Weld Design

Problem Statement

References

The following spreadsheet encompasses the investigation of figure 1 to identify a suitable beam and carry out weld design to secure the denoted baseplate.

A beam is to be selected with restrictions upon volumetric dimensions highlighted in sections below.
Selection process is documented in the report below.

Furthermore, this investigation will include the justification of the selected beam to minimise various properties of the beam through methods of analysis. Finally, this investigation will also justify the weld profile and size of the beam.

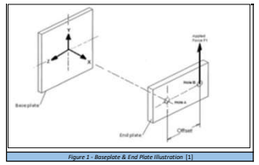

Figure 1 - Baseplate & End Plate Illustration [1]

Note: Force F1 acts in opposite direction (specified with negative force F1 in *Given Data* section.

Requirements

The following section denotes the requirements of this investigation concerning the design of the beam and weld:

> Mild Steel Beam Material
> Wide: 100mm, Height: 250mm, Thickness: 6mm
> For the beam connecting to the baseplate and end plate.
> Selection from Supplied or Self-Researched manufacturer's catalogues.
> Centre of Area (C of A) superimposed with the coordinate system outside of the baseplate and inside the end plate where Hole A is located.
- (see figure 1)
> Justification of Mild Steel Beam via methods of analysis with minimisation of:
> Torsional
> Lateral
> Longitudinal Deflection
> Selection and justification of weld profile.
> Selection and justification of suitable weld size.

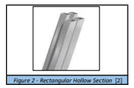

Figure 2 - Rectangular Hollow Section [2]

Selection

The following mild steel beam has been selected due to the following factors:

> Viable for a range of applications in engineering and construction.
> High tensile strength.
> High impact strength.
> Good ductility and weldability.
> Can be easily joined and able to withstand changing loads.
> Cannot be damaged by insects, rot or fire.

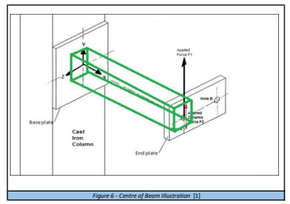

Figure 6 - Centre of Beam Illustration [1]

Assumptions

Properties that are neglected:

> Weight of beam
> Torsional Deflection of end plate
> Weld between your selected beam and end plate.

> Applied force is acting on the outside of end plate.
> Assume parallel loads.

Specifications

The end plate experiences an applied force in the vertical direction identified as F1. The value of this force acts in a downward direction of magnitude 5kN.

Executive Summary

The selected weld for the stucture depicted in *Figure 1* has been a **Rectangular Hollow Section**, from analysis of the C450PLUS structure and the physical properties display its effectiveness in achieving the project requirements. [2]

The thinnest section is 6mm thick, and calculations show that the weld should be no smaller than 2/3 the thickness of the beam material, in this case 4mm. [5]
The minimum required weld leg length is 5.46mm, hence, a weld leg length of between 10mm to 15mm is suitable.

The weld on the base plate to the beam is larger due to the larger bending component involved. [7]
The weld profile for the selected system is to be recommended a **tee joint** with double bevel.
To prioritise cost, a **butt weld** can also be utilised for the system.

Data

The following section highlights all calculations and data around the weld design of the beam to baseplate.

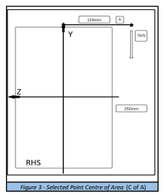

Figure 3 - Selected Point Centre of Area (C of A)

Note: Selected a point 'A' as point where the shear force and torsion combines to produce the greatest resultant force.

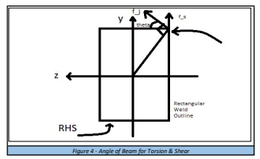

Figure 4 - Angle of Beam for Torsion & Shear

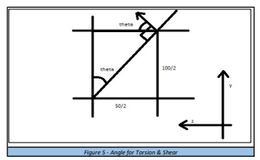

Figure 5 - Angle for Torsion & Shear

Given Data

Description	Property	Value	Unit	Symbol	Expression	
End Plate Size	End Plate Height	350.00	mm	ep_h	-	[1]
	End Plate Width	400.00	mm	ep_w	-	"
	End Plate Thickness	16.00	mm	ep_t	-	"
Base Plate Size	Base Plate Height	500.00	mm	bp_h	-	"
	Base Plate Width	500.00	mm	bp_w	-	"
	Base Plate Thickness	16.00	mm	bp_t	-	"
	Length of Beam	1500.00	mm	l	-	"
Specified FOS	Factor of Safety	2.00	-	FOS	-	"
Force Y-Direction	Hole B Force	-5000.00	N	F_b	F1	"
Holes (A&B)	Offset Distance	159.00	mm	o	Offset	"
	Diametre	16.00	mm	d	Diametre of A & B Holes	"

Compiled Data

Rectangular Hollow Section	Beam Height	100.00	mm	b_h	-	[2]
	Beam Width	50.00	mm	b_w	-	"
	Beam Thickness	6.00	mm	b_t	-	"
	Allowable Shear Stress	96.60	Pa	t_all	Given from Datasheet	[3]

Calculations - Baseplate

Beam to Base Plate	Moment	-80000.00	Nmm	M	F_b*bp_t	[4]
Bending	Moment of Inertia	5833.33	Nmm	Z_w	(b_w*b_h)+((b_w)^2/3)	"
	Component due to Bending	-13.71	N/mm	f_bnd	M/Z_w	"
Shear	Assumption of Width	1.00	mm	w	Acting upon each mm.	"
	Perimetre of Beam	300.00	mm	p	(b_h*2)+(b_w*2)	"
	Area of Weld	300.00	mm^2	A_w	w*p	"
	Force	-5000.00	N	V	F_b	"
	Force due to Shear	-16.67	N/mm	f_s	V/A_w	"
Torsion	Torque	-2000000.00	Pa	T	F_b*bp_w	"
	Radius of Beam	55.90	mm	r_b	SQRT((b_w/2)^2+(b_h/2)^2)	"
	Twisting Moment of Intertia	562500.00	Pa	J_w	((b_w*b_h)^3)/6	"
Beam	theta	1.11	radians	theta_rads	ATAN(b_t/(b_t/2))	"
Angles	theta	63.43	degrees	theta_degs	ATAN(b_w/(b_w/2))*180/PI()	"
Force Components Torsion	Force due to Torsion	-198.76	N/mm	f_j	(T*r_b)/J_w	"
	Force due to Torsion y -axis	-177.78	N/mm	f_jy	f_j*SIN(theta_rads)	"
	Force due to Torsion z -axis	-88.89	N/mm	f_jz	f_j*COS(theta_rads)	"
Summing Vectorial Components	Force acting on Component	214.24	N/mm	f	SQRT((f_bnd)^2+(f_s+f_jy)^2+(f_jz)^2))	"
Weld	Weld Leg Length	4.44	mm	w_l	(T*FOS)/t_all	"
	Advisable Weld Factor	0.67	-	w_fac	Researched Value	[5]
	Advisable Weld Length	4.00	mm	w_ad	b_t*w_fac	[4]

Calculations - End Plate

Beam to End Plate	Moment	-80000.00	Nmm	M_ep	F_b*ep_t	"
Bending	Component due to Bending	-13.71	N/mm	f_bnd_ep	M_ep/Z_w	"
Shear	Assumption of Width	1.00	mm	w_ep	Acting upon each mm.	[6]
Torsion	Torque	-2000000.00	Pa	T_ep	F_b*ep_w	[4]
Force Components Torsion	Force due to Torsion	-198.76	N/mm	f_j_ep	(T_ep*r_b)/J_w	"
	Force due to Torsion y -axis	-177.78	N/mm	f_jy_ep	f_j_ep*SIN(theta_rads)	"
	Force due to Torsion z -axis	-88.89	N/mm	f_jz_ep	f_j_ep*COS(theta_rads)	"
Summing Vectorial Components	Force acting on Component	214.24	N/mm	f_ep	SQRT((f_bnd_ep)^2+(f_s+f_jy_ep)^2+(f_jz_ep)^2))	"
Weld	Weld Leg Length	4.44	mm	w_l_ep	(f_ep*FOS)/t_all	"

Results & Comments

The factor of safety for the end plate to beam weld has denoted an appropriate value with the thinnest section of the beam at 6mm.
Generally it is viable to use a weld that is no smaller than 0.67 the thickness of the beam material and therefore, in this investigation the result would be 4mm. [5]

The minimum required weld leg length is 5.46mm for the beam to baseplate and therefore, the weld leg length recommended for suitability to this weld is approximately 10mm to 15mm.

As expected the weld of the beam to end plate is a lower value then that of the weld of the beam to the baseplate.
The results show the weld of the beam to the end plate to have a minimum required weld leg length of 4.44mm, therefore, the weld leg length recommeneded for suitability to this weld is approximately 6mm to 8mm.

The other governing factor is the size of the weld on the base plate to the beam which should be larger due to a larger bending component involved.

The weld profile suitable therefore, for this system would be a tee joint or even potentially a corner joint with double bevel, J or fillet. For this investigation and prioritisation of labour and cost, it would be recommended that a double bevel be utilized for a balance of support and welding process. To save further on the weld cost a butt weld can also be used as illustrated in *figure 6* . [7]

The maximum **convexity, c** , of the weld has been referenced and researched to be acceptable of value 5/16 of the width for welds with widths less than 8mm. Therefore, the weld should have a c of approximately **1.6mm**. [8]

References

[1] Assignment Specification Sheet
[2] MECH2400 9400 Design of Bolted Connections to AS4100 Bolt Modulus 2021
[3] Design Capacity Tables for Structural Steel Hollow Sections
[4] Lecture Notes
[5] Mechanical Engineering Design - Shigley's 8th Edition Textbook - McGraw Hill
[6] MECH3460 Weld Design Lecture 2021 Rev 1
[7] Researched - Weld Guru Website - Weld Types & Joints
[8] GE Grid Solutions - Weldment Visual Inspection Requirements

Dynamically Loaded Bolt Analysis

Problem Statement

References

This investigation aims to encompass the design of a suitable bolt connection between based plate and mild steel beam. More specifically, the beam is a Tubular Square Hollow Section that is experiencing pre-defined force. The investigation primarily aims to select a suitable grade and number of bolts.

Furthermore, this investigation will determine the worst case loading per bolt incoporating the , 'Bolt Modulus' described in referenced material, a visualisation of deflection of bolts under load and evaluation of the mean and alternating stresses.

Finally, there will be a discussion and reporting of insights accumulated in this investigation.

Executive Summary

The final design has been evaluated to select **four** grade **5.8 M12 Bolts**. [4]

Through the investigative results carried out, it is clearly denoted to be safe for the whole system.
Furthermore, in comparison with **Socket Head Cap Screws**, the bolts selected have denoted to be of lower cost,
have a lower requirement of force and possess higher strength in comparison with cap screws.

Number of M12 Bolts	Condition
1	Unsafe
2	Unsafe
3	Marginally Safe
4	Safe + One Bolt Failure

Table 1 - Bolt Selection Summary

To reduce weight, cost and manufacturing process, grade **5.8 M8 Bolts**, maybe applied at the comprimise of support however, safety would not be comprimised to a significant standard. [6]

The bolt prices have been estimated to be approximately **10 AUD** for **x4 - 5.8 M12 Bolts**,
the overall cost of this system has been estimated at approximately 650 to 700 AUD inclusive of weld, mild steel beam and bolt costs.

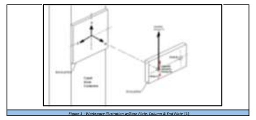

Figure 1 - Workspace Illustration w/Base Plate, Column & End Plate [1]

Selection - Bolt Number

The number of bolts within the workspace determines the security of the system and therefore, the safety of the system. With the determination of the number of bolts there are many factors that are to be considered including, support of the system prior to failure, the cost of material and components, efficiency of construction and labor.
In terms of cost and safety therefore, it would be appropriate and resonable for the system to incorporate four bolts as this will secure all edges of the beam to the base plate and also provide support along all points of contact with reasonable strength as denoted from analysis of this investigation.

FS

Description	Value	Symbol
FOS (Safe)	2.1	FOS_sf
FOS	2.0	FOS_2

Requirements

The following highlights the requirements within the investigation:

> Perform analysis on fasterners design.
> Specifiy the number of bolts or socket head cap screws.
> Specifiy the diameter of bolts or socket head cap screws.
> The grade of the bolts or socket head cap screws.
> Utilization of optimisation or solver.
> Determine loading per bolt.
> Visualisation of force deflection diagram for bolted joint design.
> Evaluate mean and alternating stresses.

Assumptions

The following section denotes the assumptions involved in the bolt design:

> Define the depth to between 200mm.
> Define the thickness to between 400mm.
> Selection of fastener is limited to either bolt or socket head cap screws.
> Utilizes the same beam and specifications of said beam from *Part A* of this investigation.

Specifications

The following section denotes the specifications of this investigation:

> Column is of material cast iron.
> Base plate and end plate are both of material mild steel.
> Force F1 is now translated to *Hole 4* - static force of magnitude 5kN
> Force F2 is a linear force acting upon *Hole 4* location of +/-3kN

Data

The following section highlights all calculations and data around the bolt selection and design of attachment of the beam to baseplate.

Given Data

Description	Property	Value	Unit	Symbol	Expression	Ref.
End Plate	End Plate Height	350	mm	ep_h2	-	[1]
	End Plate Width	400	"	ep_w2	-	
	End Plate Thickness	16	"	ep_t2	-	
Base Plate	Base Plate Height	500	"	bp_h2	-	
	Base Plate Width	500	"	bp_w2	-	
	Base Plate Thickness	16	"	bp_t2	-	
Column	Column Width	500	"	c_w	-	
	Column Depth	200	"	c_d	-	
	Column Thickness	400	"	c_t	-	
Forces	Force 1	5000	N	F1_1	-	
	Force 2	3000	"	F2_2	-	
Specified Value	Factor of Safety	2	-	FOS_2	-	
	Reliabilty Factor	0.868	-	RF	-	
	Endurance Limit	111.7	N/mm^2	ed_L	-	
	Endurance Limit	0.155	-	ed_L_p	0.155*Su*Reliability Factor	
	Proof Stress	75	%	ps	-	
Distribution Cones	Angle of Stress	25	Degrees	ang_s	-	

Compiled Data

Change this for Testing:

Description	Property	Value	Unit	Symbol	Expression	Ref.
Properties of Bolt Strength						
Bolt Grade Comparison						
TESTING GRADES - CHANGE:	Youngs Modulus	200.00	GPa	YM	-	
	Ultimate Tensile Strength	830.00	N/mm^2	UTS	-	
	Proof Strength	598.00	"	PF_s	-	
	Yield Strength	660.00	"	YS	Se=Se'*Ka Kb Kc Ke Kf	[4]
	Se'	128.65	N	Se_1	ed_L_p*UTS	
	Se	111.67	N	Se	Se_1*RF	

Compiled Bolts Tested:

Description	Property	Value	Unit	Symbol	Expression	Ref.
4.8	Youngs Modulus	200.00	GPa	-	-	[9]
	Ultimate Tensile Strength	420.00	N/mm^2	-	-	
	Proof Strength	302.00	"	-	-	
	Yield Strength	340.00	"	-	-	
	Se'	65.10	N	-	Se=Se'*Ka Kb Kc Ke Kf	[4]
	Se	56.51	N	-	-	
5.8	Youngs Modulus	200.00	GPa	-	-	
	Ultimate Tensile Strength	520.00	N/mm^2	-	-	
	Proof Strength	374.00	"	-	-	
	Yield Strength	420.00	"	-	-	
	Se'	80.60	N	-	Se=Se'*Ka Kb Kc Ke Kf	[4]
	Se	69.96	N	-	-	
8.8	Youngs Modulus	200.00	GPa	-	-	
	Ultimate Tensile Strength	830.00	N/mm^2	-	-	
	Proof Strength	598.00	"	-	-	
	Yield Strength	660.00	"	-	-	
	Se'	128.65	N	-	Se=Se'*Ka Kb Kc Ke Kf	[4]
	Se	111.67	N	-	-	
9.8	Youngs Modulus	200.00	GPa	-	-	
	Ultimate Tensile Strength	900.00	N/mm^2	-	-	
	Proof Strength	648.00	"	-	-	
	Yield Strength	720.00	"	-	-	
	Se'	139.50	N	-	Se=Se'*Ka Kb Kc Ke Kf	[4]
	Se	121.09	N	-	-	
10.8	Youngs Modulus	200.00	GPa	-	-	
	Ultimate Tensile Strength	1040.00	N/mm^2	-	-	
	Proof Strength	749.00	"	-	-	
	Yield Strength	940.00	"	-	-	
	Se'	161.20	N	-	Se=Se'*Ka Kb Kc Ke Kf	[4]
	Se	139.92	N	-	-	
12.9	Youngs Modulus	200.00	GPa	-	-	
	Ultimate Tensile Strength	1220.00	N/mm^2	-	-	
	Proof Strength	878.00	"	-	-	
	Yield Strength	1100.00	"	-	-	
	Se'	189.10	N	-	Se=Se'*Ka Kb Kc Ke Kf	[4]
	Se	164.14	N	-	-	
Altered w/Testing	Int Bolts	4.00	-	int_b	-	
	Preload	0.78	-	prl	*Referenced Material*	[5]
	P	10000.00	N	Force	-	
	E	195000.00	N/mm^2	E	-	

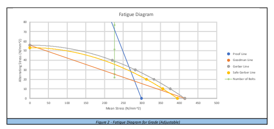

Figure 2 - Fatigue Diagram for Grade (Adjustable)

The diagram above is able to be adjusted automatically with the alterated tested grades and values desired by the user. Furthermore, the relationship is able to denote that the higher grades are over supportive and estimating safety. Therefore, the ideal grade was investigated at approximately 4.8 to 8.8 M12 bolt specifications.

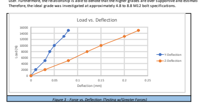

Figure 3 - Force vs. Deflection (Testing w/Greater Forces)

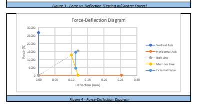

Figure 4 - Force-Deflection Diagram

Calculations

The following section highlights all calculations performed inorder to make selection of the fastener for the beam to baseplate.

Calculations & Plotting - Grade & Fatigue

Proof Line [4]

Description	sigma_a	sigma_m	Units	Symbol	Expression
	0.00	299.00	N/mm^2	pl_sm	PF_s/FOS_2
	299.00	0.00	"	pl_sa	PF_s/FOS_2

Goodman Line [4]

	sigma_a	sigma_m	Units	Symbol	Expression
	0.00	415.00	N/mm^2	gl_sm	UTS/FOS_2
	55.83	0.00	"	gl_sa	Se/FOS_2

Gerber Line [4]

	sigma_a	sigma_m	Units	Symbol	Expression
	0.00	415.00	N/mm^2		SQRT(1-FOS_2*D160/Se)*UTS/FOS_2
	10.00	376.00	"		"
	20.00	332.47	"		"
	30.00	282.29	"		"
	40.00	221.00	"		"
	55.83	0.00	"		"
Space for Testing other Values					

Safe Gerber Line [4]

	sigma_a	sigma_m	Units	Symbol	Expression
	0.00	395.24	N/mm^2		SQRT(1-FOS_sf*D170/Se)*UTS/FOS_sf
	10.00	356.14	"		"
	20.00	312.18	"		"
	53.18	0.00	"		"
Space for Testing other Values					

Calculations - Fine Pitch Thread [4]

Description	Property	Value	Unit	Symbol	Expression	Ref.
ALTERED w/Testing	Major Diametre	5.00	mm	md	-	
	Washer Factor	1.5	-	wf	*Referenced Material*	[5]
	Washer Diametre	7.50	mm	wd	wf*md	
	Area of Stem	19.63	mm^2	aos	PI()*((md)^2/4)	
Set using Table 2	Estimated Stress Area	14.92	"	est_sa	TABLE 2*aos	
	Grip Length	30	mm	gl	*Given*	
	Loss of Area due to Thread	0.19	N/mm^2	loa_th	*Referenced Material*	[5]

Table 2 - Thread Depths vs Bolt Diametre [4]

Thread Depth - *Referenced Material*			
Diametre	Value	Unit	Symbol
4	0.76	mm	
5	0.76	mm	
8	0.78	mm	
9	0.78	mm	
10	0.78	mm	
12	0.80	mm	

Calculations - Cone Angle Stress Ratio [4]

Description	Property	Value	Unit	Symbol	Expression
Cone Angle Conversion	Cone Angle Radians	0.44	radians	ca_rads	RADIANS(25)
	Angle TAN	0.47	"	ang_TAN	TAN(ca_rads)
	Bolt Stiffness	127627.20	N/mm	bolt_st	aos*E/gl
	Stiffness of Flanges	628992.45	"	bolt_fst	ang_TAN*PI()*E*md/(2*LN(5*(ang_TAN*gl+0.5*md)/(ang_TAN*gl+2.5*md)))
	Ratio of External Load	0.17	-	ratio_el	bolt_st/(bolt_st+bolt_fst)

Calculations - Mean & Alternating Stress [5]

Description	Property	Value	Unit	Symbol	Expression
Forces	Preload Force	6960.48	N	pre_f	PF_s*est_sa*prl
	Max Force per Bolt	7382.18	"	max_f	pre_f+Force*ratio_el/int_b
	Min Force per Bolt	6538.78	"	min_f	pre_f-Force*ratio_el/int_b
Stresses	Max Bolt Stress	494.70	N/mm^2	max_bs	max_f/est_sa
	Min Bolt Stress	438.18	"	min_bs	min_f/est_sa
Mean & Alternating Stresses	Mean Bolt Stress	466.44	N/mm^2	mean_bs	AVERAGE(E200:E201)
	Alternating Bolt Stress	28.26	"	a_bs	(max_bs-min_bs)/2

Table 3 - Grade of Bolt - Solver

Number of Bolts	*Diametre*		Bolt M/Grade Size	
4	5.00	mm	5.8	-
3	5.00	"	5.8	-
2	5.00	"	5.8	-
1	6.45	"	7.0	-

Table 4 - Results for Alternating & Mean Stress vs. Number of Bolts

Grade	Values			Units
	Number of Bolts	sigma_a	sigma_m	
4.8	1	153.75	226.5	N/mm^2
	2	76.87	226.5	"
	3	51.25	226.5	"
	4	38.43	226.5	"
	5	30.75	226.5	"
	6	25.62	226.5	"
	7	21.96	226.5	"

Table 5 - Results for Alternating & Mean Stress vs. Number of Bolts

Grade	Values			Units
	Number of Bolts	sigma_a	sigma_m	
8.8	1	110.14	466.44	N/mm^2
	2	55.07	466.44	"
	3	36.71	466.44	"
	4	27.53	466.44	"
	5	22.03	466.44	"
	6	18.36	466.44	"
	7	15.73	466.44	"

Allowance for FOS [5]

Description	Property	Value	Unit	Symbol	Expression
FOS Evaluation	Safe Gerber Line	-20.88	N/mm^2	sgl	(1-((FOS_sf*mean_bs/UTS)^2))*(Se/FOS_sf)
	Normal Gerber Line	76.40	"	ngl	((1-(mean_bs/UTS)^2)*Se)

Solver for Bolt Diametre

Description	Property	Value	Unit	Symbol	Expression
Safe	sigma_a - Goal	-20.88	N/mm^2	sa_goal	sgl
Normal	-	76.40	"	-	ngl

Calculations - Force Deflection [5]

Description	Property	Value	Unit	Symbol	Expression
	Beam Height	100.00	mm	bh_2	-
	Beam Width	50.00	"	bw_2	-
	Beam Thickness	6.00	"	bt_2	-
	Length	1500.00	mm	len_b	-
	Moment of Inertia - X-X	1121192.00	mm^4	mi_xx	((bw_2*(bh_2)^3)/12)-(((bw_2-bt_2)*(bh_2-6)^3)/12)
	Moment of Inertia - Y-Y	374392.00	"	mi_yy	((bh_2*(bw_2)^3)/12)-(((bh_2-6)*(bw_2-6)^3)/12)
	Max Y-Deflection	0.05	mm	max_yd	(Force*(len_b)^3)/(3*YM*(10^6)*(mi_xx))
	Max Z-Deflection	0.15	"	max_zd	(Force*(len_b)^3)/(3*YM*(10^6)*(mi_yy))
	Bolt Syt	1100.00	N/mm^2	bolt_syt	*Lecture Notes*
	Bolt Pre-Load Tension	12803.56	N	bpr_t	est_sa*prl*bolt_syt
	Extension of Bolt due Fi	0.10	-	ext_bfi	bpr_t/bolt_st
	Fi Member	-12803.56	N	fi_m	bpr_t*-1
	Contraction of Member due Fi	-0.02	-	cont_fim	fi_m/bolt_fst
	New Bolt Tension	14490.37	N	nb_t	bpr_t+(ratio_el*Force)
	Extension of Bolt with xtern/F	0.11	-	ext_bxF	nb_t/bolt_st
	New Flange Compression	-4490.37	N	nf_com	fi_m+Force*(1-ratio_el)
	Contaction of Member due Fm	-0.01	-	con_mfm	nf_com/bolt_fst

Table 10 - Compiled Deflection Data w/varying Loads

Force (N)	Y-Deflection (mm)	Z-Deflection (mm)
0	0	0
2000	0.01	0.03
5000	0.03	0.08
8000	0.04	0.12
10000	0.05	0.15
13000	0.07	0.20
15000	0.08	0.23

Calculations - Plotting Deflection [5]

Property	x-axis	y-axis	Expressions		
Vertical Axis	0	0	0	0	-
	0	26887.48	0	bpr_t*FOS_sf	
Horizontal Axis	0	0	0	0	-
	0.25	0	FOS_sf*(ext_bfi-cont_fim)		-
Bolt Line	0	0	0	0	-
	0.12	15401.50	ext_bfi-cont_fim	bpr_t*(1+bolt_st/bolt_fst)	
Member Line	0.12	0	ext_bfi-cont_fim	0	
	0.10	12803.56	bpr_t/bolt_st	prl*bolt_syt*est_sa	
External Force	0.11	4490.37	(ext_bfi-cont_fim)+con_mfm	NEGATIVE(1)*nf_com	
	0.11	14490.37	nb_t/bolt_st	nb_t	

Discussion

The following section highlights the discussion of all results, variables and individual invesitagtions that have been compiled through this spreadsheet. [6]

The solver function and excel algorithm setup within this spreadsheet has allowed for efficient investigation of the system by manipulating key variables and parameters of this design. Results denote that through altering and investigating the amount of bolts to secure the beam and base plate to the column, four bolts would be a viable option with a average estimated cost of approximately **15-20$ AUD**. Furthermore the investigation also denoted that higher grade bolts simply increased costs and over supported the connection of the beam-baseplate to the column. The most viable grade of bolt therefore, is **5.8 M12 bolts**. These display cost effectiveness and appropriate safety and support even with one bolt failure upon any of the conventional positions of the bolt.

The most significant invesitgations carried out by the algorithms setup and the key grades and threads that were tested have results compiled in the tables; *table 4 to table 9*. It is clear that **grade 5.8 with M12** would allow effective and ensure safety. The system can still take **M8** bolts as tested results denote in sections below. [4]

The utilized Young's Modulus from values of 195 GPa & 200 GPa had little effects. The smaller cone angle was tested with degrees from 25 to 30 and had effects on increasing alternating stress form 10 to 20% (dependent on grade tested). [6]

Further Compiled Results

Due to limitations of this investigation, only a range of grades have been tested and individual results with related number of bolts can be seen below:

Table 6 - Results for Alternating & Mean Stress vs. Number of Bolts Grade 4.8 M8

Grade	Bolts	M	tress - Alt (N/mm	ss - Mean (N/m	Stress - AFS (N/mm^2)	eSF
4.8	1	8	35.20	262.00	4.70	-30.51
4.8	2	"	17.60	244.40	9.00	-8.63
4.8	3	"	11.73	238.53	10.33	-1.40
4.8	4	"	8.80	235.60	11.00	2.20

Table 7 - Results for Alternating & Mean Stress vs. Number of Bolts Grade 5.8 M8

Grade	Bolts	M	tress - Alt (N/mm	ss - Mean (N/m	Stress - AFS (N/mm^2)	eSF
5.8	1	8	35.20	262.00	4.70	-30.51
5.8	2	"	17.60	244.40	9.00	-8.63
5.8	3	"	11.73	238.53	10.33	-1.40
5.8	4	"	8.80	235.60	11.00	2.20

Table 8 - Results for Alternating & Mean Stress vs. Number of Bolts Grade 8.8 M12

Grade	Bolts	M	tress - Alt (N/mm	ss - Mean (N/m	Stress - AFS (N/mm^2)	eSF
8.8	1	12	18.71	466.91	21.44	2.73
8.8	2	"	9.35	457.55	23.54	14.19
8.8	3	"	6.24	454.44	24.23	18.00
8.8	4	"	4.68	452.88	24.58	19.90

Table 9 - Results for Alternating & Mean Stress vs. Number of Bolts Grade 9.8 M12

Grade	Bolts	M	tress - Alt (N/mm	ss - Mean (N/m	Stress - AFS (N/mm^2)	eSF
9.8	1	12	18.70	504.71	23.60	4.90
9.8	2	"	9.35	495.35	25.70	16.35
9.8	3	"	6.24	492.24	26.39	20.16
9.8	4	"	4.68	490.67	26.74	22.06

Cost

Finally, the overall cost of this system has been estimated at approximately **650 to 700 AUD** inclusive of **weld**, **mild steel beam** and **bolt** costs.
The bolt prices have been estimated to be approximately **10 AUD** for **x4 - 5.8 M12 Bolts**

References

[1] Assignment Specification Sheet
[2] MECH2400 9400 Design of Bolted Connections to AS4100 Bolt Modulus 2021
[3] Design Capacity Tables for Structural Steel Hollow Sections
[4] Lecture Notes
[5] Mechanical Engineering Design - Shigley's 8th Edition Textbook - McGraw Hill
[6] MECH3460 Weld Design Lecture 2021 Rev 1
[7] Researched - Weld Guru Website - Weld Types & Joints
[8] GE Grid Solutions - Weldment Visual Inspection Requirements
[9] Datasheet - Mild Steel Bolt Grades