Summer Fellowship Report

On

Testing,Validation and Correction of Osdag Modules

Submitted by

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Acknowledgment

I would like to thank FOSSEE Team for providing me an opportunity to work on something I am very interested in.The Internship was a great platform to improve my knowledge and develop new skills.It helped me to enchance my knowledge in Structural Steel Design,Python and Software Testing. I feel grateful to meet new people,professionals and work under their guidence through this Internship period.

I would like to acknowledge and thanks the members of Osdag team: Danish Ansari (Assistant Project Manager),Sourabh Das (Project Research Associate),Deepthi Reddy (Project Research Associate), Darshan Viswakarma (Project Research Associate),B Anand Swaroop Goud (Project Research Associate),Yash Lokhande (Project Research Assistant), Kumari Anjali Jatav (Project Research Assistant) who made us feel comfortable to work form home and planned all the tasks meticulously during this period.

I am grateful that I got a chance to work under Prof. Siddhartha Ghosh, who took time to hear our contribution and provided valuable suggestions.

Contents

Chapter 1

Introduction

1.1 What is Osdag?

Osdag is a cross-platform free open source software for the Design and Detailing of Steel Structures.It allows the user to Design Steel Connections,members which is typically optimised by following the Industry best practices using a graphical user Interface(GUI).GUI provides a 3D visualisation of the designed component.It also creates a detailed professional design report with standard views of the designed component.
Osdag is primarily built upon Python and Python based floss tools such as PyQt,PythonOCC,OpenCascade etc.

1.2 Who can use ?

Osdag is created both for educational purpose and industry professionals. As Osdag is currently funded by MHRD, Osdag team is developing software in such a way that it can be used by the students during their academics and to give them a better insight look in the subject.
Osdag can be used by anyone starting from novice to professionals. It's simple user interface makes it flexible and attractive than other software. Video tutorials are available to help get started. The video tutorials of Osdag can be accessed here.

Chapter 2

Testing Osdag Modules

I have Tested the Osdag modules with Various Design examples by Calculations in MS-Excel for Tension members,Fin plate connection,Beam to Beam,Column to Column - Cover plate connection and Column to Column End plate connection.For the calculations I have followed the DDCL prepared by Osdag team,Various Text books,Indian Standards and International standards.

2.1 Tension Members-Bolted and Welded

Tension Member is of the Module which is being developed(Both Bolted and Welded) and will be released in the next version of Osdag. They are the structural elements that are subjected to direct axial tensile load,which tends to elongate the members. The Excel sheet of Tension members is attached vide Appendix - A

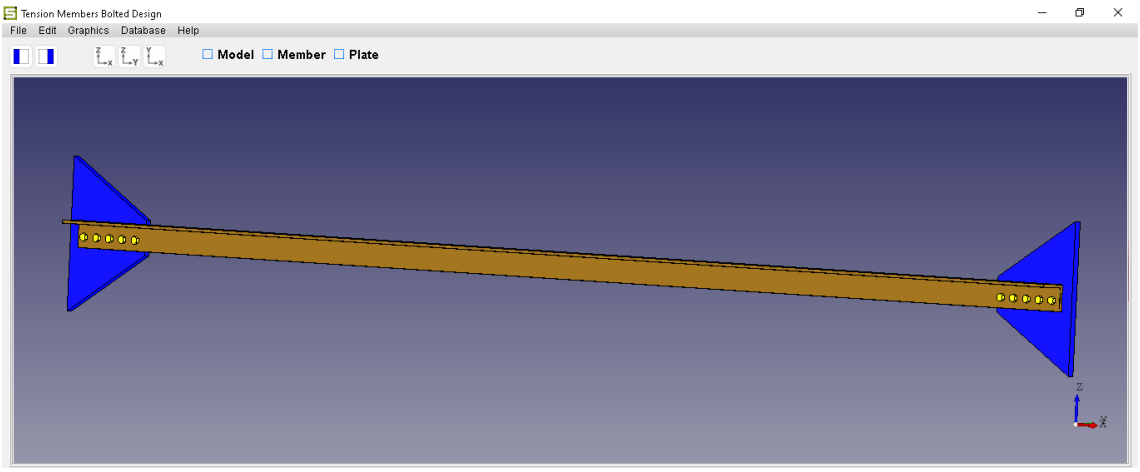

Figure 2.1: 3D drawing output of typical Tension member Bolted connection

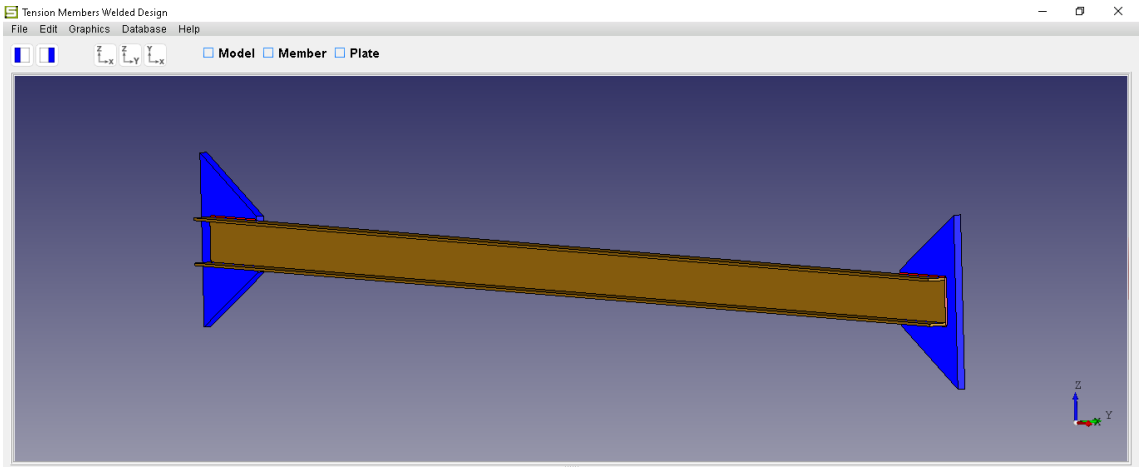

Figure 2.2: 3D drawing output of typical Tension member Welded connection

2.2 Fin Plate Connection

Fin plate connection is one of the four connections in Shear connection module.It is used to transfer Both Axial force and Shear force acting on beam to the column.Fin plate is bolted to beam and welded to column.The calculations were done in a way such that it can be used for all types of connectivities i.e. Column flange - Beam web,Column web - Beam web and Beam to Beam.The Excel sheet of Fin plate connection is attached vide Appendix - B

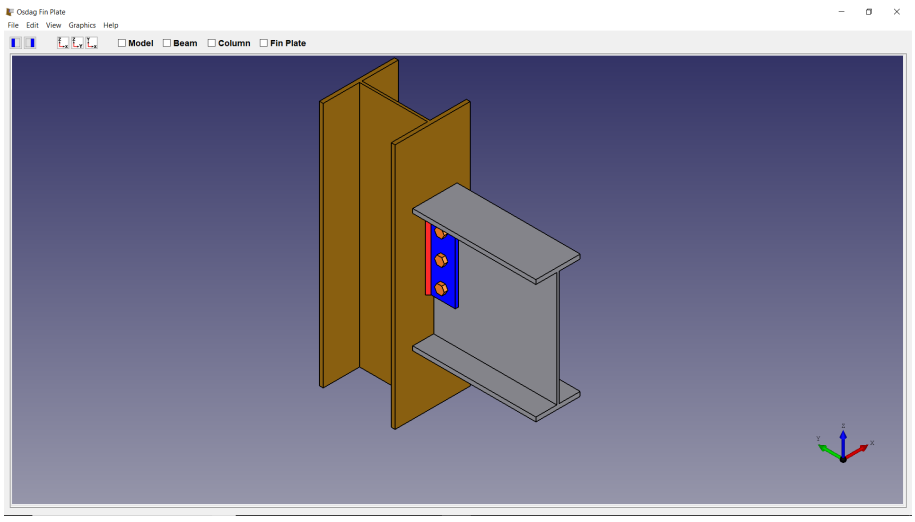

Figure 2.3: 3D drawing output of typical Fin plate connection

2.3 Beam to Beam and Column to Column Cover Plate Connection-Bolted

BB Cover plate and CC cover plate comes under the moment connection module.When the available member cannot cater the whole span/height it is joined with another member using Cover plate.All splice connections are moment connections.BB and CC cover plate splice is designed to take axial,shear and Moment load.The Excel sheets were prepared in such a way that 'n' number of examples can be solved in just two clicks which saves a lot of time.The Excel sheet of CC Cover plate Bolted is attached vide Appendix - C

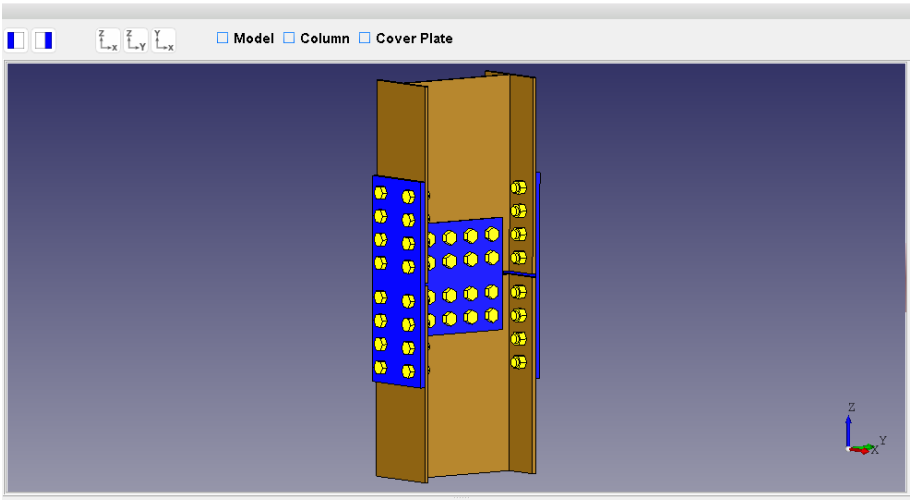

Figure 2.4: 3D drawing output of typical Column to Column Cover plate connection

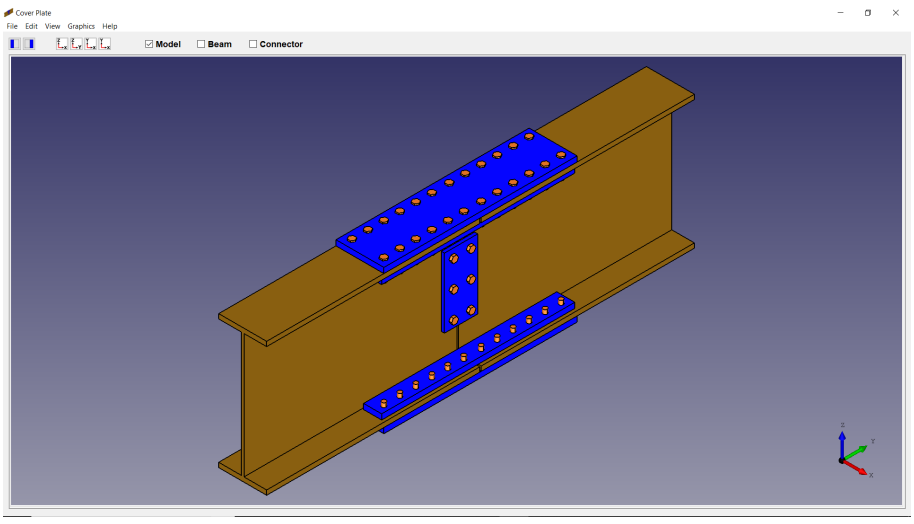

Figure 2.5: 3D drawing output of typical Beam to Beam Cover plate connection

2.4 Column to Column End Plate Connection

Column End plate is used to join two columns.In some cases,we cannot provide cover plate due to insufficient clear web height or longer plates or higher number of bolts.Then,End splice plate can be used to join two columns.It is a sub connection of the moment connection module.The Excel sheet of CC End plate is attached vide Appendix - D

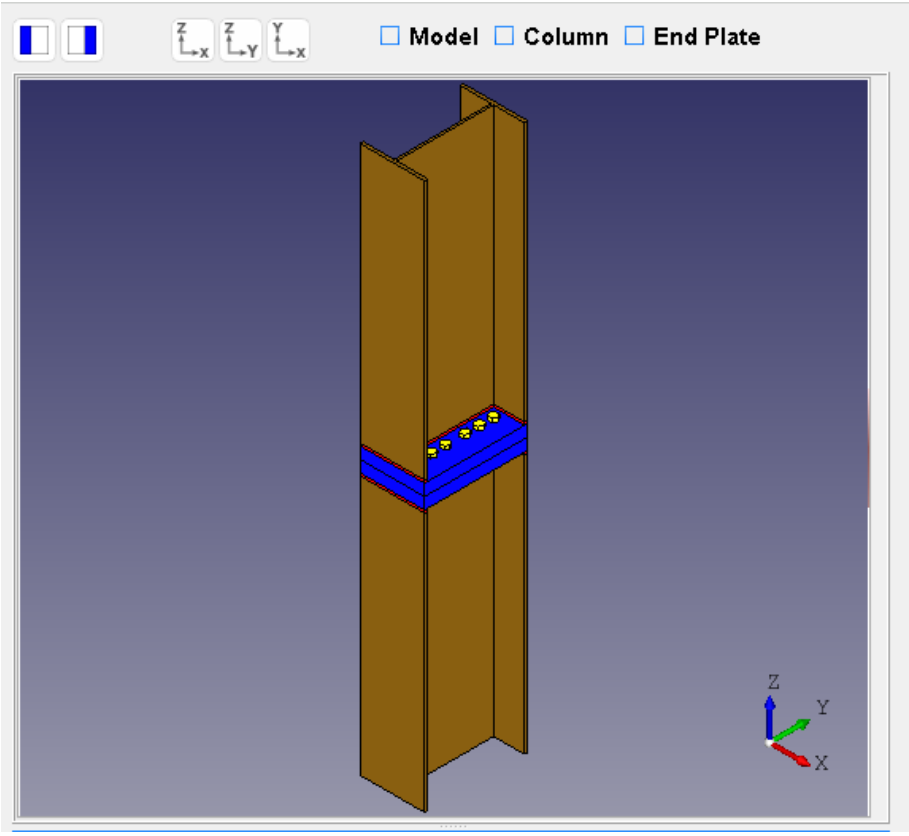

Figure 2.6: 3D drawing output of typical Column to Column End plate connection

Chapter 3

Updating the Database

There was a need of Updating the database with correct values and section properties for Hollow steel sections.

3.1 Replacing the existing Section properties with IS 808 Revised version

The Existing Database had many mistakes in the section properties i.e it was not matching with those given in IS code books.So there was a need of Updating the Database so that the output in Osdag console can be matched with Excel calculations.The section properties were replaced with IS 808 Revised Version code book consisting of Beams,Columns,Channels and Angle sections.

3.2 Adding new Steel section to Database

With the development of Section modeller,which is a new feature there was a need of adding section properties of Square,Rectangular and Circular hollow sections from IS 4923,IS 1161.

Chapter 4

Validations,Corrections and Adding functions to Calculate Section Data

One of the feature which is being developed is the Design Preferences.It allows the user to develop his own customized section.Almost all types of available section in IS 800 can be customized and its section properties can be foundout.

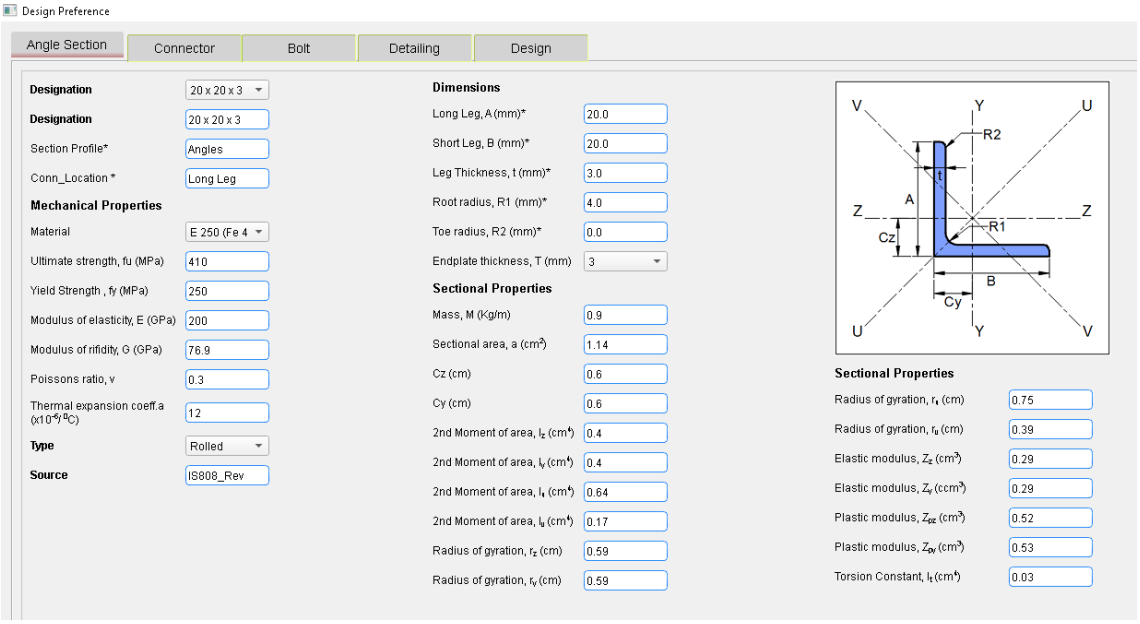

Figure 4.1: Layout of the Design preference Tab

4.1 Channel,Angle sections

The formulas used to calculate the section properties were derived for both Channel and Angle section.The revised IS 808 version had those

formulas but there were errors in it,which were also rectified.Also some functions were added to the python code to calculate plastic section modulus.

CHANNEL SECTION

1) Rectification in Izz =$[(BD^3)/12-((B-t)*(D-2*T)^3)/12]$
2) Rectification in Czz= $[(BD^2/2-(B-t)\times(D-2\times T)D/2)/A]$
3) Rectification in Iyy = $[DB^3/12+BD (Cyy–B/2))^2-((D-2\times T)\times(B-t)^3/12-(D-2\times T)(B-t)(Cyy-(B+t)/2)^2]$

ANGLE SECTION

1) Cyy= $[[0.5\ ab^2-0.5\ (b^2-t^2)(a-t)]/A]$
2) Cxx= $[[0.5\ ba^2-0.5\ (b-t)(a^2-t^2)]/A]$
3) Izz= $[a^3b/12-(b-t)\times(a-t)^3/12 + ab(a/2-Czz)^2-(a-t)(b-t)[(a+t)/2-Czz]^2]$
4) Iyy= $[ab^3/12-(b-t)^3\times(a-t)/12 + ab(b/2-Cyy)^2-(a-t)(b-t)[(b+t)/2-Cyy]^2]$
5) Ixy= $[ab(a/2-Czz)(b/2-Cyy)-(a-t)(b-t)[0.5(a+t)-Czz][0.5(b+t)-Cyy]]$
6) Zzz= $[Izz/(a-Czz)]$
7) Zyy= $[Iyy/(b-Cyy)]$

Figure 4.2: Rectified Formulas

Appendices

Appendix A

Excel Sheet for Tension Members Connection

Section	90x90x10	
length	3000	mm
axial load	350	KN
Ag	1710	mm^2
fy	230	Mpa
gamma mo	1.1	
Fu	410	Mpa
Fub	900	Mpa
Nn	1	
Dia of bolt	16	mm
Anb	157	mm^2
gamma Mb	1.25	
gamma Ml	1.25	
Hole diameter	18	mm
end distance	30.6	mm
pitch	40	mm
kb is small of	0.650	
connected leg	90	mm
outstanding leg	90	mm
thickness	10	mm
Rvv	17.5	mm
root radius	8.5	mm
no of rows of bolts	1	
no of columns of bolts	6	
Anc	620	mm^2
Ago	900	mm^2
Avg	2850	mm^2
Avn	1860	mm^2
Atg	357.5	mm^2
Atn	267.5	mm^2
pitch	50	mm
End	35	mm
Gauge	0	mm
Edge	35.75	mm

For Bearing Bolts		
Tension yielding capacity	357.55	KN
Bolt Shearing capacity	65.26	KN
Bolt Bearing capacity	85.28	KN
Bolt value	65.26	KN
No of bolts	5.362860781	
Adopted bolts	6	
Bolt force	58.33333333	KN
Rupture capacity		
beta	1.170	>0.7 AND <1.411
Tdn	403.20	KN
Block shear capacity (Tdb1)	423.01	KN
Tdb2	391.76	KN
Design strength of member	357.55	KN
Slenderness check	171.43	
Efficiency	0.98	
Gusset plate design		
Max Height of plate	90	mm
Plate thickness	20	mm
Plate length	320	mm
Tension yielding capacity	376.3636364	KN
Rupture capacity	425.088	KN
Block shear(Tdb1)	846.0285481	KN
(Tdb2)	783.513734	KN

	Grade	1200	1200			
Bolt selection		**lower bolt**	**Selected bolt**	**bolt selection proof**		
Dia	20	12	16	Dia	12	16
Dia of hole	22	13	18	Anb	84.3	157
edge	40	25	35	Fub	1200	1200
Gauge	50	30	40	Shearing	46.72	87.02
Min depth required	98.5	68.5	88.5	Bearing	51.09	64.39
	not possible	0.519	0.491	Capacity	46.72	64.39
				No of bolts	7.49	5.44
					8	6
						hence 16

		Grade selection proof	
Grade	8.8	9.8	10.9
dia	16	16	16
Anb	157	157	157
Fub	800	900	1000
Shearing	58.01	65.26	72.52
Bearing	64.39	64.39	64.39
Bolt value	58.01	64.39	64.39
No of bolts	6.03	5.44	5.44
	8	6	6
		hence 9.8	

Section	ISA 180x180x18	
fy	230	Mpa
fu	410	Mpa
Length	4500	mm
Load	1300000	N
Ag	6220	mm^2
gamma Mo	1.1	
Connected leg	180	mm
Outstanding leg	180	mm
thickness	18	mm
Root radius	18	mm
Ryy	35.4	mm
Anc	2916	mm^2
Ago	3240	mm^2
gamma Mw	1.25	
Fwd	189.37	N/mm^2
weld size	13	mm
throat thk	9.1	mm
weld strength	1723.28	N/mm^2
Effective weld length	755	mm
web weld	154	mm
flange weld	301	mm
plate length	353	mm
Lc	327	mm
bs	180	mm
beta	1.14	
gamma Ml	1.25	
plate height	232	mm
Req plate thickness	34.54	mm
plate thickness	36	mm
plate height for check	180	mm

Member Checks		
Tension yielding	1300.55	kN
Tension rupture	1633.10	kN
Design strength	1300.55	kN
Efficiency	1.00	
Slenderness	127.12	
Gusset plate checks		
yielding	1354.91	kN
Rupture	1912.896	kN
Tdb2	3556.96	kN
Avg	11772	mm^2
Avn	11772	mm^2
Atg	7416	mm^2
Atn	7416	mm^2
length	756	mm
	188.96	N/mm^2
Stress	1719.58	N/mm

Weld size checks		
Gusset plate thickness	36	mm
Thickness of web	18	mm
Min weld size as per IS 800 based on thicker part	10	mm
based on thickness of web as per IS 800	13.5	mm
Min weld size adopted	13	mm
Max weld size	18	mm
Adopted	13	mm
Throat tickness	9.1	mm

Appendix B

Excel Sheet for Fin Plate Connection

Input File Name	fin1			
Input Key	Value	Output Key	Osdag Value	Calculated Value
Module	Fin Plate	Bolt.Diameter	16	
MainModule	Shear Connection	Bolt.Grade_Provided	8.8	
Connectivity	Column flange-Beam web	Bolt.Shear	58012.16	58012.16
Material	E 165 (Fe 290)	Bolt.Bearing	72384	72384
Load.Shear	60	Bolt.Capacity	58012.16	58012.16
Load.Axial	40	Bolt.Force (kN)	43673.47	43673.47
Member.Supporting_Section.Designation	UC 356 x 406 x 393	Bolt.Line	1	1
Member.Supporting_Section.Material	E 300 (Fe 440)	Bolt.OneLine	2	2
Member.Supporting_Section.Fu	440	Bolt.Gauge	0	0
Member.Supporting.Section.Fy	280	Bolt.EdgeDist	35	35
Member.Supported_Section.Designation	MB 500	Bolt.Pitch	230	230
Member.Supported_Section.Material	E 250 (Fe 410 W)B	Bolt.EndDist	35	35
Member.Supported_Section.Fu	410	Plate.Thickness	12	12
Member.Supported_Section.Fy	250	Plate.Height	300	300
Bolt.Diameter	[16.0]	Plate.Length	80	80
Bolt.Grade	[3.6, 4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 9.8, 10.9, 12.9]	Plate.Shear	311769.15	311769.15
Bolt.Type	Bearing Bolt	Plate.Rupture	689040	689040
Bolt.TensionType	Bearing Bolt	Plate.BlockShear	340541.68	340541.68
Bolt.Bolt_Hole_Type	Standard	Plate.TensionYield	540000	540000
Bolt.Slip_Factor	0.3	Plate.TensionRupture	706579.2	706579.2
Connector.Plate.Thickness_List	.0, 4.0, 5.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0, 22.0, 24.0, 26.0, 28.0, 30	Plate.BlockShearAxial	489223.66	489223.66
Connector.Material	E 165 (Fe 290)	Plate.MomDemand	2700000	2700000
Connector.Fu	290	Plate.MomCapacity	40500000	40500000
Connector.Fy_20	165	Member.shear_yielding	401520.87	401520.87
Connector.Fy_20_40	165	Member.shear_rupture	1455336	1455336
Connector.Fy_40	165	Member.shear_blockshear	432963.81	432963.81
Weld.Type	Fillet	Member.tension_yielding	1159090.91	1159090.91
Weld.Fab	Shop Weld	Member.tension_rupture	1397122.56	1397122.56
Weld.Material_Grade_OverWrite	410	Member.tension_blockshear	623579.91	623579.91
Detailing.Edge_type	a - Sheared or hand flame cut	Section.MomCapacity	470454545.5	470454545.5
Detailing.Gap	10	Weld.Size	10	10
Detailing.Corrosive_Influences	False	Weld.Strength	937.62	937.7
		Weld.Stress	204.98	204.98

Connectivity	Column flange-Beam web
Shear load(KN)	60
Axial load(kN)	40
Bolt diameter(mm)	16
Bolt type	Bearing Bolt
Bolt grade	8.8
Plate thickness(mm)	12
Plate fy(Mpa)	250
Plate fu(Mpa)	410
Supported Section :	**MB 500**
Area(mm^2)	11000
Depth(mm)	500
Breadth(mm)	180
Thickness of web(mm)	10.2
Thickness of flange(mm)	17.2
Root radius 1(mm)	17
Root radius 2(mm)	8.5
Iz(mm^4)	452000000
Iy(mm^4)	13600000
Rz(mm)	202
Ry(mm)	35.1
Zz(mm^3)	1800000
Zy(mm^3)	152000
Zpz(mm^3)	2070000
depth of web(mm)	431.6
For bearing type	
Dia of hole(mm)	18
Anb(mm^2)	157
Nn	1
fub(Mpa)	800
Pitch(mm)	40
End(mm)	35
Gauge(mm)	230
Edge(mm)	35
gamma mb	1.25
Kb	0.65
For friction grip type	
Muf	0.3
ne	1
Kh	1
Fo	87920
gamma mf	1.25
Gap bw beam and column	10
Supporting section:	**UC 356 x 406 x 393**
Area(mm^2)	50060
Depth(mm)	419
Breadth(mm)	407
Thickness of web(mm)	30.6
Thickness of flange(mm)	49.2
Root radius 1(mm)	15.2
Root radius 2(mm)	0
Iz(mm^4)	1466180000
Iy(mm^4)	553650000
Rz(mm)	171
Ry(mm)	105
Zz(mm^3)	6998000
Zy(mm^3)	2721000
gamma mw	1.25
Notch height(nh)	75

Vp(kN)	1001.125367
Design shear force(Vd)	150.168805 >50

Bolt design checks	
Shear capacity(kN)	58012.15505
Bearing capacity(kN)	72384
Friction grip bolt	21100.8
Design strength(kN)	58012.15505
Ru	72.11
no of bolts	0
Adopted bolts	2
nc	1
nr	2
Y	230
Xmax	0
Vmh	11.73913043
Vmv	0
Vbv	30
Abh	20
Vres	43673.4748
ymax	115
Ri^2	26450

Member checks	
Shear yielding(kN)	401520.869
Shear yielding(kN)(Beam to Beam)	341292.7387
Shear rupture(kN)	1455336
Shear rupture(kN)(Beam to Beam)	1220098.5
Avg(mm^2)	2703
Avn(mm^2)	2427.6
Atg(mm^2)	357
Atn(mm^2)	265.2
Tdb1	432.9638076
Tdb2	494.8814552
Tension block shear(Tdb)	432963.8076
Tension yielding (kN)	1159090.909
Tension yielding (kN)(Beam to Beam)	985227.2727
Tension rupture(kN)	1397122.56
Tension rupture(kN)(Beam to Beam)	1171294.56
Avg(mm^2)	714
Avn(mm^2)	530.4
Atg(mm^2)	2346
Atn(mm^2)	2162.4
Tdb1	732.0286828
Tdb2	623.5799054
Tension block axial(Tdb)	623579.9054
Moment developed	2700000
Moment capacity of plate	470454545.5
Combined capacity of plate	0.01

Plate design checks		
Minimum plate ht(mm)	300	
Maximum plate height(mm) column to beam	411.6	
Max plate height for Beam to Beam single notch	390.8	
Max plate height for Beam to Beam double notc	350	
plate height(mm)	300	
plate width(mm)	80	
Maximum plate thickness(mm)	8	
Provided plate thickness(mm)	12	
Shear yielding(kN)	311769.1454	
Shear rupture(kN)	689040	
Block shear under shear load		
Avg(mm^2)	3180	
Avn(mm^2)	2856	
Atg(mm^2)	420	
Atn(mm^2)	312	
Tdb1	340.5416784	
Tdb2	407.2929026	
Tdb	340541.6784	
Block shear under axial load		
Avg(mm^2)	840	
Avn(mm^2)	624	
Atg(mm^2)	2760	
Atn(mm^2)	2544	
Tdb1	603.9333339	
Tdb2	489.2236594	
Tdb	489223.6594	
Tension yielding(kN)	540000	
Tension rupture(kN)	706579.2	
Moment capacity(N-mm)		
Moment developed	2700000	
Moment capacity of plate	40500000	
Combined capacity of plate	0.07	<1

Weld design	
For column web-beam web	
Max thickness governing	49.2
thickness of thicker part(mm)beam to beam	
Minimum weld size(mm)	10
Maximum weld size(mm)	12
funit	133.95
weld size(mm)	10
Throat thickness(mm)	7
Fwd(kN-mm)	937.7
Leff(mm)	280
Stress acting on weld:	
Mu	2700000
Ymax	140
Ip	3658666.667
Vwh(N-mm^2)	103.32
Vw(N-mm^2)	107.14
Aw(N-mm^2)	71.43
Ru(N-mm^2)	204.98
Long joint check:	
Blw	1.142857143
Fwd	1071.657143

Appendix C

Excel Sheet for Column to Column Cover plate Connection

Input File Name	column_bolted1			
Input Key	**Value**	**Output Key**	**Osdag Value**	**Calculated Value**
Bolt.Bolt_Hole_Type	Standard	Applied Axial Load (kN)	1446.55	1446.55
Bolt.Diameter	['12']	Applied Shear Load (kN)	100	100
Bolt.Grade	['3.6']	Applied Moment Load (kNm)	346.91	346.9
Bolt.Material_Grade_OverWrite	410	Bolt.Diameter	12	12
Bolt.Slip_Factor	0.3	Bolt.Grade_Provided	3.6	3.6
Bolt.TensionType	Pretensioned	Web_Plate.Height (mm)	290	290
Bolt.Type	Bearing Bolt	Web_Plate.Width	530	530
Connector.Flange_Plate.Preferences	Outside	Web_Plate.Thickness	12	12
Connector.Flange_Plate.Thickness_list	, '16', '18', '20', '22', '24', '26', '28', '30', '32', '36', '40', '25', '28', '32', '36', '40', '4	Web_plate.pitch_provided	30	30
Connector.Material	E 250 (Fe 410 W)A	Web_plate.end_dist_provided	25	25
Connector.Web_Plate.Thickness_List	, '16', '18', '20', '22', '24', '26', '28', '30', '32', '36', '40', '25', '28', '32', '36', '40', '4	Web_plate.gauge_provided	30	30
Design.Design_Method	Limit State Design	Web_plate.edge_dist_provided	25	25
Detailing.Corrosive_Influences	No	Web_plate.Bolt_Line	16	16
Detailing.Edge_type	a - Sheared or hand flame cut	Web_plate.Bolt_OneLine	9	9
Detailing.Gap	10	Web_plate.Bolt_required	144	144
Load.Axial	100	WebBolt.ShearCapacity	25.7	25.70
Load.Moment	50	WebBolt.BearingCapacity	102.34	102.34
Load.Shear	100	WebBolt.Capacity	25.7	25.70
Material	E 250 (Fe 410 W)A	WebBolt.Force	19.83	19.84
Member.Designation	PBP 360 X 174.2	Flange_Plate.Width (mm)	379	379
Member.Material	E 250 (Fe 410 W)A	flange_plate.Length	1130	1130
Module	Column Coverplate Connection	flange_plate.Thickness	22	22
		Flange_Plate.InnerWidth	0	0
		flange_plate.InnerLength	0	0
		flange_plate.innerthickness_provided	0	0
		Flange_plate.pitch_provided	30	30
		Flange_plate.end_dist_provided	25	25
		Flange_plate.gauge_provided	38	38
		Flange_plate.edge_dist_provided	25.25	25.25
		Flange_plate.Bolt_Line	36	36
		Flange_plate.Bolt_OneLine	8	8
		Flange_plate.Bolt_required	288	288.00
		FlangeBolt.ShearCapacity	12.85	12.85
		FlangeBolt.BearingCapacity	104.38	104.38
		FlangeBolt.Capacity	12.85	12.85
		FlangeBolt.Force	9.45	9.44
		section.tension_yielding_capacity	1686.89	1686.89
		section.tension_rupture_capacity	1656.07	1656.08
		section.block_shear_capacity	3377.84	3377.84
		Section.flange_capacity	1656.07	1656.08
		Flange_plate.tension_yielding_capacity (kN)	1819.2	1819.2
		Flange_plate.tension_rupture_capacity (kN)	1785.96	1785.96
		flange_plate.block_shear_capacity	3642.77	3642.77
		flange_plate.tension_capacity_flange_plate	1785.96	1785.96
		section.tension_yielding_capacity_web	1397.24	1397.24
		section.tension_rupture_capacity_web	1199.69	1199.69
		section.block_shear_capacity_web	2093.75	2093.75
		section.Tension_capacity_web	1199.69	1199.69
		Web_plate.tension_yielding	1581.82	1581.82
		Web_plate.tension_rupture	1225.67	1225.68
		Web_plate.tension_blockshear	2570.32	2570.32
		Web_plate.capacity	1225.67	1225.68
		web_plate.shear_yielding_capacity	913.26	913.27
		web_plate.shear_rupture_capacity	589.7	589.70
		web_plate.block_shear_capacity	1808.69	1808.69
		web_plate.shear_capacity_web_plate	589.7	589.70
		Web_Plate.MomDemand	69.42	69.43
		Section.MomCapacity	693.82	693.82
		Section.ShearCapacity	484.02	484.02
		Section.AxialCapacity	4821.82	4821.82
		Plastic Moment Capacity (kNm)	693.82	693.82
		Moment Deformation Criteria (kNm)	922.91	922.91

Connectivity	Beam cover plate
Moment (kN-m)	50
Shear load(KN)	100
Axial load(kN)	100
Bolt diameter(mm)	12
Bolt type	Bearing Bolt
Bolt grade	3.6
Section size :	PBP 360 X 174.2
Area(mm^2)	22100
Depth(mm)	361
Breadth(mm)	379
Thickness of web(mm)	20
Thickness of flange(mm)	20.4
Root radius 1(mm)	15
Root radius 2(mm)	0
Iz(mm^4)	50900
Iy(mm^4)	18500
Rz(mm)	15.1
Ry(mm)	9.1
Zz(mm^3)	2820000
Zy(mm^3)	978000
Zpz(mm^3)	3180000
Zpy(mm^3)	1500
Ze	341760.1333
Zw	512640.20
Fu(mpa)	**410**
Fy(mpa)	**240**
Depth of web(mm)	320.2
Bp	1
For bearing type(for flange plate)	
Dia of hole(mm)	13
Anb(mm^2)	84.3
Nn	**1**
fub(Mpa)	330
Pitch(mm)	30
End(mm)	
Gauge(mm)	
Edge(mm)	
gamma mb	
Kb	0.52
For friction grip type	
Muf	0.3
ne	1
Kh	1
Fo	19473.3
gamma mf	1.25
For bearing type(for web plate)	
Dia of hole(mm)	13
Anb(mm^2)	84.3
Nn	**2**
fub(Mpa)	330
Pitch(mm)	30
End(mm)	25
Gauge(mm)	30
Edge(mm)	25
gamma mb	
Kb	0.52
For friction grip type	
Muf	0.3
ne	2
Kh	1
Fo	19473.3
gamma mf	1.25

Bolt design checks	
For flange plate	
Shear capacity(kN)	12.85
Bearing capacity(kN)	104.38
Friction grip bolt	3.51
Design strength(kN)	9.64
Ru	141.166385
no of bolts	288
Adopted bolts	288
nc	36
nr	8
Lc	1080
Lr	328.5
L	1080
15*d	180
Bij	0.625
Bij with limits	0.75
Vres	9.447152778

Plate design checks	
Flange splice cover plate	
Height(mm)	379
Lenght(mm)	1130
Inner flange plate height(mm)	0
Inner flange plate length(mm)	379
thickness(mm)	22
plate fy	240
plate fu	410
Total height contributing(mm)	379
Tension yielding capacity(kN)	1819.2
Tension rupture capacity(kN)	1785.96
Avg	23540
Avn	13530
Atg	6127
Atn	4125
Block shear capacity(Tdb1)	4182.98
(Tdb2)	3642.77
Flange tension capacity(kN)	1785.96
Web plate checks(For axial)	
Height(mm)	290
Length(mm)	530
thickness(mm)	12
Tension yielding capacity(kN)	1581.82
Tension rupture capacity(kN)	1225.68
Avg	5640
Avn	3300
Atg	3180
Atn	1932
Block shear capacity(Tdb1)	2620.77
(Tdb2)	2570.32
web tension capacity(kN) in axial	1225.68
For shear	
Shear yielding capacity(kN)	913.27
Shear rupture capacity(kN)	589.70
Avg	2820
Avn	1650
Atg	3180
Atn	1854
Block shear capacity(Tdb1)	1808.69
(Tdb2)	1913.79
web tension capacity(kN) in shear	589.70

Member checks	
Member capacity	
Axial member capacity(kN)	4821.82
Shear capacity(kN)	484.02
Plastic moment capacity(kN)	693.82
Moment deformation criteria	922.91
Moment capacity of member	693.82
Load consideration	
Applied axial load(kN)	1446.55
Applied shear load(kN)	100
Applied moment load(kN-m)	346.91
Forces carried by web	
Axial force in web(kN)	419.18
Moment in web(kN-m)	55.93
Forces carried by flange	
Axial force in flange(kN)	506.07
Moment in flange(kN-m)	290.98
flange force(kN)	1360.39
Member capacity for Flange	
Tension yielding capacity(kN)	1686.89
Tension rupture capacity(kN)	1656.08
Avg	21828
Avn	12546
Atg	5681.4
Atn	3825
Block shear capacity(Tdb1)	3878.75
(Tdb2)	3377.84
Flange tension capacity(kN)	1656.08
Member capacity for web	
Web tension yielding (kN)	1397.24
web rupture capacity(kN)	1199.69
Avg	9400
Avn	5500
Atg	5300
Atn	3220
Block shear capacity(Tdb1)	2134.63
(Tdb2)	2093.75
Web tension capacity(kN)	1199.6928

Bolt design checks	
For web plate	
Shear capacity(kN)	25.70
Bearing capacity(kN)	102.34
Friction grip bolt	8.18125
Design strength(kN)	22.49
Ru	19.16366887
no of bolts	12
Adopted bolts	144
nc	16
nr	9
Y	30
Xmax	105
Tmh	10.79
Tmv	9.44
Vbv	1.39
Abh	5.830
Vres	19.84
ymax	120
Moment demand	69.43
Ri^2	**772200**
Lc	480
Lr	240
L	480
15*d	180
Bij	0.875
Bij with limits	0.875

Appendix D

Excel Sheet for Column to Column End plate Connection

Input File Name	ccep2			
Input Key	Value	Output Key	Osdag Value	Calculated Value
Bolt.Bolt_Hole_Type	Standard	Section.MomCapacity	277.27	277.27
Bolt.Diameter	['08', '10', '12', '14', '16', '18', '20', '22', '24', '27', '30', '33']	Section.ShearCapacity	451.03	451.03
Bolt.Grade	['3.6', '4.6', '4.8', '5.6', '5.8', '6.8', '8.8', '9.8', '10.9', '12.9']	Section.AxialCapacity	2545.45	2545.5
Bolt.Material_Grade_OverWrite	410	Applied Axial Load (kN)	763.64	763.64
Bolt.Slip_Factor	0.3	Applied Shear Load (kN)	40	40
Bolt.TensionType	Pretensioned	Applied Moment Load (kNm)	138.64	138.64
Bolt.Type	Friction Grip Bolt	Bolt.Shear	58.3	58.30
Connectivity	Extended Both Ways	Bolt.Bearing	0	0
Connector.Material	E 250 (Fe 410 W)A	Bolt.Capacity	58.3	58.30
Connector.Plate.Thickness_List	['6', '8', '10', '12', '14', '16', '18', '20', '22', '25', '28', '32', '36', '40', '45', '50', '56', '63	Bolt.Tension	147.68	312.3
Design.Design_Method	Limit State Design	Bolt.y_sqr	365889.28	365889.28
Detailing.Corrosive_Influences	No	Bolt.t_b	232162.57	232166.3585
Detailing.Edge_type	a - Sheared or hand flame cut	Bolt.v_sb	5000	5000
Detailing.Gap	10	Bolt.Diameter	33	33
Load.Axial		Bolt.Grade	5.6	5.6
Load.Moment		Bolt.Pitch	82.5	82.50
Load.Shear		Bolt.EndDist	65	65
Material	E 250 (Fe 410 W)A	ColumnEndPlate.nbw	2	2.00
Member.Designation	PBP 300 X 88.46	ColumnEndPlate.nbf	1	1.00
Member.Material	E 250 (Fe 410 W)A	ColumnEndPlate.nb	8	8
Module	Column Endplate Connection	Bolt.pitch2_web	147.2	147.2
		Bolt.pitch2_flange	82.8	82.8
		Plate.Thickness	63	63
		Plate.Height	562	562
		Plate.Length	308	308
		Plate.MomCapacity	30	17.12
		Plate.m_ep	15.09	15.0908133
		Stiffener.height	100	100
		Stiffener.width	130	130
		Stiffener.thickness	6	6
		Stiffener.weld	Groove Weld	

Connectivity	CC End plate
Moment (kN-m)	0
Shear load(KN)	0
Axial load(kN)	0
Bolt diameter(mm)	33
Bolt type	Friction Grip Bolt
Bolt grade	5.6
Section size :	PBP 300 X 88.46
Area(mm^2)	11200
Depth(mm)	302
Breadth(mm)	308
Thickness of web(mm)	12.4
Thickness of flange(mm)	12.4
Root radius 1(mm)	15
Root radius 2(mm)	0
Iz(mm^4)	18500
Iy(mm^4)	6040
Rz(mm)	12.8
Ry(mm)	7.32
Zz(mm^3)	1220000
Zy(mm^3)	392000
Zpz(mm^3)	1370000
Zpy(mm^3)	600
Ze	158802.336
Zw	238203.50
Fu(mpa)	**410**
Fy(mpa)	**250**
Depth of web(mm)	277.2
Bp	0.890510949
For bearing type(for End plate)	
Dia of hole(mm)	36
Anb(mm^2)	694
Nn	**1**
fub(Mpa)	500
Pitch(mm)	82.5
End(mm)	65
Gauge(mm)	
Edge(mm)	
gamma mb	
Kb	0.51
For friction grip type	
Muf	0.3
ne	1
Kh	1
Fo	242900
gamma mf	1.25

Bolt design checks	
For end plate	
Shear capacity(kN)	160.27
Bearing capacity(kN)	869.44
Friction grip bolt	58.296
Design strength(kN)	58.30
Tension capacity provided(Tdb)	312.3
No of bolts along web	2
No of bolts along flange	1
Total no of bolts(n)	8
Ymax	360.8
P2 along web	147.2
Y sq	365889.28
Tension capacity req(Tb)	232166.3585

Plate design checks	
End plate	
Height(mm)	308
Lenght(mm)	562
beff	82.5
Thickness of plate	63
Mdp	17.12
plate fy	230
plate fu	410
Y2	278.3
Tb2	200.9060822
Mep	13.06
Mep	15.0908133

Member checks	
Member capacity	
Axial member capacity(kN)	2545.46
Shear capacity(kN)	451.03
Plastic moment capacity(kN)	277.27
Moment deformation criteria	415.91
Moment capacity of member	277.27
Load consideration	
Applied axial load(kN)	763.64
Applied shear load(kN)	40
Applied moment load(kN-m)	138.64

Stiffner plate checks	
Ms	15.0908133
Md	0
Vd	0
Stiffener height	100
Stiffener width	130
Stiffener thickness	6