[\frac{A_{vg} f_u}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}\right]$$
$$T_{db2} = \left[\frac{A_{vg} f_u}{\gamma_{m1}} + \frac{0.9 A_u f_u}{\sqrt{3}\gamma_{m0}}\right]$$
$$T_{db} = \min(T_{db1}, T_{db2}) = 305.54 \text{ kN}$$

Web Tension Capacity Summary:

Required: $A_w = 105.85$ kN

Provided: $T_d = \min(T_{dg}, T_{dn}, T_{db}) = 305.54$ kN

2.2.12 Flange Plate Capacity Check for Axial Load - Outside

Tension Yielding Capacity

$$T_{dg} = \frac{A_{vg} f_u}{\gamma_{m0}}$$
$$A_g = l \times t = 1254 \times 14.0$$
$$T_{dg} = 397.73 \text{ kN}$$

Tension Rupture Capacity

$$T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}} = 433.94 \text{ kN}$$

Block Shear Capacity

$$T_{db1} = \left[\frac{A_{vg} f_u}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}\right]$$
$$T_{db2} = \left[\frac{A_{vg} f_u}{\gamma_{m1}} + \frac{0.9 A_u f_u}{\sqrt{3}\gamma_{m0}}\right]$$
$$T_{db} = \min(T_{db1})$$

Flange Plate Tension Capacity Summary

Required: $f_f = 287.24$ kN

$T_{db2} = 1005.48$ kN

Provided, $T_d = \min(T_{dg}, T_{dn}, T_{db}) = 397.73$ kN

Web Plate Capacity Check for Axial Load

Tension Yielding Capacity

$$T_{dg} = \frac{A_{vg} f_u}{\gamma_{m0}}$$
$$A_g = l \times t = 1254 \times 14.0$$
$$T_{dg} = 690.91 \text{ kN}$$

Tension Rupture Capacity

$$T_{dn} = \frac{0.9 A_n f_u}{\gamma_{m1}} = 566.78 \text{ kN}$$

Block Shear Capacity

$$T_{db1} = \left[\frac{A_{vg} f_u}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}\right]$$
$$T_{db2} = \left[\frac{A_{vg} f_u}{\gamma_{m1}} + \frac{0.9 A_u f_u}{\sqrt{3}\gamma_{m0}}\right]$$
$$T_{db} = \min(T_{db1}, T_{db2}) = 708.5 \text{ kN}$$

Web Plate Tension Capacity Summary

Required: $A_w = 105.85$ kN

Provided: $T_a = \min(T_{dg}, T_{dn}, T_{db}) = 566.78$ kN

Web Plate Capacity for Shear Load

Shear Yielding Capacity

$$v_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}} = 3989.9 \text{ kN}$$

Allowable shear capacity: $v_d = 0.6 v_{dy} = 239.34$ kN

Shear Rupture Capacity

$$v_{dn} = \frac{0.75 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} = 272.69 \text{ kN}$$

Block Shear Capacity

$$V_{db1} = \left[\frac{A_{vg} f_u}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}\right]$$
$$V_{db2} = \left[\frac{A_{tg} f_y}{\gamma_{m0}} + \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}}\right]$$
$$V_{db} = \min(V_{db1}, V_{db2}) = 449.97 \text{ kN}$$

Web Plate Shear Capacity Summary

$$V_d = \min(S_c, V_{dn}, T_{db}) = 239.34 \text{ kN}$$

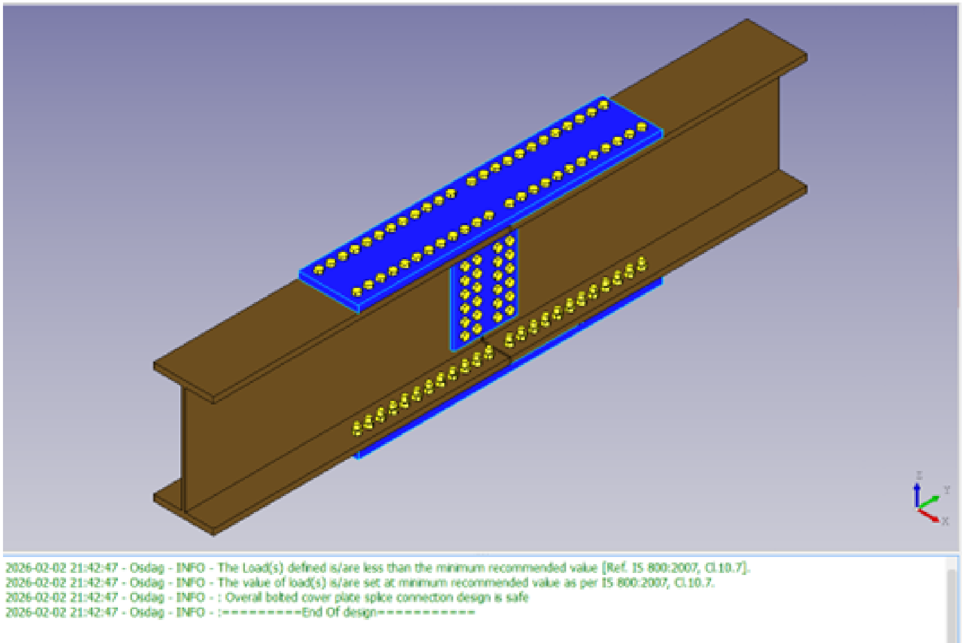

Figure 2.1: 3D View of the Connection (Refrence: Osdag)

Chapter 3

Internship Task 1

3.1 Task 1:Design of weld in tension member - Welded to End Gusset

3.1.1 Given Data

- Welded to End Gusset
- Axial Force (kN) = 100
- Length (mm) = 1000
- Section Profile = **Angles**
- Section Designation = 90*60*8
- Material = E-165
- Ultimate Strength of Weld, f_u (MPa) = 290
- Ultimate Strength of Member, f_u (MPa) = 290
- Yield Strength of Member, f_y (MPa) = 165
- Cz (mm) = 29.8
- Cy (mm) = 14.9

Design Shear Strength of Section:

$$F_{wd} = \frac{f_u}{\sqrt{3}\gamma_{mw}} = \frac{290}{\sqrt{3} \times 1.25} = 134 \text{ MPa}$$

Throat Thickness,

$$t = 0.7 \times 8 = 5.6 \text{ mm}$$

Strength per unit length of weld:

$$R = F_{wd} \times t = 134 \times 5.6 = 750.4 \text{ N/mm}$$

Required Effective Length of Weld:

$$L_{\text{eff}} = 134 \text{ mm}$$

In Osdag,

$$L_{\text{eff}} = 224 \text{ mm}$$

$$P_1 = \frac{Ty}{d} - \frac{P_2}{2}$$

$$P_3 = T\left(1 - \frac{y}{d}\right)$$

$$P_2 = R_w \times L_w 2$$

Total welding Resistance,

$$R_w \times L_w = 100\,\text{kN}$$

Since it is equal to the applied force.

$$L_{w1} + L_{w2} + L_{w3} = 224\,\text{mm}$$

Assume, L_{w2} to be the full-size weld d.
Thus, $\mathrm{L}_{w2} = 90\,\text{mm}$
Then,

$$P_2 = 40.178\,\text{kN}$$

$$P_1 = 40.198\text{kN}$$

$$P_3 = 46.711\text{kN}$$

Now,

$$L_w 1 = \frac{P_1}{R_w} = 29.17\text{mm}$$

and,

$$L_w 3 = \frac{P_3}{R_w} = 104.63\text{mm}$$

3.2 Task 2: Design of weld in tension member - Welded to End Gusset

3.2.1 Given Data

- Welded to End Gusset
- Axial Force (kN) = 100
- Length (mm) = 1000
- Section Profile = **Back-to-Back Angles**

- Section Designation = 90*60*8
- Material = E-165
- Ultimate Strength of Weld, f_u (MPa) = 290
- Ultimate Strength of Member, f_u (MPa) = 290
- Yield Strength of Member, f_y (MPa) = 165
- Cz (mm) = 29.8
- Cy (mm) = 14.9
- R_w = 293.84mm
- L_eff = 348mm

Now,

$$P_2 = R_w \times L_w 2$$

Assume, L_{w2} = depth of angle = 90mmP_2 = 26.445kN

$$L_{w1} = \frac{P_1}{R_w}$$

And,

$$L_{w3} = \frac{P_3}{R_w}$$

Now,

$$P_1 = \frac{Ty}{d} - \frac{P_2}{2} = 19.889\text{kN}$$

and,

$$P_3 = T \times (1 - \frac{y}{d}) = 53.577\text{kN}$$

Then, $L_{w1} = \frac{P_1}{R_w}$ = 67.69mm

and, $L_{w3} = \frac{P_3}{R_w}$ = 182.34mm

3.3 Task 3: Design of weld in tension member - Welded to End Gusset

3.3.1 Given Data

- Welded to End Gusset
- Axial Force (kN) = 100
- Length (mm) = 1000
- Section Profile = **Star Angles**

- Section Designation = 90*60*8
- Material = E-165
- Ultimate Strength of Weld, f_u (MPa) = 290
- Ultimate Strength of Member, f_u (MPa) = 290
- Yield Strength of Member, f_y (MPa) = 165

This section i.e, Star angle is a symmetrical shape. So the weld is equally distributed over each sides.

Design Shear Strength of Section:

$$F_{wd} = \frac{f_u}{\sqrt{3}\gamma_{mw}} = \frac{290}{\sqrt{3} \times 1.25} = 134 \text{ MPa}$$

Throat Thickness,

$$t = 0.7 \times 8 = 5.6 \text{ mm}$$

Strength per unit length of weld:

$$R = F_{wd} \times t = 134 \times 5.6 = 750.4 \text{ N/mm}$$

Required Effective Length of Weld:

$$L_{\text{eff}} = 134 \text{ mm}$$

In Osdag,

$$L_{\text{eff}} = 224 \text{ mm}$$

3.4 Task 4: Design of weld in tension Member - Welded to End Gusset

3.4.1 Given Data

- Welded to End Gusset
- Axial Force (kN) = 100
- Length (mm) = 1000
- Section Profile = **Channel**
- Section Designation = MC 100
- Material = E-165
- Ultimate Strength of Weld, f_u (MPa) = 290
- Ultimate Strength of Member, f_u (MPa) = 290
- Yield Strength of Member, f_y (MPa) = 165

- Depth of section (mm) = 100

Design Shear Strength of Section:

$$F_{wd} = \frac{f_u}{\sqrt{3}\gamma_{mw}} = \frac{290}{\sqrt{3} \times 1.25} = 134 \text{ MPa}$$

Throat Thickness,

$$t = 0.7 \times 5 = 3.5\text{mm}$$

Strength per unit length of weld:

$$R = F_{wd} \times t = 134 \times 3.5 = 469\text{N/mm}$$

Required Effective Length of Weld:

$$L_{\text{eff}} = 214\text{mm}$$

In OSDAG,

$$L_{\text{eff}} = 216\text{mm}$$

3.5 Task 5: Design of weld in tension member - Welded to End Gusset

3.5.1 Given Data

- Welded to End Gusset
- Axial Force (kN) = 100
- Length (mm) = 1000
- Section Profile = **Back-to-Back Channel**
- Section Designation = MC 100
- Material = E-165
- Ultimate Strength of Weld, f_u (MPa) = 290
- Ultimate Strength of Member, f_u (MPa) = 290
- Yield Strength of Member, f_y (MPa) = 165
- Depth of section (mm) = 100

Design Shear Strength of Section:

$$F_{wd} = \frac{f_u}{\sqrt{3}\gamma_{mw}} = \frac{290}{\sqrt{3} \times 1.25} = 134 \text{ MPa}$$

Throat Thickness,

$$t = 0.7 \times 5 = 3.5\text{mm}$$

Strength per unit length of weld:

$$R = F_{wd} \times t = 134 \times 3.5 = 469\text{N/mm}$$

Required Effective Length of Weld:

$$L_{\text{eff}} = 214\text{mm}$$

In OSDAG,

$$L_{\text{eff}} = 380\text{mm}$$

3.6 Task 6: Design a connection to joint two plates of size 250 * 12 mm of grade Fe410 to mobilize full plate tension strength using shop fillet welds, if a lap joint is used.

Solution:

Strength of plate,

$$T_{dg} = \frac{f_y A_g}{\gamma_{m0}}$$

$$T_{dg} = \frac{250 \times (250 \times 12)}{1.10} = 681.82 \text{ kN}$$

Size of Weld

As per IS Code 800:2007, Table 21 and Clause 10.5.8.1 for minimum and maximum size of weld,

$$\text{Minimum} = 5 \text{ mm}$$

$$\text{Maximum} = 12 - 1.5 = 10.5 \text{ mm}$$

Adopt 8 mm weld.

$$t = 0.7s = 0.7 \times 8 = 5.6 \text{ mm}$$

Strength of weld per unit length,

$$R_w = \left(\frac{f_u}{\sqrt{3}\gamma_{mw}} \right) t$$

$$R_w = \frac{410}{\sqrt{3} \times 1.25} \times 5.6$$

$$R_w = 1060.48 \text{ N/mm}$$

Required length of weld,

$$L_{req} = \frac{681.82 \times 10^3}{1060.48}$$

$$L_{req} = 643 \text{ mm} \approx 645 \text{ mm}$$

Weld length available at end = 150 mm
Length of weld on one side,

$$\frac{650 - 150}{2} = 250 \text{ mm} < (150 \times 5.6)$$

Hence, long joint correction is not required.

3.7 Task 7: Design a connection to join two plates of size 150×8 mm of grade Fe410 to mobilize full plate tension strength using shop fillet welds, if a lap joint is used.

Solution

Strength of plate,

$$T_{dg} = \frac{f_y A_g}{\gamma_{m0}}$$

$$T_{dg} = \frac{250 \times (150 \times 8)}{1.10} = 272.73 \text{ kN}$$

Size of Weld

As per IS Code 800:2007, Table 21 and Clause 10.5.8.1 for minimum and maximum size of weld,

$$\text{Minimum size} = 3 \text{ mm}$$

$$\text{Maximum size} = 8 - 1.5 = 6.5 \text{ mm}$$

Adopt a **6 mm fillet weld**.

$$t = 0.7s = 0.7 \times 6 = 4.2 \text{ mm}$$

Strength of weld per unit length,

$$R_w = \frac{f_u\, t}{\sqrt{3}\, \gamma_{mw}}$$

where

$$\gamma_{mw} = 1.25$$

Hence,

$$R_w = \frac{410 \times 4.2}{\sqrt{3} \times 1.25}$$

$$R_w = 795.36 \text{ N/mm}$$

Required length of weld,

$$L_{\text{req}} = \frac{T_{dg}}{R_w} = \frac{272.73 \times 10^3}{795.36}$$

$$L_{\text{req}} = 342.91 \text{ mm} \approx 345 \text{ mm}$$

Hence, the required weld length is

$$\boxed{L_{\text{req}} = 345 \text{ mm}}$$

3.8 Task 8: Design a connection to join two plates of size $250 \times 8\,\text{mm}$ of grade Fe410 to mobilize full plate tension strength using shop fillet welds, if a lap joint is used.

Solution

Strength of plate,

$$T_{dg} = \frac{f_y A_g}{\gamma_{m0}}$$

$$T_{dg} = \frac{250 \times (250 \times 8)}{1.10} = 454.55 \text{ kN}$$

Size of Weld

As per IS Code 800:2007, Table 21 and Clause 10.5.8.1 for minimum and maximum size of weld,

$$\text{Minimum size} = 3 \text{ mm}$$

$$\text{Maximum size} = 8 - 1.5 = 6.5 \text{ mm}$$

Adopt a 6 mm fillet weld.

$$t = 0.7s = 0.7 \times 6 = 4.2 \text{ mm}$$

Strength of weld per unit length,

$$R_w = \frac{f_u\, t}{\sqrt{3}\, \gamma_{mw}}$$

where

$$\gamma_{mw} = 1.25$$

Therefore,

$$R_w = \frac{410 \times 4.2}{\sqrt{3} \times 1.25} = 795.36 \text{ N/mm}$$

Required length of weld,

$$L_{\text{req}} = \frac{T_{dg}}{R_w} = \frac{454.55 \times 10^3}{795.36}$$

$$L_{\text{req}} = 571.5 \text{ mm} \approx 575 \text{ mm}$$

Hence,

$$\boxed{L_{\text{req}} = 575 \text{ mm}}$$

3.9 Task 9: Design a connection to join two plates of size $150 \times 12\,\text{mm}$ of grade Fe410 to mobilize full plate tension strength using shop fillet welds, if a lap joint is used.

Solution

Strength of plate,

$$T_{dg} = \frac{f_y A_g}{\gamma_{m0}}$$

$$T_{dg} = \frac{250 \times (150 \times 12)}{1.10} = 409.1 \text{ kN}$$

Size of Weld

As per IS Code 800:2007, Table 21 and Clause 10.5.8.1 for minimum and maximum size of weld,

$$\text{Minimum size} = 5 \text{ mm}$$

$$\text{Maximum size} = 12 - 1.5 = 10.5 \text{ mm}$$

Adopt an 8 mm fillet weld.

$$t = 0.7s = 0.7 \times 8 = 5.6 \text{ mm}$$

Strength of Weld per Unit Length

$$R_w = \frac{f_u\, t}{\sqrt{3}\,\gamma_{mw}}$$

where

$$\gamma_{mw} = 1.25$$

Hence,

$$R_w = \frac{410 \times 5.6}{\sqrt{3} \times 1.25} = 1060.48 \text{ N/mm}$$

Required Length of Weld

$$L_{\text{req}} = \frac{T_{dg}}{R_w} = \frac{409.1 \times 10^3}{1060.48}$$

$$L_{\text{req}} = 385.76 \text{ mm} \approx 390 \text{ mm}$$

Therefore,

$$\boxed{L_{\text{req}} = 390 \text{ mm}}$$

3.10 Task 10: Design a connection to joint plates of size $200 \times 10\,\text{mm}$ of grade Fe410, to bear an axial force of $80\,\text{kN}$ using shop fillet welds if a lap joint is used.

Solution

$$P = 80\,\text{kN}$$

Design shear strength of weld,

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

where

$$\gamma_{mw} = 1.5$$

Hence,

$$f_{wd} = \frac{410}{\sqrt{3} \times 1.5} = 157.81 \text{ MPa}$$

Size of Weld

As per IS 800:2007, Table 21 and Clause 10.5.8.1,

$$\text{Minimum size} = 3 \text{ mm}$$

$$\text{Maximum size} = 10 - 1.5 = 8.5 \text{ mm}$$

Assume

$$s = 8 \text{ mm}$$

Effective throat thickness,

$$t = 0.7s = 0.7 \times 8 = 5.6 \text{ mm}$$

Strength of weld per unit length,

$$R_w = f_{wd} \times t$$

$$R_w = 157.81 \times 5.6 = 883.736 \text{ N/mm}$$

Required weld length,

$$L_{\text{req}} = \frac{P}{R_w} = \frac{80 \times 10^3}{883.736} = 90.49 \text{ mm} \approx 95 \text{ mm}$$

$$L_{\text{req}} = 95 \text{ mm}$$

Length to be provided on each side,

$$\frac{95}{2} = 47.5 \text{ mm} < 75 \text{ mm}$$

Hence,

$$\text{New } L_{\text{req}} = 2 \times 75 = 150 \text{ mm}$$

Hence provide 75 mm weld on each side with an end return of

$$2 \times 8 = 16 \text{ mm.}$$

Overall weld length,

$$2(75 + 2 \times 8) = 182 \text{ mm.}$$

3.11 Task 11: Design a connection to joint plates of size $250 \times 12\,\text{mm}$ of grade Fe410, to bear an axial load of $100\,\text{kN}$ using shop fillet welds if a lap joint is used.

Solution

$$P = 100 \text{ kN}$$

Design shear strength of weld,

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

where

$$\gamma_{mw} = 1.5$$

Hence,

$$f_{wd} = \frac{410}{\sqrt{3} \times 1.5} = 157.81 \text{ MPa}$$

Size of Weld

As per IS Code 800:2007, Table 21 and Clause 10.5.8.1 for minimum and maximum size of weld,

$$\text{Minimum size} = 5 \text{ mm}$$

$$\text{Maximum size} = 12 - 1.5 = 10.5 \text{ mm}$$

Assume weld size,

$$s = 8 \text{ mm}$$

Effective throat thickness,

$$t = 0.7s = 0.7 \times 8 = 5.6 \text{ mm}$$

Strength of weld per unit length,

$$R_w = f_{wd} \times t$$

$$R_w = 157.81 \times 5.6 = 883.736 \text{ N/mm}$$

Required length of weld,

$$L_{\text{req}} = \frac{P}{R_w} = \frac{100 \times 10^3}{883.736} = 113.12 \text{ mm} \approx 120 \text{ mm}$$

$$L_{\text{req}} = 120 \text{ mm}$$

Length to be provided on each side,

$$\frac{120}{2} = 60 \text{ mm} < 75 \text{ mm}$$

Hence,

$$\text{New required length} = 2 \times 75 = 150 \text{ mm}$$

Hence provide a 75 mm weld on each side with an end return of

$$2 \times 8 = 16 \text{ mm.}$$

Overall length required for weld,

$$2(75 + 2 \times 8) = 182 \text{ mm.}$$

3.12 Task 12: An ISMC 250 is used to transmit a factored force of 700 kN. The channel section is connected to a gusset plate of 10 mm thickness. Design a fillet weld if the overlap is limited to 300 mm. Use slot welds if required.

Solution:

$$P = 700 \text{ kN} = 700 \times 10^3 \text{ N}$$

From IS Code 808:1989,
The properties of ISMC 250 are:

$$t_w = 7.2 \text{ mm}$$

As slot welds are required,

$$\text{Maximum size of weld} = 7.2 - 1.5 = 5.7 \text{ mm}$$

Adopt a **5 mm** size weld.

$$\text{Throat thickness,} \qquad t_t = 0.7 \times 5 = 3.5 \text{ mm}$$

Strength of weld (per mm),

$$R_w = \frac{f_u}{\sqrt{3}\,\gamma_{mw}} \times t_t$$

where

$$\gamma_{mw} = 1.5$$

$$R_w = \frac{3.5 \times 410}{\sqrt{3} \times 1.5} = 552 \text{ N/mm}$$

Required length of weld,

$$L_{\text{req}} = \frac{P}{R_w} = \frac{700 \times 10^3}{552} = 1268 \text{ mm} \approx 1270 \text{ mm}$$

The maximum length of weld that can be provided in the channel is

$$(300 \times 2) + 250 = 850 \text{ mm} < 1270 \text{ mm}$$

Hence, use two slot welds of width

$$25 \text{ mm}$$

since

$$3t = 3 \times 7.2 = 21.6 \text{ mm}$$

or 25 mm, whichever is greater.
Assume the length of each slot weld as x mm.

$$2 \times 300 + 250 + 4x = 1270$$

$$4x = 420$$

$$x = 105 \text{ mm}$$

Therefore, provide **105 mm long fillet welds in slots**.

3.13 Task 13: An ISMC 150 is used to transmit a factored force of 500 kN. The channel section is connected to a gusset plate of 10 mm thickness. Design a fillet weld if the overlap is limited to 350 mm. Use slot welds if required.

Solution:

$$P = 500 \text{ kN} = 500 \times 10^3 \text{ N}$$

From IS Code 808:1989,
The properties of ISMC 150 are

$$t_w = 5.7 \text{ mm}$$

As slot welds are required,

$$\text{Maximum size of weld} = 5.7 - 1.5 = 4.2 \text{ mm}$$

Adopt a **4 mm** size weld.

$$\text{Throat thickness,} \qquad t_t = 0.7 \times 4 = 2.8 \text{ mm}$$

Strength of weld (per mm),

$$R_w = \frac{f_u}{\sqrt{3}\gamma_{mw}} \times t_t$$

where

$$\gamma_{mw} = 1.5$$

$$R_w = \frac{2.8 \times 410}{\sqrt{3} \times 1.5} = 441.87 \text{ N/mm}$$

Required length of weld,

$$L_{\text{req}} = \frac{P}{R_w} = \frac{500 \times 10^3}{441.87} = 1131.56 \text{ mm} \approx 1140 \text{ mm}$$

The maximum length of weld that can be provided in the channel is

$$(350 \times 2) + 250 = 950 \text{ mm} < 1140 \text{ mm}$$

Hence, use two slot welds of width 25 mm
since

$$3t = 3 \times 5.7 = 17.1 \text{ mm}$$

or 25 mm, whichever is greater.

Assume the length of each slot weld as x mm.

$$2 \times 350 + 250 + 4x = 1140$$

$$950 + 4x = 1140$$

$$4x = 190$$

$$x = 47.5 \text{ mm} \approx 48 \text{ mm}$$

Hence, provide **48 mm long fillet welds in slots**.

3.14 Task 14: Determine the size and length of the fillet weld for the lap joint to transmit a factored load of 120 kN shown in the figure, assuming site welds, Fe410 steel, and E41 electrode.Assume width of plate as 75 mm.

Solution:

$$P = 120\,\text{kN} = 120 \times 10^3\,\text{N}$$

From IS 800:2007, Table 21 and Clause 10.5.8, for minimum and maximum size of weld,

$$\text{Minimum size} = 3\,\text{mm}$$

$$\text{Maximum size} = 8 - 1.5 = 6.5\,\text{mm}$$

Adopt a **6 mm** size weld.

$$\text{Effective throat thickness,} \qquad t_t = 0.7 \times 6 = 4.2\,\text{mm}$$

Strength of weld,

$$R_w = \frac{f_u}{\sqrt{3}\,\gamma_{mw}} \times t_t$$

where

$$\gamma_{mw} = 1.50$$

$$R_w = \frac{410 \times 4.2}{\sqrt{3} \times 1.5} = 662.7\,\text{N/mm}$$

Assuming that there are two longitudinal welds,

$$L_{\text{req}} = \frac{P}{R_w} = \frac{120 \times 10^3}{662.7} = 181\,\text{mm} \approx 190\,\text{mm}$$

Hence, provide 95 mm weld on each side with an end return of $2{\times}6 = 12\,\text{mm}$. Therefore, the overall length of weld provided is

$$2(95 + 2 \times 6) = 214\,\text{mm}.$$

3.15 Task 15: Rework the above question using 8 mm welds.

Solution:

$$s = 8\ \text{mm}$$

Effective throat thickness,

$$t_t = 0.7 \times 8 = 5.6 \text{ mm}$$

Strength of weld,

$$R_w = \frac{f_u}{\sqrt{3}\,\gamma_{mw}} \times t_t$$

where

$$\gamma_{mw} = 1.5$$

$$R_w = \frac{410 \times 5.6}{\sqrt{3} \times 1.5} = 883.7 \text{ N/mm}$$

Required length of weld,

$$L_{\text{req}} = \frac{P}{R_w} = \frac{120 \times 10^3}{883.7} = 135.7 \text{ mm} \approx 140 \text{ mm}$$

Length to be provided on each side,

$$\frac{140}{2} = 70 \text{ mm} < 75 \text{ mm}$$

Hence, adopt

$$75 \text{ mm}$$

weld on each side.
Provide

$$75 \text{ mm}$$

weld on each side with an end return of

$$2 \times 8 = 16 \text{ mm}$$

Therefore, overall length of weld provided is

$$2(75 + 2 \times 8) = 182 \text{ mm}.$$

3.16 Task 16: Rework above question using load = 120 kN and size of weld = 3 mm.

Solution:

$$s = 3 \text{ mm}$$

Effective throat thickness,

$$t_t = 0.7 \times 3 = 2.1 \text{ mm}$$

Strength of weld,

$$R_w = \frac{f_u}{\sqrt{3}\,\gamma_{mw}} \times t_t$$

where

$$\gamma_{mw} = 1.5$$

$$R_w = \frac{410 \times 2.1}{\sqrt{3} \times 1.5} = 331 \text{ N/mm}$$

Required length of weld,

$$L_{\text{req}} = \frac{P}{R_w} = \frac{120 \times 10^3}{331} = 362.54 \text{ mm} \approx 363 \text{ mm}$$

Two possible solutions are:

(i) If only longitudinal welds are provided,

$$\text{Length of each side weld} = \frac{363}{2} = 181.5 \text{ mm}$$

Total length on each side including end return,

$$= 181.5 + 2 \times 3 = 187.5 \text{ mm.}$$

(ii) If welds are provided on three sides,

$$\text{Length of each side weld} = \frac{363 - 75}{2} = 144 \text{ mm} > 75 \text{ mm}$$

(where 75 mm is the width of the plate).

Practically, **Case (ii)** is suitable.

3.17 Task 17: SOR in Excel for Tamil Nadu.

In this task, I have made the complete excel database for the Tamil Nadu Schedule of Rates (SOR) for the material, labors, and different types of work and many other miscellaneous items.

3.18 Task 18: SOR in Excel for Gujrat.

In this task, I have made the excel database for the Gujrat Schedule of Rates (SOR) for the bridge works including the different types of works, materials etc.

3.19 Task 19: SOR in Excel for Karnataka.

In this task, I have made the complete excel database for the Karnataka Schedule of Rates (SOR) for the material, labors, and different types of work and many other miscellaneous items.

Chapter 4

Conclusions

Tasks Accomplished

- Developed concept and validated **welded gusset plate connection design examples** for various steel sections, including:
  - **Single Angle Sections**
  - **Back-to-Back Angle Sections**
  - **Star Angle Sections**
  - **Channel Sections**
  - **Back-to-Back Channel Sections**
- Performed **Lap Joint Weld Design** calculations and prepared corresponding design examples in accordance with relevant steel design provisions.
- Compiled and organized **Schedule of Rates (SOR) data** in Microsoft Excel for the states of **Tamil Nadu, Karnataka, and Gujarat**, supporting cost estimation and structural steel design applications.
- Contributed to the preparation of standardized design examples and SOR databases to support the development and enhancement of the **OSDAG Steel Connection Design Module**.

Skills Developed

- Acquired practical knowledge of **steel connection design** and welded connection detailing for various structural steel sections.
- Enhanced proficiency in designing **gusset plate weld connections** for single angles, back-to-back angles, star angles, channels, and back-to-back channels.
- Developed a strong understanding of **lap joint weld design** and its implementation in structural steel design applications.
- Improved skills in interpreting and applying relevant provisions of **IS 800:2007** for steel structure design.

- Improved skills in interpreting and applying relevant provisions of **IS 808:1989** for steel structure design.
- Gained experience in **Microsoft Excel** for compiling, organizing, and validating **Schedule of Rates (SOR)** data for different Indian states.
- Strengthened technical documentation, data management, and analytical skills through the preparation of standardized design examples and cost databases.
- Enhanced problem-solving abilities and attention to detail while working on engineering design and data verification tasks in the Osdag development environment.
- Enhance the professional lifestyle during this internship, mainly the conversation style.
- Developed the Latex report writing skill during this internship and this helps me very lot.

Chapter A

Appendix

Internship Work Report

Name:	Ahmad
Project:	Osdag
Internship:	FOSSEE Spring Semester Long Internship 2026

DATE	DAY	TASK	Hours Worked
16 Feb 2026	Monday	First onboard meeting with team and selected students by Part Karia	
17 Feb 2026	Tuesday	Leave	
18 Feb 2026	Wednesday	Allocation of works	
21 Feb 2026	Saturday	Task Assigned: Check the length of welding in tension member weld to end gusset	4
24 Feb 2026	Tuesday	Review the previous problem and solve that task	4
25 Feb 2026	Wednesday	Meeting held with the mentor for reviewing the previous problem	4
26 Feb 2026	Thursday	Work on same problem and held meeting with the mentor	4
28 Feb 2026	Saturday	New task assigned: Design of Lap Joint welded connection	4
10 March 2026	Tuesday	Task Submission and reviewing with the mentor in the meeting	4
13 March 2026	Friday	New Task assigned: Design of Slot weld	4
16 March 2026	Monday	Task Submitted and review by mentor	4
25 March 2026	Wednesday	Meeting with mentor on the SOR in Excel and Task assigned	4

26 March 2026	Thursday	Meeting with mentor and reviewing the work of SOR in Excel	4
27 March 2026	Friday	Meeting with mentor and reviewing the work of SOR in Excel	4
30 March 2026	Monday	Meeting with mentor and reviewing the work of SOR in Excel	4
31 March 2026	Tuesday	Meeting with mentor and reviewing the work of SOR in Excel	4
01 April 2026		Exam Break	
02 April 2026	Thursday	Meeting with mentor and reviewing the work of SOR in Excel	4
04 April 2026	Saturday	Meeting with mentor and reviewing the work of SOR in Excel	4
07 April 2026	Tuesday	Meeting with mentor and reviewing the work of SOR in Excel	4
08 April 2026	Wednesday	Meeting with mentor and reviewing the work of SOR in Excel	4
09 April 2026	Thursday	Meeting with mentor for the work of SOR in Excel	4
10 April 2026	Thursday	SOR work in excel	4
17 April 2026	Friday	Meeting with mentor and reviewing the work of SOR in Excel	4
18-28 April 2026	Wednesday	Entry of data in Excel for the Karnataka SOR	4
29 April 2026	Wednesday	Meeting with mentor and reviewing the work of SOR in Excel	4
06 May 2026	Wednesday	SOR in Excel data submitted to mentor	4
22 May - 12 June 2026	Wednesday	End Semester Exam Break	
21 June 2026	Sunday	Report Submit	

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- Siddhartha Ghosh, Danish Ansari, Ajmal Babu Mahasrankintakam, Dharma TejaNuli, Reshma Konjari, M. Swathi, and Subhrajit Dutta. Osdag: A Software for Structural Steel Design Using IS 800:2007. In Sondipon Adhikari, Anjan Dutta, and Satyabrata Choudhury, editors, Advances in Structural Technologies, volume 81 of Lecture Notes in Civil Engineering, pages 219–231, Singapore, 2021. Springer Singapore.

- FOSSEE Project. FOSSEE News - January 2018, vol 1 issue 3. Accessed: 2024-12-05.

- FOSSEE Project. Osdag website. Accessed: 2024-12-05

Reference Books

- Design of Steel Structures by **S.K. Duggal**.
- Steel Design by **William T. Segui**.
- Design of Steel Structures by **N. Subramanian**.

Codes & Standards

- **IS 800:2007** - Code of Practice for General Construction in Steel.
- **IS 2062:2011 and IS 808:1998** - Hot rolled structural steel.
- **SP 16 & SP 6** - Design Aids for Structural Engineers (Steel Table).
- Use of **IS 1367 PART III**.
- **INSDAG Design Manual** for Structural Steelwork.

Digital Learning

- **NPTEL** Lectures on Design of Steel Structures.
- **Engineering Explained** & **Civil Engineering Academy** YouTube channels.