Summer Fellowship Report

On

Preparation of DDCL

Submitted by

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Under the guidance of

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Acknowledgement

The success and final outcome of this project required a lot of guidance and assistance from many people and I am extremely privileged to have got this all along the completion of my project. All that I have done is only due to such supervision and assistance and I would not forget to thank them.

I would like to specially acknowledge Prof. Siddhartha Ghosh with my deepest gratitude who in spite of being busy with his duties, took time out to hear, guide and keep me on the correct path and allowing me to carry out my project at their esteemed research lab (SSRR lab).

I would also like to acknowledge the members of the Osdag team; saurabh das (project research assistant) Danish Ansari (Project Research Assistant), Ajmal Babu MS (Project Research Engineer),for their careful and precious guidance which was extremely valuable for my both theoretical and practical study.

Contents

Chapter 1

Introduction

1.1 Osdag Internship

The FOSSEE Summer Fellowship 2019 is an ambitious scheme initiated by the FOSSEE project. FOSSEE stands for Free/Libre and Open Source Software for Education. The development of Osdag is currently funded by the Ministry of Human Resource Development (MHRD), Govt. of India, through the FOSSEE project under the National Mission on Education (NME) through ICT.

1.2 What is Osdag?

It allows the user to design steel connections, members and systems using an interactive graphical user interface. The interactive GUI provides a 3D (CAD) visualisation of the designed component and creates images for construction/fabrication drawings. The design is typically optimised following industry best practices. Among other features, it allows the user to create a professional design report of the design component.

1.3 Why osdag is use?

The Osdag project is to develop a free and open-source software for structural steel design (and detailing) as per the Indian Standard IS 800 : 2007.
Creation of 3D CAD models that can be imported to generic CAD softwares.
User-friendly input and output docs, with text-validated fields grouped according to the design flow.
Video tutorials are available to help get started. The video tutorials of Osdag can be accessed at https://osdag.fossee.in/resources/videos

Chapter 2

Preparation of DDCL

2.1 What is DDCL

There are many design procedure for each connectivity, they have need to as per norms and to create more elaborate procedure.In this report I had created DDCL for moment connections using Latex.
For preparation of DDCL I have followed Indian Standard codes, various text books, To make the new design procedure with cover plate connection, I tried the some basics moment concepts and various combinations of design preferences. And taking the above points in consideration make the .tex and .pdf files of the design procedure.

2.2 DDCL for cover plate fastener connection

Cover plate is a use for connecting beams to beam.In this connection usually assumed that the flange splice carries all the moment and the web splice carries the shear. A cover plate can be fastened to a permanent member either by bolts and rivets.cover plates not only serve as a method of joining steel members together, but also strengthen the joint.They are mainly used in bridges and buildings structure.The DDCL of cover plate is attached with Appendix A

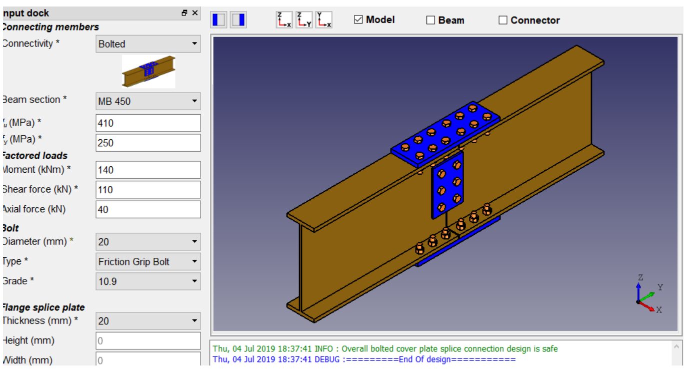


Figure 2.1: 3D drawing output of cover plate connection

Chapter 3

conclusion

On the whole, this internship was a useful experience. I have gained new knowledge, skills and met many new people. I achieved several of my learning goals.
Related to my study I learned more about the steel connection and behaviour of failure. Furthermore I experienced that the importance the steel structure.
The internship was also good to find out what my strengths and weaknesses are. This helped me to define what skills and knowledge I have to improve in the coming time.
At last this internship has given me new insights and motivation to pursue a career in steel structure.
I would like to thanks to convey my thanks to FOSSEE for providing me an opportunity.It certainly lifted my structural designing skill.
Now I look forward to facing the upcoming challenges of the structural world.

Reference

- IS 800:2007. Indian Standard Code of Practice for General Construction in Steel, 2007.

- N. Subramanian. Design of Steel Structures, Oxford University Press,12 edition.

- S.K.Duggal. Design of Steel Structures,3 edition.

Appendices

Appendix A

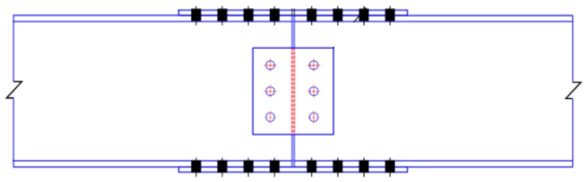
DDCL for Cover plate

Osdag

Open steel design and graphics

Design and Detailing Check List (DDCL)
and
Design and Detailing Query (DDQ)

cover plate moment splice connection



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Contents

Input data

- Connecting members

  Connectivity = Beam to beam cover plate moment splice connection

  Primary Beam Section

  Secondary Beam Section

  gap between two sections

  Ultimate strength of sectionf_u

  Yield strength of section f_y

- Factored loads

  Shear force

  Moment

- Fastener Details

  Diameter (d)

  Bolt hole Type

  Bolt Type(Bearing or Friction grip bolt)

  Properties class

  Ultimate strength of bolt f_{ub}

  Bearing strength of bolt f_{yb}

  Slip Factor

- Plate section

  Thickness of plate

  Ultimate strength of sectionf_u

  Yield strength of section f_y

Chapter 1

Material Strength

The ultimate strength (f_u) and the yield strength (f_y) of the beam material and plate material are assumed to be same.

The values of material strength will be subjected to the following limits depending on the grade of the material, in **MPa**;

1.1 Yield Stress Limits

[Reference: Table-1, IS 800 : 2007; Table-2, IS 2062 : 2011]

$$250 \leq f_y \leq 650 \tag{1.1}$$

1.2 Ultimate Stress Limits

[Reference: Table-1, IS 800 : 2007; Table-2, IS 2062 : 2011]

$$410 \leq f_u \leq 780 \tag{1.2}$$

Where,
f_y = yield stress of the beam/plate material; and
f_u = ultimate stress of the beam/plate material.

Is this check: **Ok** / **Not Ok**

Comment(s):

Chapter 2

Factored Loads

2.1 Design shear force

[ref: cl.10.7 IS 800:2007]

Design shear force (V_u) for connection is minimum of (0.15*V_d, 40kN) but greater than given shear load.
design shear capacity
[ref: cl.8.4 IS 800:2007]

$$V_d = V_p/\gamma_{mo} \tag{2.1}$$

Where,
V_p = plastic shear capacity of beam
γ_{mo} = 1.1 [ref:cl.5.4.1, IS 800:2007]

$$V_p = \frac{A_v f_{yw}}{\sqrt{3}} \tag{2.2}$$

Where,
A_v = shear area [ref:cl.8.4.1.1 of IS 800:2007 to calculate shear area]
f_{yw} = yield strength of web

Is this check: **Ok** / **Not Ok**

Comment(s):

Chapter 3

Bolt design

3.1 Bolt value for flange and web splice

3.1.1 Bearing type bolts

3.1.1.1 Shear capacity V_{dsb}

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

$$V_{dsb} = (n_n A_{nb} + n_s A_{sb}) f_{ub} / \sqrt{3} \gamma_{mb} \tag{3.1}$$

Where,

f_{ub} = Ultimate strength of a bolt
n_n = number of shear planes with threads intercepting the shear plane;
n_s = number of shear planes without threads intercepting the shear plane;
A_s = Nominal plain shank area of the bolt;
A_n = Net shear area of the bolt at threads, may be taken as area corresponding to root diameter at the thread (Ref:table 4.3,DOSS by S.K.Duggal);
γ_{mb} = partial safety factor = 1.25 [Ref:table 5,IS 800:2007]

3.1.1.2 Bearing capacity (V_{dpb})

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

$$V_{dpb} = 2.5 * k_b * d * t * f_u / \gamma_{mb} \tag{3.2}$$

Where,

k_b = is smaller of e/3d_o, (p/3d_o)-0.25 , f_{ub}/f_u,1;
e,p = end and pitch distances of the fastener along bearing direction
d_o = diameter of the hole
[for d_o refer Table 19, IS:800-20017]
f_{ub},f_u = Ultimate tensile stress of the bolt and the ultimate tensile stress of

the plate respectively;

d = Nominal diameter of the bolt

t = Summation of the thickness of the connected plates experiencing bearing stress in the same direction, or if the bolts are counter sunk, the thickness of the plate minus one half of the depth of countersinking

Note:
The bearing resistance (in the direction normal to the slots in slotted holes) of bolts in holes other than standard clearance holes may be reduced by multiplying the bearing resistance obtained as above, V_{dpb},by the factors given below:
a) Over size and short slotted holes – 0.7, and
b) Long slotted holes – 0.5

3.1.2 Friction grip type bolts

3.1.2.1 Slip resistance (V_{dsf})

[Reference: Cl. 10.4.3, IS 800:2007]

$$V_{dsf} = \mu_f n_e K_h F_o / \gamma_{mf}$$

Where,

μ_f = coefficient of friction (slip factor) = Depend on treatment of connecting surface.

n_e = number of effective interfaces offering frictional resistance to slip

K_h = 1.0 for bolts in standard holes

=0.85 for bolts in oversized holes

F_o = proof load= $f_o * A_{nb}$

A_{nb} =net area of the bolt at thread.

f_o =Proof stress= $0.7 * f_{ub}$

γ_{mf} = partial safety factor = 1.25.

A_{nb} = net area of bolt;

f_{ub} = ultimate tensile stress bolt

γ_{mf} = partial safety factor = 1.25 [Ref. table 5;IS 800:2007]

3.1.2.2 Bolt capacity(V_{db})

$$V_{db} = min(V_{dsb}, V_{dpb}) \tag{3.3}$$

From here on V_{bolt} is used where bolt capacity is considered. V_{bolt} is taken as V_{dsf} if friction grip bolting is done and is taken as V_{db} for bearing type bolts

3.1.3 Bolt group capacity

Provided of bolts are connecting to each flange of beam.
Shear capacity of bolt group = number of bolts * individual bolt capacity

3.2 Check for long joint

[Ref. cl.10.3.3.1;IS 800:2007]
if $l_j \geq$ 15d
then,reduction factor β_{ij} is given by,

$$\beta_{ij} = 1.075 - l_j/(200d)\ but\ 0.75 \ \leq\ \beta_{ij}\ \leq\ 1.0 \tag{3.4}$$

where,
l_j = the distance between the first and last rows of bolts in the joint, measured in the direction of the load transfer
d = nominal diameter of bolt
This applies for both bearing and friction grip type connections.

3.3 Check for large grip lengths

[Ref. cl.10.3.3.2;IS 800:2007]

When the grip length, lg(equal to the total thickness of the connected plates) exceeds 5 times the diameter, d of the bolts, the design shear capacity shall be reduced by a factor β_{lg},given by:

$$\beta_{lg} = 8d/(3d+1) < \beta_{lj} < 8d \tag{3.5}$$

The grip length lg shall in no case be greater than 8d.

Is this check: **Ok** / **Not Ok**

Comment(s):

3.4 Number of bolts for flange

$$force\ in\ the\ flange(P_f) = \frac{M}{D - t_f} + \frac{P}{2} \quad (3.6)$$

where,

M = bending moment

D = depth of beam

t_f =thickness of flange.

P =Axial force

$$n = P_f / V_{bolt} \quad (3.7)$$

3.5 Number of bolts for web

3.5.1 Calculation of no. of bolts for web splice connection

Slip resistance per bolt

Bearing resistance on web per bolt

Bolt value

$$N = \frac{P}{V_{db}} \quad (3.8)$$

where,

P =Axial force

V_{db} =Bolt value

3.5.2 Calculation of resultant force

[Ref:DOSS by N. Subramanian,pg no.376]

$$Resultant\ force(R) = \sqrt{(R_v)^2 + (R_h)^2} \quad (3.9)$$

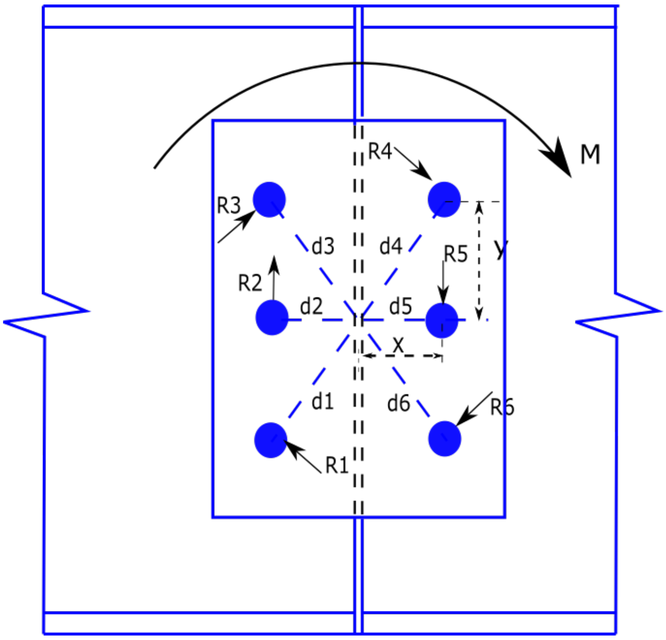

Figure 3.1: Force on connection

horizontal shear force on bolt due to eccentric moment.(R_h)

$$R_h = \frac{M * Y}{X^2 + Y^2} \tag{3.10}$$

where,

M = Factored Moment
Y = vertical distance from centroid of bolt to CG
X = horizontal force between centroid of bolt to CG

Resultant shear force $(R) \leq$ **Bolt value**(V_{db})

Is this check: **Ok** / **Not Ok**

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Chapter 4

Detailing Checks for flange and web splice

4.1 Pitch (p) and gauge (g) distances

4.1.1 Minimum pitch (p) and gauge distances

[Ref: Cl. 10.2.2, IS 800 : 2007]

$$pitch(p)/gauge(g) \geq 2.5 * bolt\, diameter \tag{4.1}$$

4.1.2 Maximum pitch (p) and gauge distances

[Ref: Cl. 10.2.3.1, IS 800 : 2007]

$$pitch(p)/gauge(g) \leq min(32 * t, 300\, mm) \tag{4.2}$$

[Ref: Cl. 10.2.3.2, 10.2.3.3, IS 800 : 2007]
When member are in compression and tension condition;

$$pitch(p)/gauge(g) \leq min(16 * tor 100 + 4 * t, 200\, mm) \tag{4.3}$$

where,
t = thickness of thinner plate being connected

4.2 End (e) and edge (e′) distances

4.2.1 Minimum end (e) and edge (e′) distances

[Ref: Cl. 10.2.4.2, IS 800 : 2007]

For sheared or hand-flame cut edges;

$$end(e)/edge(e') \ \geq \ 1.7 * d_0 \tag{4.4}$$

For rolled, machine-flame cut, sawn and planed edges;

$$end(e)/edge(e') \geq 1.5 * d_0 \tag{4.5}$$

where,
d_o = diameter of hole or size of hole (Ref :Table 19, IS 800 : 2007)

4.2.2 Maximum end (e) and edge (e′) distances

[Ref: Cl. 10.2.4.3, IS 800 : 2007]

$$end(e)/edge(e') \leq 12 * t * \varepsilon \tag{4.6}$$

Where,
$\varepsilon = \sqrt{\frac{250}{f_y}}$
t = thickness of the thinner plate;
f_y = yield stress of the plate

Is this check: **Ok** / **Not Ok**

Comment(s):

Chapter 5

Web splice Design and Checks

5.1 Plate height (h_p)

$$h_p = (Number\ of\ bolts - 1) * p + 2 * e$$

where,

p = pitch distance
e =end distance

5.2 width of web cover plate (w_p)

$$w_p \leq D - 2(t_{bf} + r_{b1} + gap)$$

Where,

D = Depth of beam
t_{bf} = Thickness of beam flange
r_{b1} = Root radius of beam
gap = Clearance between beam and beam

5.3 Check for plate

[Ref: cl no.8.4.1, IS 800:2007]

$$V_p = \frac{A_v * f_{yw}}{\sqrt{3}}$$

where,

$A_v = 2 * t * h_p$

$V_u < V_p$

5.3.1 check

[Ref: cl no. 8.4.2.1, IS 800 : 2007]

For web without stiffener

$$\frac{d}{t_w} \geq 67\epsilon$$

Is this check: **Ok** / **Not Ok**

Comment(s):

5.4 Block shear capacity

[Reference: Cl. 6.4.1, IS 800 : 2007]

Block shear capacity of the plate should be greater than the factored applied shear force.

5.4.1 Block shear path

$$T_{db1} = 2 * [\frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}] \tag{5.1}$$

$$T_{db2} = 2 * [\frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}] \tag{5.2}$$

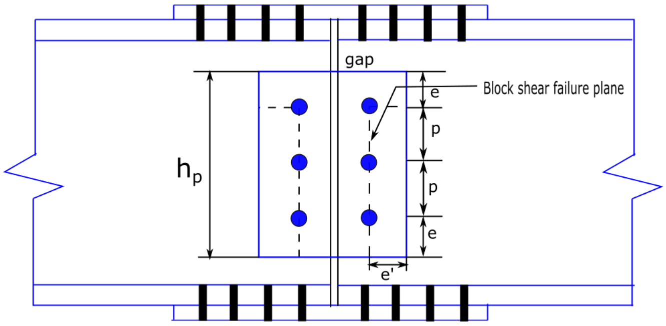

Figure 5.1: Block Shear Paths

where,
A_{vg} = Minimum gross area in shear along bolt line parallel to external force = $(h_p - e)\ *\ t_p$

A_{vn} = Minimum net area in shear along bolt line parallel to external force =$(h_p - e - (n_r - 0.5) * d_o)\ *\ t_p$

A_{tg} = Minimum gross area in tension from the bolt hole to , end bolt line, perpendicular to the line of force=$e' * t_p$

A_{tn} = Minimum net area in tension from the bolt hole to , end bolt line, perpendicular to the line of force=$(e' - (n_c - 0.5) * d_o) * t_p$

where,
n_r = number of bolt rows
n_c = number of bolt columns
f_u = Ultimate stress of the plate material
f_y = Yield stress of the plate material
e = end distance
e' = edge distance
γ_{m0} = 1.10
γ_{m1} = 1.25

For safe design,
$T_{db} \geq V_u$

Is this check: **Ok** / **Not Ok**

Comment(s):

Chapter 6

Flange splice Plate Design and Checks

6.1 Plate length (l_p)

Based on detailing,

$$l_p = (n-1)*p + 2*e$$

where,
n =number of bolts.
p =pitch distance.
e =end distance.

6.1.1 Check for maximum plate length

6.2 Plate width (w_p)

Based on detailing, taking width of flange

6.3 Check

[Ref. DOSS by N.Subramanian;pg no.428]

$$Net\ area\ of\ flange = (b_f - d_b * number) * t$$
$$Flange\ capacity = \frac{f_y * Net\ area\ of\ flange}{\gamma_{m1}}$$

Flange capacity$\geq$ Flange force

6.4 Required plate thickness (t_p)

[Ref:DOSS by N. Subramanian;pg no.428;ex.5.27]

$$t_p = \frac{P_f}{Flange\ capacity} \tag{6.1}$$

where,
P_f=Flange force

6.4.1 Minimum plate thickness

To ensure the shear strength of plate, assuming beam is designed to be safe against shear.

$t_p \geq$ Beam flange thickness

Is this check: **Ok** / **Not Ok**

Comment(s):

6.5 Block shear capacity

[Reference: Cl. 6.4.1, IS 800 : 2007]

Block shear capacity of the plate should be greater than the factored applied shear force.

6.5.1 Block shear path

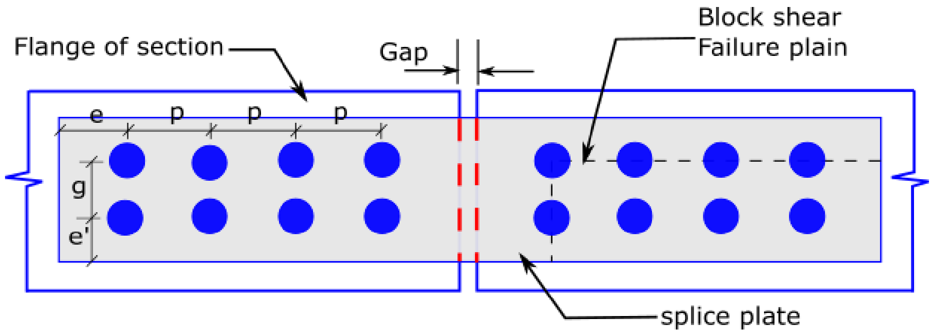

Figure 6.1: Block Shear Paths

$$T_{db1} = 2[\frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}] \quad (6.2)$$

$$T_{db2} = 2[\frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}] \quad (6.3)$$

where,

A_{vg} = Minimum gross area in shear along bolt line parallel to shear force = $(l_p/2 - e) \ * \ t_p$

A_{vn} = Minimum net area in shear along bolt line parallel to shear force = $(l_p/2 - e - (n_r - 0.5) * d_o) \ * \ t_p$

A_{tg} = Minimum gross area in tension along bolt line perpendicular to shear force =$(n \ * \ g + e') * t_p$

A_{tn} = =Minimum gross area in tension along bolt line perpendicular to shear force =$(n \ * \ g + e' - (n_c - 0.5) * d_o) * t_p$

n_r = number of bolt rows

n_c = number of bolt columns

f_u = Ultimate stress of the plate material

f_y = Yield stress of the plate material

e = end distance

e′ = edge distance

γ_{m0} = 1.10

γ_{m1} = 1.25

For safe design,
$T_{db} \geq V_u$

Is this check: **Ok** / **Not Ok**

Comment(s):

Chapter 7

Design Summary

7.0.1 Diagram

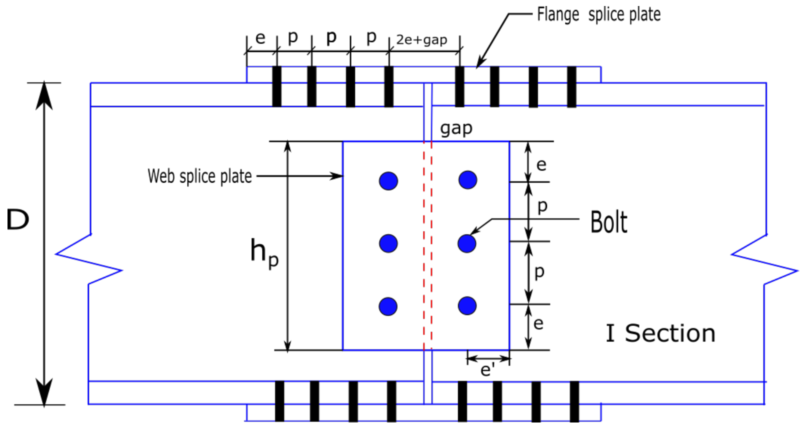

Figure 7.1: Cross section