Weld Design

Problem Statement & Executive Summary

The following spreadsheet encompasses the investigation of a suitable weld and reasoning upon selected weld, attaching the two diagonal beams that connect to rear of the vertical beams and the horizontal base plate.

The beam selected is based through restrictions upon the volumentric dimensions highlighted in the technical drawing and design of the food shredder. The beam material for welding, welding frame and the baseplate is **AISI 304 structural Steel**. Furthermore, the shredder plate and frame plate are also of same steel material.

This investigation will include the jusitification of the selected beam to minimise various undesirable effects of loads and ensure security while balancing cost and manufacturing process through a method of analysis. The specific final values will include a weld profile and specifications.

The **weld profile** to be used within the attachment of both the diagonal beam to the baseplate and the vertical end beam is a **butt weld**.

The **weld leg length** for the beam being attached to both the baseplate and the vertical end beam is to be a **14mm** weld.

The **maximum convexity** of the weld is to be approximately **4.5mm**.

Requirements & Specifications

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

> Steel AISI 304 Beam Material (both Vertical & Diagonal Welded Frame).
> Wide: 100mm, Length: 80mm, Height: 100mm, Thickness: 20mm
> Beam is connecting to the Baseplate and Vertical Beams.
> Centre of Area (C of A) superimposed with the coordinate system outside of the vertical beam.
> Selection & justification of weld profile.
> Selection & justification of suitable weld size.

Assumptions & Load

Loads applied on the system include:

> 100N Downward Vertical Force
> 1000N Tangential Force

Compiled Data & Calculations

Notes	Description	Property	Value	Unit	Symbol	Expression	Reference	Citations
	End Beam Size	End Beam Height	800	mm	eb_h	-	Defined	-
		End Beam Width	100	"	eb_w	-	"	-
		End Beam Thickness	20	"	eb_t	-	"	-
	Base Plate Size	Base Plate Height	1500	mm	bp_h	-	Defined	-
		Base Plate Width	1500	"	bp_w	-	"	-
		Base Plate Thickness	15	"	bp_t	-	"	-
		Length of Beam	80	mm	l_b	-	Defined	-
	Specified FOS	Factor of Safety	2	-	FOS	-	-	-
Downward Direction	Force Y - Direction	Hole A Force	1943.10	N	F	SQRT(((F_plt1+F_plt2+F_shrd+F_by)^2)+((F_bx)^2)))	Calculated	-
Offset - *Figure X*	Hole A	Offset Distance	300	mm	offset_d	-	Calculated	-
Diametre of Hole A		Diametre	30	"	dia_b	-	Defined	-
	Mass	Plate 1	49.46	kg	m_plt1	-	Bolt Design	-
		Plate 2	7.07	"	m_plt2	-	"	-
		Shredder Unit	45.45	"	m_shrd	-	"	-
	Forces - Belt	Tension Belt	1000.00	N	F_b	-	Defined	-
		X Component	461.75	"	F_bx	F_b*SIN(ang_rads)	Calculated	-
		Y Component	887.01	"	F_by	F_b*COS(ang_rads)	"	-
	Angle	Belt - Degrees	27.5	theta	ang_degs	-	Defined	-
		Belt - Rads	0.48	theta	ang_rads	ang_deg*(PI()/180)	Calculated	-
	Forces - Shredder	Plate 1	485.20	"	F_plt1	m_plt1*g	Calculated	-
		Plate 2	69.36	"	F_plt2	m_plt2*g	"	-
		Shredder Unit	445.86	"	F_shrd	m_shrd*g	"	-
	Acceleration due to Gravity	Gravity Constant	9.81	m/s^2	g	-	Researched	[1]
	Rectangular Hollow Beam	Beam Height	100	mm	b_h	-	Defined	-
	Diagonal - Welded Frame	Beam Width	100	"	b_w	-	"	-
		Beam Thickness	20	"	b_t	-	"	-
	AISI 304 Steel Beam Material	Tensile Strength	505	N/mm^2	Su	-	Datasheet	[3]
	Properties	Weld Shear Stress Factor	3	-	weld_f	-	Researched	[2]
Formula from Lectures		Allowable Shear Stress	119.03	MPa	t_all	Su*weld_f	Calculated	Lectures

Calculations - End Beam

Notes	Description	Property	Value	Unit	Symbol	Expression	Reference	Citations
	Beam to Base Plate							
	Bending	Moment	38861.92	Nmm	M	F_y*eb_t	Calculated	[1]
		Moment of Inertia	3533.33	"	Z_w	(b_w+b_h)+((b_w)^2/3)	"	"
		Component due to Bending	11.00	N/mm	F_bnd	M/Z_w	"	"
	Shear	Assumption of Width	1.00	mm	w	-	Assumption	Lectures
Acting upon each mm		Perimetre of Beam	400.00	"	p	(b_h*2)+(b_w*2)	Calculated	"
		Area of Weld	400.00	mm^2	A_w	w*p	"	
		Force	1943.095797	N	V	F	Defined	-
		Force due to Shear	4.86	N/mm	F_s	V/A_w	Calculated	[1]
	Torsion	Torque	2914643.70	Pa	T	F*bp_w	"	[1]
		Radius of Beam	70.71	mm	r_b	SQRT((b_w/2)^2+(b_h/2)^2)	"	"
		Twisting Moment of Inertia	1333333.33	Pa	J_w	((b_w+b_h)^3)/6	"	"
	Beam Angles	theta	1.11	radians	angB_rads	ATAN(b_t/(b_t/2))	"	"
		"	63.43	degrees	angB_degs	angB_rads*180/PI()	"	"
	Force Components Torsion	Force due to Torsion	154.57	N/mm	F_j	(T*r_b)/J_w	"	"
		Force due to Torsion Y-Axis	138.25	"	F_jy	F_j*SIN(angB_rads)	"	"
		Force due to Torsion Z-Axis	69.13	"	F_jz	F_j*COS(angB_rads)	"	"
	Summing Vectorial	Force acting on Component	159.31	"	F_comp	SQRT(((F_bnd)^2+(F_s+F_jy)^2+(F_jz)^2))	"	"
	Weld	Weld Leg Length	2.68	mm	w_l	(F_comp*FOS)/t_all	Lectures	
Researched Value		Advisable Weld Factor	0.67	-	w_fac	-	"	
		Advisable Weld Length	13.4	mm	w_ad	b_t*w_fac	"	

Calculations - Baseplate

Notes	Description	Property	Value	Unit	Symbol	Expression	Reference	Citations
	Beam to End Plate	Moment	29146.44	Nmm	M_bp	F*bp_t	Calculated	[1]
	Bending	Component due to Bending	8.25	N/mm	f_bnd_bp	M_bp/Z_w	"	"
	Shear	Assumption of Width	1.00	mm	w_bp	-	Assumption	Lectures
Acting upon each mm								
	Torsion	Torque	194309.58	Pa	T_bp	F*eb_w	Calculated	[1]
	Force Components Torsion	Force due to Torsion	10.30	N/mm	F_j_bp	(T_bp*r_b)/J_w	"	"
		Force due to Torsion Y-Axis	9.22	"	F_jy_bp	F_j_bp*SIN(angB_rads)	"	"
		Force due to Torsion Z-Axis	4.61	"	F_jz_bp	F_j_bp*COS(angB_rads)	"	"
Summing Vectorial Components	Components	Force acting on Component	16.95	"	F_bp	SQRT(((f_bnd_bp)^2+(F_s+F	"	"
	Weld	Weld Leg Length	0.28	mm	w_l_bp	(F_bp*FOS)/t_all	Lectures	-
		Advisable Weld Length	13.4	mm	w_ad_bp	w_ad	"	-

Results & Comments

The factor of safety for the end plate of the beam weld has denoted an appropriate value with the thinnest section of the beam at 20mm.

Generally, it is advisable to use a weld that is no smaller than 0.67mm, the thickness of the beam material. Therefore, through this investigation the result is a value of 3mm to the nearest common weld leg length. Through the investigation however, the advisable weld leg length should be of a higher value as mentioned with the advisable factor consideration.

Therefore, the final weld leg length is to be a length of **14mm** to the nearest common weld leg length.

This correlates to the minimum required weld leg length of a value between 3 to 5mm for the beam to the end beam and the weld leg length hence, of recommended suitability to this weld falls within the expected range of approximately 10 to 15mm. [5]

As expected the weld of the beam to the base plate is a lower value than that of the weld of the beam to the end beam (or vertical beam). The results show the weld of the beam to the base plate to have a minimum required weld leg length of 0.28mm. Therefore, the weld leg length recommended must follow the advisable leg length for safety and fall at approximately 14mm for similar reasons mentioned prior.

The size of the weld to the vertical end beam is expected to be larger due to the larger beanding component involved.

The weld profile suitable therefore, for this investigationa and system would be a **tee joint** or even potentially a **corner joint** with **double bevel**, **J** or **fillet**. [1]
For this investigation and prioritisation of labour and cost, it would be recommended to employ a **double bevel** for the balance for support and welding process. To save further on the weld cost a **butt weld** can also be used as illustrated in *figure 7*. [5]

The maximum **convexity**, **c**, of the weld has been referenced and researched to be an acceptable value of **5/16** of the width for welds with widths less than 8mm. Therefore, the weld should have a *c* of approximately **4.5mm**. [6]

References

Citation	Reference
[1]	Budynas, R. G., Nisbett, J. K., & Shigley, J. E. (2011). Shigley's mechanical engineering design. New York: McGraw-Hill.
[2]	Fanella D.A., Amon R., Knobloch B., Mazumder A. (1992) Welded Connections. In: Steel Design for Engineers and Architects. Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-9729-2_6
[3]	AZoM.com. 2021. Properties: Stainless Steel - Grade 304 (UNS S30400). [online] Available at: <https://www.azom.com/properties.aspx?ArticleID=965> [Accessed 12 November 2021].
[4]	Cavallo, C., 2021. All About 304 Steel (Properties, Strength, and Uses). [online] Thomasnet.com. Available at: <https://www.thomasnet.com/articles/metals-metal-products/all-about-304-steel-properties-strength-and-uses/> [Accessed 12 November 2021].
[5]	www.steelconstruction.info. 2021. Welding. [online] Available at: <https://www.steelconstruction.info/Welding> [Accessed 12 November 2021].
[6]	Holdren, R., 2021. What Is This Thing Called Convexity?. [online] App.aws.org. Available at: <https://app.aws.org/itrends/2010/07/it201007/it0710-23.pdf> [Accessed 12 November 2021].

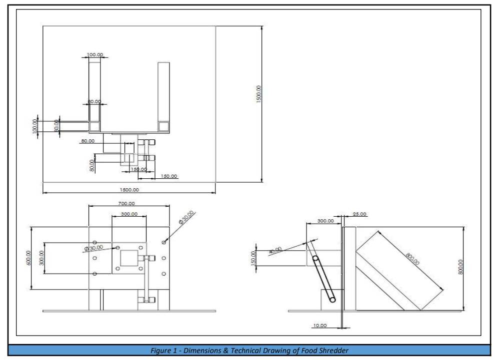
Figure 1 - Dimensions & Technical Drawing of Food Shredder

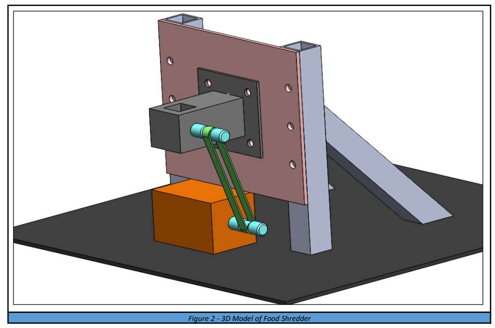
Figure 2 - 3D Model of Food Shredder

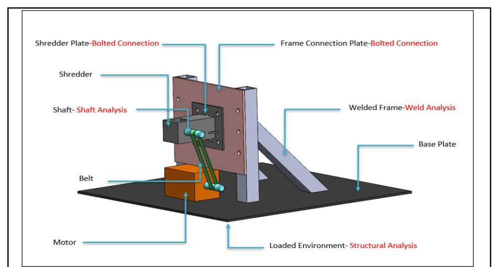

Figure 3 - Labelled 3D Model of Food Shredder

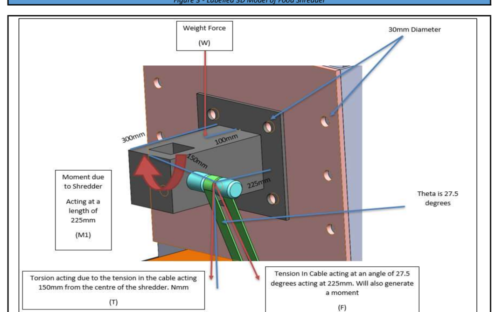

Figure 4 - FBD of System

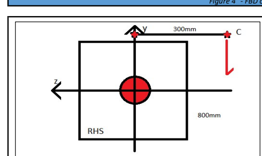

Figure 5 - Selected Point Centre of Area (C of A)

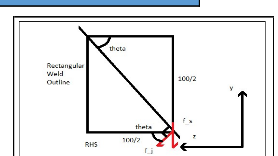

Figure 6 - Angle of Beam for Torsion & Shear

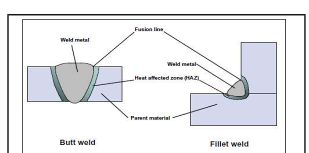

Figure 7 - Butt & Fillet Weld [5]