Engineering office for temporary structures,
exhibition and entertainment technology

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Structural Analysis

Project	project number	23BLU04
	project name	Christie Lites B Type Truss System Analysis CONDENSED
Client	company	Blumano
	street	71 Lower Baggot Street
	postal code + city	Dublin D02 P593
Operator	company	
	street	
	postal code + city	
	country	

Issuer

03/11/2023, Dipl.-Ing. Uwe Runtemund
Licensed structural engineer
Chamber of Engineer NRW, # 747230

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T R U S S S Y S T E M A N A L Y S I S

Software:	RUNTEMUND TRUSS ANALYSER V2.5
Input File:	Christie_Lites_B_Type.txt
Date:	2023-11-02
Truss System:	**Christie Lites B Type Truss** Condensed Version

P R E A M B L E

Summary

Subject of this calculation is a modular trussed beam system. It consists of elements in different lengths which can be assembled freely, as long as the construction principles of this document are respected. These are in particular:

- The bracing angle is never flatter than mentioned in this report.
- The framework is fully formed as defined here.
- Displacement offsets on connector or within the nodes does not exceed the range mentioned here.
- In case of deviating elements such as spacers, corner modules or elements without a complete framework, a separate consideration is always required.
- The manufacturer shall ensure that manufacturing is in accordance with the EN 1090 series of standards.

Basis of Calculation

The system analysis was assembled on following basis of calculation:

DIN EN 1990	2010-12	Basis of structural design (Eurocode 0)
DIN EN 1993-1-1	2010-12	Design of steel structures (Eurocode 3)
DIN EN 1999-1-1	2014-03	Design of aluminium structures (Eurocode 9)
DIN EN 17115	2018-10	Entertainment technology - Aluminium and steel trusses
DIN EN ISO 8752	2009-10	Spring type straight pins - Slotted, heavy duty

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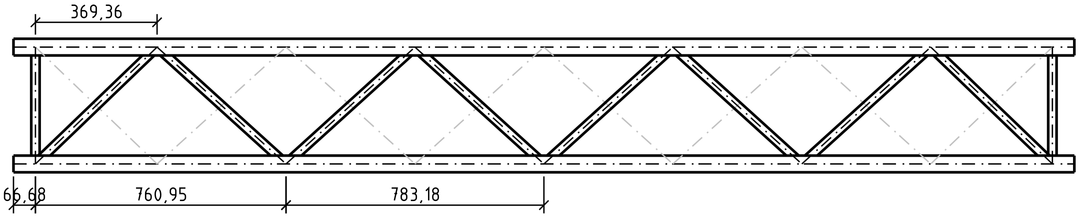
STRUCTURAL SYSTEM

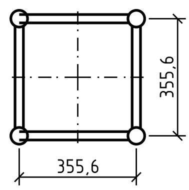
Cross-Section

The framework plane at the rear in the respective view is indicated by grey centre lines if visible.

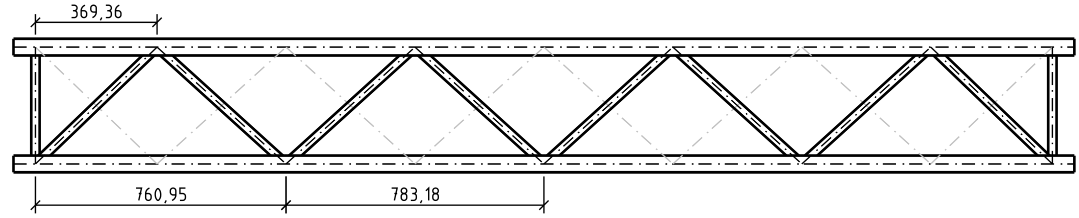
Side View From Right



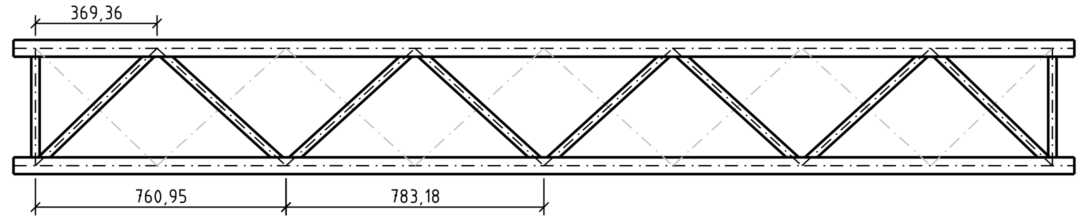
Front View



Top View

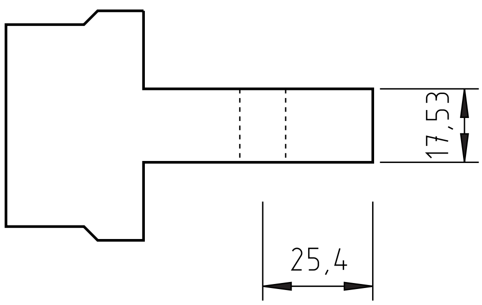


Bottom View

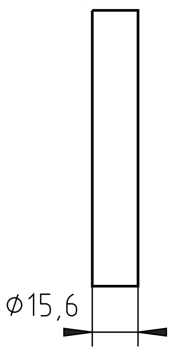


Connection Geometry

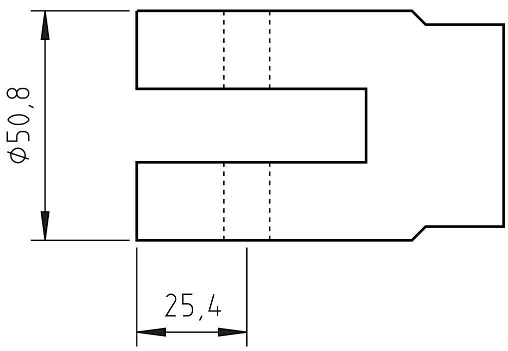
Male Fitting



Pin



Female Fitting



INPUT DATA

Truss Summary

Truss Type		= 4 Chords, Square
Connection Geometry		= Vert. Fork
Outer Dimensions	ov×oh =	407 × 407 [mm×mm]
Axis Dimensions	av×ah =	356 × 356 [mm×mm]
Self-Weight	g =	10,02 [kg/m]
Material Type		= Aluminium
Young's Modulus	E =	70000 [N/mm²]
Shear Modulus	G =	27000 [N/mm²]

Truss Cross-Section Data

Cross-Section Area	A =	19,03	[cm²]
Shear Area Timoshenko Beam	A_v,y =	3,85	[cm²]
	A_v,z =	3,85	[cm²]
2nd Moment of Inertia	I_y =	6069,93	[cm⁴]
	I_z =	6069,93	[cm⁴]
Shear Stiffness	S_v,y =	10397,92	[kN]
	S_v,z =	10397,92	[kN]

Truss Geometry Details

Flattest Vertical Brace Angle	α_v =	42,24	[°]
Flattest Horizontal Brace Angle	α_h =	42,24	[°]
Maximum Infill Width	s =	783	[mm]
Maximum Offset at Connector	e_1 =	66	[mm]
Maximum Offset in Nodes	e_2 =	0	[mm]

Cross-Section Properties

Following part and cross-section properties are used whithin this calculation:

Part	A [cm²]	I [cm⁴]	W [cm³]	Type
Chords	4,76	13,55	5,33	RO ⌀50.8×3.18 - EN AW 6061 T6
Horiz. Diagonals, All	2,22	1,40	1,10	RO ⌀25.4×3.18 - EN AW 6061 T6
Horiz. End Braces, All	2,22	1,40	1,10	RO ⌀25.4×3.18 - EN AW 6061 T6
Vert. Diagonals, All	2,22	1,40	1,10	RO ⌀25.4×3.18 - EN AW 6061 T6
Vert. End Braces, All	2,22	1,40	1,10	RO ⌀25.4×3.18 - EN AW 6061 T6
Fitting male/female	0,00	0,00	0,00	- EN AW 6061 T6
Pin	0,00	0,00	0,00	⌀15,60 - 1.0718

- If a value is 0, the value is not applicable or relevant for the part.
- Fitting means the part of the connection system which is permanently connected to the chords.
- Connector means a loose intermediate piece in the connection, if any.
- If the pin is conical, the value corresponds to the average diameter.

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Partial Safety Coefficients

Material	γ_M0	γ_M1	γ_M2	γ_Mw	γ_G	γ_Q
EN AW 6061 T6	1,00	1,10	1,25	1,25	1,35	1,50
1.0718	1,00	1,00	1,25	1,25	1,35	1,50

Material Properties

Material	f_o / f_y [N/mm²]	f_u [N/mm²]	f_u,haz [N/mm²]	f_w [N/mm²]
EN AW 6061 T6	240,00	260,00	139,36	170,00
1.0718	245,00	360,00	0,00	0,00

- If a value is 0, the value is not applicable or relevant for the part.

O U T P U T   D A T A

Determination of the Chord Design Resistance

Result

General Yielding Along Member	N_Rd =	103,80	[kN]
Local Failure at Welds	N_Rd =	74,38	[kN]
Buckling in Areas Without Welds	N_Rd =	77,17	[kN]
Buckling in Areas With Welds	N_Rd =	58,89	[kN]
Design Resistance of Chord Force	N_ch,Rd =	58,89	[kN]

Determination of the Vertical Bracing Design Resistance

Result

General Yielding Along Member	N_Rd =	48,43	[kN]
Buckling in Areas Without Welds	N_Rd =	24,21	[kN]
HAZ General	N_Rd =	24,75	[kN]
Weld Seam	N_Rd =	32,19	[kN]
HAZ Along Seam	N_Rd =	26,39	[kN]
Design Resistance of Brace Force	N_b,Rd =	24,21	[kN]

Determination of the Horizontal Bracing Design Resistance

Result

General Yielding Along Member	N_Rd =	48,43	[kN]
Buckling in Areas Without Welds	N_Rd =	24,21	[kN]
HAZ General	N_Rd =	24,75	[kN]
Weld Seam	N_Rd =	32,19	[kN]
HAZ Along Seam	N_Rd =	26,39	[kN]
Design Resistance of Brace Force	N_b,Rd =	24,21	[kN]

Determination of the Connection Design Resistance

The fitting is connected to the chords via spring steel slotted straight pins acc. to DIN EN ISO 8752.

Number of pins per fitting	n =	2	[-]
Pin diameter	d =	10,00	[mm]

Result

Slotted Pin - Shear	N_Rd =	112,26	[kN]
Slottet Pin - Hole Bearing	N_Rd =	45,72	[kN]
Pin	N_Rd =	66,02	[kN]
Fitting - Hole Bearing	N_Rd =	89,48	[kN]
Design Resistance of Connection	N_c,Rd =	45,72	[kN]

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CONCLUSION

Design Resistance of Parts

Chord	$N_{ch,Rd}$ =	58,89	[kN]
Connection	$N_{ch,Rd}$ =	45,72	[kN]
Horizontal Brace	$N_{bh,Rd}$ =	24,21	[kN]
Vertical Brace	$N_{bv,Rd}$ =	24,21	[kN]

Design Internal Forces of Truss

Normal Force	$N_{Rd} = 4 \times N_{ch,Rd}$	N_{Rd} =	182,87	[kN]
Shear Force v	$V_{z,Rd} = 2 \times N_{bv,Rd} \times \sin \alpha_v$	$V_{z,Rd}$ =	32,56	[kN]
Shear Force h	$V_{y,Rd} = 2 \times N_{bh,Rd} \times \sin \alpha_h$	$V_{y,Rd}$ =	32,56	[kN]
Bending Moment v	$M_{y,Rd} = 2 \times N_{ch,Rd} \times av$	$M_{y,Rd}$ =	32,52	[kNm]
Bending Moment h	$M_{z,Rd} = 2 \times N_{ch,Rd} \times ah$	$M_{z,Rd}$ =	32,52	[kNm]

- The design resistance values must be divided by the safety factor γ_Q to roughly estimate allowable characteristic values.
- Structural analyses may only be calculated by authorised and experienced engineering professionals.

Further Notes

- Maximum Allowable Free Applicable Load P = 50 [kg]
- Loads up to the maximum allowable free load may be positioned arbitrary on the chord. Higher loads have to be positioned in the nodes or have to be checked separately.
- On combined occurance of shear force, bending or torsion at connection or node displacement, this must be checked.

Notes to the Load Charts

- The values only apply to horizontal beams. Inclined beams or columns require assessment by experienced engineers. The installation position assumed here can be seen in chapter "Structural System".
- Both top chords or both bottom chords serve as supports. Never use one chord alone as a support.
- The values are characteristic according to Eurocode. Partial safety factors (1,35/1,5) are considered. This includes permanent and variable actions.
- The optional frequent use factor (0,85) acc. to DIN EN 17115 chapter 5.3.2 was not used in the tables. If necessary, the values can be multiplied by this.
- The values given are static loads without any factors for dynamic influences like motion or hoisting operation. These would have to be considered separately if necessary.
- The loads are only vertical. In particular, no wind loads were taken into account.
- For deviating applications basse on other codes, the partial safety factors may be adjusted.
- Interaction of internal forces at connector are considered.
- The table data have no limitation of deflection.
- The system is perfect and secured against lateral buckling.
- The self-weight of the truss system is considered.
- The deflection is calculated for an ideal Timoshenko-Beam. Because of the flexibility of the connector real deflection is a little bit higher.

- Load application occurs directly in the nodes of the vertical framework and is balanced. The load application is centric and not one-sided.
- The values are only valid for the single span girders analysed here. Complex structures are not covered by this.
- Complex structures shall always be checked by an experienced professional engineer, as the load tables usually do not cover these cases.
- Complex structures, special cases or special constructions can be analysed by Runtemund Engineering acc. to German, European or International standards.

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LOAD CHARTS

Load Chart - Single Span Beam

Span [m]	UDL [kg/m]	Defl [mm]	CPL [kg]	Defl [mm]	TPL [kg]	Defl [mm]	QPL [kg]	Defl [mm]	FPL [kg]	Defl [mm]	Swt [kg]
1	4122	1	4122	2	2061	1	1374	1	1030	1	11
2	2161	3	2837	3	1793	3	1371	3	1080	2	21
3	1414	6	2143	5	1414	5	1119	6	931	4	31
4	939	10	1714	8	1161	9	939	9	737	8	41
5	608	14	1424	11	982	13	778	14	608	12	51
6	456	21	1215	16	848	18	655	19	516	17	61
7	336	28	1056	21	744	25	563	26	447	24	71
8	256	36	931	27	661	32	493	33	393	32	81
9	201	45	831	34	594	41	437	42	349	40	91
10	162	55	747	42	537	51	391	51	313	50	101
11	132	67	677	51	489	62	353	62	283	61	111
12	110	79	617	61	447	74	321	73	258	73	121
13	92	93	565	72	411	87	293	86	236	86	131
14	78	107	519	84	379	102	268	100	216	100	141
15	67	123	478	97	351	118	247	115	199	116	151
16	58	140	442	111	325	135	227	131	184	132	161
17	50	158	409	127	302	153	210	149	170	150	171
18	44	177	379	143	281	173	194	167	157	169	181

Load Colour:
- Bending Moment decisive
- Shear Force decisive
- Connection Interaction decisive
- Nodal Joint decisive
- Load Equality decisive

Deflection Colour:
Deflection is less than w/200, w/150, w/100
Deflection is more than w/100

Abbreviations
- UDL : Uniformly Distributed Load
- CPL : Centre Point Load
- TPL : Third Point Load
- QPL : Quarter Point Load
- FPL : Fifth Point Load
- Swt : Self-Weight

Load Chart - Cantilever

Length [m]	UDL [kg/m]	Defl [mm]	EPL [kg]	Defl [mm]	Swt [kg]
0,5	2165	1	2165	2	6
1,0	1556	2	1556	3	11
1,5	1062	3	1142	5	16
2,0	672	5	898	8	21
2,5	463	7	738	11	26
3,0	338	10	625	16	31
3,5	256	14	540	21	36
4,0	201	18	474	27	41

Load Colour:
- Bending Moment decisive
- Shear Force decisive
- Connection Interaction decisive
- Nodal Joint decisive
- Load Equality decisive

Deflection Colour:
Deflection is less than w/400, w/300, w/200
Deflection is more than w/200

Abbreviations
- UDL : Uniformly Distributed Load
- EPL : End Point Load
- Swt : Self-Weight

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