Laced column Lacing elements

welding length cm 5.8	welding thickness mm		Tension applied/allowable % 25.29	applied tension stress 0.9103260	compression applied /allowable % 57.06	allowable compression stress 1.9050731	applied compression stress 1.0869565	L/d	λ max 53.049589	radius of gyration i 18.850287	box volume mm3 736000	box area mm2 7.	box thickness mm	box height mm	tension tons 6	compression tons	effective length meter	K factor	length meter	number	
8.7	4 5		34.19	0.910326087 1.2307692 0.17663043 0.5769231	43.20	1.905073171 1.6025647 1.90507317 1.6025647	1.086956522 0.6923077 0.02717391 1.4230769	20 32.857143	53.04958918 86.418952 53.0495892 86.418952	18.85028735 26.614532 18.8502874 26.614532	00 2990000	736 1300	4 5	50 70	6.7 16	8 9	1 2.3	1	1 2.3	1 2	
5.8	4		4.91	0.17663043	1.43 8	1.90507317	0.02717391	20	53.0495892	18.8502874	736000	736	4	50	1.3	0.2	<u> </u>	↦	↦	ω	
9.9 5.8	5		16.03 0.38	0.5769231	88.80 0.71	1.6025647	1.4230769	20 32.857143	86.418952	26.614532	2990000	1300	5	70	7.5	18.5	2.3	↦	2.3	4	ומכנים נטו
	4	We	~	0.013586957		1.905073171	0.013586957	20	53.04958918	18.85028735	736000	736	4	50	0.1	0.1	L	L	L	5	lacea colalilli pi acili6 ciciliciira
6.8		Weld calculations	19.66	0.707692308	57.60	1.602564706	0.923076923	32.85714286	86.41895217	26.61453237	2990000	1300		70	9.2	12	2.3		2.3		ទី
5.8	5 .		0.00		24.96						0 736000	0 736	5 .	0 50		2 3.5		<u> </u>		6	
6.5	4 5		8.97 (0 0.3230769 0.03333333 0.15384615	55.20 (1.905073171 1.6025647 1.8977561 1.60256471	0.475543478 0.8846154 0.01111111	20 32.857143	53.04958918 86.418952 54.1001781 86.4189522	18.85028735 26.614532 18.4842275 26.6145324	2990000	5 1300	4 5	0 70	0 4.2	5 11.5	1 2.3	1	1 2.3	7 8	
6.0	5		0.93 '	0.03333333	0.59	1.8977561	0.01111111	20	54.1001781	18.4842275	900000	900	5	50	0.3	0.1	↦	↦	↦	9	
6.0	5		4.27	0.15384615	37.44	1.60256471	0.6	20 32.8571429	86.4189522	26.6145324	2990000	1300	5	70	2	7.8	2.3	↦	2.3	10 sum	
											1.9E+07									m	

Roof wind Bracing

roof	wind bracing		gusset plate weld calclulation for max compression and tension								
type	cross members	straight members									
max compression tons	3.7	0.7	Note: two members connected with one gusset plate are with same force with diff direction , so there is no compression or tension force only shear force exists								
max tension tons	3.5	0.7									
buckling length meter	5.7	6									
length meters	7.5	6									
HSS height mm	100	100	shear	force =	2	6.825761	tons				
HSS thickness mm	4	4	weld thick	ness = Sw			mm				
HSS area mm2	153600	153600	weld le	ngth =	shear force / 0.2 * Fu * Sw + 2 * Sw 17.20808						
HSS volume mm3	1152000000	921600000		Bolts required							
angle count	2	2	bolt diameter	10	mm						
angle height mm	100	100	bolt strength	10.9	ton/cm2						
angle thickness mm	10	10	bolts count	2	bolts						
angle area mm2	384000	384000	Rsh	2.054601595	tons						
angle volume mm3	2880000000	2304000000	R bearing	3.744	tons						
welding thickness mm	4	4	R total max	4.109203191	tons						
welding length cm	5.8	5.8									
saved weight percentage %	60%	60%									
descision	use HSS										

Truss connections

Connection T22:

plate length	40	cm	gusset Plata design	and :+a	امامید						
plate thickness	1	cm	gusset Plate design	gusset Plate design and its wel							
weld thickness	0.5	cm	moment due to tension	-231	ton.cm						
tension	5.5	tons	lx	5333.33	cm3						
shear	15.5	tons	у	20	cm						
normal eccentricity	20	cm	Area	40	cm2						
shear eccentricity	22	cm	weld max +ve normal stress	0.72875	ton/cm						
steel ultimate stress	5.2	ton/cm2	shear stress	0.3875	ton/cm2						
steel yield stress	3.6	ton/cm2	combined stress	0.99073	ton/cm2						
			weld safety	safe							
			gusset plate +ve normal stress	0.72875	ton/cm2						
			gusset plate shear force	0.3875	ton/cm2						
			combined stress	0.99073	ton/cm2						
			plate safety	safe							

Gusset Plate Straining actions:

Tension = T = 5.5 * cos(3) + 15.5 * cos(45) = 16.5 tons

Shear = $Q = 5.5 * \sin(3) + 15.5 * \cos(45) = 11.3 tons$

use gusset plate = 20mm

Bolts Design:

Group A:

Normal force = 5.5 tons

Using 2 bolts , M16, grade 10.9

Shear for bolt = 5.5/2 = 2.8 tons

Using gusset plate thickness for bolts = 10 mm

Plate Bearing resistance $R_b = 1 \text{cm} * 5.2 \text{ ton/cm}^2 * 1.6 \text{cm} = 8.8 \text{ tons}$

Shear resistance R_{sh} = Bolt Area * F_{sh} * shear plans = (3.14 * 1.6² *0.25) * (0.2*10.9) * 1 = 4.4 t

 $R_{\text{max}} = 4.4 \text{ t}$

Max Normal force = 4.4 * 2 = 8.8 tons > applied Normal force safe

Group B:

Using 3 bolts, M20, grade 10.9

Shear for bolt = 15.5/3 = 5.2 tons

Using gusset plate thickness for bolts = 10 mm

Plate Bearing resistance $R_b = 1 \text{cm} * 5.2 \text{ ton/cm}^2 * 2 \text{cm} = 10.4 \text{ tons}$

Shear resistance R_{sh} = Bolt Area * F_{sh} * shear plans = (3.14 * 2^2 *0.25) * (0.2*10.9) * 1 = 6.8 t

 $R_{\text{max}} = 6.8 \text{ t}$

Max Normal force = 6.8 * 3 = 20.4 tons > applied Normal force safe

Connection T11:

Gusset Plate Straining actions:

Tension = T = 4 tons

Compression = C = 18 tons

use gusset plate = 20mm

weld thickness = 1.2cm

$$L_{eff} = 18/(2 * 1 * 0.2 * 5.2) = 7.2 cm$$

$$L_{act} = L_{eff} + 2 S_w = 10 cm$$

Gusset plate height = 10 cm

Gusset plate length = 20 cm

Gusset plate section Area = 10 * 2 = 20 cm

Gusset plate applied stress = $18 / 20 = 0.9 \text{ ton/cm}^2$

Gusset plate effective length = 20 * 2 = 40cm fixed free

Gusset plate smallest inertia = $2^3 * 10 / 12 = 6.67 \text{ cm}^4$

$$L_{eff}/i_{min} = 40 / (6.67 / 20)^{0.5} = 69.3$$
 < 180ok

$$F_{cr} = 0.58 f_y - (KL/i)^2 \; (\; 0.58 f_y - 0.75 \;) \; / 10000 = 1.6 \; ton/cm^2 \\ \hspace{0.5cm} > f_{applied} \;safe$$

Bolts Design:

Normal force = 18 tons

Using 3 bolts, M20, grade 10.9

Shear for bolt = 18/3 = 6 tons

Using gusset plate thickness for bolts = 10 mm

Plate Bearing resistance $R_b = 1 \text{cm} * 5.2 \text{ ton/cm}^2 * 2 \text{cm} = 10.4 \text{ tons}$

Shear resistance R_{sh} = Bolt Area * F_{sh} * shear plans = (3.14 * 2^2 *0.25) * (0.2*10.9) * 1 = 6.8 t

 $R_{\text{max}} = 6.8 \text{ t}$

Truss Elements

number	- 1	2	3	4	5	6	7	8	9	10	
	1	2				6	-				
length meter	2.8	3	3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	
K factor	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	
effective length meter	3.36	3.6	3.6	3.72	3.84	3.96	4.08	4.2	4.32	4.44	
compression tons	0	0	0	0	0	0	0.5	0.65	1	1.3	
tension tons	16	13	11	9	7	5	4	2	0.8	0.8	
box height mm	60	60	60	60	60	60	60	70	70	70	
box thickness mm	4	4	4	4	4	4	4	5	5	5	
box area mm2	896	896	896	896	896	896	896	1300	1300	1300	
box volume mm3	2508800	2688000	2688000	2777600	2867200	2956800	3046400	4550000	4680000	4810000	
radius of gyration i	22.920151	22.920151	22.920151	22.920151	22.920151	22.920151	22.920151	26.614532	26.6145324	26.6145324	
λ max	146.59589	157.06703	157.06703	162.30259	167.53816	172.77373	178.0093	157.80852	162.317336	166.826151	
L/d	46.666667	50	50	51.666667	53.333333	55	56.666667	50	51.4285714	52.8571429	
applied compression stress	0	0	0	0	0	0	0.0558036	0.05	0.07692308	0.1	
allowable compression stress	0.3489938	0.3040123	0.3040123	0.284715	0.2671984	0.2512499	0.2366878	0.3011621	0.28466328	0.26948401	
compression applied /allowable %	0.00	0.00	0.00	0.00	0.00	0.00	23.58	16.60	27.02	37.11	
applied tension stress	1.7857143	1.4508929	1.2276786	1.0044643	0.78125	0.5580357	0.4464286	0.1538462	0.06153846	0.06153846	
Tension applied/allowable %	49.60	40.30	34.10	27.90	21.70	15.50	12.40	4.27	1.71	1.71	
					We	eld calculations					
welding thickness mm	4	4	4	4	4	4	4	5	5	5	
welding length cm	10.4	8.6	7.4	6.2	5.8	5.8	5.8	6.0	6.0	6.0	

				lower e	elements							
number	1	2	3	4	5	6	7	8	9	10 s		
length meter	2	2	2	2	2	2	2	2	2	2		
K factor	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2		
effective length meter	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4		
compression tons	18	9	3	2	2	0	0	0	0	0		
tension tons	4	4	5	12	17	21	24	26	27	27		
box height mm	70	70	60	60	60	70	70	70	70	70		
box thickness mm	5	5	4	4	4	5	5	5	5	5		
box area mm2	1300	1300	896	896	896	1300	1300	1300	1300	1300		
box volume mm3	2600000	2600000	1792000	1792000	1792000	2600000	2600000	2600000	2600000	2600000		
radius of gyration i	26.614532	26.614532	22.920151	22.920151	22.920151	26.614532	26.614532	26.614532	26.6145324	26.6145324		
λ max	90.176298	90.176298	104.71135	104.71135	104.71135	90.176298	90.176298	90.176298	90.1762979	90.1762979		
L/d	28.571429	28.571429	33.333333	33.333333	33.333333	28.571429	28.571429	28.571429	28.5714286	28.5714286		
applied compression stress	1.3846154	0.6923077	0.3348214	0.2232143	0.2232143	0	0	0	0	0		
allowable compression stress	1.5594353	1.5594353	0.6840278	0.6840278	0.6840278	1.5594353	1.5594353	1.5594353	1.55943529	1.55943529		
compression applied/allowable %	88.79	44.39	48.95	32.63	32.63	0.00	0.00	0.00	0.00	0.00		
applied tension stress	0.3076923	0.3076923	0.5580357	1.3392857	1.8973214	1.6153846	1.8461538	2	2.07692308	2.07692308		
Tension applied/allowable %	8.55	8.55	15.50	37.20	52.70	44.87	51.28	55.56	57.69	57.69		
					We	Weld calculations						
welding thickness mm	5	5	4	4	4	5	5	5	5	5		
welding length cm	9.7	6.0	5.8	8.0	11.0	11.1	12.5	13.5	14.0	14.0		

				upper e	elements					
number	1	2	3	4	5	6	7	8	9	10
length meter	2	2	2	2	2	2	2	2	2	2
K factor	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
effective length meter	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
compression tons	2	7	13	18	22	24	26	27	27	27
tension tons	6	0.5	1	1.2	1.4	1.4	1.4	1.2	1	1.2
box height mm	60	70	70	70	80	80	90	90	90	90
box thickness mm	4	5	5	5	5	5	5	5	5	5
box area mm2	896	1300	1300	1300	1500	1500	1700	1700	1700	1700
box volume mm3	1792000	2600000	2600000	2600000	3000000	3000000	3400000	3400000	3400000	3400000
radius of gyration i	22.920151	26.614532	26.614532	26.614532	30.686588	30.686588	34.761089	34.761089	34.7610894	34.7610894
λ max	104.71135	90.176298	90.176298	90.176298	78.210064	78.210064	69.042715	69.042715	69.0427154	69.0427154
L/d	33.333333	28.571429	28.571429	28.571429	25	25	22.22222	22.22222	22.222222	22.222222
applied compression stress	0.2232143	0.5384615	1	1.3846154	1.4666667	1.6	1.5294118	1.5882353	1.58823529	1.58823529
allowable compression stress	0.6840278	1.5594353	1.5594353	1.5594353	1.6904071	1.6904071	1.7781517	1.7781517	1.77815172	1.77815172
compression applied/allowable%	32.63	34.53	64.13	88.79	86.76	94.65	86.01	89.32	89.32	89.32
applied tension stress	0.6696429	0.0384615	0.0769231	0.0923077	0.0933333	0.0933333	0.0823529	0.0705882	0.05882353	0.07058824
Tension applied/allowable%	18.60	1.07	2.14	2.56	2.59	2.59	2.29	1.96	1.63	1.96
					We	eld calculatio	ons			
welding thickness mm	4	5	5	5	5	5	5	5	5	5
welding length cm	5.8	6.0	7.3	9.7	11.6	12.5	13.5	14.0	14.0	14.0

				vertical	elements							
number	1	2	3	4	5	6	7	8	9	10		
length meter	2.12	2.24	2.4	2.5	2.6	2.7	2.9	3	3.1	3.2		
K factor	1	1.5	1	1.5	1	1.5	1	1.5	1	1.5		
effective length meter	2.12	3.36	2.4	3.75	2.6	4.05	2.9	4.5	3.1	4.8		
compression tons	11	9.2	9	7	5	3.7	2.5	1.3	0.5	0		
tension tons	1.2	1	0.8	0.7	0.5	0.5	0.5	0.7	1	2.2		
box height mm	60	80	80	80	70	70	70	70	70	70		
box thickness mm	4	5	5	5	5	5	5	5	5	5		
box area mm2	896	1500	1500	1500	1300	1300	1300	1300	1300	1300		
box volume mm3	1899520	3360000	3600000	3750000	3380000	3510000	3770000	3900000	4030000	4160000		
radius of gyration i	22.920151	30.686588	30.686588	30.686588	26.614532	26.614532	26.614532	26.614532	26.6145324	26.6145324		
λ max	92.495027	109.49409	78.210064	122.20323	97.690989	152.1725	108.96303	169.08056	116.477718	180.352596		
L/d	35.333333	28	30	31.25	37.142857	38.571429	41.428571	42.857143	44.2857143	45.7142857		
applied compression stress	1.2276786	0.6133333	0.6	0.4666667	0.3846154	0.2846154	0.1923077	0.1	0.03846154	0		
allowable compression stress	1.5319036	0.6255758	1.6904071	0.5022222	1.4676706	0.3238836	0.6316885	0.2623457	0.55280957	0.23057726		
compression applied/allowable%	80.14	98.04	35.49	92.92	26.21	87.88	30.44	38.12	6.96	0.00		
applied tension stress	0.1339286	0.0666667	0.0533333	0.0466667	0.0384615	0.0384615	0.0384615	0.0538462	0.07692308	0.16923077		
Tension applied/allowable%	3.72	1.85	1.48	1.30	1.07	1.07	1.07	1.50	2.14	4.70		
	Weld calculations											
welding thickness mm	4	5	5	5	5	5	5	5	5	5		
welding length cm	7.4	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0		