FOSSEE Summer Internship Report

On

Osdag Module Development

Submitted by

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Chapter 1

Introduction

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 an 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 inclusivity 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.

1.1.1 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:

No.	Resource	For Students/Researchers	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
Digital Content Access			
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

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

1.2 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.

1.2.1 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.

1.2.2 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.

For more details, visit the official FOSSEE website.

Figure 1.1: FOSSEE Projects and Activities

1.3 Osdag Software

Osdag (Open steel design and graphics) is a cross-platform, free/libre and open-source software designed for the detailing and design of steel structures based on the Indian Standard IS 800:2007. It allows users to design steel connections, members, and systems through an interactive graphical user interface (GUI) and provides 3D visualizations of designed components. The software enables easy export of CAD models to drafting tools for construction/fabrication drawings, with optimized designs following industry best practices [?, ?, ?]. Built on Python and several Python-based FLOSS tools (e.g., PyQt and PythonOCC), Osdag is licensed under the GNU Lesser General Public License (LGPL) Version 3.

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.

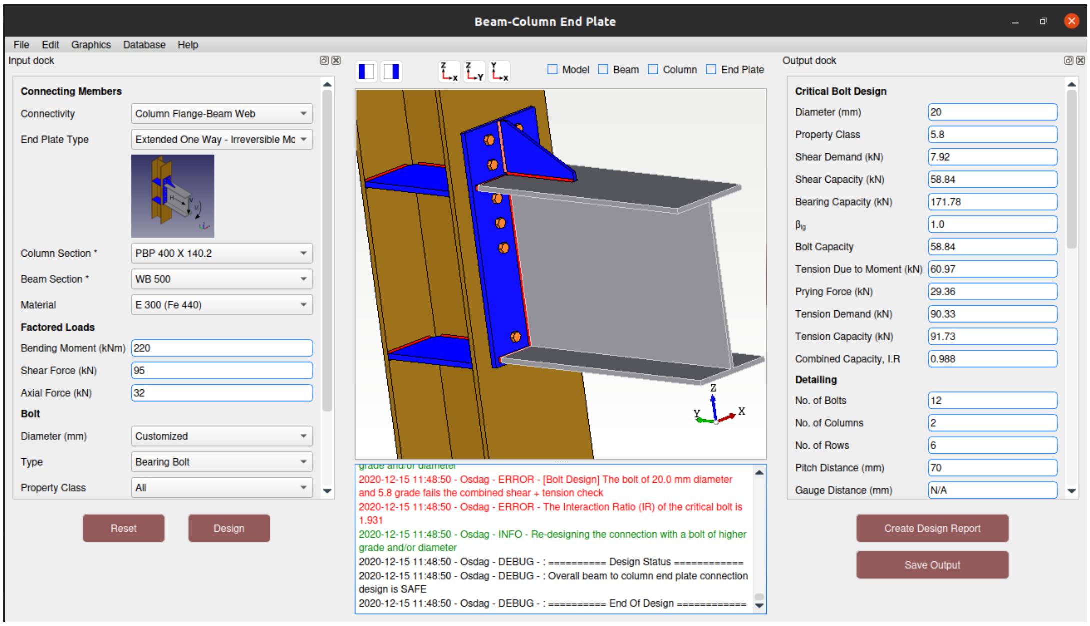


Figure 1.2: Osdag GUI

1.3.2 Features

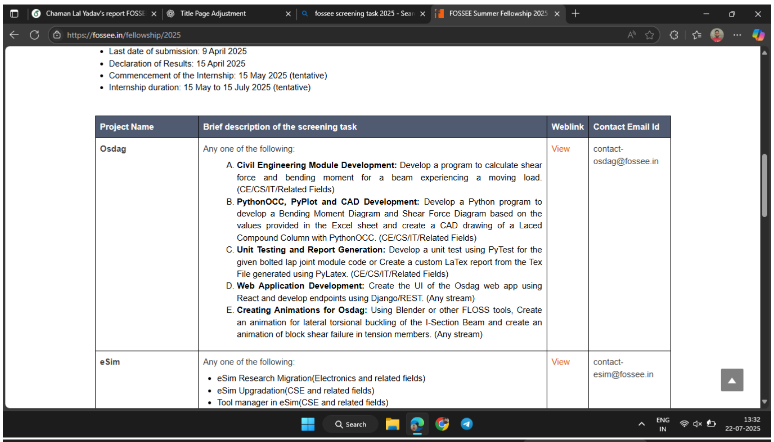
- **CAD Model**: The 3D CAD model is color-coded and can be saved in multiple formats such as IGS, STL, and STEP.
- **Design Preferences**: Customizes the design process, with advanced users able to set preferences for bolts, welds, and detailing.
- **Design Report**: Creates a detailed report in PDF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

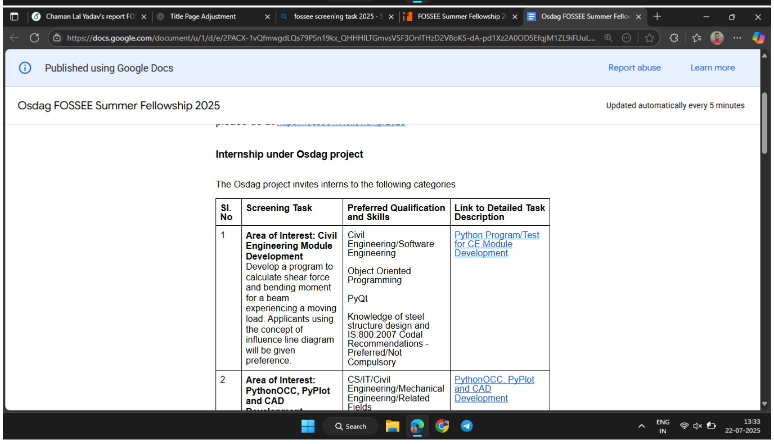
For more details, visit the official Osdag website.

Chapter 2

Screening Task

2.1 Problem Statement





2.2 Tasks Done

Determining Shear Force and Bending Moment for a Beam Experiencing a Moving Load

[Chaman Lal Yadav]

July 22, 2025

1 Introduction

In structural analysis, analyzing a beam under a moving load is essential to design structures such as railway bridges and road overbridges.

2 Problem Statement

This project aims to determine the shear force and bending moment in a simply supported beam subjected to load at two points at arbitrary positions using numerical methods and the Influence Line Diagram approach.

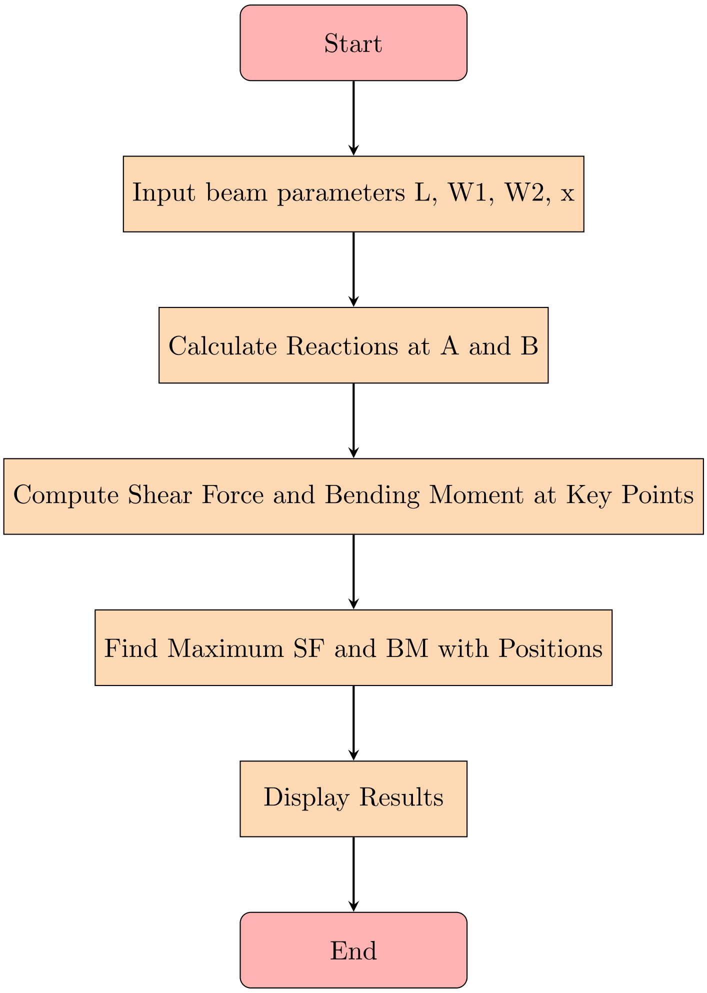
3 Methodology

The calculations are based on numerical analysis to ensure efficiency. The key steps include:

1. Take input for the beam parameter and details of the load w1, w2, x (distance between w1 and w2).
2. Compute reactions on supports.
3. Determine the maximum reactions at different positions of the load.
4. Calculate the shear force and the bending moment in key positions.
5. Identify maximum values of the shear force and bending moment along the beam.

4 Flowchart for Calculation

The flowchart below illustrates the calculation process:



5 Approach

This section explains the methodology used in the Python program to analyze a simply supported beam subjected to two moving point loads.

5.1 Input Parameters

The program accepts the following inputs:

- L: Length of the beam (m)
- w_1, w_2: Point loads in kN
- x: Distance between the two loads (m)

5.2 Reaction Calculation

Reactions at supports (R_A and R_B) are computed using:

$$R_A = w_1 \left(\frac{L - a}{L} \right) + w_2 \left(\frac{L - (a + x)}{L} \right) \tag{1}$$

$$R_B = w_1 + w_2 - R_A \tag{2}$$

where a is the moving position of the loads.

5.3 Maximum Reactions

To determine the maximum reactions, the program iterates over different positions of the moving loads and records the highest values.

5.4 Bending Moment Calculation

The bending moment at a section s depends on the position relative to the applied loads:

$$BM(s) = \begin{cases} w_2 \cdot \frac{(L-x) \cdot s(L-s)}{L^2}, & s < x \\ w_2 \cdot \frac{(L-s) \cdot x}{L}, & s \geq x \end{cases} \tag{3}$$

5.5 Shear Force Calculation

The shear force at a section t is determined as follows:

$$SF(t) = \begin{cases} -\left(w_1 \cdot \frac{t}{L} + w_2 \cdot \frac{t+x}{L} \right), & t < 0.5L \\ w_2 \left(1 - \frac{t}{L} \right) + w_1 \left(1 - \frac{t+x}{L} \right), & 0.5L < t + x \leq L \\ -\left(w_1 \cdot \frac{t+x}{L} - w_2 \left(1 - \frac{t}{L} \right) \right), & \text{otherwise} \end{cases} \tag{4}$$

5.6 Maximum Bending Moment and Shear Force

The program iterates through all positions to determine:

$$BM_{\max} = \max_y \left(w_1 \cdot \frac{y(L-y)}{L} + w_2 \cdot \frac{(y+x)(L-(y+x))}{L} \right) \tag{5}$$

$$SF_{\max} = \max_z \left(\begin{cases} w_1 \cdot \frac{z}{L} + w_2 \cdot \frac{z+x}{L}, & z > 0.5L \\ w_2 \cdot \frac{z}{L} + w_1 \cdot \frac{z+x}{L}, & \text{otherwise} \end{cases} \right) \tag{6}$$

6 Python Implementation

The following Python code calculates the shear force and bending moment for a given beam:

```
#print('hello chaman ') FOSSEE 2025 @NIT_kurukshetra


class bm_Data:
    def __init__(self):
        self.L=float(input("Enter length of the beam in metre: "))
        self.w1=float(input("Enter load w1 in KN: "))
        self.w2=float(input("Enter load w2 in KN: "))
        self.x=float(input("Enter distance between w1 and w2: "))


beamdata=bm_Data()

def Reacn(beamdata,a=0):
    ord_1=(beamdata.L-a)/beamdata.L
    ord_2=(beamdata.L-(a+beamdata.x))/beamdata.L
    Rx_A = beamdata.w1*ord_1+beamdata.w2*ord_2
    Rx_B = beamdata.w1+ beamdata.w2-Rx_A #1 more way
    return Rx_A,Rx_B


def max_Rxn(beamdata):
    max_rxa=0.0
    max_rxb=0.0

    for a in range (0,int(beamdata.L+1)):

        Rx_A,Rx_B=Reacn(beamdata,a)
        if Rx_A>max_rxa and Rx_A<=(beamdata.w1+beamdata.w2):
            max_rxa=Rx_A
            pos_a=a

        if Rx_B>max_rxb and Rx_B<=(beamdata.w1+beamdata.w2):
            max_rxb=Rx_B
            pos_b=a

    print(f"\nMaximum Rx_A: {max_rxa:.2f} KN @ w1 at {pos_a} m ")
    print(f"Maximum Rx_B: {max_rxb:.2f} KN @ w1 at {pos_b} m ")

max_Rxn(beamdata)


def BM_01(beamdata,s):
    if s<beamdata.x:
        bm_ord2=(beamdata.L-beamdata.x)*(s*(beamdata.L-s))/(beamdata.L*beamdata.L)
    else:
     bm_ord2=(beamdata.L-s)*beamdata.x/beamdata.L
    bm = beamdata.w1*0+beamdata.w2*bm_ord2
    return round(bm,2)

lis_BM_01=[]
for  s in range(0,int(beamdata.L+1)):
    lis_BM_01.append(BM_01(beamdata,s))

print(f"BM_01 at w1=0 m is: {lis_BM_01}")
```

```
def SF_01(beamdata,t):

    ord_1= t/beamdata.L
    ord_2= (t+beamdata.x)/beamdata.L

    if (t)<0.5*beamdata.L:
         Sf=  -(beamdata.w1*ord_1 + beamdata.w2*ord_2)
    elif (t>0.5*beamdata.L and t+beamdata.x<=beamdata.L):
         Sf= (beamdata.w2*(1-ord_1) + beamdata.w1*(1-ord_2))
    else:
        Sf=((-beamdata.w1*(ord_2) + beamdata.w2*(1-ord_1)))

    return round(Sf,2)


lis_SF_01=[]
for t in range(0,int(beamdata.L+1-beamdata.x)):
    lis_SF_01.append((SF_01(beamdata,t)))

print("SF_01 at mid-span is:",lis_SF_01)



def max_BM(beamdata):
    max_val=0.00
    for y in range(0,int(beamdata.L+1)):
        ord_1= y*(beamdata.L-y)/beamdata.L
        ord_2= (y+beamdata.x)*(beamdata.L-(y+beamdata.x))/beamdata.L
        Bm_y= (beamdata.w1*ord_1 + beamdata.w2*ord_2)


        if Bm_y>max_val:
            max_val=round(Bm_y,2)
            pos_y=y


    print(f"max BM is {max_val:.2f}  kN-m and position y from left support is {pos_y} m\n")




def max_SF(beamdata):
    max_val=0.00
    for z in range(0,int(beamdata.L+1)):
        ord_1= z/beamdata.L
        ord_2= (z+beamdata.x)/beamdata.L
        if z>0.5*beamdata.L:
         Sf_z= (beamdata.w1*ord_1 + beamdata.w2*ord_2)
        else:
         Sf_z= (beamdata.w2*ord_1 + beamdata.w1*ord_2)


        if Sf_z>max_val:
            max_val=Sf_z
            pos_z=z
    print(f"\nmax SF is {max_val:.2f} kN and position z from left support is {pos_z:} m")

max_SF(beamdata)
```

```
max_BM(beamdata)
```

Listing 1: Python Code for Beam Analysis

7 Results and Discussion

The computed values for the reactions, shear forces, and bending moments provide a basis for the efficient design of the beam. The maximum shear force and the bending moment positions are identified for structural safety The output

obtained through the program is

1. Maximum Reaction at A
2. Maximum Reaction at B
3. Bending Moment BM-01
4. Shear Force SF-01
5. Maximum Shear Force SF-max
6. Maximum Bending Moment BM-max

8 Conclusion

This report presents an algorithmic approach to analyzing a beam simply supported under moving loads. The numerical approach ensures accurate and computationally efficient results, suitable for practical engineering applications.

9 References

1. Structural Analysis - 1 by Saraswati Setia Ma'am.
2. Structural Analysis - 1 by Bhavikatti.
3. ILD lecture by Rehan Ahmed.

Chapter 3

Internship Task 1- Fin Plate DDCL

3.1 Task 1: Fin Plate connection

Fetch Reports from osdag module analyse the reports, check its formulas aligning with IS code or not, and make a comprehensive DDCL for the same. Also if any errors in formula or any mismatch in it ,record them into a separate overleaf file.

3.2 Task 1: Tasks Done

Design and detailing checklist (DDCL)

Fin Plate Connection

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02 June 2025

Contents

Chapter 1

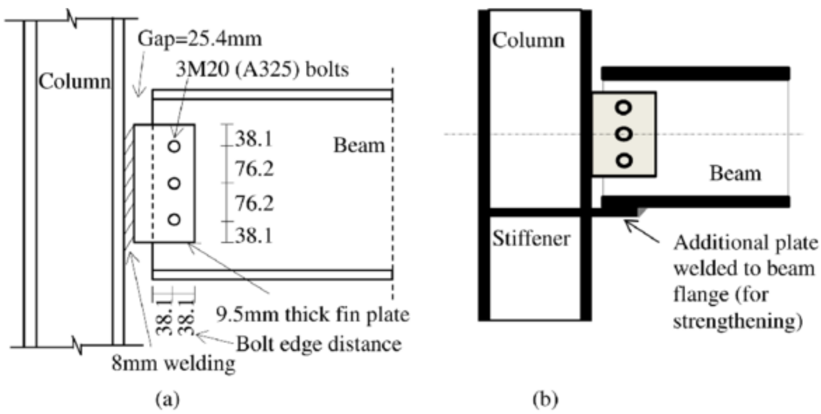
Theory

Introduction

Fin plate connections are a common type of simple shear connection used in steel structures. Consisting of a vertical steel plate welded to a supporting member (such as a column or girder) and bolted to the web of a beam, fin plate connections allow for quick erection, accommodate small rotations, and permit some degree of slip. These connections are vital in modern steel construction, favored for their simplicity, economic fabrication, and ease of installation on site.

- Fin Plate connection are pre-welded to columns in factory and bolted with beams on the site.

Diagram



Chapter 2

Design and Detailing Checklist for Osdag Software

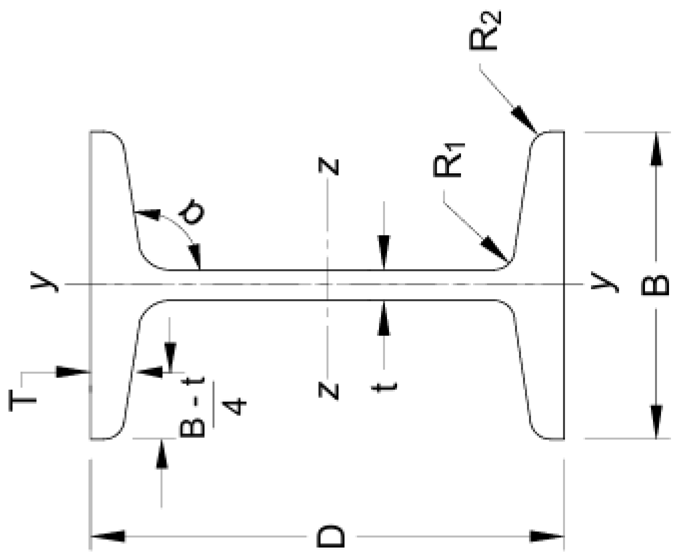
The following are the input parameters that the user will have to input on the Osdag Software.

- **Connectivity:*** The users will have a choice to choose between Column Flange-Beam Web, Column Web-Beam Web, and Beam-Beam.
- **Column Section:*** The user may choose any section of their choice for the column.
- **Beam Section:*** The user may choose any section of their choice for the beam.
- **Material Property:*** The user will have the option to choose from the available grades of steel.
- **Factored Shear Force(in kN):*** The user will have to input the factored shear force.
- **Factored Axial Load(in kN):*** The user will have to input the factored axial force.
- **Diameter of Bolt:*** The user has the choice of specifying the diameter of the bolt or choosing the most optimized design provided by the software.
- **Type of the bolt:*** The user will have a choice to specify the bolt type as friction type (HSFG) or bearing type.
- **Property (Grade) of Bolt:*** The user has the choice of specifying the grade of the bolt or choosing the most optimized design provided by the software.

The user will also have the option of changing the **Design Preferences** from **Edit > Design Preferences or CTRL + P**. These options for the design of a Fin Plate Connection include:

- **Connector:** The user can choose material of the connector fin between E 165, E250 and E 300.
- **Type of Bolt:** The choice in this section is between a pre-tensioned bolt and a non pre-tensioned bolt.
- **Type of Hole:** The user can choose between a standard hole or an oversized hole.
- **Slip Factor:** For a high-strength friction grip (HSFG) bolt, the user can define the slip factor.
- **Edge Preparation Method**: This relates to the fabrication aspect where the user can specify whether the hole has sheared or hand flame cut edges or Rolled, machine-flame cut, sawn and planed edges. This helps in determining the formula for the diameter of hole.
- **Gap between Beam and Support:**
- **Exposure of Members to Corrosive Surfaces:** The user can specify whether the members will be exposed corrosive surfaces or not. This will help in effective calculation of minimum and maximum end and edge distances.
- **Weld:** The user can choose type of weld fabrication- shop weld or field weld and also choose material of the weld.

***Input Compulsory.**



Chapter 3

Design Checks

3.1 Initial Section Check

Shear Yielding Capacity of secondary beam

The shear in beam to beam connection is taken by web of the secondary beam.Thus Shear Yielding Capacity is given by :

$$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$$

For beam to beam connection, A_v = (D-2t+r-notch height) x T
For column web to beam web or column flange to beam web connection, A_v = D x T

Ref: IS 800:2007, Cl.10.4.3

Allowable Shear Capacity of secondary beam

Allowable Shear Capacity is taken as 60 percent of the SYC .It should be greater than shear yielding capacity of the secondary beam in case of beam beam connection, and greater than shear yielding capacity of the beam in other connections.

$$V_d = 0.6 \times V_{dy}$$

Limited to low shear

Reference: IS-800:2007 cl 8.2.1.3

Tension Yielding Capacity

The axial tension in the secondary beam is taken by web of the secondary beam.It should be lower than Tension Yielding Capacity of the web of the secondary beam.

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

Ref: IS 800:2007, Cl.6.2

3.2 Load Consideration

Applied Axial Force

This takes input for axial force(in KN) considered in calculation.

Applied Shear Force

This takes input for axial force(in KN) considered in calculation.

$$V_u = \max(V_y, V_{ymin}), \quad V_{ymin} = \min(0.15V_{dy}, 40.0)$$

Ref: IS 800:2007, Cl.10.7

3.3 Bolt Design

Bolt should be designed with proper pitch distance, gauge distance, edge distance and end distance in Range. Further, it should be checked against shear and bearing.

Pitch

Pitch should be provided in below range , minimum it should be taken as 2.5 times the diameter of the bolt.

$$p_{\text{min}} = 2.5d, \quad p_{\text{max}} = \min(32t, 300)$$

Ref: IS 800:2007, Cl.10.2.2, Cl.10.2.3

Gauge

Gauge should be provided in below range , minimum it should be taken as 2.5 times the diameter of the bolt.

$$g_{\text{min}} = 2.5d, \quad g_{\text{max}} = \min(32t, 300)$$

End Distances

$$e_{\text{min}} = 1.7d_0, \quad e_{\text{max}} = \min(12t\varepsilon)$$

Ref: IS 800:2007, Cl.10.2.4.2, Cl.10.2.4.3

Edge Distances

$$e'_{\text{min}} = 1.7d_0, \quad e'_{\text{max}} = \min(12t\varepsilon)$$

Ref: IS 800:2007, Cl.10.2.4.2, Cl.10.2.4.3

Moment Demand

The moment demand on the bolt group is calculated from applied shear and eccentricity.

$$M_d = \frac{V_u \cdot e_{cc} + M_w}{10^6}$$

Where:
M_d: Moment demand on bolts (in kNm)
V_u: Ultimate shear force (in N)
e_{cc}: Eccentricity between load and bolt group centroid (in mm)
M_w: External moment acting on the web (in Nmm)

Bolt Force Parameters

This section calculates the force distribution on individual bolts due to applied shear and moment.

- l_n: Length between bolts in a row

  $$l_n = p \cdot (n_r - 1)$$

  where p is pitch distance and n_r is the number of bolt rows.

- $y_{\max}$: Maximum vertical distance from centroid to outermost bolt in the row

  $$y_{\max} = \frac{l_n}{2}$$

- $x_{\max}$: Maximum horizontal distance from centroid to bolt column

  $$x_{\max} = \frac{g \cdot (n_c - 1)}{2}$$

  where g is gauge distance and n_c is the number of bolt columns.

Bolt Force

This section determines the resultant force on each bolt due to applied shear and moment acting on the bolt group.

- v_{bv}: **Applied shear per bolt**

  $$v_{bv} = \frac{V_u}{n_r \cdot n_c}$$

  Where,
  V_u is the factored shear force,
  n_r is the number of bolt rows,
  and n_c is the number of bolt columns.

- t_{mh}: **Moment-induced force along the height (vertical component)**

$$t_{mh} = \frac{M_d \cdot y_{\max}}{\sum r_i^2}$$

Where,
M_d is the moment demand and
$y_{\max}$ is the vertical distance from the centroid to the bolt.

- t_{mv}: **Moment-induced force along the width (horizontal component)**

$$t_{mv} = \frac{M_d \cdot x_{\max}}{\sum r_i^2}$$

Where, $x_{\max}$ is the horizontal distance from the centroid to the bolt.

- a_{bh}: **Additional bolt force from axial load (if applicable)**

$$a_{bh} = \frac{A_u}{n_r \cdot n_c}$$

Where A_u is the axial force (often zero for pure shear).

- v_{res}: **Resultant force on each bolt**

$$v_{res} = \sqrt{(v_{bv} + t_{mv})^2 + (t_{mh} + a_{bh})^2}$$

$$v_{bv} = \frac{V_u}{n_r \cdot n_c}, \quad t_{mh} = \frac{M_d \cdot y_{\max}}{\sum r_i^2}, \quad t_{mv} = \frac{M_d \cdot x_{\max}}{\sum r_i^2}$$
$$v_{res} = \sqrt{(v_{bv} + t_{mv})^2 + (t_{mh} + a_{bh})^2}$$

Bolt Shear Capacity

Shear Capacity of the bolt is calculated as

$$V_{dsb} = \frac{f_u n_n A_{nb}}{\sqrt{3}\gamma_{mb}}$$

Ref: IS 800:2007, Cl.10.3.3

Bolt Bearing Capacity

Bearing Capacity of the bolt is calculated as

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

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

Ref: IS 800:2007, Cl.10.3.4

Bolt Capacity

Minimum of the two: bolt shear capacity and bolt bearing capacity is taken as bolt capacity.**Bolt Capacity should be higher than Bolt Force calculated above.**

$$V_{db} = \min(V_{dsb}, V_{dpb})$$

Ref: IS 800:2007, Cl.10.3.2

Long Joint Reduction (optional)

When the length of the joint of a splice,l_j exceeds $15d$ in the direction of the load then nominal shear capacity of the bolt is reduced by factor β_i. If $l_j \geq 15d$;

$$V_{rd} = \beta_{lj} V_{db} \quad \beta_{lj} = 1.075 - \frac{l}{200d},\ 0.75 \leq \beta_{lj} \leq 1.0$$

Ref: IS 800:2007, Cl.10.3.3.1 No. of bolts can be calculated as:

$$N = \frac{\text{Factored Shear Force } (V_u)}{\text{Bolt Capacity } (V_{db})}$$

Round off to nearest integer take even number of bolts.

3.4 Plate Design

Min and Max Plate Height

Minimum and maximum plate height criteria are used to ensure proper load transfer, avoid interference with beam flanges.

$$h_{\min} = 0.6(d_b - 2t_f - 2r), \quad h_{\max} = d_b - t_{bf} + r - \text{notch height}$$

Ref: INSDAG, Ch.5, Sec.5.2.3

Min Plate Width

$$w_{\min} = 2e_{\min} + (n_c - 1)p_{\min}$$

Shear Yielding Strength

Shear yielding occurs when the material yields due to high shear stress. To ensure structural safety, the design shear capacity is calculated by considering this yielding mechanism. The expression for shear yielding strength is:

$$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$$

where,
A_v is the shear area,
f_y is the yield strength of the material, and
γ_{m0} is the partial safety factor for material strength.

Allowable Shear Capacity

To provide an additional safety margin and account for uncertainties, the design codes recommend using a reduced shear capacity. The allowable design shear force is calculated as:

$$V_d = 0.6 \cdot V_{dy}$$

Ref: IS 800:2007, Cl.10.4.3

Shear Rupture Capacity

Checks for brittle fracture along the net shear plane, typically near bolt holes or cutouts. This failure mode is sudden and must be considered separately from shear yielding.

$$V_{dn} = \frac{0.75 A_{vn} f_u}{\sqrt{3}\gamma_{m1}}$$

A_{vn} = net shear area
f_u = ultimate tensile strength
γ_{m1} = partial safety factor for rupture
Ref: AISC, Sect. J4

Block Shear in Shear

Two cases as given in Cl 6.4.1 of IS 800:2007 are evaluated; the minimum of the two governs:

$$V_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}, \quad V_{db2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$$
$$V_{db} = \min(V_{db1}, V_{db2})$$

A_{vg}, A_{vn} = shear areas (gross, net)
A_{tg}, A_{tn} = tension areas (gross, net)
f_y, f_u = yield and ultimate strengths
γ_{m0}, γ_{m1} = safety factors

Ref: IS 800:2007, Cl.6.4

3.4.1 Shear Capacity

Minimum of the three calculated above is adopted as shear capacity of the plate.

- Allowable Shear Capacity (S_c)
- Shear Rupture Capacity (V_{dn}), and
- Block Shear Capacity in Shear (V_{db})

Tension Yielding

Checks axial tension failure in yielding.

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

where,
A_g = gross cross-section areas
f_y = yield strength of the Plate
γ_{m0} = safety factors
Ref: IS 800:2007, Cl.6.2, Cl.6.3.1

3.4.2 Tension Rupture Capacity

Tension Rupture checks for failure against plate failure due to tension.

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

A_{ns}= net cross-section of the plate
f_u= ultimate strength of the plate
γ_{m1}= partial safety factors

Block Shear in Tension

Block shear can also govern in tension members with bolt holes or cutouts.

$$T_{db1}, T_{db2} \text{ (same as shear case)}$$

Ref: IS 800:2007, Cl.6.4

3.4.3 Tension Capacity

Minimum of the three calculated above is adopted as Tension capacity of the plate.

- Tension Yield Capacity (T_{dg})
- Tension Rupture Capacity (T_{dn}), and
- Block Shear Capacity in Tension (T_{db})

Moment Capacity

Checks plastic moment resistance of the section.

$$M_{dz} = \frac{\beta_b Z_p f_y}{\gamma_{m0}}$$

where,
β_b = 1.0 for plastic and compact sections
β_b = z_e/z_p for semi-compact sections

Z_p, Z_e = plastic and elastic section moduli of the cross-section
f_y = yield strength of the Plate γ_{m0} = partial safety factors (see 5.4.1 Table 5)
Ref: IS 800:2007, Cl.8.2.1.2

Interaction Ratio

9.3.2.1

3.5 Section Design

Minimum and maximum plate height criteria are used to ensure proper load transfer, avoid interference with beam flanges.

$$h_{\min} = 0.6(d_b - 2t_f - 2r), \quad h_{\max} = d_b - t_{bf} + r - \text{notch height}$$

Ref: INSDAG, Ch.5, Sec.5.2.3

$$w_{\min} = 2e_{\min} + (n_c - 1)p_{\min}$$

Shear Yielding Strength

Shear yielding occurs when the material yields due to high shear stress. To ensure structural safety, the design shear capacity is calculated by considering this yielding mechanism. The expression for shear yielding strength is:

$$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$$

where,
A_v is the shear area,
f_y is the yield strength of the material, and
γ_{m0} is the partial safety factor for material strength.

Allowable Shear Capacity

To provide an additional safety margin and account for uncertainties, the design codes recommend using a reduced shear capacity. The allowable design shear force is calculated as:

$$V_d = 0.6 \cdot V_{dy}$$

Ref: IS 800:2007, Cl.10.4.3

Shear Rupture Capacity

Checks for brittle fracture along the net shear plane, typically near bolt holes or cutouts. This failure mode is sudden and must be considered separately from shear yielding.

$$V_{dn} = \frac{0.75 A_{vn} f_u}{\sqrt{3}\gamma_{m1}}$$

A_{vn} = net shear area
f_u = ultimate tensile strength
γ_{m1} = partial safety factor for rupture
Ref: AISC, Sect. J4

Block Shear in Shear

Two cases as given in Cl 6.4.1 of IS 800:2007 are evaluated; the minimum of the two governs:

$$V_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}, \quad V_{db2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$$
$$V_{db} = \min(V_{db1}, V_{db2})$$

A_{vg}, A_{vn} = shear areas (gross, net)
A_{tg}, A_{tn} = tension areas (gross, net)
f_y, f_u = yield and ultimate strengths
γ_{m0}, γ_{m1} = safety factors

Ref: IS 800:2007, Cl.6.4

3.5.1 Shear Capacity

Minimum of the three calculated above is adopted as shear capacity of the plate.

- Allowable Shear Capacity (S_c)
- Shear Rupture Capacity (V_{dn}), and
- Block Shear Capacity in Shear (V_{db})

Tension Yielding

Checks axial tension failure in yielding.

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

where,
A_g = gross cross-section areas
f_y = yield strength of the Plate
γ_{m0} = safety factors
Ref: IS 800:2007, Cl.6.2, Cl.6.3.1

3.5.2 Tension Rupture Capacity

Tension Rupture checks for failure against plate failure due to tension.

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

A_{ns}= net cross-section of the plate
f_u= ultimate strength of the plate
γ_{m1}= partial safety factors

Block Shear in Tension

Block shear can also govern in tension members with bolt holes or cutouts.

$$T_{db1}, T_{db2} \text{ (same as shear case)}$$

Ref: IS 800:2007, Cl.6.4

3.5.3 Tension Capacity

Minimum of the three calculated above is adopted as Tension capacity of the plate.

- Tension Yield Capacity (T_{dg})
- Tension Rupture Capacity (T_{dn}), and
- Block Shear Capacity in Tension (T_{db})

Moment Capacity

Checks plastic moment resistance of the section.

$$M_{dz} = \frac{\beta_b Z_p f_y}{\gamma_{m0}}$$

where, β_b = 1.0 for plastic and compact sections
β_b = z_e/z_p for semi-compact sections
Z_p, Z_e = plastic and elastic section moduli of the cross-section
f_y = yield strength of the Plate γ_{m0} = partial safety factors (see 5.4.1 Table 5)
Ref: IS 800:2007, Cl.8.2.1.2

Interaction Ratio

This ratio as recommended by code is calculated as

$$\text{IR} = \frac{M_d}{M_{dz}} + \frac{V_u}{T_d} \leq 1$$

3.6 Weld Design

Minimum and Maximum Weld Size

According to IS 800:2007 (Cl. 10.5.5.1), the weld size must be selected within a prescribed range to ensure structural adequacy and proper fusion between the base metals.

- The **minimum weld size** is specified to ensure sufficient heat input and proper fusion during welding. IS 800 prescribes it as the greater of:
  - 3 mm (standard minimum), or
  - the minimum thickness of the connected plates.

  $$s_{\min} = \max(3, \text{min thickness}),$$

  See Table 21 and choose value of minimum thickness of weld (δ_{min}).

- The **maximum weld size** is limited to avoid overwelding, which can lead to excessive heat input and distortion. It should not exceed the thinner of the plates being joined.

$$s_{\max} = \text{min (thickness of plate, thickness of section)}$$

Ref: IS 800:2007, Cl. 10.5.5.1

Weld Strength

Welds must be capable of carrying the design loads safely. The resultant force in a weld (R_w) is calculated using the vector sum of in-plane and out-of-plane components.

$$R_w = \sqrt{(T_{wh} + A_{wh})^2 + (T_{wv} + V_{wv})^2}$$

where,

$$T_{wh} = \frac{M \times y_{\text{max}}}{I_{pw}}; \quad T_{wv} = \frac{M \times x_{\text{max}}}{I_{pw}}; \quad V_{wv} = \frac{V}{l_w}; \quad A_{wh} = \frac{A}{l_w}$$

- T_{wh}: Horizontal shear due to torsion or moment
- A_{wh}: Applied horizontal load
- T_{wv}: Vertical shear due to torsion or moment
- V_{wv}: Applied vertical load

The design strength of the weld is given by:

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

- t_t: Throat thickness of weld
- f_u: Ultimate tensile strength of weld metal (usually same as base metal)

- γ_{mw}: Partial safety factor for weld material (see Table 5, IS 800:2007)

This equation ensures that the weld strength accounts for the shear stress on the throat of the weld and includes a safety factor.
Ref: IS 800:2007, Cl. 10.5.7.1.1

References

Chapter 4

Internship Task 2- End Plate DDCL

4.1 Task 2: End Plate connection

Fetch Reports from osdag module analyse the reports, check its formulas aligning with IS code or not, and make a comprehensive DDCL for the same. Also if any errors in formula or any mismatch in it ,record them into a separate overleaf file.

4.2 Task 2: Tasks Done

Design and detailing checklist (DDCL)

End Plate Connection

Prepared by:
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Under the guidance of
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July 24, 2025

Contents

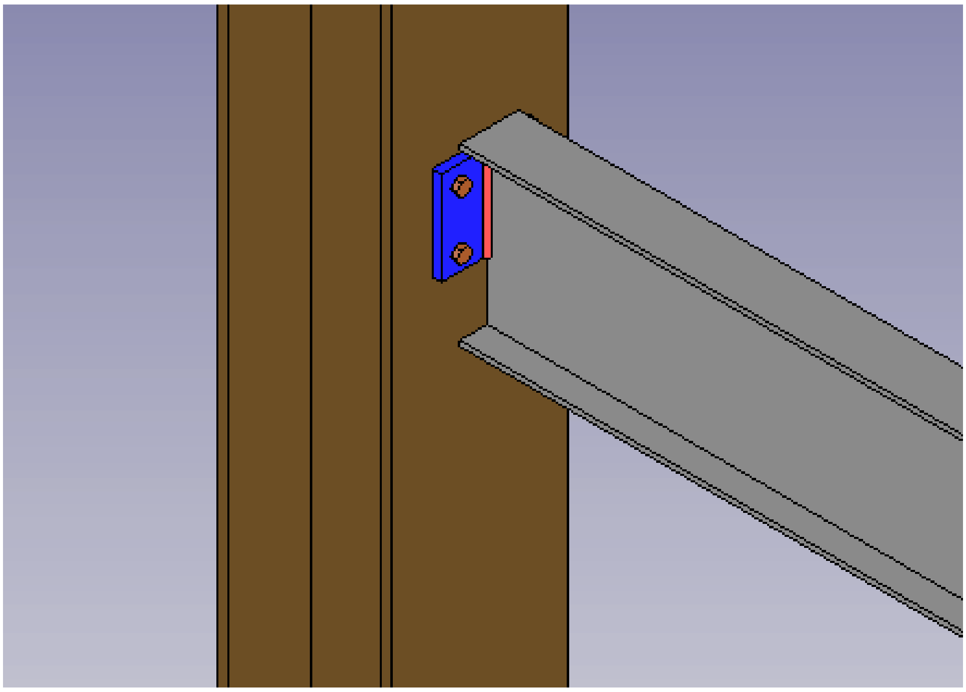
Chapter 1

Theory

Introduction

In steel structures, connecting different members like beams and columns is a very important part of the design. One common way to do this is called the "end plate connection". Basically, an end plate connection is when a plate is welded to the end of a beam, and then that plate is bolted to another structure like a column or another beam. This type of connection is widely used in buildings, bridges, and even industrial structures because it is simple, fast, and strong. Studying end plate connections is important because it helps us understand how the forces move from one member to another and how the entire structure behaves under loads.

Diagram



Chapter 2

Design and Detailing Checklist for Osdag Software

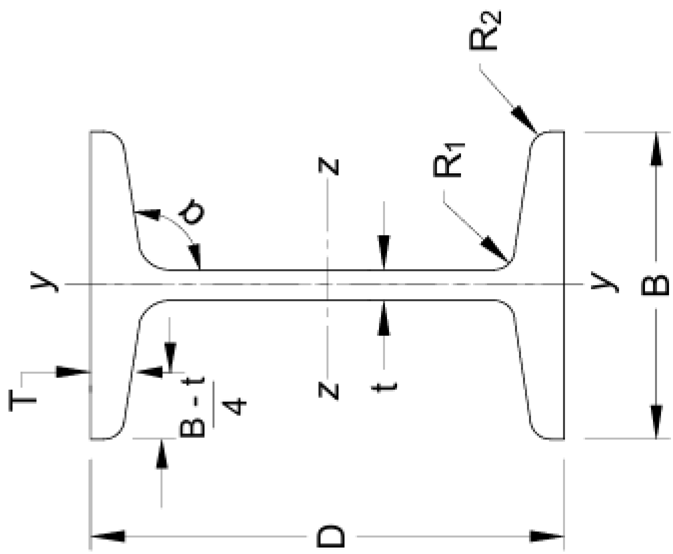
The following are the input parameters that the user will have to input on the Osdag Software.

- **Connectivity:*** The users will have a choice to choose between Column Flange-Beam Web, Column Web-Beam Web, and Beam-Beam.
- **Column Section:*** The user may choose any section of their choice for the column.
- **Beam Section:*** The user may choose any section of their choice for the beam.
- **Material Property:*** The user will have the option to choose from the available grades of steel.
- **Factored Shear Force(in kN):*** The user will have to input the factored shear force.
- **Factored Axial Load(in kN):*** The user will have to input the factored axial force.
- **Diameter of Bolt:*** The user has the choice of specifying the diameter of the bolt or choosing the most optimized design provided by the software.
- **Type of the bolt:*** The user will have a choice to specify the bolt type as friction type (HSFG) or bearing type.
- **Property (Grade) of Bolt:*** The user has the choice of specifying the grade of the bolt or choosing the most optimized design provided by the software.

The user will also have the option of changing the **Design Preferences** from **Edit > Design Preferences or CTRL + P**. These options for the design of a Fin Plate Connection include:

- **Connector:** The user can choose material of the connector fin between E 165, E250 and E 300.
- **Type of Bolt:** The choice in this section is between a pre-tensioned bolt and a non pre-tensioned bolt.
- **Type of Hole:** The user can choose between a standard hole or an oversized hole.
- **Slip Factor:** For a high-strength friction grip (HSFG) bolt, the user can define the slip factor.
- **Edge Preparation Method**: This relates to the fabrication aspect where the user can specify whether the hole has sheared or hand flame cut edges or Rolled, machine-flame cut, sawn and planed edges. This helps in determining the formula for the diameter of hole.
- **Gap between Beam and Support:**
- **Exposure of Members to Corrosive Surfaces:** The user can specify whether the members will be exposed corrosive surfaces or not. This will help in effective calculation of minimum and maximum end and edge distances.
- **Weld:** The user can choose type of weld fabrication- shop weld or field weld and also choose material of the weld.

***Input Compulsory.**



Chapter 3

Design Checks

3.1 Section Design Check

Shear Yielding Capacity of secondary beam

The shear in beam to beam connection is taken by web of the secondary beam.Thus Shear Yielding Capacity is given by :

$$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$$

For beam to beam connection, A_v = (D-2t+r-notch height) x T
For column web to beam web or column flange to beam web connection, A_v = D x T

Ref: IS 800:2007, Cl.10.4.3

Allowable Shear Capacity of secondary beam

Allowable Shear Capacity is taken as 60 percent of the SYC .It should be greater than shear yielding capacity of the secondary beam in case of beam beam connection, and greater than shear yielding capacity of the beam in other connections.

$$V_d = 0.6 \times V_{dy}$$

Limited to low shear

Tension Yielding Capacity

The axial tension in the secondary beam is taken by web of the secondary beam.It should be lower than Tension Yielding Capacity of the web of the secondary beam.

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

Ref: IS 800:2007, Cl.6.2

3.2 Bolt Design

Bolt should be designed with proper pitch distance, gauge distance, edge distance and end distance in Range. Further, it should be checked against shear and bearing.

3.2.1 pitch, gauge, end, edge distance

Pitch(mm) Pitch should be provided in below range , minimum it should be taken as 2.5 times the diameter of the bolt.

$$p_{\min} = 2.5d, \quad p_{\max} = \min(32t, 300)$$

Ref: IS 800:2007, Cl.10.2.2, Cl.10.2.3
End Distances(mm)

$$e_{\min} = 1.7d_0, \quad e_{\max} = \min(12t\varepsilon)$$

Ref: IS 800:2007, Cl.10.2.4.2, Cl.10.2.4.3
Edge Distances(mm)

$$e'_{\min} = 1.7d_0, \quad e'_{\max} = \min(12t\varepsilon)$$

Ref: IS 800:2007, Cl.10.2.4.2, Cl.10.2.4.3
Gauge(mm) Gauge should be provided in below range , minimum it should be taken as 2.5 times the diameter of the bolt.

$$g_{\min} = 2.5d, \quad g_{\max} = \min(32t, 300)$$

3.2.2 Shear Check of bolts

Shear demand per bolt

$$V_{bv} = \frac{V_u}{n}$$

where:V_u = factored shear force
n = number of bolts sharing the load

Design for friction grip type botling in which slip is not allowed, slip resistance should be greater than the applied factored shear force. It can be calculated as

Slip Resistance of bolt, $$V_{dsf} = \frac{\mu_t \, n_e \, K_h \, F_o}{\gamma_{mf}}$$

μ_f = 0.55 see Table 20, IS 800:2007
n_e= no of interfences offering frictional resistance to slip
γ_{mf} = 1.10 or 1.25 depends on conditions refer 10.4.3
$F_o = 0.70 f_u A_{nb}$

Ref: IS 800:2007, Cl.10.3.2

Bolt Capacity: In HFSG bolt connection bolt capacity is slip resistance of the bolt since no slip is allowed. If slip occurs then connnection is considered to fail.

$$V_{db} = V_{dsf}$$

Bolt capacity of bolt should be higher than shear demand per bolt.
Ref: IS 800:2007, Cl.10.3.2

Long Joint Reduction Factor When the length of the joint of a splice,l_j exceeds $15d$ in the direction of the load then nominal shear capacity of the bolt is reduced by factor β_i.

If $l_j \geq 15d$;

$$V_{rd} = \beta_{lj} V_{db} \quad \beta_{lj} = 1.075 - \frac{l}{200d},\ 0.75 \leq \beta_{lj} \leq 1.0$$

Ref: IS 800:2007, Cl.10.3.3.1

Large grip length reduction factor

$$l_g = \Sigma(T_p + t_{member})$$

Ref: IS 800:2007 cl 10.3.3.2
Packing plate reduction factor

$$t_{pk} = \text{gap}$$

Ref: IS 800:2007 cl 10.3.3.3

If reduction factor is applicable it should be multiplied with bolt capacity and the resultant value shall
Bolt capacity post reduction factor

$$V_{rd} = \beta_{lj}\, \beta lg\, \beta pk\, V_{db}$$

Ref: IS 800:2007 cl 10.3.3.3

Tension Check of the bolts

$$\text{Tension Demand} = \frac{\text{Axial force (P)}}{n}$$

$$\text{Bolt Prying Force } Q = \frac{l_v}{2l_e}\left[T_e - \frac{\beta\eta f_o b_e t^4}{27 l_e l_v^2}\right]$$

$$\text{where} \quad l_v = e - \frac{R_1}{2}$$

$$f_o = 0.7 f_{ub}$$

$$l_e = \min\left(e,\ 1.1t\sqrt{\frac{\beta f_o}{f_y}}\right); \quad \beta = 1(\text{ pre-tensioned bolt}), \quad \eta = 1.5$$

$$b_e = \frac{B}{n_c}$$

Ref: IS 800:2007 cl 10.3.4.7

Bolt tension force (kN),

$$T_f = T_1 + Q$$

Interaction Ratio for Bolt Design

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

V_{sb} = factored shear force on bolt
V_{db} = design shear capacity of bolt
T_b = factored tensile force on bolt
T_{db} = design tensile capacity of bolt

Ref: IS 800:2007, Cl.10.3.6

3.3 Plate Design

Min and Max Plate Height

Minimum and maximum plate height criteria are used to ensure proper load transfer, avoid interference with beam flanges.

$$h_{\min} = 0.6(d_b - 2t_f - 2r_r), \quad h_{\max} = d_b - t_{bf} + r_{b1} - \text{notch height}$$

Ref: INSDAG, Ch.5, Sec.5.2.3

Min Plate Thickness (MM

Min thickness of the plate should be minimum of the thickness of the two connecting sections .

Min Plate Width

$$w_{\min} = g' + 2e'_{\min}$$

Shear Yielding Strength

Shear yielding occurs when the material yields due to high shear stress. To ensure structural safety, the design shear capacity is calculated by considering this yielding mechanism. The expression for shear yielding strength is:

$$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$$

where,
A_v is the shear area,
f_y is the yield strength of the material, and
γ_{m0} is the partial safety factor for material strength.

Allowable Shear Capacity
To provide an additional safety margin and account for uncertainties, the design codes recommend using a reduced shear capacity. The allowable design shear force is calculated as:

$$V_d = 0.6 \cdot V_{dy}$$

Ref: IS 800:2007, Cl.10.4.3

Shear Rupture Capacity

Checks for brittle fracture along the net shear plane, typically near bolt holes or cutouts. This failure mode is sudden and must be considered separately from shear yielding.

$$V_{dn} = \frac{0.75 A_{vn} f_u}{\sqrt{3}\gamma_{m1}}$$

A_{vn} = net shear area
f_u = ultimate tensile strength
γ_{m1} = partial safety factor for rupture
Ref: AISC, Sect. J4

Block Shear in Shear

Two cases as given in Cl 6.4.1 of IS 800:2007 are evaluated; the minimum of the two governs:

$$V_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}, \quad V_{db2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$$
$$V_{db} = \min(V_{db1}, V_{db2})$$

A_{vg}, A_{vn} = shear areas (gross, net)
A_{tg}, A_{tn} = tension areas (gross, net)
f_y, f_u = yield and ultimate strengths
γ_{m0}, γ_{m1} = safety factors

Ref: IS 800:2007, Cl.6.4

3.3.1 Shear Capacity

Minimum of the three calculated above is adopted as shear capacity of the plate.

- Allowable Shear Capacity (S_c)
- Shear Rupture Capacity (V_{dn}), and
- Block Shear Capacity in Shear (V_{db})

Plate Moment Demand

$$M = T_e \cdot \text{ecc}$$

$$\text{ecc} = \frac{g}{2} - \frac{t_w}{2} - s$$

Moment demand arises due to eccentric load transfer from bolts. The eccentricity is calculated from the bolt line to the center of the web.

M = moment demand on plate
T_e = tensile force per bolt
ecc = eccentricity from bolt line to web center
g = bolt gauge (center-to-center of bolt group)
t_w = web thickness of supported beam
s = offset or weld set-back (if any)

Ref: IS 800:2007, Cl.10.4.7

Moment Capacity

Checks plastic moment resistance of the section.

$$M_{dz} = \frac{\beta_b Z_p f_y}{\gamma_{m0}}$$

where,
β_b = 1.0 for plastic and compact sections
β_b = z_e/z_p for semi-compact sections
Z_p, Z_e = plastic and elastic section moduli of the cross-section
f_y = yield strength of the Plate γ_{m0} = partial safety factors (see 5.4.1 Table 5)
Ref: IS 800:2007, Cl.8.2.1.2

3.4 Weld Design

Minimum Weld Size

$$s_{\text{min}} = \max(3, \text{ based on thinner part thickness})$$

Ensures adequate fusion and durability of the weld. Also prevents early failure or corrosion due to under-sizing.

s_{min} = minimum weld size
t = thickness of the thinner connected part

Ref: IS 800:2007, Cl.10.5.2.3

Maximum Weld Size

$$s_{\text{max}} = \min(0.7t, \text{ thinner part thickness})$$

Restricts overwelding and ensures proper joint configuration. Protects the edge of thinner plates from being overheated.

s_{max} = maximum weld size
t = thickness of the thinner part

Ref: IS 800:2007, Cl.10.5.3.1

Required Weld Strength (N/MM)

$$R_w = \sqrt{A_{wh}^2 + V_{wv}^2}$$

Required weld strength is based on the vector sum of axial and shear forces. This ensures the weld can resist combined stresses safely.

R_w = required weld strength (N/mm)
A_{wh} = axial force per mm length
V_{wv} = shear force per mm length

Available Weld Strength (N/MM)

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

Weld design strength is calculated based on the weld throat and material capacity. It accounts for safety factors to prevent brittle fracture.

f_w = design strength of weld (N/mm)
t_t = weld throat thickness = $0.7s$
f_u = ultimate strength of weld material
γ_{mw} = partial safety factor for weld (typically 1.25)

Ref: IS 800:2007, Cl.10.5.7.1.1

References

Chapter 5

Internship Task 3- Cleat angle DDCL

5.1 Task 3: Cleat angle connection

Fetch Reports from osdag module analyse the reports, check its formulas aligning with IS code or not, and make a comprehensive DDCL for the same. Also if any errors in formula or any mismatch in it ,record them into a separate overleaf file.

5.2 Task 3: Tasks Done

Design and detailing checklist (DDCL)

Cleat Angle Connection

Prepared by:
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Under the guidance of
Prof. Siddhartha Ghosh

Indian Institute of Technology Bombay
July 24, 2025

Contents

Chapter 1

Theory

Cleat Angle Connection: Types Based on Member Orientation

Cleat angle connections are widely used in steel structures for joining beams and columns. Depending on how the cleat (L-shaped steel angle) is connected, there are several types:

1. Beam Web to Column Flange Connection

In this web of the beam is connected to Flange of the column using angle section which can connected etither by bolt or by weld to the section memebers.

2. Beam Web to Column Web Connection

In this web of the beam is connected to web of the column using angle section which can connected etither by bolt or by weld to the section memebers.

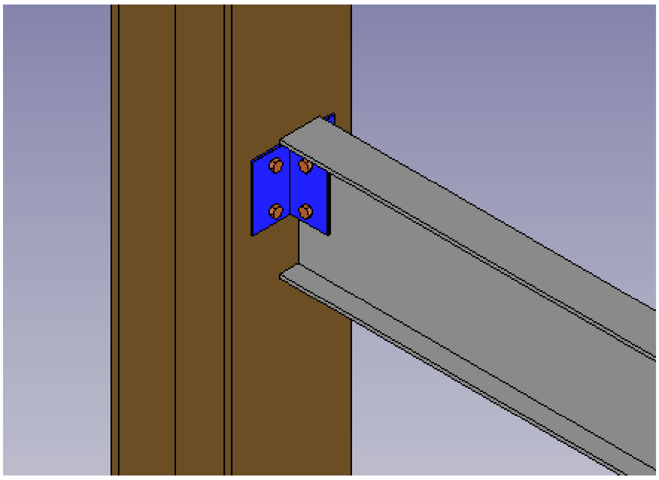
3. Beam Web to Beam Web or Beam Flange

In this Primary beam is connected to secondary beam web to web using angle section which can connected etither by bolt or by weld to the section memebers.

4. Beam Flange to Column Flange

- **Description:** Cleat angle is connected between the flanges of both the beam and the column.
- **Application:** Less common, used where special detailing is needed.

Diagram



Chapter 2

Design and Detailing Checklist for Osdag Software

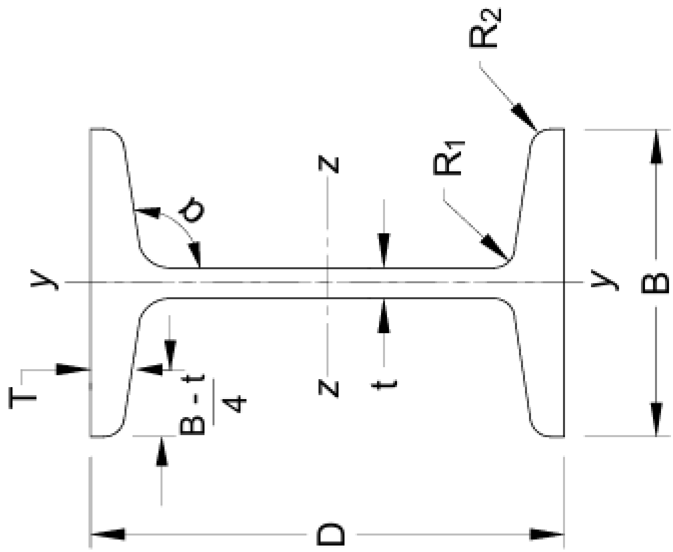
The following are the input parameters that the user will have to input on the Osdag Software.

- **Connectivity:*** The users will have a choice to choose between Column Flange-Beam Web, Column Web-Beam Web, and Beam-Beam.
- **Column Section:*** The user may choose any section of their choice for the column.
  In beam -beam connection user may choose from Primary Beam .
- **Beam Section:*** The user may choose any section of their choice for the beam.
  In beam to beam connection user may choose from Secondary Beam.
- **Material Property:*** The user will have the option to choose from the available grades of steel.
- **Factored Shear Force(in kN):*** The user will have to input the factored shear force.
- **Diameter of Bolt (mm):*** The user has the choice of specifying the diameter of the bolt or choosing the most optimized design provided by the software.
- **Type of the bolt:*** The user will have a choice to specify the bolt type as friction Grip Bolt (HSFG) or Bearing Bolt.
- **Property Class (Grade) of Bolt:*** The user has the choice of specifying the grade of the bolt or choosing the most optimized design provided by the software.
- Cleat Angle/ Cleat Section

The user will also have the option of changing the **Design Preferences** from **Edit > Design Preferences or CTRL + P**. These options for the design of a Fin Plate Connection include:

- **Type of Bolt:** The choice in this section is between a pre-tensioned bolt and a non pre-tensioned bolt.
- **Type of Hole:** The user can choose between a standard hole or an oversized hole.
- **Slip Factor:** For a high-strength friction grip (HSFG) bolt, the user can define the slip factor.
- **Edge Preparation Method**: This relates to the fabrication aspect where the user can specify whether the hole has sheared or hand flame cut edges or Rolled, machine-flame cut, sawn and planed edges. This helps in determining the formula for the diameter of hole.
- **Gap between Beam and Support:**
- **Exposure of Members to Corrosive Surfaces:** The user can specify whether the members will be exposed corrosive surfaces or not. This will help in effective calculation of minimum and maximum end and edge distances.

***Input Compulsory.**



Chapter 3

Design Checks

3.1 Initial Section Check

Shear Yielding Capacity of secondary beam

The shear in beam to beam connection is taken by web of the secondary beam.Thus Shear Yielding Capacity is given by :

$$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$$

For beam to beam connection, A_v = (D-2t+r-notch height) x T
For column web to beam web or column flange to beam web connection, A_v = D x T

Ref: IS 800:2007, Cl.10.4.3

Allowable Shear Capacity of secondary beam

Allowable Shear Capacity is taken as 60 percent of the SYC .It should be greater than shear yielding capacity of the secondary beam in case of beam beam connection, and greater than shear yielding capacity of the beam in other connections.

$$V_d = 0.6 \times V_{dy}$$

Limited to low shear

3.2 Load Consideration

The load consideration for the cleat angle connection is based on the applied shear force and the minimum required shear as per IS 800:2007.

Applied Shear Force

This is Factored value of Shear Force as input by user.

V_y : Input by User in KN

Minimum Required Shear Force

According to IS 800:2007, Clause 10.7, the minimum shear force to be considered is:

$V_{y\ min} = \min(0.15 V_{dy}, 40.0)$ **i.e, 15 percent of shear yielding capacity pf secondary beam.**

Design Shear Force

$$V_u = \max(V_y, V_{y,\min})$$

Reference: IS 800:2007, Clause 10.7.

3.3 Design of Bolt connected to secondary Beam

1. dia of the bolt
2. property class of the bolt
3. No. of bolt rows
4. No. of bolt columns

3.3.1 Min and max pitch

As per IS 800:2007, the pitch distance between bolts ensures proper force transfer and avoids tearing or bearing failure in the connected plates. Clause 10.2.2 specifies the minimum pitch, while Clause 10.2.3 gives the limit for the maximum pitch.

$$p_{\min} = 2.5d$$
$$p_{\max} = \min(32t, 300)$$

where:

- d = nominal bolt diameter
- t = thickness of the thinner connected plate

Reference: IS 800:2007, Clause 10.2.2 and Clause 10.2.3.

3.3.2 Min and max Gauge

According to IS 800:2007, the gauge distance is the transverse spacing between bolt lines. Proper gauge distances are essential to avoid tearing and ensure uniform force distribution. Clause 10.2.2 provides the minimum gauge distance, while Clause 10.2.3 specifies the maximum allowable gauge.

$$g_{\min} = 2.5d$$
$$g_{\max} = \min(32t, 300)$$

where:

- d = nominal bolt diameter
- t = thickness of the thinner connected plate

Reference: IS 800:2007, Clause 10.2.2 and Clause 10.2.3.

3.3.3 Min and max End Distance

As per IS 800:2007, the end distance is the distance from the center of a bolt hole to the nearest edge of the connected plate in the direction of load. Adequate end distances are crucial to prevent tearing or shearing failure.

$$e_{\min} = 1.7d_0$$

$$e_{\max} = 12t\varepsilon \quad ; \quad \varepsilon = \sqrt{\frac{250}{f_y}}$$

where:

- d_0 = diameter of the bolt hole

- t = thickness of the connected plate
- f_y = yield strength of the connected beam,(plate)

Note: The yield strength f_y used in calculating maximum end and edge distances refers to the connected plate material, NOT THE BOLT. This ensures proper ductility and tearing resistance of the plate around bolt holes. *Reference:* IS 800:2007, Clause 10.2.4.2 and Clause 10.2.4.3.

3.3.4 Min and max Edge Distance

Edge distance is the distance from the center of the bolt hole to the nearest edge of the plate, measured perpendicular to the direction of the load. According to IS 800:2007, adequate edge distances help prevent splitting or tearing of the connected plate.

$$e'_{\text{min}} = 1.7d_0$$

$$e'_{\text{max}} = 12t\varepsilon \quad ; \quad \varepsilon = \sqrt{\frac{250}{f_y}}$$

where:

- d_0 = diameter of bolt hole
- t = thickness of the connected plate (e.g., cleat angle or beam web)
- f_y = yield strength of the connected plate material

Note: The value of f_y must correspond to the material in which the bolt hole is made, not the bolt itself.
Reference: IS 800:2007, Clause 10.2.4.2 and Clause 10.2.4.3.

3.4 Design of Bolts connected to column or primary beam

All step will be same as fone for design of bolts connected to secondary beam.

3.4.1 Min and Max Pitch

Remain Same as above

3.4.2 Min and Max Gauge

Remain Same as above

3.4.3 Min and Max End and Edge distance

NOTE: One change may occur in calculation of end and edge distance. Depending upon yield stress of column section or primary beam, value of f_y may change in formula $\varepsilon = \sqrt{\frac{250}{f_y}}$

3.5 Cleat Angle Checks

3.5.1 Min cleat angle height

To ensure adequate engagement and structural integrity, the height of the cleat angle must satisfy the minimum dimension requirement. According to INSDAG (Chapter 5, Section 5.2.3), the minimum height of the cleat angle leg connected to the supported beam is given by:

$$h_{\text{min}} = 0.6\,(d_b - 2t_f - 2r)$$

where:

- d_b = depth of the supported beam

- t_f = thickness of the beam flange
- r = root radius or toe radius of the beam flange

This condition ensures the cleat angle covers the web of the supported beam sufficiently without interference from the flanges.
Reference: INSDAG, Chapter 5, Section 5.2.3.

3.5.2 Max cleat angle height

The maximum allowable height of the cleat angle ensures that it fits within the available depth between the flanges of the supporting beam without causing interference. As per INSDAG (Chapter 5, Section 5.2.3), the maximum cleat angle height is given by:

$$h_{\max} = d_s - t_{bf} + r_b - h_{\text{notch}}$$

where:

- d_s = depth of the supporting beam
- t_{bf} = thickness of the beam flange
- r_b = root radius or fillet radius of the beam
- h_{notch} = height of any notch at the end of the cleat angle

This ensures the cleat angle does not extend into the fillet or flange region of the supporting beam.
Reference: INSDAG, Chapter 5, Section 5.2.3.

3.5.3 Min length of cleat angle on supported leg

The minimum leg length of the cleat angle must be sufficient to accommodate bolt spacing, edge distances, and thickness tolerances. According to design guidelines, it is calculated as:

$$L_{\min} = \max\left(\text{gap},\ t_{\text{cleat}} + r + 2e'_{\min} + (n_c - 1)g_{\min}\right)$$

where:

- gap = spacing between cleat and supported member
- t_{cleat} = thickness of cleat angle
- r = root radius or toe radius of cleat
- $e'_{\min}$ = minimum edge distance
- n_c = number of bolt columns
- $g_{\min}$ = minimum gauge distance

This ensures that the cleat leg is long enough to house all bolts with minimum required distances and proper clearance.

3.5.4 Min length of cleat angle on supporting leg

The minimum leg length of the cleat angle on supporting leg is calculated as:

$$L_{\min} = \max\left(\text{gap},\ t_{\text{cleat}} + r + 2e'_{\min} + (n_c - 1)g_{\min}\right)$$

3.5.5 Min cleat angle thickness

The cleat angle thickness must be sufficient to resist shear and bearing without excessive deformation. A practical guideline is to provide a thickness not less than half the thickness of the supported beam web:

$$t_{\text{cleat}} \geq 0.5 \times t_{\text{web}}$$

where:

- t_{cleat} = thickness of cleat angle
- t_{web} = thickness of the web of the supported beam

This ensures that the cleat is structurally compatible with the supported member and capable of safe load transmission without buckling or excessive deformation.

3.5.6 Shear Yielding capacity

The shear yielding capacity of the cleat angle ensures that the connection can safely transfer the applied shear force without yielding. According to IS 800:2007, Clause 10.4.3, the design shear strength in yielding is given by:

$$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$$

where:

- V_{dy} = design shear yielding capacity
- A_v = shear area of the cleat angle (typically 2 × leg height × thickness)
- f_y = yield strength of the cleat angle material
- γ_{m0} = partial safety factor for material strength (usually 1.1)

This check ensures the cleat angle is strong enough in shear to resist the applied force without yielding.
Reference: IS 800:2007, Clause 10.4.3.

3.5.7 Block Shear in Shear

Block shear is a possible failure mode involving a combination of shear along a plane and tension along an orthogonal plane. According to IS 800:2007, Clause 6.4, the design block shear strength is given by:

$$V_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$$

$$V_{db2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$$

$$V_{db} = \min(V_{db1}, V_{db2})$$

where:

- A_{vg} = gross area in shear
- A_{vn} = net area in shear
- A_{tg} = gross area in tension
- A_{tn} = net area in tension
- f_y = yield strength of the cleat material
- f_u = ultimate tensile strength of the cleat material
- γ_{m0}, γ_{m1} = partial safety factors (typically 1.1 and 1.25)

The lower of V_{db1} and V_{db2} is taken as the design block shear strength. *Reference: IS 800:2007 Cl 6.4.1*

3.5.8 Shear capacity

The final design shear capacity of the cleat angle is governed by the lower of the shear yielding capacity and the block shear capacity. This ensures that the cleat does not fail under the applied shear load.

$$V_d = \min(V_{dy}, V_{db})$$

Reference: IS 800:2007 Cl 6.1

3.5.9 Moment Capacity

The moment capacity of the cleat angle is evaluated to ensure it can resist any induced moment from eccentric load transfer or connection geometry. According to IS 800:2007, Clause 8.2.1.2, the design moment capacity is calculated as:

$$M_{dz} = \frac{\beta_b Z_p f_y}{\gamma_{m0}}$$

where:

- M_{dz} = design moment capacity about major axis
- β_b = plastic section coefficient (typically 1.0 for full plastic stress distribution)
- Z_p = plastic section modulus of the cleat angle
- f_y = yield strength of the cleat angle material
- γ_{m0} = partial safety factor for material strength (usually 1.1)

This capacity must be checked where cleat angles are subjected to eccentric shear or moment due to connection eccentricity.
Reference: IS 800:2007, Clause 8.2.1.2.

Chapter 6

Internship Task 4- Seated angle DDCL

6.1 Task 4: Seated angle connection

Fetch Reports from osdag module analyse the reports, check its formulas aligning with IS code or not, and make a comprehensive DDCL for the same. Also if any errors in formula or any mismatch in it ,record them into a separate overleaf file.

6.2 Task 4: Tasks Done

Design and detailing checklist (DDCL)

Seated Angle Connection

Prepared by:
Chaman Lal Yadav

Mentor
Parth karia

Under the guidance of
Prof. Siddhartha Ghosh

Indian Institute of Technology Bombay
19 June 2025

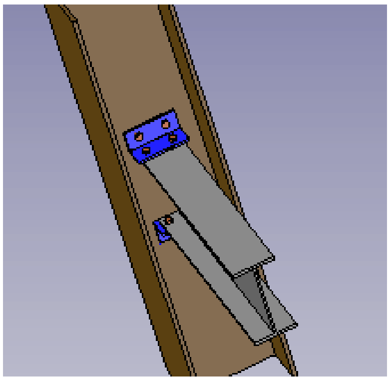
Contents

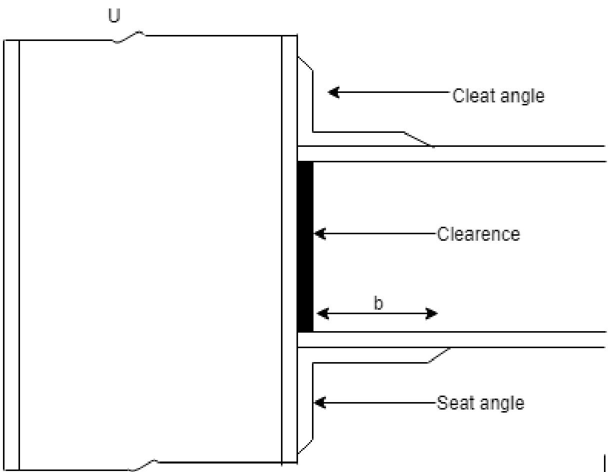
Chapter 1

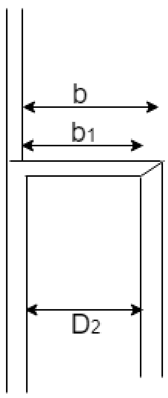
Theory

1.1 Introduction

Seated connection is a simple shear connection which consists of an angle section connected to column or primary beam and another beam (called secondary beam in beam to beam connection) seats over the angle section, generally connected with bolts.







Chapter 2

Design and Detailing Checklist for Osdag Software

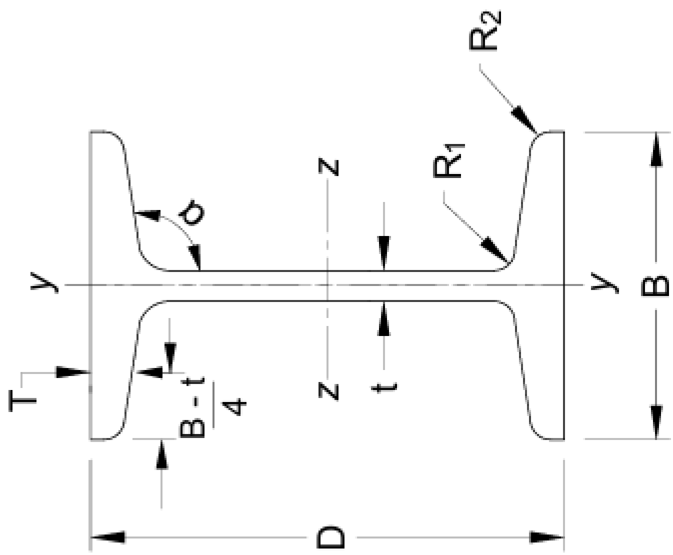
The following are the input parameters that the user will have to input on the Osdag Software.

- **Connectivity:*** The users will have a choice to choose between Column Flange-Beam Web, Column Web-Beam Web, and Beam-Beam.
- **Column Section:*** The user may choose any section of their choice for the column.
  In beam -beam connection user may choose from Primary Beam .
- **Beam Section:*** The user may choose any section of their choice for the beam.
  In beam to beam connection user may choose from Secondary Beam.
- **Material Property:*** The user will have the option to choose from the available grades of steel.
- **Factored Shear Force(in kN):*** The user will have to input the factored shear force.
- **Diameter of Bolt (mm):*** The user has the choice of specifying the diameter of the bolt or choosing the most optimized design provided by the software.
- **Type of the bolt:*** The user will have a choice to specify the bolt type as friction Grip Bolt (HSFG) or Bearing Bolt.
- **Property Class (Grade) of Bolt:*** The user has the choice of specifying the grade of the bolt or choosing the most optimized design provided by the software.
- Seated Angle/ Cleat Section

The user will also have the option of changing the **Design Preferences** from **Edit** > **Design Preferences or CTRL + P**. These options for the design of a Fin Plate Connection include:

- **Type of Bolt:** The choice in this section is between a pre-tensioned bolt and a non pre-tensioned bolt.
- **Type of Hole:** The user can choose between a standard hole or an oversized hole.
- **Slip Factor:** For a high-strength friction grip (HSFG) bolt, the user can define the slip factor.
- **Edge Preparation Method**: This relates to the fabrication aspect where the user can specify whether the hole has sheared or hand flame cut edges or Rolled, machine-flame cut, sawn and planed edges. This helps in determining the formula for the diameter of hole.
- **Gap between Beam and Support:**
- **Exposure of Members to Corrosive Surfaces:** The user can specify whether the members will be exposed corrosive surfaces or not. This will help in effective calculation of minimum and maximum end and edge distances.

***Input Compulsory.**



Chapter 3

Design Checks

3.1 Initial Section Check

Shear Yielding Capacity of secondary beam

The shear in beam to beam connection is taken by web of the secondary beam.Thus Shear Yielding Capacity is given by :

$$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}}$$

For beam to beam connection, A_v = (D-2t+r-notch height) x T
For column web to beam web or column flange to beam web connection, A_v = D x T

Ref: IS 800:2007, Cl.10.4.3

Allowable Shear Capacity of secondary beam

Allowable Shear Capacity is taken as 60 percent of the SYC .It should be greater than shear yielding capacity of the secondary beam in case of beam beam connection, and greater than shear yielding capacity of the beam in other connections.

$$V_d = 0.6 \times V_{dy}$$

Limited to low shear

3.2 Load Consideration

The load consideration for the cleat angle connection is based on the applied shear force and the minimum required shear as per IS 800:2007.

Applied Shear Force

This is Factored value of Shear Force as input by user.

$$V_y : \text{Input by User in KN}$$

Minimum Required Shear Force

According to IS 800:2007, Clause 10.7, the minimum shear force to be considered is:

$$V_{y\,min} = \min(0.15V_{dy}, 40.0) \quad \textbf{i.e, 15 percent of shear yielding capacity pf secondary beam.}$$

Design Shear Force

$$V_u = \max(V_y, V_{y,\min})$$

Reference: IS 800:2007, Clause 10.7.

3.3 Design of Bolt connected to Column

1. diameter of the bolt (mm)
2. property class of the bolt
3. No. of bolt rows
4. No. of bolt columns

3.3.1 Large Grip Length reduction factor

while considering long joints, Grip Length which is equal to the total thickness of the connected plates can be expressed as

$$\textbf{Grip Length } l_g = \Sigma(t_p + t_{member})$$

where, t_p= thickness of the seated angle section
t_member = thickness of the column web or column flange based on type of connection.

$$\text{If } l_g \geq 5d, \quad V_{rd} = \beta_{lg} V_{db}$$
$$\text{If } l_g < 5d, \quad V_{rd} = V_{db}$$
$$\text{If} l_g \leq 8d, \text{then} \quad \beta_{lg} = \frac{8d}{3d + l_g} \quad (\text{but } \beta_{lg} \leq \beta_{lj})$$

Now, b_{ij} can be calculated from IS 800:2007 Cl. 10.3.3.1 as

$$\beta_{ij} = 1.075 - \frac{l_j}{200d} \quad \text{but,} \quad 0.75 \leq \beta_{ij} \leq 1.0 \qquad \text{[Ref. IS 800:2007, Cl. 10.3.3.1]}$$

where
d = Nominal diameter of the fastener.
[Ref. IS 800:2007, Cl. 10.3.3.2]

3.3.2 Min and max pitch

As per IS 800:2007, the pitch distance between bolts ensures proper force transfer and avoids tearing or bearing failure in the connected plates. Clause 10.2.2 specifies the minimum pitch, while Clause 10.2.3 gives the limit for the maximum pitch.

$$p_{\min} = 2.5d \quad ; \qquad p_{\max} = \min(32t, 300)$$

where:

- d = nominal bolt diameter
- t = thickness of the thinner connected plate

Reference: IS 800:2007, Clause 10.2.2 and Clause 10.2.3.

3.3.3 Min and max End Distance

As per IS 800:2007, the end distance is the distance from the center of a bolt hole to the nearest edge of the connected plate in the direction of load. Adequate end distances are crucial to prevent tearing or shearing failure.

$$e_{\min} = 1.7d_0$$

$$e_{\max} = 12t\varepsilon \quad ; \quad \varepsilon = \sqrt{\frac{250}{f_y}}$$

where:

- d_0 = diameter of the bolt hole
- t = thickness of the connected plate
- f_y = yield strength of the connected beam,(plate)

Note: The yield strength f_y used in calculating maximum end and edge distances refers to the connected plate material, NOT THE BOLT. This ensures proper ductility and tearing resistance of the plate around bolt holes.
Reference: IS 800:2007, Clause 10.2.4.2 and Clause 10.2.4.3.

3.3.4 Min and max Edge Distance

Edge distance is the distance from the center of the bolt hole to the nearest edge of the plate, measured perpendicular to the direction of the load. According to IS 800:2007, adequate edge distances help prevent splitting or tearing of the connected plate.

$$e'_{\min} = 1.7d_0$$

$$e'_{\max} = 12t\varepsilon \quad ; \quad \varepsilon = \sqrt{\frac{250}{f_y}}$$

where:

- d_0 = diameter of bolt hole
- t = thickness of the connected plate (e.g., cleat angle or beam web)
- f_y = yield strength of the connected plate material

Note: The value of f_y must correspond to the material in which the bolt hole is made, not the bolt itself.
Reference: IS 800:2007, Clause 10.2.4.2 and Clause 10.2.4.3.

3.3.5 Shear Capacity of the bolt(kN)

The design shear capacity of bolt can be calculated as per IS 800:2007 Cl 10.3.3

$$\textbf{Design Shear capacity of Bolt,} \quad V_{dsb} = \frac{f_{ub}\, n_n\, A_{nb}}{\sqrt{3}\,\gamma_{mb}}$$

where,
f_u = ultimate tensile strength of the bolt
n_n = number of shear planes with threads intercepting the shear plane;
A_{nb} = net shear area of the bolt at threads,

[Ref. IS 800:2007, Cl. 10.3.3]

Bolt Bearing Capacity

Bearing Capacity of the bolt is calculated as

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

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

Ref: IS 800:2007, Cl.10.3.4

Bolt Capacity

Minimum of the two: bolt shear capacity and bolt bearing capacity is taken as bolt capacity.**Bolt Capacity should be higher than Bolt Force calculated above.**

$$V_{db} = \min(V_{dsb}, V_{dpb})$$

Ref: IS 800:2007, Cl.10.3.2

3.4 Detailing Check of Seated Angle

Minimum Width on Column: This ensures enough plate width to accommodate bolts and edge distances.

$$w_{\min} = 4e' + t_w + 2r_r + \left(\frac{n_c}{2} - 1\right) g$$

Minimum Width on Beam: This provides sufficient space for bolt layout on the seated member.

$$w_{\min} = 4e' + t_w + 2r_r$$

Minimum Leg Length on Column: This ensures angle leg is long enough to cover bolts and clearances.

$$l_{\min} = 2e' + t + r_{ra} + (n_r - 1)p$$

3.5 Seated Angle Checks

Shear Capacity of Seated Angle:

It checks whether the angle can resist the applied shear force.

$$V_{dy} = \frac{A_v f_y}{\sqrt{3}\,\gamma_{m0}}$$

Ref:

$$V_d = 0.6\,V_{dy}$$

Ref:

Bearing Length Requirement:

It ensures enough contact length for proper bearing of the load applied without excessive deformation. It can be calculated as:

$$b_{l,\text{req}} = \frac{V\,\gamma_{m0}}{t_w f_y} - t_f - r_r$$

Minimum Leg Length Requirement:

It ensures seated leg is long enough to cover the bearing length and clearance.

$$b_1 = \max(b_{l,\text{req}},\, t_f + r_r)$$

$$b_2 = \max(b_1 + \text{gap} - t - r_{ra},\, 0)$$

Moment Capacity Check:

It Verifies angle can resist moment due to eccentric Load. Moment Demand is calculated as

$$\textbf{Moment Demand, } M = V \cdot \text{eccentricity}$$

$$\text{if } b_2 \leq b_1 \quad \text{ecc} = \frac{b_2}{b_1} \cdot \frac{b_2}{2}$$

Design Moment capacity of the Angle Section:
It should be greater than Moment Demand to bear the connection safely.

$$M_{dz} = \frac{\beta_b Z_p f_y}{\gamma_{m0}}$$

Ref: IS 800:2007, Cl 8.2.1.2

Chapter 7

Internship Task 5- Gantry girder Module

7.1 Task 5: gantry girder DDCL

Create a fresh DDCL for Gantry Girder module from scratch taking reference from Indian Standards, and mention all necessary parameters.

7.2 Task 5: Tasks Done

Design and detailing checklist (DDCL)

Gantry Girder

Prepared by:
Chaman Lal Yadav

Mentor
Parth karia

Under the guidance of
Prof. Siddhartha Ghosh

Indian Institute of Technology Bombay
28 June 2025

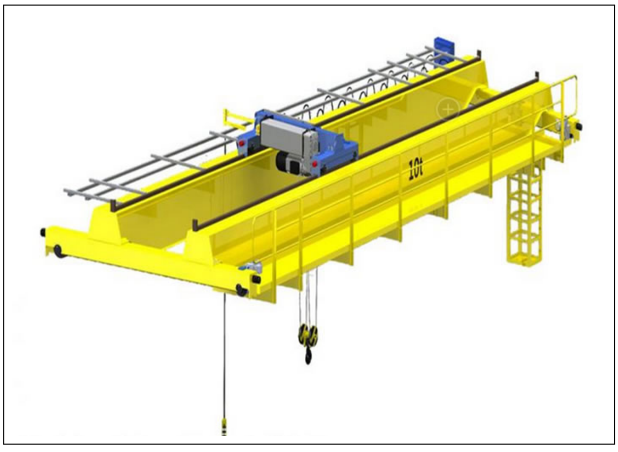
Contents

Chapter 1

Theory

1.1 Images

Gantry Girder crane sys 1



Gantry Girder Crane system 2

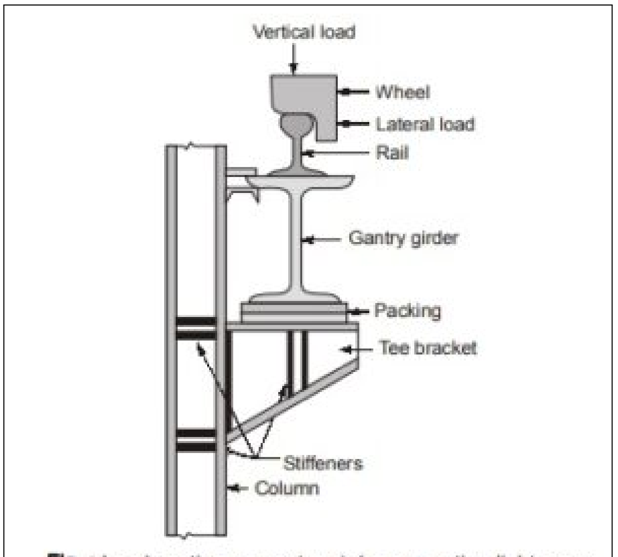


Fig. : Loads acting on gantry girder supporting light crane

Section view of gantry girder

1.2 Introduction

Gantry girders are special types of beams used to support overhead cranes in factories, workshops, and warehouses. These cranes are used to lift and move heavy materials from one place to another. The gantry girder carries the

load from the crane wheels and transfers it to the columns.
Unlike normal beams, gantry girders have to bear not only vertical loads but also horizontal forces caused by the movement and braking of the crane. They also face impact loads when the crane starts or stops suddenly. So, the design of gantry girders must be strong and safe to handle these conditions.
In India, the design of gantry girders follows **IS 800:2007** for general steel structures and **IS 3177:1999** for overhead cranes. These codes give guidelines for load calculation, impact factors, and deflection limits.
Gantry girders play an important role in industries where heavy lifting is required. Understanding their theory helps in designing safe and efficient crane systems.

Chapter 2

Design and Detailing check list

User will enter these input parameters on the interface which will be displayed in left panel of the window as input dock.

2.1 Input Parameters entered by the user:

- **Crane Capacity or Lifted Load (kN):**
- **Weight of crane excluding crab or trolley (kN):** This load act as udl all over the span of crane girder.
- **Weight of Trolley or Crab(in kN):** lifted load + trolley wt
- **Self Weight of Girder and Rails(kN):** 2kN/m often assumed
- **Span of crane between rails(in m):**
- **Min hook approach(in m):**
- **Wheel base(in m):**
- **span of gantry girder(in m):**
- **Height of rail section(in mm):**

Chapter 3

Design of the Gantry Girder

Reaction Force

$$R_A = \frac{W_C}{2} + \frac{W_t \times (B - a)}{B}$$

where, W_c is weight of crane girder without trolley or crab
W_t is weight of trolley + crane capacity (Lifted loads)
B is span of crane girder
a is min hook approach

Each wheel load

This load is transferred to the gantry girder through two wheels, with the wheelbase being b.

$$\text{Load on gantry girder from each wheel (W)} = \frac{R_A}{2}$$

Total vertical load

$$\textbf{Factored wheel Load, } W_{total,vertical} = 1.5 \times W$$

3.1 Max bending moment

Since, $b < 0.586L$, the maximum bending moment will occur when the center of the span is midway between the center of gravity (CG) of loads and one wheel load. Hence, the distance of one wheel from the center of the span is:

$$\frac{1}{2} \times \frac{b}{2} = \frac{b}{4} \quad \text{m}$$

Let the self-weight of the girder be:

$$w_1 = \frac{2W}{250}$$

Where: W = Maximum wheel load (kN) + Weight of rail:

$$w_2 = 0.2 \text{ (kN/m)}$$

Total load per unit length on gantry girder:

$$w = w_1 + w_2 \quad \text{(kN/m)}$$

he maximum bending moment M_z in a simply supported gantry girder due to vertical loads (including impact and self-weight) is given by:

$$M_z = M_{\text{wheel}} + M_{\text{impact}} + M_{\text{DL}}$$

where:

$$M_{\text{wheel}} = R \cdot a$$
$$M_{\text{impact}} = 0.25 \cdot M_{\text{wheel}}$$
$$M_{\text{DL}} = \frac{w \cdot L^2}{8}$$

R = reaction due to wheel load,
a = distance from support to point of load application,
w = uniformly distributed load (e.g., self-weight + rail weight),
L = span of gantry girder.

Maximum Bending Moment Due to Lateral Force in Gantry Girder

The lateral force (also called surge force) acts horizontally on the gantry girder due to the acceleration or deceleration of the crane trolley. It is commonly assumed as:

$$H_{\text{total}} = \beta \cdot (W_{\text{lift}} + W_{\text{trolley}}) \tag{3.1}$$

where:

- $\beta = 0.10$ — assumed percentage of surge force (typically 10%),
- W_{lift} — weight of the lifted load,
- W_{trolley} — self-weight of the trolley and mechanisms.

This total surge force is equally divided among the wheels:

$$H = \frac{H_{\text{total}}}{n} \tag{3.2}$$

where:

- H — lateral load per wheel,
- $n = 4$ — number of wheels (typical for two end carriages, each with 2 wheels).

The factored horizontal load is:

$$H_f = \gamma_f \cdot H \tag{3.3}$$

where:

- $\gamma_f = 1.5$ — load factor for horizontal loads.

The lateral bending moment is proportionally related to the vertical bending moment:

$$M_y = \left(\frac{H_f}{V_f}\right) \cdot M_z \tag{3.4}$$

where:

- M_y — lateral bending moment,
- V_f — factored vertical wheel load,
- M_z — maximum vertical bending moment due to vertical loads.

Maximum Shear Force in Gantry Girder

The maximum vertical shear force V_z in a gantry girder occurs when one wheel is just on the support and the other is still on the span. It is given by:

$$V_z = V_f + \frac{V_f \cdot b}{L} \tag{3.5}$$

Here, V_f is the factored vertical wheel load, s is the distance between crane wheels (wheelbase), and L is the span of the gantry girder.
The impact due to vertical force increases the shear force, and is added as:

$$V_{\text{impact}} = \alpha \cdot V_z \tag{3.6}$$

Where $\alpha = 0.25$ is the impact factor as per standard practice.
The dead load from the self-weight of the girder and rail also adds to shear, estimated as:

$$V_{\text{DL}} = \frac{w \cdot L}{2} \tag{3.7}$$

Where w is the factored uniform load per meter from self-weight and rails.
Therefore, the total vertical shear force is:

$$V_{\text{total}} = V_z + V_{\text{impact}} + V_{\text{DL}} \tag{3.8}$$

To estimate lateral shear due to crane surge force (horizontal), the proportioning method is used:

$$V_y = \left(\frac{H_f}{V_f}\right) \cdot V_{\text{total}} \tag{3.9}$$

Here, H_f is the factored horizontal load per wheel. The ratio $\frac{H_f}{V_f}$ captures the relative effect of horizontal load compared to vertical load.

Beam Design Data and Assumptions

Minimum Economic Depth

$$\text{Minimum depth} = \frac{L}{12}$$

Compression Flange Width

The width of the compression flange may be taken as:

$$\text{Flange width range} = \frac{L}{40} \text{ to } \frac{L}{30}$$

Required Plastic Section Modulus

$$Z_p = \frac{1.4 \times M}{f_y}$$

Trial Section

Let us try:

- ISMB 550
- ISMC 250 placed on the compression flange

3.2 Checks for moment

Moment capacity should be higher than max bending moment ,M_z

$$M_{dz} = \beta_b Z_{pz} \frac{f_y}{\gamma_{m0}} \leq 1.2 Z_e \frac{f_y}{\gamma_{m0}}$$

3.3 Moment capacity of compression flange about y-axis

$$M_{dy,f} = \beta_b Z_{pyf} \frac{f_y}{\gamma_{m0}} \leq 1.2 Z_{ey,f} \frac{f_y}{\gamma_{m0}}$$

3.4 combined check for local moment capacity

$$\frac{M_z}{M_{dz}} + \frac{M_y, f}{Mdy, f} \leq 1.0$$

3.5 Check for Buckling Resistance

Since a gantry girder is composed of I-section with channel on the top flange, we shall refer following formula to check for buckling resistance.

$$M_{cr} = c_1 \frac{\pi^2 E I_Y h_f}{2L_{LT}^2} \times [1 + \frac{1}{20}(\frac{KL/r_y}{h_f/t_f})^2]^{0.5})$$

This formula is for I-sec tion only not for composite I-section + channel

Design bending strength: It can be calculated as

$$M_{dz} = \beta_b Z_{pz} f_{bd} > M_z$$

then check for biaxial bending as:

$$\frac{M_z}{M_{dz}} + \frac{M_y}{M_{dy}} \leq 1.0$$

3.6 check for Shear

The section is checked for shear capacity,

$$\text{Shear Capacity} = \frac{A_v f_{yw}}{\sqrt{3}\gamma_{m0}} > \text{maximum shear force}$$

where, A_v = shear area = depth of i section X web thickness of i section (example: for iswb 600 , A_v = 600 x 11.2)

Reference: Limit state design of steel structures by S.K duggal – example no 12.1

Allowable shear cap

allowable shear cap = 0.6 x shear capacity

Referance: IS-800:2007 cl 8.2.1.3

case of low shear so, no reduction will be therefore in the moment capacity

3.7 Check for Web Buckling

Web should be checked for buckling under the wheel load

$$\text{Buckling resistance(kN)} = (b_1 + n_1) t_w f_{cd} \times 10^{-3} > \text{max wheel load(kN)}$$

where, b_1= bearing length i.e diameter of the wheel
n_1 = 0.5 x depth of i section + 2 x web-thickness of channel

For f_{cd} refer table 9(c) IS-800:2007

$$\lambda_w = 2.45 \frac{d_1}{t_w} = 2.45 \frac{h - 2(t_f + R1)}{t_w}$$ Ref: S.k duggal dss example no 12.1

3.8 Deflection check under wheel load

$$\delta = WL^3 \times \frac{1}{6EI}(\frac{3a}{4L} - \frac{a^3}{L^3})$$

where, W= max static wheel load $= \frac{\text{Factored wheel load}}{1.5}$
L= span of the gantry girder a= $\frac{L-b}{2}$;b= wheelbase

Permissible deflection

Permissible max deflection for gantry girder is taken as $\frac{L}{500}$

3.9 Design of connections

Now we will use fillet weld to connect I-section with channel section. Required shear cap of the weld,q $= \frac{VA\bar{y}}{I_z}$
where, V= max shear force due to wheel load only
A= min area of contact between channel section and i section
$\bar{y}$ = (distance of NA of built up section from extreme fibre of compression flange)$\bar{Y}$ - web thickness of channel
Thickness of weld(MM) $= \frac{1.50\times\sqrt{3}\,q}{0.7f_u}$ (round off to highest natural number)

The End

Chapter 8

Bugs in osdag

Bugs in osdag

Prepared by:

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Mentor

Parth karia

Under the guidance of

Prof. Siddhartha Ghosh

Indian Institute of Technology Bombay

9 june 2025

Contents

Chapter 1

Fin Plate connection

1.0.1 Shear Yielding Capacity

Shear Yielding Capacity of beam to beam connection - current: A_v = 150
correct: A_v= D - 2 (T + r)

1.0.2 Shear Rupture Capacity of plate

Shear Rupture Capacity of plate and section - miscalculation multiply with 0.75 instead of 1.

1.0.3 PITCH of the Bolt:

Bolt Design > pitch , should be min of 16t or 200 IS 800 10.2.3.2

1.0.4 Interaction ratio referance is wrong

interactionn ratio referance: current is 10.7 ; correct: is 800-9.3.1.1

Chapter 2

End plate connecction

2.0.1 SECTION DESIGN CHECK

SECTION DESIGN CHECK > Shear capacity : value display in newton : **correct: value should display in KN.** problem: /divide by 1000 is written in report but thats not being calculated in calculation part.

2.0.2 SECTION DESIGN CHECK

SECTION DESIGN CHECK > Tension capacity : value display in newton : **correct: value should display in KN.** problem: /divide by 1000 is written in report but thats not being calculated in calculation part.

2.0.3 Min Gauge Distance

Min Gauge Distance - formula ambiguous

2.0.4 Weld Strength calculation

Weld Strength calculation: **Weld strength required calculation is erroraneous. LOOK FOR CALCULATION OF WELD LENGTH**

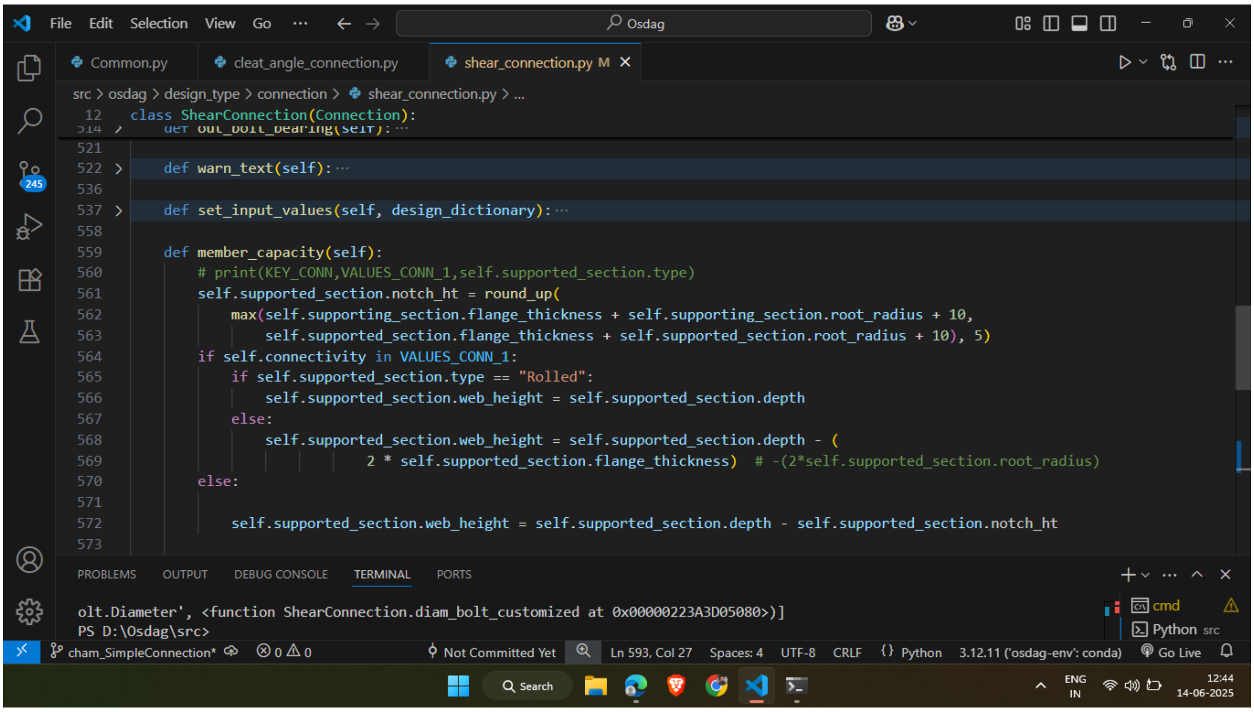
Chapter 3

Cleat angle connection

3.0.1 Initial section check

The reported shear area used in the yielding capacity calculation is incorrect.

$$V_{dy} = \frac{A_v f_y}{\sqrt{3}\gamma_{m0}} \quad \textbf{correct, } A_v = D - 2(T + R_1)$$



3.0.2 Load consideration

Applied shear force : there is calculation error in value $0.15V_{dy}$

3.1 Bolt Design

3.1.1 pitch formula dont align with is code cl 10.2.2

should be 16t instead of 32 t in formula

3.2 cleat angle check

1. shear yielding

2. **Block shear in shear**
3. **shear yielding** 4. Referances not mentioned

3.3 moment capacity

:

3.3.1 moment demand is wrong.

3.3.2 formula is not mentioned.

Chapter 4

Seated Angle connectionn

4.1 Shear Capacity

shear referance is wrong it is not in **Cl 10.4.3** it is in **Cl 8.4.1**
allowable shear capacity: **Ref: is 800:2007 Cl 8.2.1.3**

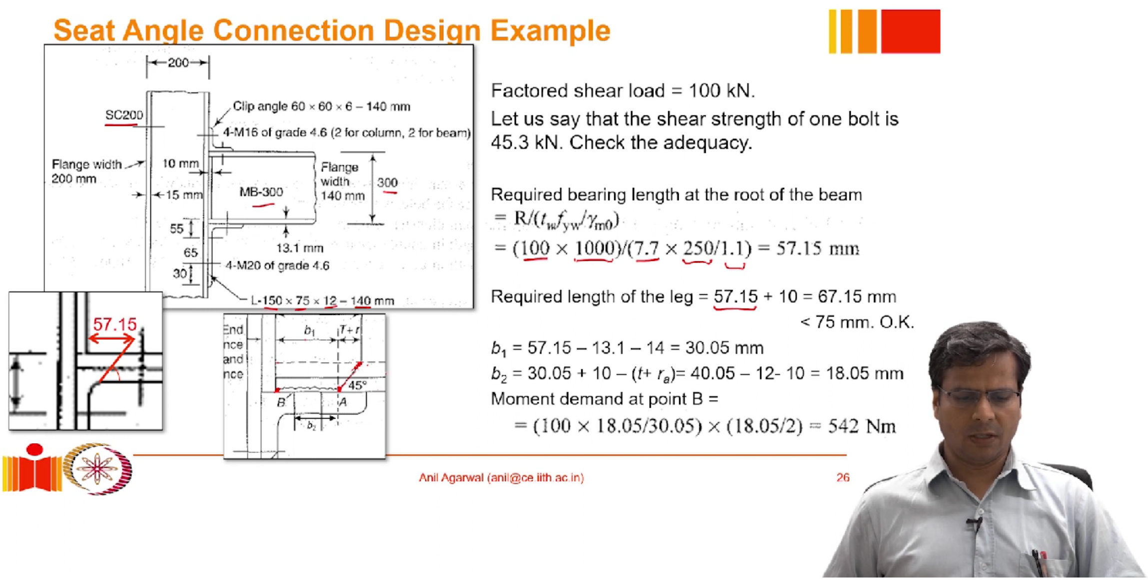
4.2 Shear Check at end

shear check is missing at end. We shall check for shear capacity by outstanding leg of the angle section also. It can be calculated as: **shear taken by angle is considered to be taken by outstanding leg of the angle thus,**

$$\text{Shear capacity of the outstanding leg} = \frac{\text{angle width,w} \times \text{angle thickness,t}}{\sqrt{3} \times \gamma_{m0}}$$

4.3 min angle width length wrong

No referance given , formula doesnt align with diagram. **Detailing check is not clear**



Chapter 5

Base plate connection

Shear Strength of Column: Calculation Issue

Clause Reference from IS 800:2007

The issue in the calculation of shear strength of the column pertains to the area not being calculated correctly. According to **IS 800:2007**, the shear strength of a member can be determined as specified in **Clause 8.4.1**. The effective shear area is defined based on the geometry of the section, and proper calculation of this area is crucial for accurate determination of the shear strength.
The relevant clause from IS 800:2007 is as follows:

> "The design shear strength of the cross-section shall be calculated using the effective shear area (A_v). For rolled sections and built-up sections, the effective shear area is taken as the area of the web. For sections with holes or openings, appropriate deductions shall be made."

Problem Statement

The calculation error arises due to an incorrect evaluation of the **effective shear area (**A_v**)**. It is essential to:

- Identify the correct geometry of the column section.
- Deduct any area reductions due to holes, openings, or other discontinuities as specified.
- Use the net area for determining the shear capacity.

Recommended Solution

To resolve the issue:

1. Verify the cross-sectional geometry of the column and calculate the web area precisely.
2. For sections with holes or openings, subtract the area of such discontinuities.
3. Recompute the shear strength using the corrected effective shear area, as defined in IS 800:2007.

Example Calculation

Assume a column with a web depth of d and thickness t. The effective shear area is given by:

$$A_v = d \cdot t$$

If there are n holes with a diameter d_h, the corrected effective shear area becomes:

$$A_v = (d \cdot t) - n \cdot \frac{\pi}{4} d_h^2$$

This corrected area should be used in further design calculations.

Effective Bearing Area of Base Plate: Correction as per IS 800:2007

Issue in the Reported Formula

The formula provided in the report for calculating the effective bearing area of the base plate is:

$$A = (D + 2c)(B + 2c) - [D - 2(T + c)]\,[B - 2(T + c)]$$

While the term $(D+2c)(B+2c)$ correctly represents the gross area of the base plate as per *N. Subramanian* (Clause 9.17.2), the subtraction term $[D - 2(T + c)][B - 2(T + c)]$ is incorrect. This term does not align with the effective bearing area requirements specified in **Figure 9** of **IS 800:2007**.

Correct Formula as per IS 800:2007

According to Figure 9 of IS 800:2007, the correct formula for the effective bearing area of the base plate is:

$$A_{\text{eff}} = (D - 2c)(2c + t_{\text{web}}) + 2(2c + T_{\text{flange}})(B + 2c),$$

where:

- D: Depth of the column.
- B: Width of the column.
- c: Projection of the base plate beyond the column face.
- t_{web}: Thickness of the web of the column.
- T_{flange}: Thickness of the flange of the column.

This formula accounts for the contributions of both the web and the flanges of the column in determining the effective bearing area.

Comparison and Correction

The reported formula incorrectly subtracts an area term based on uniform projections, while the correct formula integrates the structural details of the column, including the web thickness and flange contributions. This ensures compliance with IS 800:2007 and reflects the actual load transfer mechanism.

Illustration from IS 800:2007

The following figure, referenced from **Figure 9** of IS 800:2007, illustrates the effective bearing area of the base plate:

Conclusion

The subtraction term in the report's formula must be replaced with the correct expression derived from IS 800:2007, as detailed above. This correction ensures accurate and standard-compliant calculation of the effective bearing area.

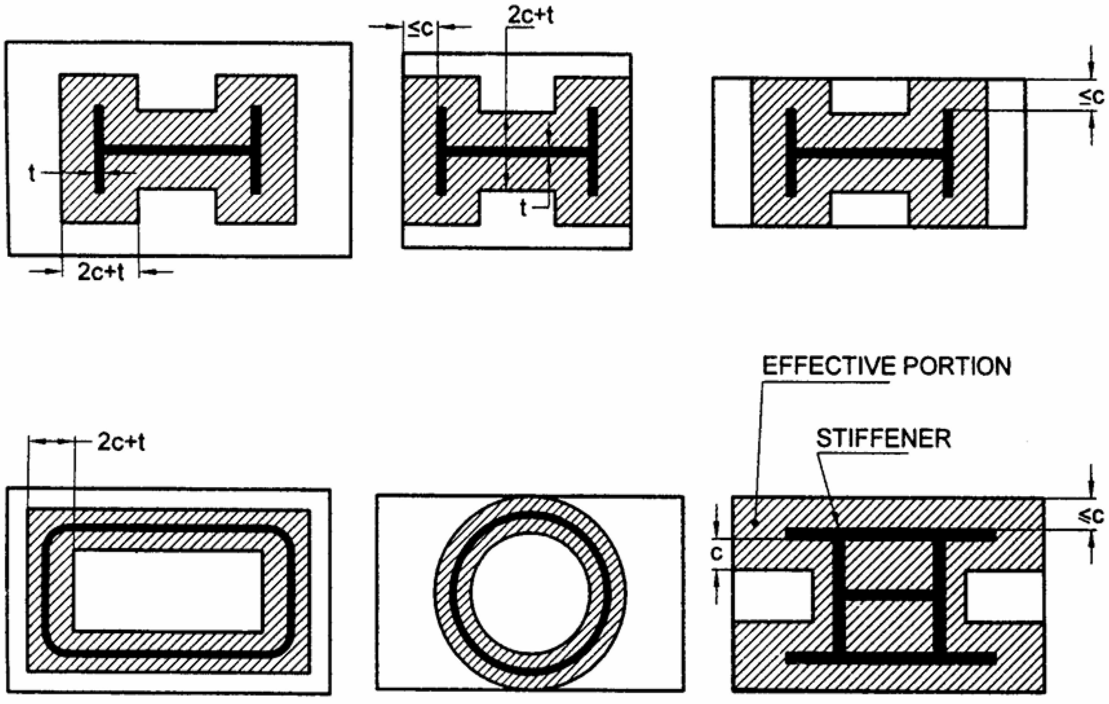


FIG. 9 EFFECTIVE AREA OF A BASE PLATE

Figure 5.1: Effective Bearing Area of Base Plate (Figure 9 from IS 800:2007)

Chapter 9

Conclusions

9.1 Tasks Accomplished

- Developed gantry girder module (from scratch)
- Verified all designs with IS codes
- Prepared DDCLs for all modules

9.2 Skills Developed

- **Design Verification:** IS code-based calculation checks
- **Documentation:** DDCL writing and formatting
- **Programming:** Python backend module development
- **Structural Concepts:** Steel connections and girder behavior
- **Teamwork:** Collaboration and code debugging

Chapter A

Appendix

FOSSEE Summer Fellowship 2025 Report

NAME	CHAMAN LAL YADAV		
PROJECT	OSDAG MODULE DEVELOPMENT		
INTERNSHIP	SUMMER FELLOWSHIP 2025 – Full Time (ON CAMPUS)		
DATE	**TASK**	**HRS WORKED**	**Day**
01 Jun	Installation & Setup		
02 Jun	Exploring Osdag Features	8	Mon
03 Jun	Module 1-Fin Plate formulas	8	Tue
04 Jun	Module 1-Fin Plate calculations	8	Wed
05 Jun	Module 1-Fin Plate calculations	8	Thu
06 Jun	Module 1-Fin Plate DDCL	8	Fri
07 Jun	Module 1-Fin Plate DDCL	8	Sat
09 Jun	Module 1-Fin Plate Bug Report	8	Mon
10 Jun	Module 1-Fin Plate Bug Report	8	Tue
11 Jun	Module 2-End Plate formulas	8	Wed
12 Jun	Module 2-End Plate calculations	8	Thu
13 Jun	Module 2-End Plate calculations	8	Fri
14 Jun	Module 2-End Plate DDCL	8	Sat
15 Jun			
16 Jun	Module 2-End Plate DDCL	8	Mon
17Jun	Module 2-End Plate Bug Report	8	Tue
18 Jun	Module 2-End Plate Bug Report	8	Wed
19 Jun	Module 3-Cleat angle formulas	8	Thu
20 Jun	Module 3-Cleat angle calculation	8	Fri
21 Jun	Module 3-Cleat angle calculation	8	Sat
22 Jun			
23 Jun	Module 3 Bugs Report	8	Mon
24 Jun	Mod 4-Seated angle formulas	8	Tue
25 Jun	Mod 4-Seated angle calculations	8	Wed
26 Jun	Module 4-Seated angle DDCL	8	Thu
27 Jun	Module 4 Bugs Report	8	Fri
28 Jun	Photo session & feedback talks with parth sir		Sat
03 Jul	Gantry girder concepts	8	Thu
04 Jul	Gantry girder concepts & DDCL	8	Fri
05 Jul	Gantry girder concepts & DDCL	8	Sat
06 Jul			Sun
07 Jul	Understanding gui part	8	Mon
08 Jul	Understanding gui part	8	Tue

09 Jul	Understanding gui part	8	Wed
13 Jul			Sun
14 Jul to19 Jul	Gantry girder algorithm	8	

- All the DDCL and Bugs Report has been shared with my mentor Parth sir.

Bibliography

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- IIT hyderabad prof anil's lectures on seated angle connection url=https://youtu.be/vSeMzD_gziA?feature=shared
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- IS 800:2007 edition