REF: Heals/SM

08.03.2023

Colliers
The Harlequin Building
65 Southwark Street
London
SE1 0HR

FAO – Leigh Rowley

Dear Leigh

Heals Staircase – Existing Structure Review

As part of the existing structure review associated with the installation of a new staircase within an existing stair void, we have undertaken a site visit to review the existing structural configuration locally to the proposed works. Alongside the site visit and in order to assess the implications of the proposal on the existing structure, we have reviewed the available drawings indicating the existing building layout and the design submittals by Alpine Group, comprising of design drawing, 3D model and structural calculations.

During the initial site visit the existing structure was exposed, allowing a clear view of the structural configuration and framing around the existing void. From what could be seen it appeared that the existing reinforced concrete waffle slab previously extended into or fully over the existing void. Evidence of the formation of the void being a post original slab construction modification could be seen in the general construction of the edges of the void. In these areas it appears that the original waffle slab has been cut back with a reinforced concrete edge perimeter cast around the void. This is evidenced by the general visible form and surface quality of the edge concrete at the joints. The existing stair removed from the area is supported on one edge of the void and from the concrete floor slab below. Full details of the ground floor slab have not been confirmed, however, from what could be seen it appears to be a reinforced concrete ground bearing slab.

The proposed stair details as presented by Alpine Group and appended to this summary consist of a steel framed stair structure primarily supported by the existing ground bearing slab. Some additional support to the landing areas, upper flights and surrounding fins is taken from the reinforced concrete suspended floor slab, however, as noted, the main stair loads area transferred directly to ground. Structural calculations completed by Thetis Engineering Ltd have been provided as part of the design package and these confirm details of locations where the new stair will be supported from the base and suspended slab elements and the corresponding loadings for each of these points.

The provided calculations as appended to this summary suggest a maximum ULS leg load to the slab from the primary CHS posts of 26.5kN supported from 300x300x10 thick steel baseplates. The maximum ULS load to the secondary SHS members is calculated to be 15.0kN supported from 200x50x10 thick steel baseplates. In addition to these loads, the flat plate balusters also provide supplementary support with a maximum load of 2.5kN transferred from these to the base slab.

20 Britton Street, EC1M 5TX | Tel: 020 7490 4353
E-mail: info@furnesspartnership.com | www.furnesspartnership.com
Furness Partnership Limited Registered in England No.4604621
LONDON & BRADFORD

Full details of the base slab haven't been confirmed, however as part of the installation it will need to be confirmed that the slab is a minimum of 150mm thick reinforced concrete. This stipulation is part of the anchor design for the stair; however, on the basis that the slab is founded on firm consolidated ground, it will also ensure stair loads can be effectively transferred to the bearing strata.

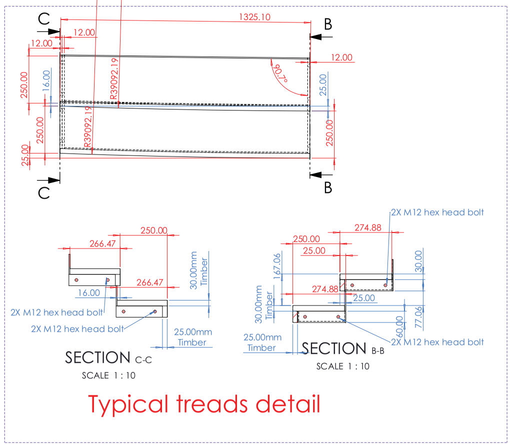
As previously noted, the majority of the stair loads are transferred to the ground bearing slab, however there are areas to the perimeter where the flat plate fins/balusters fix into the existing reinforced slab, providing partial support to landing areas and the upper flights. The worst case ULS load through the fixings in these areas is noted as 4.5kN, however due to the number of fixing points the general applied load through the slab fixings would be significantly less than this. As previously commented, it is believed the area where the stair void is situated was previously infilled as a continuous part of the reinforced concrete waffle slab. Then at some point, presumably when the original stair was installed, the concrete was removed and trimmed back as can currently be seen in the exposed site condition. The design floor loading for the retained waffle slab would have been high due to its retail usage. This in combination with the overall reduction in loading due to the extent of removed concrete and the relatively low stair loads applied to the suspended slab would mean that by inspection, subject to the structure being in good condition, the existing suspended slab would be suitable for the applied loads from the stair installation.

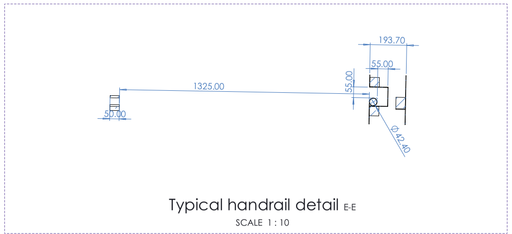
As described above, based on the completed site inspection and a review of the provided design details, subject to final confirmation of the existing configuration and condition, the existing structure would be suitable to accommodate the applied loads from the proposed stair installation.

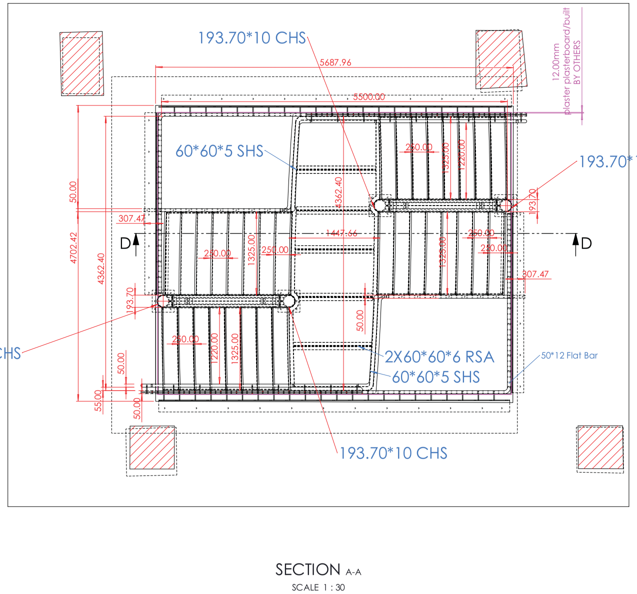
Yours sincerely
For Furness Partnership

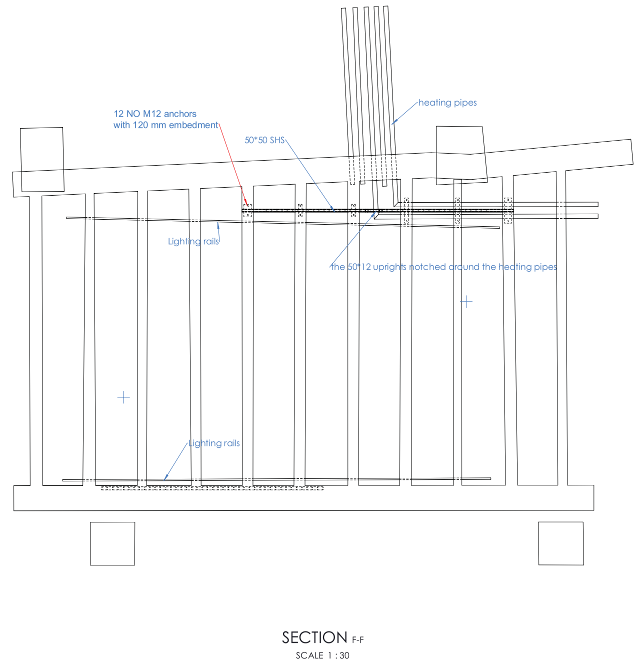
Sebastian Maudling
Director

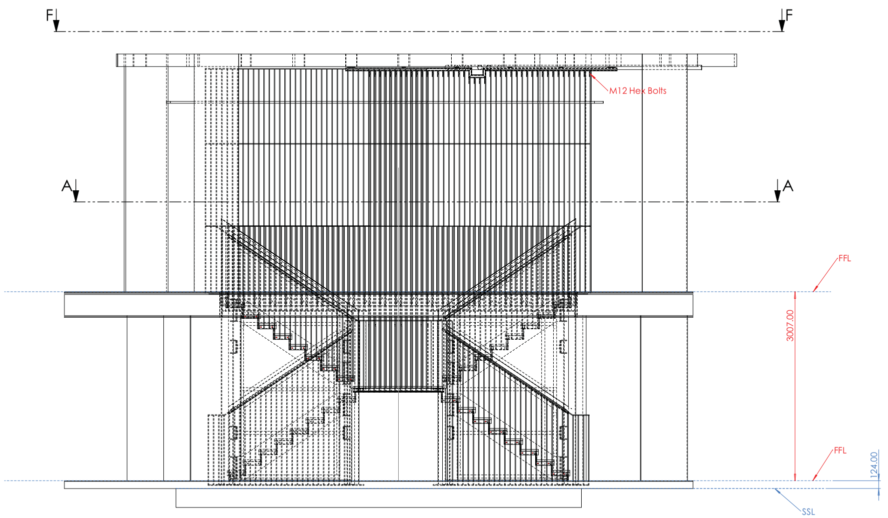
20 Britton Street, EC1M 5TX | Tel: 020 7490 4353
E-mail: info@furnesspartnership.com | www.furnesspartnership.com
Furness Partnership Limited Registered in England No.4604621
LONDON & BRADFORD

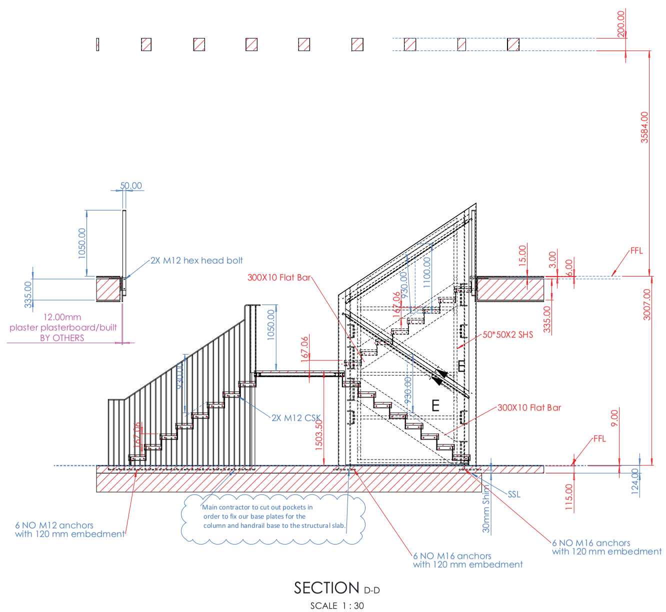












GENERAL NOTES:
1) Figured dimensions only to be used. Do not scale from this drawing.
2) Levels are shown in metres, dimensions are shown in millimetres.
3) This drawing is to be read in conjunction with all relevant architects & engineers drawings.
4) All hot rolled sections to be grade S355JR in accordance with BS EN 10025-2 U.N.O.
5) All hot rolled flats/plates to be grade S275JR in accordance with BS EN 10025-2 U.N.O.
6) All hot rolled hollow sections to be grade S355J2H in accordance with BS EN 10210 U.N.O.
7) All connections to be designed in accordance with BS EN 5950
8) Refer to the project data sheets for all surface preparations and treatments
9) All steelwork to comply with execution class 2 CE marking

Drawing Note:
Finsh : Primer paint
All welds 6mm fillet
See the link below for the 3D rendered model:
https://sketchfab.com/3d-models/a7555-heals-p01-04c569c0eea846d88a67db281b09eff3

ACCEPTANCE CLASSIFICATION			
CLASSIFICATION		MEANING	ADDITIONAL CHECKS
A	"Accepted"	Information submitted may be released for construction.	Reviewer to confirm acceptance of the following: Datums; Finished Floor Levels (FFL) Structural Slab Levels (SSL) Top Of Steel Levels (TOS) Dimensions; Setting out dimensions Gridlines/Coordinates Clearances Heights Widths Specifications; Material Grade/Type
B	"Accepted subject to comments"	Information submitted must be amended in line with the comments, but need not be re-submitted.	
C	"Not Accepted"	Information must be amended in the way indicated and re-submitted for acceptance.	

PRELIMINARY

REV	DESCRIPTION	BY	DATE
C2	ISSUED FOR APPROVAL / COMMENTS	A.S	02/02/2023
P1	ISSUED FOR APPROVAL / COMMENTS	A.S	02/01/2023

Alpine Group (1974) Ltd
Manor Farm | Abbotts Ann | Andover | SP11 7DB
01264 710613 | www.alpinegroupuk.com

CLIENT	A7555 - Heals, Tottenham Court Rd		
CONTRACT	A7555 - Heals, Tottenham Court Rd		
DRAWING TITLE	Basement to ground floor level		
DRAWN BY	A.S	CHECKED BY	G.T
DRAWING SIZE	A0	DRAWING SCALES	1:5 1:10 1:20 1:50
DRAWING No.	A7555 - GA - 01	REV No.	C2

Contents

1.0 Introduction

Thetis Engineering Ltd has been engaged by Alpine Group to design a stair for Heals, Tottenham Court. The staircase comprises a four flights of stairs joined at hal landing with flat stringers between central column supports and folded plate treads propped by balustrade stanchions.

These calculations justify the principle structural elements that comprise the staircase and balustrade system as well as the connection to the existing structure. The design of the frame elements upon which the stair is to take support is outside of the scope of this document. Reaction loads have been provided.

2.0 CDM Regulations

Under the Construction (Design and Management) Regulations 2015 we have responsibilities as designers to ensure that on notifiable projects (i.e. projects lasting longer than 30 days or involve more than 500 person days of work) the client understands their own duties required by the regulations. For notifiable projects the client must ensure that a principle designer is appointed as soon as practicable in the design phase of the project.

As designers we are required by the CDM regulations to, where we can, eliminate hazards and risks. There appears to be no special risks associated with the erection and eventual demolition of this building so far as we can assess in our capacity as designers.

The contractor is responsible for ensuring the stability of the structure at all times and that the works are carried out in accordance with the Construction, Design and Management Regulations and in strict compliance with all relevant Codes of Practice, Building Regulations and good building practice. All site works should follow good working practice in the construction industry. The Contractor should follow the HSE Guidelines with regards to manual handling.

3.0 Design Standards

Design Codes

Eurocode 1: BE EN 1991-1-1:2002	Actions on structures – Part 1-1: General actions – Densities, self-weight, imposed loads for buildings
Eurocode 3: BS EN 1993-1-1:2005	Design of steel structures – Part 1-1: General rules and rules for buildings

4.0 Structural Loadings Schedule

Treads:

Dead:

Tread self weight accounted for in model	
Finishes	0.50 kN/m^2
Load acting on 260mm wide tread	0.15 kN/m

Imposed:

Class C35	4.00 kN/m^2 Or 4.00kN PL
Load acting on 260mm wide tread	1.04 kN/m

Balustrades:

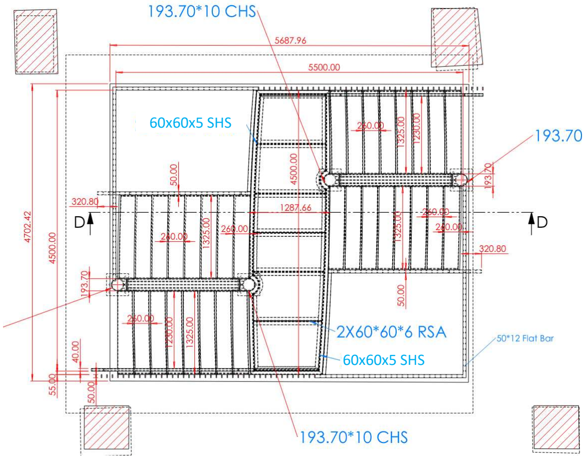
Dead:

Self weight	0.75 kN/m

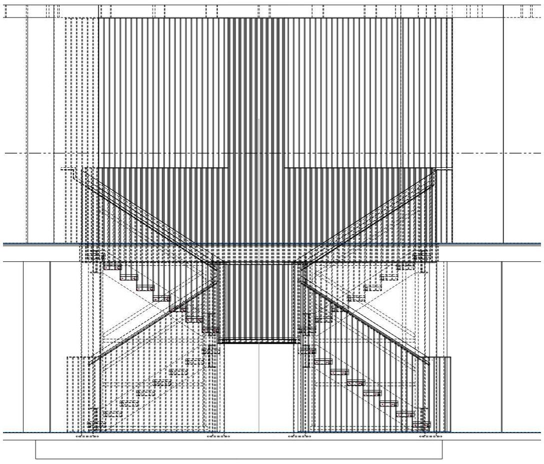
Imposed:

Horizontal	1.50 kN/m
Vertical	0.60 kN/m Or 1.0 kN PL

5.0 Stair Geometry

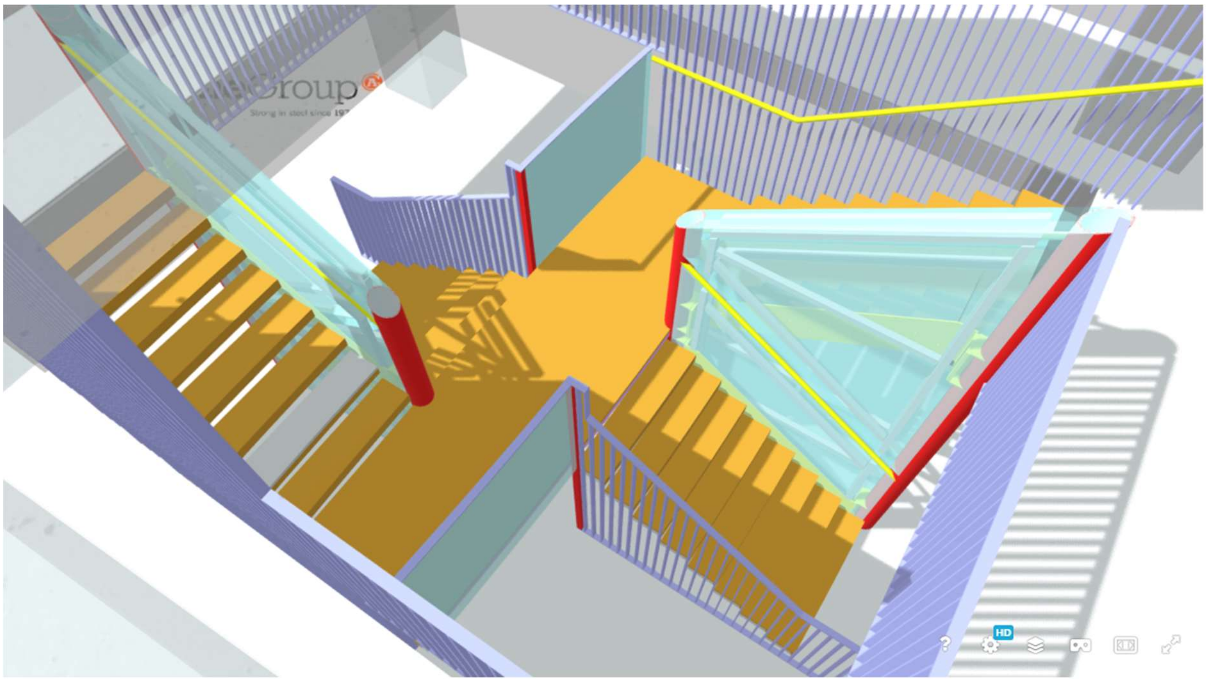


Plan view



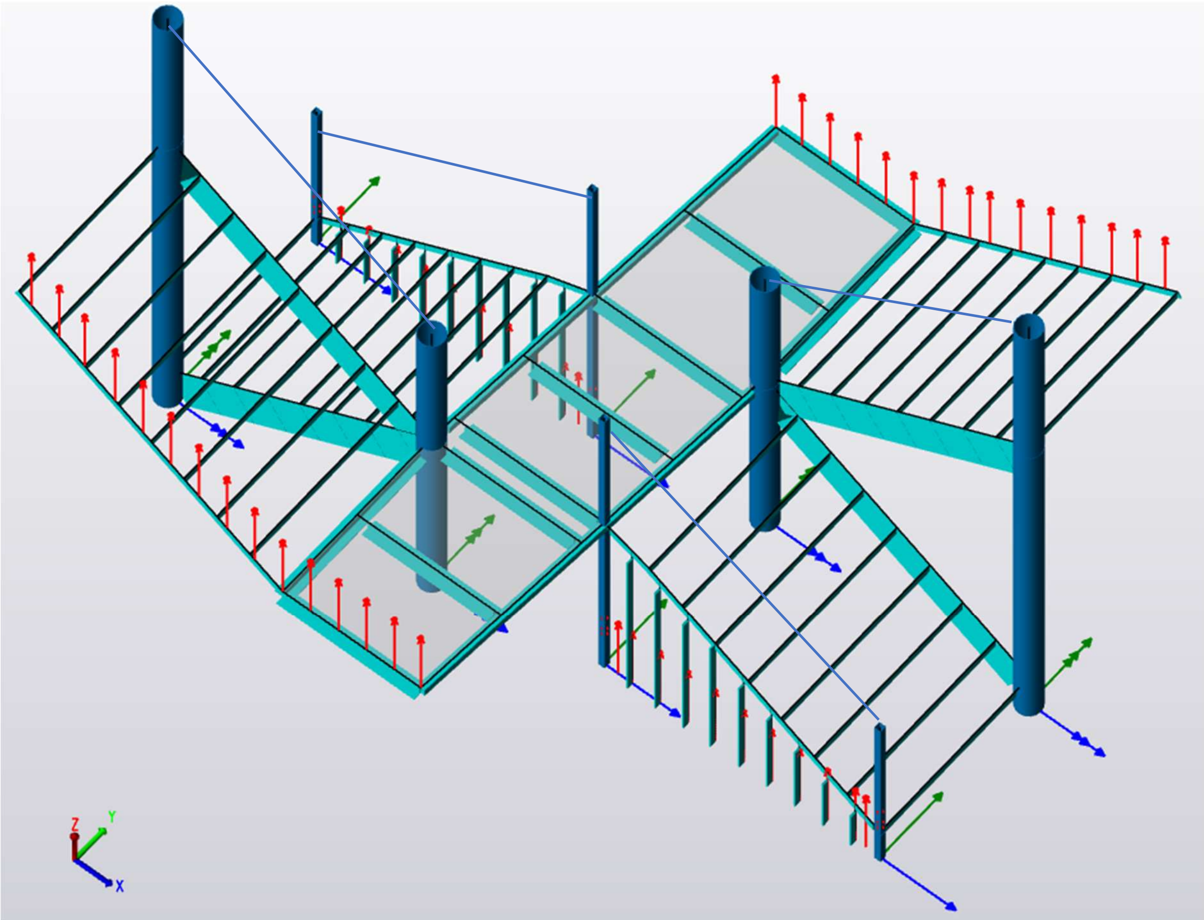
Elevation view

See Alpine Group drawings for full details.



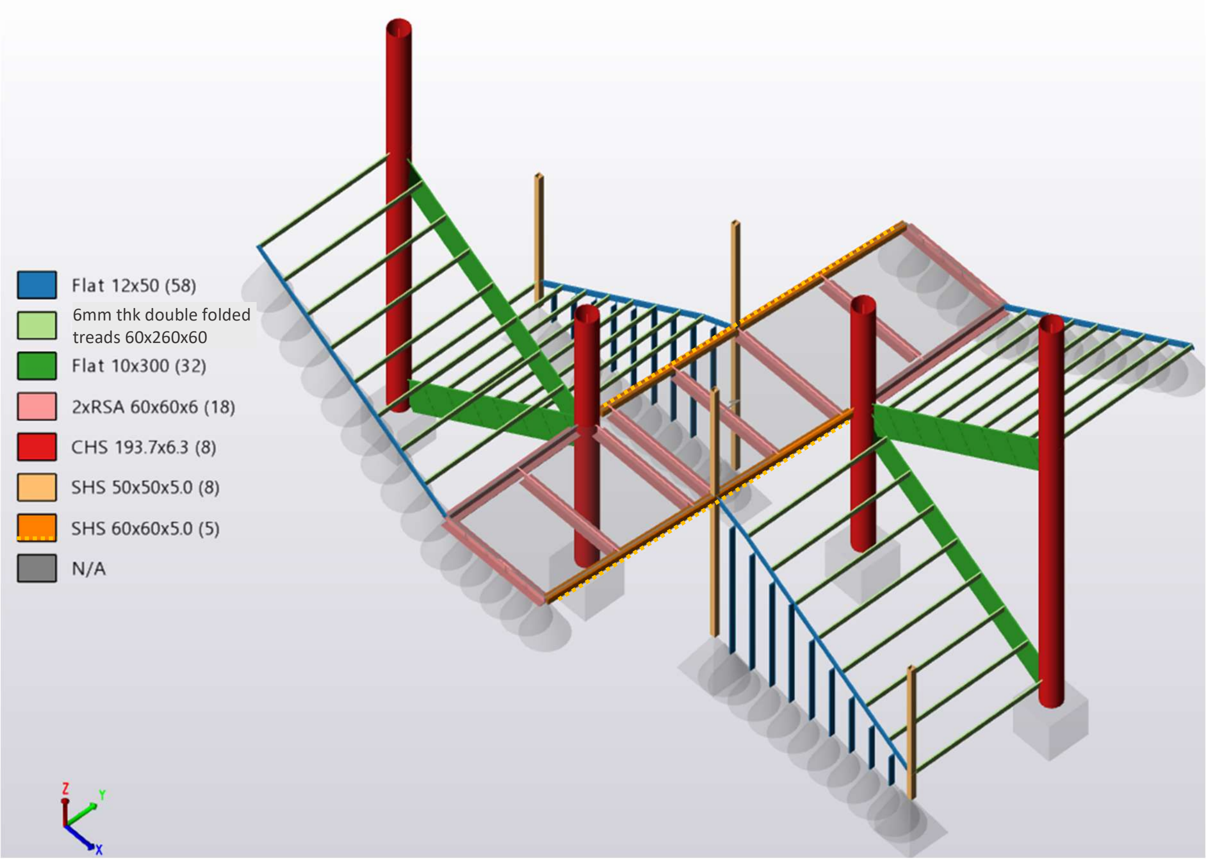
Alpine Group — Strong in steel since 1974	Contract No.	2220323	Sheet No.	6	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

6.0 Model Geometry



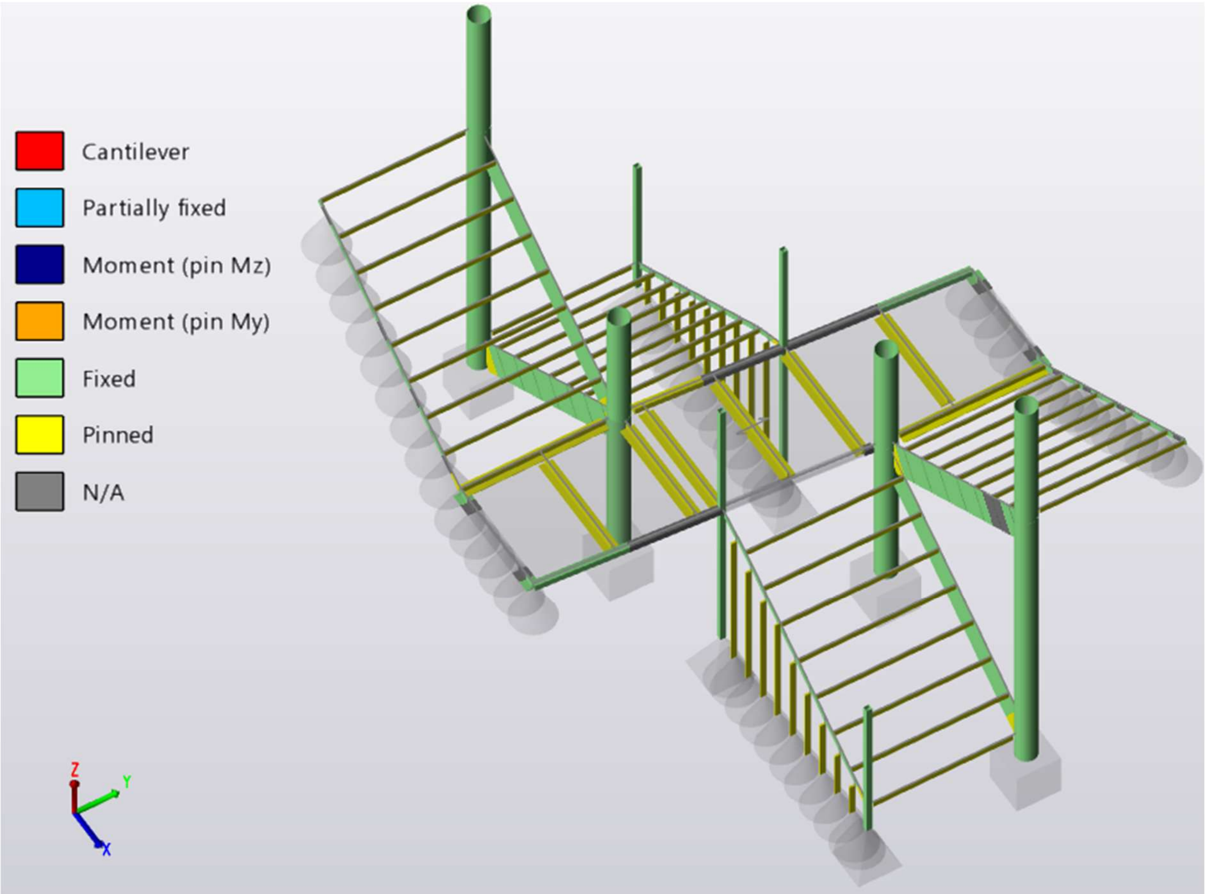
AlpineGroup Strong in steel since 1974	Contract No.	2220323	Sheet No.	7	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

Section sizes



	Contract No.	2220323	Sheet No.	8	Rev.	P1
AlpineGroup Strong in steel since 1974	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

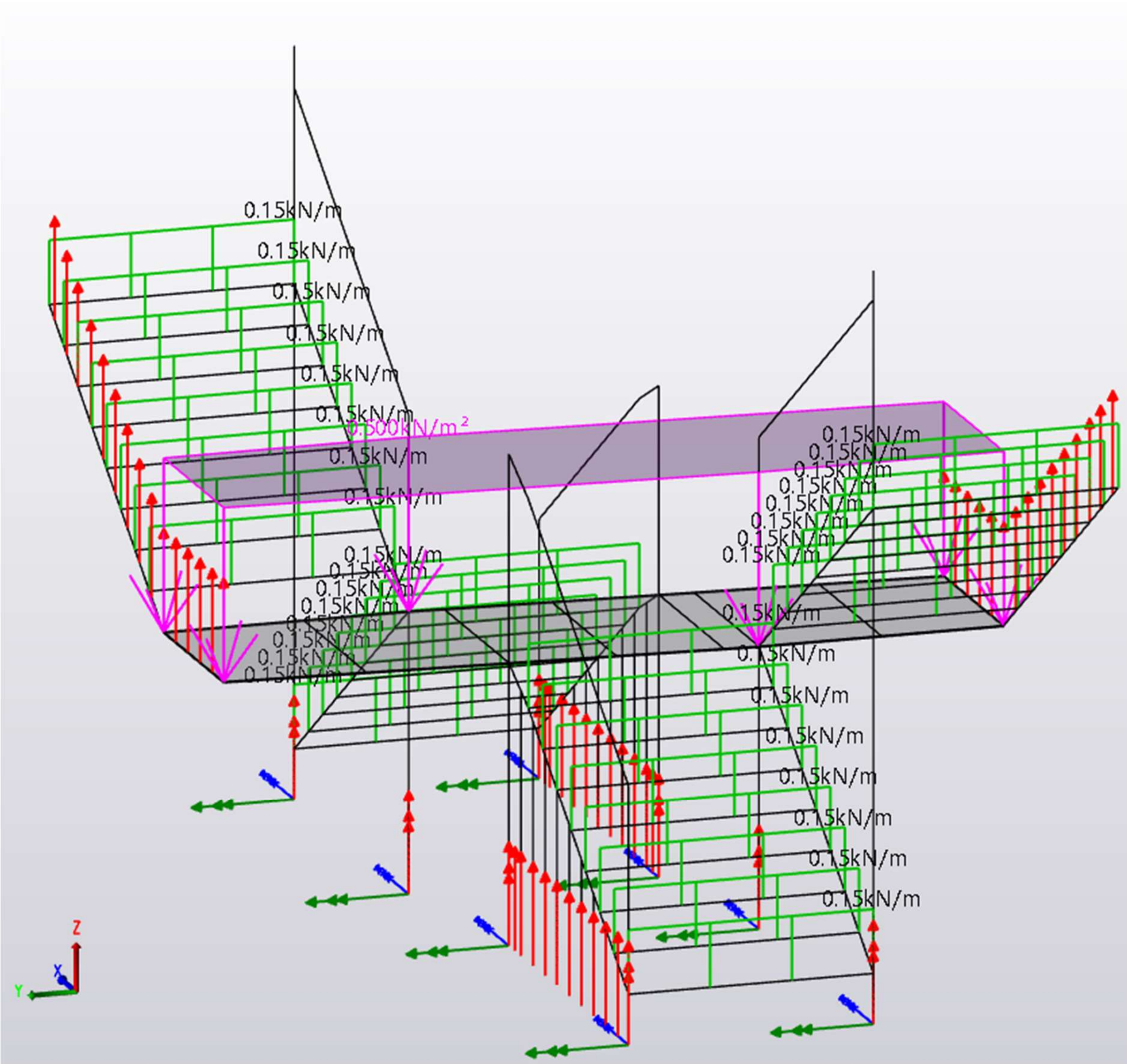
Connection fixity



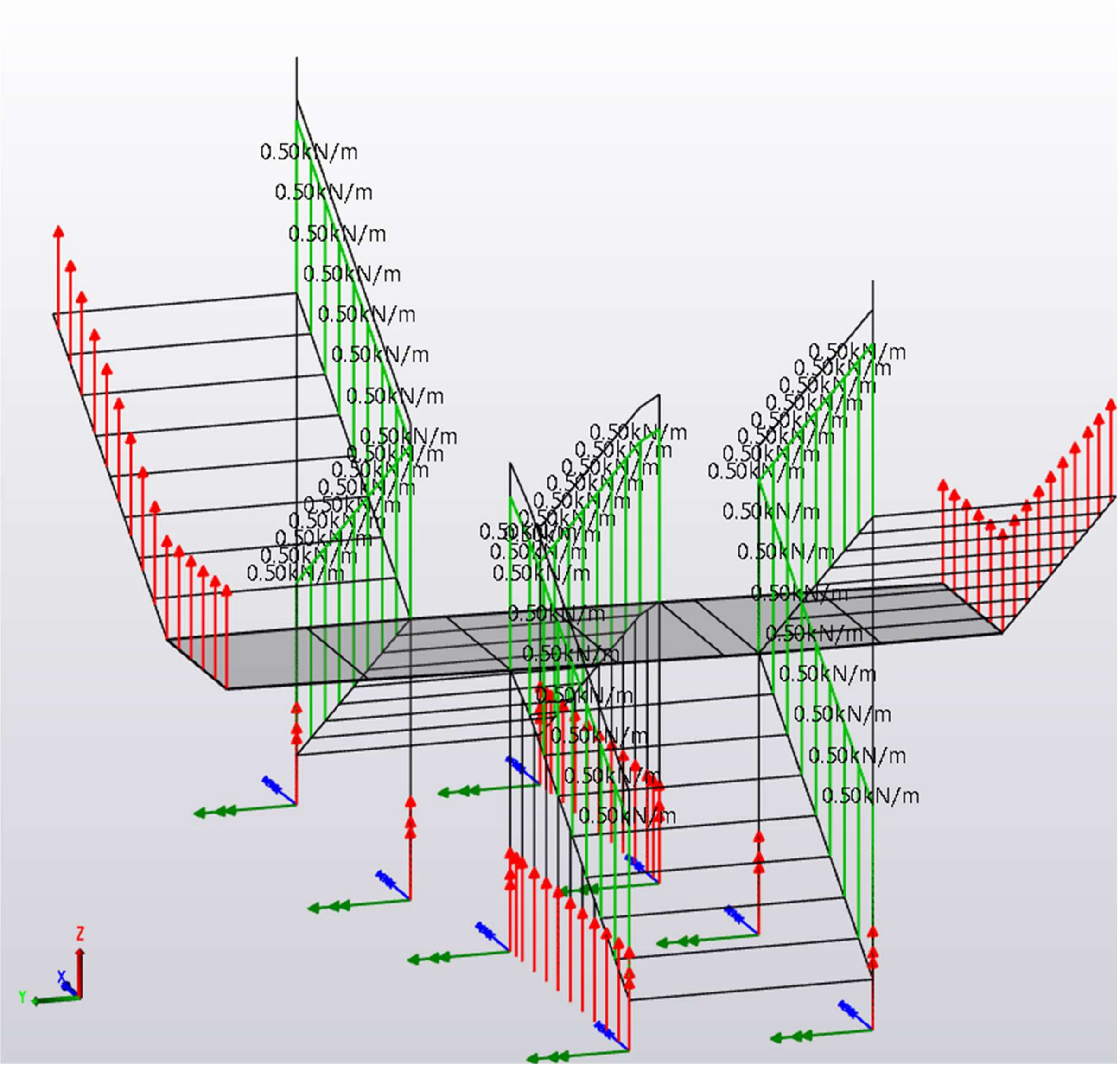
AlpineGroup Strong in steel since 1974	Contract No.	2220323	Sheet No.	9	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

7.0 Model Loading

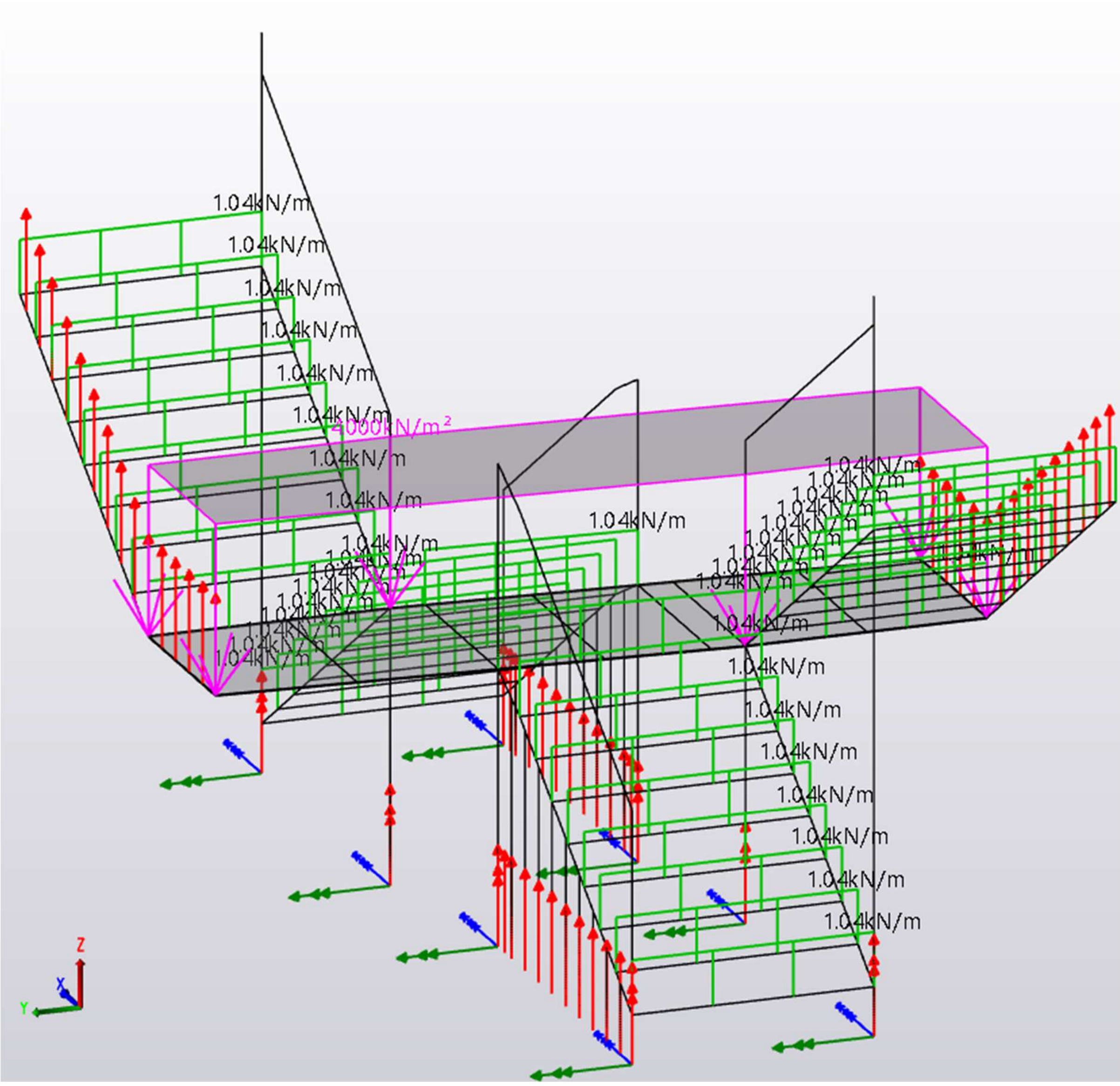
Superimposed Dead Load (Treads and landings):



Superimposed Dead Load (Balustrades):

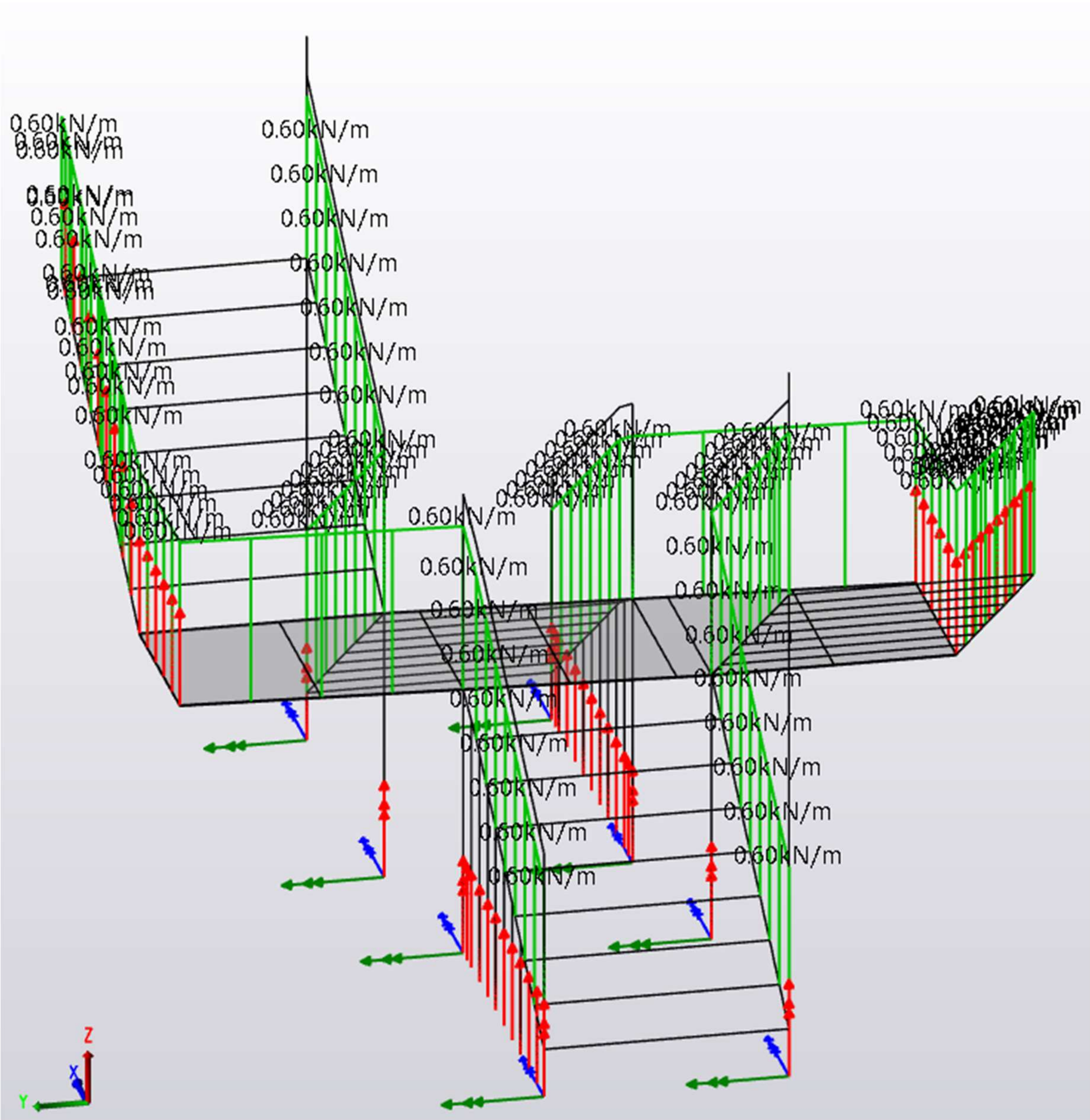


Vertical Live Load (treads and landings):



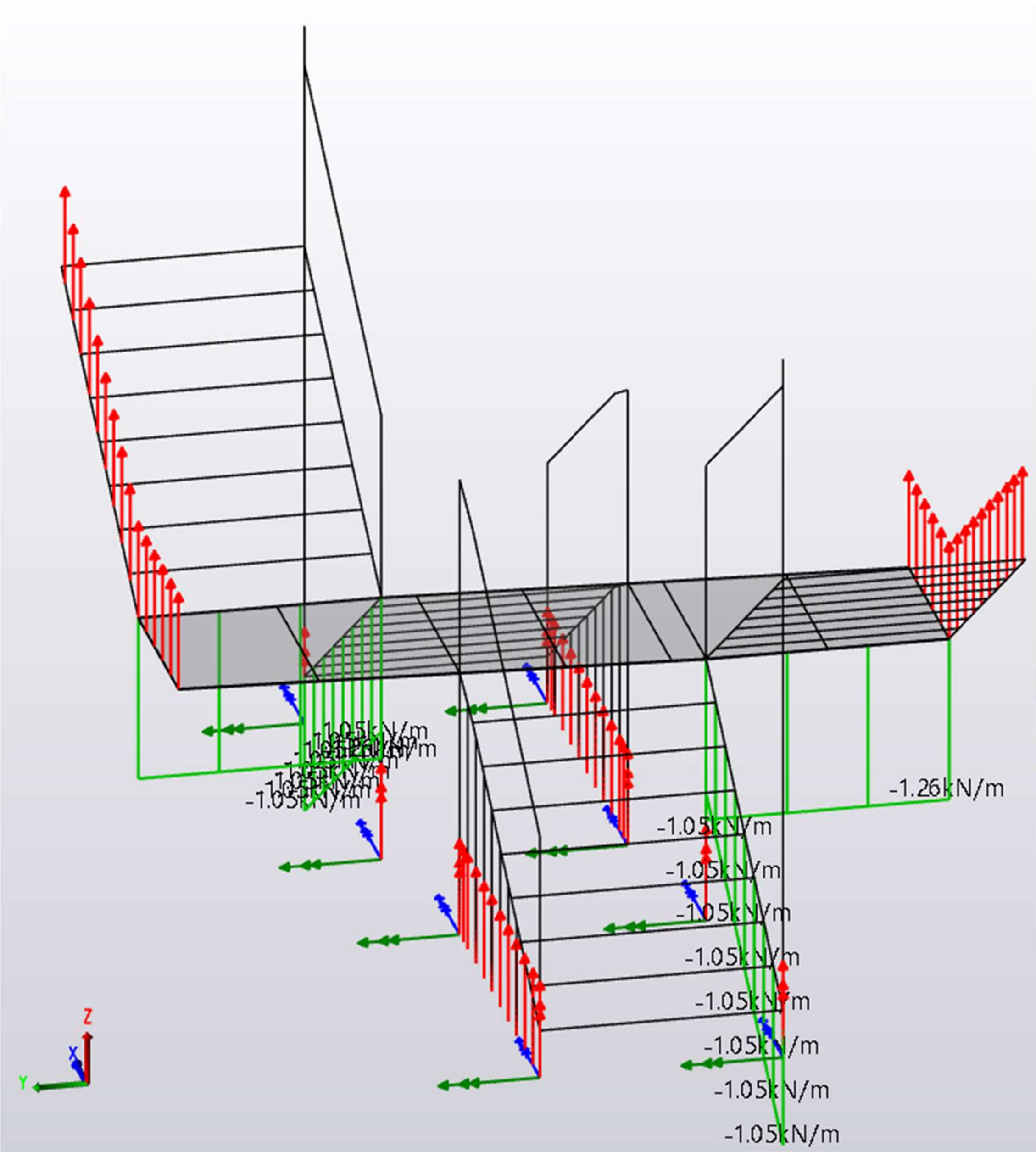
AlpineGroup Strong in steel since 1974	Contract No.	2220323	Sheet No.	12	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

Vertical Live Load (Balustrade):



AlpineGroup Strong in steel since 1974	Contract No.	2220323	Sheet No.	13	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

Imposed Load (outer balustrade push):

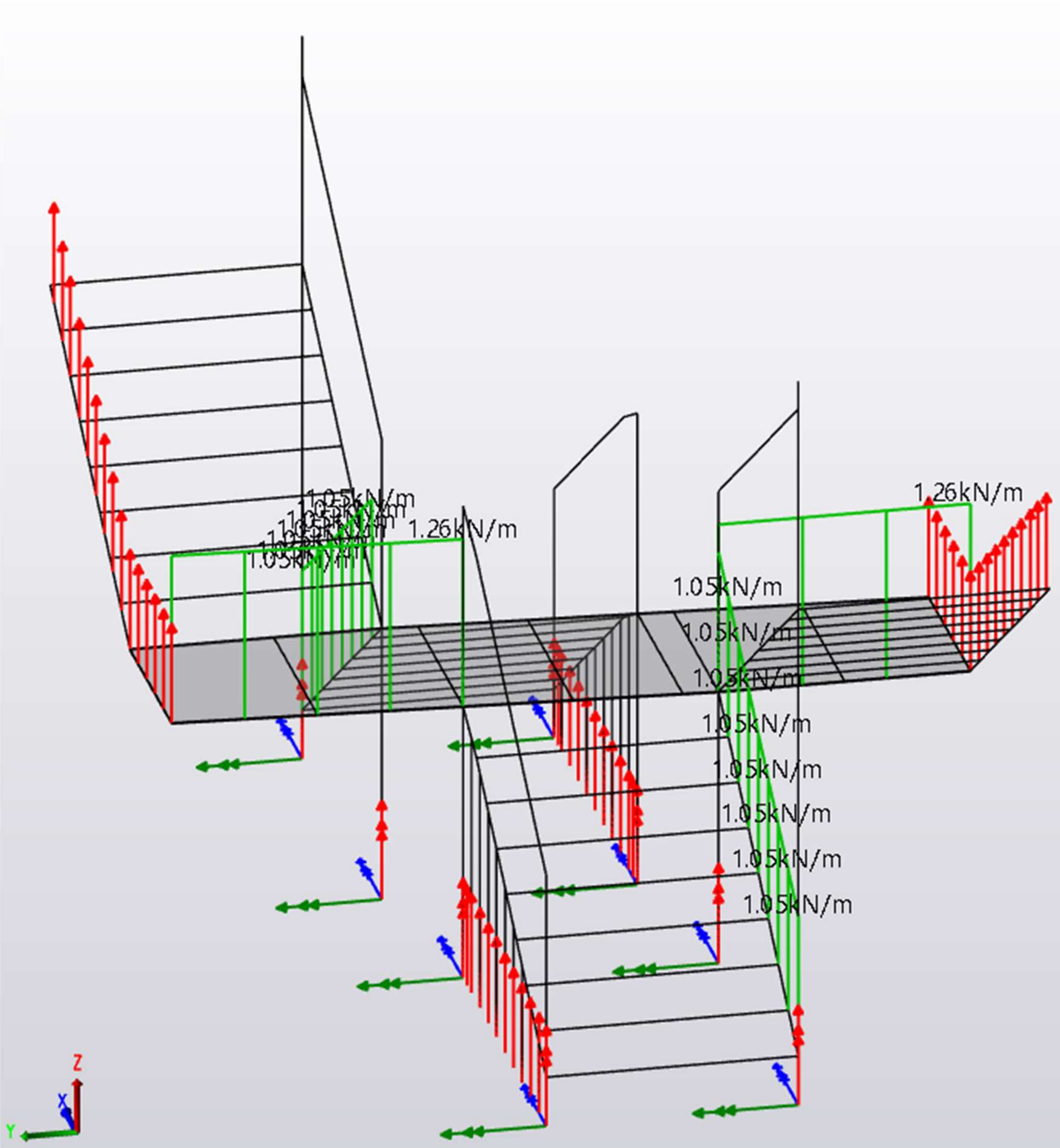


Torsional moment in stringers from horizontal balustrade loads has been accounted for by modelling the vertical reaction in the adjacent stringer resulting from the moment transfer through the tread:

Balustrade height = 1.0m on stair (1.2m on landing)
Horizontal load = 1.5 kN/m
BM = 1.0*1.5 = 1.5 kNm/m (1.2x1.5 = 1.8 kNm/m on landing)
Tread width = 1.43m
Vertical reaction on opposite stringer = 1.5/1.43 = 1.05 kN/m (1.8/1.43 = 1.26kN/m on landing)
Horizontal load on balustrade from a ‘push’ or ‘pull’ action creates an equal and opposite force at the base that cancels out the force in the macro design of the system.
The horizontal force has been considered in the local design of the balustrade.

AlpineGroup Strong in steel since 1974	Contract No.	2220323	Sheet No.	14	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

Imposed Load (outer balustrade pull):



Torsional moment in stringers from horizontal balustrade loads has been accounted for by modelling the vertical reaction in the adjacent stringer resulting from the moment transfer through the tread:

Balustrade height = 1.0m on stair (1.2m on landing)
Horizontal load = 1.5 kN/m
BM = 1.0*1.5 = 1.5 kNm/m (1.2x1.5 = 1.8 kNm/m on landing)
Tread width = 1.43m
Vertical reaction on opposite stringer = 1.5/1.43 = 1.05 kN/m (1.8/1.43 = 1.26kN/m on landing)
Horizontal load on balustrade from a ‘push’ or ‘pull’ action creates an equal and opposite force at the base that cancels out the force in the macro design of the system.
The horizontal force has been considered in the local design of the balustrade.

Loadcases:

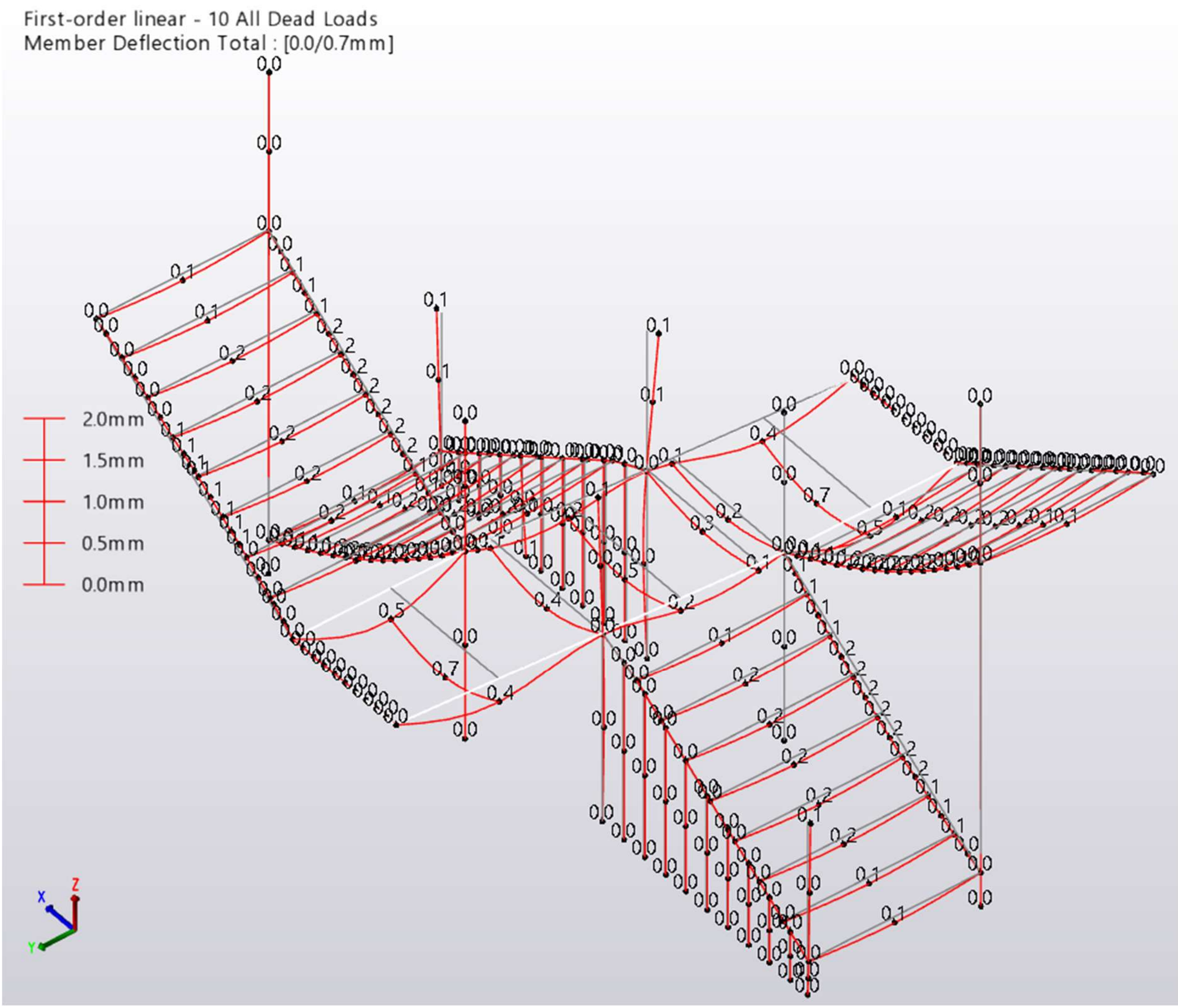
#	Loadcase Title	Type	Calc Automatically	Include in Generator	Imposed Load Reductions	Pattern Load	Pattern Ecc. Moments for Precast Columns
1	**Self weight - excluding slabs**	SelfWeight	☑	☑			
2	**Slab self weight**	Slab Dry	☑	☑			
3	SID Treads	Dead		☑			
4	SID Balustrade	Dead		☑			
5	Vert Live Treads	Imposed		☑	☐	☐	☐
6	Vert Live Balustrade	Imposed		☑	☐	☐	☐
7	Outer Balustrade Push	Imposed		☑	☐	☐	☐
8	Outer Balustrade Pull	Imposed		☑	☐	☐	☐
9	Inner Balustrade Push	Imposed		☑	☐	☐	☐
10	Inner Balustrade Pull	Imposed		☑	☐	☐	☐

Load Combinations:

#	Design Combination Title	Camber	Class	Active	Strength	Service
1	Dead + Vert Live	☐	Gravity	☑	☑	☑
2	Dead + Vert Live + Outer Push + Inner Push	☐	Gravity	☑	☑	☐
3	Dead + Vert Live + Outer Push + Inner Pull	☐	Gravity	☑	☑	☐
4	Dead + Vert Live + Outer Pull + Inner Push	☐	Gravity	☑	☑	☐
5	Dead + Vert Live + Outer Pull + Inner Pull	☐	Gravity	☑	☑	☐
6	Vert Live + Outer Push + Inner Push	☐	Gravity	☑	☐	☑
7	Vert Live + Outer Push + Inner Pull	☐	Gravity	☑	☐	☑
8	Vert Live + Outer Pull + Inner Push	☐	Gravity	☑	☐	☑
9	Vert Live + Outer Pull + Inner Pull	☐	Gravity	☑	☐	☑
10	All Dead Loads	☐	Gravity	☑	☑	☑

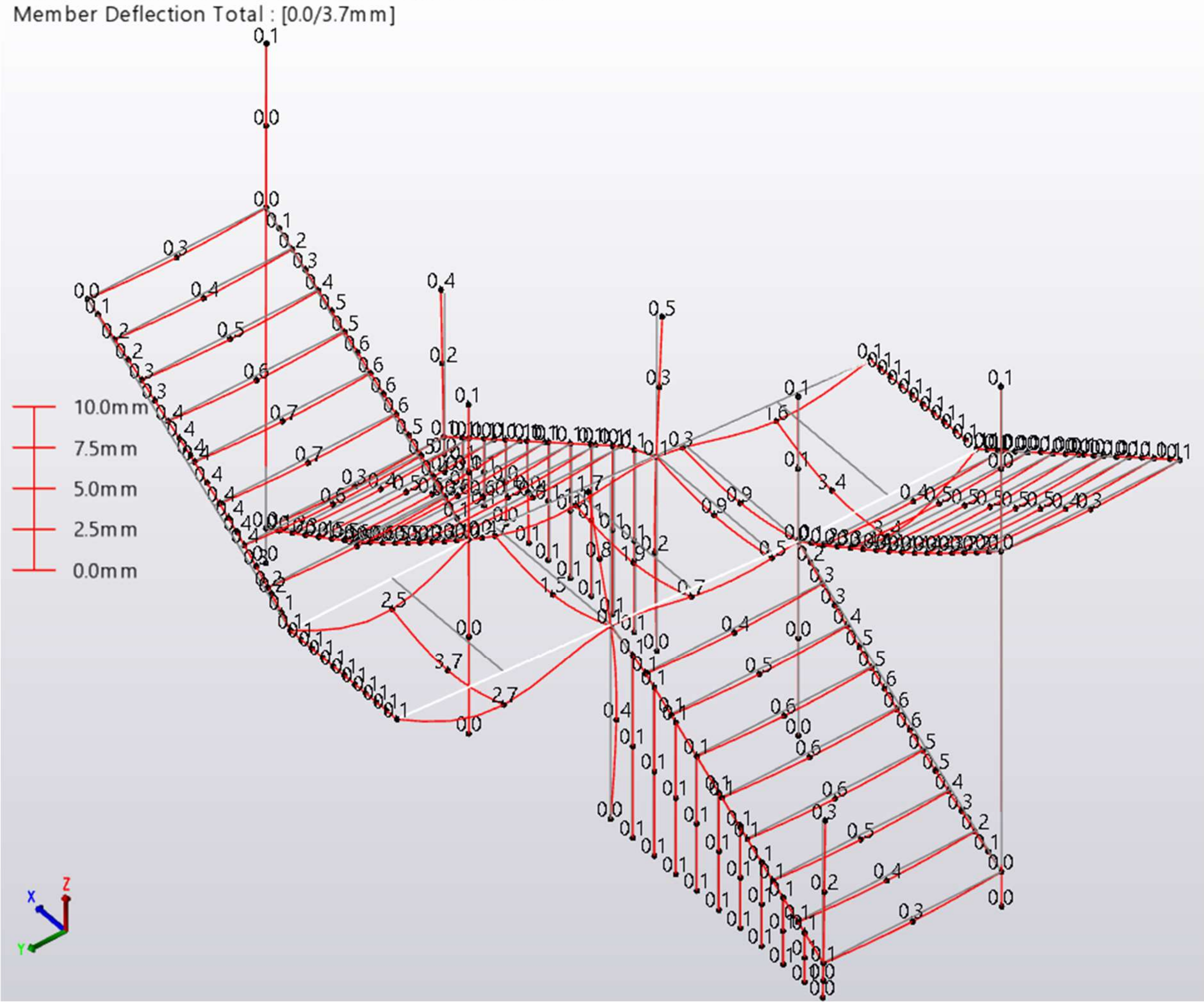
AlpineGroup — Strong in steel since 1974	Contract No.	2220323	Sheet No.	16	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

8.0 Analysis Model Graphical Output



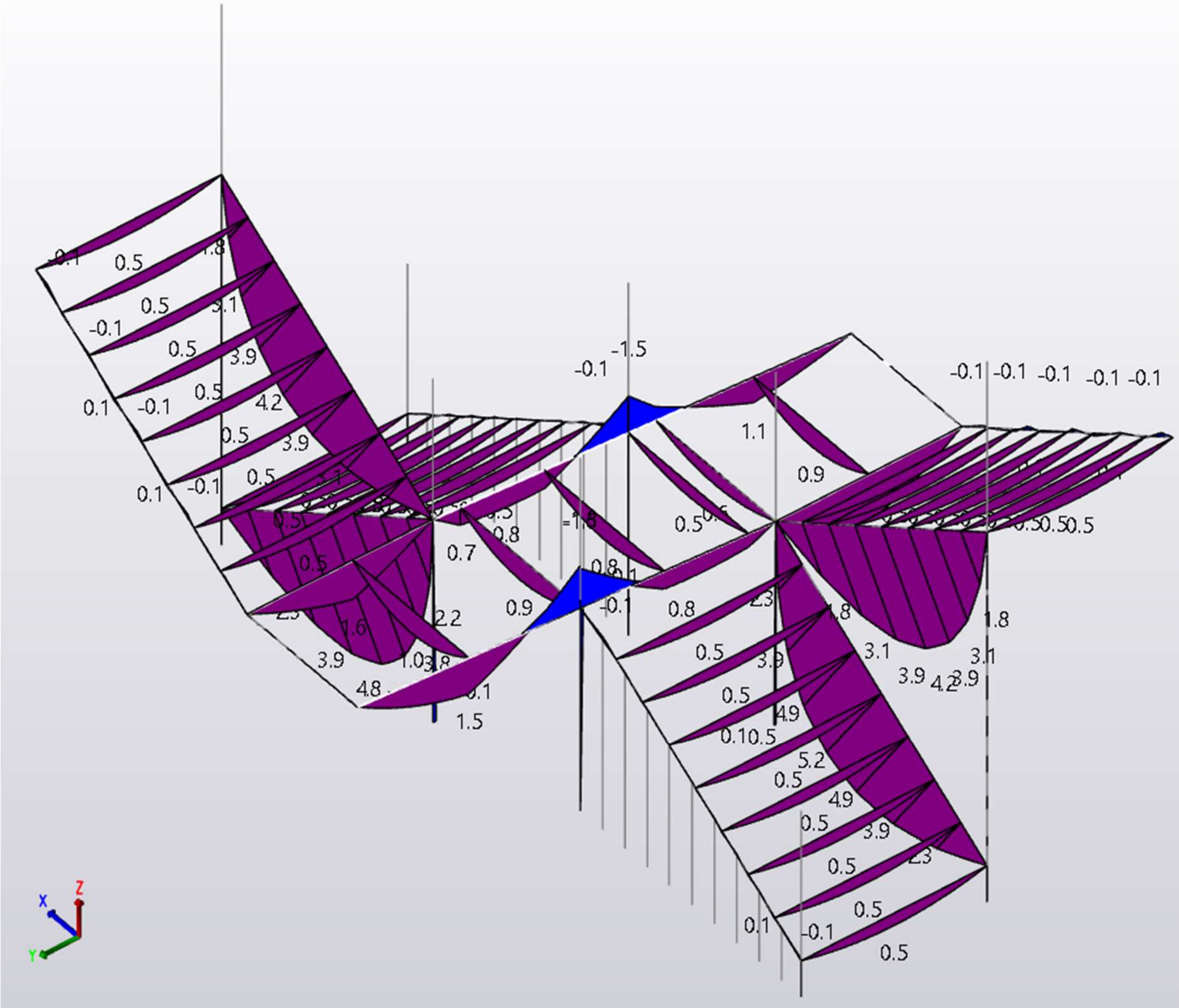
AlpineGroup Strong in steel since 1974	Contract No.	2220323	Sheet No.	17	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

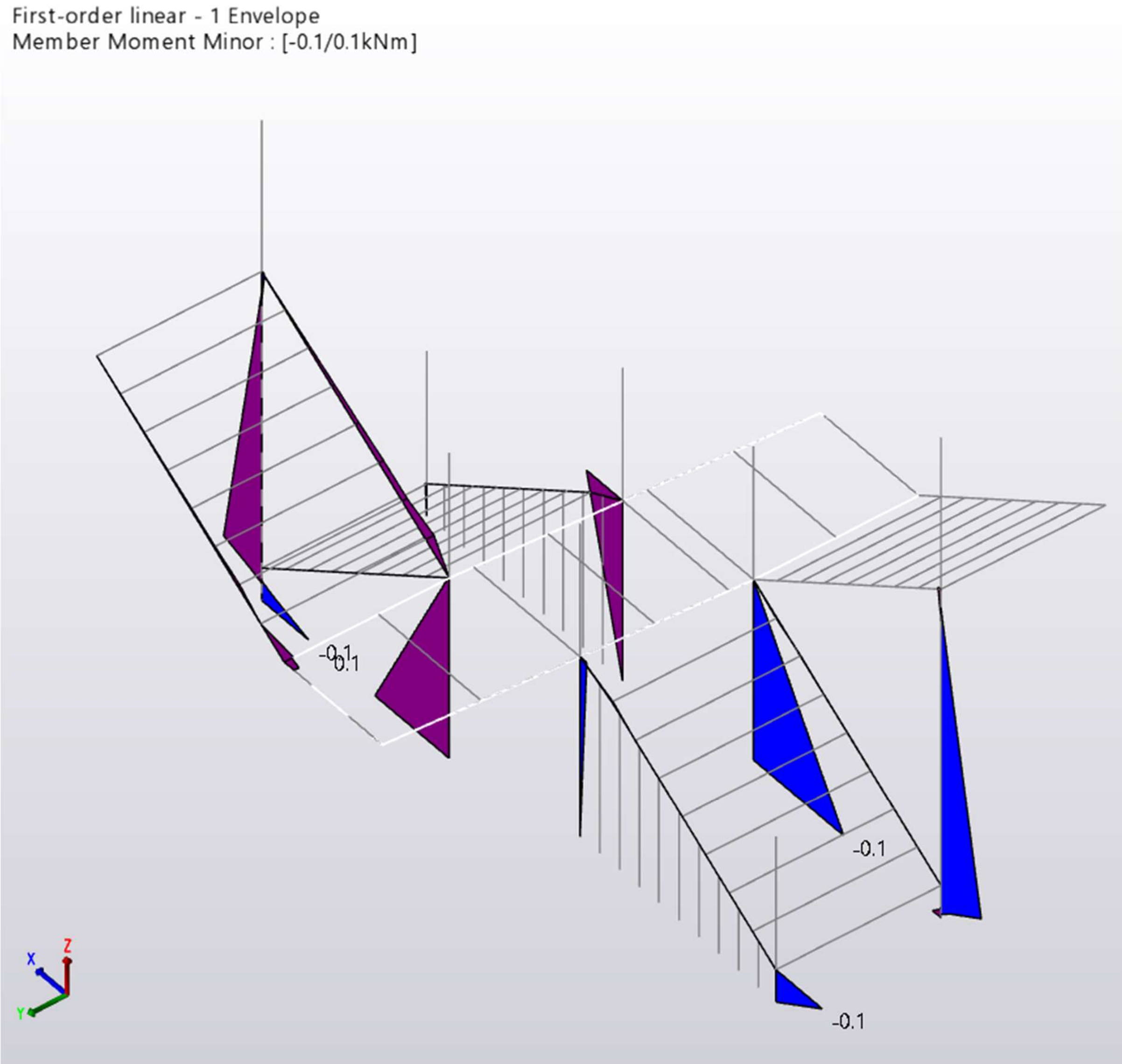
First-order linear - 9 Vert Live + Outer Pull + Inner Pull
Member Deflection Total : [0.0/3.7mm]



AlpineGroup Strong in steel since 1974	Contract No.	2220323	Sheet No.	18	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

First-order linear - 1 Envelope
Member Moment Major : [-1.8/5.2kNm]

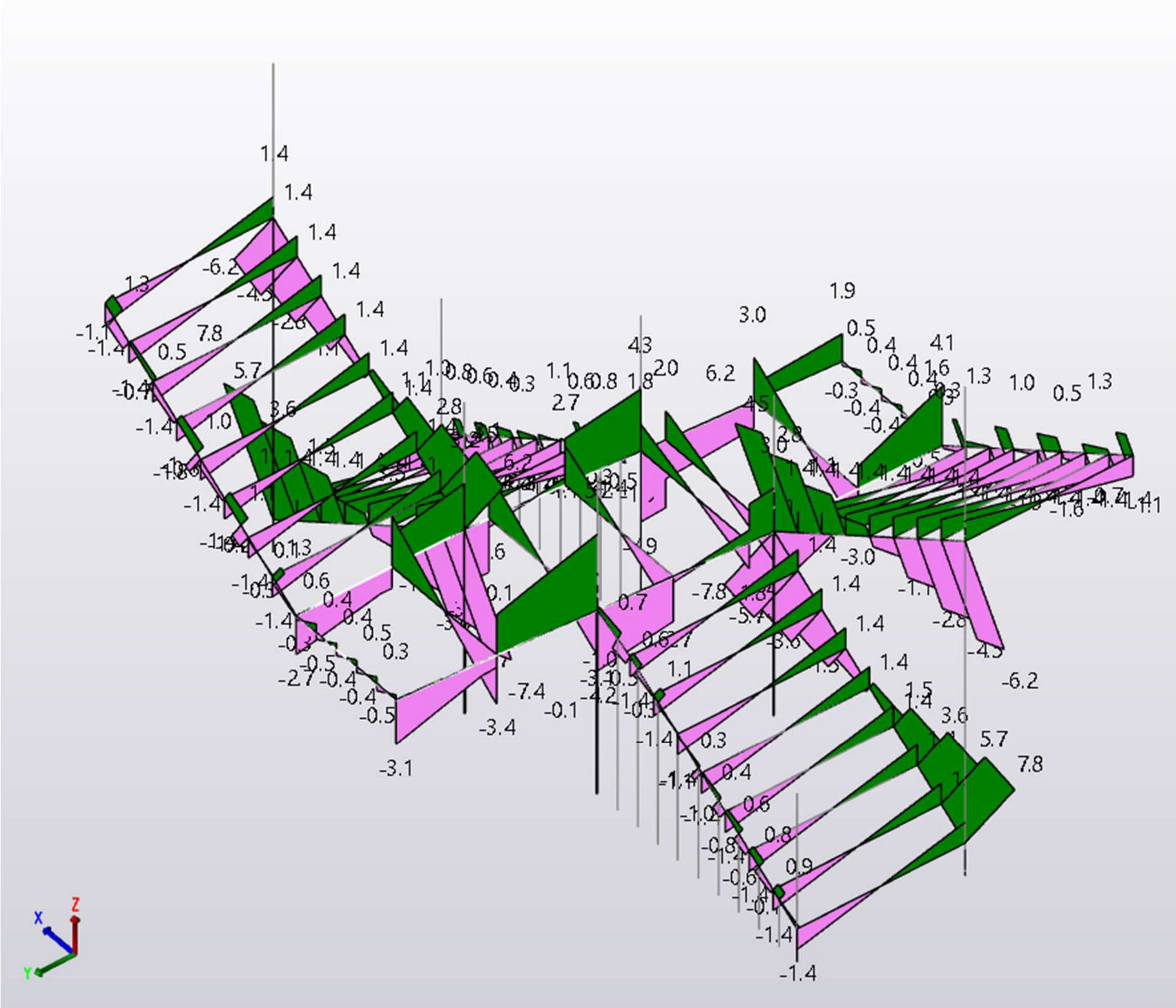




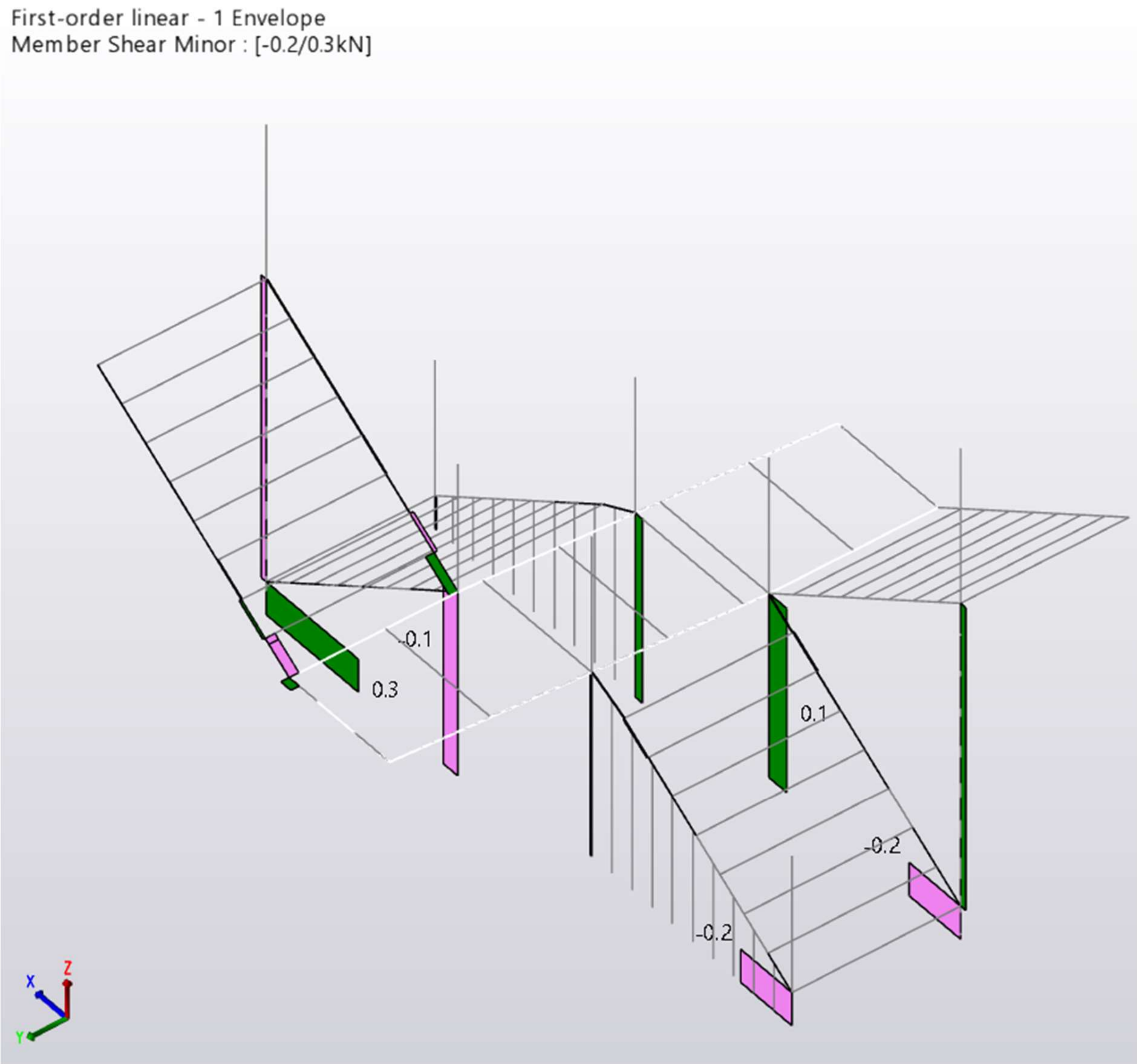
First-order linear - 1 Envelope
Member Moment Minor : [-0.1/0.1kNm]
-0.1
-0.1
-0.1
-0.1
X
Z
Y

AlpineGroup Strong in steel since 1974	Contract No.	2220323	Sheet No.	20	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

First-order linear - 1 Envelope
Member Shear Major : [-7.8/7.8kN]

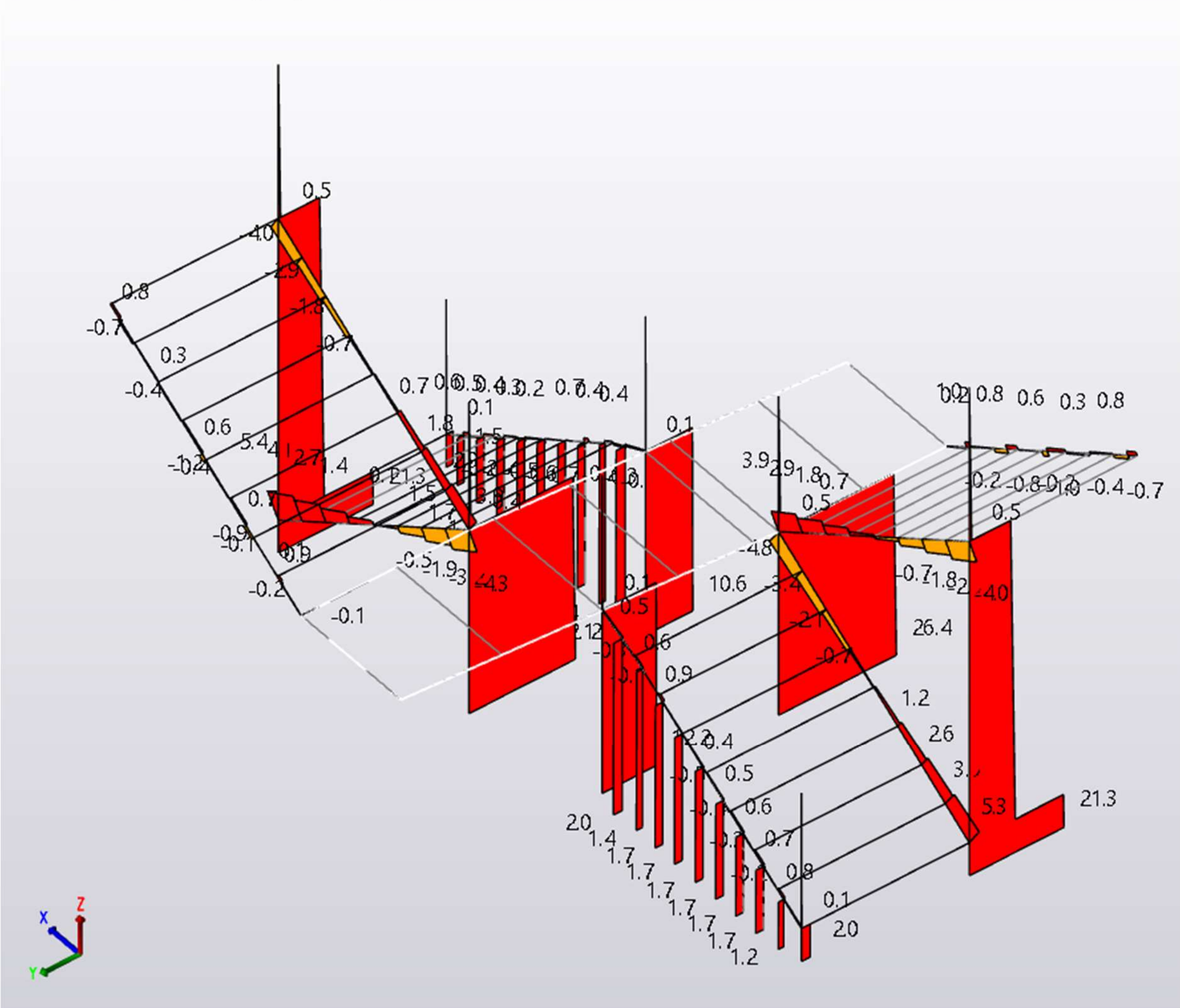


	Contract No.	2220323	Sheet No.	21	Rev.	P1
AlpineGroup Strong in steel since 1974	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

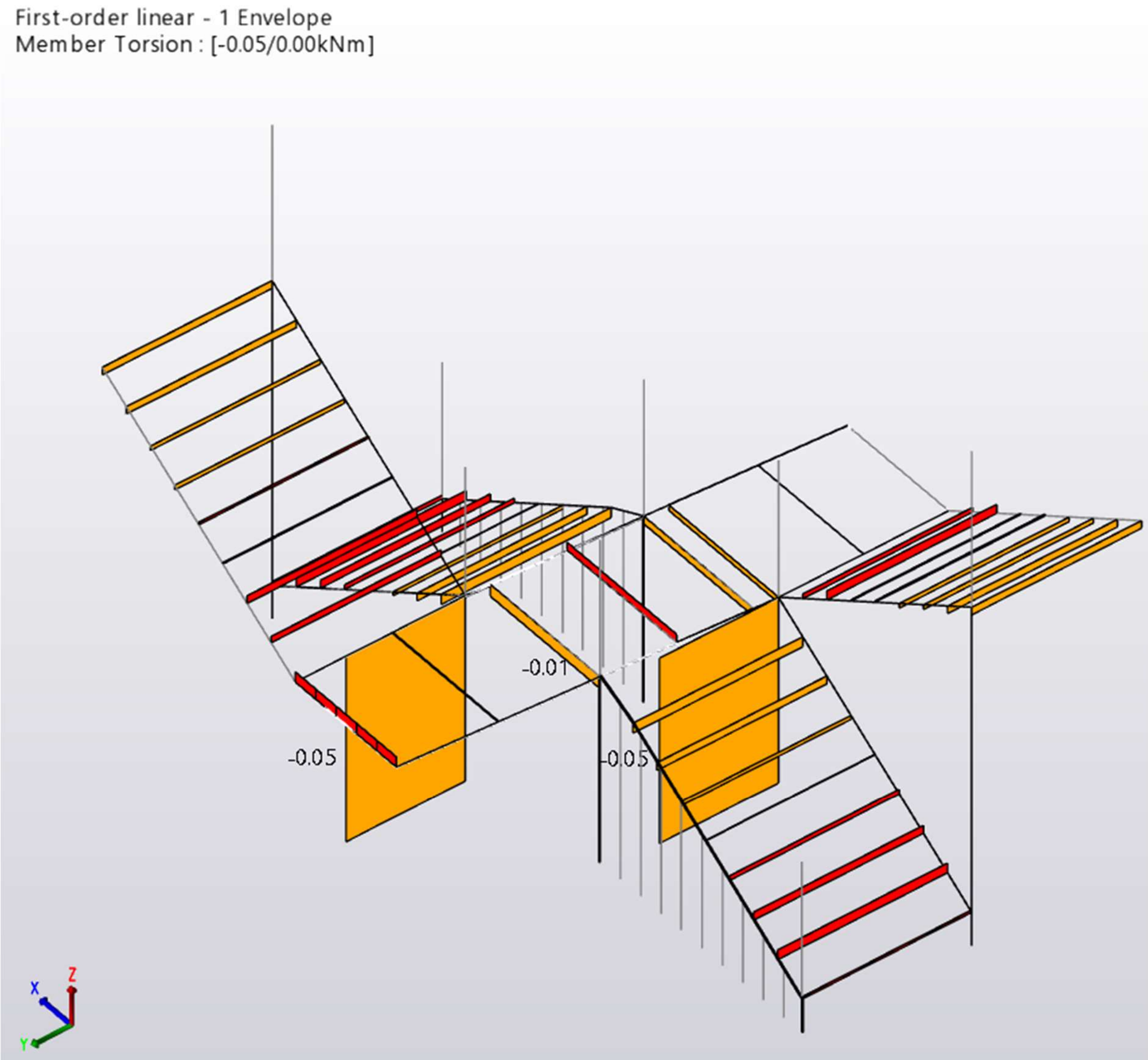


AlpineGroup Strong in steel since 1974	Contract No.	2220323	Sheet No.	22	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

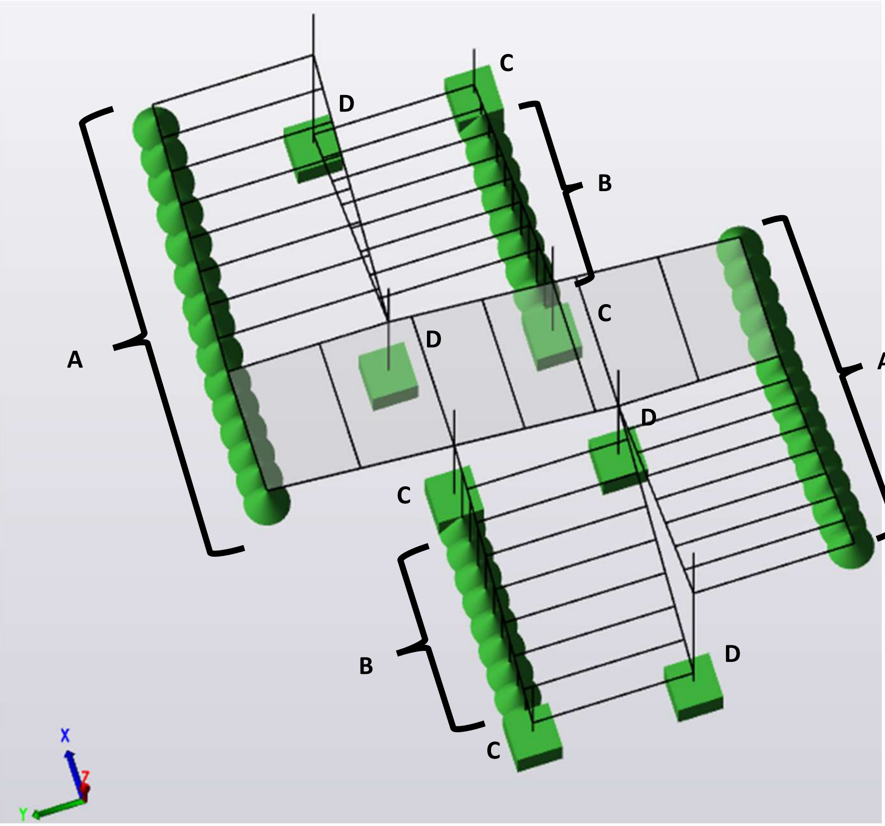
First-order linear - 1 Envelope
Member Axial Force : [-4.8/26.4kN]



AlpineGroup Strong in steel since 1974	Contract No.	2220323	Sheet No.	23	Rev.	P1
	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					



9.0 Support Reactions



Envelopes, First-order linear, Factored force envelope support reactions

Support	Combination	Reactions					
		F_Z [kN]	F_X [kN]	F_Y [kN]	M_X [kNm]	M_Y [kNm]	M_Z [kNm]
A	Maximum	4.5	0	0	0	0	0
	Minimum	0.0	0	0	0	0	0
B	Maximum	2.5	0	0	0	0	0
	Minimum	0.0	0	0	0	0	0
C	Maximum	15.0	0.5	0.5	0	0	0
	Minimum	0.0	-0.5	-0.5	0	0	0
D	Maximum	26.5	0.5	0.5	0.5	0.5	0.5
	Minimum	6.0	-0.5	-0.5	-0.5	-0.5	-0.5

10.0 Steel Stringer Design

Section size

Section size			300 mm deep x	10 mm thick
Steel grade		Grade	S275	
Design strength		py =	275	N/mm²
Youngs modulus		E =	205	kN/mm²
Going		=	288	mm
Stringer slope		=	30	degrees
Tread spacing along stringer	= 288 / Cos 30	=	333	mm
Effective length between fixings		=	333	mm

Properties

Area	$= d.t$	= 300 x 10 / 100	= 30.0	cm^2
Ixx	$= t.d^3 / 12$	= (10 x 300^3) / (12 x 10000)	= 2250.0	cm^4
Iyy	$= d.t^3 / 12$	= (300 x 10^3) / (12 x 10000)	= 2.5	cm^4
Zxx	$= t.d^2 / 6$	= (10 x 300^2) / (6 x 1000)	= 150.00	cm^3
Zyy	$= d.t^2 / 6$	= (300 x 10^2) / (6 x 1000)	= 5.00	cm^3
Sxx	$= t.d^2 / 4$	= (10 x 300^2) / (4 x 1000)	= 225.00	cm^3
Syy	$= d.t^2 / 4$	= (300 x 10^2) / (4 x 1000)	= 7.50	cm^3
rxx	$= (Ixx / A)^{0.5}$	= (2250 / 30)^0.5	= 8.67	cm
ryy	$= (Iyy / A)^{0.5}$	= (2.5 / 30)^0.5	= 0.29	cm
Plastic moment capacity M_C		= py 1.2 Z	= 49.5	kNm (ULS)

Bending strength BS5950-1 : 2000 : Annex I : B.2.7

λ_{LT}	$= 2.8 (\beta w \, Le \, d / t^2)^{0.5}$		
Classification		= Semi-compac	AD 310
βw		= 0.67	
L_E		= 333	mm
λ_{LT}	= 2.8 x sqrt (0.67 x 333 x 300 / 10^2)	= 72.5	
p_E	$= (\pi^2 E / \lambda_{LT}^2)$	= 385.0	N/mm²
λ_{LO}	$= 0.4 (\pi^2 E / p_Y)^{0.5}$	= 34.4	
α_{LT}		= 7.0	
η_{LT}	$= \alpha_{LT} (\lambda_{LT} - \lambda_{LO}) / 1000$	= 0.267	
ϕ_{LT}	$= 0.5 [p_y + (\eta_{LT} + 1) p_E]$	= 381.4	N/mm²
p_b	$= \dfrac{p_E \, p_Y}{\phi_{LT} + (\phi_{LT}^2 - p_E \, p_Y)^{0.5}}$	= 182.5	N/mm²
Moment capacity	= pb 1.2 Z	= 32.9	kNm (ULS)

Stair span		=	2.304	m on plan (maximum)
		=	2.661	m on slope
Stair width		=	1.430	m
Stringer selfweight		=	0.33	kN/m^2
Selfweight of treads and infill		=	1.93	kN/m^2
Selfweight of balustrading		=	0.8	kN/m per side
Total dead load		=	3.31	kN/m^2
Live load		=	4.0	kN/m^2
Load factors : Dead load		=	1.4	
: Live load		=	1.6	
Total load	= (1.4 x 3.31) + (1.6 x 4)	=	11.1	kN/m^2 (ULS)
	= (0.5 x 1.43 x 2.304) x 11.1	=	18.3	kN (ULS)
Applied bending moment	= (0.5 x 1.43 x 2.304) x 11.1 x 2.661 / 8	=	6.1	kNm (ULS)
Unity factor	= 6.1 / 32.9	=	0.186	
Deflection				
Live load only	= (0.5 x 1.43 x 2.304) x 4	=	6.6	kN / stringer
Ixx		=	2250.0	cm^4
Deflection	= (5 x 6.6 x 10^5 x 2.661^3) / (384 x 205 x 2250)	=	0.4	mm = span / 6653
End reactions				
Dead load	= (0.25 x 1.43 x 2.304) x 3.31	=	2.7	kN (Unfactored)
Live load	= (0.25 x 1.43 x 2.304) x 4	=	3.3	kN (Unfactored)
Total		=	9.2	kN (ULS)

<u>Provide 300x10 mild steel flat plate stringer.</u>

Forces from Tekla model @ ULS:

Shear major	=	7.8 kN
Shear minor	=	0.0 kN
Moment major	=	5.2 kNm
Moment minor	=	0 kNm
Torsion	=	0 kNm
Axial	=	5.5 kN

Stringer major axis plastic section modulus = $10*300^2/4$ = 225,000mm^3

Stringer minor axis plastic section modulus = $300*10^2/4$ = 7,500mm^3

Major axis bending stress	=	5,200,000/225,000	=	23.11 N/mm^2
Shear stress	=	(7,800)/(300*10)	=	2.6 N/mm^2
Axial stress	=	5,500/(300*10)	=	1.9 N/mm^2

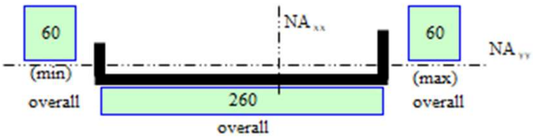
Total stress < 275 N/mm^2 THEREFORE OK

11.0 Tread Design

Loading

Live load	: UDL	=	4.0	kN/m^2 on plan
	: Point load	=	4.0	kN
Dead load	: Swt steel	=	7850	kg/m^3
	: Tread infill weight	=	2500	kg/m^3
	: Tread in fill depth	=	50	mm

Tread



Thickness			=	6	mm			
Span			=	1.233	m			
Swt + tread infill			=	0.61	kN (unfactored)	=	1.91	kN/m^2 (Unfactored)
Live load / tread	(i)	UDL	=	1.28	kN (unfactored)			
	(ii)	CPL	=	4.00	kN (unfactored)			
Total load	(i)	UDL	=	2.91	kN (ULS)	: Dead + Live		
	(ii)	UDL	=	0.86	kN (ULS)	: Dead		
		CPL	=	6.40	kN (ULS)	: Live		
End connection to stringer			=	Pinned				
BM	(i)		=	**0.45**	kNm (ULS)	: UDL Live check		
	(ii)		=	**2.11**	kNm (ULS)	: CPL Live check	: Critical	
Distance to NAyy from underside			=	11.9	mm			
Distance to NAxx from left hand side			=	130.0	mm			
$I_{NA\ yy}$			=	574208	mm^4			
$I_{NA\ xx}$			=	1.9E+07	mm^4			
Zyy (min)			=	11938	mm^3			
Area			=	2208	mm^2			
r_{yy}			=	16.2	mm			
r_{xx}			=	93.4	mm			
p_y			=	275	N/mm^2			

BS5950-1:2000 : Clause 4.3.7 & Table 2

L_E / r	=	76.2	
β_w	=	1.0	

Tread (cont.)

$(\beta w)^{0.5} L_E / r$ = 77

D / T = 44

pb = 201 N/mm²

Enter pb obtained from sheet "Table 20"

Bending capacity to be based on pb Zy

MR = pb Zy ≈ **2.40** kNm (ULS)

UF (i) = 0.19 : UDL Live check PASS

(ii) = 0.88 : CPL Live check PASS

Deflection checks

IGNORING STRINGER ROTATION

End connection to stringer = Pinned

Youngs modulus = 205000 N/mm²

(i) Live : UDL load = 5 WL³ / 384 EI

Dead	=	0.13	mm	
Live	=	0.27	mm	
Total	=	0.4	mm	: Span / 3083

(ii) Live : Point load = 1 PL³ / 48 EI

Dead	=	0.13	mm	
Live	=	1.33	mm	
Total	=	1.46	mm	: Span / 845

Maximum = 1.46 : Span / 845

Worst case bending moment from analysis model = 2.0 kNm @ ULS < 2.40 kNm THEREFORE OK

ADOPT 6mm TK S275 FOLDED PLATE TREADS

12.0 Balustrade Design

Balustrade Post design

Section size		1 number	50 mm deep x	12	mm thick
Steel grade			Grade	275	
Design strength			py =	275	N/mm²
Modulus of elasticity			E =	205	kN/mm²
Loading on handrailing					
Horizontal			=	1.5	kN/m
Vertical	(i)		=	0.6	kN/m
	(ii)		or	1.0	kN
Post spacing			=	0.130	m (max)
Post height from fixing point to handrail			=	1.1	m
Horizontal distance between post centreline and connection			=	0.035	m
Design load factor			=	1.5	
Handrail loads					
Horizontal		= (1.5 x 1.5) x 0.13	=	0.3	kN (uls) / per span
Vertical	(i)	= (0.6 x 1.5) x 0.13	=	0.12	kN (uls) / per span
	(ii)	= (1 x 1.5)	=	1.5	kN (uls) / per span
BM due to horizontal load		= 0.3 x 1.1 / 1	=	0.33	kNm (ULS) / plate
BM due to vertical load		= 1.5 x 0.035 / 1	=	0.06	kNm (ULS) / plate
BM total		= 0.33 + 0.06	=	0.39	kNm (ULS) / plate
Axial load due to vertical loads			=	1.50	kN (ULS) / plate
Section properties per plate			A =	600	mm²
			Ixx =	125000	mm⁴
			Iyy =	7200	mm⁴
			rxx =	14.44	mm
			ryy =	3.47	mm
			Zxx =	5000	mm³
			Sxx =	7500	mm³
Plastic moment capacity per plate	M_p	= py 1.2 Z	=	1.65	kNm (ULS)
Bending stress per plate		= 0.39 x 10^6 / (1.2 x 5000)	=	65.0	N/mm²
Axial stress per plate		= 1.5 x 10^3 / 600	=	2.5	N/mm²

Bending strength	BS5950-1 : 2000 : Annex B				
B.2.7	λ_{LT}	= $2.8(\beta w\, Le\, d/t^2)^{0.5}$			
	Effective length factor		=	1.0	
	Le	= 1 x 1.1 x 1000	=	1100	m
	d/t	= 50 / 12	=	4.2	PLASTIC
	βw		=	1.00	
	λ_{LT}	= 2.8 x sqrt (1 x 1100 x 50 / 12^2)	=	54.8	
	p_E	= $(\pi^2 E/\lambda_{LT}^2)$	=	673.8	N/mm^2
	λ_{LO}	= $0.4(\pi^2 E/p_Y)^{0.5}$	=	34.4	
	α_{LT}		=	7.0	
	η_{LT}	= $\alpha_{LT}(\lambda_{LT} - \lambda_{LO})/1000$	=	0.143	
	ϕ_{LT}	= $0.5[p_y + (\eta_{LT}+1)p_E]$	=	522.6	N/mm^2
	p_b	= $\dfrac{p_E\, p_Y}{\phi_{LT} + (\phi_{LT}^2 - p_E\, p_Y)^{0.5}}$	=	226.3	N/mm^2
Moment capacity per plate	Mb	= pb 1.2 Z	=	1.36	kNm (ULS)
Unity factor per plate		d 65 / 226.3	=	0.288	
Deflection			=	3.4	mm = Height / 324

Connection loads

Horizontal load	=	0.30	kN (uls)
Vertical load	=	1.50	kN (uls)
Bending momen	=	0.39	kNm (uls)

Provide 50mm deep x 12mm thick plate post at 0.13m centres

	Contract No.	2220323	Sheet No.	31	Rev.	P1
AlpineGroup Strong in steel since 1974	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

Handrail design

Section size		50 mm deep x	12	mm thick
Steel grade		Grade =	S275	
Design strength		py =	275	N/mm^2
Modulus of elasticity		E =	205	kN/mm^2

Loading on handrailing

Horizontal		=	1.5	kN/m
Vertical	(i)	=	0.6	kN/m
	(ii)	or	1.0	kN
Post spacing		=	0.130	m (max)
Design load factor		=	1.5	

Handrail loads

Horizontal		= (1.5 x 1.5) x 0.13	= 0.3	kN (uls) / per span	
BM		= 0.3 x 0.13 / 8	= 0.01	kNm (uls)	
Vertical	(i)	= (0.6 x 1.5) x 0.13	= 0.12	kN (uls) / per span	
	(ii)	= (1 x 1.5)	= 1.5	kN (uls) / per span	
BM	(i)	= 0.12 x 0.13 / 8	= 0.01	kNm (uls)	
	(ii)	= 1.5 x 0.13 / 4	= 0.05	kNm (uls)	Critical

Section properties	Zxx =	5000	mm^3
	Sxx =	7500	mm^3
	Zyy =	1200	mm^3
	Syy =	1800	mm^3

Plastic moment capacity M_p	= py 1.2 Z	= 1.65	kNm (ULS)
py Zyy	= 275 x 1200 / 10^6	= 0.33	kNm (ULS)
Bending stress due to horizontal loads	= 0.01 x 10^6 / (1.2 x 5000)	= 1.7	N/mm^2
Bending stress due to vertical loads	= 0.05 x 10^6 / (1.2 x 1200)	= 34.8	N/mm^2

Bending strength BS5950-1 : 2000 : Annex B

B.2.7	λ_{LT}	$= 2.8 (\beta w \, Le \, d / t^2)^{0.5}$		
	Effective length factor		1.0	
	Le	= 1 x 0.13 x 1000	= 130	m
	d/t	= 50 / 12	= 4.2	PLASTIC
	βw		= 1.00	
	λ_{LT}	= 2.8 x sqrt (1 x 130 x 50 / 12^2)	= 18.9	

p_E	$= (\pi^2 E / \lambda_{LT}^2)$	=	5664.1	N/mm²
λ_{LO}	$= 0.4 (\pi^2 E / p_Y)^{0.5}$	=	34.4	
α_{LT}		=	7.0	
η_{LT}	$= \alpha_{LT} (\lambda_{LT} . \lambda_{LO}) / 1000$	=	0.000	
ϕ_{LT}	$= 0.5 [p_y + (\eta_{LT} + 1) p_E]$	=	2969.6	N/mm²
p_b	$= \dfrac{p_E p_Y}{\phi_{LT} + (\phi_{LT}^2 - p_E p_Y)^{0.5}}$	=	275.0	N/mm²

Moment capacity Mb $= pb\ 1.2\ Z$ = 1.65 kNm (ULS)

Unity factor d $0.01 / 1.65 + 0.05 / 0.33$ = 0.158

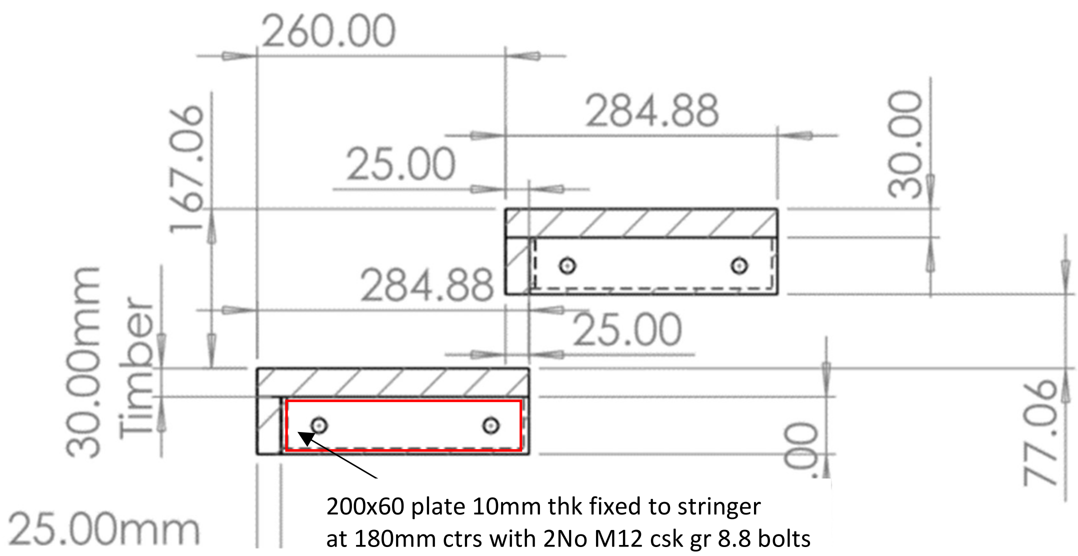
Loads to posts

Horizontal	=	**0.30**	kN (uls)
Vertical	=	**1.50**	kN (uls)

<u>Solid mild steel 50mm x 12mm handrail is adequate.</u>

13.0 Connection Design

Tread Connection to Stringer:



Connection comprises 10mm thk 200x60mm S275 horizontal plate welded with 6FW to tread.
2 No. countersunk M12 grd. 8.8 bolts to 300x10mm thk stringer

Forces from Tekla model @ ULS:

Shear major	=	1.4 kN
Shear minor	=	0 kN
Moment major	=	0 kNm
Moment minor	=	0 kNm
Torsion	=	0 kNm
Axial	=	0 kN

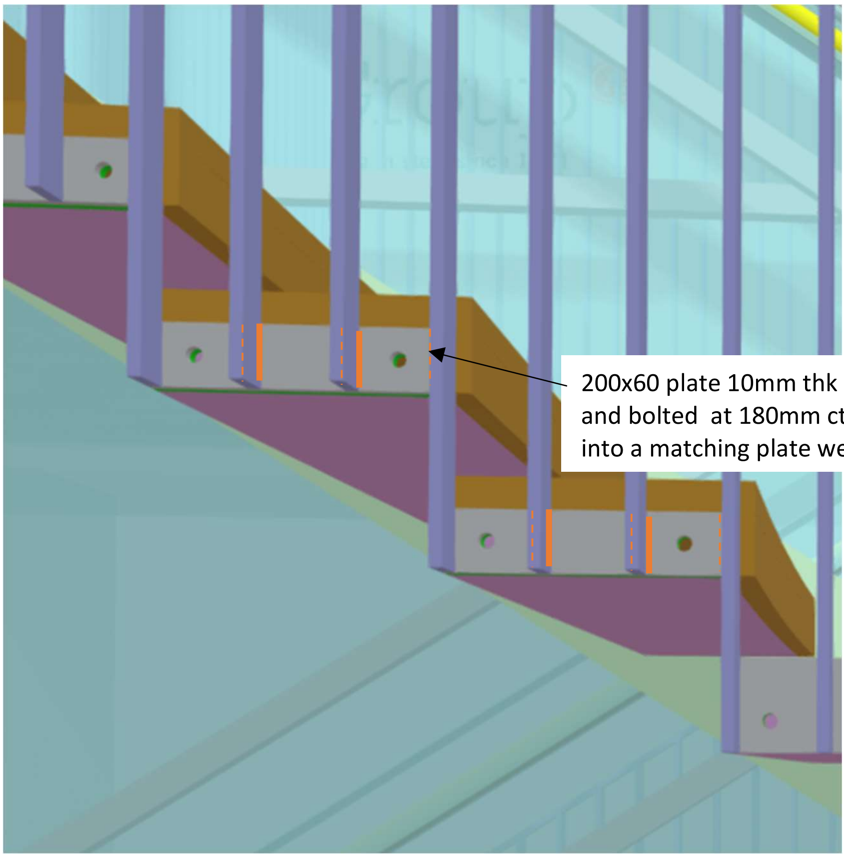
Bolts: M12 grade 8.8, by inspection OK

By inspection welds OK

ADOPT CONNECTION AS DETAILED

	Contract No.	2220323	Sheet No.	34	Rev.	P1
AlpineGroup — Strong in steel since 1974	Project	Heals Stair				
	Design by	DKH	Date	11/01/23	Chkd.	OJS
	Description					

<u>Tread Connection to hangers:</u>



Weld length L = 5x(60-2x6) = 240mm

F_{Rd} = 0.94 x 240 = 225.6 kN

Each tread support takes

Forces from Tekla model @ ULS:

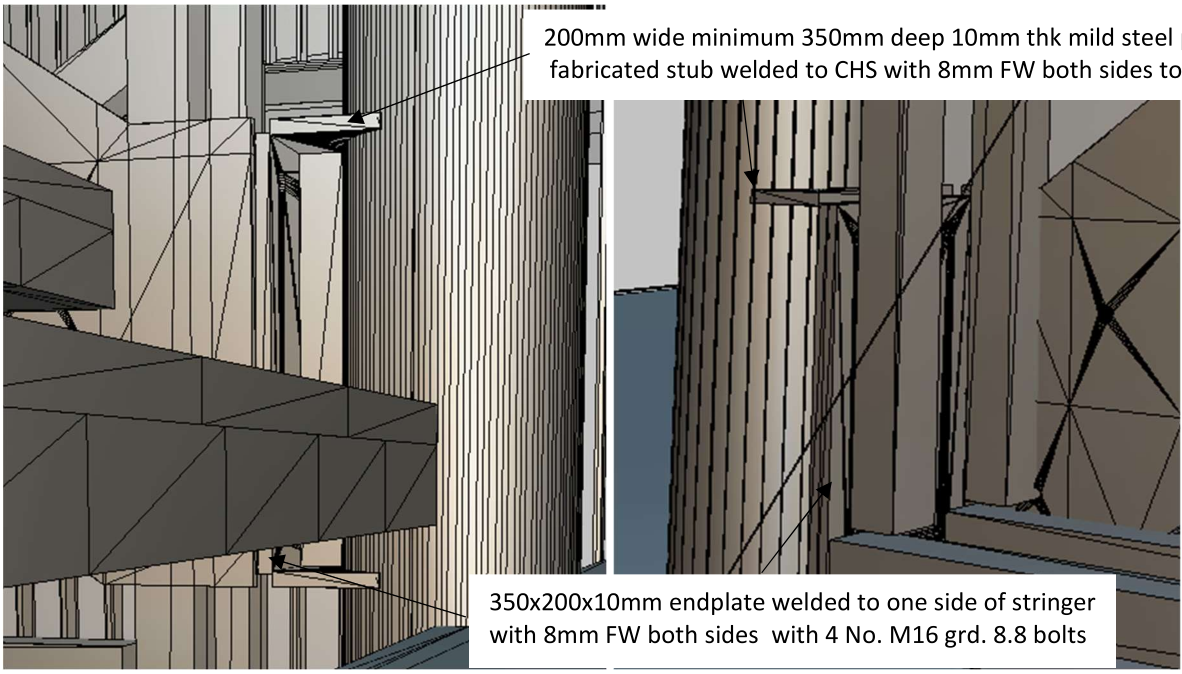
Shear major	=	1.4 kN
Shear minor	=	0 kN
Moment major	=	0 kNm
Moment minor	=	0 kNm
Torsion	=	0 kNm
Axial	=	0 kN

Bolts: 2No M12 grade 8.8, by inspection OK

By inspection welds OK

<u>ADOPT CONNECTION AS DETAILED</u>

Check Typical Stringer Top and bottom Connection to column:



Connection is nominally pinned, comprising 350x200x10mm endplate welded to one side of stringer with 8mm FW both sides with 4 No. M16 grd. 8.8 bolts.

Worst case forces on connection @ ULS (rounded up to nearest 0.5kN):

Shear major	=	8.0 kN
Shear minor	=	0.0 kN
Moment major	=	0.0 kNm
Moment minor	=	0 kNm
Torsion	=	0 kNm
Axial	=	5.5 kN

Check endplate in bending from axial tension:

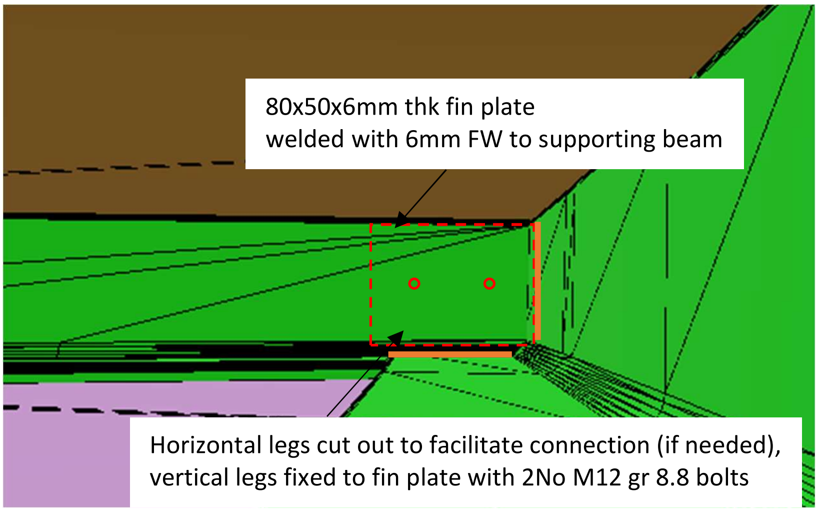
Horizontal bolt cross centres = 100mm
Vertical bolt crossc entres = 250mm
Moment in plate = 5.5/2*0.10= 0.28 kNm
Plate elastic section modulus = $200*10^2/6$ = 3,333 mm^3
Bending stress = 280,000/3,333 = 82.5N/mm^2 < 275 N/mm^2 THEREFORE OK

Check stub weld:

Weld length L = 3.14x194 – 2x8 = 593mm
F_{Rd} = 593x1.25 = 741.45 kN

By inspection welds OK

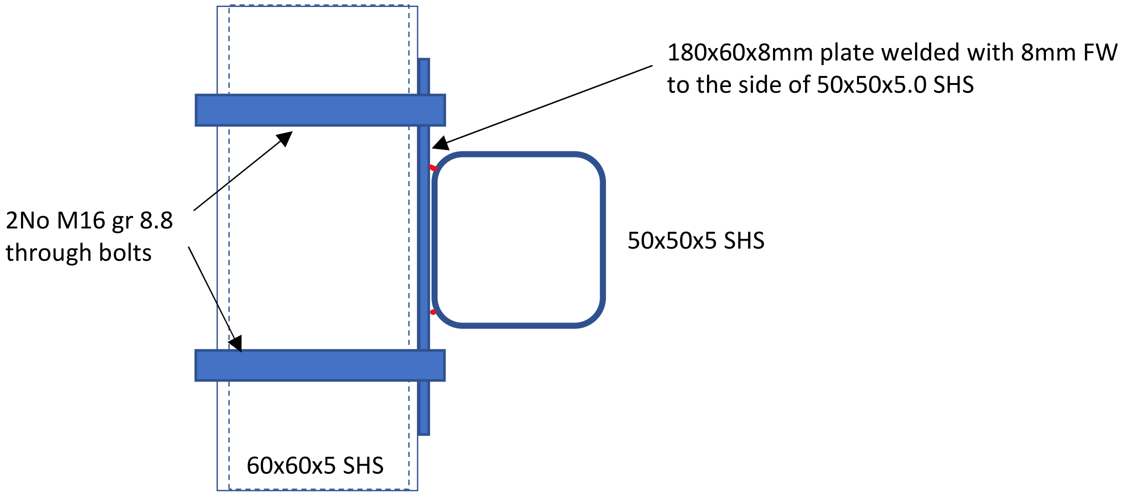
Check pinned landing frame connection:



V_{Rd} = 3.5kN < 27.5kN single shear resistanc eof M12 gr 8.8 bolt
t=6mm > 4.3mm min thickness for punching shear

Adopt connection as detailed

Check landing frame connection to SHS column:



Bearing on the 5mm SHS wall will govern

$2F_b$ = 2x11.7 = 23.4 kN > 5.5 kN THEREFORE OK
t=5mm > 3.4mm min thickness for punching shear

Adopt connection as detailed

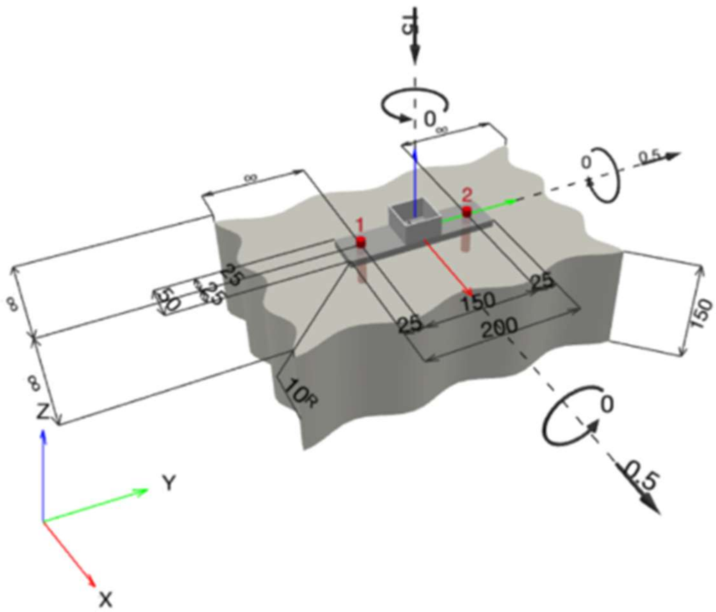
SHS base plate connection to concrete slab

1 Input data

Anchor type and size:	**HUS4-H 12 h_nom1**
Return period (service life in years):	50
Item number:	2293565 HUS4-H 12x70 10/-/-
Effective embedment depth:	h_{ef} = 45.9 mm ($h_{ef,ETA}$ = 45.9 mm), h_{nom} = 60.0 mm
Material:	1.5525
Approval No.:	ETA-20/0867
Issued I Valid:	14/07/2022 | -
Proof:	Design Method EN 1992-4, Mechanical
Stand-off installation:	e_b = 0.0 mm (no stand-off); t = 10.0 mm
Baseplate[R] :	l_x x l_y x t = 50.0 mm x 200.0 mm x 10.0 mm; (Recommended plate thickness: not calculated)
Profile:	Square hollow, 50 x 50 x 2; (L x W x T) = 50.0 mm x 50.0 mm x 2.0 mm
Base material:	cracked concrete, C20/25, $f_{c,cyl}$ = 20.00 N/mm^2; h = 150.0 mm, User-defined partial material safety factor γ_c = 1.500
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	No reinforcement or Reinforcement spacing >= 150 mm (any Ø) or >= 100 mm (Ø <= 10 mm)
	no longitudinal edge reinforcement

[R] - The anchor calculation is based on a rigid baseplate assumption.

Geometry [mm] & Loading [kN, kNm]



1.1 Load combination

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combination 1	N = -15.000; V_x = 0.500; V_y = 0.500; M_x = 0.000; M_y = 0.000; M_z = 0.000;	no	no	3

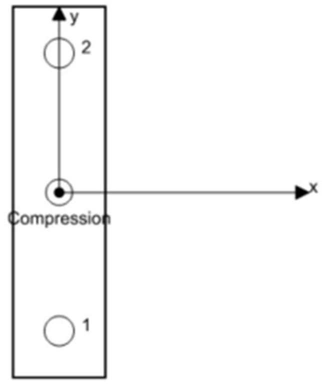
2 Load case/Resulting anchor forces

Anchor reactions [kN]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0.000	0.354	0.250	0.250
2	0.000	0.354	0.250	0.250

max. concrete compressive strain: 0.05 [‰]
max. concrete compressive stress: 1.50 [N/mm^2]
resulting tension force in (x/y)=(0.0/0.0): 0.000 [kN]
resulting compression force in (x/y)=(0.0/0.0): 15.000 [kN]

Anchor forces are calculated based on the assumption of a rigid baseplate.



3 Tension load (EOTA TR 029, Section 5.2.2)

	Load [kN]	Capacity [kN]	Utilization β_N [%]	Status
Steel failure*	N/A	N/A	N/A	N/A
Concrete Breakout failure**	N/A	N/A	N/A	N/A
Splitting failure**	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (anchors in tension)

4 Shear load (EN 1992-4, Section 7.2.2)

	Load [kN]	Capacity [kN]	Utilization β_V [%]	Status
Steel failure (without lever arm)*	0.354	24.896	2	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout failure**	0.354	14.278	3	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (relevant anchors)

5 Displacements (highest loaded anchor)

Short term loading:

N_{Sk}	=	0.000 [kN]	δ_N	=	0.0000 [mm]
V_{Sk}	=	0.262 [kN]	δ_V	=	0.0189 [mm]
			δ_{NV}	=	0.0189 [mm]

Long term loading:

N_{Sk}	=	0.000 [kN]	δ_N	=	0.0000 [mm]
V_{Sk}	=	0.262 [kN]	δ_V	=	0.0271 [mm]
			δ_{NV}	=	0.0271 [mm]

Comments: Tension displacements are valid with half of the required installation torque moment for uncracked concrete! Shear displacements are valid without friction between the concrete and the baseplate! The gap due to the drilled hole and clearance hole tolerances are not included in this calculation!

The acceptable anchor displacements depend on the fastened construction and must be defined by the designer!

6 Warnings

- The anchor design methods in PROFIS Engineering require rigid baseplates per current regulations (AS 5216:2021, ETAG 001/Annex C, EOTA TR029 etc.). This means load re-distribution on the anchors due to elastic deformations of the baseplate are not considered - the baseplate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Engineering calculates the minimum required baseplate thickness with CBFEM to limit the stress of the baseplate based on the assumptions explained above. The proof if the rigid baseplate assumption is valid is not carried out by PROFIS Engineering. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- In general, the conditions given in ETAG 001, Annex C, section 4.2.2.1 and 4.2.2.3 b) are not fulfilled because the diameter of the clearance hole in the fixture acc. to Annex 3, Table 3 is greater than the values given in Annex C, Table 4.1 and AS5126 for the corresponding diameter of the anchor. Therefore the design resistance for anchor groups is limited to twice the steel resistance (of a single anchor) in accordance with the approval.
- Checking the transfer of loads into the base material is required in accordance with EN 1992-4, Annex A!
- The design is only valid if the clearance hole in the fixture is not larger than the value given in Table 6.1 of EN 1992-4! For larger diameters of the clearance hole see section 6.2.2 of EN 1992-4!
- The accessory list in this report is for the information of the user only. In any case, the instructions for use provided with the product have to be followed to ensure a proper installation.
- For the determination of the $\psi_{re,V}$ (concrete edge failure) the minimum concrete cover defined in the design settings is used as the concrete cover of the edge reinforcement.
- The characteristic bond resistances depend on the return period (service life in years): 50

Fastening meets the design criteria!

7 Installation data

Baseplate, steel: S 235; E = 210,000.00 N/mm^2; f_{yk} = 235.00 N/mm^2
Profile: Square hollow, 50 x 50 x 2; (L x W x T) = 50.0 mm x 50.0 mm x 2.0 mm
Hole diameter in the fixture: d_f = 16.0 mm
Plate thickness (input): 10.0 mm
Recommended plate thickness: not calculated
Drilling method: Hammer drilled
Cleaning: Clean the drill hole. Under the conditions - according to fastener size and drilling direction - given in the ETA and MPII (IFU), the cleaning of the drill hole may be omitted.

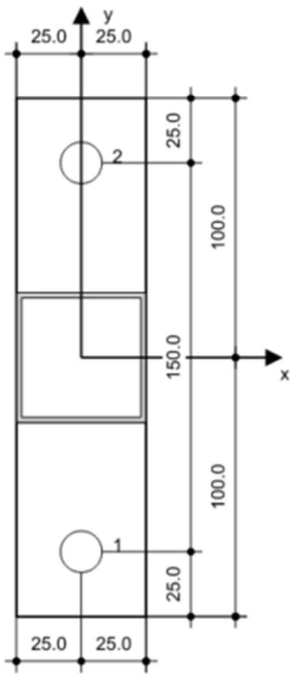
Anchor type and size: HUS4-H 12 h_nom1
Item number: 2293565 HUS4-H 12x70 10/-/-

Maximum installation torque: Hilti SIW 22T-A
Hole diameter in the base material: 12.0 mm
Hole depth in the base material: 70.0 mm
Minimum thickness of the base material: 100.0 mm

Hilti HUS screw anchor with 60 mm embedment, 12 h_nom1, Steel galvanized, installation per ETA-20/0867

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• Manual blow-out pump	• Hilti SIW 22T-A impact screw driver



Coordinates Anchor [mm]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.0	-75.0	-	-	-	-
2	0.0	75.0	-	-	-	-

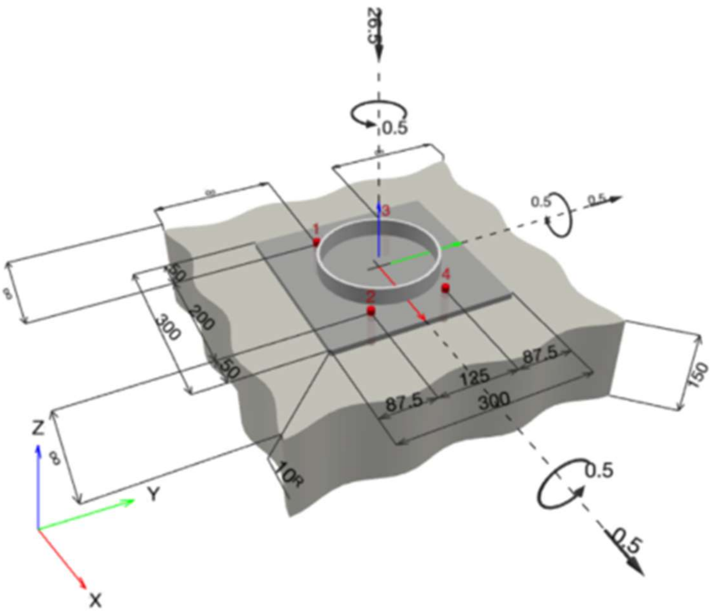
<u>CHS column base plate connection ot concrete slab</u>

1 Input data

Anchor type and size:	**HUS4-H 12 h_nom1**
Return period (service life in years):	50
Item number:	2293565 HUS4-H 12x70 10/-/-
Effective embedment depth:	h_{ef} = 45.9 mm ($h_{ef,ETA}$ = 45.9 mm), h_{nom} = 60.0 mm
Material:	1.5525
Approval No.:	ETA-20/0867
Issued I Valid:	14/07/2022 | -
Proof:	Design Method EN 1992-4, Mechanical
Stand-off installation:	e_b = 0.0 mm (no stand-off); t = 10.0 mm
Baseplate^R :	l_x x l_y x t = 300.0 mm x 300.0 mm x 10.0 mm; (Recommended plate thickness: not calculated)
Profile:	Pipe, 193,7 x 5,0; (L x W x T) = 193.7 mm x 193.7 mm x 5.0 mm
Base material:	cracked concrete, C20/25, $f_{c,cyl}$ = 20.00 N/mm^2; h = 150.0 mm, User-defined partial material safety factor γ_c = 1.500
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	No reinforcement or Reinforcement spacing >= 150 mm (any Ø) or >= 100 mm (Ø <= 10 mm)
	no longitudinal edge reinforcement

^{R} - The anchor calculation is based on a rigid baseplate assumption.

Geometry [mm] & Loading [kN, kNm]



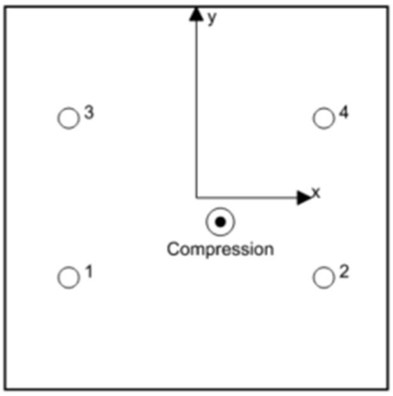
1.1 Load combination

Case	Description	Forces [kN] / Moments [kNm]	Seismic	Fire	Max. Util. Anchor [%]
1	Combination 1	N = -26.500; V_x = 0.500; V_y = 0.500; M_x = 0.500; M_y = 0.500; M_z = 0.500;	no	no	10

2 Load case/Resulting anchor forces

Anchor reactions [kN]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0.000	1.035	0.687	-0.774
2	0.000	1.233	0.687	1.024
3	0.000	0.889	-0.437	-0.774
4	0.000	1.113	-0.437	1.024



max. concrete compressive strain: 0.02 [‰]
max. concrete compressive stress: 0.52 [N/mm^2]
resulting tension force in (x/y)=(0.0/0.0): 0.000 [kN]
resulting compression force in (x/y)=(18.9/-18.9): 26.500 [kN]

Anchor forces are calculated based on the assumption of a rigid baseplate.

3 Tension load (EN 1992-4, Section 7.2.1)

	Load [kN]	Capacity [kN]	Utilization β_N [%]	Status
Steel failure*	N/A	N/A	N/A	N/A
Concrete Breakout failure**	N/A	N/A	N/A	N/A
Splitting failure**	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (anchors in tension)

4 Shear load (EN 1992-4, Section 7.2.2)

	Load [kN]	Capacity [kN]	Utilization β_V [%]	Status
Steel failure (without lever arm)*	1.233	24.896	5	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout failure*	1.233	13.619	10	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (relevant anchors)

5 Displacements (highest loaded anchor)

Short term loading:

N_{Sk}	=	0.000 [kN]	δ_N	=	0.0000 [mm]
V_{Sk}	=	0.913 [kN]	δ_V	=	0.0658 [mm]
			δ_{NV}	=	0.0658 [mm]

Long term loading:

N_{Sk}	=	0.000 [kN]	δ_N	=	0.0000 [mm]
V_{Sk}	=	0.913 [kN]	δ_V	=	0.0946 [mm]
			δ_{NV}	=	0.0946 [mm]

Comments: Tension displacements are valid with half of the required installation torque moment for uncracked concrete! Shear displacements are valid without friction between the concrete and the baseplate! The gap due to the drilled hole and clearance hole tolerances are not included in this calculation!

The acceptable anchor displacements depend on the fastened construction and must be defined by the designer!

6 Warnings

- The anchor design methods in PROFIS Engineering require rigid baseplates per current regulations (AS 5216:2021, ETAG 001/Annex C, EOTA TR029 etc.). This means load re-distribution on the anchors due to elastic deformations of the baseplate are not considered - the baseplate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Engineering calculates the minimum required baseplate thickness with CBFEM to limit the stress of the baseplate based on the assumptions explained above. The proof if the rigid baseplate assumption is valid is not carried out by PROFIS Engineering. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- In general, the conditions given in ETAG 001, Annex C, section 4.2.2.1 and 4.2.2.3 b) are not fulfilled because the diameter of the clearance hole in the fixture acc. to Annex 3, Table 3 is greater than the values given in Annex C, Table 4.1 and AS5126 for the corresponding diameter of the anchor. Therefore the design resistance for anchor groups is limited to twice the steel resistance (of a single anchor) in accordance with the approval.
- Checking the transfer of loads into the base material is required in accordance with EN 1992-4, Annex A!
- The design is only valid if the clearance hole in the fixture is not larger than the value given in Table 6.1 of EN 1992-4! For larger diameters of the clearance hole see section 6.2.2 of EN 1992-4!
- The accessory list in this report is for the information of the user only. In any case, the instructions for use provided with the product have to be followed to ensure a proper installation.
- For the determination of the $\psi_{re,v}$ (concrete edge failure) the minimum concrete cover defined in the design settings is used as the concrete cover of the edge reinforcement.
- The characteristic bond resistances depend on the return period (service life in years): 50

Fastening meets the design criteria!

7 Installation data

Baseplate, steel: S 275; E = 210,000.00 N/mm^2; f_{yk} = 275.00 N/mm^2

Profile: Pipe, 193,7 x 5,0; (L x W x T) = 193.7 mm x 193.7 mm x 5.0 mm

Hole diameter in the fixture: d_f = 16.0 mm

Plate thickness (input): 10.0 mm

Recommended plate thickness: not calculated

Drilling method: Hammer drilled

Cleaning: Clean the drill hole. Under the conditions - according to fastener size and drilling direction - given in the ETA and MPII (IFU), the cleaning of the drill hole may be omitted.

Anchor type and size: HUS4-H 12 h_nom1

Item number: 2293565 HUS4-H 12x70 10/-/-

Maximum installation torque: Hilti SIW 22T-A

Hole diameter in the base material: 12.0 mm

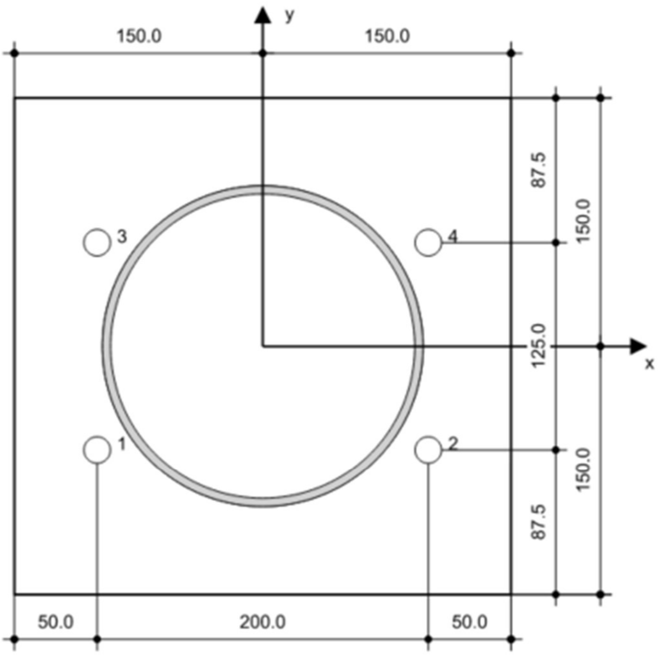
Hole depth in the base material: 70.0 mm

Minimum thickness of the base material: 100.0 mm

Hilti HUS screw anchor with 60 mm embedment, 12 h_nom1, Steel galvanized, installation per ETA-20/0867

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• Manual blow-out pump	• Hilti SIW 22T-A impact screw driver



Coordinates Anchor [mm]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-100.0	-62.5	-	-	-	-
2	100.0	-62.5	-	-	-	-
3	-100.0	62.5	-	-	-	-
4	100.0	62.5	-	-	-	-