Base Load Power Hub (BLPH)

Secondary Structures Design Report

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

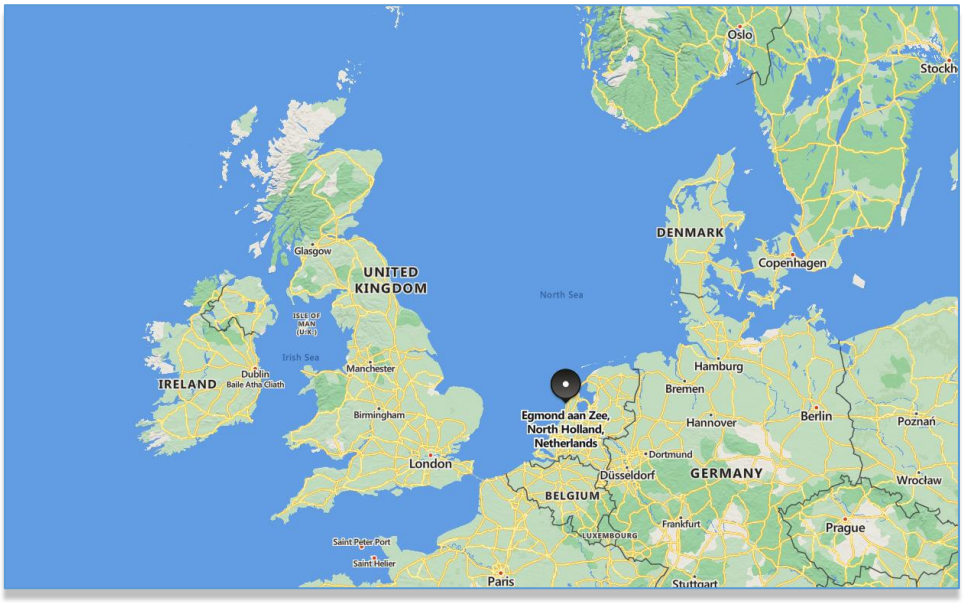


Figure 1.1 - HOLLANDSE KUST NOORD WIND PARK Location Map

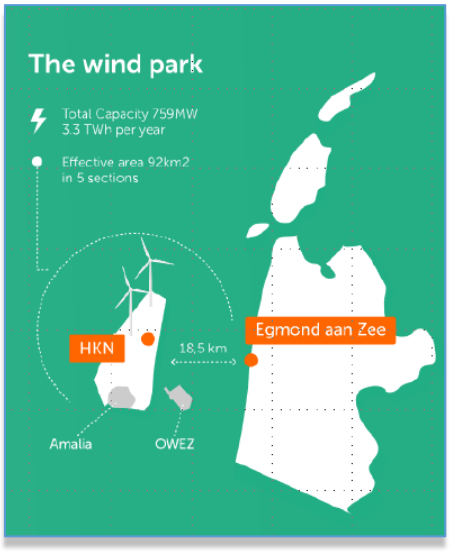


Figure 1.2 - Wind Park Details

The wind farm consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.1.2 Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

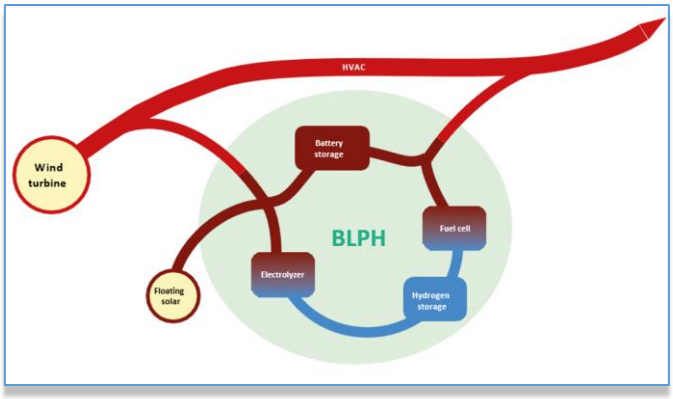


Figure 1.3 - BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2 DOCUMENT SCOPE

This report presents the structural analyses of the secondary structure of BLPH topside and TP.

The checks cover both operating and temporary condition for the following items:

- Secondary floor beams
- Floor plates and gratings
- Topside and TP stairs
- Induced vortex shedding on members.
- Caissons frame structure

The analysis has been performed in compliance with the requirements, criteria and parameters reported in the Structural Design Premises, Ref./28/.

All structural analyses have been carried out using the structural analysis program SACS, the proprietary software developed by Bentley, Ref./43/.

The International System of Units (SI) has been used in all engineering assessments and calculations.

Structural Code checks are performed according to BD EN ISO 19902 for tubular members and tubular joints, Ref./7/, and according to Eurocode 3 for non-tubular structural elements, Ref./10/.

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3 REFERENCES

3.1 CODES AND STANDARDS

Doc. No.	Description
/1/ BS EN ISO 19900	General requirements for offshore structures - 2019
/2/ BS EN ISO 19901-1	Specific requirements for offshore structures - Part 1: Metocean design and operating considerations - 2015
/3/ BS EN ISO 19901-2	Seismic design procedures and criteria
/4/ BS EN ISO 19901-3	Specific requirements for offshore structures – Part 3: Topsides structure - 2014
/5/ BS EN ISO 19901-5	Specific requirements for offshore structures – Part 5: Weight Management - 2021
/6/ BS EN ISO 19901-6	Specific requirements for offshore structures – Part 6: Marine Operations – 2009
/7/ BS EN ISO 19902	Petroleum and natural gas industries - Fixed steel offshore structures – 2020
/8/ ISO 19906:2019	Petroleum and natural gas industries – Arctic offshore structures
/9/ EN 1991-1-3:2003 & A1:2015	EN, Eurocode 1 – Actions on Structures – Part 1-3: General actions – Snow loads - Incorporating corrigenda December 2004 and March 2009, December 2015.
/10/ EN 1993-1-1	Design of steel structures – Part 1-1: General rules and rules for buildings
/11/ API RP 2A-WSD	Recommended practice for planning, designing and constructing fixed offshore platforms – Working stress design – 22nd edition – 2014
/12/ DNV-ST-0145	DNV, Offshore substations
/13/ DNV-RP-C201	DNV, Buckling Strength of Plated Structures, October 2010.
/14/ DNV-RP-C204	Design against accidental loads – 2019
/15/ DNV-RP-C205	DNV - Environmental conditions and environmental loads - September 2019, amended September 2021.
/16/ DNV-OS-C101	Design of offshore steel structures, general- LRFD method, 2021
/17/ DNV-OS-B101	Metallic materials, 2021
/18/ DNV-ST-0126	Support structures for wind turbine, 2018
/19/ ISO 14122-1 to 4	Safety of machinery – Permanent means of access to machinery

3.2 COMPANY SPECIFICATIONS

Doc. No.	Description
/20/ DEP 37.19.00.12	Gen - Offshore Topsides Structures
/21/ DEP 37.19.00.30	Gen - Fixed Steel Offshore Structures (Adoption of IOGP S-631-11, Amendments / Supplements to ISO 19902:2020).

3.3 PROJECT DOCUMENTS

Doc. No.	Description
/22/ 123A90-DDL-MD-RE-01006	Monthly Weight Report
/23/ 123A90-PML-MD-PRO-01002	Weight Control Procedure
/24/ 123A90-DDL-PP-DS-70070	Plot Plans
/25/ Pending	Handling Philosophy Report
/26/ 123A90-DDL-ST-SP-90017	Structural Design Basis
/27/ 123A90-DDL-ST-SP-90018	Structural Material Specification for Topside & TP
/28/ 123A90-DDL-ST-SP-90118	Structural Material Specification for Flange & Bolts
/29/ 123A90-DDL-ST-RE-90000	BLPH Platform – In-service report
/30/ 123A90-DDL-ST-RE-90002	BLPH Platform – Topside transportation analysis
/31/ 123A90-DDL-ST-RE-90120	Structural verification against accidental loads
/32/ 123A90-DDL-ST-TN-90119	Evaluating ISO and DNV approaches
/33/ 1724000887-MAC-CA-00004	BLPH Platform - Mechanical Calculation Hydrogen Vent
/34/ K559-2254-CWIWP4202202-B01-001	BLPH Project - General Arrangements
/35/ 123A90-DDL-ST-DD-90037	BLPH Standard Drawings - Handrails
/36/ 123A90-DDL-ST-DD-90038	BLPH Standard Drawings – Heavy Duty Handrails
/37/ 123A90-DDL-ST-DD-90069	BLPH Topside – Lower Deck Equipment Supports

3.4 OTHER DOCUMENTS

Doc. No.	Description
/38/ K559–2254-ST-PHI-001	BLPH Structural Topsides Design & Installation Philosophy, Rev.1, 09 December 2022
/39/ SR.20.01165	Meteocean criteria for Hollandse Kust Noord Wind Farm zone (shell), Rev A03, 05-02-2021

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/40/ 144671-VOOW-TF-ENG-REP-1052	Wave Loads and Effects for BLPH, Rev. 0, 16 December 2021
/41/ 144671-VOOW-TF-ENG-REP-1016	Wave Run-up Study, Rev.2, 29 November 2021
/42/ 144671-VOOW-TF-ENG-REP-1103	Wave Impact Analysis, Rev.1, 7 May 2021
/43/ 144671-VOOW-TF-ENG-REP-1054	Foundation Load Document for BLPH, Rev.1, 07 April 2022
/44/ 144671-VOOW-TF-ENG-REP-1055	Design Verification Primary Steel for BLPH, Rev.1, 13 April 2022
/45/ 144671-VOOW-TF-ENG-REP-1056	Ship Impact for BLPH, Rev.0, 07 March 2022
/46/ 144671-VOOW-TF-ENG-REP-1502	Main Access Platform – Wave Run-up Braces
/47/ 144671-VOOW-GEN-SUR-REP-0074	Foundation As-built Survey CW70 HNA6
/48/ K559-2254-PM-PLN-003	Basic Design Engineering Package, Rev2, 06 July 2023
/49/ DK-TYYY-TNI-RPT-000-10002_B_IFC	Meteocean data for Tyra field development, 15/06/2018
/50/ CWHKN-DEN-PJA-RPT-00006	Metocean criteria for Hollandse Kust Noord Wind Farm zone (containing 1000ys wave)

3.5 SOFTWARE

Doc. No.	Description
/51/ SACS	Structural Analysis Computer System – BENTLEY Inc- v15

4 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY)	Crosswind
CONTRACTOR (CTR)	ROSETTI MARINO S.p.A.
PROJECT	HOLLANDSE KUST NOORD WIND PARK Project
T&I CONTRACTOR	DEME
ALS	Accidental Limit State
BEB	Best Estimate Bathymetry
BESS	BATTERY ENERGY STORAGE SYSTEM
BG	Box Girder
BLPH	Base Load Power Hub
Ce	Snow Exposure Coefficient
CF	Caisson Frame
CL	Concentrated Load
CoG	Centre of Gravity
CTV	Crew Transfer Vessel
CW	CrossWind
DAF	Dynamic Amplification Factor
DFF	Damage Fatigue Factors
DLB	Ductility Level Blast
DNV	Det Norske Veritas
DOP	Dropped Object Protection
DP	Dynamic Positioning
El.	Elevation
EPCI	Engineering Procurement Construction and Installation
FEED	Front End Engineering Design
HAT	Highest Astronomical Tide
HKN	Hollandse Kust Noord
ICCP	Impressed Current Corrosion Protection
LAT	Lowest Astronomical Tide

LRFD	Load and Resistance Factor Design
MSL	Mean Sea Level
NTE	Not-to-Exceed
OD	Outside Diameter
PAU	Pre-Assembled Unit (H2 Vessels)
PG	Plate Girder
PV	Photovoltaic
SCE	Safety Critical Equipment
sk	Characteristic Value of Snow on the Ground/Platform
SGSI	Shell Global Solutions International
SHL	Static Hook Load
T&I	Transport & Installation
ToS	Top of Steel
TP	Transition Piece
TSO	Transmission System Operator
SLB	Strength Level Blast
UC	Unity Check
UDL	Uniformly Distributed Load
VIV	Vortex Induced Vibration
VOOW	Van Oord Offshore Wind
WTG	Wind Turbine Generator
W2W	Walk to Work

Table 4.1 - Definitions and Abbreviations

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5 DESIGN DATA

Design Data are taken from Structural Design Basis Report, ref. /28/.

5.1 WIND DATA

Omni-Directional wind speed data are reported in section 7.5 of Design Basis, Ref. ref. /28/,and reported below.

Averaging Time	Return period (years)						
	1	2	5	10	50	100	1000
1hr	31.8	33.4	35.1	36.4	39.1	40.1	43.4
10 min	33.7	35.5	37.4	38.8	41.7	42.9	46.5
3s	39.4	41.6	44.1	45.9	49.7	51.1	56.0

Table 5.1 - Omni-Directional Wind velocities [m/s] at 125 m MSL

Wind speeds are provided at 125m MSL. Wind speeds at any specified averaging time or elevation, will be calculated according to following equations, Ref./2/:

$U(z, t) = U(z) * [1 - 0.41 * Iu(z) * \ln(t/t0)]$

U(z) = 1-hour mean wind speed given by:

$U(z) = U0 * [1 + C * \ln(z/zr)]$

$C = 0.0573 * (1 + 0.15 * U0)1/2$

$Iu = 0.06 * [1 + 0.043 * U0] * (z/zr)-0.22$

U0 = 1-hour average at the reference elevation, zr

zr = 10 m above sea level.

Directional exceedance data for wind is presented in Fig. 5.1. The wind predominantly blows from the south-west.

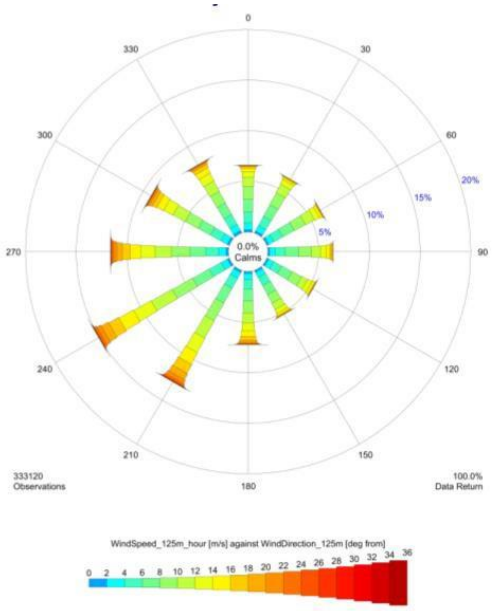


Figure 5.1 - Mean Hourly Wind Speed Distribution at 125 m MSL

5.2 TEMPERATURE AND METEO DATA

Description	Unit	Value
Ambient Conditions		
Ambient Temperature (min/nom/max) – hourly @ +10m	°C	-8.4 / 10.5 / 25.0
Atmospheric Pressure (nominal) – hourly @ +10m	mbar	1013.7
Specific Humidity (min/nom/max) – hourly @ +10m	x 10^{-3}	4.2/6.5/9.5
Wind Conditions		
Annual average wind speed (at 100 m)	m/s	9.56
Extreme Wind Speed for 1-Year Recurrence Period (at 100 m)	m/s	33.1
Extreme Wind Speed for 50-Year Recurrence Period (at 100 m)	m/s	41.0
Marine Conditions		
Sea Water Temperature (min/max)	°C	1.3 / 20.2
Average Sea Water Density	kg/m^3	1025

Table 5.2 - Meteorological and Oceanographic Data (source HKN2018 data @1979-2018), ref. /40/.

5.3 RAIN FALL

Rain Fall [mm]													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Min	14.1	18.1	9.1	1.2	10.3	17.3	6.2	20.7	27.2	43.0	22.2	28.1	646.6
Mean	75.0	62.5	48.6	39.6	47.4	47.9	58.2	73.0	91.0	102.7	108.5	89.3	843.6
Max	143.2	119.4	106.4	79.8	92.7	117.9	160.7	154.7	178.6	188.7	179.3	138.1	1056.1

Table 5.3 - Rain Fall, ref. /40/.

5.4 SNOW DATA

Snow loads, Ref. /28/:

- The Snow Exposure Coefficient (Ce) for every site in the Netherlands and Dutch Continental Shelf is Ce = 1.0.
- The Characteristic Value of Snow Load on the Ground/Platform (sk) shall be taken as sk = 0.7 kN/m^2.
- In the Netherlands including, its Continental Shelf, no exceptional snow loads need to be considered.

5.5 ICE ACCRETION DATA

Atmospheric and marine ice accretion are specified in following Table. Ice from sea spay and rain / snow will be considered separately, i.e., are not concurrent.

Height	Sea Spray		Ice by Rain/Snow	
rel. to LAT	Thickness	Density	Thickness	Density
[m]	[mm]	[Kg/m^3]	[mm]	[Kg/m^3]
0 – 12.7	100	850	30	700
12.7 – 72.7	Linear 100 to 0	850	30	700

Table 5.4 - Ice Accretion on the Topside

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6 MATERIALS

6.1 STRUCTURAL STEEL PROPERTIES

For the structural analyses, steel types and grades to be used for the platform structures are summarised in Table 6-1, and specified in /26/ The material selection criteria are based on the requirements of ISO 19906:2019, ISO 19902:2020 and ISO 19901-3:2014. The materials are in accordance with the EN standard 10225:2019 and 10025:2019 and are suitable for plates, rolled sections and welded / seamless tubulars.

			EN10025-3	ISO EN 19902:2020						
Design Class	**Complexity**	**SQL**	**Hot rolled bar**	**Plates and Welded Tubular**	**Sections**	**SMLS pipes**	**THK**	**CVN inpact test**	**Material Designation**	**List of Options (EN10225-1 to -4) & EN10025-3**
DC1 TP to monopile flange connection	High	I (Z properties)	EN 10025 S420 NL	NA	NA	NA	t > 50	-40	DC1-I-420-40_Z	1, 2, 3, 4, 6, 12, 18, 24, 30
DC1 Complex lift-nodes and element connection to topside, Lift points, main complex joints	High	I (Z properties)	NA	EN 10225 S420 QLO / ML	NA	NA	25 < t <= 50	-40	DC1-I-420-40_Z DC1-I-460-40_Z	2, 7, 8, 11, 12, 17, 18
							t > 50	-40		
DC2 simple joints, primary deck girders and beams of Topside and TP, column and diagonal to lift points, main columns, Davit crane support, Bolts	Low	II	NA	EN 10225 S420 QLO / MLO	NA	NA	t < = 12	0	NA	-
							12 < t <= 25	-20	DC2-II-420-20 / DC2-II-460-20	2, 7, 8, 11 17 for t > 40mm
							25 < t <= 50	-40	DC2-II-420-40 DC2-II-460-40	
							t > 50	-40		
DC3 all other columns and diagonals, stiffeners, Secondary deck beams, Grillage and sea fastening	High	II	NA	EN 10225 S355 NLO / MLO	EN 10025 S355 MLO	EN 10225 S355 NLHHO / QLHHO API 5L X52	t < = 12	0	DC3-II-355-0 / DC3-II-X52-0	2, 7, 8 11 for plate 17 for t > 40mm
							12 < t <= 25	-20	DC3-II-355-20 / DC3-II-X52-20	
							25 < t <= 50	-40	DC3-II-355-40 / DC3-II-X52-40	
							t > 50	-40		
DC4 Equipment and vessel supports, modules supports, equipment fixing bolts	Low	III	NA	EN 10025 S355 J2	EN 10025 S355 J2	API 5L X52 EN 10210 S355 J2H	t < = 12	0	DC4-III-355-0 / DC4-III-X52-0 / DC4-III-X60-0	-
							12 < t <= 25	0		
DC5 floor plating, grating, Walkways, stairs, handrails	Any	IV	NA	EN 10025 S235 JR EN 10025 S275 J0 EN 10025 S355 J0	EN 10025 S235 JR EN 10025 S275 J0 EN 10025 S355 J0	API 5L Gr.B EN 10210 S235 JRH / EN 10210 S275 J0H / EN 10210 S355 J0H	t < = 12	10	DC5-IV-235-10 / DC5-IV-275-10 / DC5-IV-355-10 / DC5-IV-GRB-10	-
							12 < t <= 25	10		

Table 6.1 - Material Selection, Ref /26/, and requested Options

Mechanical properties for structural materials are presented in Table 6.8, Table 6.9 and Table 6.10.

- Young's Modulus = 205,000 N/mm^2
- Density = 7850 kg/m^3
- Poisson's Ratio = 0.3

Thickness (mm)	Min. Tensile Strength (N/mm²)	Min. Yield Strength (N/mm2)	Steel Type (1)
t > 250	460	320	I
Note: 1) Type I steel has Z (through the thickness) properties.			

Table 6.2 – Mechanical properties of Hot rolled bar

Thickness (mm)	Min. Tensile Strength (N/mm²)	Min. Yield Strength (N/mm2)	Steel Type (1)
t ≤ 16	500	420	I & II
16 < t ≤ 40	500	400	I & II
40 < t ≤ 63	480	390	I & II
63 < t ≤ 100	480	380	I & II
Note: 1) Type I steel has Z (through the thickness) properties.			

Table 6.3 - Mechanical properties of Plates

Thickness (mm)	Min. Tensile Strength (N/mm²)	Min. Yield Strength (N/mm2)	Steel Type
t ≤ 20	460	355	III
20 < t ≤ 40	460	345	III

Table 6.4 - Mechanical properties of Structural Seamless Tubulars

Thickness (mm)	Min. Tensile Strength (N/mm2)	Min. Yield Strength (N/mm2)	Steel Type
t ≤ 16	460/360	355/275	IV
16 < t ≤ 40	460	345	IV

Table 6.5 - Mechanical properties for Structural Sections

6.2 PLATING

Preferred plate thicknesses for primary structural steel will start at a minimum of 10 mm and increase in 5 mm steps Secondary steel lower and upper deck plate will be 8 mm thick with laydown areas of 10 mm for Dropped Object Protection (DOP).

Blast walls are not to be provided on a hydrogen processing facility, as free ventilation and free explosion venting is more important, and supportable, than obstruction walls.

6.3 GRATING

Grating will be with bearing bars 30 mm x 5 mm and mesh 30 mm x 50 mm, S235 material.

6.4 FLANGE

Flange will be designed in accordance with Ref. /18/ and to fit the existing one already installed on monopile; The specification /27/details the material requirements and tests.

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6.5 BOLTS

Bolts will be classified primary structure (or DC2), purchased in accordance with Ref./18/ and /20/. Requirements are reported in documents /27/.

7 DESIGN CRITERIA AND REQUIREMENTS

7.1 GENERAL

Structures in SOW will be designed in accordance with limit states approach of ISO codes 19901 and 19902, Refs./2/, /4/and /7/. For non-tubular sections, Eurocode, Ref./10/, is adopted. Member forces and moments derived from the global analyses are used for checking member strength and stability, and joint strength.

Four different design limit states are defined and will be satisfied by the design:

- the Serviceability Limit State (SLS), corresponding to the criteria applicable to normal use or durability;
- the Ultimate Limit State (ULS), corresponding to the ultimate capacity for carrying loads;
- the Accidental Limit State (ALS) corresponding to damage due to an accidental event;

The general requirement of ISO code is that, for the structure as a whole and for each component, the following is satisfied:

$$R_d = \frac{R_k}{\gamma_M} > \gamma_F F_r = F_d$$

Where:

- R_d is the design resistance;
- R_k is the characteristic resistance;
- γ_M is the partial resistance factor reported in section 7.2;
- F_d is the design value of action;
- F_r is the characteristic value of action;
- γ_F is the partial action factor reported in Sec.7.4.

Design according to the provisions for load and resistance factor design (LRFD) of EC3, ref. /10/ shall be performed in accordance with following equation:

$$R_u \leq \phi R_n$$

Where:

- R_u = required strength using LRFD load combinations
- R_n = nominal strength
- ϕ = resistance factor reported in Sec.7.2
- ϕ Rn = design strength.

7.2 PARTIAL RESISTANCE FACTORS

The partial resistance factors for tubular sections from ISO 19902, Ref./7/, are listed below.

Resistance factor	Value	Definition
$\gamma_{R,t}$	1.05	Partial resistance factor for axial tensile strength
$\gamma_{R,c}$	1.18	Partial resistance factor for axial compressive strength
$\gamma_{R,b}$	1.05	Partial resistance factor for bending strength
$\gamma_{R,v}$	1.05	Partial resistance factor for shear strength
$\gamma_{R,h}$	1.25	Partial resistance factor for hoop buckling strength

Table 7.1- Resistance Factors for Tubular Sections

7.2.1 Partial Resistance Factors for Non-tubular Sections

The partial resistance factors for non-tubular sections from Eurocode 3, Ref./10/, are listed below.

Resistance factor	Value	Definition
Resistance of members and cross sections		
γ_{M0}	1.00	Cross-section resistance to excessive yield strain including local buckling
γ_{M1}	1.00	Resistance of unstable elements measured during element inspection
γ_{M2}	1.25	Tensile cross-section resistance to mechanical breakdown
Resistance of connections		
γ_{M2}	1.25	Bolts, rivets, pins, welds and slabs on supporting surface
γ_{M3}	1.25	Sliding resistance at Ultimate Limit State Category C
$\gamma_{M3,SER}$	1.10	Sliding resistance at Serviceability Limit State
γ_{M4}	1.10	Injection bolt collapse resistance
γ_{M5}	1.10	Resistance of connections in open lattice trusses
$\gamma_{M6,SER}$	1.00	Resistance of pins at Serviceability Limit State
γ_{M7}	1.10	Preload of high strength bolts

Table 7.2- Resistance for Non Tubular Section

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These resistance factors apply to the design of members and are not applicable to local details, such as padeyes. Reference should be made to ISO 19902 for a full listing of partial resistance factors and to Eurocode 3, Ref./10/, for welds and bolts design resistance factors.

7.2.2 Partial Resistance Factors for Tubular Joints Check

The partial resistance factors for tubular joints checks are provided in following table.

Resistance factor	Value	Definition
$\gamma_{R,j}$	1.05	Partial resistance factor for joints
$\gamma_{z,j}$	1.17	Additional partial resistance factor for members during joint pre-strain collapse

Table 7.3 - Resistance Factors for Tubular Joints

7.2.3 Partial Resistance Factors for Accidental Limit State Actions

All partial resistance factors for the abnormal / accidental limit state conditions are set equal to 1.00.

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7.3 LOAD CLASSIFICATIONS

Design loads are classified as either global or local within ISO 19901-3, Ref. /4/ and ISO 19902, Ref./7/ and summarized in Table 7.1.

Load Type	ISO Designation	Description
Permanent (Dead)	G1	Structure self-weight; Equipment & piping dry weight; Any actions due to misalignment of structures such as between the topside and TP
Permanent (Dead)	G2	permanent action imposed on the topsides structure by self-weight of equipment and other objects that remain constant for long periods of time, but which can change from one mode of operation to another, or during a mode of operation, bulk loads
Variable (Live)	Q1	Equipment & piping contents weight; Superimposed area loads; Ice and snow accretions
Variable (Live)	Q2	Crane hook loads; Liquids in pipes and process vessels for pressure testing; Machine operations
Environmental (extreme)	Ee	Extreme quasi-static action due to wind, waves and current (eg.100-yr storm wind)
Environmental (operational)	Eo	1-yr storm wind
Inertial Response (operational)	Do	Equivalent quasi-static action representing dynamic response caused by the Eo wave condition
Inertial Response (extreme)	Do	Equivalent quasi-static action representing dynamic response caused by the Ee wave condition
Pressure (accidental)	-	Blast
Inertial (accidental)	-	Ship impact on monopile
Impact Energy (accidental)	-	Dropped Object
Transient	T	Transient Loads for Pre-Service Analyses

Table 7.4 - ISO Loads Classification

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7.4 PARTIAL ACTION FACTORS

7.4.1 Partial Action Factors for In-Service Analysis

Partial action factors to be applied for the operating and seismic conditions in compliance with ISO codes are reported in Table 7.2.

Load combination		Dead load		Live load		Environmental load	Wave dynamics
		G1	G2	Q1	Q2	Eo / Ee	Do / De
		$\gamma_{f,G1}$	$\gamma_{f,G2}$	$\gamma_{f,Q1}$	$\gamma_{f,Q2}$	$\gamma_{f,Eo}$ / $\gamma_{f,Ee}$	$\gamma_{f,D}$
Operating Gravity / Buoyancy		1.3	1.3	1.5	1.5	-	-
Operating Storm		1.3	1.3	1.5	1.5	1.22	1.25
Extreme Storm (100 years)	Max Compression	1.0	1.0	1.0	-	1.35	1.25
	Max Tension	0.9	0.9	0.8	-	1.35	1.25

Table 7.5 - Partial Action Factors for the In-Service Analysis

7.4.2 Partial Action Factors for Accidental Limit State Actions

All partial action factors for the abnormal / accidental limit state conditions are set equal to 1.00.

7.4.3 Partial Action Factors for Serviceability Limit States

All partial action factors for Serviceability Limit States conditions are set equal to 1.0.

7.5 ACCEPTANCE CRITERIA

The maximum member Unity Check (UC) will be less than unity.

7.6 SPAN LIMITS

Maximum allowable beam span limits are provided in Table 7.3.

Structural Component	Member Length / Member Height
Primary members	18
Members carrying sensitive machinery / vessels	15
All other members	22
Deck plate and stringers	30

Table 7.6 - Maximum Allowable Beam Span Limits

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On the BLPH topsides, 1 m deep Plate Girders (PGs) will be used with a span to depth ratio of 16, which is considered acceptable as the PGs will be continuous over the long span. The TP arms will be Box Girders (BGs). BGs are preferred as they have better corrosion resistance, torsional strength and are robust in a potential wave slam load application.

7.7 SERVICEABILITY LIMITS

ISO 19901-3, Ref./4/ states structural member deflections under serviceability conditions must not impair the serviceability of the structure. Corresponding deflection limits are presented in Table 7.4.

Condition	Limit for Δ_{max}	Limit for Δ_2
Deck Beams	L / 200	L / 300
Cantilever Beams	L / 100	L / 150
Deck plate thickness	-	2t or b/150 whichever is smaller

Where:

L = span of the beam, length of the cantilever;

t = deck plate thickness;

b = stiffener spacing;

Δ_{max} = final deflected shape = $\Delta_1+\Delta_2-\Delta_0$;

Δ_0 = any pre-camber (hogging) prior to the addition of any permanent or variable actions;

Δ_1 = deflection from permanent actions after applying the actions;

Δ_2 = deflection from the variable actions and any time-dependent deformations from permanent actions.

Table 7.7 - Limiting Values for Vertical Deflection

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8 TOPSIDE TOWER STAIRS DESIGN & LOADS

8.1 STRUCTURAL MODEL

The structural checks of beam member elements and tubular joints of the stairs have been performed with the software SACS, Ref. /43/, introducing the relative structural elements in the three-dimensional structural model of the BLPH Topside and TP In-Service Analysis.

The model geometry is referred to a right-handed orthogonal Cartesian coordinate reference system.

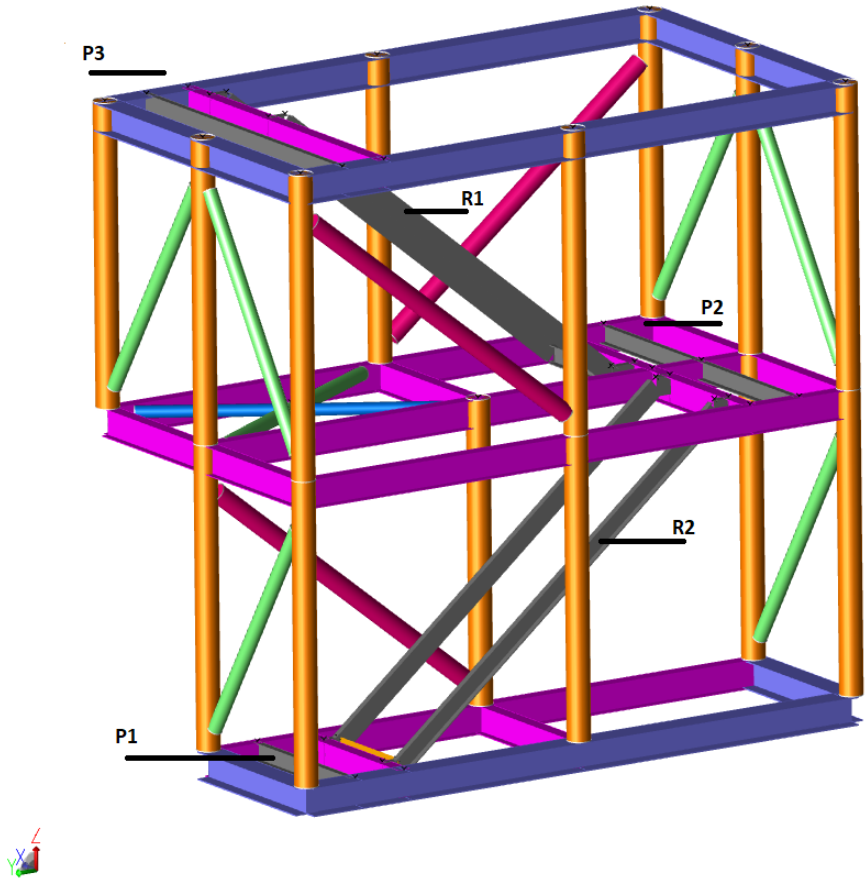


Figure 8.1 - Tower - Stairs - 3D View

The 3D-model particular of the tower stairs is represented in the following figures. Joint and member group labels are reported in appendix A.

Member Label: AB Release

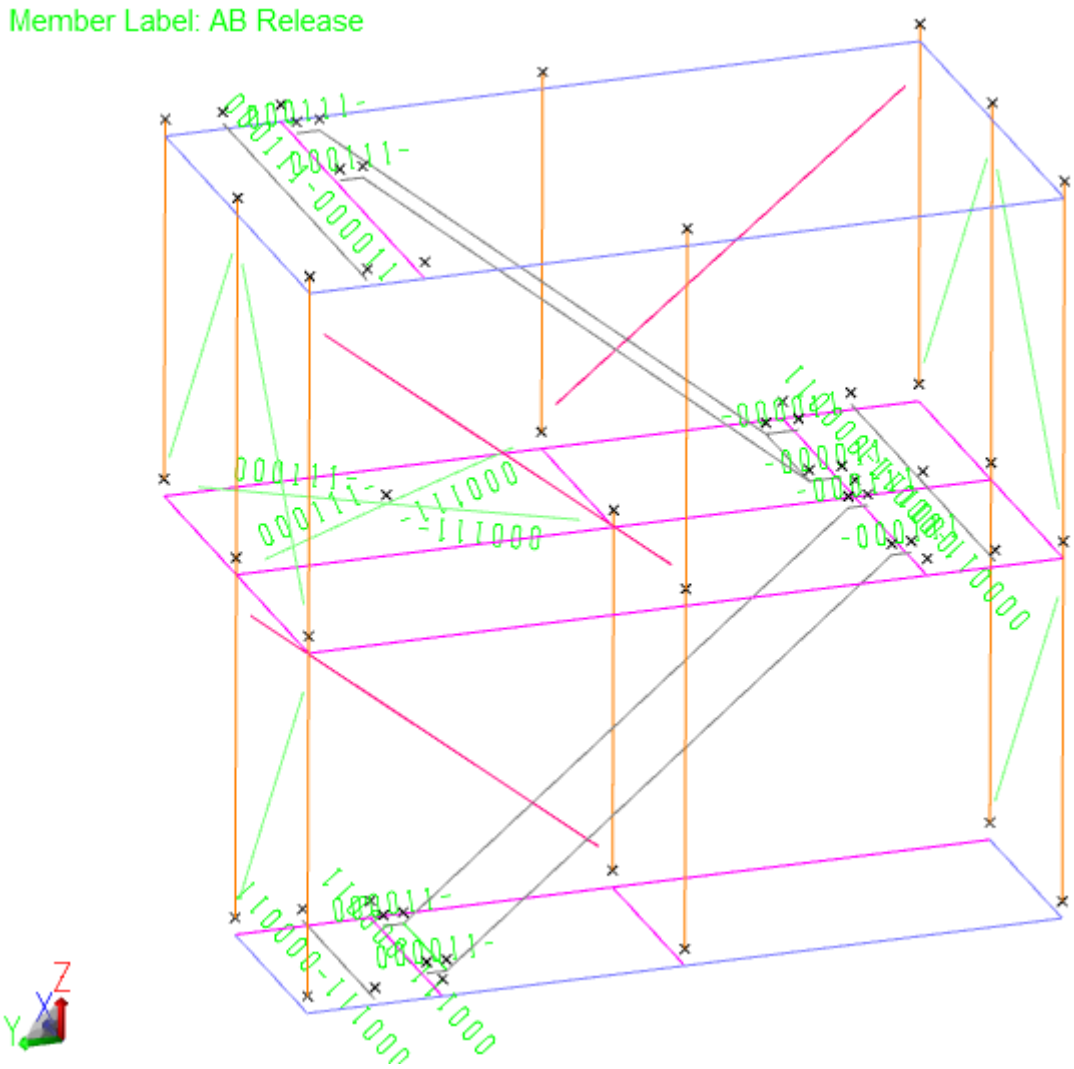


Figure 8.2 - Tower - Stairs - Member Release

Structural model members group are shown in the following SACS output excerpt.

TUBULAR MEMBER PROPERTIES

GRP	M/S	JOINT THICK M	WALL THICK CM	OUTSIDE DIAM. CM	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	***** MOMENTS OF INERTIA **** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	KY	KZ	SHEAR AREA CM**2	RING SPACE M	SECT LENG M	TAPER
ST2	1	0.00	0.818	21.91	20.5	7.9	54.203	6037.4	3018.7	3018.7	35.5	1.0	1.0	27.10	0.00	0.00	
ST3	1	0.00	0.711	16.83	20.5	7.9	36.005	2343.3	1171.6	1171.6	35.5	1.0	1.0	18.00	0.00	0.00	
ST5	1	0.00	0.927	27.31	20.5	7.9	76.834	13387.	6693.5	6693.5	35.5	1.0	1.0	38.42	0.00	0.00	
ST6	1	0.00	0.655	14.13	20.5	7.9	27.728	1261.7	630.83	630.83	35.5	1.0	1.0	13.86	0.00	0.00	

WIDE FLANGE/WIDE FLANGE COMPACT,MEMBER PROPERTIES

GRP	M/S	** FLANGE ** THICK CM	WIDTH CM	WEB THICK CM	FILET RAD. CM	DEPTH CM	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	**** MOMENTS OF INERTIA **** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	KY	KZ	FLANGE-BRC TOP M	BOT M	SECT LEN M	TPR
S03	1	1.15	16.00	0.750	1.000	33.00	20.5	7.9	62.00	28.00	0.1177E+05	788.0	35.5	1.0	1.0	0.0	0.0	0.00	
S04	1	1.65	30.00	0.950	2.000	33.00	20.5	7.9	133.0	127.0	0.2769E+05	7435.	35.5	1.0	1.0	0.0	0.0	0.00	

CHANNEL MEMBER REPORT

GRP	M/S	STIFN USAGE	HEIGHT CM	WIDTH CM	WEB THICK CM	FLANGE THICK CM	Y-BAR CM	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	***** MOMENTS OF INERTIA ***** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	KY	KZ	BRACE LEN. M	SECT LEN. M
S07	1	NO	22.00	8.00	0.900	1.250	2.0	20.5	7.9	37.00	16.00	2690.	197.0	27.5	1.0	1.0	0.0	0.00

ANGLE MEMBER PROPERTIES

GRP	M/S	STIFN USAGE	HGT CM	WDTH CM	THICK CM	Y-C CM	Z-C CM	ALPHA DEG	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	***** MOMENTS OF INERTIA ***** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	PRINCIPAL KY	KZ	BRACE LEN. M	SECT LEN. M
L15	1	NO	15.0	10.0	1.00	2.4	4.9	23.98	20.5	7.9	24.00	8.454	645.2	115.0	27.5	1.0	1.0	0.00	0.00

****** SACS IV SECTION DESCRIPTION ******

SECTION LABEL	TYPE	AREA	A	B	C	D	E	F
		CROSS SECTION DETAILS						
HE340A	WF	133.00	30.00	1.65	33.00	0.950	2.000	0.000
IPE330	WF	62.00	16.00	1.15	33.00	0.750	1.000	0.000
UPN220	CHL	37.00	22.00	8.00	0.90	1.250	2.000	1.000
L15X10	ANG	24.00	15.00	10.00	1.00	0.000	0.000	0.000

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8.2 BASIC LOAD CASES

8.2.1 Gravity Loads

The structural gravity loads of the stairs modelled steelwork are evaluated automatically by SACS utilizing the specified section properties, material weights and member lengths. The weight of not modelled structures including floor gratings and handrails have been applied to the structural model in the load condition WPER.

8.2.2 Live Loads

In addition to permanent loads, Area loads for local design are to be considered as per Table 8.1.

Area Use	Deck Flooring & Stringers	
	UDL (kN / m2)	CL (kN)
General Laydown and Storage Areas	15	22.5 (+10.0 for pipe support allowance)
Floor Areas in Deck	Actual equip. +5.0 in open areas or 15.0	22.5 (+10.0 for pipe support allowance)
Temporary Refuge	5	5
Walkways, Stairs and Access Platforms	4.5	4.5

Notes:

- Concentrated Loads (CL) are applied to an area of 100 mm x 100 mm, and at the most severe position, but not added to wheel loads or distributed loads;
- Uniformly Distributed Loads (UDL) and CL are not considered to act together, except 10 kN pipe support allowance is assumed to act with any load combination.
- Wheel loads to be added to distributed loads, where relevant. Wheel loads can normally be considered acting on an area of 300 mm x 300 mm.
- Trolley route location and loads to be extracted from Mechanical Handling layouts.

Table 8.1 – Superimposed Area Loads for Local Checks

For handrail the minimum service load applied horizontally to the top of the stanchion and then along the handrail, shall be:

Area Use	Load	Ref.
Service platforms	300 N/m, per max distance in m, between the axes of two successive stanchions	/19/
Escape routes	750 N/m, per max distance in m, between the axes of two successive stanchions	Client requirement (SHELL UK)

Table 8.2 – Loads for handrails Local Checks

A live load of 4.5kN/m² has been considered for stair elements, landings and walkways check in operating conditions. Live loads are included in load condition LIST.

Basic vertical loads are reported in the following table:

BASIC VERTICAL LOADS						
$q_{_GRATING\ 30X5}$	=	50	kg/m²	=	0.5	kN/m²
$q_{_HANDRAIL}$	=	40	kg/m	=	0.4	kN/m
$q_{_LIVE}$	=	450	kg/m²	=	4.5	kN/m²

Table 8.3 - Basic Vertical Loads

The computation of stairs and landings permanent and live loads for TP Stairs are reported in the following table 10.2.

STAIRS							
STRINGER LABEL	**Elevation**		**L (*)**	**B (*)**	**$G_{HANDRAIL}$ (= L x qHAND)**	**$G_{GRATING}$ (=L x B x qGRAT)**	**Q_{LIVE} (=L x B qLIVE)**
	from	**to**	**[m]**	**[m]**	**[kN]**	**[kN]**	**[kN]**
R1	26.81	30.31	6.05	1.2	4.84	3.63	32.67
R2	23.31	26.81	5.87	1.2	4.696	3.522	31.698
(*) L = stringer length, B = width of loaded area				**TOT**	**9.536**	**7.152**	**64.368**

STAIRS						
LANDING LABEL	**Elevation**	**L (*)**	**B (*)**	**$G_{HANDRAIL}$ (= L x qHAND)**	**$G_{GRATING}$ (=L x B x qGRAT)**	**Q_{LIVE} (=L x B qLIVE)**
	[m]	**[m]**	**[m]**	**[kN]**	**[kN]**	**[kN]**
P1	23.31	2	1.29	1.636	1.29	11.61
P2	26.81	4	1.3	3.28	2.6	23.4
P3	30.31	4	1.1	3.16	2.2	19.8
(*) L = length, B = width			**TOT**	**8.076**	**6.09**	**54.81**
			TOT Stringer + Landing	**17.612**	**13.242**	**119.178**

Table 8.4 - Tower Stairs Permanent and Live load detailed calculation

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Load conditions WPER and WFLO for permanent gravity loads of not modelled elements, and LIST, for live loads, are reported in the following figures.

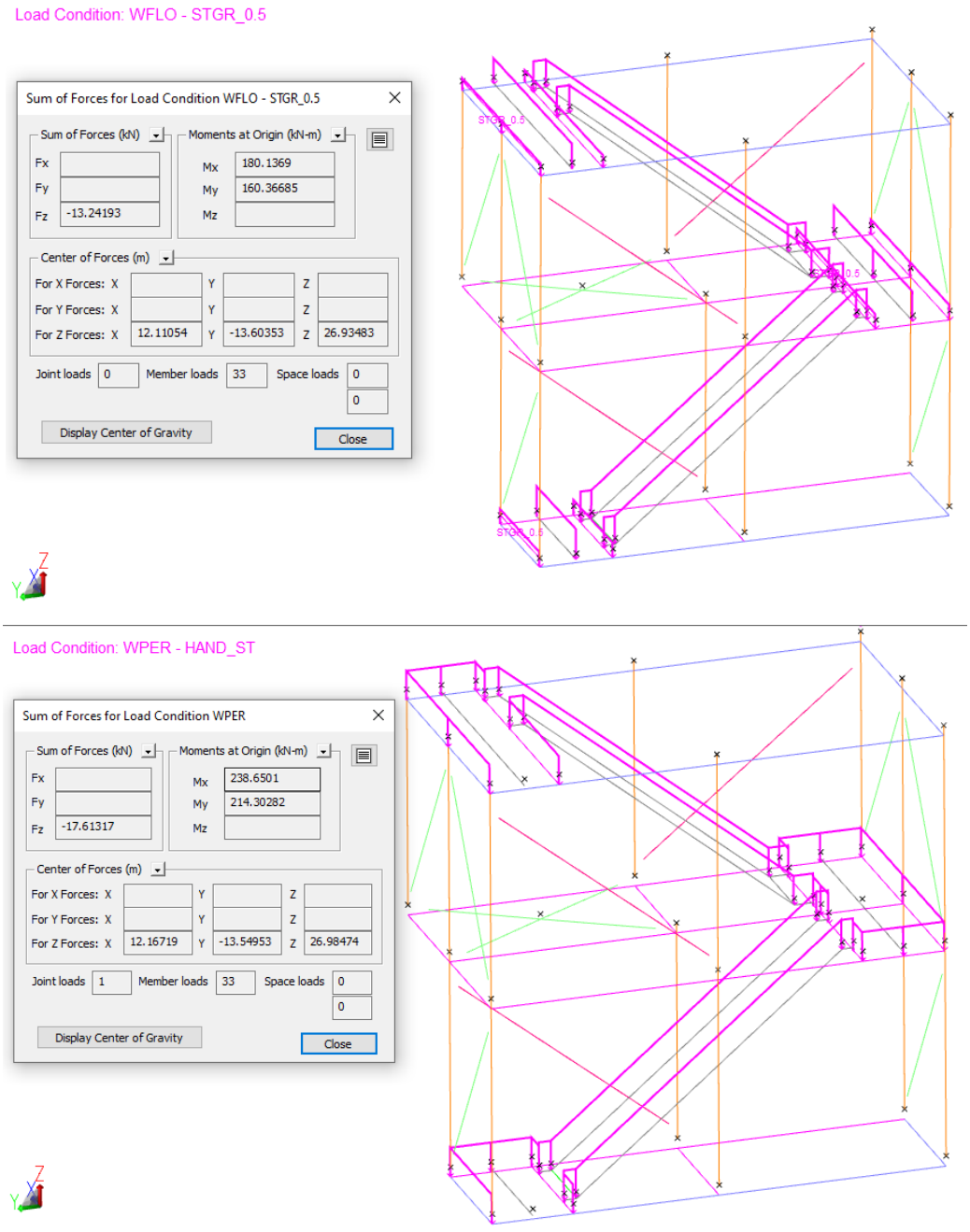


Figure 8.3 - Stairs - Permanent gravity loads of not modelled elements

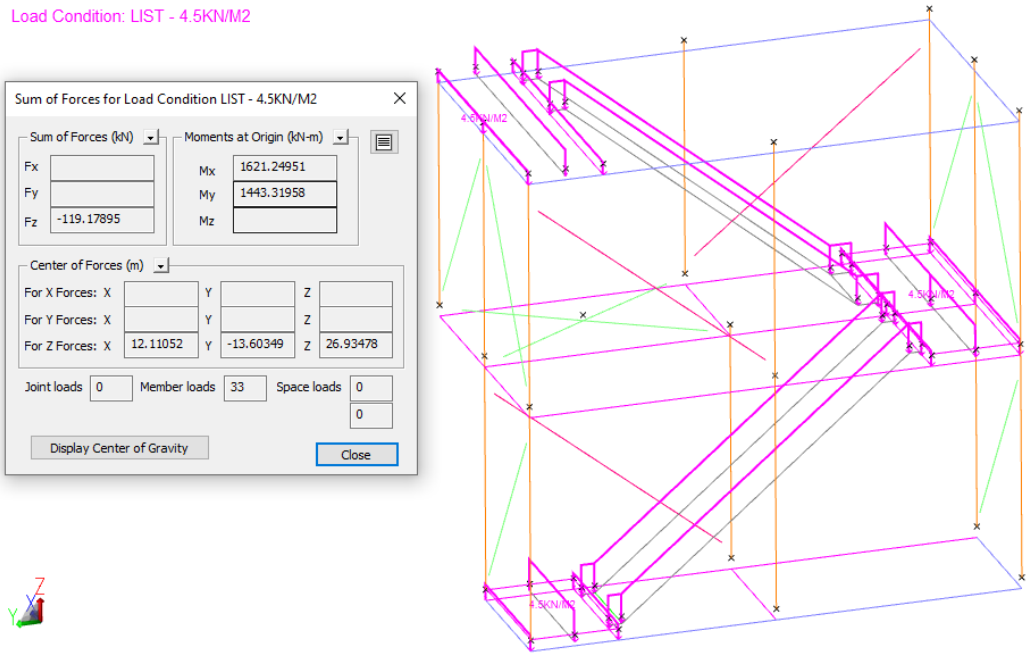


Figure 8.4 - Stairs - Live Loads

8.2.3 Wind Loads

Wind loads have been calculated according to ISO 19901-1 Ref. /2/ and Structural Design Basis, Ref-/28/ .

Wind forces on stair beams have been computed considering the 3 s gust wind velocity acting on member projected area with the proper shape coefficient from table 9.3 of Structural Design Basis. For the calculation of wind loads on beams, a shape factor of 1 has been considered.

3s GUST WIND LOADS	
Wind load conditions	Cs=1.0
qWIND_OPERATING (el. 30.31m)	0.80 kN/m2
qWIND_STORM (el. 30.31m)	1.34 kN/m2

Table 8.5 – wind pressure

The following uniform wind loads on beams have been considered:

- q_wind = 0.45 kN/m for operating conditions ;
- q_wind = 0.75 kN/m for storm conditions ;

Uniform wind load is assigned to stairs SACS model, based on max. wind pressure at the top of the structure, on the safe side.

Load conditions WOPA, WEXA, respectively for operating and storm wind loads in X direction, and load conditions WOPC, WEXC, respectively for operating and storm wind loads in Y direction, are reported in the following figures.

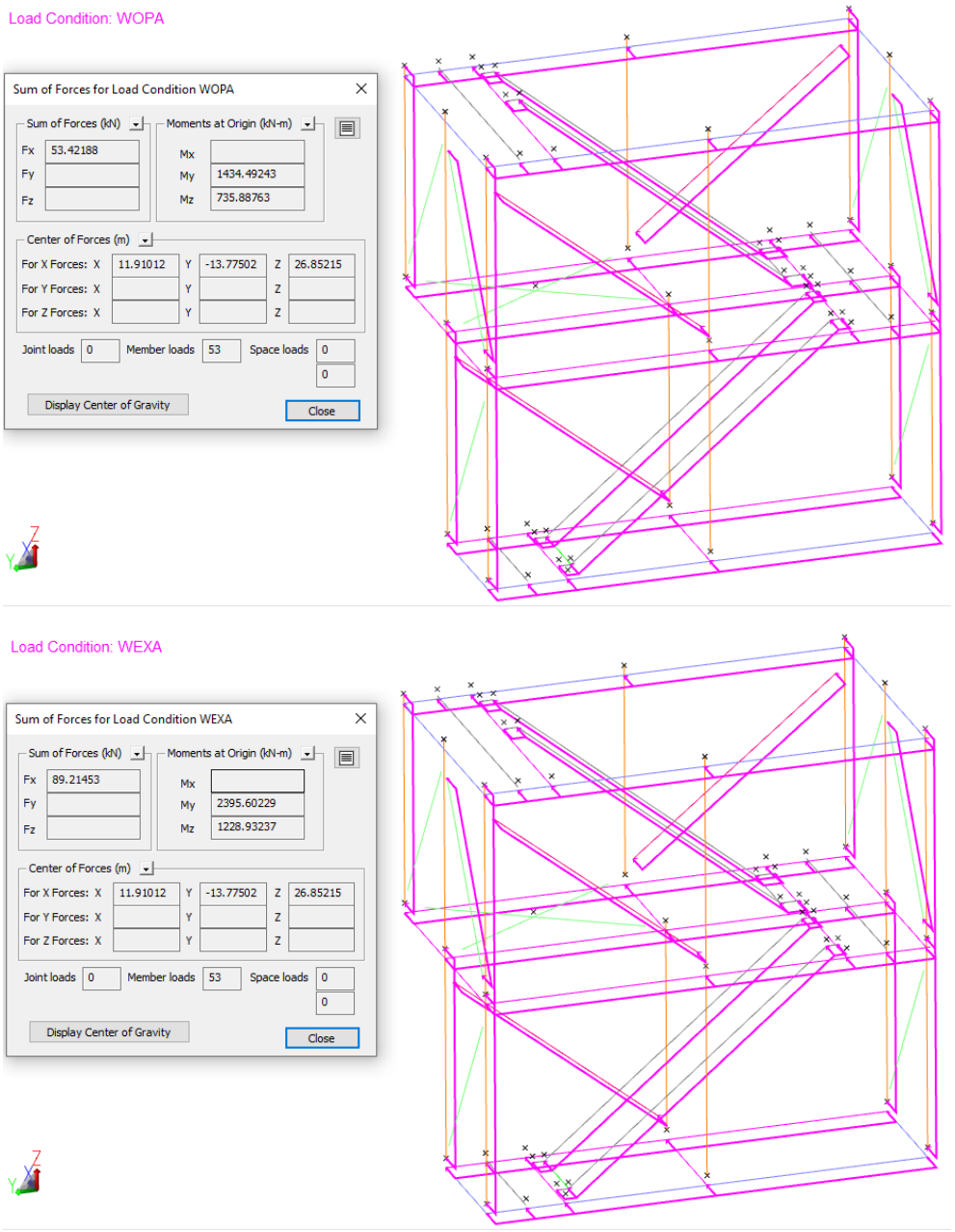


Figure 8.5 - Tower - Stairs - Operating and storm wind loads in X direction.

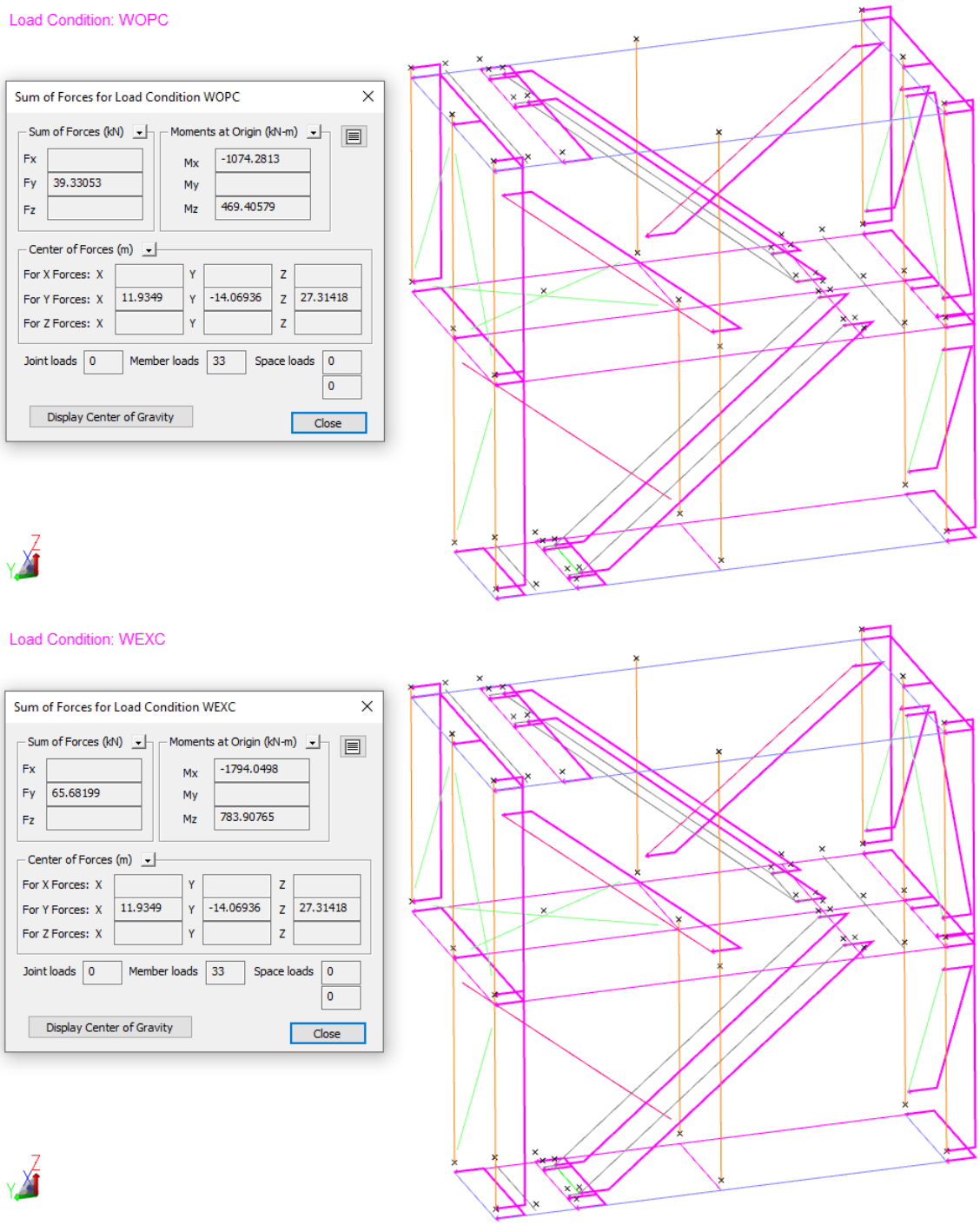


Figure 8.6 - Tower - Stairs - Operating and storm wind loads in Y direction

8.2.4 Ice And Snow Loads

Snow and ice build-up data on the platform are presented in section 5.

Three cases were considered:

1) Snow load build-up on horizontal surfaces (0.7 kN/m2 as per sec. 5.4).
2) Ice build-up on horizontal surfaces due to sea-spray (850 kg/m3 as per sec. 5). Build up is only considered on the windward side of the platform.
3) Atmospheric build-up ice (30 mm thickness as per sec. 5) on horizontal and vertical surfaces, due to snow and rain at 700 kg/m3 .

According to FEED, snow loads build-up on horizontal surfaces (case 1) and atmospheric build-up of 30 mm thick ice, on horizontal and vertical surfaces, due to snow and rain (case 3) are considered concurrent, though not accumulative on horizontal surfaces. Ice build-up on horizontal surfaces due to sea spray (case 2) is only considered on the windward side of the platform and as a separate load case, not concurrent with Snow load (case1) and atmospheric build-up (case3).

Table 8.6 – Ice and Snow Load

	Platform properties	
l	7.2	m
b	4	m

LC-1 Snow Load		
Area [m²]	Snow L. [kN/m²]	**Total Snow load[kN]**
28.8	0.7	**20.16**

LC -2 Sea Spray Load			
Area	denstiy	Thickness	**Total Spray Load**
[m²]	[kN/m³]	[m]	**[kN]**
50.4	8.3385	0.077	**32.36**

LC - 3 Ice by rain/snow			
Area	denstiy	Thickness	**Total ice Load**
[m²]	[kN/m³]	[m]	**[kN]**
121.2	6.867	0.03	**24.97**

QSIL	**LC1 + LC3**	**45.13**	**[kN]**

Snow and Ice loads have been applied in load condition QSIL as uniformly distributed loads at upper deck, intermediate deck and lower deck distributed 70%, 20% and 10% respectively.

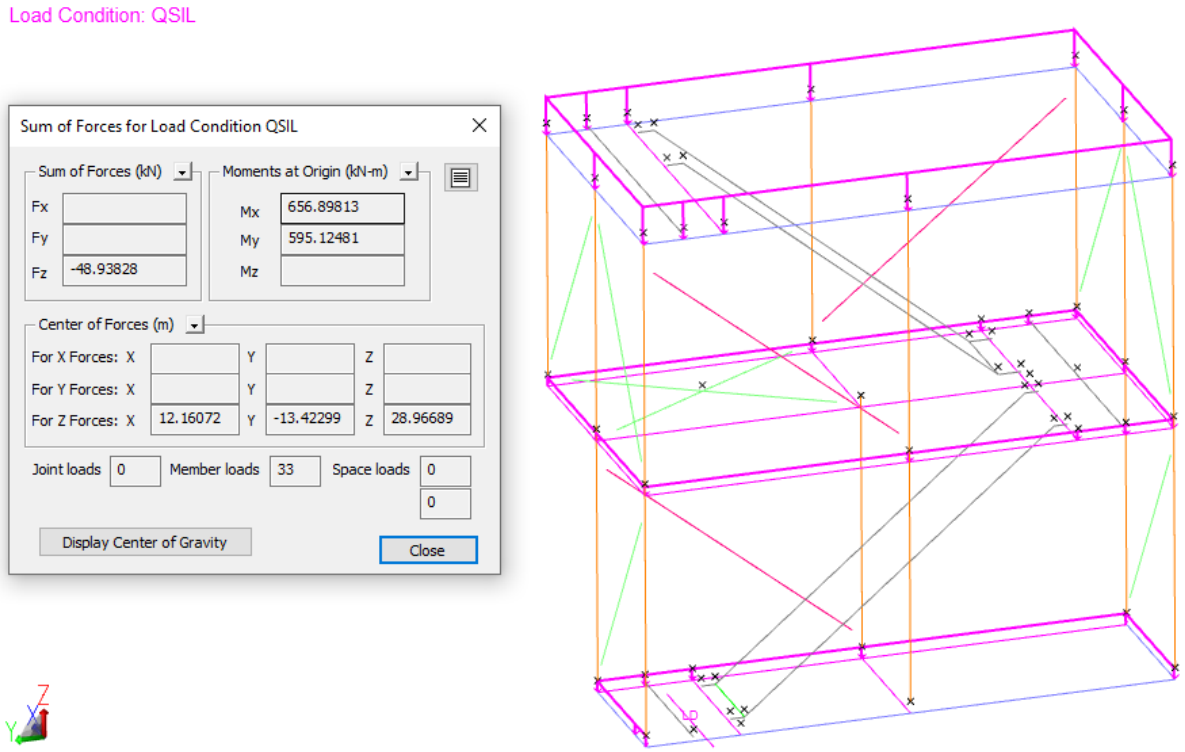


Figure 8.7 - Snow Load

8.3 BASIC LOAD CASES SUMMARY

Basic load conditions resulting forces are reported in the following SACS excerpt.

```
************* SEASTATE LOAD CASE CENTER REPORT *************
                    RELATIVE TO STRUCTURAL ORIGIN
LOAD  LOAD      ********* X - DIRECTION *********      ********* Y - DIRECTION *********      ********* Z - DIRECTION *********
CASE  LABEL      FORCE      X        Y        Z         FORCE      X        Y        Z         FORCE      X        Y        Z
                 (KN)       (M)      (M)      (M)       (KN)       (M)      (M)      (M)       (KN)       (M)      (M)      (M)

   1  DEAZ         0.00                                   0.00                                -633.67     6.25   -13.35    26.59
   2  DZTO         0.00                                   0.00                                -633.48     6.25   -13.35    26.59
   3  EQSP         0.00                                   0.00                                -181.13     3.50   -14.44    27.30
   4  EQXP      3098.85     6.19   -14.05    26.07         0.00                                   0.00
   5  EQYP         0.00                                3098.85     6.19   -14.05    26.07        0.00
   6  EQZN         0.00                                   0.00                               -3098.84     6.19   -14.05    26.07
   7  QSIL         0.00                                   0.00                                -247.40     5.97   -14.36    27.95
   8  TTNX      -178.79     9.16   -12.97    26.29         0.00                                   0.00
   9  TTPY         0.00                                 118.57     4.15   -19.64    26.93        0.00
  10  WFLO         0.00                                   0.00                                -195.52     4.64   -14.39    26.30
  11  WPER         0.00                                   0.00                                -208.56     7.01   -15.18    25.93
```

12	WSOX	53.42	11.91	-13.78	26.85	0.00				0.00			
13	WSOY	0.00				39.55	11.92	-14.05	27.29	0.00			
14	LIST	0.00				0.00				-119.18	12.11	-13.60	26.93
15	LILD	0.00				0.00				-3105.00	4.14	-14.51	26.76
16	LIWW	0.00				0.00				-182.25	8.75	-14.75	26.64
17	DEAC	0.00				0.00				-63.35	6.25	-13.35	26.59
18	G001	0.00				0.00				-1399.26	5.69	-14.02	26.53
19	Q001	0.00				0.00				-3676.61	4.78	-14.48	26.84
20	STAT	0.00				0.00				-5075.87	5.03	-14.36	26.76
21	WOPX	53.42	11.91	-13.78	26.85	0.00				0.00			
22	WONX	-53.42	11.91	-13.78	26.85	0.00				0.00			
23	WOPY	0.00				39.55	11.92	-14.05	27.29	0.00			
24	WONY	0.00				-39.55	11.92	-14.05	27.29	0.00			
25	WOPA	53.42	11.91	-13.78	26.85	0.00				0.00			
26	WOPB	37.77	11.91	-13.78	26.85	27.96	11.92	-14.05	27.29	0.00			
27	WOPC	0.00				39.55	11.92	-14.05	27.29	0.00			
28	WOPD	-37.77	11.91	-13.78	26.85	27.96	11.92	-14.05	27.29	0.00			
29	WOPE	-53.42	11.91	-13.78	26.85	0.00				0.00			
30	WOPF	-37.77	11.91	-13.78	26.85	-27.96	11.92	-14.05	27.29	0.00			
31	WOPG	0.00				-39.55	11.92	-14.05	27.29	0.00			
32	WOPH	37.77	11.91	-13.78	26.85	-27.96	11.92	-14.05	27.29	0.00			
33	WEXA	89.21	11.91	-13.78	26.85	0.00				0.00			
34	WEXB	63.07	11.91	-13.78	26.85	46.70	11.92	-14.05	27.29	0.00			
35	WEXC	0.00				66.05	11.92	-14.05	27.29	0.00			
36	WEXD	-63.07	11.91	-13.78	26.85	46.70	11.92	-14.05	27.29	0.00			
37	WEXE	-89.21	11.91	-13.78	26.85	0.00				0.00			
38	WEXF	-63.07	11.91	-13.78	26.85	-46.70	11.92	-14.05	27.29	0.00			
39	WEXG	0.00				-66.05	11.92	-14.05	27.29	0.00			
40	WEXH	63.07	11.91	-13.78	26.85	-46.70	11.92	-14.05	27.29	0.00			
41	AOPX	211.65	6.19	-14.05	26.07	0.00				0.00			
42	AOPY	0.00				211.65	6.19	-14.05	26.07	0.00			
43	AOPA	211.65	6.19	-14.05	26.07	0.00				0.00			
44	AOPB	149.64	6.19	-14.05	26.07	149.64	6.19	-14.05	26.07	0.00			
45	AOPC	0.00				211.65	6.19	-14.05	26.07	0.00			
46	AOPD	-149.64	6.19	-14.05	26.07	149.64	6.19	-14.05	26.07	0.00			
47	AOPE	-211.65	6.19	-14.05	26.07	0.00				0.00			
48	AOPF	-149.64	6.19	-14.05	26.07	-149.64	6.19	-14.05	26.07	0.00			
49	AOPG	0.00				-211.65	6.19	-14.05	26.07	0.00			
50	AOPH	149.64	6.19	-14.05	26.07	-149.64	6.19	-14.05	26.07	0.00			
51	AEXX	508.52	6.19	-14.05	26.07	0.00				0.00			
52	AEXY	0.00				508.52	6.19	-14.05	26.07	0.00			
53	AEXA	508.52	6.19	-14.05	26.07	0.00				0.00			
54	AEXB	359.52	6.19	-14.05	26.07	359.52	6.19	-14.05	26.07	0.00			
55	AEXC	0.00				508.52	6.19	-14.05	26.07	0.00			
56	AEXD	-359.52	6.19	-14.05	26.07	359.52	6.19	-14.05	26.07	0.00			
57	AEXE	-508.52	6.19	-14.05	26.07	0.00				0.00			
58	AEXF	-359.52	6.19	-14.05	26.07	-359.52	6.19	-14.05	26.07	0.00			
59	AEXG	0.00				-508.52	6.19	-14.05	26.07	0.00			
60	AEXH	359.52	6.19	-14.05	26.07	-359.52	6.19	-14.05	26.07	0.00			

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8.4 LOAD COMBINATIONS

The below load combinations have been considered for stairs checks:

- G001 : basic dead loads combination;
- Q001 : basic live loads combination;
- STAT : basic dead and live loads combination;
- ON2(A-H) : permanent, live load and operating environmental loads combination(ULS);
- EN3(A-H) : permanent, live load and extreme environmental loads combination(ULS);
- DN2(A-H) : permanent, live load and operating environmental loads combination(SLS);
- EN4(A-H) : permanent, live load and operating environmental loads combination(reduced);

Permanent Loads Basic Load Combinations G001		
Basic Load cases	Description	Load Factors
DEAZ	MODELLED STRUCTURAL ELEMENTS WEIGHT	1.00
WFLO	FLOORING AND GRATING PERMANENT LOADS	1.20
WPER	SEC & TERT STRUCTURAL PERMANENT LOADS	1.20

Variable Loads Basic Load Combinations Q001		
Basic Load cases	Description	Load Factors
LIST	STAIRS LIVE LOADS (4.5KN/M2)	1.00
QSIL	ICE AND SNOW LOADS	1.00

Table 8.7 - Basic Load Combinations

The same sets of load combinations already defined for Deck In-Service Analysis, ISO 19902 have been considered for stairs checks, taking into account:

- Operating and extreme environmental conditions;
- Live and dead loads.

Load combinations resultant forces are reported in the following Sacs excerpt. Refer to Deck In-Service Analysis , for load combination description.

********** SEASTATE LOAD CASE CENTER REPORT **********
RELATIVE TO STRUCTURAL ORIGIN

LOAD CASE	LOAD LABEL	********* X - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Y - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Z - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)
61	ON10	0.00				0.00				-7333.95	5.01	-14.37	26.76
62	ON2A	340.32	7.29	-14.00	26.22	0.00				-7333.95	5.01	-14.37	26.76
63	ON2B	240.61	7.29	-14.00	26.22	228.64	7.05	-14.05	26.25	-7333.95	5.01	-14.37	26.76
64	ON2C	0.00				323.40	7.05	-14.05	26.25	-7333.95	5.01	-14.37	26.76

65	ON2D	-240.61	7.29	-14.00	26.22	228.64	7.05	-14.05	26.25	-7333.95	5.01	-14.37	26.76
66	ON2E	-340.32	7.29	-14.00	26.22	0.00				-7333.95	5.01	-14.37	26.76
67	ON2F	-240.61	7.29	-14.00	26.22	-228.64	7.05	-14.05	26.25	-7333.95	5.01	-14.37	26.76
68	ON2G	0.00				-323.40	7.05	-14.05	26.25	-7333.95	5.01	-14.37	26.76
69	ON2H	240.61	7.29	-14.00	26.22	-228.64	7.05	-14.05	26.25	-7333.95	5.01	-14.37	26.76
70	EN3A	857.79	6.99	-14.02	26.18	0.00				-5075.87	5.03	-14.36	26.76
71	EN3B	606.46	6.99	-14.02	26.18	584.35	6.81	-14.05	26.20	-5075.87	5.03	-14.36	26.76
72	EN3C	0.00				826.52	6.81	-14.05	26.20	-5075.87	5.03	-14.36	26.76
73	EN3D	-606.46	6.99	-14.02	26.18	584.35	6.81	-14.05	26.20	-5075.87	5.03	-14.36	26.76
74	EN3E	-857.79	6.99	-14.02	26.18	0.00				-5075.87	5.03	-14.36	26.76
75	EN3F	-606.46	6.99	-14.02	26.18	-584.35	6.81	-14.05	26.20	-5075.87	5.03	-14.36	26.76
76	EN3G	0.00				-826.52	6.81	-14.05	26.20	-5075.87	5.03	-14.36	26.76
77	EN3H	606.46	6.99	-14.02	26.18	-584.35	6.81	-14.05	26.20	-5075.87	5.03	-14.36	26.76
78	EN4A	857.79	6.99	-14.02	26.18	0.00				-4200.62	5.05	-14.35	26.75
79	EN4B	606.46	6.99	-14.02	26.18	584.35	6.81	-14.05	26.20	-4200.62	5.05	-14.35	26.75
80	EN4C	0.00				826.52	6.81	-14.05	26.20	-4200.62	5.05	-14.35	26.75
81	EN4D	-606.46	6.99	-14.02	26.18	584.35	6.81	-14.05	26.20	-4200.62	5.05	-14.35	26.75
82	EN4E	-857.79	6.99	-14.02	26.18	0.00				-4200.62	5.05	-14.35	26.75
83	EN4F	-606.46	6.99	-14.02	26.18	-584.35	6.81	-14.05	26.20	-4200.62	5.05	-14.35	26.75
84	EN4G	0.00				-826.52	6.81	-14.05	26.20	-4200.62	5.05	-14.35	26.75
85	EN4H	606.46	6.99	-14.02	26.18	-584.35	6.81	-14.05	26.20	-4200.62	5.05	-14.35	26.75
86	DN10	0.00				0.00				-5075.87	5.03	-14.36	26.76
87	DN2A	265.07	7.34	-14.00	26.23	0.00				-5075.87	5.03	-14.36	26.76
88	DN2B	187.41	7.34	-14.00	26.23	177.60	7.09	-14.05	26.26	-5075.87	5.03	-14.36	26.76
89	DN2C	0.00				251.20	7.09	-14.05	26.26	-5075.87	5.03	-14.36	26.76
90	DN2D	-187.41	7.34	-14.00	26.23	177.60	7.09	-14.05	26.26	-5075.87	5.03	-14.36	26.76
91	DN2E	-265.07	7.34	-14.00	26.23	0.00				-5075.87	5.03	-14.36	26.76
92	DN2F	-187.41	7.34	-14.00	26.23	-177.60	7.09	-14.05	26.26	-5075.87	5.03	-14.36	26.76
93	DN2G	0.00				-251.20	7.09	-14.05	26.26	-5075.87	5.03	-14.36	26.76
94	DN2H	187.41	7.34	-14.00	26.23	-177.60	7.09	-14.05	26.26	-5075.87	5.03	-14.36	26.76

8.4.1 Member Check

All members were checked according to ISO 19902 and Eurocode 3, Ref./2/ and /10/, respectively for tubular and non-tubular elements. Members' code checks are reported in the following and show that the structure can withstand all In-Service load combinations, with utilization factors below 1.0.

The maximum UC value is equal to 0.824 on member TF05-TS14 for load combination EN3E. Maximum member UC are reported in following SACS excerpt and figures.

SACS-IV MEMBER UNITY CHECK RANGE SUMMARY
GROUP II - UNITY CHECKS GREATER THAN 0.70 AND LESS THAN 1.00

MEMBER	GROUP ID	MAXIMUM COMBINED UNITY CK	LOAD COND NO.	DIST FROM END	AXIAL STRESS N/MM2	BENDING STRESS Y N/MM2	BENDING STRESS Z N/MM2	SHEAR FORCE FY KN	SHEAR FORCE FZ KN	KLY/RY	KLZ/RZ	SECOND-HIGHEST UNITY CHECK	SECOND-HIGHEST LOAD COND	THIRD-HIGHEST UNITY CHECK	THIRD-HIGHEST LOAD COND
TF05-TS14	S07	0.824	EN3E	2.7	-1.76	-54.31	202.54	0.13	0.28	68.8	86.7	0.817	EN3A	0.772	EN4E
TF06-TS15	S07	0.817	EN3E	2.7	1.38	54.24	-202.67	-0.13	0.20	68.8	86.7	0.816	EN3A	0.765	EN4E

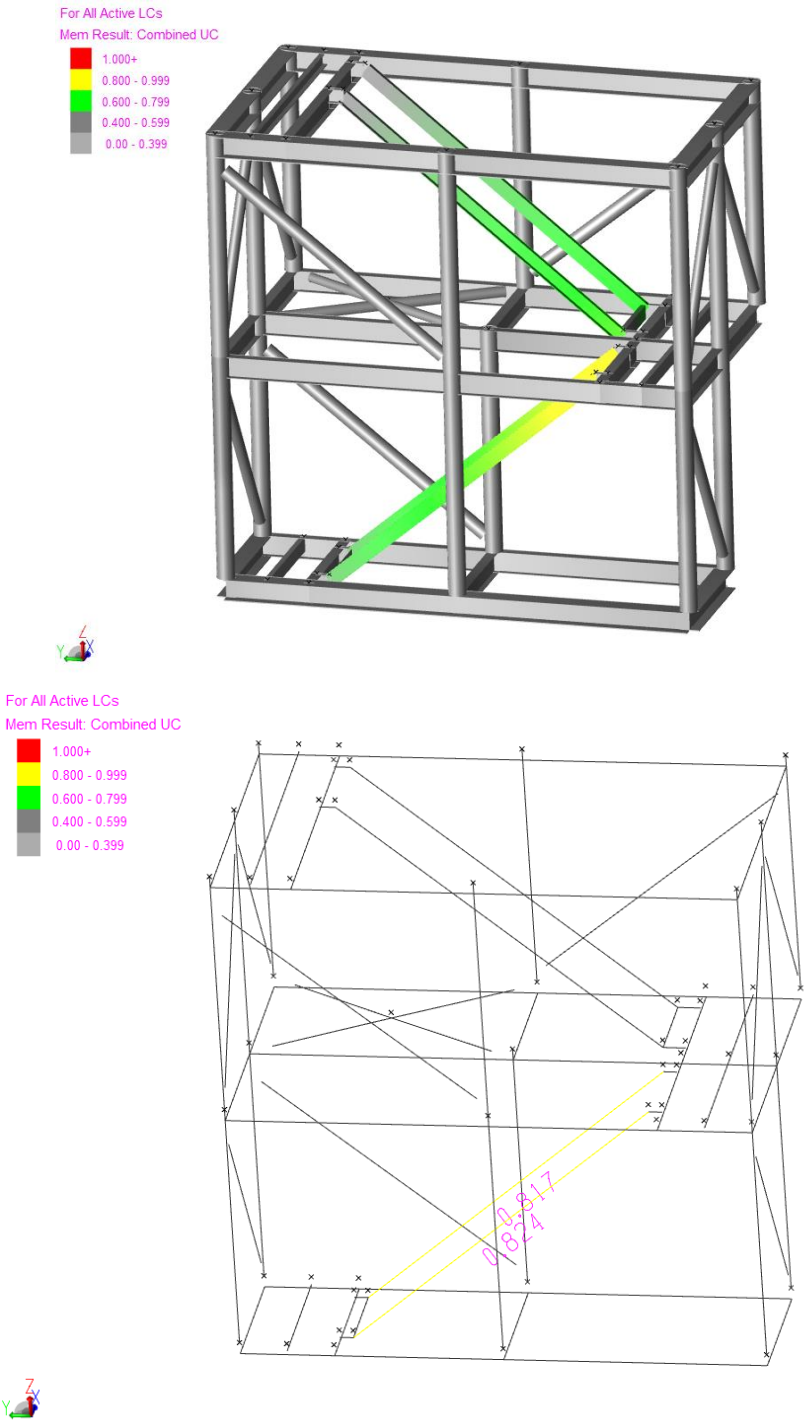


Figure 8.8 - Tower - Stairs Structural Model 3D View - UC>0.7

8.4.2 Tubular Joints Check

All tubular joints punching shear checks and strength checks are detailed in following SACS excerpt and provide utilization factors lower than 1.0, according to ISO19902, ref. /7/.

* * J O I N T   C A N   S U M M A R Y * *
(UNITY CHECK ORDER)

	**************** ORIGINAL ******************					************ LOAD DESIGN ***********				*** STRENGTH ANALYSIS ****		
JOINT	DIAMETER (CM)	THICKNESS (CM)	YLD STRS (N/MM2)	LOAD UC	STRN UC	DIAMETER (CM)	THICKNESS (CM)	YLD STRS (N/MM2)	LOAD UC	STRN UC	BRACE JOINT	LOAD CASE
TC03	27.310	0.927	355.000	0.284	0.332	27.310	0.927	355.000	0.284	0.332	TS18	EN3H
TF14	27.310	0.927	355.000	0.208	0.244	27.310	0.927	355.000	0.208	0.244	TS22	ON2D
TS22	27.310	0.927	355.000	0.201	0.235	27.310	0.927	355.000	0.201	0.235	TF14	ON2C
TT03	27.310	0.927	355.000	0.188	0.220	27.310	0.927	355.000	0.188	0.220	TS20	EN3B
TT15	27.310	0.927	355.000	0.181	0.212	27.310	0.927	355.000	0.181	0.212	TS22	ON2H
TS23	27.310	0.927	355.000	0.174	0.204	27.310	0.927	355.000	0.174	0.204	TF04	EN4G
TS01	27.310	0.927	355.000	0.171	0.200	27.310	0.927	355.000	0.171	0.200	TF02	EN3F
TT02	27.310	0.927	355.000	0.157	0.183	27.310	0.927	355.000	0.157	0.183	TS01	EN3A
TF02	27.310	0.927	355.000	0.146	0.171	27.310	0.927	355.000	0.146	0.171	TS01	ON2F
TF04	27.310	0.927	355.000	0.133	0.156	27.310	0.927	355.000	0.133	0.156	TS23	EN4G
TS18	27.310	0.927	355.000	0.115	0.135	27.310	0.927	355.000	0.115	0.135	TC03	EN3H
TS03	27.310	0.927	355.000	0.111	0.130	27.310	0.927	355.000	0.111	0.130	TT02	EN3H
TS20	27.310	0.927	355.000	0.102	0.120	27.310	0.927	355.000	0.102	0.120	TT03	EN3B
TS24	27.310	0.927	355.000	0.087	0.101	27.310	0.927	355.000	0.087	0.101	TT15	ON2B
TS21	16.830	0.711	355.000	0.067	0.078	16.830	0.711	355.000	0.067	0.078	TS19	EN3D

8.4.3 Deflection Checks

Deflection checks are performed for all the beams considering serviceability limit state load condition. The results of the deflection checks are presented in the following SACS excerpt in terms of ratios between beam span and vertical deflection for the critical combinations.

*** SPAN DEFLECTION SUMMARY REPORT **

					************* LOCAL Y DIRECTION **************					************** LOCAL Z DIRECTION *************				
SPAN ID	CANT	BEGIN JOINT	END JOINT	SPAN LENGTH M	MAX. LOAD CASE	MAXIMUM DEFL. CM	DISTANCE ALONG SPAN M	DEFL/SPAN RATIO	SPAN/DEFL RATIO	MAX. LOAD CASE	MAXIMUM DEFL. CM	DISTANCE ALONG SPAN M	DEFL/SPAN RATIO	SPAN/DEFL RATIO
C002	YES	L048	TC02	2.20	DN2C	0.231	2.20	0.0005	1908.2	DN2D	0.39	2.20	0.0009	1126.1
C003	YES	U096	TC04	2.20	DN2G	0.237	2.20	0.0005	1858.6	DN2F	0.07	2.20	0.0002	6305.7
C004	YES	U116	TC03	2.20	DN2C	0.191	2.20	0.0004	2307.5	DN2D	0.16	2.20	0.0004	2733.6
LH04	NO	TF03	TC02	3.60	DN2C	0.087	2.01	0.0002	4149.9	DN2C	0.04	1.69	0.0001	9181.6
LI01	NO	TF04	TF03	2.00	DN2C	0.043	1.50	0.0002	4616.8	DN2G	0.01	0.74	0.0000	25159.8
LI02	NO	TF04	TF02	3.60	DN2C	0.073	2.56	0.0002	4956.6	DN2G	0.01	0.79	0.0000	32528.2
LI03	NO	TF14	TF04	3.60	DN2C	0.092	1.54	0.0003	3929.0	DN2C	0.05	1.73	0.0001	6757.2
SI01	NO	TS01	TS02	2.00	DN2G	0.017	1.54	0.0001	11668.4	DN2F	0.01	0.74	0.0001	16566.3
SI02	NO	TS03	TS02	2.00	DN2G	0.020	1.28	0.0001	10112.8	DN2A	0.01	0.88	0.0000	28991.4
SI04	NO	TS20	TS19	2.00	DN2C	0.017	0.54	0.0001	11776.6	DN2G	0.01	1.06	0.0000	36291.7
SI05	NO	TS22	TS23	2.00	DN2G	0.027	1.44	0.0001	7295.7	DN2D	0.02	0.76	0.0001	12473.8
SI06	NO	TS23	TS24	2.00	DN2G	0.013	0.70	0.0001	15323.4	DN2D	0.01	1.26	0.0000	36024.2
SI07	NO	TS01	TS18	3.60	DN2H	0.082	2.04	0.0002	4382.2	DN2B	0.03	1.97	0.0001	12032.0
SI08	NO	TS18	TS22	3.60	DN2G	0.093	2.12	0.0003	3875.5	DN2D	0.01	0.94	0.0000	41791.5
SI09	NO	TS03	TS20	3.60	DN2H	0.113	1.53	0.0003	3180.1	DN2A	0.05	1.71	0.0001	7033.2

SI10	NO	TS20	TS24	3.60	DN2B	0.050	1.51	0.0001	7193.4	DN2C	0.01	2.81	0.0000	33549.2
SI11	NO	TS02	TS19	3.60	DN2H	0.117	1.62	0.0003	3074.0	DN2F	0.08	1.69	0.0002	4323.6
SI12	NO	TS19	TS23	3.60	DN2F	0.046	1.76	0.0001	7905.6	DN2D	0.01	2.20	0.0000	34054.8
SS01	NO	TF08	TS08	5.87	DN2E	4.335	3.98	0.0074	135.4	DN2G	0.99	2.94	0.0017	595.3
SS02	NO	TF09	TS09	5.87	DN2E	4.284	3.93	0.0073	137.0	DN2G	0.99	2.99	0.0017	591.5
SS03	NO	TT09	TS11	6.05	DN2E	24.327	5.74	0.0402	24.9	DN2C	1.11	3.04	0.0018	545.8
SS04	NO	TT10	TS12	6.05	DN2E	24.316	5.74	0.0402	24.9	DN2C	1.10	2.98	0.0018	552.2
UH01	NO	TC04	TT02	2.00	DN2B	0.012	0.66	0.0001	17362.1	DN2A	0.01	0.98	0.0000	21946.7
UH02	NO	TT02	TT03	2.00	DN2C	0.026	1.08	0.0001	7796.3	DN2F	0.00	0.78	0.0000	103021.0
UH03	NO	TC04	TT04	3.60	DN2G	0.073	1.51	0.0002	4945.3	DN2C	0.02	2.30	0.0000	21898.9
UH04	NO	TT04	TC03	3.60	DN2C	0.072	2.00	0.0002	5000.6	DN2C	0.04	1.87	0.0001	8798.2
UH07	NO	TT05	TT16	3.60	DN2C	0.051	1.92	0.0001	7084.7	DN2C	0.05	1.90	0.0001	6773.7
UH08	NO	TT03	TT05	3.60	DN2C	0.031	1.37	0.0001	11490.1	DN2D	0.01	2.12	0.0000	29744.2
UI01	NO	TT08	TT11	4.00	DN2G	0.095	2.53	0.0002	4200.1	DN2G	0.13	2.15	0.0003	3080.2
UU01	NO	TT13	TT12	4.00	DN2G	0.114	2.00	0.0003	3520.9	DN2D	0.19	2.00	0.0005	2078.5
C001	YES	L00D	TC01	2.20	DN2C	0.225	2.20	0.0005	1952.9	DN2F	0.43	2.20	0.0010	1013.7
LH01	NO	TC01	TF02	2.00	DN2G	0.012	0.70	0.0001	17362.5	DN2G	0.03	0.90	0.0002	6118.5
LH03	NO	TF03	TC01	3.60	DN2C	0.081	2.23	0.0002	4443.4	DN2C	0.02	1.44	0.0001	19212.3
LH02	NO	TC02	TF14	2.00	DN2H	0.007	0.68	0.0000	30480.9	DN2D	0.04	0.90	0.0002	5370.5
LI04	NO	TF07	TF10	2.00	DN2G	0.021	1.48	0.0001	9749.7	DN2C	0.02	0.94	0.0001	13330.5
LU01	NO	TF11	TF12	2.00	DN2C	0.012	1.00	0.0001	16965.2	DN2B	0.01	1.00	0.0001	13548.0
SI03	NO	TS07	TS13	4.00	DN2G	0.147	1.85	0.0004	2723.9	DN2G	0.06	1.64	0.0001	6692.7
UH05	NO	TC03	TT15	2.00	DN2C	0.008	0.70	0.0000	24023.6	DN2C	0.01	0.90	0.0001	14745.3
UH06	NO	TT15	TT16	2.00	DN2C	0.012	1.14	0.0001	16024.4	DN2E	0.00	0.58	0.0000	113802.6

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9 TRANSITION PIECE STAIRS DESIGN & LOADS

9.1 STRUCTURAL MODEL

The structural checks of beam member elements and tubular joints of the stairs have been performed with the software SACS, Ref-/54/, introducing the relative structural elements in the three-dimensional structural model of the BLPH Topside and TP In-Service Analysis.

The model geometry is referred to a right-handed orthogonal Cartesian coordinate reference system.

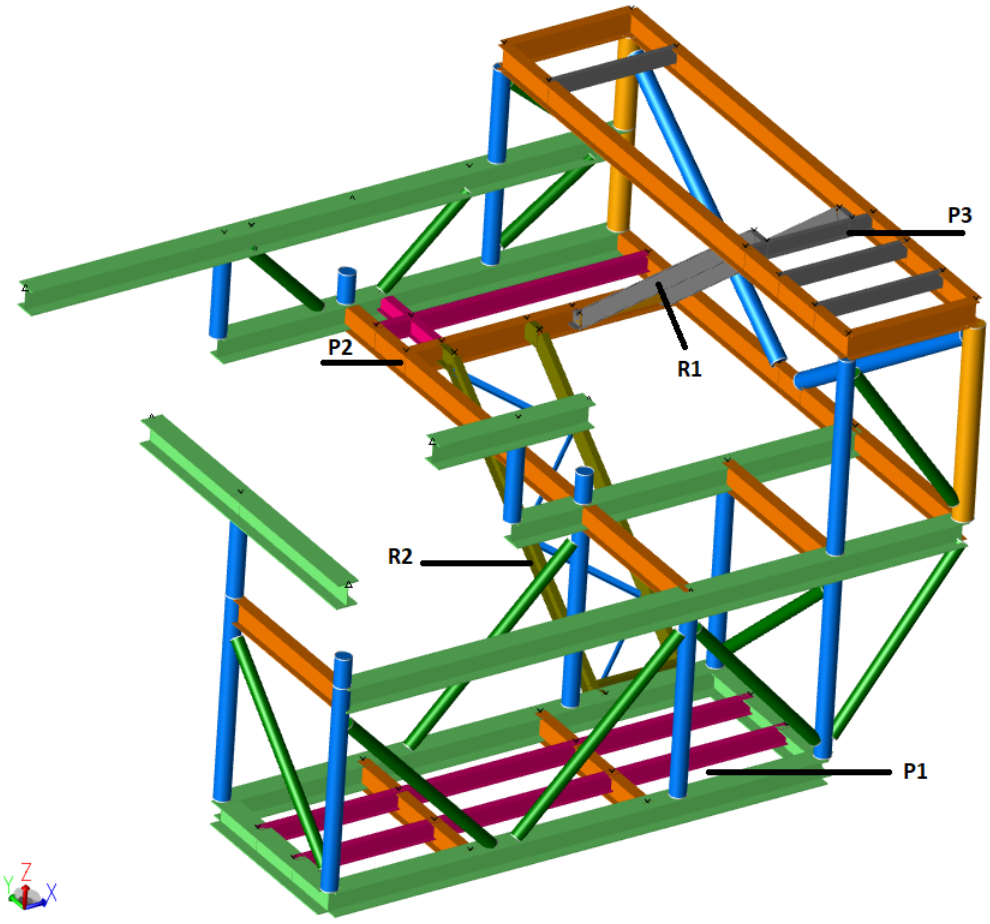


Figure 9.1 - TP - Stairs - 3D View

The Transition piece 3D-model particular of the stairs is represented in the following figures. Joint and member group labels are reported in appendix B.

Member Label : AB Release

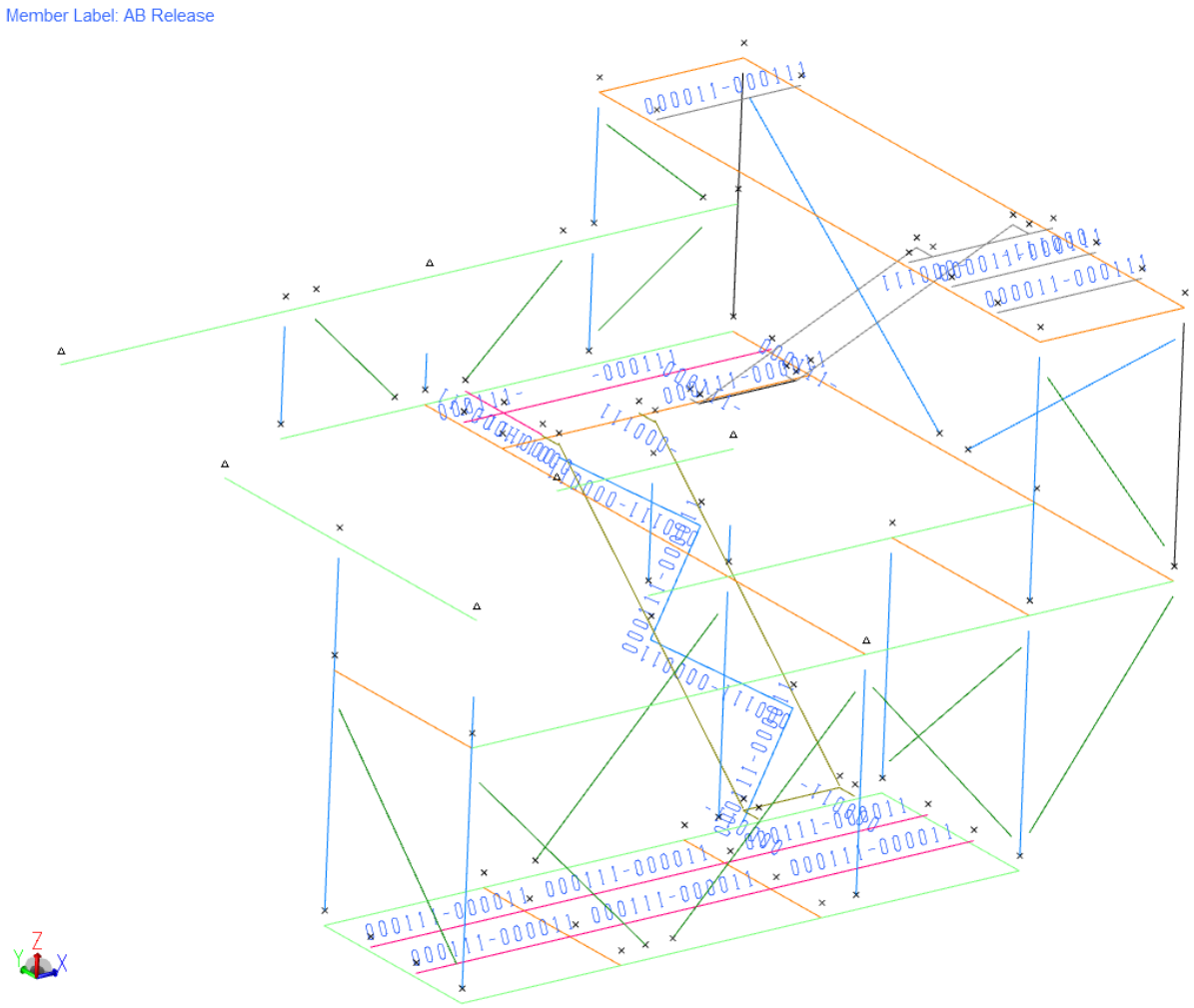


Figure 9.2 - TP - Stairs - Member Release

Structural model members group are shown in the following SACS output excerpt.

TUBULAR MEMBER PROPERTIES

GRP	M/S	JOINT THICK M	WALL THICK CM	OUTSIDE DIAM. CM	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	***** MOMENTS OF INERTIA **** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	KY	KZ	SHEAR AREA CM**2	RING SPACE M	SECT LENG M	TAPER
ST3	1	0.00	0.711	16.83	20.5	7.9	36.005	2343.3	1171.6	1171.6	35.5	1.0	1.0	18.00	0.00	0.00	
ST4	1	0.00	1.270	27.31	20.5	7.9	103.90	17654.	8827.2	8827.2	35.5	1.0	1.0	51.95	0.00	0.00	
ST5	1	0.00	1.031	21.91	20.5	7.9	67.627	7388.2	3694.1	3694.1	35.5	1.0	1.0	33.81	0.00	0.00	

WIDE FLANGE/WIDE FLANGE COMPACT,MEMBER PROPERTIES

GRP	M/S	** FLANGE ** THICK CM	WIDTH CM	WEB THICK CM	FILET RAD. CM	DEPTH CM	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	**** MOMENTS OF INERTIA **** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	KY	KZ	FLANGE-BRC TOP M	BOT M	SECT LEN M	TPR
HA3	1	1.65	30.00	0.950	0.950	33.00	20.5	7.9	129.0	124.9	0.2768E+05	7409.	35.5	1.0	1.0	0.0	0.0	0.00	
IP2	1	0.98	12.00	0.620	1.000	24.00	20.5	7.9	39.00	12.00	3891.	283.0	35.5	1.0	1.0	0.0	0.0	0.00	
IP3	1	1.15	16.00	0.750	0.750	33.00	20.5	7.9	62.00	28.00	0.1177E+05	788.0	35.5	1.0	1.0	0.0	0.0	0.00	

ANGLE MEMBER PROPERTIES

GRP	M S	STIFN USAGE	HGT CM	WDTH CM	THICK CM	Y-C CM	Z-C CM	ALPHA DEG	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	***** MOMENTS OF INERTIA ***** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	PRINCIPAL KY	KZ	BRACE LEN. M	SECT LEN. M
L15	1	NO	15.0	10.0	1.00	2.4	4.9	23.98	20.5	7.9	24.00	8.454	645.2	115.0	27.5	1.0	1.0	0.00	0.00
L10	1	NO	8.0	6.0	0.80	1.6	2.6	28.78	20.5	7.9	10.56	2.386	81.99	17.45	27.5	1.0	1.0	0.00	0.00

CHANNEL MEMBER REPORT

GRP	M S	STIFN USAGE	HEIGHT CM	WIDTH CM	WEB THICK CM	FLANGE THICK CM	Y-BAR CM	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	***** MOMENTS OF INERTIA ***** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	KY	KZ	BRACE LEN. M	SECT LEN. M
UN2	1	NO	22.00	8.00	0.900	1.250	2.3	20.5	7.9	37.55	15.12	2712.	225.7	27.5	1.0	1.0	0.0	0.00
UN3	1	NO	26.00	9.00	1.000	1.400	0.0	20.5	7.9	48.00	25.00	4820.	317.0	27.5	1.0	1.0	0.0	0.00

****** SACS IV SECTION DESCRIPTION ******

SECTION LABEL	TYPE	********** CROSS SECTION DETAILS ********** AREA (CM**2)	A (CM)	B (CM)	C (CM)	D (CM-CM**2)	E (CM-CM**2)	F (CM-CM**2)
HEA340	WF	129.03	30.00	1.65	33.00	0.950	0.000	0.000
IPE240	WF	39.00	12.00	0.98	24.00	0.620	1.000	0.000
IPE330	WF	62.00	16.00	1.15	33.00	0.750	0.000	0.000
L15X10	ANG	24.00	15.00	10.00	1.00	0.000	0.000	0.000
UPN220	CHL	37.55	22.00	8.00	0.90	1.250	0.000	0.000
UPN260	CHL	48.00	26.00	9.00	1.00	1.400	0.000	0.000
L10X10	ANG	19.00	10.00	10.00	1.00	0.000	0.000	0.000

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9.2 BASIC LOAD CASES

9.2.1 Live Loads

In addition to permanent loads, Area loads for local design are to be considered as per Table below.

Area Use	Deck Flooring & Stringers	
	UDL (kN / m2)	CL (kN)
General Laydown and Storage Areas	15	22.5 (+10.0 for pipe support allowance)
Floor Areas in Deck	Actual equip. +5.0 in open areas or 15.0	22.5 (+10.0 for pipe support allowance)
Temporary Refuge	5	5
Walkways, Stairs and Access Platforms	4.5	4.5

Notes:

- Concentrated Loads (CL) are applied to an area of 100 mm x 100 mm, and at the most severe position, but not added to wheel loads or distributed loads;
- Uniformly Distributed Loads (UDL) and CL are not considered to act together, except 10 kN pipe support allowance is assumed to act with any load combination.
- Wheel loads to be added to distributed loads, where relevant. Wheel loads can normally be considered acting on an area of 300 mm x 300 mm.
- Trolley route location and loads to be extracted from Mechanical Handling layouts.

Table 9.1 – Superimposed Area Loads for Local Checks

For handrail the minimum service load applied horizontally to the top of the stanchion and then along the handrail, shall be:

Area Use	Load	Ref.
Service platforms	300 N/m, per max distance in m, between the axes of two successive stanchions	/19/
Escape routes	750 N/m, per max distance in m, between the axes of two successive stanchions	Client Requirement (SHELL UK)

Table 9.2 – Loads for handrails Local Checks

A live load of 4.5kN/m^2 has been considered for stair elements, landings and walkways check in operating conditions. Live loads are included in load condition LIST id. 4.5kN/m^2.

Basic vertical loads are reported in the following table:

BASIC VERTICAL LOADS						
$q_{_GRATING\ 30X5}$	=	50	kg/m²	=	0.5	kN/m²
$q_{_HANDRAIL}$	=	40	kg/m	=	0.4	kN/m
$q_{_LIVE}$	=	450	kg/m²	=	4.5	kN/m²

Table 9.3 - Basic Vertical Loads

The computation of stairs and landings permanent and live loads for TP Stairs are reported in the following table 10.2.

STAIRS							
STRINGER LABEL	**Elevation**		**L (*)**	**B (*)**	**$G_{HANDRAIL}$ (= L x qHAND)**	**$G_{GRATING}$ (=L x B x qGRAT)**	**Q_{LIVE} (=L x B qLIVE)**
	from	**to**	**[m]**	**[m]**	**[kN]**	**[kN]**	**[kN]**
R1	20310	23310	5.136	1.2	4.109	3.082	27.735
R2	17510	20310	4.955	1.2	3.964	2.973	26.755
(*) L = stringer length, B = width of loaded area				**TOT**	**8.073**	**6.054**	**54.490**

STAIRS						
LANDING LABEL	**Elevation**	**L (*)**	**B (*)**	**$G_{HANDRAIL}$ (= B +2L x qHAND)**	**$G_{GRATING}$ (=L x B x qGRAT)**	**Q_{LIVE} (=L x B X qLIVE)**
	[m]	**[m]**	**[m]**	**[kN]**	**[kN]**	**[kN]**
P1	23310	2.3	1.8	1.88	2.07	18.63
P2	20310	3.84	1.35	3.192	2.592	23.328
P3	17510	6.95	2.4	6.2	8.34	75.06
(*) L = length, B = width			**TOT**	**11.27**	**13.00**	**117.01**
			TOT Stringer + Landing	**19.34**	**19.05**	**171.50**

Table 9.4 - TP Stairs Permanent and Live load detailed calculation

Load conditions WPER and WFLO for permanent gravity loads of not modelled elements, and LIST, for live loads, are reported in the following figures.

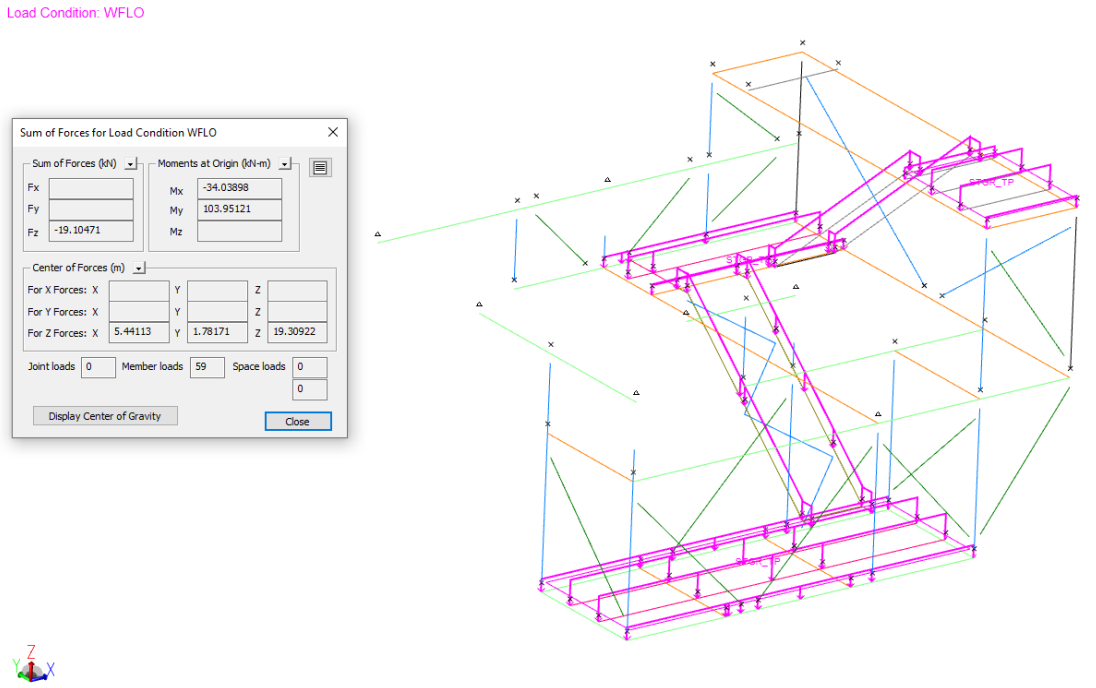


Figure 9.3 - TP - Stairs - Permanent gravity loads of not modelled elements

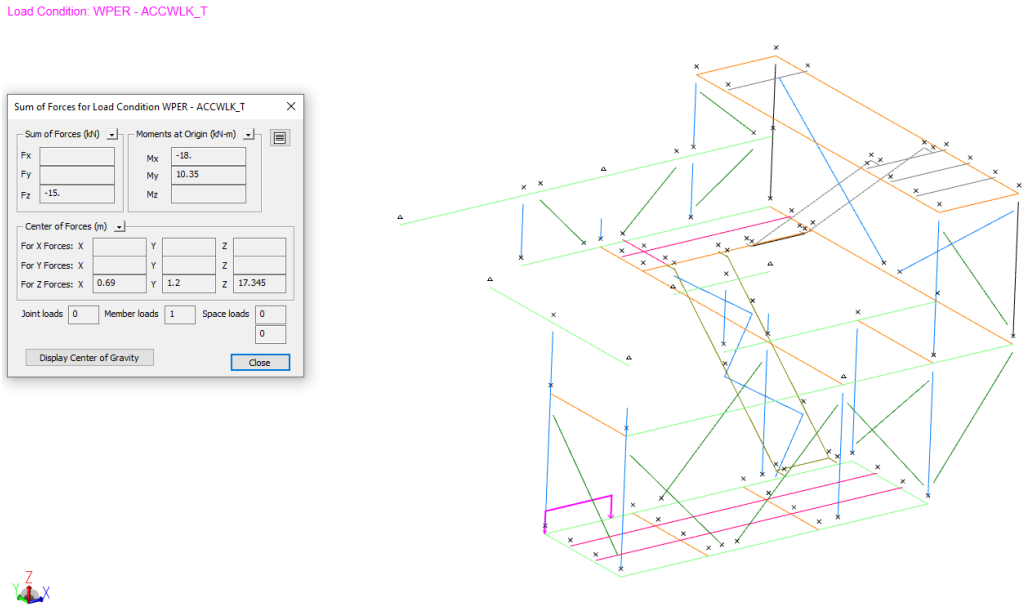


Figure 9.4 - Access walkway load

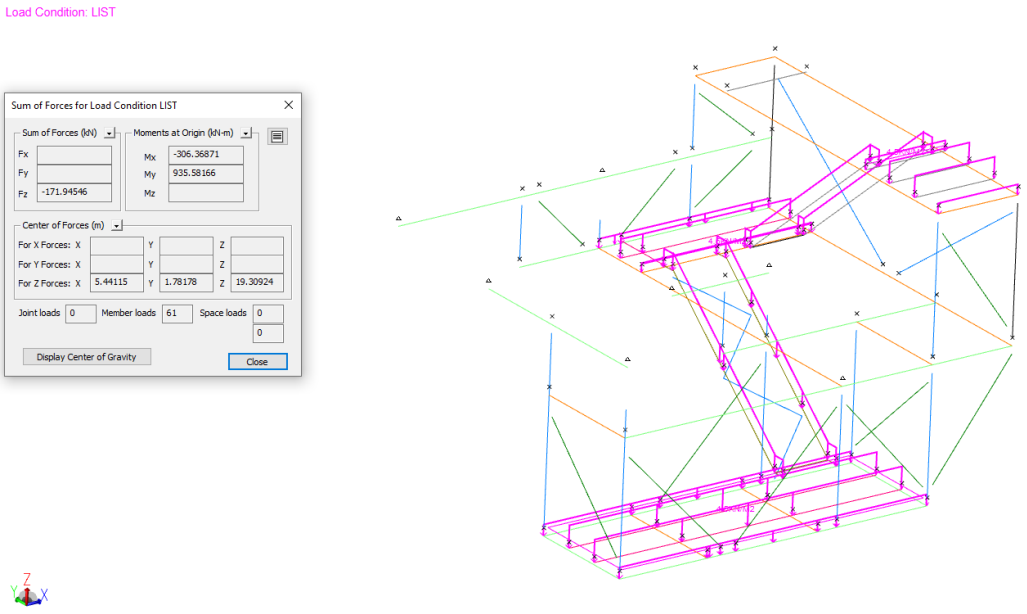


Figure 9.5 - TP - Stairs - Live Loads

9.2.2 Gravity Loads

The structural gravity loads of the stairs modelled steelwork are evaluated automatically by SACS utilizing the specified section properties, material weights and member lengths. The weight of not modelled structures including floor gratings and handrails have been applied to the structural model in the load condition WPER id. HR_ST_TP and WFLO id. STGR_TP.

9.2.3 Wind Loads

Wind loads have been calculated according to ISO 19901-1 Ref. /2/ and Structural Design Basis, Ref-/28/ .

Wind forces on stair beams have been computed considering the 3 s gust wind velocity acting on member projected area with the proper shape coefficient from table 9.3 of Structural Design Basis. For the calculation of wind loads on beams, a shape factor of 1 has been considered.

3s GUST WIND LOADS	
Wind load conditions	Cs=1.0
qWIND_OPERATING (el. 23.31m)	0.78 kN/m2
qWIND_STORM (el. 23.31m)	1.30 kN/m2

Table 9.5 - Wind Pressure

In particular the following uniform wind loads on beams have been considered :

- q_wind = 0.77 kN/m for operating conditions ;
- q_wind = 1.30 kN/m for storm conditions ;

Uniform wind load is assigned to stairs SACS model, based on max. wind pressure at the top of the structure, on the safe side.

Load conditions WOPA, WEXA, respectively for operating and storm wind loads in X direction, and load conditions WOPC, WEXC, respectively for operating and storm wind loads in Y direction, are reported in the following figures.

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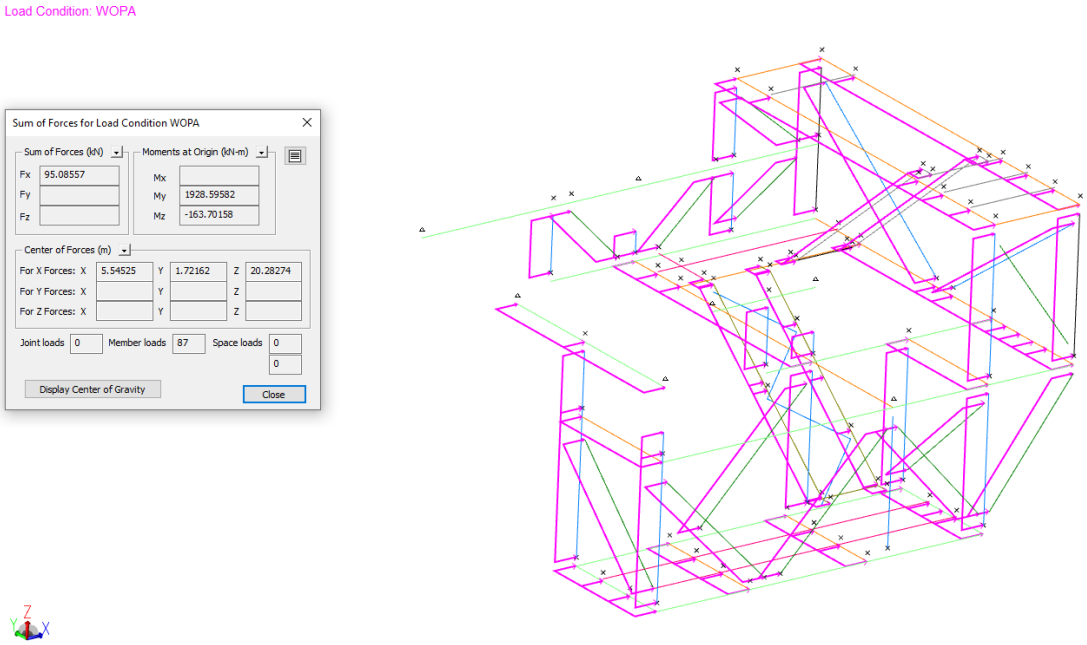


Figure 9.6 - TP - Stairs - Operating and storm wind loads in X direction

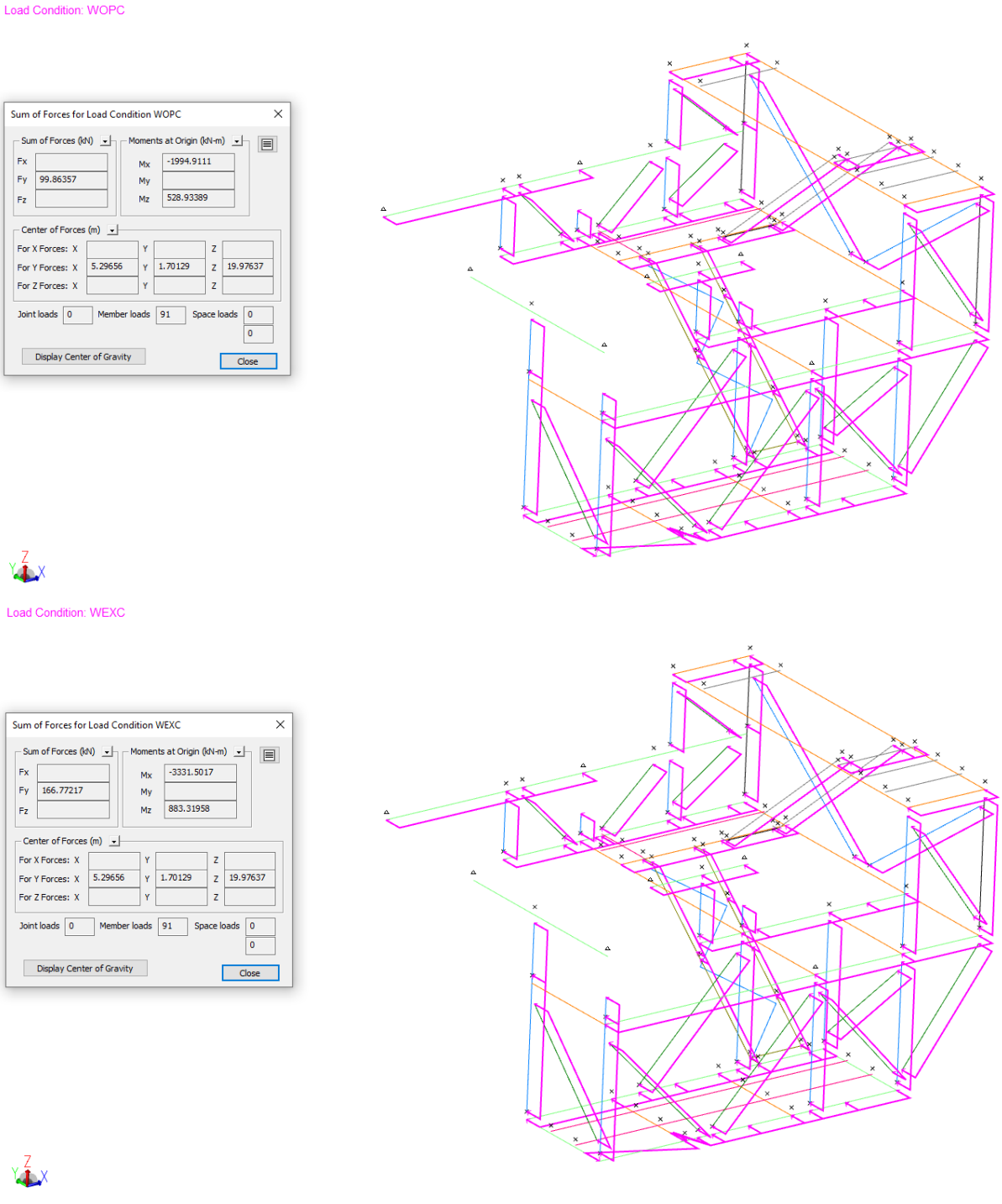


Figure 9.7 - TP - Stairs - Operating and storm wind loads in Y direction

9.3 BASIC LOAD CASES SUMMARY

Basic load conditions resulting forces are reported in the following SACS excerpt.

********** SEASTATE LOAD CASE CENTER REPORT **********
RELATIVE TO STRUCTURAL ORIGIN

LOAD CASE	LOAD LABEL	********* X - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Y - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Z - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)
1	DEAZ	0.00				0.00				-120.98	5.12	1.87	20.01
2	EQXP	179.88	4.84	1.83	19.64	0.00				0.00			
3	EQYP	0.00				179.88	4.84	1.83	19.64	0.00			
4	EQZN	0.00				0.00				-179.88	4.84	1.83	19.64
5	LIST	0.00				0.00				-171.95	5.44	1.78	19.31
6	TTNX	-25.98	8.10	2.18	21.02	0.00				0.00			
7	TTNY	0.00				-22.30	5.11	1.72	20.14	0.00			
8	TTPX	22.21	8.31	3.65	21.28	0.00				0.00			
9	TTPY	0.00				24.21	4.52	0.07	20.24	0.00			
10	WFLO	0.00				0.00				-19.10	5.44	1.78	19.31
11	WPER	0.00				0.00				-34.44	3.63	1.75	18.61
12	WSOX	-95.09	5.55	1.72	20.28	0.00				0.00			
13	WSOY	0.00				99.86	5.30	1.70	19.98	0.00			
14	G001	0.00				0.00				-179.88	4.84	1.83	19.64
15	Q001	0.00				0.00				-171.95	5.44	1.78	19.31
16	STAT	0.00				0.00				-351.83	5.14	1.81	19.48
17	WOPX	95.09	5.55	1.72	20.28	0.00				0.00			
18	WONX	-95.09	5.55	1.72	20.28	0.00				0.00			
19	WOPY	0.00				99.86	5.30	1.70	19.98	0.00			
20	WONY	0.00				-99.86	5.30	1.70	19.98	0.00			
21	WOPA	95.09	5.55	1.72	20.28	0.00				0.00			
22	WOPB	67.23	5.55	1.72	20.28	70.60	5.30	1.70	19.98	0.00			
23	WOPC	0.00				99.86	5.30	1.70	19.98	0.00			
24	WOPD	-67.23	5.55	1.72	20.28	70.60	5.30	1.70	19.98	0.00			
25	WOPE	-95.09	5.55	1.72	20.28	0.00				0.00			
26	WOPF	-67.23	5.55	1.72	20.28	-70.60	5.30	1.70	19.98	0.00			
27	WOPG	0.00				-99.86	5.30	1.70	19.98	0.00			
28	WOPH	67.23	5.55	1.72	20.28	-70.60	5.30	1.70	19.98	0.00			
29	WEXA	158.79	5.55	1.72	20.28	0.00				0.00			
30	WEXB	112.27	5.55	1.72	20.28	117.91	5.30	1.70	19.98	0.00			
31	WEXC	0.00				166.77	5.30	1.70	19.98	0.00			
32	WEXD	-112.27	5.55	1.72	20.28	117.91	5.30	1.70	19.98	0.00			
33	WEXE	-158.79	5.55	1.72	20.28	0.00				0.00			
34	WEXF	-112.27	5.55	1.72	20.28	-117.91	5.30	1.70	19.98	0.00			
35	WEXG	0.00				-166.77	5.30	1.70	19.98	0.00			
36	WEXH	112.27	5.55	1.72	20.28	-117.91	5.30	1.70	19.98	0.00			
37	AOPX	12.29	4.84	1.83	19.64	0.00				0.00			

38	AOPY	0.00				12.29	4.84	1.83	19.64	0.00
39	AOPA	12.29	4.84	1.83	19.64	0.00				0.00
40	AOPB	8.69	4.84	1.83	19.64	8.69	4.84	1.83	19.64	0.00
41	AOPC	0.00				12.29	4.84	1.83	19.64	0.00
42	AOPD	-8.69	4.84	1.83	19.64	8.69	4.84	1.83	19.64	0.00
43	AOPE	-12.29	4.84	1.83	19.64	0.00				0.00
44	AOPF	-8.69	4.84	1.83	19.64	-8.69	4.84	1.83	19.64	0.00
45	AOPG	0.00				-12.29	4.84	1.83	19.64	0.00
46	AOPH	8.69	4.84	1.83	19.64	-8.69	4.84	1.83	19.64	0.00
47	AEXX	29.52	4.84	1.83	19.64	0.00				0.00
48	AEXY	0.00				29.52	4.84	1.83	19.64	0.00
49	AEXA	29.52	4.84	1.83	19.64	0.00				0.00
50	AEXB	20.87	4.84	1.83	19.64	20.87	4.84	1.83	19.64	0.00
51	AEXC	0.00				29.52	4.84	1.83	19.64	0.00
52	AEXD	-20.87	4.84	1.83	19.64	20.87	4.84	1.83	19.64	0.00
53	AEXE	-29.52	4.84	1.83	19.64	0.00				0.00
54	AEXF	-20.87	4.84	1.83	19.64	-20.87	4.84	1.83	19.64	0.00
55	AEXG	0.00				-29.52	4.84	1.83	19.64	0.00
56	AEXH	20.87	4.84	1.83	19.64	-20.87	4.84	1.83	19.64	0.00

9.4 LOAD COMBINATIONS

The below load combinations have been considered for stairs checks:

- G001 : basic dead loads combination;
- Q001 : basic live loads combination;
- STAT : basic dead and live loads combination;
- ON2(A-H) : permanent, live load and operating environmental loads combination(ULS);
- EN3(A-H) : permanent, live load and extreme environmental loads combination(ULS);
- DN2(A-H) : permanent, live load and operating environmental loads combination(SLS);
- EN4(A-H) : permanent, live load and operating environmental loads combination(reduced);

Permanent Loads Basic Load Combinations G001		
Basic Load cases	Description	Load Factors
DEAZ	MODELLED STRUCTURAL ELEMENTS WEIGHT	1.00
WFLO	FLOORING AND GRATING PERMANENT LOADS	1.10
WPER	SEC & TERT STRUCTURAL PERMANENT LOADS	1.10

Variable Loads Basic Load Combinations Q001		
Basic Load cases	Description	Load Factors
LIST	STAIRS LIVE LOADS (4.5KN/M2)	1.00

Table 9.6 - - Basic Load Combinations

The same sets of load combinations already defined for Deck In-Service Analysis, ISO 19902 have been considered for stairs checks, taking into account:

- Operating and extreme environmental conditions;
- Live and dead loads.

Load combinations resultant forces are reported in the following Sacs excerpt.

********** SEASTATE LOAD CASE CENTER REPORT **********
RELATIVE TO STRUCTURAL ORIGIN

LOAD CASE	LOAD LABEL	********* X - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Y - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Z - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)
57	ON10	0.00				0.00				-491.76	5.16	1.81	19.46
58	ON2A	131.98	5.46	1.74	20.20	0.00				-491.76	5.16	1.81	19.46
59	ON2B	93.31	5.46	1.74	20.20	97.43	5.24	1.72	19.94	-491.76	5.16	1.81	19.46
60	ON2C	0.00				137.81	5.24	1.72	19.94	-491.76	5.16	1.81	19.46
61	ON2D	-93.31	5.46	1.74	20.20	97.43	5.24	1.72	19.94	-491.76	5.16	1.81	19.46
62	ON2E	-131.98	5.46	1.74	20.20	0.00				-491.76	5.16	1.81	19.46
63	ON2F	-93.31	5.46	1.74	20.20	-97.43	5.24	1.72	19.94	-491.76	5.16	1.81	19.46
64	ON2G	0.00				-137.81	5.24	1.72	19.94	-491.76	5.16	1.81	19.46
65	ON2H	93.31	5.46	1.74	20.20	-97.43	5.24	1.72	19.94	-491.76	5.16	1.81	19.46
66	EN3A	257.17	5.43	1.74	20.18	0.00				-351.83	5.14	1.81	19.48
67	EN3B	181.82	5.43	1.74	20.18	189.44	5.22	1.72	19.92	-351.83	5.14	1.81	19.48
68	EN3C	0.00				267.94	5.22	1.72	19.92	-351.83	5.14	1.81	19.48
69	EN3D	-181.82	5.43	1.74	20.18	189.44	5.22	1.72	19.92	-351.83	5.14	1.81	19.48
70	EN3E	-257.17	5.43	1.74	20.18	0.00				-351.83	5.14	1.81	19.48
71	EN3F	-181.82	5.43	1.74	20.18	-189.44	5.22	1.72	19.92	-351.83	5.14	1.81	19.48
72	EN3G	0.00				-267.94	5.22	1.72	19.92	-351.83	5.14	1.81	19.48
73	EN3H	181.82	5.43	1.74	20.18	-189.44	5.22	1.72	19.92	-351.83	5.14	1.81	19.48
74	E44A	257.17	5.43	1.74	20.18	0.00				-299.45	5.12	1.81	19.49
75	E44B	181.82	5.43	1.74	20.18	189.44	5.22	1.72	19.92	-299.45	5.12	1.81	19.49
76	E44C	0.00				267.94	5.22	1.72	19.92	-299.45	5.12	1.81	19.49
77	E44D	-181.82	5.43	1.74	20.18	189.44	5.22	1.72	19.92	-299.45	5.12	1.81	19.49
78	E44E	-257.17	5.43	1.74	20.18	0.00				-299.45	5.12	1.81	19.49
79	E44F	-181.82	5.43	1.74	20.18	-189.44	5.22	1.72	19.92	-299.45	5.12	1.81	19.49
80	E44G	0.00				-267.94	5.22	1.72	19.92	-299.45	5.12	1.81	19.49
81	E44H	181.82	5.43	1.74	20.18	-189.44	5.22	1.72	19.92	-299.45	5.12	1.81	19.49
82	DN10	0.00				0.00				-351.83	5.14	1.81	19.48
83	DN2A	107.37	5.47	1.73	20.21	0.00				-351.83	5.14	1.81	19.48
84	DN2B	75.91	5.47	1.73	20.21	79.29	5.25	1.72	19.94	-351.83	5.14	1.81	19.48
85	DN2C	0.00				112.15	5.25	1.72	19.94	-351.83	5.14	1.81	19.48
86	DN2D	-75.91	5.47	1.73	20.21	79.29	5.25	1.72	19.94	-351.83	5.14	1.81	19.48
87	DN2E	-107.37	5.47	1.73	20.21	0.00				-351.83	5.14	1.81	19.48
88	DN2F	-75.91	5.47	1.73	20.21	-79.29	5.25	1.72	19.94	-351.83	5.14	1.81	19.48
89	DN2G	0.00				-112.15	5.25	1.72	19.94	-351.83	5.14	1.81	19.48
90	DN2H	75.91	5.47	1.73	20.21	-79.29	5.25	1.72	19.94	-351.83	5.14	1.81	19.48

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9.4.1 Members Check

All members were checked according to ISO 19902 and Eurocode 3, Ref./2/ and /10/, respectively for tubular and non-tubular elements. Members' code checks are reported in the following and show that the structure can withstand all In-Service load combinations, with utilization factors below 1.0.

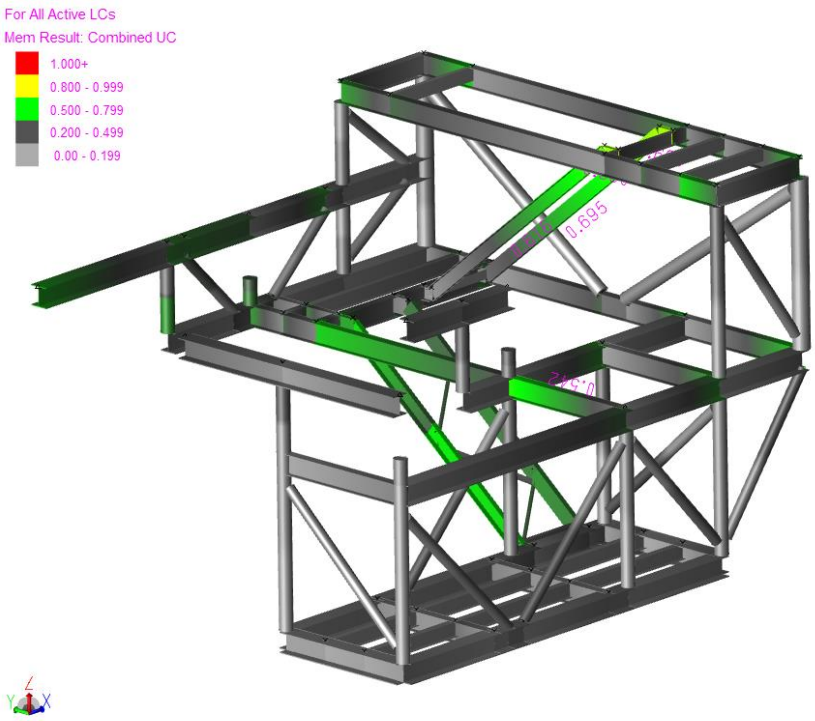
The maximum UC value is equal to 0.695 on member SM15 – SS08 for load combination ON2H. Maximum member UC are reported in following SACS excerpt and figures.

SACS-IV MEMBER UNITY CHECK RANGE SUMMARY
GROUP I - UNITY CHECKS GREATER THAN 0.00 AND LESS THAN 0.70

MEMBER	GROUP ID	MAXIMUM COMBINED UNITY CK	LOAD COND NO.	DIST FROM END	AXIAL STRESS N/MM2	BENDING STRESS Y N/MM2	BENDING STRESS Z N/MM2	SHEAR FORCE FY KN	SHEAR FORCE FZ KN	KLY/RY	KLZ/RZ	SECOND-HIGHEST UNITY CHECK	SECOND-HIGHEST LOAD COND	THIRD-HIGHEST UNITY CHECK	THIRD-HIGHEST LOAD COND
SM15-SS08	UN2	0.695	ON2H	2.3	-3.69	60.24	33.09	0.08	-0.48	60.4	81.6	0.693	ON2F	0.690	ON2E

SACS-IV MEMBER UNITY CHECK RANGE SUMMARY
GROUP II - UNITY CHECKS GREATER THAN 0.70 AND LESS THAN 0.90
** NO UNITY CHECKS IN THIS GROUP **

SACS-IV MEMBER UNITY CHECK RANGE SUMMARY
GROUP III - UNITY CHECKS GREATER THAN 0.90 AND LESS THAN 999.00
** NO UNITY CHECKS IN THIS GROUP **



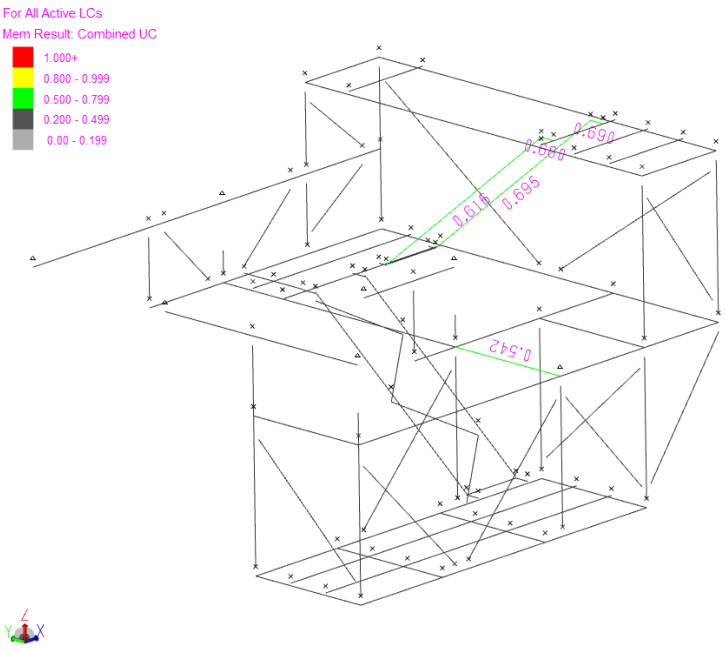


Figure 9.8 - TP - Stairs Structural Model 3D View - UC>0.5

9.4.2 Tubular Joints Check

All tubular joints punching shear checks and strength checks are detailed in following SACS excerpt and provide utilization factors lower than 1.0, according to ISO19902, ref./7/.

* * J O I N T C A N S U M M A R Y * *
(UNITY CHECK ORDER)

	ORIGINAL					LOAD DESIGN					STRENGTH ANALYSIS		
JOINT	DIAMETER (CM)	THICKNESS (CM)	YLD STRS (N/MM2)	LOAD UC	STRN UC	DIAMETER (CM)	THICKNESS (CM)	YLD STRS (N/MM2)	LOAD UC	STRN UC	BRACE JOINT	LOAD CASE
SM03	21.910	1.031	355.000	0.215	0.252	21.910	1.031	355.000	0.215	0.252	SL18	EN3C
SM02	21.910	1.031	355.000	0.180	0.211	21.910	1.031	355.000	0.180	0.211	SL03	EN3G
SL06	21.910	1.031	355.000	0.172	0.201	21.910	1.031	355.000	0.172	0.201	SM04	EN3B
SL18	21.910	1.031	355.000	0.164	0.191	21.910	1.031	355.000	0.164	0.191	SM03	EN3C
SM07	21.910	1.031	355.000	0.162	0.190	21.910	1.031	355.000	0.162	0.190	SL19	EN3G
SM30	21.910	1.031	355.000	0.146	0.171	21.910	1.031	355.000	0.146	0.171	SM33	ON2B
SM01	21.910	1.031	355.000	0.128	0.149	21.910	1.031	355.000	0.128	0.149	SL02	EN3F
SU12	27.310	1.270	355.000	0.124	0.146	27.310	1.270	355.000	0.124	0.146	SM11	EN3H
SU01	21.910	1.031	355.000	0.119	0.139	21.910	1.031	355.000	0.119	0.139	SM04	EN3A
SU11	21.910	1.031	355.000	0.118	0.138	21.910	1.031	355.000	0.118	0.138	SM33	EN3A
SU02	27.310	1.270	355.000	0.086	0.101	27.310	1.270	355.000	0.086	0.101	SM10	EN3C
SL01	21.910	1.031	355.000	0.082	0.096	21.910	1.031	355.000	0.082	0.096	SM05	E44B
SM05	21.910	1.031	355.000	0.048	0.056	21.910	1.031	355.000	0.048	0.056	SL01	E44C

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9.4.3 Deflection Checks

Deflection checks are performed for all the beams considering serviceability limit state. The results of the deflection checks are presented in the following SACS excerpt in terms of ratios between beam span and vertical deflection for the critical combinations.

********** SPAN DEFLECTION SUMMARY REPORT **********

					********** LOCAL Y DIRECTION **********					********** LOCAL Z DIRECTION **********				
SPAN ID	CANT	BEGIN JOINT	END JOINT	SPAN LENGTH M	MAX. LOAD CASE	MAXIMUM DEFL. CM	DISTANCE ALONG SPAN M	DEFL/SPAN RATIO	SPAN/DEFL RATIO	MAX. LOAD CASE	MAXIMUM DEFL. CM	DISTANCE ALONG SPAN M	DEFL/SPAN RATIO	SPAN/DEFL RATIO
FH005	NO	SL05	SL06	2.04	DN2H	0.007	1.06	0.0000	29332.2	DN2H	0.00	1.43	0.0000	54200.0
FH006	NO	SL13	SL01	2.40	DN2E	0.004	0.83	0.0000	63100.8	DN2F	0.01	1.22	0.0000	34911.3
FH007	NO	SL15	SL18	2.04	DN2D	0.016	0.66	0.0001	12670.2	DN2H	0.01	0.60	0.0000	31645.1
FH008	NO	SL02	SL03	0.34	DN2H	0.000	0.16	0.0000	191457.4	DN2B	0.00	0.22	0.0000	554121.5
SH001	YES	SM02	SM04	3.84	DN2C	0.710	3.84	0.0009	1082.4	DN2G	0.13	3.84	0.0002	6136.7
SH002	YES	SM07	SM09	3.84	DN2C	0.702	3.84	0.0009	1094.6	DN2C	0.28	3.84	0.0004	2757.2
SH005	NO	SM06	SM07	1.00	DN2G	0.002	0.51	0.0000	51212.4	DN2B	0.00	0.58	0.0000	50752.3
SH006	NO	SC05	SC04	1.00	DN2G	0.002	0.44	0.0000	40185.2	DN2D	0.00	0.49	0.0000	32882.8
SH007	NO	SC04	SC03	1.20	DN2G	0.002	0.49	0.0000	68584.5	DN2D	0.00	0.38	0.0000	53337.1
SH008	YES	SM27	SM31	3.84	DN2C	0.693	3.84	0.0009	1107.7	DN2C	0.72	3.84	0.0009	1067.5
SH009	NO	SM01	SM02	4.91	DN2G	0.072	3.29	0.0001	6773.0	DN2F	0.01	3.68	0.0000	35938.1
SH010	NO	SC02	SC01	2.40	DN2F	0.006	0.96	0.0000	40770.7	DN2G	0.01	0.89	0.0001	19960.0
SH011	NO	SC02	SC06	2.00	DN2E	0.006	0.88	0.0000	30904.8	DN2G	0.01	0.74	0.0001	16906.4
SH013	NO	SM26	SM25	1.42	DN2C	0.007	0.70	0.0000	21054.6	DN2C	0.00	0.99	0.0000	54891.2
SH014	NO	SC08	SC07	2.80	DN2C	0.029	1.15	0.0001	9559.9	DN2C	0.05	0.95	0.0002	5748.7
SH015	NO	SC09	SC10	1.42	DN2C	0.020	0.67	0.0001	7058.8	DN2C	0.01	0.81	0.0001	12844.8
SI001	NO	SM10	SM04	3.60	DN2D	0.096	1.51	0.0003	3747.0	DN2G	0.03	1.70	0.0001	13641.3
SI002	NO	SM08	SM03	2.40	DN2C	0.039	0.53	0.0002	6082.7	DN2G	0.00	1.39	0.0000	62191.6
SI003	NO	SM02	SM07	2.40	DN2G	0.022	0.53	0.0001	10722.0	DN2C	0.02	0.86	0.0001	15199.7
SI004	NO	SM07	SM27	5.30	DN2B	0.161	2.96	0.0003	3301.5	DN2G	0.15	3.20	0.0003	3626.4
SI005	NO	SM05	SM01	2.40	DN2G	0.010	1.44	0.0000	24204.0	DN2G	0.01	0.82	0.0000	46583.9
SI006	NO	SM31	SM11	3.60	DN2C	0.126	1.46	0.0004	2850.1	DN2C	0.07	1.55	0.0002	5345.7
SI007	NO	SM22	SM24	3.84	DN2H	0.063	1.77	0.0002	6054.5	DN2G	0.11	2.00	0.0003	3626.6
SI008	NO	SM17	SM29	1.35	DN2H	0.018	0.50	0.0001	7702.1	DN2C	0.01	0.67	0.0001	19104.5
SI009	NO	SM21	SM16	3.84	DN2G	0.129	2.22	0.0003	2985.3	DN2C	0.14	1.85	0.0004	2700.0
STU3	NO	SM20	SS06	5.14	DN2A	17.520	4.85	0.0341	29.3	DN2G	0.52	2.46	0.0010	987.7
STU4	NO	SM19	SS05	5.14	DN2E	17.343	4.85	0.0338	29.6	DN2G	0.57	2.60	0.0011	894.9
TI001	NO	SU12	SU11	1.80	DN2D	0.019	0.49	0.0001	9457.5	DN2H	0.00	0.88	0.0000	90275.2
TI002	NO	SU12	SU02	7.70	DN2E	0.749	4.21	0.0010	1028.3	DN2E	0.16	4.56	0.0002	4824.9
TI003	NO	SU01	SU11	7.70	DN2E	0.750	3.44	0.0010	1027.1	DN2G	0.32	3.27	0.0004	2422.9
TI004	NO	SU01	SU02	1.80	DN2B	0.018	1.33	0.0001	10233.1	DN2B	0.00	0.83	0.0000	55376.9
TU001	NO	SU09	SU10	1.80	DN2C	0.001	0.90	0.0000	304651.4	DN2E	0.00	0.90	0.0000	229093.0
TU002	NO	SU08	SU07	1.80	DN2G	0.088	0.66	0.0005	2038.2	DN2F	0.03	0.97	0.0001	6675.4
TU003	NO	SU05	SU06	1.80	DN2C	0.001	0.90	0.0000	123104.3	DN2E	0.01	0.90	0.0001	15757.1
TU004	NO	SU03	SU04	1.80	DN2C	0.001	0.90	0.0000	123106.5	DN2F	0.01	0.90	0.0001	15757.2
FI001	NO	SL10	SL23	1.98	DN2G	0.002	0.99	0.0000	111416.5	DN2A	0.01	0.99	0.0001	15483.9
FI002	NO	SL07	SL22	1.98	DN2G	0.002	0.99	0.0000	111415.6	DN2H	0.01	0.99	0.0001	15483.9
FI003	NO	SL23	SL27	2.50	DN2G	0.004	1.25	0.0000	56005.4	DN2H	0.03	1.25	0.0001	8180.4
FI004	NO	SL22	SL26	2.50	DN2G	0.004	1.25	0.0000	56005.4	DN2C	0.03	1.25	0.0001	8180.4
FI005	NO	SL27	SL12	2.46	DN2G	0.004	1.23	0.0000	58412.7	DN2D	0.03	1.23	0.0001	8510.8
FI006	NO	SL26	SL09	2.46	DN2G	0.004	1.23	0.0000	58412.5	DN2B	0.03	1.23	0.0001	8510.8
FI007	NO	SL21	SL20	2.40	DN2A	0.008	1.82	0.0000	29638.2	DN2D	0.02	1.20	0.0001	9687.5
FI008	NO	SL24	SL25	2.40	DN2A	0.008	1.79	0.0000	29560.1	DN2C	0.03	1.20	0.0001	8825.3
FH001	NO	SL03	SL05	2.28	DN2D	0.014	1.39	0.0001	16147.6	DN2F	0.00	1.23	0.0000	66117.5
FH002	NO	SL02	SL01	2.28	DN2D	0.009	1.19	0.0000	26742.6	DN2H	0.01	1.05	0.0000	36957.3
FH003	NO	SL18	SL06	2.40	DN2B	0.007	0.61	0.0000	33407.7	DN2E	0.01	1.19	0.0000	36455.3
FH004	NO	SL13	SL15	4.91	DN2H	0.020	1.89	0.0000	24494.5	DN2D	0.05	2.77	0.0001	9614.7

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10 PAU ACCESS STAIRS DESIGN & LOADS

10.1 STRUCTURAL MODEL

The structural checks of beam member elements and tubular joints of the Pau access stairs have been performed with the software SACS, Ref. /43/, modelling the two structures separately.

These modules have been verified for operating, extreme and transportation conditions.

The model geometry is referred to a right-handed orthogonal Cartesian coordinate reference system.

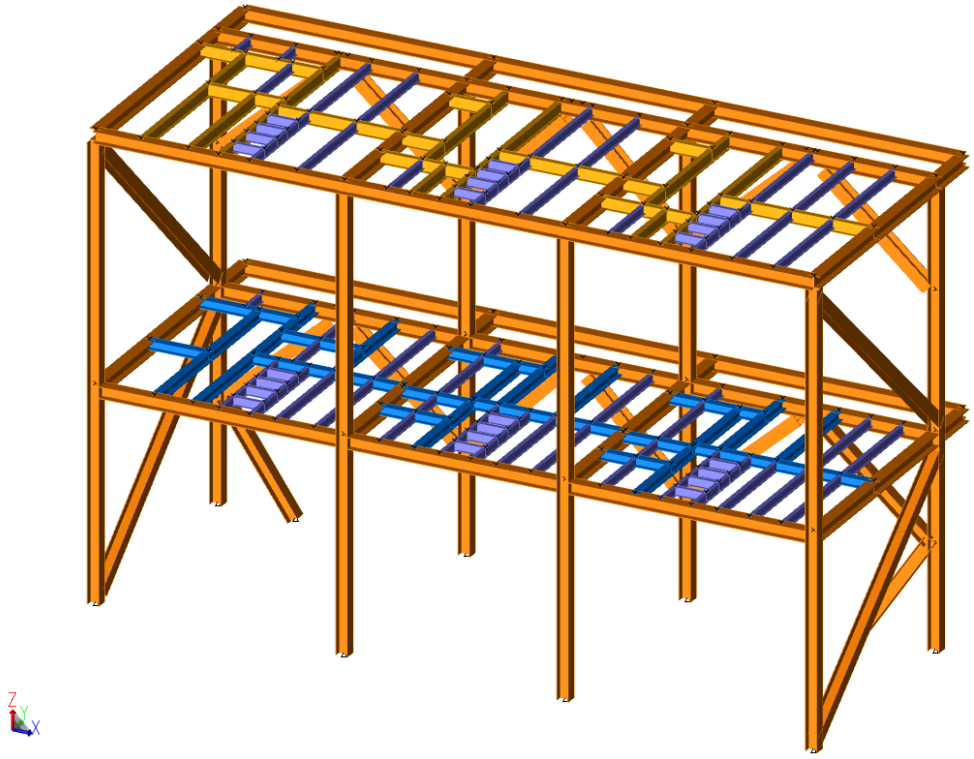


Figure 10.1 - PAU – North Stairs - 3D View

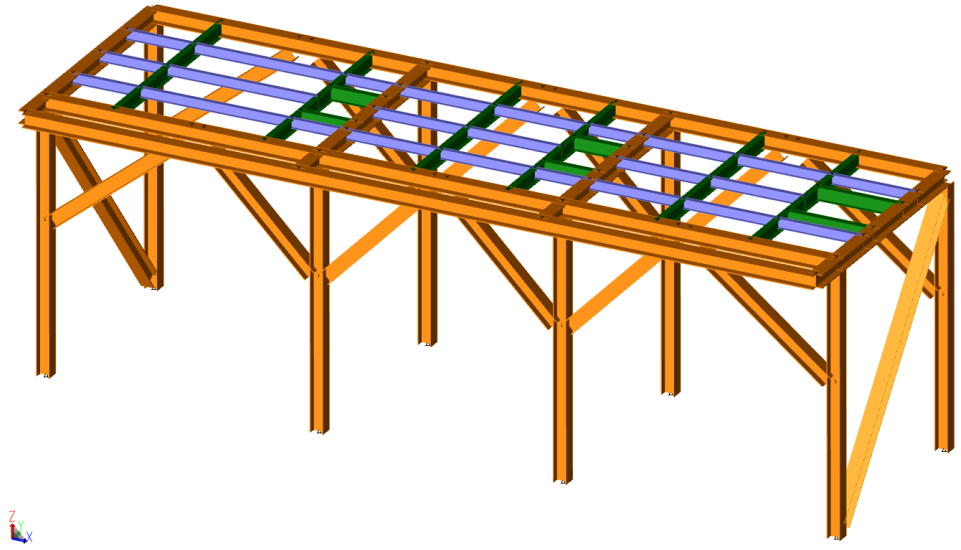


Figure 10.2 - PAU – South Stairs - 3D View

Members' releases and joints' fixities

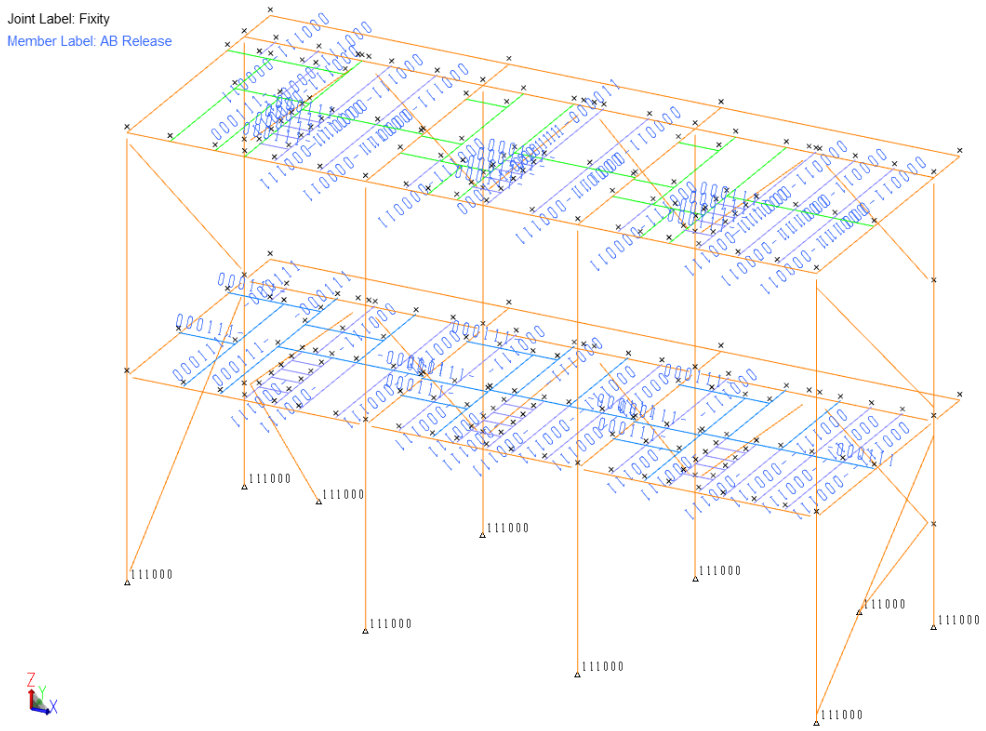


Figure 10.3 - PAU – North Stairs – Member release and external constraints

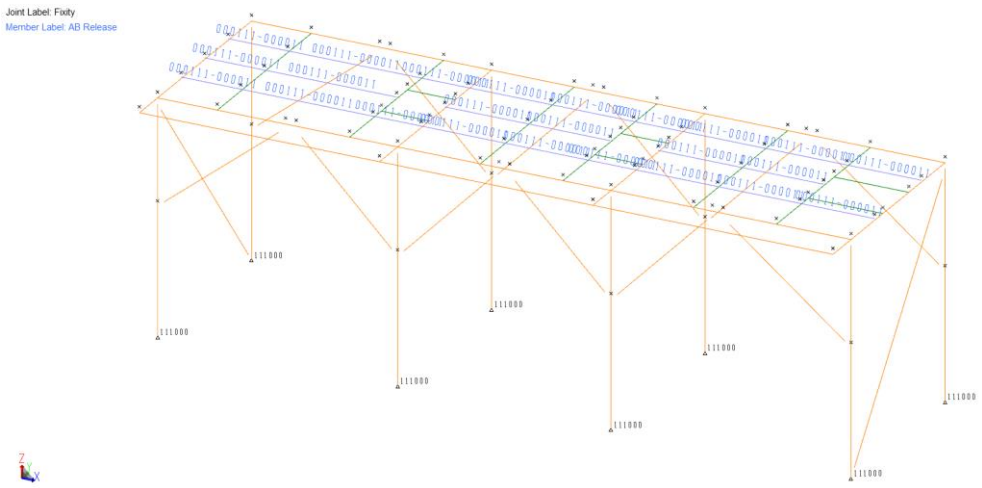


Figure 10.4 - - PAU – South Stairs - Member release and external constraints

Structural model members group are shown in the following SACS output excerpt.

WIDE FLANGE/WIDE FLANGE COMPACT,MEMBER PROPERTIES

GRP	M/S	** FLANGE ** THICK CM	WIDTH CM	WEB THICK CM	FILET RAD. CM	DEPTH CM	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	**** MOMENTS OF INERTIA **** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	KY	KZ	FLANGE-BRC TOP M	BOT M	SECT TPR LEN M
NORTH STAIRS																		
HE2	1	1.60	22.00	0.950	0.950	22.00	20.5	7.9	88.26	67.81	7866.	2841.	35.5	1.0	1.0	0.0	0.0	0.00
HE3	1	1.30	16.00	0.800	0.800	16.00	20.5	7.9	52.32	26.96	2414.	888.0	35.5	1.0	1.0	0.0	0.0	0.00
IP2	1	0.74	8.20	0.500	0.500	16.00	20.5	7.9	19.40	3.016	834.6	68.15	35.5	1.0	1.0	0.0	0.0	0.00
IP3	1	0.92	11.00	0.590	0.590	22.00	20.5	7.9	32.13	7.465	2653.	204.4	35.5	1.0	1.0	0.0	0.0	0.00
SOUTH STAIRS																		
HE2	1	1.60	22.00	0.950	0.950	22.00	20.5	7.9	88.26	67.81	7866.	2841.	35.5	1.0	1.0	0.0	0.0	0.00
IP1	1	0.74	8.20	0.500	0.500	16.00	20.5	7.9	19.40	3.016	834.6	68.15	35.5	1.0	1.0	0.0	0.0	0.00
IP2	1	0.92	11.00	0.590	0.590	22.00	20.5	7.9	32.13	7.465	2653.	204.4	35.5	1.0	1.0	0.0	0.0	0.00

Member Section Report

Section	Type		AX(cm2)	J(cm4)	IY(cm4)	IZ(cm4)	A(cm)	B(cm)	C(cm)	D(cm)	E(cm)	F(cm)
NORTH STAIRS												
HEB160	WF	*	52.320	26.956	2413.601	888.038	16.000	1.300	16.000	0.800		
HEB220	WF	*	88.260	67.813	7865.471	2840.810	22.000	1.600	22.000	0.950		
IPE160	WF	*	19.396	3.016	834.626	68.153	8.200	0.740	16.000	0.500		
IPE220	WF	*	32.134	7.465	2652.771	204.432	11.000	0.920	22.000	0.590		
SOUTH STAIRS												
HEB220	WF	*	88.260	67.813	7865.471	2840.810	22.000	1.600	22.000	0.950		
IPE160	WF	*	19.396	3.016	834.626	68.153	8.200	0.740	16.000	0.500		
IPE220	WF	*	32.134	7.465	2652.771	204.432	11.000	0.920	22.000	0.590		

10.2 BASIC LOAD CASES

10.2.1 Modelled Structure Self Weight

The structural gravity loads of the modelled steelwork are evaluated automatically by SACS utilizing the specified section properties, material weights and member lengths.

Steel density: 7.85 t/m^3

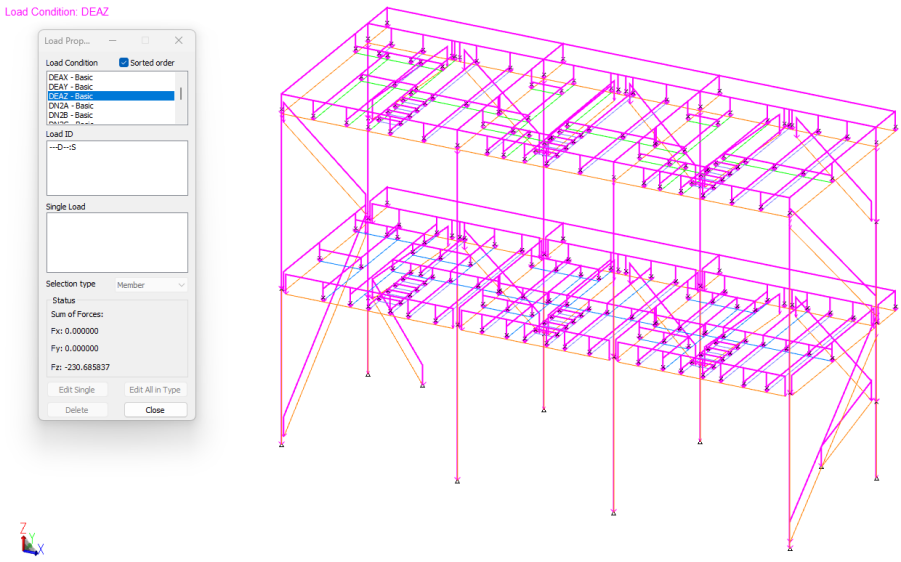


Figure 10.5 - PAU – North Stairs – Modelled structure dead load

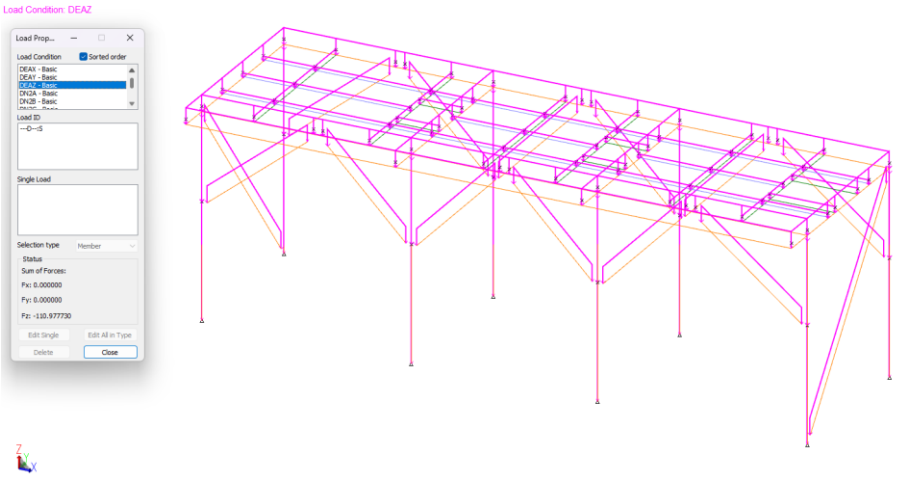


Figure 10.6 - PAU – South Stairs – Modelled structure dead load

10.2.2 Permanent loads

Permanent loads consist on the grating load and the piping supports on the modules. Load condition PAUL has been assigned to the models.

Stairs	Load Condition	Description	Load	Area	Total
North	PAUL	Grating + Piping supports	2.5 kN/m^2	2x70.2 m^2	351 kN
South	PAUL	Grating + Piping supports	2.5 kN/m^2	54.6 m^2	137 kN

Table 10.1 – Pau Stairs - Permanent loads

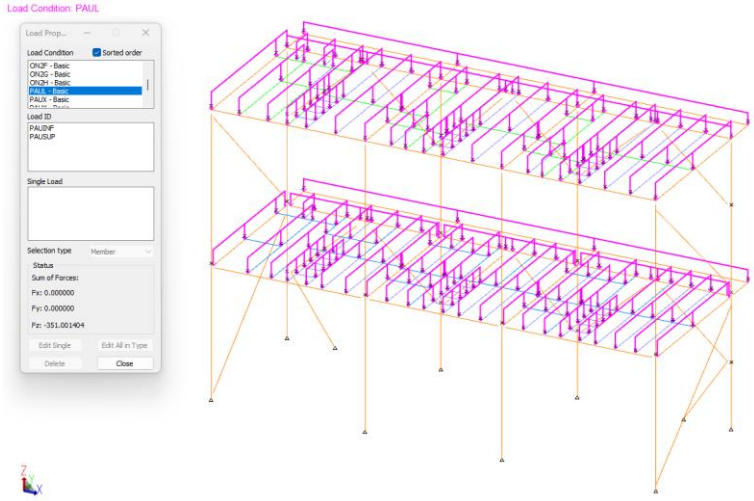


Figure 10.7 - PAU – North Stairs – Permanent loads

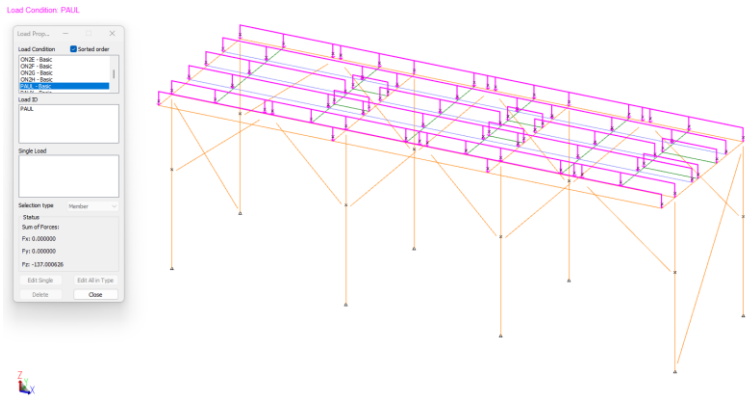


Figure 10.8 - PAU – South Stairs – Modelled structure dead load

10.2.3 Wind Loads

Wind loads have been calculated according to ISO 19901-1 Ref. /2/ and Structural Design Basis, Ref-/28/ .

Wind forces on stair beams have been computed considering the 3 s gust wind velocity acting on member projected area with the proper shape coefficient from table 9.3 of Structural Design Basis. For the calculation of wind loads on beams, a shape factor of 1 has been considered.

3s GUST WIND LOADS	
Wind load conditions	Cs=1.0
qWIND_OPERATING (el. 38.71m)	0.83 kN/m2
qWIND_OPERATING (el. 34.81m)	0.81 kN/m2
qWIND_STORM (el. 38.71m)	1.38 kN/m2
qWIND_STORM (el. 34.81m)	1.35 kN/m2
qWIND_TRANSPORT (el. 38.71m)	0.70 kN/m2
qWIND_TRANSPORT (el. 34.81m)	0.70 kN/m2

Table 10.2 – wind pressure

The following uniform wind loads on the PAU stairs have been considered:

Operating Wind Global forces X direction (Positive / Negative)									
Load Condition	**Location**	**Descr.**	**L [m]**	**H [m]**	**N**	**A [m2]**	**max el.**	**p [kN/m2]**	**F [kN]**
WOPX / WONX	ABOVE UPPER DECK	acc stair NORTH	5.5	8.4	0.25	11.55	38.71	0.83	9.6
		acc stair SOUTH	5.5	4.5	0.25	6.1875	34.81	0.81	5.0

Operating Wind Global Forces Y direction (Positive / Negative)									
Load Condition	**Location**	**Descr.**	**L [m]**	**H [m]**	**N**	**A [m2]**	**max el.**	**p [kN/m2]**	**F [kN]**
WOPY / WONY	ABOVE UPPER DECK	acc stair NORTH	13	4.5	0.25	14.625	38.71	0.83	12.11
		acc stair NORTH	13	3.9	0.1	5.07	34.21	0.81	4.10
		acc stair SOUTH	13	4.5	0.1	5.85	34.81	0.81	4.74

Extreme Wind Global Forces X direction (Positive / Negative)									
›ad Condition	**Location**	**Descr.**	**L [m]**	**H [m]**	**N**	**A [m2]**	**max el.**	**p [kN/m2]**	**F [kN]**
WEPX / WENX	ABOVE UPPER DECK	acc stair NORTH	5.5	8.4	0.25	11.55	38.71	1.38	16.0
		acc stair SOUTH	5.5	4.5	0.25	6.1875	34.81	1.35	8.4

Extreme Wind Global Forces Y direction (Positive / Negative)									
›ad Condition	**Location**	**Descr.**	**L [m]**	**H [m]**	**N**	**A [m2]**	**max el.**	**p [kN/m2]**	**F [kN]**
WEPY / WENY	ABOVE UPPER DECK	acc stair NORTH	13	4.5	0.25	14.625	38.71	1.38	20.22
		acc stair NORTH	13	3.9	0.1	5.07	34.21	1.35	6.85
		acc stair SOUTH	13	4.5	0.1	5.85	34.81	1.35	

Transport Wind Global forces X direction (Positive / Negative)									
Load Condition	**Location**	**Descr.**	**L [m]**	**H [m]**	**N**	**A [m2]**	**max el.**	**p [kN/m2]**	**F [kN]**
WTPX / WTNX	ABOVE UPPER DECK	acc stair SOUTH	5.5	8.4	0.25	11.55	15	0.70	8.1
		acc stair NORTH	5.5	4.5	0.25	6.1875	10	0.70	4.3

Transport Wind Global Forces Y direction (Positive / Negative)									
Load Condition	**Location**	**Descr.**	**L [m]**	**H [m]**	**N**	**A [m2]**	**max el.**	**p [kN/m2]**	**F [kN]**
WTPY / WTNY	ABOVE UPPER DECK	acc stair NORTH	13	4.5	0.25	14.625	15	0.70	10.23
		acc stair NORTH	13	3.9	0.1	5.07	15	0.70	3.55
		acc stair SOUTH	13	4.5	0.1	5.85	10	0.70	4.09

Table 10.3 – PAU stairs wind loads

Uniform wind load is assigned to stairs SACS model, based on max. wind pressure at the top of the structure, on the safe side.

Wind load conditions reported in Table 10.3 are shown in the following figures.

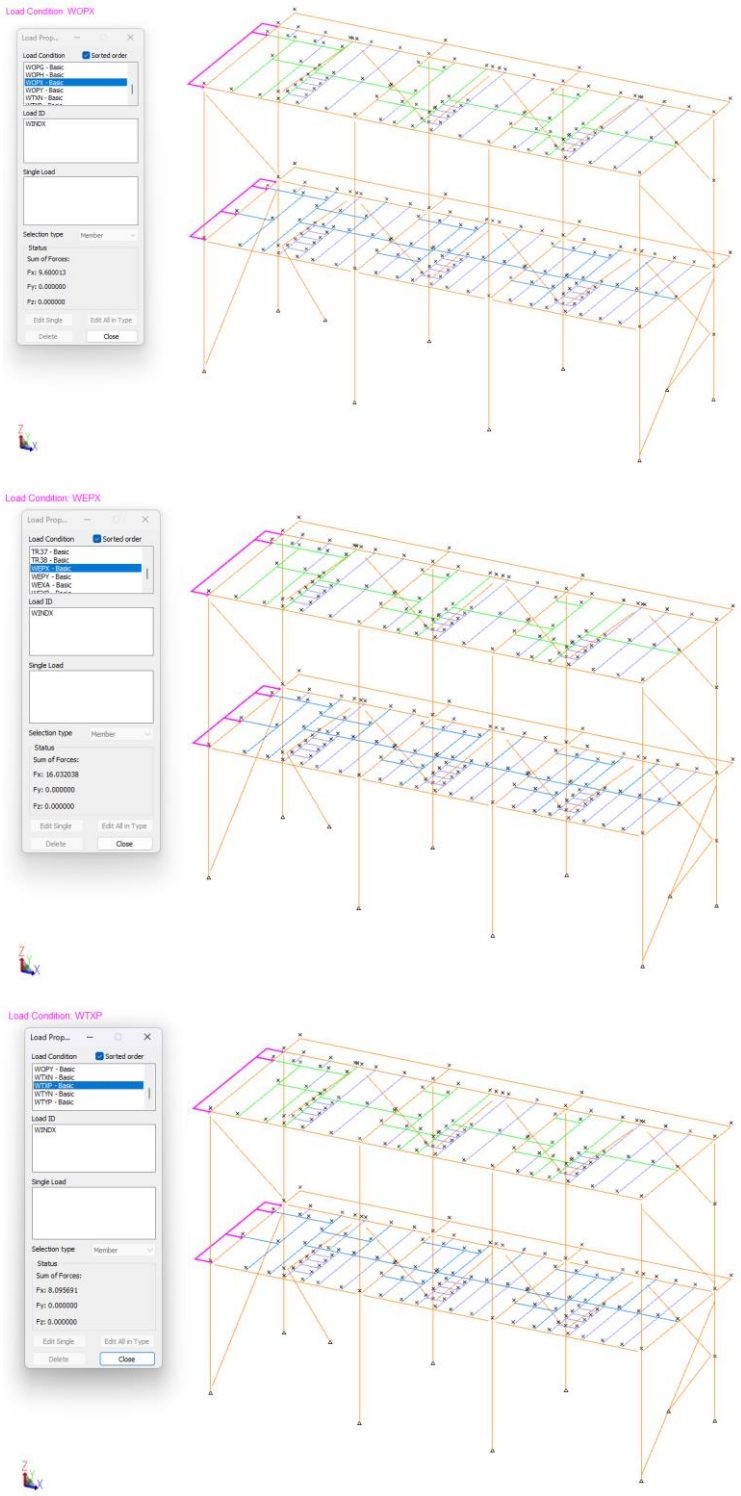


Figure 10.9 - PAU – North Stairs – Operating, storm and transport wind loads in X direction

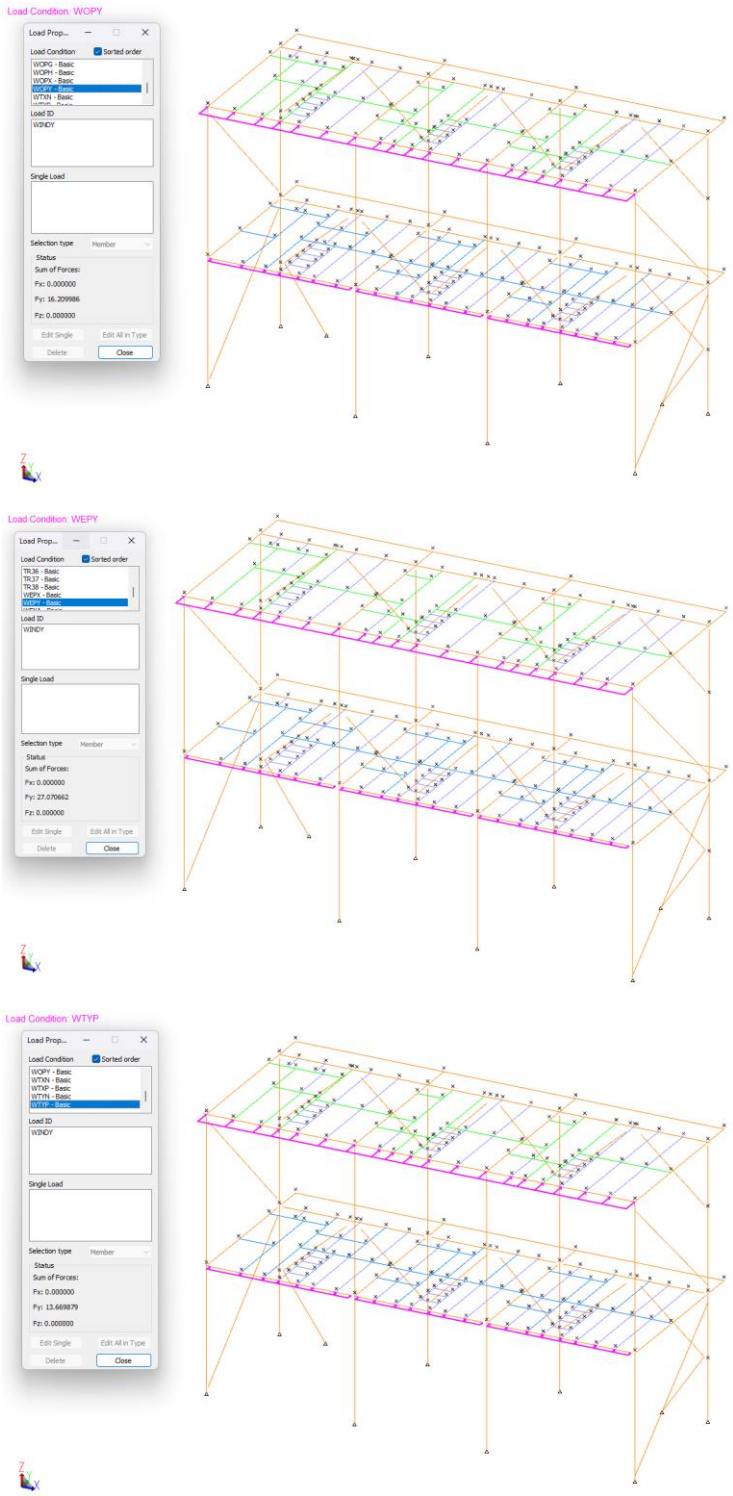


Figure 10.10 - PAU – North Stairs – Operating, storm and transport wind loads in Y direction

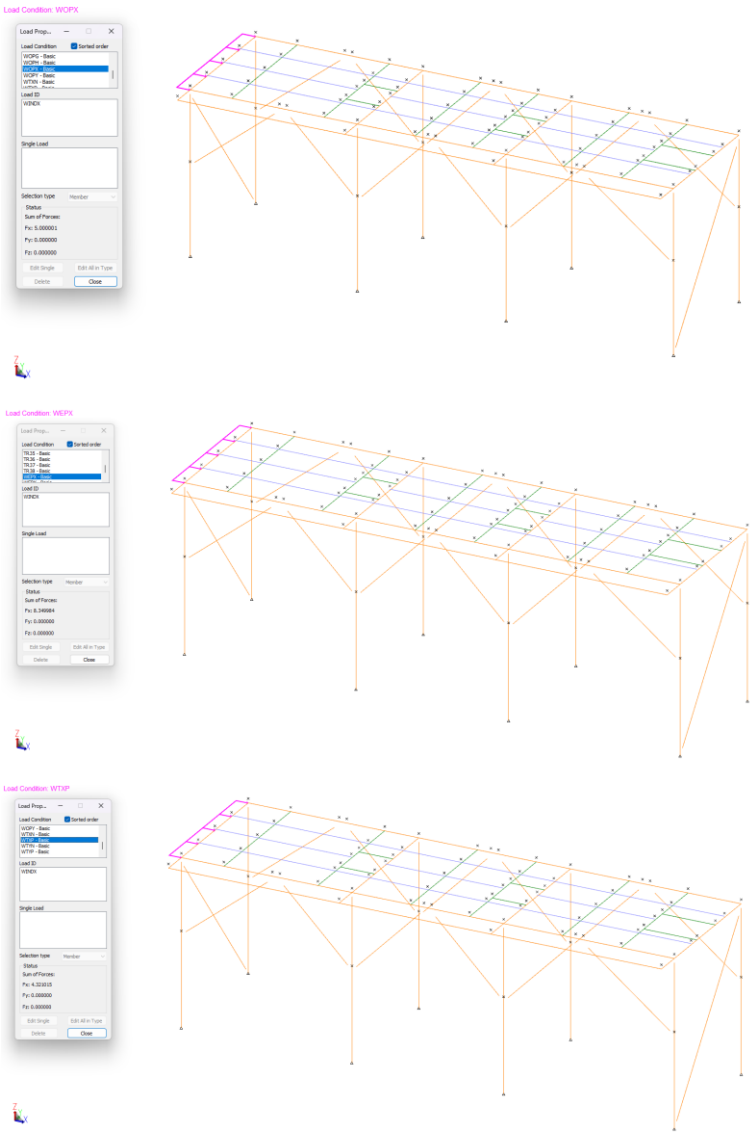


Figure 10.11 - PAU – South Stairs – Operating, storm and transport wind loads in X direction

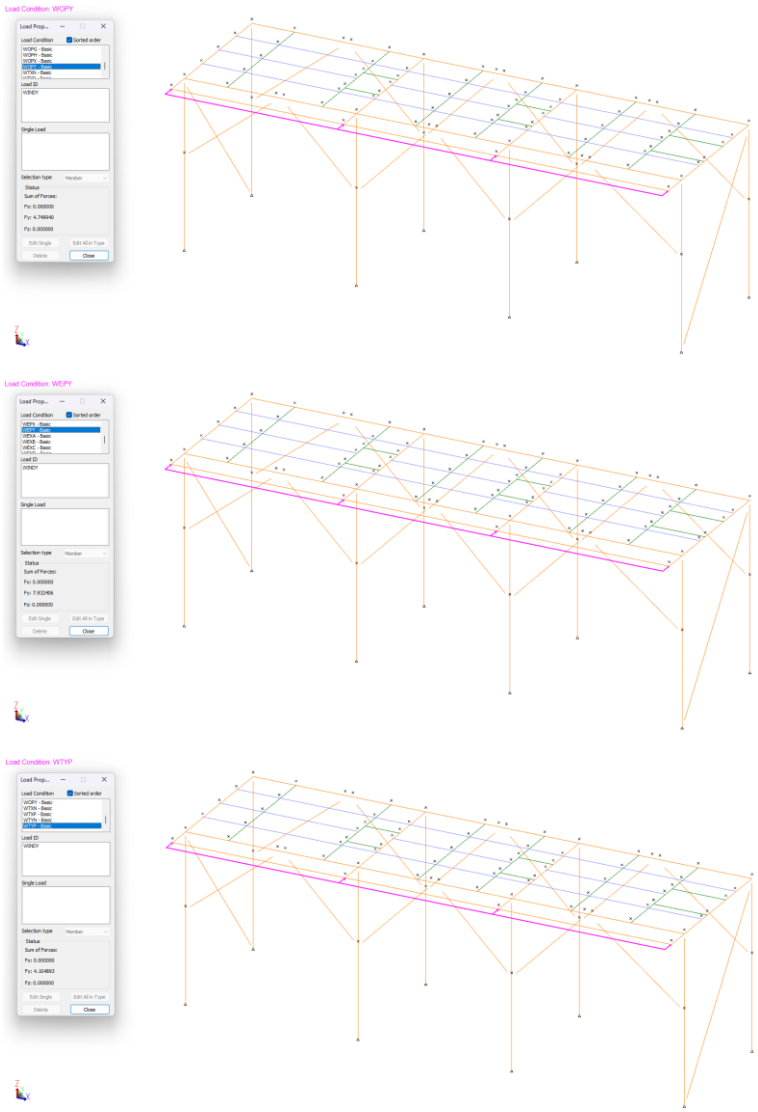


Figure 10.12 - PAU – South Stairs – Operating, storm and transport wind loads in Y direction

10.2.4 Ice And Snow Loads

Snow and ice build-up data on the platform are presented in section 5. The load condition SNOW has been applied to the top horizontal surface of the structure (0.7 kN/m2 as per sec. 5.4):

Stairs	Load Condition	Description	Load	Area	Total
North	SNOW	Snow Load	0.7 kN/m^2	70.2 m^2	52.65 kN
South	SNOW	Snow Load	0.7 kN/m^2	54.6 m^2	38.36 kN

Table 10.4 – Pau Stairs - Permanent loads

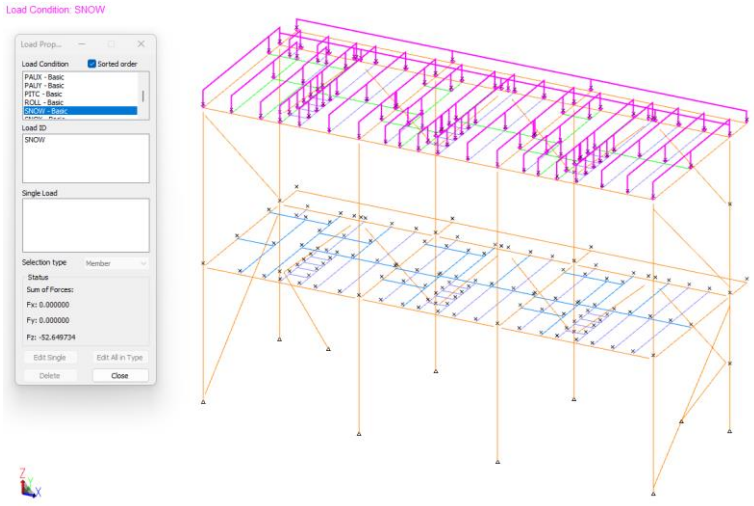


Figure 10.13 - PAU – North Stairs – Snow load

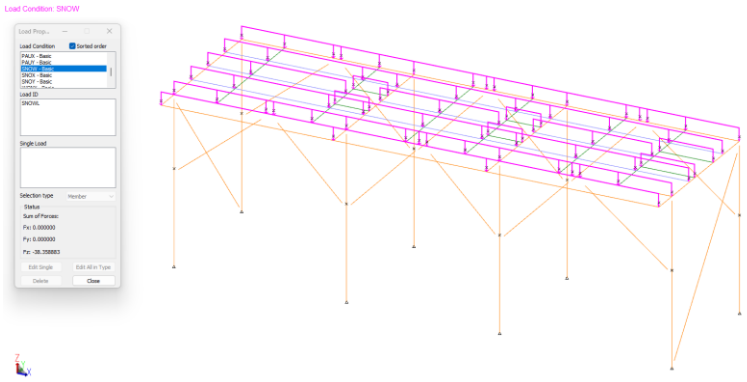


Figure 10.14 - PAU – South Stairs – Snow load

10.2.5 Basic gravity load combinations

The following load combinations for gravity loads have been assumed for use.

- G001 : basic dead loads combination;
- G001 : basic dead + live loads combination;

Load Combination	DEAZ	PAUL	SNOW
G001	1.00	1.00	
G002	1.00	1.00	1.00

Table 10.5 – Gravity loads basic combinations

10.2.6 Hydrodynamic Inertia Loads

Static equivalent inertia loads for BLPH Topside structures due to hydrodynamic loads (waves) on monopile have been computed from acceleration as per in-service calculation report ref./29/, and recalled in the following table:

Case	Location	Elevation (LAT)	Sea State	Max. Acceleration	
-	-	[m]	-	[m/s2]	[g]
Operational	Topsides CoG	28	Operational	0.67	0.07
Extreme	Topsides CoG	28	Extreme	1.61	0.16

Table 10.6 – Topsides Accelerations from Wave Loading on Monopile

Sixteen load conditions have been defined for hydrodynamic inertia loads, considering 8 directions 45° spaced, both for Operating (load cases AOPA-H) and Extreme conditions (load cases AEXA-H), in accordance with Structural Design Premises ref./26/, assuming Operational acceleration 0.1g and Extreme acceleration 0.2g.

PAU stairs	Case	Direction	Design acceleration [g]	Mass load case	Inertia force [kN]
North	Operational	X, Y	0.1g	G002	63.43
North	Extreme	X, Y	0.2g	G002	116.34
South	Operational	X, Y	0.1g	G002	
South	Extreme	X, Y	0.2g	G002	

Table 10.7 – Hydrodinamic inertia loads

In the following, four load cases applied loads are reported as example.

- Load condition AOPA: Operating hydrodynamic inertia loads positive X direction

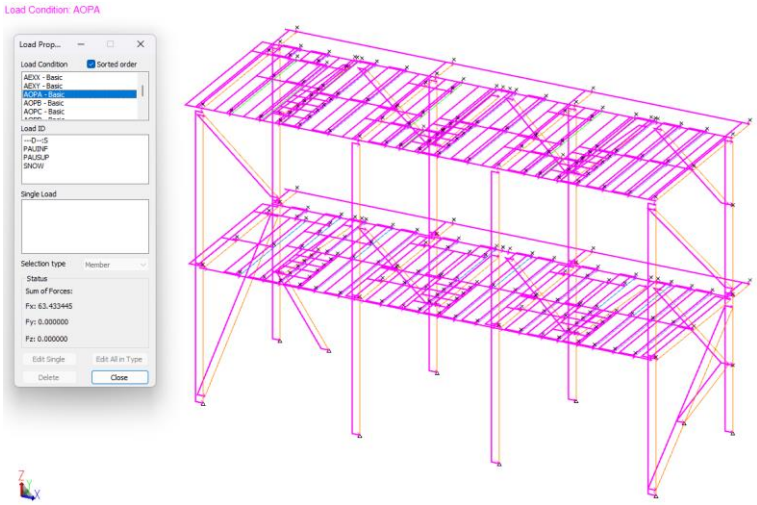


Figure 10.15 - PAU – North Stairs – load condition AOPA

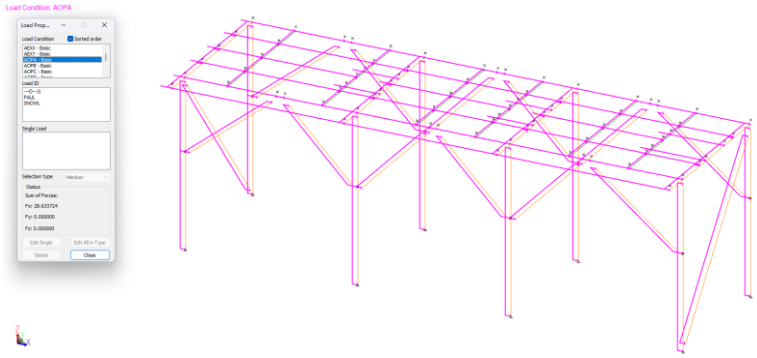


Figure 10.16 - PAU – South Stairs – load condition AOPA

- Load condition AOPC: Operating hydrodynamic inertia loads positive Y direction

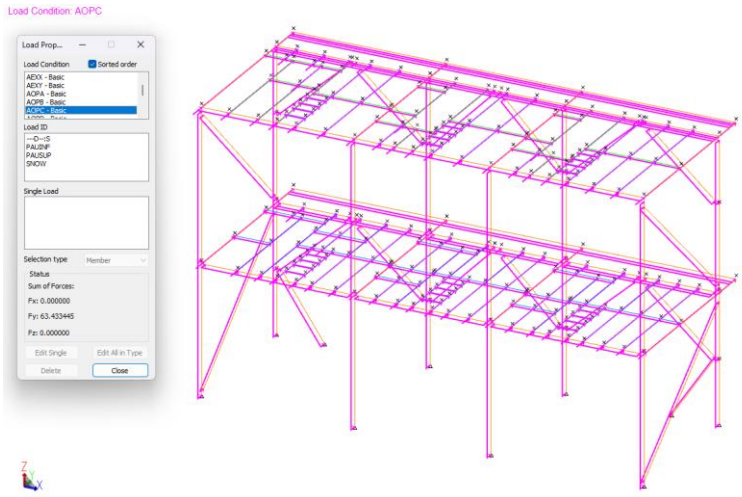


Figure 10.17 - PAU – North Stairs – load condition AOPC

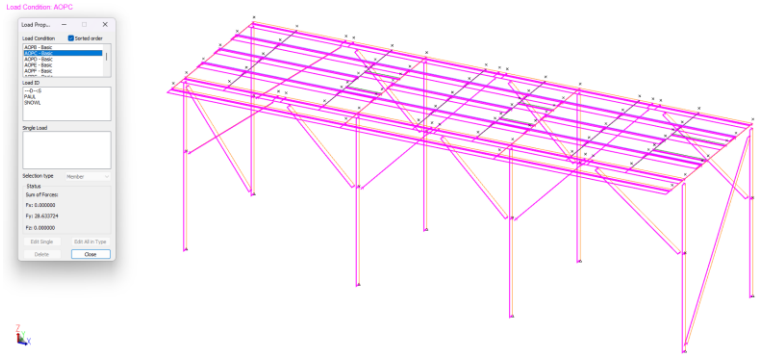


Figure 10.18 - PAU – South Stairs – load condition AOPC

- Load condition AEXA: Extreme hydrodynamic inertia loads positive X direction

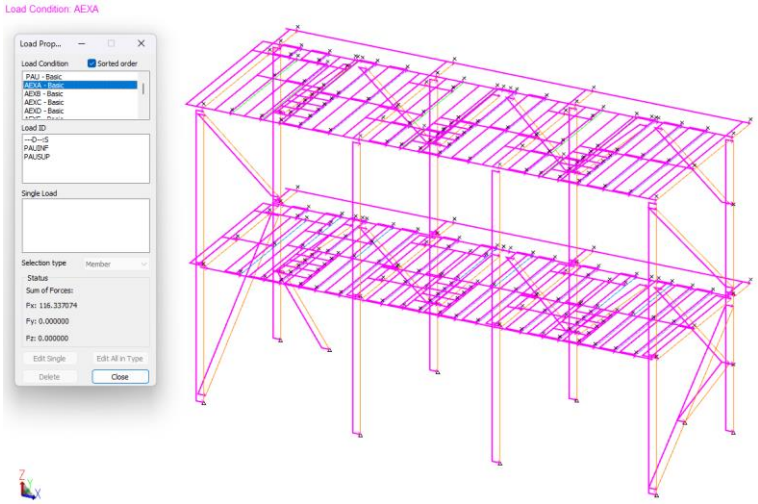


Figure 10.19 - PAU – North Stairs – load condition AEXA

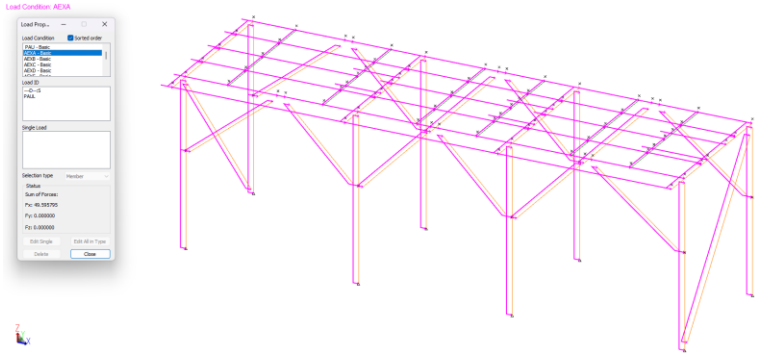


Figure 10.20 - PAU – South Stairs – load condition AEXA

- Load condition AEXC: Extreme hydrodynamic inertia loads positive Y direction

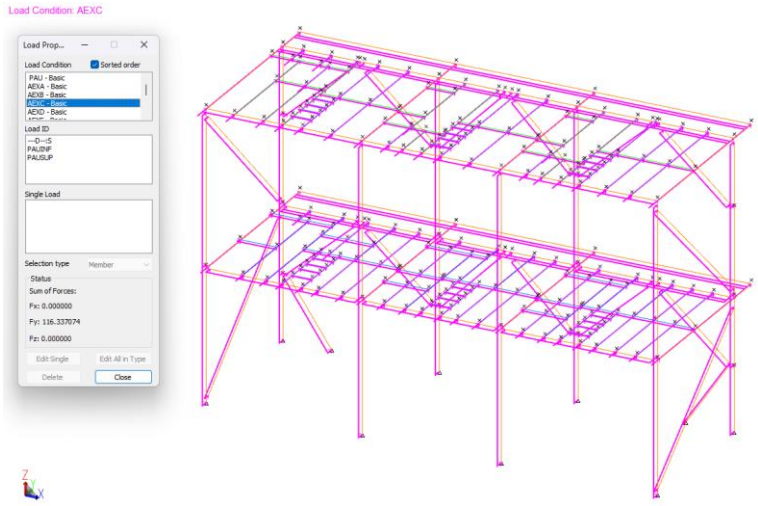


Figure 10.21 - PAU – North Stairs – load condition AEXC

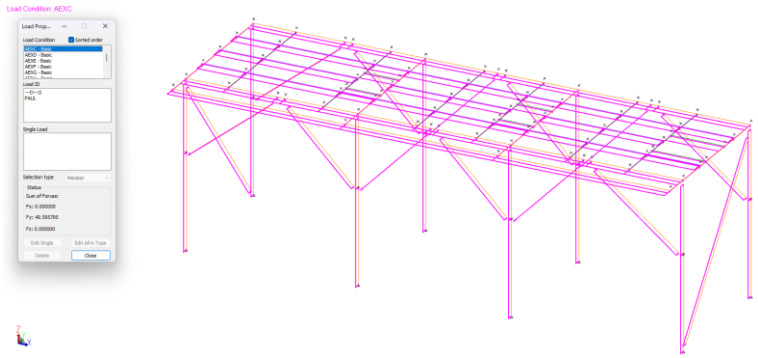


Figure 10.22 - PAU – South Stairs – load condition AEXC

10.2.7 Transportation Inertia Loads

According to the PAU stairs position on the barge during transportation, as per ref. /30/, max. accelerations for the two stair modules are computed as follows:

TRANSPORT FORCES ON CARGO

In accordance with: DNVGL ST N001 2018-amended 2020

Barge data			Cargo barge		P-mak	
	Length	L =	91.50	m		
	Breadth	B =	27.40	m		
	Depth	D =	6.10	m		
	Draft	d =	2.70	m	from barge keel	
Cargo data					PAU - access stair	
	Weight	W =	1.00	kN		
	C.o.G.	x =	23.50	m	from c.g. of barge	
		y =	2.40	m	from centerline	
		z =	14.50	m	from barge deck	
	distance from roll axis	d_t =	18.06	m	on water plane	
	d_t angle	α_t =	0.13	rad	from vertical	
	distance from pitch axis	d_l =	29.54	m	on water plane	
	d_l angle	α_l =	0.92	rad	from vertical	
Motion data			(single amplitude, in 10 sec full cycle period)			
	Transportation duration		Unrestricted operations			
	Transportation area		Non-benign			
			Roll	Pitch	Heave	
	Maximum amplitude	a =	20.0	12.5		deg
	Max acceleration	ä =	0.138	0.086		rad/s^2
		ä =			0.2	g
Forces, per unit weight, due to:			Roll	Pitch	Heave	Gravity
	Inertia force = (W/g) d ä	F =	0.25	0.26	0.20	
	Transverse components	F_t =	0.25		0.07	0.34
	Vertical components	F_v =	0.03		0.19	0.94
	Longitudinal components	F_l =		0.16	0.04	0.22
	Vertical components	F_v =		0.21	0.20	0.98
Accelerations at cargo c.o.g.			Transv.	Longit.	Vertical	
1	+ Roll + Heave		0.66		1.16	g
2	+ Roll - Heave		0.53		0.79	g
3	- Roll + Heave		-0.66		1.09	g
4	- Roll - Heave		-0.53		0.72	g
5	+ Pitch + Heave			0.42	1.38	g
6	+ Pitch - Heave			0.33	0.99	g
7	- Pitch + Heave			-0.42	0.97	g
8	- Pitch - Heave			-0.33	0.57	g

From the performed computation, the following transportation accelerations have been selected for design:

- Roll 0.7g
- Pitch 0.5g
- Heave ±0.5g

The following load cases have been created to model transportation inertia forces:

PAU stairs	Load Case	Description	Direction	Design acceleration [g]	Mass load case	Inertia force [kN]
North	ROLL	Roll	X	0.7	G001	407.20
	PITC	Pitch	Y	0.5	G001	290.84
	HEAP	Heave	Z	0.5	G001	290.84
	HEAN	Heave	Z	-0.5	G001	-290.84
South	ROLL	Roll	X	0.7	G001	173.60
	PITC	Pitch	Y	0.5	G001	124.00
	HEAP	Heave	Z	0.5	G001	124.00
	HEAN	Heave	Z	-0.5	G001	-124.00

Table 10.8 – Transportation inertia loads

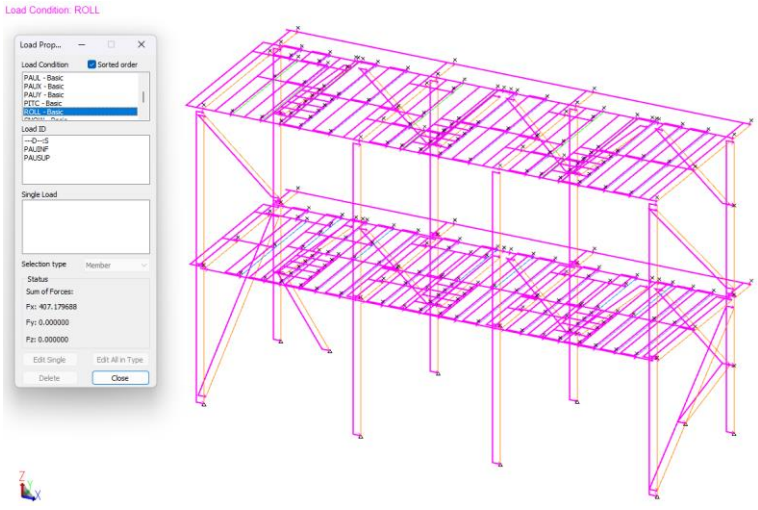


Figure 10.23 - PAU – North Stairs – load condition ROLL

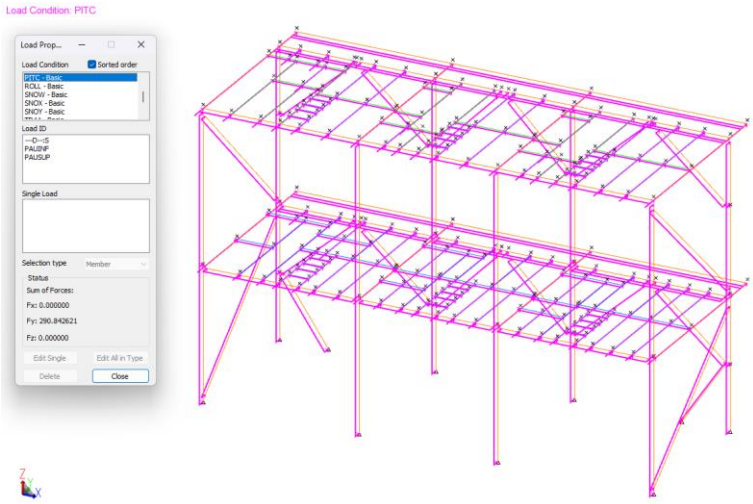


Figure 10.24 - PAU – North Stairs – load condition PITC

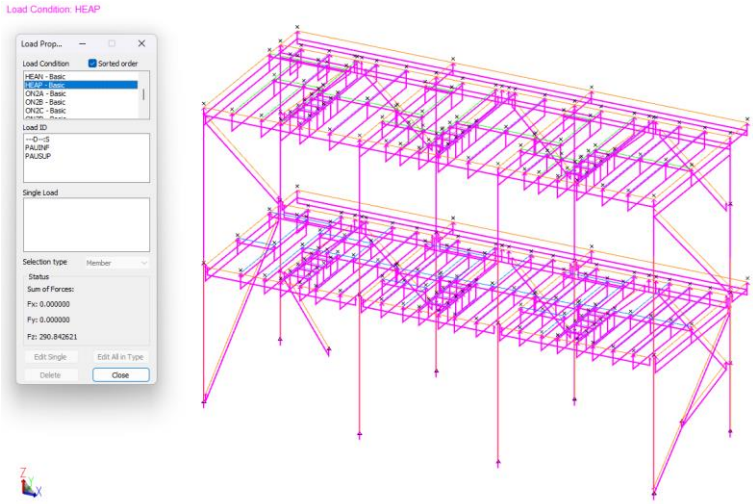


Figure 10.25 - PAU – North Stairs – load condition HEAP

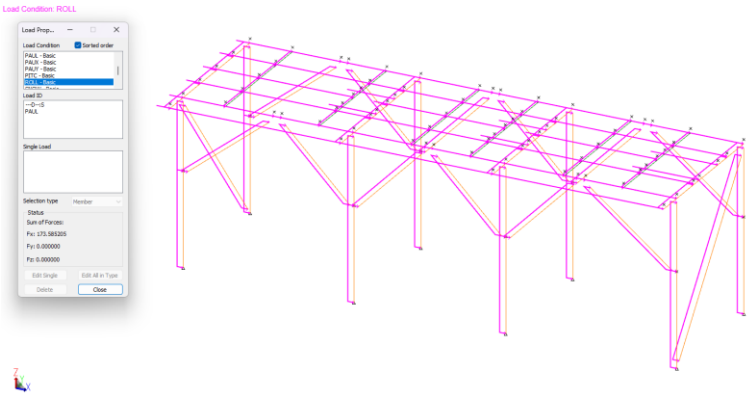


Figure 10.26 - PAU – South Stairs – load condition ROLL

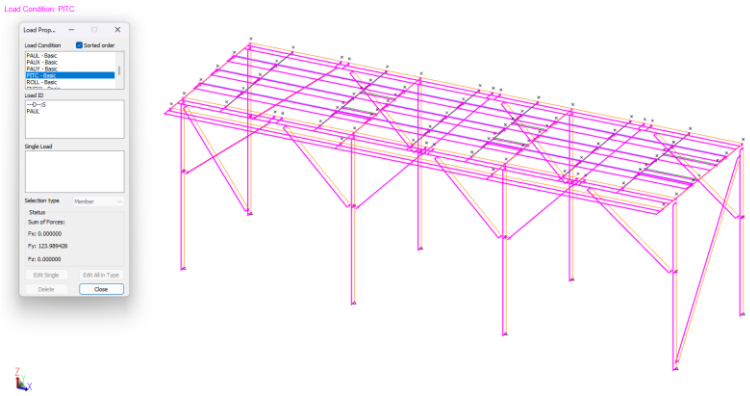


Figure 10.27 - PAU – South Stairs – load condition PITC

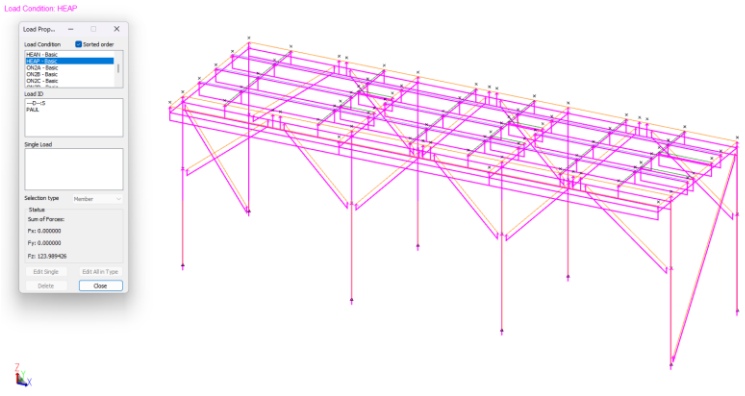


Figure 10.28 - PAU – South Stairs – load condition HEAP

10.3 BASIC LOAD CASES SUMMARY

Basic load conditions resulting forces are reported in the following SACS excerpts.

10.3.1 North Stairs

********** SEASTATE LOAD CASE CENTER REPORT **********
RELATIVE TO STRUCTURAL ORIGIN

LOAD CASE	LOAD LABEL	********* X - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Y - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Z - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)
4	DEAZ	0.00				0.00				-230.69	6.47	-2.60	35.53
9	PAUL	0.00				0.00				-351.00	6.62	-2.77	36.37
12	SNOW	0.00				0.00				-52.65	6.53	-2.74	38.61
15	WONX	-9.60	13.00	-3.19	36.41	0.00				0.00			
16	WONY	0.00				-16.21	6.50	0.00	37.46	0.00			
17	WOPX	9.60	0.00	-3.19	36.41	0.00				0.00			
18	WOPY	0.00				16.21	6.50	-5.40	37.46	0.00			
27	WEPX	16.03	0.00	-3.19	36.41	0.00				0.00			
28	WEPY	0.00				27.07	6.50	-5.41	37.46	0.00			
39	AOPA	63.43	6.56	-2.71	36.25	0.00				0.00			
40	AOPB	44.85	6.56	-2.71	36.25	44.85	6.56	-2.71	36.25	0.00			
41	AOPC	0.00				63.43	6.56	-2.71	36.25	0.00			
42	AOPD	-44.85	6.56	-2.71	36.25	44.85	6.56	-2.71	36.25	0.00			
43	AOPE	-63.43	6.56	-2.71	36.25	0.00				0.00			
44	AOPF	-44.85	6.56	-2.71	36.25	-44.85	6.56	-2.71	36.25	0.00			
45	AOPG	0.00				-63.43	6.56	-2.71	36.25	0.00			
46	AOPH	44.85	6.56	-2.71	36.25	-44.85	6.56	-2.71	36.25	0.00			
49	AEXA	126.87	6.56	-2.71	36.25	0.00				0.00			
50	AEXB	89.69	6.56	-2.71	36.25	89.69	6.56	-2.71	36.25	0.00			
51	AEXC	0.00				126.87	6.56	-2.71	36.25	0.00			
52	AEXD	-89.69	6.56	-2.71	36.25	89.69	6.56	-2.71	36.25	0.00			
53	AEXE	-126.87	6.56	-2.71	36.25	0.00				0.00			
54	AEXF	-89.69	6.56	-2.71	36.25	-89.69	6.56	-2.71	36.25	0.00			
55	AEXG	0.00				-126.87	6.56	-2.71	36.25	0.00			
56	AEXH	89.69	6.56	-2.71	36.25	-89.69	6.56	-2.71	36.25	0.00			
57	G001	0.00				0.00				-581.68	6.56	-2.70	36.03
82	ROLL	407.18	6.56	-2.70	36.03	0.00				0.00			
83	PITC	0.00				290.84	6.56	-2.70	36.03	0.00			
84	HEAN	0.00				0.00				-290.84	6.56	-2.70	36.03
85	HEAP	0.00				0.00				290.84	6.56	-2.70	36.03
86	WTXP	8.10	0.00	-3.19	36.41	0.00				0.00			
87	WTXN	-8.10	13.00	-3.19	36.41	0.00				0.00			
88	WTYP	0.00				13.67	6.50	-5.41	37.46	0.00			
89	WTYN	0.00				-13.67	6.50	0.00	37.46	0.00			

10.3.2 South Stairs

********** SEASTATE LOAD CASE CENTER REPORT **********
RELATIVE TO STRUCTURAL ORIGIN

LOAD CASE	LOAD LABEL	********* X - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Y - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Z - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)
4	DEAZ	0.00				0.00				-110.98	6.53	-2.02	33.82
9	PAUL	0.00				0.00				-137.00	6.59	-2.16	34.71
12	SNOW	0.00				0.00				-38.36	6.59	-2.16	34.71
15	WONX	-5.00	13.00	-1.76	34.70	0.00				0.00			
16	WONY	0.00				-4.75	6.50	0.00	34.70	0.00			
17	WOPX	5.00	0.00	-1.76	34.70	0.00				0.00			
18	WOPY	0.00				4.75	6.50	-4.21	34.70	0.00			
19	WEPX	8.35	0.00	-1.76	34.70	0.00				0.00			
20	WEPY	0.00				7.93	6.50	-4.21	34.70	0.00			
37	AOPX	28.63	6.57	-2.10	34.37	0.00				0.00			
38	AOPY	0.00				28.63	6.57	-2.10	34.37	0.00			
39	AOPA	28.63	6.57	-2.10	34.37	0.00				0.00			
40	AOPB	20.24	6.57	-2.10	34.37	20.24	6.57	-2.10	34.37	0.00			
41	AOPC	0.00				28.63	6.57	-2.10	34.37	0.00			
42	AOPD	-20.24	6.57	-2.10	34.37	20.24	6.57	-2.10	34.37	0.00			
43	AOPE	-28.63	6.57	-2.10	34.37	0.00				0.00			
44	AOPF	-20.24	6.57	-2.10	34.37	-20.24	6.57	-2.10	34.37	0.00			
45	AOPG	0.00				-28.63	6.57	-2.10	34.37	0.00			
46	AOPH	20.24	6.57	-2.10	34.37	-20.24	6.57	-2.10	34.37	0.00			
47	AEXX	49.60	6.56	-2.09	34.31	0.00				0.00			
48	AEXY	0.00				49.60	6.56	-2.09	34.31	0.00			
49	AEXA	49.60	6.56	-2.09	34.31	0.00				0.00			
50	AEXB	35.06	6.56	-2.09	34.31	35.06	6.56	-2.09	34.31	0.00			

51	AEXC	0.00				49.60	6.56	-2.09	34.31	0.00					
52	AEXD	-35.06	6.56	-2.09	34.31	35.06	6.56	-2.09	34.31	0.00					
53	AEXE	-49.60	6.56	-2.09	34.31	0.00				0.00					
54	AEXF	-35.06	6.56	-2.09	34.31	-35.06	6.56	-2.09	34.31	0.00					
55	AEXG	0.00				-49.60	6.56	-2.09	34.31	0.00					
56	AEXH	35.06	6.56	-2.09	34.31	-35.06	6.56	-2.09	34.31	0.00					
57	G001	0.00				0.00				-247.98	6.56	-2.09	34.31		
58	G002	0.00				0.00				-286.34	6.57	-2.10	34.37		
83	ROLL	173.59	6.56	-2.09	34.31	0.00				0.00					
84	PITC	0.00				123.99	6.56	-2.09	34.31	0.00					
85	HEAN	0.00				0.00				-123.99	6.56	-2.09	34.31		
86	HEAP	0.00				0.00				123.99	6.56	-2.09	34.31		
87	WTXP	4.32	0.00	-1.76	34.70	0.00				0.00					
88	WTXN	-4.32	13.00	-1.76	34.70	0.00				0.00					
89	WTYP	0.00				4.10	6.50	-4.21	34.70	0.00					
90	WTYN	0.00				-4.11	6.50	0.00	34.70	0.00					

10.4 LOAD COMBINATIONS

The below load combinations have been considered for stairs checks:

- G001: basic dead loads combination;
- G002: basic dead+live loads combination;
- ON2(A-H): permanent, live load and operating environmental loads combination (ULS);
- EN3(A-H): permanent, live load and extreme environmental loads combination (ULS);
- EN4(A-H): permanent, live load and extreme environmental loads combination (ULS);
- TR1(1-8): permanent, live load and transportation inertia loads combination situation 1 (ULS);
- TR2(1-8): permanent, live load and transportation inertia loads combination situation 2 (ULS);
- TR2(1-8): permanent, live load and transportation inertia loads combination situation 3 (ULS);
- DN2(A-H): permanent, live load and operating environmental loads combination (SLS);

LCOMB	WOPX	WOPY	WONX	WONY
WOPA	1.00			
WOPB	0.71	0.71		
WOPC		1.00		
WOPD		0.71	0.71	
WOPE			1.00	
WOPF			0.71	0.71
WOPG				1.00
WOPH	0.71			0.71

LCOMB	WEPX	WEPY	WENX	WENY
WEXA	1.00			
WEXB	0.71	0.71		
WEXC		1.00		
WEXD		0.71	0.71	
WEXE			1.00	
WEXF			0.71	0.71
WEXG				1.00
WEXH	0.71			0.71

Table 10.9 – Wind loads pre-combinations

LOAD	LOAD CASE																	
COMB	G001	SNOW	WOPA	WOPB	WOPC	WOPD	WOPE	WOPF	WOPG	WOPH	AOPA	AOPB	AOPC	AOPD	AOPE	AOPF	AOPG	AOPH
ON2A	1.30	1.50	1.22								1.25							
ON2B	1.30	1.50		1.22								1.25						
ON2C	1.30	1.50			1.22								1.25					
ON2D	1.30	1.50				1.22								1.25				
ON2E	1.30	1.50					1.22								1.25			
ON2F	1.30	1.50						1.22								1.25		
ON2G	1.30	1.50							1.22								1.25	
ON2H	1.30	1.50								1.22								1.25

Table 10.10 – ULS Load Combinations – Operative

LOAD	LOAD CASE																	
COMB	G001	SNOW	WOPA	WOPB	WOPC	WOPD	WOPE	WOPF	WOPG	WOPH	AOPA	AOPB	AOPC	AOPD	AOPE	AOPF	AOPG	AOPH
DN2A	1.00	1.00	1.00								1.00							
DN2B	1.00	1.00		1.00								1.00						
DN2C	1.00	1.00			1.00								1.00					
DN2D	1.00	1.00				1.00								1.00				
DN2E	1.00	1.00					1.00								1.00			
DN2F	1.00	1.00						1.00								1.00		
DN2G	1.00	1.00							1.00								1.00	
DN2H	1.00	1.00								1.00								1.00

Table 10.11 – SLS Load Combinations – Operative

LOAD	LOAD CASE																	
COMB	G001	SNOW	WEXA	WEXB	WEXC	WEXD	WEXE	WEXF	WEXG	WEXH	AEXA	AEXB	AEXC	AEXD	AEXE	AEXF	AEXG	AEXH
EN3A	1.00	1.00	1.35								1.45							
EN3B	1.00	1.00		1.35								1.45						
EN3C	1.00	1.00			1.35								1.45					
EN3D	1.00	1.00				1.35								1.45				
EN3E	1.00	1.00					1.35								1.45			
EN3F	1.00	1.00						1.35								1.45		
EN3G	1.00	1.00							1.35								1.45	
EN3H	1.00	1.00								1.35								1.45
EN4A	0.90		1.35								1.45							
EN4B	0.90			1.35								1.45						
EN4C	0.90				1.35								1.45					
EN4D	0.90					1.35								1.45				
EN4E	0.90						1.35								1.45			
EN4F	0.90							1.35								1.45		
EN4G	0.90								1.35								1.45	
EN4H	0.90									1.35								1.45

Table 10.12 – ULS Load Combinations- Extreme

LOAD	LOAD CASE								
COMB	G001	ROLL	PITC	HEAP	HEAN	WTXP	WTXN	WTYP	WTYN
TR11	1.30	1.00		1.00		1.00			
TR12	1.30	1.00		1.00		1.00			
TR13	1.30	-1.00			1.00		1.00		
TR14	1.30	-1.00			1.00		1.00		
TR15	1.30		1.00	1.00				1.00	
TR16	1.30		1.00	1.00				1.00	
TR17	1.30		-1.00		1.00				1.00
TR18	1.30		-1.00		1.00				1.00
TR21	1.10	1.35		1.35		1.35			
TR22	1.10	1.35		1.35		1.35			
TR23	1.10	-1.35			1.35		1.35		
TR24	1.10	-1.35			1.35		1.35		
TR25	1.10		1.35	1.35				1.35	
TR26	1.10		1.35	1.35				1.35	
TR27	1.10		-1.35		1.35				1.35
TR28	1.10		-1.35		1.35				1.35
TR31	0.90	1.35		1.35		1.35			
TR32	0.90	1.35		1.35		1.35			
TR33	0.90	-1.35			1.35		1.35		
TR34	0.90	-1.35			1.35		1.35		
TR35	0.90		1.35	1.35				1.35	
TR36	0.90		1.35	1.35				1.35	
TR37	0.90		-1.35		1.35				1.35
TR38	0.90		-1.35		1.35				1.35

Load combinations resultant forces are reported in the following Sacs excerpt.

10.4.1 North Stairs

********** SEASTATE LOAD CASE CENTER REPORT **********
RELATIVE TO STRUCTURAL ORIGIN

LOAD CASE	LOAD LABEL	********* X - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Y - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Z - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)
57	G001	0.00				0.00				-581.68	6.56	-2.70	36.03
58	ON2A	91.00	5.71	-2.77	36.27	0.00				-835.17	6.55	-2.71	36.28
59	ON2B	64.34	5.71	-2.77	36.27	70.04	6.54	-3.24	36.49	-835.17	6.55	-2.71	36.28
60	ON2C	0.00				99.07	6.54	-3.24	36.49	-835.17	6.55	-2.71	36.28
61	ON2D	-64.34	7.38	-2.77	36.27	70.04	6.54	-3.24	36.49	-835.17	6.55	-2.71	36.28
62	ON2E	-91.00	7.38	-2.77	36.27	0.00				-835.17	6.55	-2.71	36.28
63	ON2F	-64.34	7.38	-2.77	36.27	-70.04	6.54	-2.17	36.49	-835.17	6.55	-2.71	36.28
64	ON2G	0.00				-99.07	6.54	-2.17	36.49	-835.17	6.55	-2.71	36.28
65	ON2H	64.34	5.71	-2.77	36.27	-70.04	6.54	-2.17	36.49	-835.17	6.55	-2.71	36.28
66	EN3A	205.60	5.86	-2.76	36.26	0.00				-634.33	6.56	-2.71	36.25
67	EN3B	145.36	5.86	-2.76	36.26	155.90	6.55	-3.15	36.45	-634.33	6.56	-2.71	36.25
68	EN3C	0.00				220.50	6.55	-3.15	36.45	-634.33	6.56	-2.71	36.25
69	EN3D	-145.36	7.23	-2.76	36.26	155.90	6.55	-3.15	36.45	-634.33	6.56	-2.71	36.25
70	EN3E	-205.60	7.23	-2.76	36.26	0.00				-634.33	6.56	-2.71	36.25
71	EN3F	-145.36	7.23	-2.76	36.26	-155.89	6.55	-2.26	36.45	-634.33	6.56	-2.71	36.25
72	EN3G	0.00				-220.50	6.55	-2.26	36.45	-634.33	6.56	-2.71	36.25
73	EN3H	145.36	5.86	-2.76	36.26	-155.89	6.55	-2.26	36.45	-634.33	6.56	-2.71	36.25
74	EN4A	205.60	5.86	-2.76	36.26	0.00				-523.52	6.56	-2.70	36.03
75	EN4B	145.36	5.86	-2.76	36.26	155.90	6.55	-3.15	36.45	-523.52	6.56	-2.70	36.03
76	EN4C	0.00				220.50	6.55	-3.15	36.45	-523.52	6.56	-2.70	36.03
77	EN4D	-145.36	7.23	-2.76	36.26	155.90	6.55	-3.15	36.45	-523.52	6.56	-2.70	36.03
78	EN4E	-205.60	7.23	-2.76	36.26	0.00				-523.52	6.56	-2.70	36.03
79	EN4F	-145.36	7.23	-2.76	36.26	-155.89	6.55	-2.26	36.45	-523.52	6.56	-2.70	36.03
80	EN4G	0.00				-220.50	6.55	-2.26	36.45	-523.52	6.56	-2.70	36.03
81	EN4H	145.36	5.86	-2.76	36.26	-155.89	6.55	-2.26	36.45	-523.52	6.56	-2.70	36.03
90	TR11	415.28	6.43	-2.71	36.04	0.00				-465.35	6.56	-2.70	36.03
91	TR12	415.28	6.43	-2.71	36.04	0.00				-1047.03	6.56	-2.70	36.03
92	TR13	-415.28	6.68	-2.71	36.04	0.00				-465.35	6.56	-2.70	36.03
93	TR14	-415.28	6.68	-2.71	36.04	0.00				-1047.03	6.56	-2.70	36.03
94	TR15	0.00				304.51	6.55	-2.82	36.10	-465.35	6.56	-2.70	36.03
95	TR16	0.00				304.51	6.55	-2.82	36.10	-1047.03	6.56	-2.70	36.03
96	TR17	0.00				-304.51	6.55	-2.58	36.10	-465.35	6.56	-2.70	36.03
97	TR18	0.00				-304.51	6.55	-2.58	36.10	-1047.03	6.56	-2.70	36.03
98	TR21	560.62	6.43	-2.71	36.04	0.00				-247.22	6.56	-2.70	36.03
99	TR22	560.62	6.43	-2.71	36.04	0.00				-1032.49	6.56	-2.70	36.03
100	TR23	-560.62	6.68	-2.71	36.04	0.00				-247.22	6.56	-2.70	36.03
101	TR24	-560.62	6.68	-2.71	36.04	0.00				-1032.49	6.56	-2.70	36.03
102	TR25	0.00				411.09	6.55	-2.82	36.10	-247.22	6.56	-2.70	36.03
103	TR26	0.00				411.09	6.55	-2.82	36.10	-1032.49	6.56	-2.70	36.03
104	TR27	0.00				-411.09	6.55	-2.58	36.10	-247.22	6.56	-2.70	36.03
105	TR28	0.00				-411.09	6.55	-2.58	36.10	-1032.49	6.56	-2.70	36.03
106	TR31	560.62	6.43	-2.71	36.04	0.00				-130.88	6.56	-2.70	36.03
107	TR32	560.62	6.43	-2.71	36.04	0.00				-916.15	6.56	-2.70	36.03
108	TR33	-560.62	6.68	-2.71	36.04	0.00				-130.88	6.56	-2.70	36.03
109	TR34	-560.62	6.68	-2.71	36.04	0.00				-916.15	6.56	-2.70	36.03
110	TR35	0.00				411.09	6.55	-2.82	36.10	-130.88	6.56	-2.70	36.03
111	TR36	0.00				411.09	6.55	-2.82	36.10	-916.15	6.56	-2.70	36.03
112	TR37	0.00				-411.09	6.55	-2.58	36.10	-130.88	6.56	-2.70	36.03
113	TR38	0.00				-411.09	6.55	-2.58	36.10	-916.15	6.56	-2.70	36.03
114	DN2A	73.03	5.69	-2.77	36.27	0.00				-581.68	6.56	-2.70	36.03
115	DN2B	51.63	5.69	-2.77	36.27	56.31	6.54	-3.25	36.49	-581.68	6.56	-2.70	36.03
116	DN2C	0.00				79.64	6.54	-3.25	36.49	-581.68	6.56	-2.70	36.03
117	DN2D	-51.63	7.40	-2.77	36.27	56.31	6.54	-3.25	36.49	-581.68	6.56	-2.70	36.03
118	DN2E	-73.03	7.40	-2.77	36.27	0.00				-581.68	6.56	-2.70	36.03
119	DN2F	-51.63	7.40	-2.77	36.27	-56.31	6.54	-2.15	36.49	-581.68	6.56	-2.70	36.03
120	DN2G	0.00				-79.64	6.54	-2.15	36.49	-581.68	6.56	-2.70	36.03
121	DN2H	51.63	5.69	-2.77	36.27	-56.31	6.54	-2.15	36.49	-581.68	6.56	-2.70	36.03

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10.4.2 South Stairs

********** SEASTATE LOAD CASE CENTER REPORT **********
RELATIVE TO STRUCTURAL ORIGIN

LOAD CASE	LOAD LABEL	********* X - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Y - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Z - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)
57	G001	0.00				0.00				-247.98	6.56	-2.09	34.31
58	G002	0.00				0.00				-286.34	6.57	-2.10	34.37
59	ON2A	41.89	5.61	-2.05	34.41	0.00				-379.91	6.57	-2.10	34.37
60	ON2B	29.62	5.61	-2.05	34.41	29.40	6.56	-2.40	34.41	-379.91	6.57	-2.10	34.37
61	ON2C	0.00				41.59	6.56	-2.40	34.41	-379.91	6.57	-2.10	34.37
62	ON2D	-29.62	7.50	-2.05	34.41	29.40	6.56	-2.40	34.41	-379.91	6.57	-2.10	34.37
63	ON2E	-41.89	7.50	-2.05	34.41	0.00				-379.91	6.57	-2.10	34.37
64	ON2F	-29.62	7.50	-2.05	34.41	-29.40	6.56	-1.81	34.41	-379.91	6.57	-2.10	34.37
65	ON2G	0.00				-41.59	6.56	-1.81	34.41	-379.91	6.57	-2.10	34.37
66	ON2H	29.62	5.61	-2.05	34.41	-29.40	6.56	-1.81	34.41	-379.91	6.57	-2.10	34.37
67	EN3A	83.19	5.68	-2.05	34.36	0.00				-286.34	6.57	-2.10	34.37
68	EN3B	58.81	5.68	-2.05	34.36	58.41	6.56	-2.37	34.36	-286.34	6.57	-2.10	34.37
69	EN3C	0.00				82.62	6.56	-2.37	34.36	-286.34	6.57	-2.10	34.37
70	EN3D	-58.81	7.44	-2.05	34.36	58.41	6.56	-2.37	34.36	-286.34	6.57	-2.10	34.37
71	EN3E	-83.19	7.44	-2.05	34.36	0.00				-286.34	6.57	-2.10	34.37
72	EN3F	-58.81	7.44	-2.05	34.36	-58.41	6.56	-1.82	34.36	-286.34	6.57	-2.10	34.37
73	EN3G	0.00				-82.62	6.56	-1.82	34.36	-286.34	6.57	-2.10	34.37
74	EN3H	58.81	5.68	-2.05	34.36	-58.41	6.56	-1.82	34.36	-286.34	6.57	-2.10	34.37
75	EN4A	83.19	5.68	-2.05	34.36	0.00				-223.18	6.56	-2.09	34.31
76	EN4B	58.81	5.68	-2.05	34.36	58.41	6.56	-2.37	34.36	-223.18	6.56	-2.09	34.31
77	EN4C	0.00				82.62	6.56	-2.37	34.36	-223.18	6.56	-2.09	34.31
78	EN4D	-58.81	7.44	-2.05	34.36	58.41	6.56	-2.37	34.36	-223.18	6.56	-2.09	34.31
79	EN4E	-83.19	7.44	-2.05	34.36	0.00				-223.18	6.56	-2.09	34.31
80	EN4F	-58.81	7.44	-2.05	34.36	-58.41	6.56	-1.82	34.36	-223.18	6.56	-2.09	34.31
81	EN4G	0.00				-82.62	6.56	-1.82	34.36	-223.18	6.56	-2.09	34.31
82	EN4H	58.81	5.68	-2.05	34.36	-58.41	6.56	-1.82	34.36	-223.18	6.56	-2.09	34.31
91	TR11	177.91	6.41	-2.09	34.32	0.00				-198.38	6.56	-2.09	34.31
92	TR12	177.91	6.41	-2.09	34.32	0.00				-446.36	6.56	-2.09	34.31
93	TR13	-177.91	6.72	-2.09	34.32	0.00				-198.38	6.56	-2.09	34.31
94	TR14	-177.91	6.72	-2.09	34.32	0.00				-446.36	6.56	-2.09	34.31
95	TR15	0.00				128.09	6.56	-2.16	34.32	-198.38	6.56	-2.09	34.31
96	TR16	0.00				128.09	6.56	-2.16	34.32	-446.36	6.56	-2.09	34.31
97	TR17	0.00				-128.09	6.56	-2.03	34.32	-198.38	6.56	-2.09	34.31
98	TR18	0.00				-128.09	6.56	-2.03	34.32	-446.36	6.56	-2.09	34.31
99	TR21	240.17	6.41	-2.09	34.32	0.00				-105.39	6.56	-2.09	34.31
100	TR22	240.17	6.41	-2.09	34.32	0.00				-440.16	6.56	-2.09	34.31
101	TR23	-240.17	6.72	-2.09	34.32	0.00				-105.39	6.56	-2.09	34.31
102	TR24	-240.17	6.72	-2.09	34.32	0.00				-440.16	6.56	-2.09	34.31
103	TR25	0.00				172.93	6.56	-2.16	34.32	-105.39	6.56	-2.09	34.31
104	TR26	0.00				172.93	6.56	-2.16	34.32	-440.16	6.56	-2.09	34.31
105	TR27	0.00				-172.93	6.56	-2.03	34.32	-105.39	6.56	-2.09	34.31
106	TR28	0.00				-172.93	6.56	-2.03	34.32	-440.16	6.56	-2.09	34.31
107	TR31	240.17	6.41	-2.09	34.32	0.00				-55.80	6.56	-2.09	34.31
108	TR32	240.17	6.41	-2.09	34.32	0.00				-390.57	6.56	-2.09	34.31
109	TR33	-240.17	6.72	-2.09	34.32	0.00				-55.80	6.56	-2.09	34.31
110	TR34	-240.17	6.72	-2.09	34.32	0.00				-390.57	6.56	-2.09	34.31
111	TR35	0.00				172.93	6.56	-2.16	34.32	-55.80	6.56	-2.09	34.31
112	TR36	0.00				172.93	6.56	-2.16	34.32	-390.57	6.56	-2.09	34.31
113	TR37	0.00				-172.93	6.56	-2.03	34.32	-55.80	6.56	-2.09	34.31
114	TR38	0.00				-172.93	6.56	-2.03	34.32	-390.57	6.56	-2.09	34.31
115	DN2A	33.63	5.59	-2.05	34.42	0.00				-286.34	6.57	-2.10	34.37
116	DN2B	23.78	5.59	-2.05	34.42	23.60	6.56	-2.40	34.41	-286.34	6.57	-2.10	34.37
117	DN2C	0.00				33.38	6.56	-2.40	34.41	-286.34	6.57	-2.10	34.37
118	DN2D	-23.78	7.52	-2.05	34.42	23.60	6.56	-2.40	34.41	-286.34	6.57	-2.10	34.37
119	DN2E	-33.63	7.52	-2.05	34.42	0.00				-286.34	6.57	-2.10	34.37
120	DN2F	-23.78	7.52	-2.05	34.42	-23.60	6.56	-1.80	34.41	-286.34	6.57	-2.10	34.37
121	DN2G	0.00				-33.38	6.56	-1.80	34.41	-286.34	6.57	-2.10	34.37
122	DN2H	23.78	5.59	-2.05	34.42	-23.60	6.56	-1.80	34.41	-286.34	6.57	-2.10	34.37

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10.5 RESULTS

All members were checked according to ISO 19902 and Eurocode 3, Ref./2/ and /10/, respectively for tubular and non-tubular elements. Members' code checks are reported in the following and show that the structure can withstand all In-Service and Transportation load combinations, with utilization factors below 1.0.

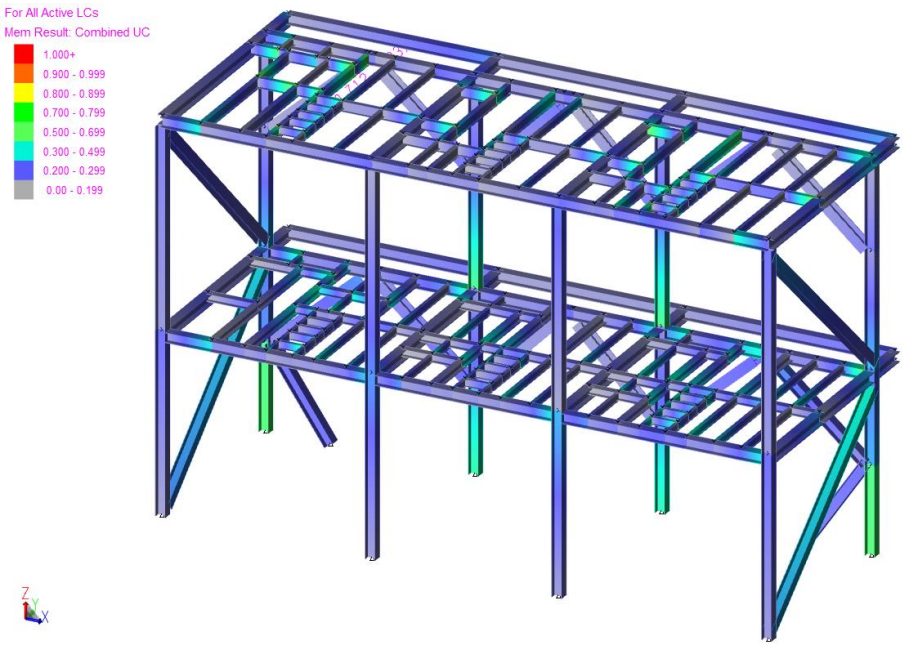
Deflection checks are performed for all the beams considering serviceability limit state load condition.

10.5.1 North Stairs

The maximum UC value is equal to 0.71 on member 003X-0043 for load combination TR35. Maximum member UC are reported in following SACS excerpt and figures.

* * * M E M B E R G R O U P S U M M A R Y * * *
ISO 19902:2007 / EC3:2005
(EN 1993-1-1:2005/NA NONE)

GRUP ID	CRITICAL MEMBER	LOAD COND	MAX. UNITY CHECK	DIST FROM END M	* APPLIED STRESSES * AXIAL N/MM2	BEND-Y N/MM2	BEND-Z N/MM2	*** ALLOWABLE STRESSES *** AXIAL N/MM2	EULER N/MM2	BEND-Y N/MM2	BEND-Z N/MM2	CRIT COND	EFFECTIVE LENGTHS KLY M	KLZ M	CM VALUES * Y	Z
HE2	00A0-SP16	TR28	0.49	0.5	5.2	-9.6	-212.8	322.7	3561.7	362.0	489.2	BN+AX	2.25	0.48	0.00	0.00
HE3	0078-0077	TR28	0.39	0.0	5.3	70.7	89.9	322.7	477.8	365.5	490.0	BN+AX	4.42	1.02	0.00	0.00
IP2	0050-0051	TR24	0.42	0.0	3.3	37.3	-152.4	322.7	683.3	368.0	500.6	BN+AX	1.02	1.02	0.00	0.00
IP3	003X-0043	TR35	0.71	0.6	-1.9	-4.0	224.0	322.7	855.0	322.7	322.7	BN+AX	4.42	0.63	0.93	0.40



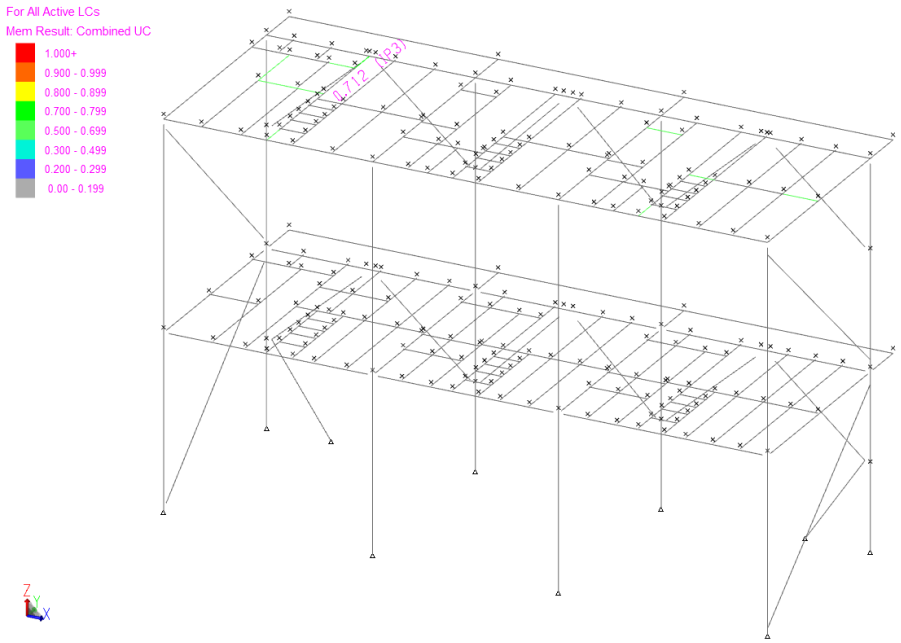


Figure 10.29 - PAU – North Stairs Structural Model 3D View - UC>0.7

The results of the deflection checks are presented in the following SACS excerpt in terms of ratios between beam span and vertical deflection for the critical combinations.

********** SPAN DEFLECTION SUMMARY REPORT **********

SPAN ID	CANT	BEGIN JOINT	END JOINT	SPAN LENGTH M	LOCAL Y DIRECTION MAX. LOAD CASE	MAXIMUM DEFL. CM	DISTANCE ALONG SPAN M	DEFL/SPAN RATIO	SPAN/DEFL RATIO	LOCAL Z DIRECTION MAX. LOAD CASE	MAXIMUM DEFL. CM	DISTANCE ALONG SPAN M	DEFL/SPAN RATIO	SPAN/DEFL RATIO
C001	YES	0035	002Q	0.98	DN2F	0.022	0.98	0.0001	8951.9	DN2C	0.02	0.98	0.0001	11276.8
C002	YES	002U	0045	0.98	DN2F	0.017	0.98	0.0001	11865.4	DN2C	0.03	0.98	0.0002	5737.7
C003	YES	0030	004A	0.98	DN2A	0.014	0.98	0.0001	14046.2	DN2C	0.03	0.98	0.0002	5740.3
C004	YES	0034	003C	0.98	DN2A	0.015	0.98	0.0001	12766.8	DN2C	0.03	0.98	0.0002	6102.4
C005	YES	0000	SP13	0.87	DN2F	0.011	0.87	0.0001	15661.5	DN2G	0.03	0.87	0.0002	5150.7
C006	YES	0004	SP14	0.87	DN2E	0.010	0.87	0.0001	16910.1	DN2C	0.04	0.87	0.0002	4533.5
C007	YES	000A	SP15	0.87	DN2A	0.009	0.87	0.0001	19134.6	DN2C	0.04	0.87	0.0002	4819.2
C008	YES	000F	SP16	0.87	DN2A	0.008	0.87	0.0000	22851.9	DN2G	0.06	0.87	0.0003	3054.9
HF01	NO	SP09	SP13	4.20	DN2A	0.028	1.84	0.0001	14757.3	DN2G	0.05	2.28	0.0001	8036.0
HF02	NO	SP14	SP10	4.20	DN2H	0.011	1.02	0.0000	37797.3	DN2G	0.06	2.14	0.0001	7243.0
HF03	NO	SP15	SP11	4.20	DN2F	0.012	3.00	0.0000	33871.1	DN2G	0.06	2.14	0.0001	6856.0
HF04	NO	SP09	SP10	4.28	DN2G	0.017	3.13	0.0000	25932.3	DN2A	0.07	1.77	0.0002	5827.9
HF07	NO	SP13	SP14	4.28	DN2C	0.017	3.13	0.0000	25702.2	DN2A	0.03	1.65	0.0001	13015.4
HF08	NO	SP10	SP11	3.78	DN2B	0.023	2.17	0.0001	16401.4	DN2A	0.03	1.61	0.0001	13100.4
HF09	NO	SP14	SP15	3.78	DN2B	0.025	1.99	0.0001	14840.2	DN2C	0.02	1.99	0.0000	21739.3
HF10	NO	SP11	SP12	4.28	DN2G	0.066	2.17	0.0002	6470.5	DN2E	0.07	2.63	0.0002	5956.4
HF11	NO	SP15	SP16	4.28	DN2C	0.065	2.04	0.0002	6543.7	DN2E	0.03	2.63	0.0001	13316.4
HF12	NO	0000	000F	13.00	DN2G	0.263	6.82	0.0002	4941.3	DN2F	0.08	10.30	0.0001	16313.9
HF16	NO	SP12	SP16	4.20	DN2F	0.037	1.14	0.0001	11279.9	DN2G	0.09	2.06	0.0002	4512.1
HF17	NO	000M	001F	1.76	DN2C	0.006	0.78	0.0000	29718.3	DN2B	0.01	0.96	0.0001	14111.7
HF18	NO	000P	001J	1.06	DN2H	0.009	0.62	0.0001	11372.6	DN2C	0.00	0.53	0.0000	475227.5
HF19	NO	000V	001E	3.79	DN2A	0.023	2.02	0.0001	16438.2	DN2F	0.12	1.91	0.0003	3140.2
HF20	NO	000W	0046	4.42	DN2G	0.022	1.48	0.0001	19971.7	DN2E	0.46	2.22	0.0010	956.1
HF21	NO	001P	0077	1.48	DN2D	0.007	0.35	0.0000	21777.3	DN2E	0.00	0.77	0.0000	99438.3
HF22	NO	0078	001R	2.74	DN2G	0.011	1.38	0.0000	23911.8	DN2E	0.07	1.32	0.0002	4021.1
HF23	NO	001Z	001Y	1.26	DN2H	0.004	0.88	0.0000	35701.4	DN2H	0.00	0.63	0.0000	62820.9
HF24	NO	0085	0087	1.26	DN2D	0.003	0.84	0.0000	38200.5	DN2E	0.00	0.64	0.0000	44761.3
HF25	NO	0024	0029	1.72	DN2D	0.005	1.03	0.0000	31473.1	DN2C	0.02	0.91	0.0001	7907.3
HF26	NO	0028	0011	3.79	DN2F	0.015	1.56	0.0000	26108.2	DN2F	0.26	1.85	0.0007	1435.1
HF27	NO	0088	0021	2.74	DN2B	0.015	0.92	0.0001	18864.3	DN2D	0.08	1.35	0.0003	3635.4
HF28	NO	001V	001T	2.25	DN2H	0.008	0.81	0.0000	27433.7	DN2C	0.06	1.12	0.0003	3546.0
HF29	NO	001W	0022	2.25	DN2E	0.021	1.26	0.0001	10495.9	DN2A	0.03	1.21	0.0002	6599.5
HF30	NO	0025	002A	1.72	DN2E	0.006	1.05	0.0000	27283.8	DN2B	0.02	0.91	0.0001	7804.9
HF31	NO	0026	002C	1.26	DN2A	0.003	0.86	0.0000	41321.3	DN2H	0.00	0.63	0.0000	65525.4

HF32	NO	0095	0097	1.26	DN2E	0.003	0.89	0.0000	42266.5	DN2E	0.00	0.63	0.0000	44910.5
HF33	NO	001X	0015	3.79	DN2F	0.027	1.49	0.0001	14177.5	DN2D	0.27	1.85	0.0007	1399.1
HF34	NO	0098	000I	3.24	DN2F	0.033	0.94	0.0001	9856.8	DN2D	0.13	1.62	0.0004	2483.7
HF35	NO	002F	002P	2.25	DN2F	0.045	1.28	0.0002	4967.4	DN2H	0.04	1.24	0.0002	5482.2
HF36	NO	002G	002M	2.25	DN2F	0.014	0.74	0.0001	16258.4	DN2G	0.06	1.13	0.0003	3569.9
HS01	NO	002Q	0034	13.00	DN2C	0.442	6.58	0.0003	2943.9	DN2D	0.09	10.34	0.0001	14436.8
HS02	NO	003B	0035	4.42	DN2H	0.037	1.33	0.0001	12039.3	DN2C	0.07	2.16	0.0002	5912.3
HS03	NO	0035	0003	2.15	DN2C	0.024	0.79	0.0001	9075.5	DN2A	0.01	1.23	0.0000	23083.0
HS04	NO	0045	0005	2.15	DN2C	0.025	0.91	0.0001	8475.1	DN2A	0.01	1.16	0.0000	22679.2
HS05	NO	003B	003L	2.22	DN2D	0.018	0.76	0.0001	12217.3	DN2A	0.03	1.29	0.0001	8654.8
HS07	NO	0008	0045	1.90	DN2B	0.007	0.93	0.0000	26260.4	DN2H	0.00	0.75	0.0000	134526.7
HS08	NO	0009	004A	1.90	DN2D	0.006	0.78	0.0000	29322.7	DN2B	0.00	0.55	0.0000	98118.0
HS09	NO	003N	003S	4.00	DN2C	0.037	1.92	0.0001	10849.7	DN2B	0.03	1.73	0.0001	11788.3
HS10	NO	004A	0031	2.15	DN2C	0.029	1.03	0.0001	7312.3	DN2E	0.01	1.22	0.0001	16218.4
HS11	NO	0032	003C	2.15	DN2C	0.029	1.45	0.0001	7396.3	DN2E	0.01	0.97	0.0000	20314.5
HS12	NO	003I	003S	4.50	DN2C	0.075	2.74	0.0002	6016.6	DN2F	0.11	2.22	0.0002	4204.4
HS13	NO	0045	003N	4.42	DN2E	0.029	2.58	0.0001	15058.9	DN2G	0.11	2.28	0.0003	3885.4
HS14	NO	004A	003S	4.42	DN2E	0.034	2.57	0.0001	13144.3	DN2G	0.11	2.29	0.0003	3949.7
HS15	NO	003I	003C	4.42	DN2F	0.059	1.72	0.0001	7446.1	DN2C	0.12	2.13	0.0003	3547.6
HS17	NO	0036	003X	2.22	DN2D	0.020	0.94	0.0001	11020.7	DN2F	0.04	1.05	0.0002	5826.5
HS18	NO	00B6	00B7	1.40	DN2D	0.012	0.32	0.0001	11687.6	DN2D	0.01	0.81	0.0000	21078.7
HS19	NO	003W	003K	3.79	DN2D	0.047	2.65	0.0001	8147.6	DN2C	0.17	1.86	0.0005	2203.6
HS20	NO	00C0	00C3	2.44	DN2C	0.058	1.42	0.0002	4251.9	DN2H	0.02	1.22	0.0001	10017.7
HS21	NO	003L	0043	4.42	DN2D	0.035	2.62	0.0001	12712.9	DN2E	0.51	2.21	0.0012	866.6
HS22	NO	00C4	0041	2.28	DN2C	0.025	1.54	0.0001	8995.9	DN2G	0.03	1.07	0.0001	7091.5
HS23	NO	004E	00D8	0.76	DN2D	0.003	0.19	0.0000	27503.4	DN2C	0.00	0.28	0.0000	1139049.5
HS24	NO	00D7	00E1	0.76	DN2D	0.003	0.19	0.0000	24265.3	DN2C	0.00	0.32	0.0000	51086.1
HS25	NO	004F	004O	1.72	DN2B	0.007	0.77	0.0000	23593.7	DN2H	0.01	0.84	0.0001	15128.3
HS26	NO	00E4	00E3	1.31	DN2H	0.003	0.30	0.0000	47804.4	DN2H	0.00	0.65	0.0000	54922.7
HS27	NO	00D5	00D9	3.11	DN2H	0.012	0.83	0.0000	25117.3	DN2F	0.04	1.46	0.0001	7891.0
HS28	NO	003P	0047	4.42	DN2E	0.034	2.35	0.0001	12928.3	DN2G	0.48	2.17	0.0011	925.9
HS30	NO	00E5	004S	2.28	DN2E	0.011	1.74	0.0000	21219.0	DN2H	0.03	1.06	0.0001	7506.9
HS31	NO	00G4	004J	0.76	DN2F	0.003	0.58	0.0000	22243.9	DN2C	0.00	0.47	0.0000	1032231.9
HS32	NO	00G1	00G7	0.76	DN2F	0.004	0.19	0.0001	19323.7	DN2C	0.00	0.32	0.0000	47409.3
HS33	NO	004H	004V	1.72	DN2C	0.021	0.80	0.0001	8370.7	DN2B	0.01	0.84	0.0001	15949.2
HS34	NO	00G9	00G8	1.31	DN2C	0.008	0.29	0.0001	16118.1	DN2B	0.00	0.65	0.0000	53152.9
HS35	NO	00G0	00G5	3.11	DN2B	0.014	0.82	0.0000	22829.5	DN2F	0.04	1.45	0.0001	8031.6
HS36	NO	003U	004C	4.42	DN2F	0.060	2.38	0.0001	7389.5	DN2G	0.60	2.17	0.0014	731.8
HS37	NO	00H1	00H8	2.78	DN2C	0.032	2.23	0.0001	8576.5	DN2C	0.11	1.36	0.0004	2475.1
IF01	NO	0042	0038	0.63	DN2H	0.008	0.26	0.0001	8185.0	DN2F	0.00	0.30	0.0000	129584.1
IF02	NO	001M	000Y	2.17	DN2G	0.032	1.35	0.0001	6734.7	DN2A	0.04	1.07	0.0002	5868.4
IF03	NO	001N	000Z	2.17	DN2G	0.032	1.35	0.0001	6781.5	DN2A	0.04	1.07	0.0002	5969.1
IF04	NO	0048	0051	2.25	DN2H	0.017	0.69	0.0001	12867.1	DN2E	0.06	1.16	0.0003	3682.5
IF05	NO	001Q	0079	2.17	DN2D	0.016	1.54	0.0001	13335.4	DN2H	0.09	0.98	0.0004	2317.6
IF06	NO	0080	0081	4.42	DN2E	0.037	1.15	0.0001	12077.0	DN2A	0.18	2.14	0.0004	2398.8
IF07	NO	0083	0084	4.42	DN2F	0.017	2.07	0.0000	25760.8	DN2F	0.20	2.21	0.0005	2195.9
IF08	NO	001T	0012	2.17	DN2A	0.011	1.67	0.0001	18966.4	DN2F	0.09	0.98	0.0004	2382.9
IF09	NO	0023	0013	2.17	DN2A	0.011	1.67	0.0001	19347.9	DN2A	0.03	1.08	0.0002	6256.4
IF10	NO	0022	0091	2.17	DN2A	0.007	0.43	0.0000	32126.1	DN2A	0.08	0.98	0.0004	2655.8
IF11	NO	0089	0092	4.42	DN2E	0.043	1.19	0.0001	10301.6	DN2A	0.18	2.14	0.0004	2516.9
IF12	NO	0093	0094	4.42	DN2F	0.025	2.07	0.0001	17961.7	DN2E	0.21	2.23	0.0005	2109.8
IF13	NO	0016	002M	2.17	DN2G	0.013	0.93	0.0001	16869.9	DN2A	0.10	1.20	0.0004	2268.5
IF14	NO	002N	0017	2.17	DN2G	0.013	1.22	0.0001	16754.7	DN2H	0.04	1.08	0.0002	6163.4
IF15	NO	002P	00A7	2.17	DN2G	0.033	0.91	0.0002	6638.5	DN2H	0.10	0.98	0.0005	2169.3
IF16	NO	0099	00A3	2.25	DN2F	0.063	1.21	0.0003	3548.3	DN2H	0.07	1.21	0.0003	3248.7
IF17	NO	00A3	00A4	2.17	DN2G	0.040	0.91	0.0002	5446.4	DN2H	0.06	1.00	0.0003	3446.1
IF20	NO	00A0	00A5	2.25	DN2F	0.054	1.19	0.0002	4178.4	DN2G	0.05	1.19	0.0002	4120.3
IF21	NO	00A5	00A6	2.17	DN2G	0.031	0.91	0.0001	7064.7	DN2G	0.05	1.02	0.0002	4438.3
IS01	NO	00B2	00B8	0.63	DN2A	0.000	0.31	0.0000	167343.3	DN2D	0.00	0.31	0.0000	130291.1
IS02	NO	00B3	00B9	0.63	DN2A	0.000	0.31	0.0000	167342.9	DN2A	0.00	0.31	0.0000	130290.1
IS03	NO	00C2	00C3	1.35	DN2A	0.008	0.67	0.0001	17703.5	DN2C	0.01	0.67	0.0001	19187.8
IS04	NO	0044	003M	4.42	DN2E	0.076	1.26	0.0002	5823.8	DN2G	0.49	2.65	0.0011	897.8
IS05	NO	00B4	00C6	4.42	DN2H	0.151	4.42	0.0003	2931.5	DN2H	0.29	2.25	0.0007	1538.1
IS06	NO	00D9	00E0	1.31	DN2A	0.007	0.65	0.0001	19361.4	DN2G	0.01	0.65	0.0000	20838.7
IS07	NO	003R	0049	4.42	DN2E	0.071	3.07	0.0002	6250.9	DN2D	0.44	3.12	0.0010	1011.9
IS08	NO	00D6	00E7	4.42	DN2A	0.130	4.42	0.0003	3402.0	DN2F	0.30	3.08	0.0007	1478.7
IS09	NO	00G5	00G6	1.31	DN2A	0.007	0.65	0.0001	19361.4	DN2D	0.01	0.65	0.0000	20838.7
IS10	NO	004D	003V	4.42	DN2E	0.088	1.35	0.0002	5000.8	DN2B	0.62	2.65	0.0014	718.4
IS11	NO	00H3	00H5	4.42	DN2B	0.218	4.42	0.0005	2030.8	DN2B	0.48	2.25	0.0011	928.8
IS12	NO	00H2	00H4	4.42	DN2B	0.192	4.42	0.0004	2302.4	DN2F	0.36	3.55	0.0008	1241.0

Max deflection/span ratio are within the limits 1/300 for supported beams and 1/150 for cantilevers.

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10.5.2 South Stairs

The maximum UC value is equal to 0.58 on member 0051-0022 for load combination TR28. Maximum member UC are reported in following SACS excerpt and figures.

```
                                  * * *  M E M B E R   G R O U P   S U M M A R Y  * * *
                                                ISO 19902:2007 / EC3:2005
                                              (EN 1993-1-1:2005/NA NONE)
                          MAX.   DIST                                                                          EFFECTIVE       CM
GRUP CRITICAL LOAD       UNITY   FROM    * APPLIED STRESSES *     *** ALLOWABLE STRESSES ***    CRIT        LENGTHS     * VALUES *
 ID    MEMBER   COND      CHECK   END     AXIAL BEND-Y BEND-Z     AXIAL  EULER BEND-Y BEND-Z    COND       KLY    KLZ     Y      Z
                            M       N/MM2  N/MM2  N/MM2     N/MM2  N/MM2  N/MM2  N/MM2                    M      M

HE2 000N-0038 TR22        0.37    0.0     -12.8 -119.0    -2.0     322.7  321.6  362.0  489.2   BN+AX     2.50   4.50   0.94   0.47
IP1 0053-0056 TR26        0.36    1.2     -10.5   24.2   -57.8      85.2  115.6  230.2  426.8   BN+COM    2.48   2.48   1.00   1.00
IP2 0051-0022 TR28        0.58    0.9      -4.0   -0.8  -169.8     322.7 1348.0  322.7  322.7   BN+AX     3.52   0.88   0.95   0.40
```

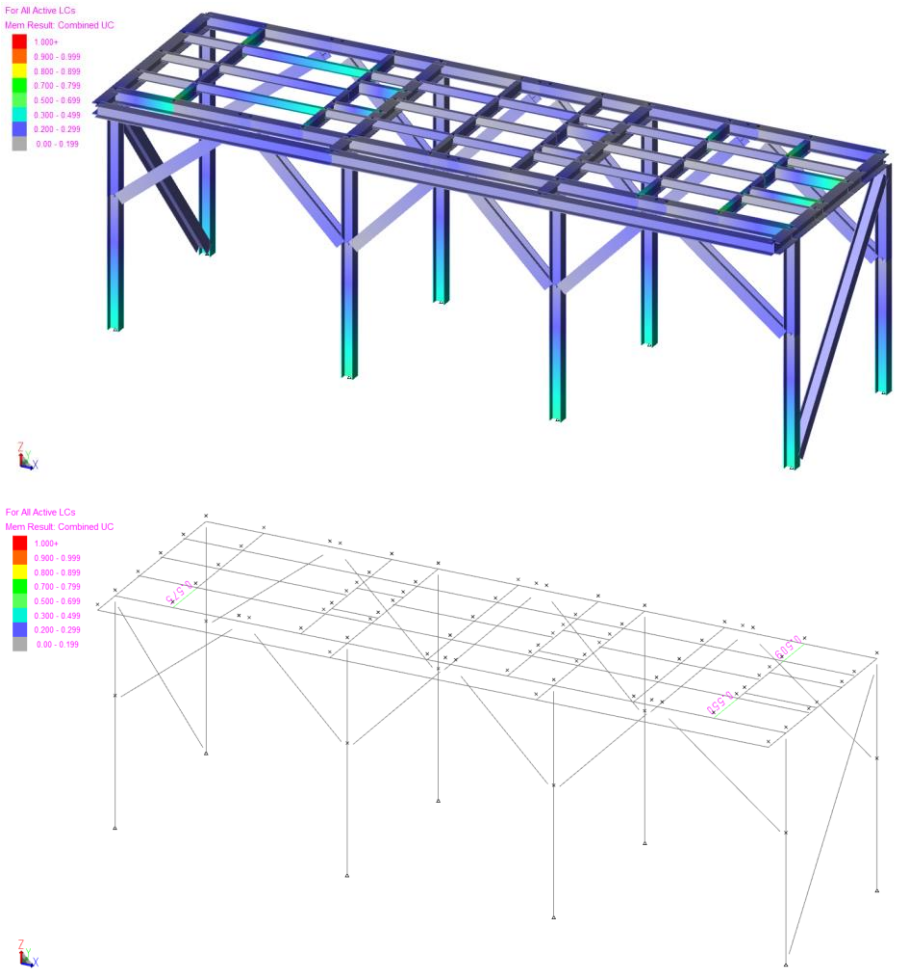


Figure 10.30 - PAU – South Stairs Structural Model 3D View - UC>0.5

The results of the deflection checks are presented in the following SACS excerpt in terms of ratios between beam span and vertical deflection for the critical combinations.

********** SPAN DEFLECTION SUMMARY REPORT **********

SPAN ID	CANT	BEGIN JOINT	END JOINT	SPAN LENGTH M	LOCAL Y DIRECTION MAX. LOAD CASE	LOCAL Y DIRECTION MAXIMUM DEFL. CM	LOCAL Y DIRECTION DISTANCE ALONG SPAN M	LOCAL Y DIRECTION DEFL/SPAN RATIO	LOCAL Y DIRECTION SPAN/DEFL RATIO	LOCAL Z DIRECTION MAX. LOAD CASE	LOCAL Z DIRECTION MAXIMUM DEFL. CM	LOCAL Z DIRECTION DISTANCE ALONG SPAN M	LOCAL Z DIRECTION DEFL/SPAN RATIO	LOCAL Z DIRECTION SPAN/DEFL RATIO
C001	NO	0020	0037	4.28	TR28	0.015	2.53	0.0000	28368.8	TR24	0.62	2.10	0.0014	690.6
C002	NO	0000	0036	4.28	TR28	0.037	2.48	0.0001	11436.6	TR24	0.56	2.10	0.0013	759.3
C003	NO	0019	0038	4.28	TR26	0.305	2.28	0.0007	1402.9	TR22	0.68	2.15	0.0016	627.5
C004	NO	0003	0039	4.28	TR26	0.310	2.28	0.0007	1379.4	TR22	0.59	2.15	0.0014	728.2
C005	NO	0018	0040	4.28	TR26	0.302	2.28	0.0007	1415.3	TR24	0.67	2.15	0.0016	642.5
C006	NO	0007	0041	4.28	TR26	0.305	2.28	0.0007	1404.8	TR24	0.61	2.15	0.0014	704.0
C007	NO	0012	0042	4.28	TR26	0.049	2.38	0.0001	8676.3	TR22	0.64	2.10	0.0015	669.8
C008	NO	0009	0043	4.28	TR26	0.036	2.20	0.0001	12008.5	TR22	0.55	2.10	0.0013	778.5
CA01	YES	0020	0017	0.68	TR26	0.038	0.68	0.0003	3545.6	TR28	0.03	0.68	0.0002	5348.2
CA02	YES	0012	0014	0.68	TR26	0.047	0.68	0.0003	2914.9	TR26	0.01	0.68	0.0001	13271.6
CA03	YES	0019	0016	0.68	TR22	0.022	0.68	0.0002	6119.3	TR28	0.10	0.68	0.0007	1423.1
CA04	YES	0018	0015	0.68	TR26	0.024	0.68	0.0002	5671.5	TR28	0.09	0.68	0.0007	1440.6
H001	NO	0001	0022	3.52	TR28	0.110	0.53	0.0003	3196.6	TR16	0.26	1.76	0.0007	1339.7
H002	NO	0002	0023	3.52	TR22	0.073	1.92	0.0002	4848.3	TR14	0.27	1.76	0.0008	1311.5
H003	NO	0069	0071	3.52	TR24	0.064	1.94	0.0002	5473.2	TR18	0.22	1.76	0.0006	1575.0
H004	NO	0005	0024	3.52	TR24	0.064	1.97	0.0002	5474.7	TR14	0.21	1.76	0.0006	1696.2
H005	NO	0074	0076	3.52	TR26	0.075	0.51	0.0002	4671.2	TR14	0.22	1.76	0.0006	1575.2
H006	NO	0008	0025	3.52	TR28	0.082	0.42	0.0002	4296.3	TR14	0.25	1.76	0.0007	1385.8
H007	NO	0000	0020	3.52	TR28	0.067	0.77	0.0002	5276.8	TR26	0.04	1.76	0.0001	9598.5
H008	NO	0003	0019	3.52	TR22	0.071	1.87	0.0002	4980.2	TR28	0.05	0.93	0.0001	7701.6
H009	NO	0007	0018	3.52	TR24	0.066	1.90	0.0002	5367.4	TR28	0.05	0.93	0.0001	7773.8
H010	NO	0009	0012	3.52	TR24	0.061	1.98	0.0002	5799.0	TR28	0.05	1.52	0.0001	7135.8
H013	NO	0020	0006	2.40	TR28	0.116	0.78	0.0005	2076.2	TR22	0.03	1.35	0.0001	7417.9
H015	NO	0017	0014	13.00	TR28	1.743	6.30	0.0013	745.7	TR28	0.14	10.52	0.0001	9185.0
I005	NO	0031	0032	0.90	TR28	0.017	0.67	0.0002	5361.6	TR24	0.00	0.45	0.0000	99000.4
I006	NO	0026	0027	0.90	TR26	0.016	0.68	0.0002	5743.6	TR24	0.00	0.45	0.0000	99568.9
I007	NO	0033	0034	0.90	TR28	0.010	0.67	0.0001	9205.5	TR28	0.00	0.46	0.0000	90946.9
I008	NO	0028	0029	0.90	TR26	0.010	0.68	0.0001	9251.2	TR26	0.00	0.46	0.0000	91555.2
I009	NO	0035	0010	1.40	TR28	0.048	1.08	0.0003	2922.4	TR14	0.00	0.70	0.0000	34563.5
I010	NO	0030	0011	1.40	TR37	0.046	1.09	0.0003	3019.7	TR16	0.00	0.70	0.0000	34396.3
I011	NO	0053	0056	2.48	TR37	0.442	1.24	0.0018	561.1	TR16	0.10	1.24	0.0004	2480.4
I012	NO	0052	0084	2.48	TR28	0.442	1.24	0.0018	561.1	TR14	0.10	1.24	0.0004	2480.4
I013	NO	0051	0054	2.48	TR27	0.442	1.24	0.0018	561.1	TR18	0.10	1.24	0.0004	2480.4
I014	NO	0048	0051	1.12	TR28	0.019	0.56	0.0002	6011.3	TR14	0.00	0.56	0.0000	23243.3
I015	NO	0049	0052	1.12	TR27	0.019	0.56	0.0002	6011.3	TR14	0.00	0.56	0.0000	23243.0
I016	NO	0050	0053	1.12	TR38	0.019	0.56	0.0002	6011.3	TR16	0.00	0.56	0.0000	23243.2
I017	NO	0057	0077	1.55	TR28	0.068	0.77	0.0004	2286.0	TR18	0.02	0.77	0.0001	9554.4
I018	NO	0066	0081	1.55	TR27	0.068	0.77	0.0004	2286.0	TR12	0.02	0.77	0.0001	9554.5
I019	NO	0055	0079	1.55	TR28	0.068	0.77	0.0004	2286.0	TR16	0.02	0.77	0.0001	9554.4
I020	NO	0079	0062	1.55	TR28	0.068	0.77	0.0004	2286.0	TR16	0.02	0.77	0.0001	9554.3
I021	NO	0081	0082	1.55	TR38	0.068	0.77	0.0004	2286.0	TR12	0.02	0.77	0.0001	9554.3
I022	NO	0077	0058	1.55	TR28	0.068	0.77	0.0004	2286.0	TR12	0.02	0.77	0.0001	9554.3
I023	NO	0059	0078	1.55	TR38	0.068	0.77	0.0004	2285.9	TR16	0.02	0.77	0.0001	9554.3
I024	NO	0067	0083	1.55	TR37	0.068	0.77	0.0004	2285.9	TR12	0.02	0.77	0.0001	9554.4
I025	NO	0063	0080	1.55	TR27	0.068	0.77	0.0004	2285.9	TR18	0.02	0.77	0.0001	9554.4
I026	NO	0078	0060	1.55	TR28	0.068	0.77	0.0004	2285.9	TR18	0.02	0.77	0.0001	9553.7
I027	NO	0083	0068	1.55	TR27	0.068	0.77	0.0004	2285.9	TR14	0.02	0.77	0.0001	9554.1
I028	NO	0080	0064	1.55	TR38	0.068	0.77	0.0004	2285.9	TR16	0.02	0.77	0.0001	9553.7
I029	NO	0060	0061	1.40	TR37	0.045	0.70	0.0003	3096.2	TR16	0.01	0.70	0.0001	12685.9
I030	NO	0064	0065	1.40	TR38	0.045	0.70	0.0003	3096.2	TR18	0.01	0.70	0.0001	12685.9

Max deflection/span ratio are within the limits 1/300 for supported beams and 1/150 for cantilevers.

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11 SECONDARY BEAM FLOORS

The checks of the secondary beams are performed combining the dead weights with the distributed and concentrated live loads defined in design basis and summarized in the following table.

Area Use	Deck Flooring & Stringers	
	UDL (kN / m2)	CL (kN)
General Laydown and Storage Areas	15	22.5 (+10.0 for pipe support allowance)
Floor Areas in Deck	Actual equip. +5.0 in open areas or 15.0	22.5 (+10.0 for pipe support allowance)
Temporary Refuge	5	5
Walkways, Stairs and Access Platforms	4.5	4.5

Table 11.1 - Superimposed area loads for local checks

The checks are performed considering the beams simply supported at both ends.

L_b for the checked beams corresponds to their own lengths; nevertheless, being beams simply supported, so upper flange being compressed, and having 8/10mm plates connecting the top of the beams, lateral buckling checks can be disregarded.

The results are reported in the following sections divided by beam kinds for each floor, these results cover the basic case (dead weight and live loads). For detailed cases (i.e. handling, equipment support) please see dedicated sections.

The most stressed beam is checked for pipe support allowance (distributed load = 15 kN/m2 + concentrated load = 10 kN simultaneously acting).

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11.1 PLAN AT ELEVATION +23.310

The following figure shows the secondary beams – and their properties - considered at elevation +23.310 m.

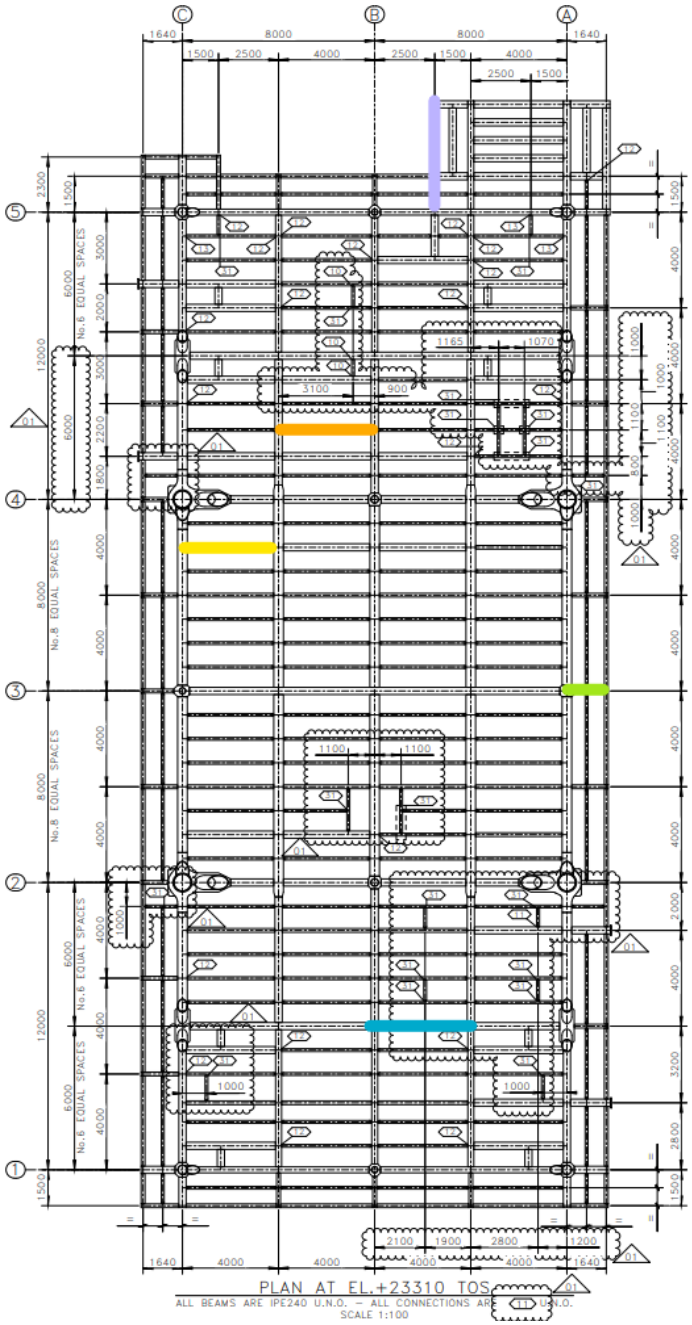


Figure 11.1 - Secondary beams checked at el. +23.31 m

Table 11.2 - +23.310m - Secondary beams legend

BEAMS AT EL+23.31 m					
BEAM NAME + COLOR	BEAM	LENGTH	DISTRIBUTED LOAD	CONCENTRATED LOAD	Max UC
		[mm]	[kN/m^2]	[kN]	
A	IPE240	4000	15	32.5	0.53
B	IPE240	1640	4.5	4.5	0.48
C	IPE330	4000	15	32.5	0.23
D	HEA340	4000	15	32.5	0.10
E	HEA500	4500	15	32.5	0.20
F	IPE330	1640	4.5	4.5	0.23

11.1.1 IPE240 – A – 4000mm

Table 11.3 - IPE240 - A - 4000mm

BEAM CHECK UNDER DISTRIBUTED LOAD

DESCRIPTION: Utility deck - IPE240 - A - L:4000 — **- MAX UC = 0.52**

DATA			
Shape:	IPE240		
f_y =	355	MPa	Plate yield strength
I =	3.892E+07	mm	Moment of inertia
W_{el} =	3.243E+05	mm^3	Elastic section modulus
A_v =	1914	mm^2	Shear area
L =	4.000	m	Beam span
b =	1.100	m	Beam spacing
q_G =	2.00	kN/m^2	Permanent distributed load
q_Q =	15.00	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =	1.30		Permanent load factor
$\gamma_{f,Q}$ =	1.50		Variable load factor
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =	27.6	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)\, b$ =	18.7	kN/m	Total unfactored distributed load
γ_{M0} =	1.10		Strength resistance factor
Restraint scheme	1		Support - Support
BENDING CHECK			
M_{ed} = 1 / 8 $p_1 L^2$ =	55.2	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =	104.7	kNm	> M_{Ed} - UC = 0.53 - Bending check
SHEAR CHECK			
V_{ed} = 1 / 2 p_1 L =	55	kN	Design shear force
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =	357	kN	> VEd - UC = 0.15 - Shear check
DEFLECTION CHECK			
f = 5 / 384 $p_2 L^4$ / E I =	7.6	mm	Maximum deflection
L / f =	524		> 200 - UC = 0.38 - Deflection check
f = 5 / 384 $q_Q L^4$ / E I =	6.7	mm	Maximum deflection
L / f =	594		> 300 - UC = 0.50 - Deflection check

BEAM CHECK UNDER CONCENTRATED LOAD

DESCRIPTION: Utility deck - IPE240 - A - L:4000 — **- MAX UC = 0.52**

DATA			
Shape:	IPE240		
f_y =	355	MPa	Plate yield strength
I =	3.892E+07	mm	Moment of inertia
W_{el} =	3.243E+05	mm^3	Elastic section modulus
A_v =	1914	mm^2	Shear area
L =	4.000	m	Beam span
b =	1.100	m	Beam spacing
q_G =	2.00	kN/m^2	Permanent distributed load
F_Q =	32.50	kN	Variable concentrated load
$\gamma_{f,G}$ =	1.30		Permanent load factor
$\gamma_{f,Q}$ =	1.50		Variable load factor
$p_1 = \gamma_{f,G}\, q_G\, b$ =	2.9	kN/m	Factored distributed load
$p_2 = q_G\, b$ =	2.2	kN/m	Unfactored distributed load
$F_1 = \gamma_{f,Q}\, F_Q$ =	48.8	kN	Factored concentrated load
γ_{M0} =	1.10		Strength resistance factor
Restraint scheme	1		Support - Support
BENDING CHECK			
$M_{ed} = p_1 L^2 / 8 + F_1 L / 4$ =	54.5	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =	104.7	kNm	> M_{Ed} - UC = 0.52 - Bending check
SHEAR CHECK			
$V_{ed} = p_1 L / 2 + F_1$ =	54	kN	Design shear force
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =	357	kN	> VEd - UC = 0.15 - Shear check
DEFLECTION CHECK			
f = (5 / 384 $p_2 L^4$ + $F_Q L^3$ / 48) / E I	6.2	mm	Maximum deflection
L / f =	645		> 200 - UC = 0.31 - Deflection check
f = ($F_Q L^3$ / 48) / E I =	5.4	mm	Maximum deflection
L / f =	736		> 300 - UC = 0.41 - Deflection check

11.1.2 IPE240 – B - 1640mm

Table 11.4 - IPE240 – B - 1640mm

BEAM CHECK UNDER DISTRIBUTED LOAD				
DESCRIPTION: Utility deck - IPE240 - B - L:1640				**- MAX UC = 0.48**
DATA				
Shape:		IPE240		
f_y =		355	MPa	Plate yield strength
I =		3.892E+07	mm	Moment of inertia
W_{el} =		3.243E+05	mm^3	Elastic section modulus
A_v =		1914	mm^2	Shear area
L =		1.640	m	Beam span
b =		4.000	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
q_Q =		4.50	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =		37.4	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)\, b$ =		26.0	kN/m	Total unfactored distributed load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		4		Fixed - Free
BENDING CHECK				
M_{ed} =	1 / 2 $p_1 L^2$ =	50.3	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		104.7	kNm	> M_{Ed} - UC = 0.48 - Bending check
SHEAR CHECK				
V_{ed} =	1 / 1 $p_1 L$ =	61	kN	Design shear force
$V_{c,Rd} = A_v (f_y/\sqrt{3}) / \gamma_{M0}$ =		357	kN	> VEd - UC = 0.17 - Shear check
DEFLECTION CHECK				
f =	1 / 8 $p_2 L^4 / E I$ =	2.9	mm	Maximum deflection
L / f =		570		> 100 - UC = 0.18 - Deflection check
f =	1 / 8 $q_Q L^4 / E I$ =	2.0	mm	Maximum deflection
L / f =		823		> 150 - UC = 0.18 - Deflection check

BEAM CHECK UNDER CONCENTRATED LOAD			
DESCRIPTION: Utility deck - IPE240 - B - L:1640			**- MAX UC = 0.23**
DATA			
Shape:	IPE240		
f_y =	355	MPa	Plate yield strength
I =	3.892E+07	mm	Moment of inertia
W_{el} =	3.243E+05	mm^3	Elastic section modulus
A_v =	1914	mm^2	Shear area
L =	1.640	m	Beam span
b =	4.000	m	Beam spacing
q_G =	2.00	kN/m^2	Permanent distributed load
F_Q =	4.50	kN	Variable concentrated load
$\gamma_{f,G}$ =	1.30		Permanent load factor
$\gamma_{f,Q}$ =	1.50		Variable load factor
$p_1 = \gamma_{f,G}\, q_G\, b$ =	10.4	kN/m	Factored distributed load
$p_2 = q_G\, b$ =	8.0	kN/m	Unfactored distributed load
$F_1 = \gamma_{f,Q}\, F_Q$ =	6.8	kN	Factored concentrated load
γ_{M0} =	1.10		Strength resistance factor
Restraint scheme	4		Fixed - Free
BENDING CHECK			
$M_{ed} = p_1 L^2 / 2 + F_1 L$ =	25.1	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =	104.7	kNm	> M_{Ed} - UC = 0.24 - Bending check
SHEAR CHECK			
$V_{ed} = p_1 L + F_1$ =	24	kN	Design shear force
$V_{c,Rd} = A_v (f_y/\sqrt{3}) / \gamma_{M0}$ =	357	kN	> VEd - UC = 0.07 - Shear check
DEFLECTION CHECK			
$f = (p_2 L^4 / 8 + F_Q L^3 / 3) / E I$ =	1.7	mm	Maximum deflection
L / f =	945		> 100 - UC = 0.11 - Deflection check
$f = (F_Q L^3 / 3) / E I$ =	0.8	mm	Maximum deflection
L / f =	2026		> 150 - UC = 0.07 - Deflection check

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11.1.3 IPE 330 – C - 4000 mm

Table 11.5 - IPE 330 – C - 4000 mm

BEAM CHECK UNDER DISTRIBUTED LOAD				
DESCRIPTION: Utility deck - IPE330 - C - L:4000				**- MAX UC = 0.21**
DATA				
Shape:		IPE330		
f_y =		355	MPa	Plate yield strength
I =		1.177E+08	mm	Moment of inertia
W_{el} =		7.131E+05	mm^3	Elastic section modulus
A_v =		3069	mm^2	Shear area
L =		4.000	m	Beam span
b =		1.000	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
q_Q =		15.00	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =		25.1	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)\, b$ =		17.0	kN/m	Total unfactored distributed load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		1		Support - Support
BENDING CHECK				
M_{ed} =	1 / 8 $p_1 L^2$ =	50.2	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		230.2	kNm	> M_{Ed} - UC = 0.22 - Bending check
SHEAR CHECK				
V_{ed} =	1 / 2 $p_1 L$ =	50	kN	Design shear force
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =		572	kN	> VEd - UC = 0.09 - Shear check
DEFLECTION CHECK				
f =	5 / 384 $p_2 L^4 / E I$ =	2.3	mm	Maximum deflection
L / f =		1744		> 200 - UC = 0.11 - Deflection check
f =	5 / 384 $q_Q L^4 / E I$ =	2.0	mm	Maximum deflection
L / f =		1977		> 300 - UC = 0.15 - Deflection check

BEAM CHECK UNDER CONCENTRATED LOAD			
DESCRIPTION: Utility deck - IPE330 - C - L:4000			**- MAX UC = 0.23**
DATA			
Shape:	IPE330		
f_y =	355	MPa	Plate yield strength
I =	1.177E+08	mm	Moment of inertia
W_{el} =	7.131E+05	mm^3	Elastic section modulus
A_v =	3069	mm^2	Shear area
L =	4.000	m	Beam span
b =	1.000	m	Beam spacing
q_G =	2.00	kN/m^2	Permanent distributed load
F_Q =	32.50	kN	Variable concentrated load
$\gamma_{f,G}$ =	1.30		Permanent load factor
$\gamma_{f,Q}$ =	1.50		Variable load factor
$p_1 = \gamma_{f,G}\, q_G\, b$ =	2.6	kN/m	Factored distributed load
$p_2 = q_G\, b$ =	2.0	kN/m	Unfactored distributed load
$F_1 = \gamma_{f,Q}\, F_Q$ =	48.8	kN	Factored concentrated load
γ_{M0} =	1.10		Strength resistance factor
Restraint scheme	1		Support - Support
BENDING CHECK			
$M_{ed} = p_1 L^2 / 8 + F_1 L / 4$ =	54.0	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =	230.2	kNm	> M_{Ed} - UC = 0.23 - Bending check
SHEAR CHECK			
$V_{ed} = p_1 L / 2 + F_1$ =	54	kN	Design shear force
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =	572	kN	> VEd - UC = 0.09 - Shear check
DEFLECTION CHECK			
$f = (5 / 384\, p_2 L^4 + F_Q L^3 / 48) / E I$	2.0	mm	Maximum deflection
L / f =	1977		> 200 - UC = 0.10 - Deflection check
$f = (F_Q L^3 / 48) / E I$ =	1.8	mm	Maximum deflection
L / f =	2227		> 300 - UC = 0.13 - Deflection check

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11.1.4 HEA340– D - 4000 mm

Table 11.6 - HEA340– D - 4000 mm

BEAM CHECK UNDER DISTRIBUTED LOAD				
DESCRIPTION: Level 1 - Utility deck -HEA340- D - L:4000				**- MAX UC = 0.09**
DATA				
Shape:		HE340A		
f_y =		355	MPa	Plate yield strength
I =		2.769E+08	mm	Moment of inertia
W_{el} =		1.678E+06	mm^3	Elastic section modulus
A_v =		8373	mm^2	Shear area
L =		4.000	m	Beam span
b =		1.000	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
q_Q =		15.00	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =		25.1	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)\, b$ =		17.0	kN/m	Total unfactored distributed load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		1		Support - Support
BENDING CHECK				
M_{ed} =	$1/8\ p_1 L^2$ =	50.2	kNm	Design bending moment
$M_{c,Rd} = W_{el}\, f_y / \gamma_{M0}$ =		541.7	kNm	> M_{Ed} - UC = 0.09 - Bending check
SHEAR CHECK				
V_{ed} =	$1/2\ p_1 L$ =	50	kN	Design shear force
$V_{c,Rd} = A_v\, (f_y/\sqrt{3}) / \gamma_{M0}$ =		1560	kN	> VEd - UC = 0.03 - Shear check
DEFLECTION CHECK				
f =	$5/384\ p_2 L^4 / E\, I$ =	1.0	mm	Maximum deflection
L / f =		4105		> 200 - UC = 0.04 - Deflection check
f =	$5/384\ q_Q L^4 / E\, I$ =	0.9	mm	Maximum deflection
L / f =		4652		> 300 - UC = 0.06 - Deflection check

BEAM CHECK UNDER CONCENTRATED LOAD				
DESCRIPTION: Level 1 - Utility deck - HEA340- D - L:4000				**- MAX UC = 0.09**
DATA				
Shape:		HE340A		
f_y =		355	MPa	Plate yield strength
I =		2.769E+08	mm	Moment of inertia
W_{el} =		1.678E+06	mm^3	Elastic section modulus
A_v =		8373	mm^2	Shear area
L =		4.000	m	Beam span
b =		1.000	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
F_Q =		32.50	kN	Variable concentrated load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = \gamma_{f,G}\, q_G\, b$ =		2.6	kN/m	Factored distributed load
$p_2 = q_G\, b$ =		2.0	kN/m	Unfactored distributed load
$F_1 = \gamma_{f,Q}\, F_Q$ =		48.8	kN	Factored concentrated load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		1		Support - Support
BENDING CHECK				
$M_{ed} = p_1 L^2/8 + F_1 L/4$ =		54.0	kNm	Design bending moment
$M_{c,Rd} = W_{el}\, f_y / \gamma_{M0}$ =		541.7	kNm	> M_{Ed} - UC = 0.10 - Bending check
SHEAR CHECK				
$V_{ed} = p_1 L/2 + F_1$ =		54	kN	Design shear force
$V_{c,Rd} = A_v\, (f_y/\sqrt{3}) / \gamma_{M0}$ =		1560	kN	> VEd - UC = 0.03 - Shear check
DEFLECTION CHECK				
$f = (5/384\ p_2 L^4 + F_Q L^3/48) / E\, I$		0.9	mm	Maximum deflection
L / f =		4652		> 200 - UC = 0.03 - Deflection check
$f = (F_Q L^3/48) / E\, I$ =		0.7	mm	Maximum deflection
L / f =		5368		> 300 - UC = 0.03 - Deflection check

11.1.5 HEA500 – E - 4500 mm

Table 11.7 - HEA500 – E - 4500 mm

BEAM CHECK UNDER DISTRIBUTED LOAD				
DESCRIPTION: Level 1 - Utility deck -HEA500 - E - L:4500				**- MAX UC = 0.16**
DATA				
Shape:		HE500A		
f_y =		355	MPa	Plate yield strength
I =		8.697E+08	mm	Moment of inertia
W_{el} =		3.550E+06	mm^3	Elastic section modulus
A_v =		11214	mm^2	Shear area
L =		4.500	m	Beam span
b =		0.750	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
q_Q =		15.00	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =		18.8	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)\, b$ =		12.8	kN/m	Total unfactored distributed load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		4		Fixed - Free
BENDING CHECK				
M_{ed} =	1 / 2 $p_1 L^2$ =	190.6	kNm	Design bending moment
$M_{c,Rd} = W_{el}\, f_y / \gamma_{M0}$ =		1145.7	kNm	> M_{Ed} - UC = 0.17 - Bending check
SHEAR CHECK				
V_{ed} =	1 / 1 $p_1 L$ =	85	kN	Design shear force
$V_{c,Rd} = A_v\, (f_y / \sqrt{3}) / \gamma_{M0}$ =		2089	kN	> VEd - UC = 0.04 - Shear check
DEFLECTION CHECK				
f =	1 / 8 $p_2 L^4 / E I$ =	3.6	mm	Maximum deflection
L / f =		1258		> 100 - UC = 0.08 - Deflection check
f =	1 / 8 $q_Q L^4 / E I$ =	3.2	mm	Maximum deflection
L / f =		1425		> 150 - UC = 0.11 - Deflection check

BEAM CHECK UNDER CONCENTRATED LOAD			
DESCRIPTION: Utility deck - HEA500 - E - L:4500			**- MAX UC = 0.2**
DATA			
Shape:	HE500A		
f_y =	355	MPa	Plate yield strength
I =	8.697E+08	mm	Moment of inertia
W_{el} =	3.550E+06	mm^3	Elastic section modulus
A_v =	11214	mm^2	Shear area
L =	4.500	m	Beam span
b =	0.750	m	Beam spacing
q_G =	2.00	kN/m^2	Permanent distributed load
F_Q =	32.50	kN	Variable concentrated load
$\gamma_{f,G}$ =	1.30		Permanent load factor
$\gamma_{f,Q}$ =	1.50		Variable load factor
$p_1 = \gamma_{f,G}\, q_G\, b$ =	2.0	kN/m	Factored distributed load
$p_2 = q_G\, b$ =	1.5	kN/m	Unfactored distributed load
$F_1 = \gamma_{f,Q}\, F_Q$ =	48.8	kN	Factored concentrated load
γ_{M0} =	1.10		Strength resistance factor
Restraint scheme	4		Fixed - Free
BENDING CHECK			
$M_{ed} = p_1 L^2 / 2 + F_1 L$ =	239.1	kNm	Design bending moment
$M_{c,Rd} = W_{el}\, f_y / \gamma_{M0}$ =	1145.7	kNm	> M_{Ed} - UC = 0.21 - Bending check
SHEAR CHECK			
$V_{ed} = p_1 L + F_1$ =	58	kN	Design shear force
$V_{c,Rd} = A_v\, (f_y / \sqrt{3}) / \gamma_{M0}$ =	2089	kN	> VEd - UC = 0.03 - Shear check
DEFLECTION CHECK			
f = ($p_2 L^4$ /8+ $F_Q L^3$ / 3) / E I =	6.0	mm	Maximum deflection
L / f =	754		> 100 - UC = 0.13 - Deflection check
f = ($F_Q L^3$ / 3) / E I =	5.4	mm	Maximum deflection
L / f =	833		> 150 - UC = 0.18 - Deflection check

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11.1.6 IPE330 – F - 1640 mm

Table 11.8 – IPE330 – F - 1640 mm

BEAM CHECK UNDER CONCENTRATED LOAD							
DESCRIPTION:	Utility Deck - IPE240 - B - L:1640					- MAX UC = 0.23	
DATA							
Shape:		IPE240					
f_y =		355	MPa	Plate yield strength			
I =		3.892E+07	mm	Moment of inertia			
W_{el} =		3.243E+05	mm^3	Elastic section modulus			
A_v =		1914	mm^2	Shear area			
L =		1.640	m	Beam span			
b =		4.000	m	Beam spacing			
q_G =		2.00	kN/m^2	Permanent distributed load			
F_Q =		4.50	kN	Variable concentrated load			
$\gamma_{f,G}$ =		1.30		Permanent load factor			
$\gamma_{f,Q}$ =		1.50		Variable load factor			
$p_1 = \gamma_{f,G} q_G b$ =		10.4	kN/m	Factored distributed load			
$p_2 = q_G b$ =		8.0	kN/m	Unfactored distributed load			
$F_1 = \gamma_{f,Q} F_Q$ =		6.8	kN	Factored concentrated load			
γ_{M0} =		1.10		Strength resistance factor			
Restraint scheme		4		Fixed - Free			
BENDING CHECK							
$M_{ed} = p_1 L^2 / 2 + F_1 L$ =		25.1	kNm	Design bending moment			
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		104.7	kNm	> M_{Ed} - UC =	0.24	- Bending check	
SHEAR CHECK							
$V_{ed} = p_1 L + F_1$ =		24	kN	Design shear force			
$V_{c,Rd} = A_v (f_y /\sqrt{3}) / \gamma_{M0}$ =		357	kN	> VEd - UC =	0.07	- Shear check	
DEFLECTION CHECK							
$f = (p_2 L^4 / 8 + F_Q L^3 / 3) / E I$ =		1.7	mm	Maximum deflection			
L / f =		968		> 100 - UC =	0.10	- Deflection check	
$f = (F_Q L^3 / 3) / E I$ =		0.8	mm	Maximum deflection			
L / f =		2026		> 150 - UC =	0.07	- Deflection check	

BEAM CHECK UNDER DISTRIBUTED LOAD							
DESCRIPTION:	Utility Deck - IPE330 - B - L:1640					- MAX UC = 0.21	
DATA							
Shape:		IPE330					
f_y =		355	MPa	Plate yield strength			
I =		1.177E+08	mm	Moment of inertia			
W_{el} =		7.131E+05	mm^3	Elastic section modulus			
A_v =		3081	mm^2	Shear area			
L =		1.640	m	Beam span			
b =		4.000	m	Beam spacing			
q_G =		2.00	kN/m^2	Permanent distributed load			
q_Q =		4.50	kN/m^2	Variable distributed load			
$\gamma_{f,G}$ =		1.30		Permanent load factor			
$\gamma_{f,Q}$ =		1.50		Variable load factor			
$p_1 = (\gamma_{f,G} q_G + \gamma_{f,Q} q_Q) b$ =		37.4	kN/m	Total factored distributed load			
$p_2 = (q_G + q_Q) b$ =		26.0	kN/m	Total unfactored distributed load			
$p_Q = q_Q b$ =		18.0	kN/m	Variable unfactored distributed load			
γ_{M0} =		1.10		Strength resistance factor			
Restraint scheme		4		Fixed - Free			
BENDING CHECK							
M_{ed} =	1 / 2 $p_1 L^2$ =	50.3	kNm	Design bending moment			
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		230.2	kNm	> M_{Ed} - UC =	0.22	- Bending check	
SHEAR CHECK							
V_{ed} =	1 / 1 $p_1 L$ =	61	kN	Design shear force			
$V_{c,Rd} = A_v (f_y /\sqrt{3}) / \gamma_{M0}$ =		574	kN	> VEd - UC =	0.11	- Shear check	
DEFLECTION CHECK							
f =	1 / 8 $p_2 L^4 / E I$ =	1.0	mm	Maximum deflection			
L / f =		1724		> 200 - UC =	0.12	- Deflection check	
f =	1 / 8 $p_Q L^4 / E I$ =	0.7	mm	Maximum deflection			
L / f =		2490		> 300 - UC =	0.12	- Deflection check	

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11.2 PLAN AT ELEVATION +30.310

The following figure shows the secondary beams – and their properties - considered at elevation +30.310 m.

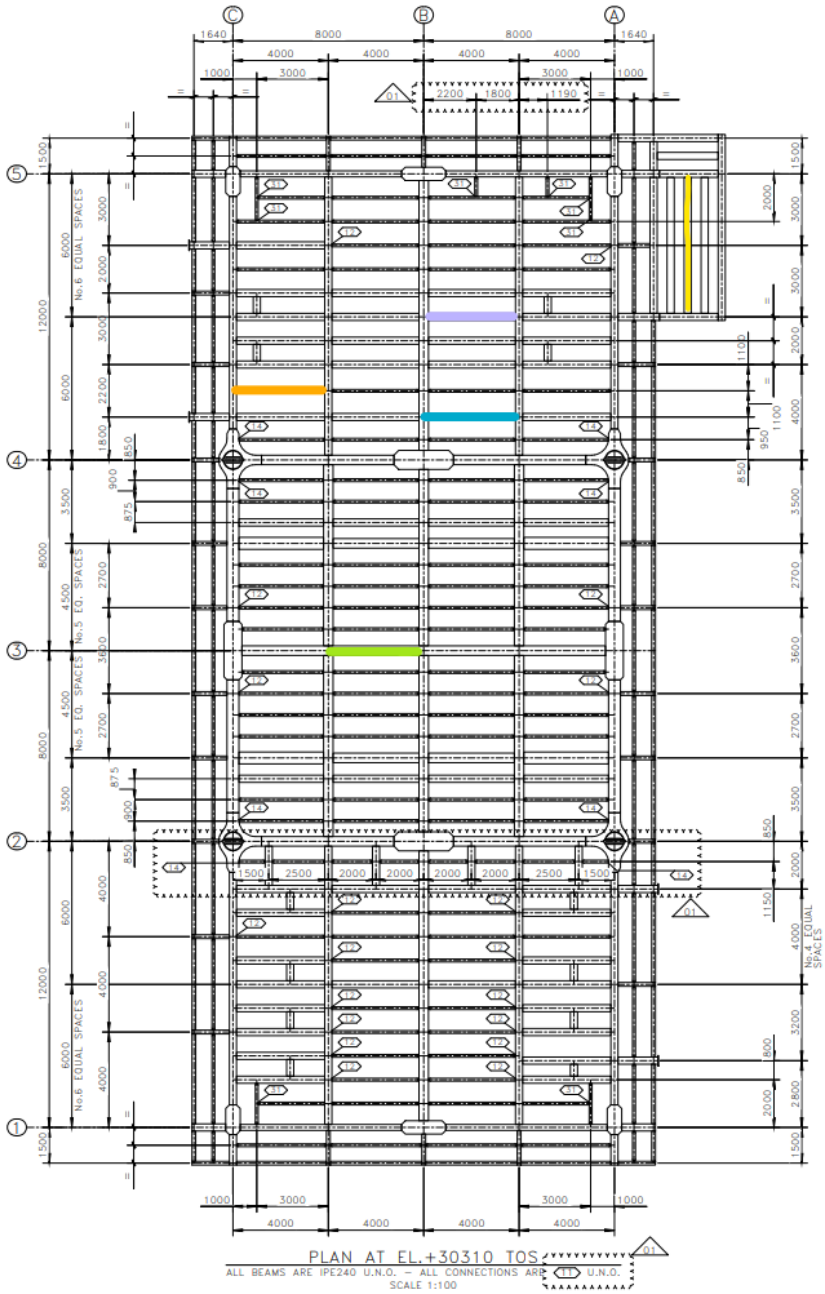


Figure 11.2 - Secondary beams checked at el. +30.31 m

Table 11.9 - +30.310m - Secondary beams legend

BEAMS AT EL+30.31 m					
BEAM NAME + COLOR	BEAM	LENGTH [mm]	DISTRIBUTED LOAD [kN/m²]	CONCENTRATED LOAD [kN]	Max UC
A	IPE240	4000	15	32.5	0.53
B	IPE330	4000	15	32.5	0.23
C	HEA340	4000	15	32.5	0.1
D	HEA340	6000	15	32.5	0.16
E	HEA500	4000	15	32.5	0.05

11.2.1 IPE240 – A – 4000mm

Table 11.10 - IPE240 – A – 4000mm

BEAM CHECK UNDER DISTRIBUTED LOAD

DESCRIPTION: Utility deck - IPE240 - A - L:4000 — **- MAX UC = 0.52**

DATA			
Shape:	IPE240		
f_y =	355	MPa	Plate yield strength
I =	3.892E+07	mm	Moment of inertia
W_{el} =	3.243E+05	mm^3	Elastic section modulus
A_v =	1914	mm^2	Shear area
L =	4.000	m	Beam span
b =	1.100	m	Beam spacing
q_G =	2.00	kN/m^2	Permanent distributed load
q_Q =	15.00	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =	1.30		Permanent load factor
$\gamma_{f,Q}$ =	1.50		Variable load factor
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =	27.6	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)\, b$ =	18.7	kN/m	Total unfactored distributed load
γ_{M0} =	1.10		Strength resistance factor
Restraint scheme	1		Support - Support
BENDING CHECK			
M_{ed} = 1 / 8 $p_1 L^2$ =	55.2	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =	104.7	kNm	> M_{Ed} - UC = 0.53 - Bending check
SHEAR CHECK			
V_{ed} = 1 / 2 p_1 L =	55	kN	Design shear force
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =	357	kN	> VEd - UC = 0.15 - Shear check
DEFLECTION CHECK			
f = 5 / 384 $p_2 L^4$ / E I =	7.6	mm	Maximum deflection
L / f =	524		> 200 - UC = 0.38 - Deflection check
f = 5 / 384 $q_Q L^4$ / E I =	6.7	mm	Maximum deflection
L / f =	594		> 300 - UC = 0.50 - Deflection check

BEAM CHECK UNDER CONCENTRATED LOAD

DESCRIPTION: Utility deck - IPE240 - A - L:4000 — **- MAX UC = 0.52**

DATA			
Shape:	IPE240		
f_y =	355	MPa	Plate yield strength
I =	3.892E+07	mm	Moment of inertia
W_{el} =	3.243E+05	mm^3	Elastic section modulus
A_v =	1914	mm^2	Shear area
L =	4.000	m	Beam span
b =	1.100	m	Beam spacing
q_G =	2.00	kN/m^2	Permanent distributed load
F_Q =	32.50	kN	Variable concentrated load
$\gamma_{f,G}$ =	1.30		Permanent load factor
$\gamma_{f,Q}$ =	1.50		Variable load factor
$p_1 = \gamma_{f,G}\, q_G\, b$ =	2.9	kN/m	Factored distributed load
$p_2 = q_G\, b$ =	2.2	kN/m	Unfactored distributed load
$F_1 = \gamma_{f,Q}\, F_Q$ =	48.8	kN	Factored concentrated load
γ_{M0} =	1.10		Strength resistance factor
Restraint scheme	1		Support - Support
BENDING CHECK			
$M_{ed} = p_1 L^2 / 8 + F_1 L / 4$ =	54.5	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =	104.7	kNm	> M_{Ed} - UC = 0.52 - Bending check
SHEAR CHECK			
$V_{ed} = p_1 L / 2 + F_1$ =	54	kN	Design shear force
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =	357	kN	> VEd - UC = 0.15 - Shear check
DEFLECTION CHECK			
f = (5 / 384 $p_2 L^4$ + $F_Q L^3$ / 48) / E I	6.2	mm	Maximum deflection
L / f =	645		> 200 - UC = 0.31 - Deflection check
f = ($F_Q L^3$ / 48) / E I =	5.4	mm	Maximum deflection
L / f =	736		> 300 - UC = 0.41 - Deflection check

11.2.2 IPE330 – B – 4000mm

Table 11.11 - IPE330 – B – 4000mm

BEAM CHECK UNDER DISTRIBUTED LOAD				
DESCRIPTION: Utility deck - IPE330 - B - L:4000				**- MAX UC = 0.19**
DATA				
Shape:		IPE330		
f_y =		355	MPa	Plate yield strength
I =		1.177E+08	mm	Moment of inertia
W_{el} =		7.131E+05	mm^3	Elastic section modulus
A_v =		3069	mm^2	Shear area
L =		4.000	m	Beam span
b =		0.900	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
q_Q =		15.00	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =		22.6	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)\, b$ =		15.3	kN/m	Total unfactored distributed load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		1		Support - Support
BENDING CHECK				
M_{ed} =	1 / 8 $p_1 L^2$ =	45.2	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		230.2	kNm	> M_{Ed} - UC = 0.20 - Bending check
SHEAR CHECK				
V_{ed} =	1 / 2 $p_1 L$ =	45	kN	Design shear force
$V_{c,Rd} = A_v (f_y/\sqrt{3}) / \gamma_{M0}$ =		572	kN	> VEd - UC = 0.08 - Shear check
DEFLECTION CHECK				
f =	5 / 384 $p_2 L^4$ / E I =	2.1	mm	Maximum deflection
L / f =		1938		> 200 - UC = 0.10 - Deflection check
f =	5 / 384 $q_Q L^4$ / E I =	1.8	mm	Maximum deflection
L / f =		2196		> 300 - UC = 0.14 - Deflection check

BEAM CHECK UNDER CONCENTRATED LOAD				
DESCRIPTION: Utility deck - IPE330 - B - L:4000				**- MAX UC = 0.23**
DATA				
Shape:		IPE330		
f_y =		355	MPa	Plate yield strength
I =		1.177E+08	mm	Moment of inertia
W_{el} =		7.131E+05	mm^3	Elastic section modulus
A_v =		3069	mm^2	Shear area
L =		4.000	m	Beam span
b =		0.900	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
F_Q =		32.50	kN	Variable concentrated load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = \gamma_{f,G}\, q_G\, b$ =		2.3	kN/m	Factored distributed load
$p_2 = q_G\, b$ =		1.8	kN/m	Unfactored distributed load
$F_1 = \gamma_{f,Q}\, F_Q$ =		48.8	kN	Factored concentrated load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		1		Support - Support
BENDING CHECK				
$M_{ed} = p_1 L^2 / 8 + F_1 L / 4$ =		53.4	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		230.2	kNm	> M_{Ed} - UC = 0.23 - Bending check
SHEAR CHECK				
$V_{ed} = p_1 L / 2 + F_1$ =		53	kN	Design shear force
$V_{c,Rd} = A_v (f_y/\sqrt{3}) / \gamma_{M0}$ =		572	kN	> VEd - UC = 0.09 - Shear check
DEFLECTION CHECK				
$f = (5 / 384\, p_2 L^4 + F_Q L^3 / 48) / E I$		2.0	mm	Maximum deflection
L / f =		2004		> 200 - UC = 0.10 - Deflection check
$f = (F_Q L^3 / 48) / E I$ =		1.8	mm	Maximum deflection
L / f =		2227		> 300 - UC = 0.13 - Deflection check

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11.2.3 HEA340 – C – 4000mm

Table 11.12 - HEA340 – C – 4000mm

BEAM CHECK UNDER DISTRIBUTED LOAD				
DESCRIPTION: Level 1 - Utility deck -HEA340- C - L:4000				**- MAX UC = 0.09**
DATA				
Shape:		HE340A		
f_y =		355	MPa	Plate yield strength
I =		2.769E+08	mm	Moment of inertia
W_{el} =		1.678E+06	mm^3	Elastic section modulus
A_v =		8373	mm^2	Shear area
L =		4.000	m	Beam span
b =		1.000	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
q_Q =		15.00	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =		25.1	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)\, b$ =		17.0	kN/m	Total unfactored distributed load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		1		Support - Support
BENDING CHECK				
M_{ed} =	$1/8\ p_1 L^2$ =	50.2	kNm	Design bending moment
$M_{c,Rd} = W_{el}\, f_y / \gamma_{M0}$ =		541.7	kNm	> M_{Ed} - UC = 0.09 - Bending check
SHEAR CHECK				
V_{ed} =	$1/2\ p_1 L$ =	50	kN	Design shear force
$V_{c,Rd} = A_v\, (f_y/\sqrt{3}) / \gamma_{M0}$ =		1560	kN	> VEd - UC = 0.03 - Shear check
DEFLECTION CHECK				
f =	$5/384\ p_2 L^4 / E\, I$ =	1.0	mm	Maximum deflection
L / f =		4105		> 200 - UC = 0.04 - Deflection check
f =	$5/384\ q_Q L^4 / E\, I$ =	0.9	mm	Maximum deflection
L / f =		4652		> 300 - UC = 0.06 - Deflection check

BEAM CHECK UNDER CONCENTRATED LOAD			
DESCRIPTION: Level 1 - Utility deck - HEA340- C - L:4000			**- MAX UC = 0.09**
DATA			
Shape:	HE340A		
f_y =	355	MPa	Plate yield strength
I =	2.769E+08	mm	Moment of inertia
W_{el} =	1.678E+06	mm^3	Elastic section modulus
A_v =	8373	mm^2	Shear area
L =	4.000	m	Beam span
b =	1.000	m	Beam spacing
q_G =	2.00	kN/m^2	Permanent distributed load
F_Q =	32.50	kN	Variable concentrated load
$\gamma_{f,G}$ =	1.30		Permanent load factor
$\gamma_{f,Q}$ =	1.50		Variable load factor
$p_1 = \gamma_{f,G}\, q_G\, b$ =	2.6	kN/m	Factored distributed load
$p_2 = q_G\, b$ =	2.0	kN/m	Unfactored distributed load
$F_1 = \gamma_{f,Q}\, F_Q$ =	48.8	kN	Factored concentrated load
γ_{M0} =	1.10		Strength resistance factor
Restraint scheme	1		Support - Support
BENDING CHECK			
$M_{ed} = p_1 L^2 / 8 + F_1 L / 4$ =	54.0	kNm	Design bending moment
$M_{c,Rd} = W_{el}\, f_y / \gamma_{M0}$ =	541.7	kNm	> M_{Ed} - UC = 0.10 - Bending check
SHEAR CHECK			
$V_{ed} = p_1 L / 2 + F_1$ =	54	kN	Design shear force
$V_{c,Rd} = A_v\, (f_y/\sqrt{3}) / \gamma_{M0}$ =	1560	kN	> VEd - UC = 0.03 - Shear check
DEFLECTION CHECK			
$f = (5/384\ p_2 L^4 + F_Q L^3 / 48) / E\, I$	0.9	mm	Maximum deflection
L / f =	4652		> 200 - UC = 0.03 - Deflection check
$f = (F_Q L^3 / 48) / E\, I$ =	0.7	mm	Maximum deflection
L / f =	5368		> 300 - UC = 0.03 - Deflection check

11.2.4 HEA340 – D – 6000mm

Table 11.13 - HEA340 – D – 6000mm

BEAM CHECK UNDER DISTRIBUTED LOAD				
DESCRIPTION: Level 1 - Utility deck -HEA340- D - L:6000				**- MAX UC = 0.14**
DATA				
Shape:		HE340A		
f_y =		355	MPa	Plate yield strength
I =		2.769E+08	mm	Moment of inertia
W_{el} =		1.678E+06	mm^3	Elastic section modulus
A_v =		8373	mm^2	Shear area
L =		6.000	m	Beam span
b =		0.715	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
q_Q =		15.00	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =		17.9	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)\, b$ =		12.2	kN/m	Total unfactored distributed load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		1		Support - Support
BENDING CHECK				
M_{ed} =	$1/8\ p_1 L^2$ =	80.8	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		541.7	kNm	> M_{Ed} - UC = 0.15 - Bending check
SHEAR CHECK				
V_{ed} =	$1/2\ p_1 L$ =	54	kN	Design shear force
$V_{c,Rd} = A_v (f_y/\sqrt{3}) / \gamma_{M0}$ =		1560	kN	> VEd - UC = 0.03 - Shear check
DEFLECTION CHECK				
f =	$5/384\ p_2 L^4 / E I$ =	3.5	mm	Maximum deflection
L / f =		1701		> 200 - UC = 0.09 - Deflection check
f =	$5/384\ q_Q L^4 / E I$ =	3.1	mm	Maximum deflection
L / f =		1928		> 300 - UC = 0.16 - Deflection check

BEAM CHECK UNDER CONCENTRATED LOAD				
DESCRIPTION: Level 1 - Utility deck - HEA340- D - L:6000				**- MAX UC = 0.15**
DATA				
Shape:		HE340A		
f_y =		355	MPa	Plate yield strength
I =		2.769E+08	mm	Moment of inertia
W_{el} =		1.678E+06	mm^3	Elastic section modulus
A_v =		8373	mm^2	Shear area
L =		6.000	m	Beam span
b =		0.715	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
F_Q =		32.50	kN	Variable concentrated load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = \gamma_{f,G}\, q_G\, b$ =		1.9	kN/m	Factored distributed load
$p_2 = q_G\, b$ =		1.4	kN/m	Unfactored distributed load
$F_1 = \gamma_{f,Q}\, F_Q$ =		48.8	kN	Factored concentrated load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		1		Support - Support
BENDING CHECK				
$M_{ed} = p_1 L^2 / 8 + F_1 L / 4$ =		81.5	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		541.7	kNm	> M_{Ed} - UC = 0.15 - Bending check
SHEAR CHECK				
$V_{ed} = p_1 L / 2 + F_1$ =		54	kN	Design shear force
$V_{c,Rd} = A_v (f_y/\sqrt{3}) / \gamma_{M0}$ =		1560	kN	> VEd - UC = 0.03 - Shear check
DEFLECTION CHECK				
f = $(5/384\ p_2 L^4 + F_Q L^3 / 48) / E I$		2.9	mm	Maximum deflection
L / f =		2048		> 200 - UC = 0.07 - Deflection check
f = $(F_Q L^3 / 48) / E I$ =		2.5	mm	Maximum deflection
L / f =		2386		> 300 - UC = 0.06 - Deflection check

11.2.5 HEA500 – E – 4000mm

Table 11.14 - HEA500 – E – 4000mm

BEAM CHECK UNDER DISTRIBUTED LOAD				
DESCRIPTION: Level 1 - Utility deck -HEA500 - E - L:4000				**- MAX UC = 0.04**
DATA				
Shape:		HE500A		
f_y =		355	MPa	Plate yield strength
I =		8.697E+08	mm	Moment of inertia
W_{el} =		3.550E+06	mm^3	Elastic section modulus
A_v =		11214	mm^2	Shear area
L =		4.000	m	Beam span
b =		1.000	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
q_Q =		15.00	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =		25.1	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)\, b$ =		17.0	kN/m	Total unfactored distributed load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		1		Support - Support
BENDING CHECK				
M_{ed} =	1 / 8 $p_1 L^2$ =	50.2	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		1145.7	kNm	> M_{Ed} - UC = 0.04 - Bending check
SHEAR CHECK				
V_{ed} =	1 / 2 $p_1 L$ =	50	kN	Design shear force
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =		2089	kN	> VEd - UC = 0.02 - Shear check
DEFLECTION CHECK				
f =	5 / 384 $p_2 L^4$ / E I =	0.3	mm	Maximum deflection
L / f =		12893		> 100 - UC = 0.01 - Deflection check
f =	5 / 384 $q_Q L^4$ / E I =	0.3	mm	Maximum deflection
L / f =		14612		> 150 - UC = 0.01 - Deflection check

BEAM CHECK UNDER CONCENTRATED LOAD				
DESCRIPTION: Level 1 - Utility deck - HEA500- E - L:4000				**- MAX UC = 0.04**
DATA				
Shape:		HE500A		
f_y =		355	MPa	Plate yield strength
I =		8.697E+08	mm	Moment of inertia
W_{el} =		3.550E+06	mm^3	Elastic section modulus
A_v =		11214	mm^2	Shear area
L =		4.000	m	Beam span
b =		1.000	m	Beam spacing
q_G =		2.00	kN/m^2	Permanent distributed load
F_Q =		32.50	kN	Variable concentrated load
$\gamma_{f,G}$ =		1.30		Permanent load factor
$\gamma_{f,Q}$ =		1.50		Variable load factor
$p_1 = \gamma_{f,G}\, q_G\, b$ =		2.6	kN/m	Factored distributed load
$p_2 = q_G\, b$ =		2.0	kN/m	Unfactored distributed load
$F_1 = \gamma_{f,Q}\, F_Q$ =		48.8	kN	Factored concentrated load
γ_{M0} =		1.10		Strength resistance factor
Restraint scheme		1		Support - Support
BENDING CHECK				
$M_{ed} = p_1 L^2 / 8 + F_1 L / 4$ =		54.0	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		1145.7	kNm	> M_{Ed} - UC = 0.05 - Bending check
SHEAR CHECK				
$V_{ed} = p_1 L / 2 + F_1$ =		54	kN	Design shear force
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =		2089	kN	> VEd - UC = 0.03 - Shear check
DEFLECTION CHECK				
f = $(5 / 384\, p_2 L^4 + F_Q L^3 / 48) / E I$		0.3	mm	Maximum deflection
L / f =		14612		> 200 - UC = 0.01 - Deflection check
f = $(F_Q L^3 / 48) / E I$ =		0.2	mm	Maximum deflection
L / f =		16860		> 300 - UC = 0.01 - Deflection check

11.2.6 PIPE SUPPORT ALLOWANCE

In the following, the check for the most stressed secondary beam (IPE240) is checked under a distributed load of 15 kN/m^2 and a concentrated load of 10 kN at midspan acting simultaneously, for pipe support allowance.

Table 11.15 – IPE240 – Pipe support allowance

BEAM CHECK UNDER CONCENTRATED LOAD						
DESCRIPTION: Utility Deck - IPE240 - A - L:4000					**- MAX UC = 0.67**	
DATA						
Shape:	IPE240					
f_y =	355	MPa	Plate yield strength			
I =	3.892E+07	mm	Moment of inertia			
W_{el} =	3.243E+05	mm^3	Elastic section modulus			
A_v =	1914	mm^2	Shear area			
L =	4.000	m	Beam span			
b =	1.100	m	Beam spacing			
q_G =	2.00	kN/m^2	Permanent distributed load			
q_Q =	15.00	kN/m^2	Variable distributed load			
F_Q =	10.00	kN	Variable concentrated load			
$\gamma_{f,G}$ =	1.30		Permanent load factor			
$\gamma_{f,Q}$ =	1.50		Variable load factor			
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, b$ =	27.6	kN/m	Factored distributed load			
$p_2 = (q_G + q_Q)\, b$ =	18.7	kN/m	Unfactored distributed load			
$F_1 = \gamma_{f,Q}\, F_Q$ =	15.0	kN	Factored concentrated load			
γ_{M0} =	1.10		Strength resistance factor			
Restraint scheme	1		Support - Support			
BENDING CHECK						
$M_{ed} = p_1 L^2 / 8 + F_1 L / 4$ =	70.2	kNm	Design bending moment			
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =	104.7	kNm	> M_{Ed} - UC =	0.67	- Bending check	
SHEAR CHECK						
$V_{ed} = p_1 L / 2 + F_1$ =	70	kN	Design shear force			
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =	357	kN	> VEd - UC =	0.20	- Shear check	
DEFLECTION CHECK						
$f = (5 / 384\, p_? L^4 + F_Q L^3 / 48) / E I$ =	9.3	mm	Maximum deflection			
L / f =	432		> 200 - UC =	0.46	- Deflection check	
$f = (5/384\, q_Q b L^4 + F_Q L^3 / 48) / E I$ =	8.4	mm	Maximum deflection			
L / f =	478		> 300 - UC =	0.63	- Deflection check	

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12 FLOOR PLATES

The checks of the floor plates are performed combining the dead weights with the distributed and concentrated live loads defined in design basis.

The checks are performed considering all the plates edges fixed and the span equal to the secondary beams spacing.

12.1 PLATE 8MM

This section shows the results for 8mm thick plate; these plates are used for floor areas, temporary refuge, walkways, stairs and access platforms. They are loaded with a distributed load of 15kN/m2 and a concentrated load of 5kN.

Table 12.1 – 8mm thk PLATE

PLATE CHECK UNDER DISTRIBUTED LOAD			
DESCRIPTION: Thk 8.0 mm			**- MAX UC = 0.93**
DATA			
f_y =	355	MPa	Plate yield strength
t =	8	mm	Plate thickness
b =	1100	mm	Plate span (beam spacing)
B =	1000	mm	Nominal plate width
I = B t^3 / 12 =	4.267E+04	mm^4	Moment of inertia
Wel = B t^2 / 6 =	1.067E+04	mm^3	Elastic section modulus
Av = B t =	8000	mm^2	Shear area
q_G =	1.00	kN/m^2	Permanent distributed load
q_Q =	15.00	kN/m^2	Variable distributed load
$\gamma_{f,G}$ =	1.30		Permanent load factor
$\gamma_{f,Q}$ =	1.50		Variable load factor
$p_1 = (\gamma_{f,G} q_G + \gamma_{f,Q} q_Q)$ B =	23.8	kN/m	Total factored distributed load
$p_2 = (q_G + q_Q)$ B =	16.0	kN/m	Total unfactored distributed load
γ_{M0} =	1.10		Strength resistance factor
Restraint scheme	3		Fixed - Fixed
BENDING CHECK			
M_{ed} = 1 / 12 p_1 b^2 =	2.4	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =	3.4	kNm	> M_{Ed} - UC = **0.70** **- Bending check**
SHEAR CHECK			
V_{ed} = 1 / 2 p_1 b =	13	kN	Design shear force
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =	1491	kN	> V_{Ed} - UC = **0.01** **- Shear check**
DEFLECTION CHECK			
f = 1 / 384 p_2 b^4 / E I =	6.8	mm	Maximum deflection
b / f =	162		> 150 - UC = **0.93** **- Deflection check**

PLATE CHECK UNDER CONCENTRATED LOAD			
DESCRIPTION: Thk 8.0 mm			**- MAX UC = 0.61**
DATA			
f_y =	355	MPa	Plate yield strength
t =	8	mm	Plate thickness
b =	1100	mm	Plate span (beam spacing)
B =	1000	mm	Nominal plate width
I = B t^3 / 12 =	4.267E+04	mm^4	Moment of inertia
Wel = B t^2 / 6 =	1.067E+04	mm^3	Elastic section modulus
Av = B t =	8000	mm^2	Shear area
q_G =	1.00	kN/m^2	Permanent distributed load
q_Q =	5.00	kN	Variable distributed load
$\gamma_{f,G}$ =	1.30		Permanent load factor
$\gamma_{f,Q}$ =	1.50		Variable load factor
$p_1 = \gamma_{f,G} q_G$ b =	1.4	kN/m	Total factored distributed load
$p_2 = q_G$ b =	1.1	kN/m	Total unfactored distributed load
$F_1 = \gamma_{f,Q} F_Q$ =	7.5	kN	Factored concentrated load
γ_{M0} =	1.10		Strength resistance factor
Restraint scheme	3		Fixed - Fixed
BENDING CHECK			
$M_{ed} = p_1 b^2 / 12 + F_1$ b / 8 =	1.2	kNm	Design bending moment
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =	3.4	kNm	> M_{Ed} - UC = **0.34** **- Bending check**
SHEAR CHECK			
$V_{ed} = p_1$ b / 2 + F_1 =	8	kN	Design shear force
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =	1491	kN	> V_{Ed} - UC = **0.01** **- Shear check**
DEFLECTION CHECK			
f = (1/ 384 p_2 b^4 + F_Q b^3 / 192) / E I =	4.4	mm	Maximum deflection
b / f =	248		> 150 - UC = **0.61** **- Deflection check**

12.2 PLATE 10MM

This section shows the results for 10mm thick plate; these plates are used for laydown are and are loaded with a distributed load of 15kN/m2 and a concentrated load of 22.5kN.

Table 12.2 – 8mm thk PLATE

PLATE CHECK UNDER CONCENTRATED LOAD				
DESCRIPTION:	Thk 10 mm			**- MAX UC = 0.57**
DATA				
f_y =	355	MPa	Plate yield strength	
t =	10	mm	Plate thickness	
b =	715	mm	Plate span (beam spacing)	
B =	1000	mm	Nominal plate width	
I = B t^3 / 12 =	8.333E+04	mm^4	Moment of inertia	
Wel = B t^2 / 6 =	1.667E+04	mm^3	Elastic section modulus	
Av = B t =	10000	mm^2	Shear area	
q_G =	1.00	kN/m^2	Permanent distributed load	
q_Q =	22.50	kN	Variable distributed load	
$\gamma_{f,G}$ =	1.30		Permanent load factor	
$\gamma_{f,Q}$ =	1.50		Variable load factor	
$p_1 = \gamma_{f,G}\, q_G\, b$ =	0.9	kN/m	Total factored distributed load	
$p_2 = q_G\, b$ =	0.7	kN/m	Total unfactored distributed load	
$F_1 = \gamma_{f,Q}\, F_Q$ =	33.8	kN	Factored concentrated load	
γ_{M0} =	1.10		Strength resistance factor	
Restraint scheme	3		Fixed - Fixed	
BENDING CHECK				
$M_{ed} = p_1\, b^2 / 12 + F_1\, b / 8$ =	3.1	kNm	Design bending moment	
$M_{c,Rd} = W_{el}\, f_y / \gamma_{M0}$ =	5.4	kNm	> M_{Ed} - UC = **0.57**	**- Bending check**
SHEAR CHECK				
$V_{ed} = p_1\, b / 2 + F_1$ =	34	kN	Design shear force	
$V_{c,Rd} = A_v\, (f_y / \sqrt{3}) / \gamma_{M0}$ =	1863	kN	> V_{Ed} - UC = **0.02**	**- Shear check**
DEFLECTION CHECK				
f = (1/ 384 $p_2\, b^4 + F_Q\, b^3$ / 192) / E I =	2.5	mm	Maximum deflection	
b / f =	282		> 150 - UC = **0.53**	**- Deflection check**

PLATE CHECK UNDER DISTRIBUTED LOAD				
DESCRIPTION:	Thk 10 mm			**- MAX UC = 0.19**
DATA				
f_y =	355	MPa	Plate yield strength	
t =	10	mm	Plate thickness	
b =	715	mm	Plate span (beam spacing)	
B =	1000	mm	Nominal plate width	
I = B t^3 / 12 =	8.333E+04	mm^4	Moment of inertia	
Wel = B t^2 / 6 =	1.667E+04	mm^3	Elastic section modulus	
Av = B t =	10000	mm^2	Shear area	
q_G =	1.00	kN/m^2	Permanent distributed load	
q_Q =	15.00	kN/m^2	Variable distributed load	
$\gamma_{f,G}$ =	1.30		Permanent load factor	
$\gamma_{f,Q}$ =	1.50		Variable load factor	
$p_1 = (\gamma_{f,G}\, q_G + \gamma_{f,Q}\, q_Q)\, B$ =	23.8	kN/m	Total factored distributed load	
$p_2 = (q_G + q_Q)\, B$ =	16.0	kN/m	Total unfactored distributed load	
γ_{M0} =	1.10		Strength resistance factor	
Restraint scheme	3		Fixed - Fixed	
BENDING CHECK				
M_{ed} = 1 / 12 $p_1\, b^2$ =	1.0	kNm	Design bending moment	
$M_{c,Rd} = W_{el}\, f_y / \gamma_{M0}$ =	5.4	kNm	> M_{Ed} - UC = **0.19**	**- Bending check**
SHEAR CHECK				
V_{ed} = 1 / 2 $p_1\, b$ =	9	kN	Design shear force	
$V_{c,Rd} = A_v\, (f_y / \sqrt{3}) / \gamma_{M0}$ =	1863	kN	> V_{Ed} - UC = **0.00**	**- Shear check**
DEFLECTION CHECK				
f = 1 / 384 $p_2\, b^4$ / E I =	0.6	mm	Maximum deflection	
b / f =	1149		> 150 - UC = **0.13**	**- Deflection check**

13 GRATING

This section shows the results for grating check loaded with a distributed load of 4.5kN/m².

Table 13.1 - Grating check

BEAM CHECK UNDER DISTRIBUTED LOAD						
DESCRIPTION: Grating 30 x 5 - 30 x 50						**Max UC = 0.30**
DATA						
Single bar shape		30x5	mm			
Number of bars		33		bar in one meter		
f_y =		235	MPa	Plate yield strength		
I =		3.713E+05	mm	Moment of inertia		
W_{el} =		2.475E+04	mm^3	Elastic section modulus		
A_v =		4950	mm^2	Shear area		
L =		1.250	m	Beam spacing		
b =		1.000	m	Nominal width		
q_G =		1.00	kN/m^2	Permanent distributed load		
q_Q =		4.50	kN/m^2	Variable distributed load		
$\gamma_{f,G}$ =		1.30		Permanent load factor		
$\gamma_{f,Q}$ =		1.50		Variable load factor		
$p_1 = (\gamma_{f,G} q_G + \gamma_{f,Q} q_Q) b$ =		8.1	kN/m	Total factored distributed load		
$p_2 = (q_G + q_Q) b$ =		5.5	kN/m	Total unfactored distributed load		
γ_{M0} =		1.10		Strength resistance factor		
Restraint scheme		1		Support - Support		
BENDING CHECK						
M_{ed} =	1 / 8 $p_1 L^2$ =	1.6	kNm	Design bending moment		
$M_{c,Rd} = W_{el} f_y / \gamma_{M0}$ =		5.3	kNm	> M_{Ed} - UC =	**0.30**	**- Bending check**
SHEAR CHECK						
V_{ed} =	1 / 2 $p_1 L$ =	5	kN	Design shear force		
$V_{c,Rd} = A_v (f_y / \sqrt{3}) / \gamma_{M0}$ =		611	kN	> VEd - UC =	**0.01**	**- Shear check**
DEFLECTION CHECK						
f =	5 / 384 $p_2 L^4 / E I$ =	2.2	mm	Maximum deflection		
L / f =		557		> 300 - UC =	**0.27**	**- Deflection check**

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14 VORTEX SHEDDING

14.1 VORTEX INDUCED VIBRATION PRINCIPLE

This section presents the results of wind induced vortex shedding analysis and checks performed on tubulars members of TP and tower stairs. The checks are performed for both columns and bracings considering the maximum member lengths.

The methodology used to establish the effects Vortex Induced Vibration (VIV) is developed according to DNVGL-RP-C205, Ref. /15/.

The following approach is used:

1) Establish the member natural frequency referring to Roark formula:

$$n_e = \frac{K_n}{2\pi}\sqrt{\frac{EIg}{wl^4}}$$

Where:

n_e = natural frequency
K_n = 16.135 (intermediate fixed/hinged)
g = gravitational acceleration
E = modulus of elasticity
I = moment of Inertia
w = weight
l = tube length

2) Define the resonance wind velocity (Uw) given by:

$$U_w = 0.8\frac{n_e\, b}{St}$$

Where:

ne = natural frequency
b = member diameter
St= Strouhal number (0.20 for circular members)

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14.2 TOWER STAIRS VIV

14.2.1 Diagonal 168.3x7.11 – 3200mm

The following figure shows the member position.

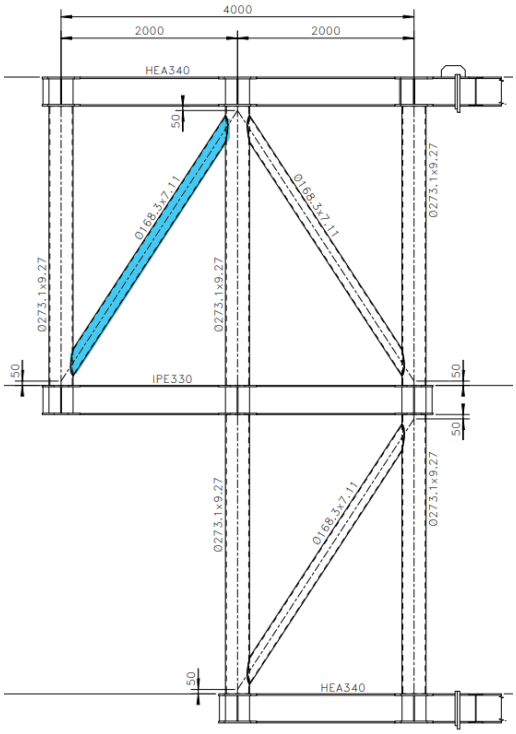


Figure 14.1 - Tower Stairs diagonal member position

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Table 14.1 - 168.3x7.11 - 3200mm

Tower Stairs - 168.3x7.11 - L: 3200mm			
1 - CROSS-FLOW VIBRATIONS			
D	168.3	mm	Member diameter
t	7.11	mm	Member thickness
I	1.172E+07	mm^4	Member section inertia
L	3.20	m	Member length
me	28.3	kg/m	Effective mass per unit length
rc	4		Restraint code - Intermediate fixed/hinged
K1	16.135		Roark's formulas - Table 36
f1	74.0	1/s	First natural frequency of member
St	0.20		Strouhal number
Uw*	49.8	m/s	Limiting wind velocity
U	32.2	m/s	1-year, 1min wind at height z
Check	U < Uw* - Check satisfied - No risk of vortex shedding occurrence		
ρs	7850	kg/m^3	Steel density
ρ	1.25	kg/m^3	Air density
$\delta = 2 \pi \zeta$	0.0094		Structural dumping (ζ 0.0015)
Ks	15.05		Stability parameter
ν	1.511E-05	m^2/s	Air kinematic viscosity
Re*	5.548E+05		Reynolds number at wind velocity Uw*
Check	Check satisfied - No risk of vortex shedding occurrence		

2 - IN-LINE VIBRATIONS			
me	28.3	kg/m	Effective mass per unit length
$\delta = 2 \pi \zeta$	0.0094		Structural dumping (ζ = 0.002)
ρ	1.25	kg/m^3	Air density
D	168.3	mm	Member diameter
ks	15.05		Stability parameter (section 9.1.8)
Check	Ks > 2.0 - No risk of in-line vibrations		
St	0.20		Strouhal number
f1	74.0	1/s	First natural frequency of member
U	32.2	m/s	1-year, 1min wind at height z
VR	2.58		Reduced velocity
Check	Check NOT satisfied - Vortex shedding can occur		

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14.2.2 Diagonal 291.1x8.18 – 4300mm

The following figure shows the member position.

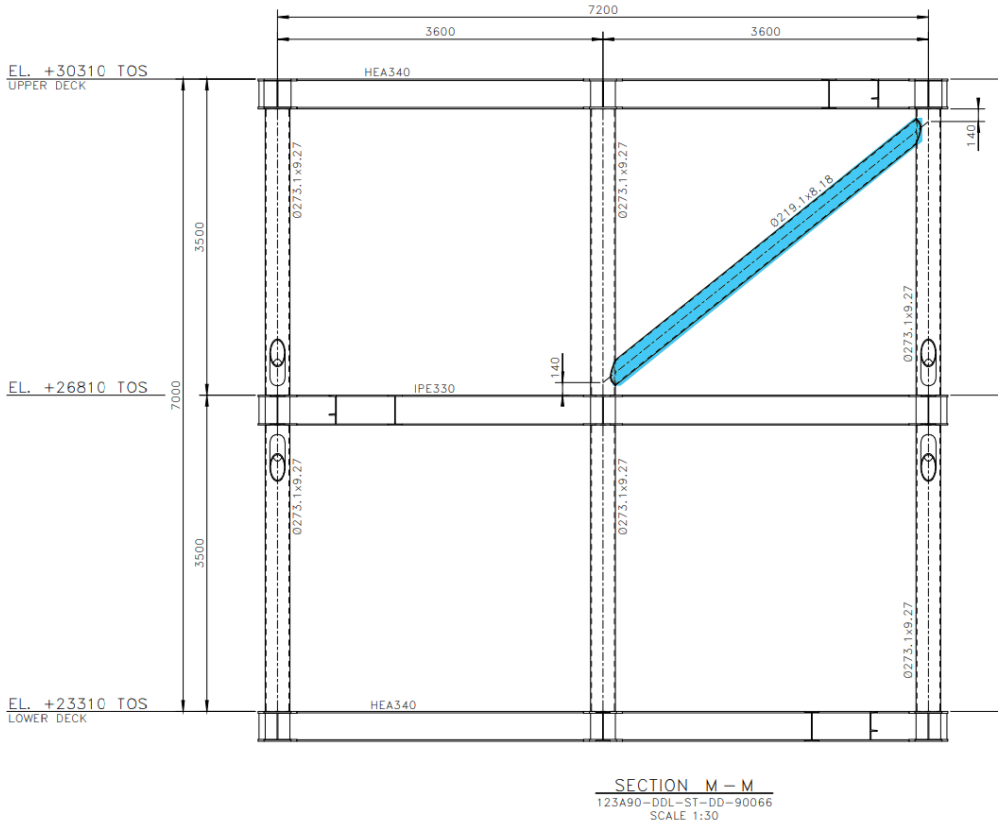


Figure 14.2 - Tower Stairs diagonal member position 2

Table 14.2 - - 219.1x8.18 - 4300 mm

TP Stairs - 219.1x8.18 - L: 4300mm			
1 - CROSS-FLOW VIBRATIONS			
D	219.1	mm	Member diameter
t	8.18	mm	Member thickness
I	3.019E+07	mm^4	Member section inertia
L	4.30	m	Member length
me	42.5	kg/m	Effective mass per unit length
rc	4		Restraint code - Intermediate fixed/hinged
K1	16.135		Roark's formulas - Table 36
f1	53.6	1/s	First natural frequency of member
St	0.20		Strouhal number
Uw*	47.0	m/s	Limiting wind velocity
U	32.2	m/s	1-year, 1min wind at height z
Check	U < Uw* - Check satisfied - No risk of vortex shedding occurrence		
ρs	7850	kg/m^3	Steel density
ρ	1.25	kg/m^3	Air density
$\delta = 2\pi\zeta$	0.0094		Structural dumping (ζ 0.0015)
Ks	13.37		Stability parameter
ν	1.511E-05	m^2/s	Air kinematic viscosity
Re*	6.812E+05		Reynolds number at wind velocity Uw*
Check	Check NOT satisfied - Vortex shedding can occur		

2 - IN-LINE VIBRATIONS			
me	42.5	kg/m	Effective mass per unit length
$\delta = 2\pi\zeta$	0.0094		Structural dumping (ζ = 0.002)
ρ	1.25	kg/m^3	Air density
D	219.1	mm	Member diameter
ks	13.37		Stability parameter (section 9.1.8)
Check	Ks > 2.0 - No risk of in-line vibrations		
St	0.20		Strouhal number
f1	53.6	1/s	First natural frequency of member
U	32.2	m/s	1-year, 1min wind at height z
VR	2.74		Reduced velocity
Check	Check NOT satisfied - Vortex shedding can occur		

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14.3 TP STAIRS VIV

14.3.1 Diagonal 168.3x7.11 – 3120mm

The following figure shows the member position.

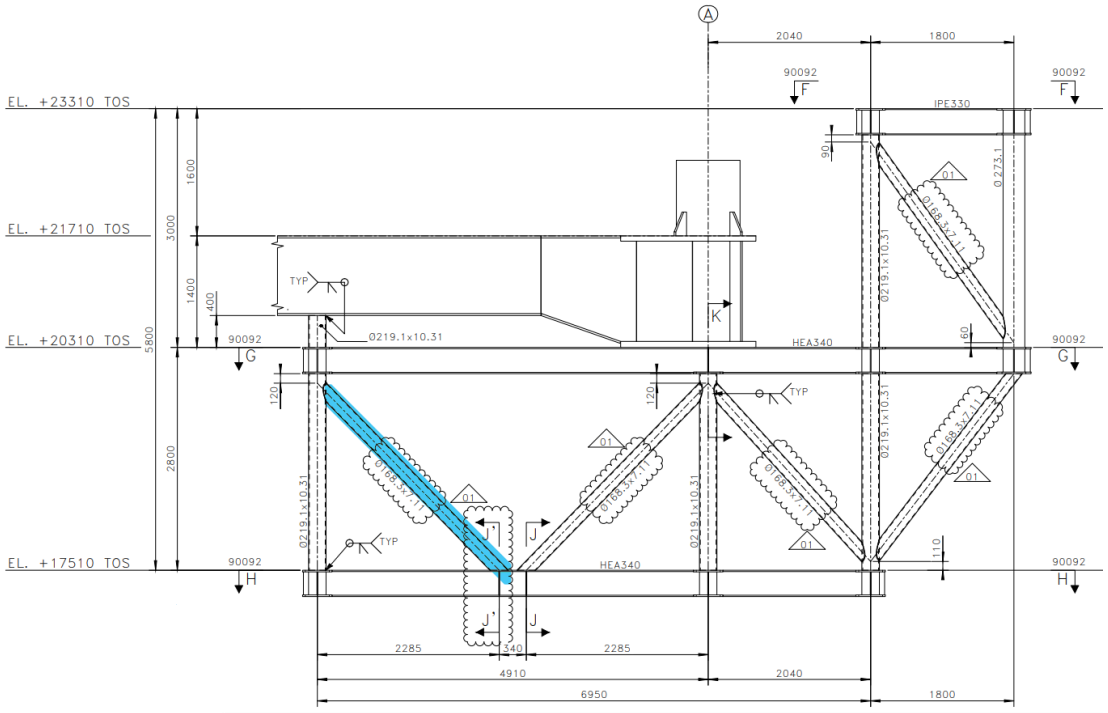


Figure 14.3 - TP Stairs diagonal member position

Table 14.3 - - 168.3x7.11 - 3120mm

TP Stairs - 168.3x7.11 - L: 3120mm			
1 - CROSS-FLOW VIBRATIONS			
D	168.3	mm	Member diameter
t	7.11	mm	Member thickness
I	1.172E+07	mm^4	Member section inertia
L	3.12	m	Member length
me	28.3	kg/m	Effective mass per unit length
rc	4		Restraint code - Intermediate fixed/hinged
K1	16.135		Roark's formulas - Table 36
f1	77.8	1/s	First natural frequency of member
St	0.20		Strouhal number
Uw*	52.4	m/s	Limiting wind velocity
U	32.2	m/s	1-year, 1min wind at height z
Check	U < Uw* - Check satisfied - No risk of vortex shedding occurrence		
ρ_s	7850	kg/m^3	Steel density
ρ	1.25	kg/m^3	Air density
$\delta = 2\pi\zeta$	0.0094		Structural dumping (ζ = 0.0015)
Ks	15.05		Stability parameter
ν	1.511E-05	m^2/s	Air kinematic viscosity
Re*	5.836E+05		Reynolds number at wind velocity Uw*
Check	Check satisfied - No risk of vortex shedding occurrence		
2 - IN-LINE VIBRATIONS			
me	28.3	kg/m	Effective mass per unit length
$\delta = 2\pi\zeta$	0.0094		Structural dumping (ζ = 0.002)
ρ	1.25	kg/m^3	Air density
D	168.3	mm	Member diameter
ks	15.05		Stability parameter (section 9.1.8)
Check	Ks > 2.0 - No risk of in-line vibrations		
St	0.20		Strouhal number
f1	77.8	1/s	First natural frequency of member
U	32.2	m/s	1-year, 1min wind at height z
VR	2.46		Reduced velocity
Check	Check NOT satisfied - Vortex shedding can occur		

14.3.2 Diagonal 291.1x10.31– 4230mm

The following figure shows the member position.

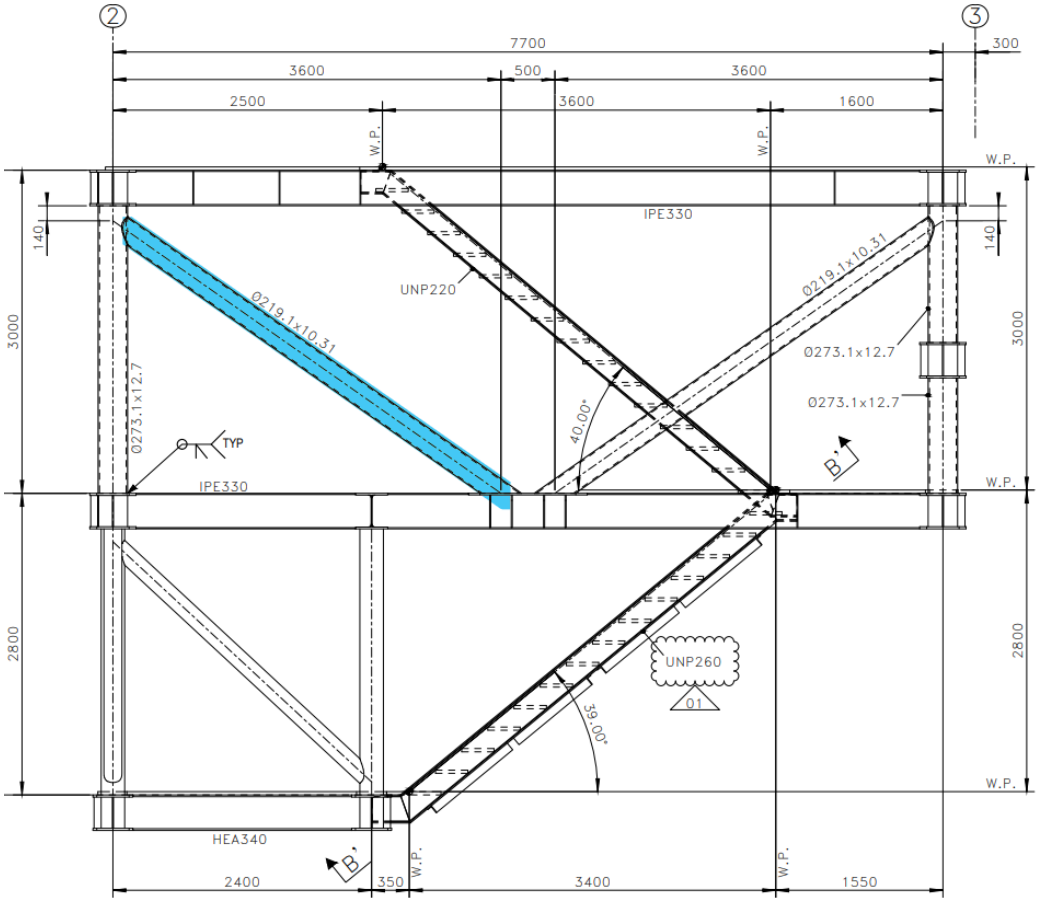


Figure 14.4 - TP Stairs diagonal member position 2

Table 14.4 - - 219.1x10.31 - 4230mm

TP Stairs - 219.1x10.31 - L: 4230mm			
1 - CROSS-FLOW VIBRATIONS			
D	219.1	mm	Member diameter
t	10.31	mm	Member thickness
I	3.694E+07	mm^4	Member section inertia
L	4.23	m	Member length
me	53.1	kg/m	Effective mass per unit length
rc	4		Restraint code - Intermediate fixed/hinged
K1	16.135		Roark's formulas - Table 36
f1	54.9	1/s	First natural frequency of member
St	0.20		Strouhal number
Uw*	48.1	m/s	Limiting wind velocity
U	32.2	m/s	1-year, 1min wind at height z
Check	U < Uw* - Check satisfied - No risk of vortex shedding occurrence		
ρs	7850	kg/m^3	Steel density
ρ	1.25	kg/m^3	Air density
δ = 2 π ζ	0.0094		Structural dumping (ζ = 0.0015)
Ks	16.68		Stability parameter
ν	1.511E-05	m^2/s	Air kinematic viscosity
Re*	6.972E+05		Reynolds number at wind velocity Uw*
Check	Check satisfied - No risk of vortex shedding occurrence		

2 - IN-LINE VIBRATIONS			
me	53.1	kg/m	Effective mass per unit length
δ = 2 π ζ	0.0094		Structural dumping (ζ = 0.002)
ρ	1.25	kg/m^3	Air density
D	219.1	mm	Member diameter
ks	16.68		Stability parameter (section 9.1.8)
Check	Ks > 2.0 - No risk of in-line vibrations		
St	0.20		Strouhal number
f1	54.9	1/s	First natural frequency of member
U	32.2	m/s	1-year, 1min wind at height z
VR	2.68		Reduced velocity
Check	Check NOT satisfied - Vortex shedding can occur		

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15 VENT SUPPORT

Vent support has been checked for in-service loads, according to Eurocode 3, ref. /10/.

The 3D SACS model for structural checks has been extracted as local model from in-service SACS model, ref./29/, and it is shown in the following figures.

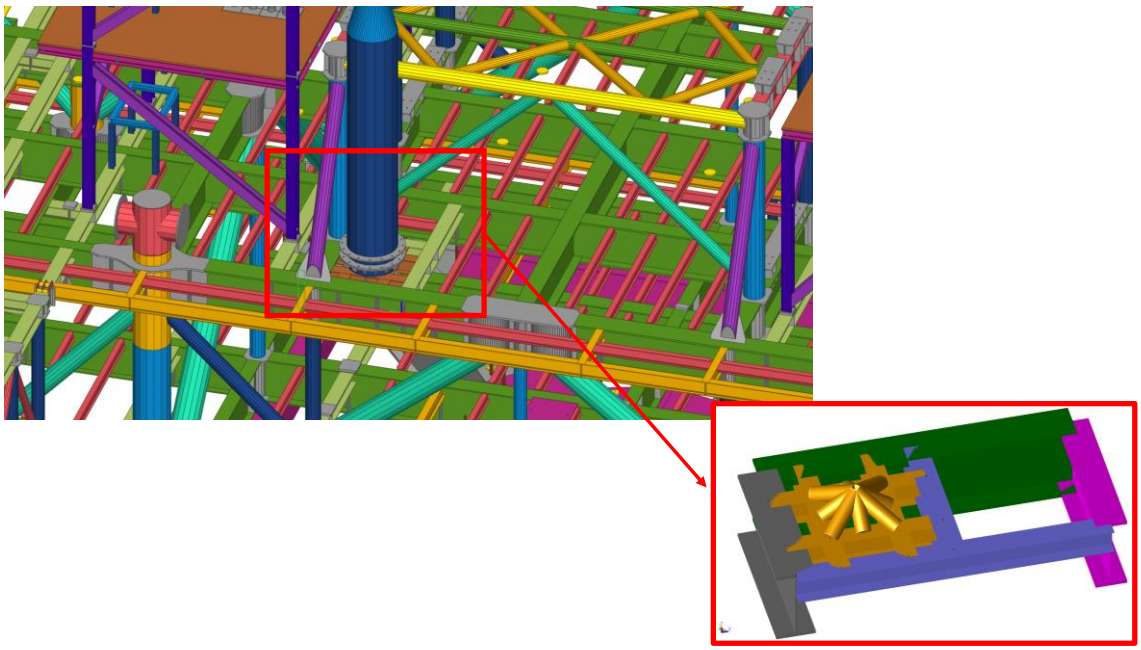


Figure 15.1 – Vent Support

Dummy elements were used to connect the UD beams to the ref. point of Vent (were the actions were calculated by Supplier)

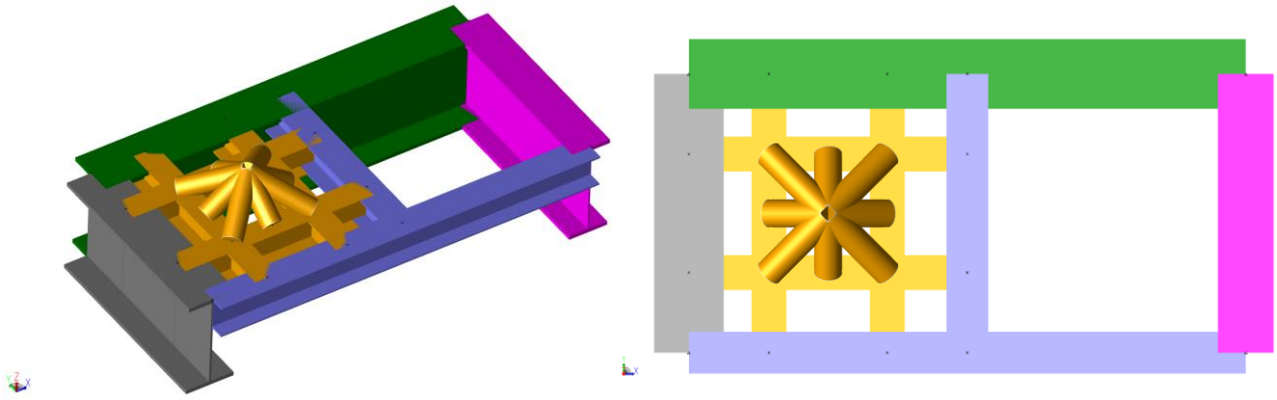


Figure 15.2 – Vent Support – SACS model

15.1 STRUCTURAL MODEL

The local model is made by the beams directly connected to the vent support and to the principal beams. In the following figure the external and internal restraints are reported, in order to restore real boundary conditions of the local model.

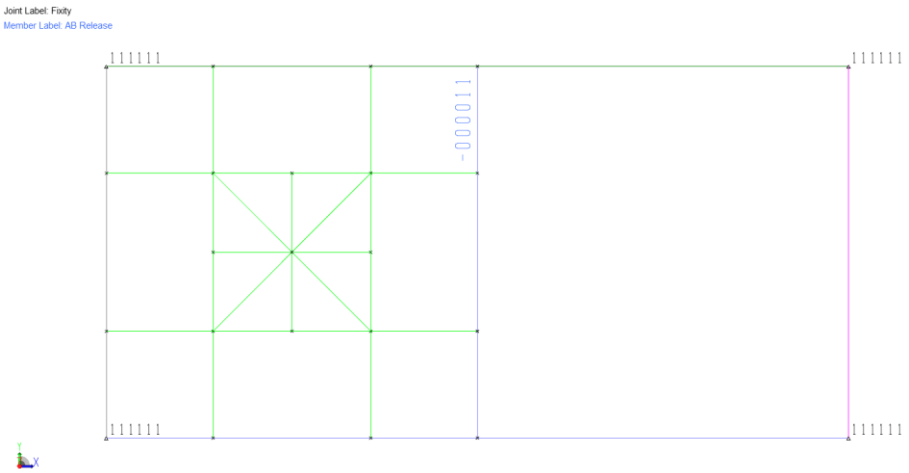


Figure 15.3 – Vent Support – SACS model – external restraints and internal releases

From Figure 15.2 it can be observed that four beam elements have been added: these beams (group DUM) are dummy rigid elements that have been added to assign the vent forces at the correct point, in order to be redistributed to the correct points on the principal beams.

Structural model members joints, groups and sections are shown in the following SACS output excerpt and figures.

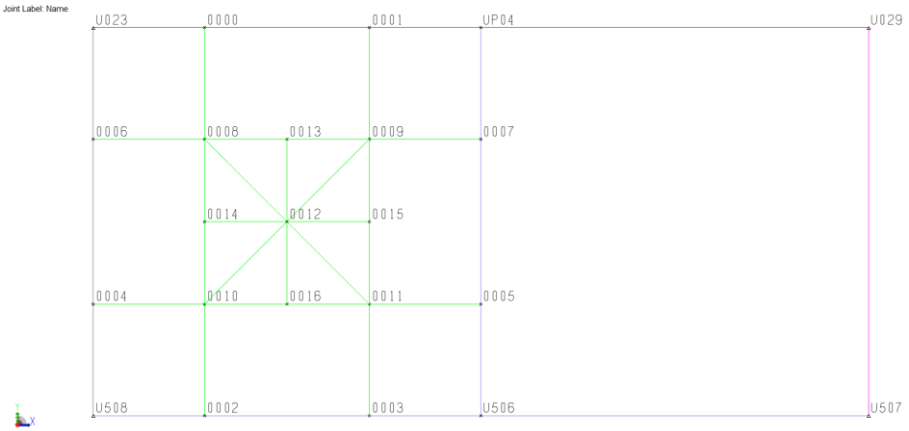


Figure 15.4 – Vent Support – SACS model – Joints labels

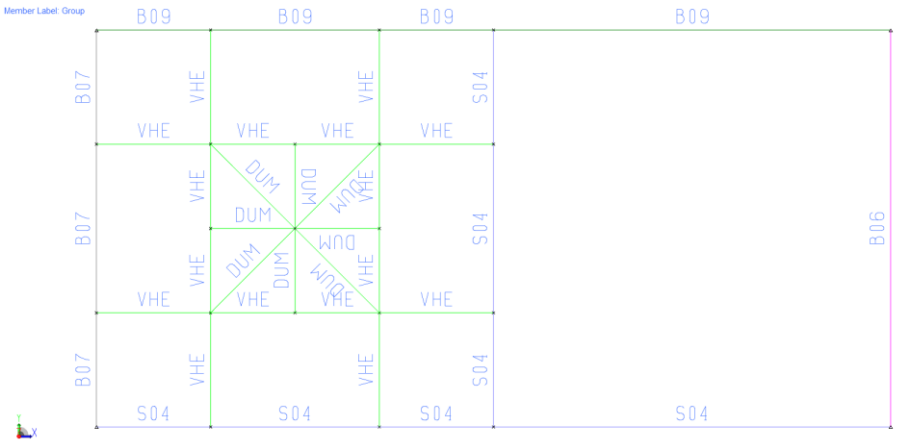


Figure 15.5 – Vent Support – SACS model – Member groups

TUBULAR MEMBER PROPERTIES

GRP	M/S	JOINT THICK M	WALL THICK CM	OUTSIDE DIAM. CM	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	***** MOMENTS OF INERTIA **** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	KY	KZ	SHEAR AREA CM**2	RING SPACE M	SECT TAPER LENG M
DUM	9	0.00	2.000	20.00	2000.0	772.2	113.10	9274.0	4637.0	4637.0	36.0	1.0	1.0	56.55	0.00	0.00

WIDE FLANGE/WIDE FLANGE COMPACT,MEMBER PROPERTIES

GRP	M/S	** FLANGE ** THICK CM	WIDTH CM	WEB THICK CM	FILET RAD. CM	DEPTH CM	E 1000 KN/CM2	G 1000 KN/CM2	AXIAL AREA CM**2	**** MOMENTS OF INERTIA **** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	KY	KZ	FLANGE-BRC TOP M	BOT M	SECT TPR LEN M
S04	1	1.65	30.00	0.950	2.700	33.00	20.5	7.9	133.5	127.2	0.2769E+05	7436.	35.5	1.0	1.0	0.0	0.0	0.00
VHE	1	1.50	25.00	1.000	1.000	33.00	20.5	7.9	105.0	69.38	0.2087E+05	3909.	35.5	1.0	1.0	0.0	0.0	0.00

Member Section Report

Section	Type	AX(cm2)	J(cm4)	IY(cm4)	IZ(cm4)	A(cm)	B(cm)	C(cm)	D(cm)	E(cm)	F(cm)
PG06	PLG *	458.000	1771.429	835042.68	42692.546	40.000	4.000	100.000	1.500		
PG07	PLG *	584.000	2403.880	1051914.7	83394.664	50.000	4.000	100.000	2.000		
PG09	PLG *	538.000	2198.096	1019469.4	83359.210	50.000	4.000	100.000	1.500		
VHESEC	WF *	105.000	69.378	20868.748	3908.750	25.000	1.500	33.000	1.000		

An * indicates that AX, J, IY and IZ are computed values, not user defined.

15.2 BASIC LOAD CASES

Basic load cases are taken from "Mechanical Calculation Hydrogen Vent" report, ref./33/.

Max. support loads for all load combinations at the vent base from ref./33/ are reported in the following table:

Load Comb.	Vertical Load [kN]	Uplift [kN]	Resultant Shear [kN]	Resultant Moment [kNm]	Torsion [kNm]
Envelope	-57.41	0.00	43.26	317.61	0.00

Table 15.1 – Vent support loads as per ref./33/

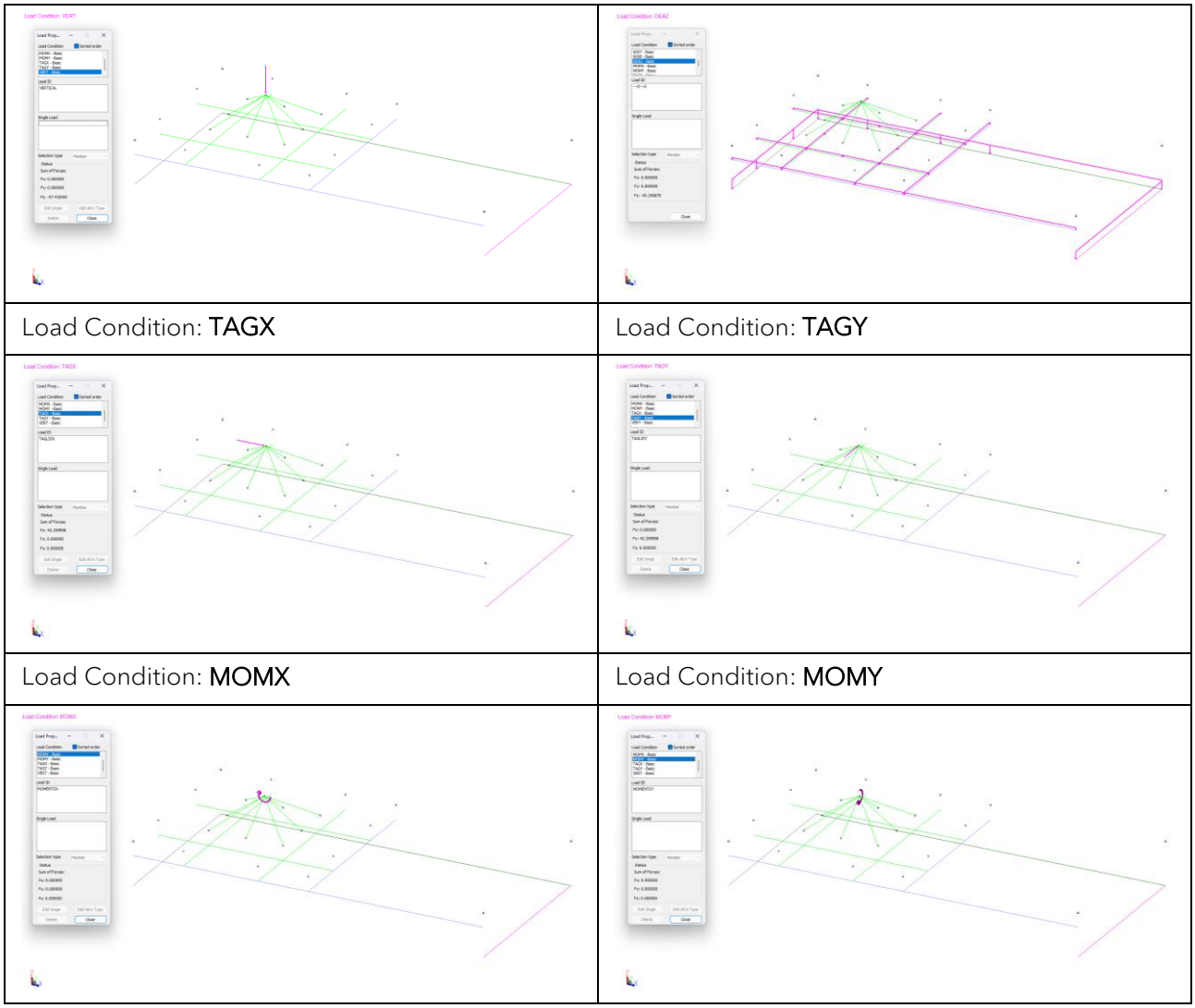
These loads are assigned at joint 0012 in both principal directions X, Y, in order to combine loads and consider max. loads applied in all directions. Joint 0012 is created to simulate the correct elevation at which base loads are extracted.

Joint	Load Case	Fx [kN]	Fy [kN]	Fz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
0012	VERT			-57.4			
0012	TAGX	43.26					
0012	TAGY		43.26				
0012	MOMX					317.61	
0012	MOMY				-317.61		

Table 15.2 – Vent support loads – SACS model

Load condition DEAZ is defined to compute the self-weight of the modelled elements. In the following figures, the aforementioned load conditions are represented.

Load Condition: **VERT**	Load Condition: **DEAZ**



Load Condition: **TAGX**	Load Condition: **TAGY**
Load Condition: **MOMX**	Load Condition: **MOMY**

Figure 15.6 – Vent Support – SACS model – Load cases

In the following SACS excerpt, the basic load cases are reported.

```
                                        ************* SEASTATE LOAD CASE CENTER REPORT *************
                                                        RELATIVE TO STRUCTURAL ORIGIN
LOAD   LOAD        ********* X - DIRECTION *********      ********* Y - DIRECTION *********      ********* Z - DIRECTION *********
CASE   LABEL       FORCE       X         Y         Z       FORCE       X         Y         Z       FORCE       X         Y         Z
                    (KN)      (M)       (M)       (M)       (KN)      (M)       (M)       (M)       (KN)      (M)       (M)       (M)

    1  DEAZ          0.00                                    0.00                                  -45.24     -6.23      3.78     29.90
    2  MOMX          0.00                                    0.00                                    0.00
    3  MOMY          0.00                                    0.00                                    0.00
    4  TAGX         43.26     -7.00      3.50     30.61       0.00                                    0.00
    5  TAGY          0.00                                   43.26     -7.00      3.50     30.61       0.00
    6  VERT          0.00                                    0.00                                  -57.41     -7.00      3.50     30.61
    7  0001         64.89     -7.00      3.50     30.61       0.00                                 -133.45     -6.66      3.62     30.30
    8  0002         45.42     -7.00      3.50     30.61      45.42     -7.00      3.50     30.61  -133.45     -6.66      3.62     30.30
    9  0003          0.00                                   64.89     -7.00      3.50     30.61  -133.45     -6.66      3.62     30.30
   10  0004        -45.42     -7.00      3.50     30.61      45.42     -7.00      3.50     30.61  -133.45     -6.66      3.62     30.30
   11  0005        -64.89     -7.00      3.50     30.61       0.00                                 -133.45     -6.66      3.62     30.30
```

12	0006	-45.42	-7.00	3.50	30.61	-45.42	-7.00	3.50	30.61	-133.45	-6.66	3.62	30.30
13	0007	0.00				-64.89	-7.00	3.50	30.61	-133.45	-6.66	3.62	30.30
14	0008	45.42	-7.00	3.50	30.61	-45.42	-7.00	3.50	30.61	-133.45	-6.66	3.62	30.30

15.3 LOAD COMBINATIONS

The following load combinations at ULS, on the safe side, are assumed for structural checks according to Eurocode 3 ref. /10/.

Load Comb.	DEAZ	VERT	TAGX	TAGY	MOMX	MOMY
0001	1.30	1.30	1.50		1.50	
0002	1.30	1.30	1.05	1.05	1.05	1.05
0003	1.30	1.30		1.50		1.50
0004	1.30	1.30	-1.05	1.05	-1.05	1.05
0005	1.30	1.30	-1.50		-1.50	
0006	1.30	1.30	-1.05	-1.05	-1.05	-1.05
0007	1.30	1.30		-1.50		-1.50
0008	1.30	1.30	1.05	-1.05	1.05	-1.05

Table 15.3 – Vent support ULS Load Combinations – SACS model

In the following SACS excerpt, the load combinations are reported.

********** SEASTATE LOAD CASE CENTER REPORT **********
RELATIVE TO STRUCTURAL ORIGIN

LOAD CASE	LOAD LABEL	********* X - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Y - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)	********* Z - DIRECTION ********* FORCE (KN)	X (M)	Y (M)	Z (M)
7	0001	64.89	-7.00	3.50	30.61	0.00				-133.45	-6.66	3.62	30.30
8	0002	45.42	-7.00	3.50	30.61	45.42	-7.00	3.50	30.61	-133.45	-6.66	3.62	30.30
9	0003	0.00				64.89	-7.00	3.50	30.61	-133.45	-6.66	3.62	30.30
10	0004	-45.42	-7.00	3.50	30.61	45.42	-7.00	3.50	30.61	-133.45	-6.66	3.62	30.30
11	0005	-64.89	-7.00	3.50	30.61	0.00				-133.45	-6.66	3.62	30.30
12	0006	-45.42	-7.00	3.50	30.61	-45.42	-7.00	3.50	30.61	-133.45	-6.66	3.62	30.30
13	0007	0.00				-64.89	-7.00	3.50	30.61	-133.45	-6.66	3.62	30.30
14	0008	45.42	-7.00	3.50	30.61	-45.42	-7.00	3.50	30.61	-133.45	-6.66	3.62	30.30

15.4 RESULTS

15.4.1 Base Member check

All members were checked according to ISO 19902 and Eurocode 3, Ref./2/ and /10/, respectively for tubular and non-tubular elements. Members' code checks are reported in the following and show that the structure can withstand all In-Service and Transportation load combinations, with utilization factors below 1.0.

The maximum UC value is equal to 0.71 on member 003X-0043 for load combination TR35. Maximum member UC are reported in following SACS excerpt and figures.

* * * M E M B E R G R O U P S U M M A R Y * * *
ISO 19902:2007 / EC3:2005
(EN 1993-1-1:2005/NA NONE)

GRUP ID	CRITICAL MEMBER	LOAD COND	MAX. UNITY CHECK	DIST FROM END M	* APPLIED STRESSES * AXIAL N/MM2	BEND-Y N/MM2	BEND-Z N/MM2	*** ALLOWABLE STRESSES *** AXIAL N/MM2	EULER N/MM2	BEND-Y N/MM2	BEND-Z N/MM2	CRIT COND	EFFECTIVE LENGTHS KLY M	KLZ M	CM * VALUES * Y	Z
B06	U507-U029	0001	0.00	2.0	0.0	-0.1	0.0	363.6	931.4	403.6	553.9	WSHBUC	16.00	4.50	0.00	0.00
B07	0006-U023	0005	0.03	0.6	-0.0	-2.6	-0.2	363.6	1426.8	405.0	555.1	SHEAR	8.00	4.50	0.40	0.66
B09	U023-0000	0003	0.08	0.0	-0.1	-5.3	-1.0	363.6	1497.6	399.0	550.9	WSHBUC	16.00	4.00	0.55	0.79
S04	U508-0002	0008	0.24	0.0	2.4	-66.6	-18.1	322.7	704.5	338.7	487.7	BN+AX	4.00	4.00	0.00	0.00
VHE	0006-0008	0004	0.26	0.0	-4.9	-13.2	16.5	322.7	1883.0	358.8	491.5	SHEAR	2.00	2.00	0.52	0.40

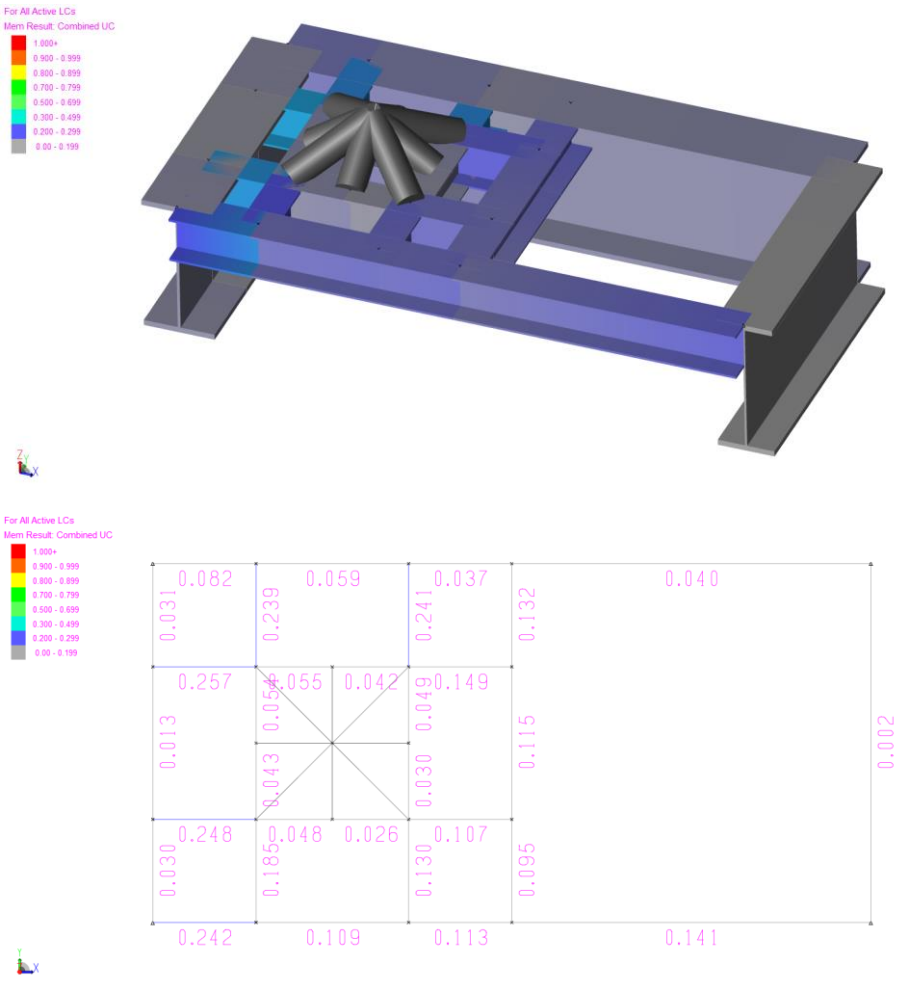


Figure 15.7 – Vent support – Member UC

15.4.2 Bolt base connection check

016 M27 bolts cl.8.8 are placed on the base flange of the Vent.

According to the load cases and load combinations presented in the previous sections, checks can be performed.

Shear Check

ULS Max. Shear $V_{Ed} = F*1.5 = 43.26*1.5 = 65$ kN

Max. shear per bolt $F_{v,Ed} = 65/16 = 4$ kN < $F_{V,Rd} = 176$ kN OK

Tension Check

ULS Max Moment $M_{Ed} = M*1.5 = 317.6*1.5 = 476.4$ kNm

ULS Max. Tension $F_{t,Ed} = M_{Ed}*d_{max}/\sum d_i - 1.3*F_Z/16 = 476.4*0.623/1.614 - 1.3*57.4/16 = 87.3$ kN

Max. shear per bolt $F_{t,Ed} = 87.3$ kN < $F_{T,Rd} = 264.4$ kN OK

Shear+Tension Check

$F_{v.Ed}/F_{v,Rd} + F_{t.Ed}/1.4*F_{t,Rd} = 4/176 + 87.3/(1.4*264.4) = 0.02 + 0.24 = 0.26 < 1.0$ OK

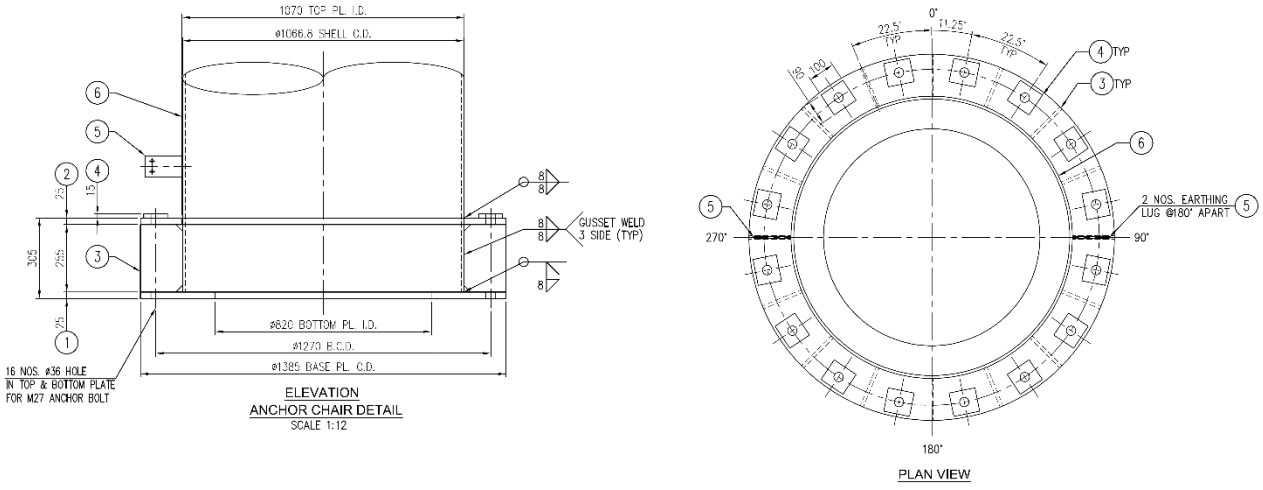


Figure 15.8 – Vent support – Bolted base connection

16 EQUIPMENT SUPPORT

16.1 TWIST LOCK SUPPORTS

Twist Locks checks cover fuel cell containers and water treatment supports, since the same twist locks are used as anchors with lower loads.

Max. forces acting on the twist lock anchors are taken from relative calculation report ref. /34/, reported in APPENDIX D.

Minimum Breaking load admissible values for twist locks are taken from DNV certification, reported in APPENDIX D.

Checks are performed comparing max. acting ULS reactions (max. envelope) against MBL resistances for twist locks, as per Table 16.1.

Reaction	Acting ULS [kN]	Resistance SWL [kN]	UC < 1.0	Check
Compression	362	2000	0.18	OK
Tension	275	500	0.55	OK
Shear	$\sqrt{(154^2+98^2)}$ = 183	420	0.44	OK

Table 16.1 – Twist Lock checks

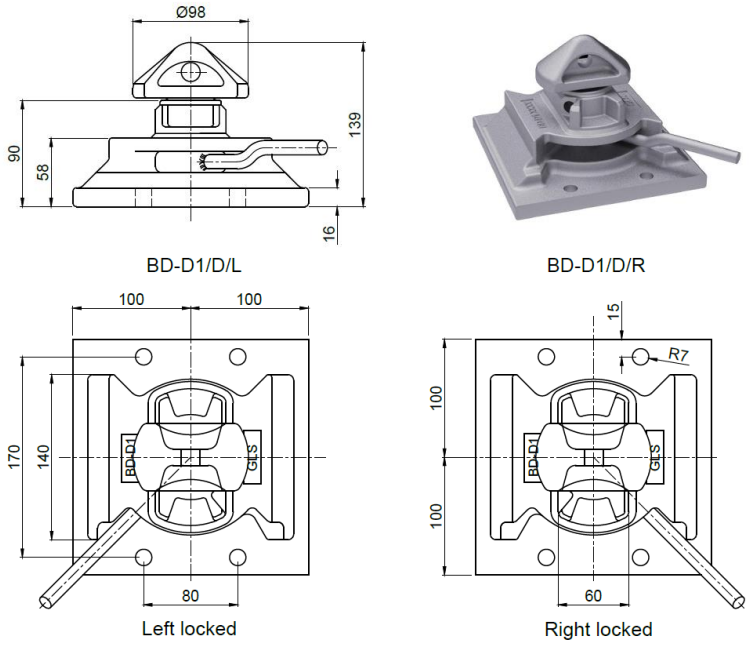


Figure 16.1 – Twist Lock geometry

16.2 BOLTED CONNECTIONS

Checks are performed considering inertia forces computed at the most external equipment object, as per following image, except where otherwise specified.

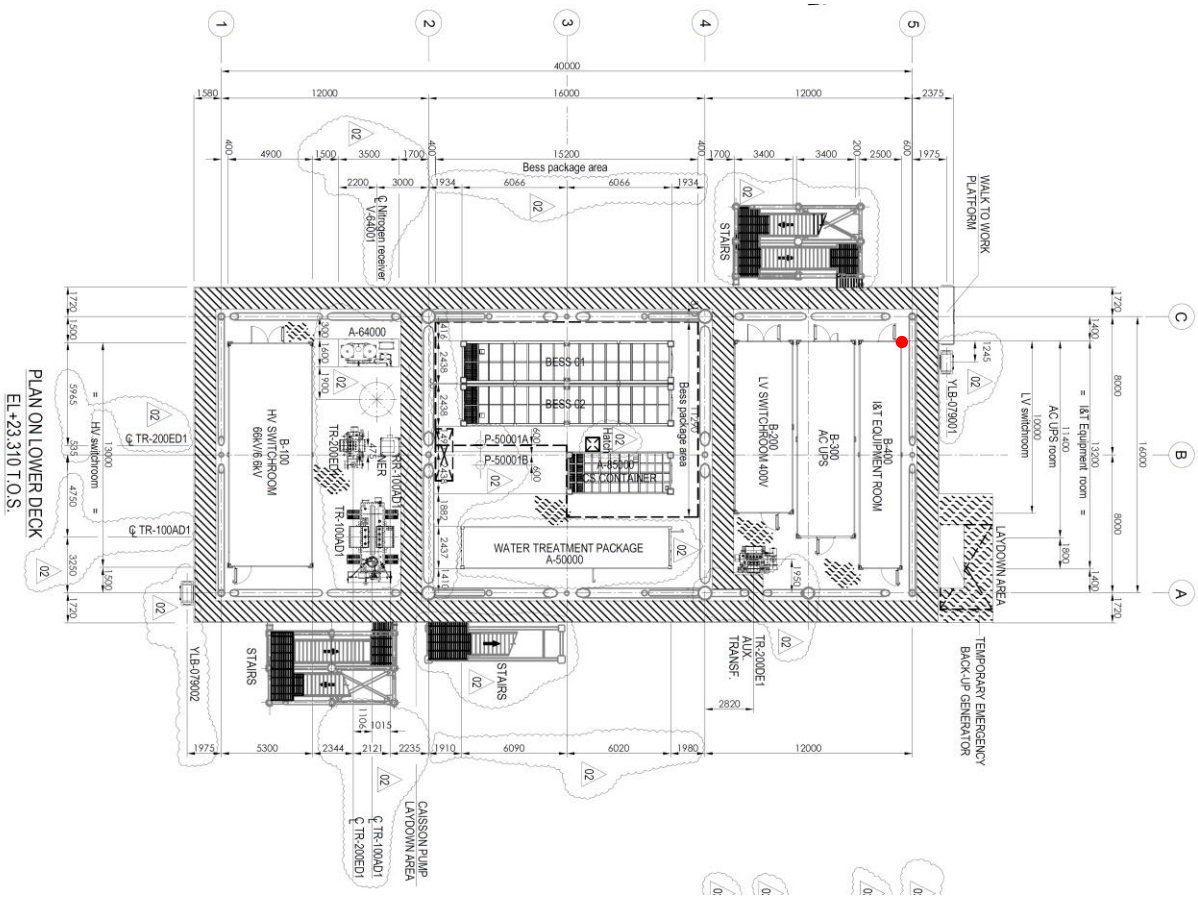


Figure 16.2 – Acceleration point for equipments El.+23.310m

TRANSPORT FORCES ON CARGO						
In accordance with: DNVGL ST N001 2018-amended 2020						
Barge data			Cargo barge		P-mak	
	Length	L =	91.50	m		
	Breadth	B =	27.40	m		
	Depth	D =	6.10	m		
	Draft	d =	2.70	m	from barge keel	
Cargo data						
	Weight	W =	1.00	kN		
	C.o.G.	x =	35.00	m	from c.g. of barge	
		y =	10.00	m	from centerline	
		z =	7.00	m	from barge deck	
	distance from roll axis	d_t =	14.43	m	on water plane	
	d_t angle	α_t =	0.77	rad	from vertical	
	distance from pitch axis	d_l =	36.51	m	on water plane	
	d_l angle	α_l =	1.28	rad	from vertical	
Motion data			(single amplitude, in 10 sec full cycle period)			
	Transportation duration		Unrestricted operations			
	Transportation area		Non-benign			
			Roll	Pitch	Heave	
	Maximum amplitude	a =	20.0	12.5		deg
	Max acceleration	ä =	0.138	0.086		rad/s^2
		ä =			0.2	g
Forces, per unit weight, due to:			Roll	Pitch	Heave	Gravity
	Inertia force = (W/g) d ä	F =	0.20	0.32	0.20	
	Transverse components	F_t =	0.15		0.07	0.34
	Vertical components	F_v =	0.14		0.19	0.94
	Longitudinal components	F_l =		0.09	0.04	0.22
	Vertical components	F_v =		0.31	0.20	0.98
Accelerations at cargo c.o.g.			Transv.	Longit.	Vertical	
1	**+ Roll + Heave**		0.56		1.27	g
2	**+ Roll - Heave**		0.42		0.89	g
3	**- Roll + Heave**		-0.56		0.99	g
4	**- Roll - Heave**		-0.42		0.61	g
5	**+ Pitch + Heave**			0.35	1.48	g
6	**+ Pitch - Heave**			0.26	1.09	g
7	**- Pitch + Heave**			-0.35	0.86	g
8	**- Pitch - Heave**			-0.26	0.47	g

From the computation above, max inertia accelerations for equipments at El.+23.310m are the following:

- Roll: 0.6g
- Pitch: 0.4g
- Heave: ±0.5g

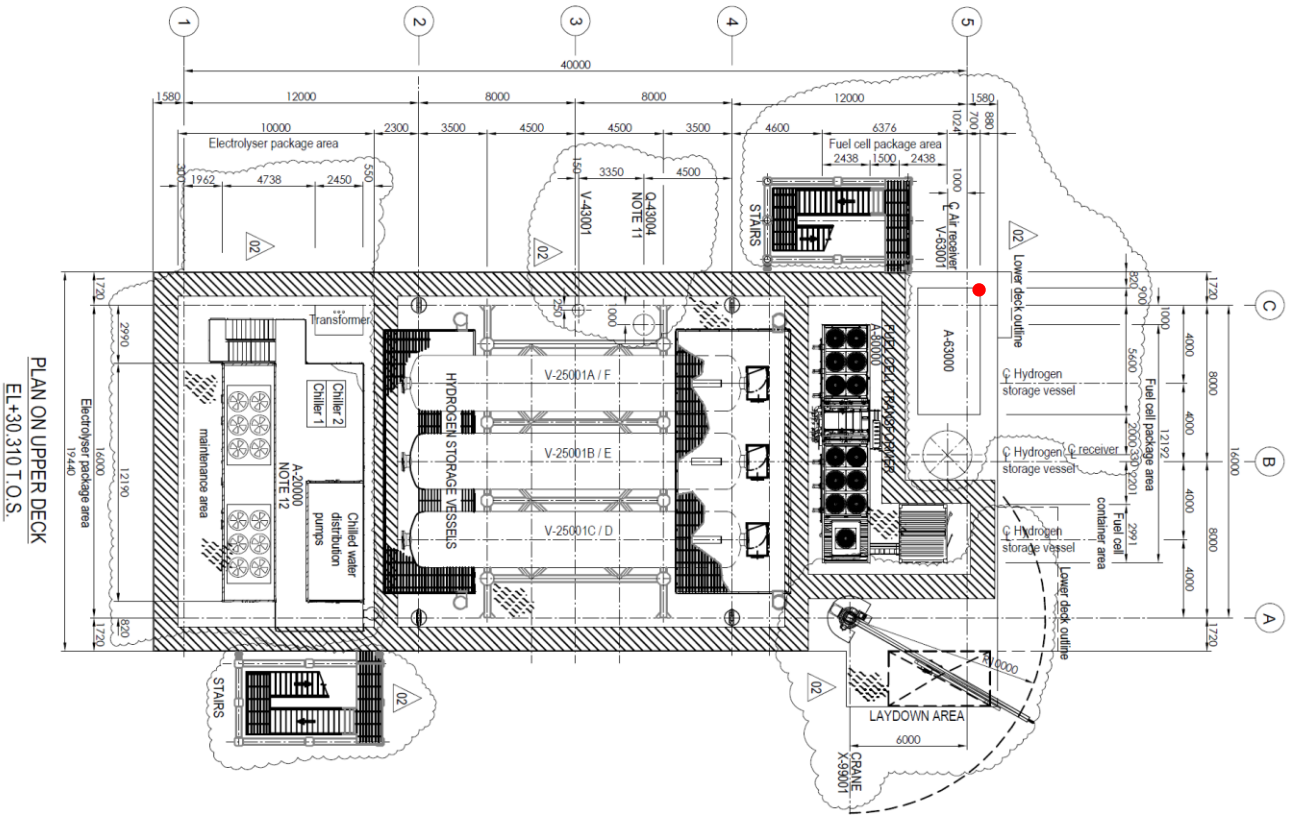


Figure 16.3 – Acceleration point for equipments El.+30.310m

TRANSPORT FORCES ON CARGO						
In accordance with: DNVGL ST N001 2018-amended 2020						
Barge data			Cargo barge		P-mak	
	Length	L =	91.50	m		
	Breadth	B =	27.40	m		
	Depth	D =	6.10	m		
	Draft	d =	2.70	m	from barge keel	
Cargo data						
	Weight	W =	1.00	kN		
	C.o.G.	x =	36.00	m	from c.g. of barge	
		y =	10.00	m	from centerline	
		z =	13.50	m	from barge deck	
	distance from roll axis	d_t =	19.64	m	on water plane	
	d_t angle	α_t =	0.53	rad	from vertical	
	distance from pitch axis	d_l =	39.77	m	on water plane	
	d_l angle	α_l =	1.13	rad	from vertical	
Motion data			(single amplitude, in 10 sec full cycle period)			
	Transportation duration		Unrestricted operations			
	Transportation area		Non-benign			
			Roll	Pitch	Heave	
	Maximum amplitude	a =	20.0	12.5		deg
	Max acceleration	ä =	0.138	0.086		rad/s^2
		ä =			0.2	g
Forces, per unit weight, due to:			Roll	Pitch	Heave	Gravity
	Inertia force = (W/g) d ä	F =	0.28	0.35	0.20	
	Transverse components	F_t =	0.24		0.07	0.34
	Vertical components	F_v =	0.14		0.19	0.94
	Longitudinal components	F_l =		0.15	0.04	0.22
	Vertical components	F_v =		0.32	0.20	0.98
Accelerations at cargo c.o.g.			Transv.	Longit.	Vertical	
1	**+ Roll + Heave**		0.65		1.27	g
2	**+ Roll - Heave**		0.51		0.89	g
3	**- Roll + Heave**		-0.65		0.99	g
4	**- Roll - Heave**		-0.51		0.61	g
5	**+ Pitch + Heave**			0.41	1.49	g
6	**+ Pitch - Heave**			0.32	1.10	g
7	**- Pitch + Heave**			-0.41	0.86	g
8	**- Pitch - Heave**			-0.32	0.46	g

From the computation above, max inertia accelerations for equipments at El.+31.310m are the following:

- Roll: 0.65g
- Pitch: 0.45g
- Heave: ±0.55g

16.2.1 Bess 01-02

Bess support scheme is reported in the following figure. Supports are according to structural drawing ref. /37/.

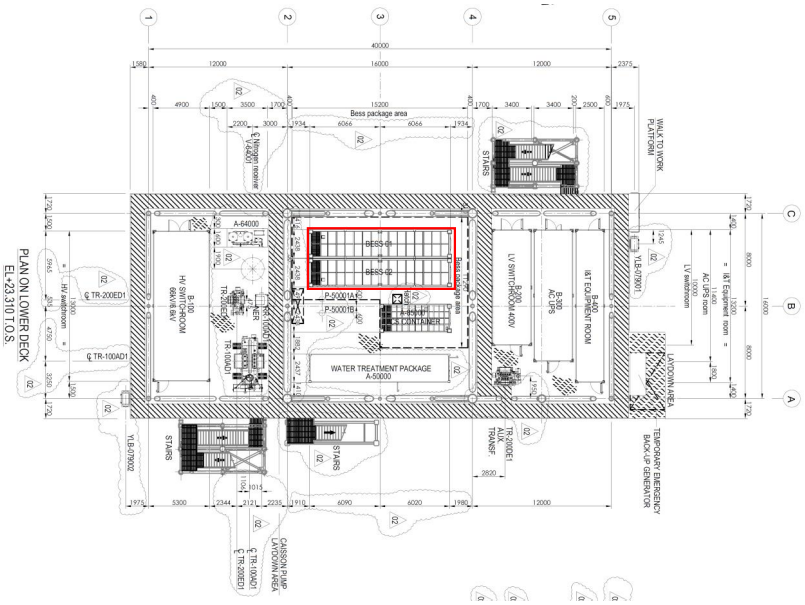


Figure 16.4 – BESS 01-02 location

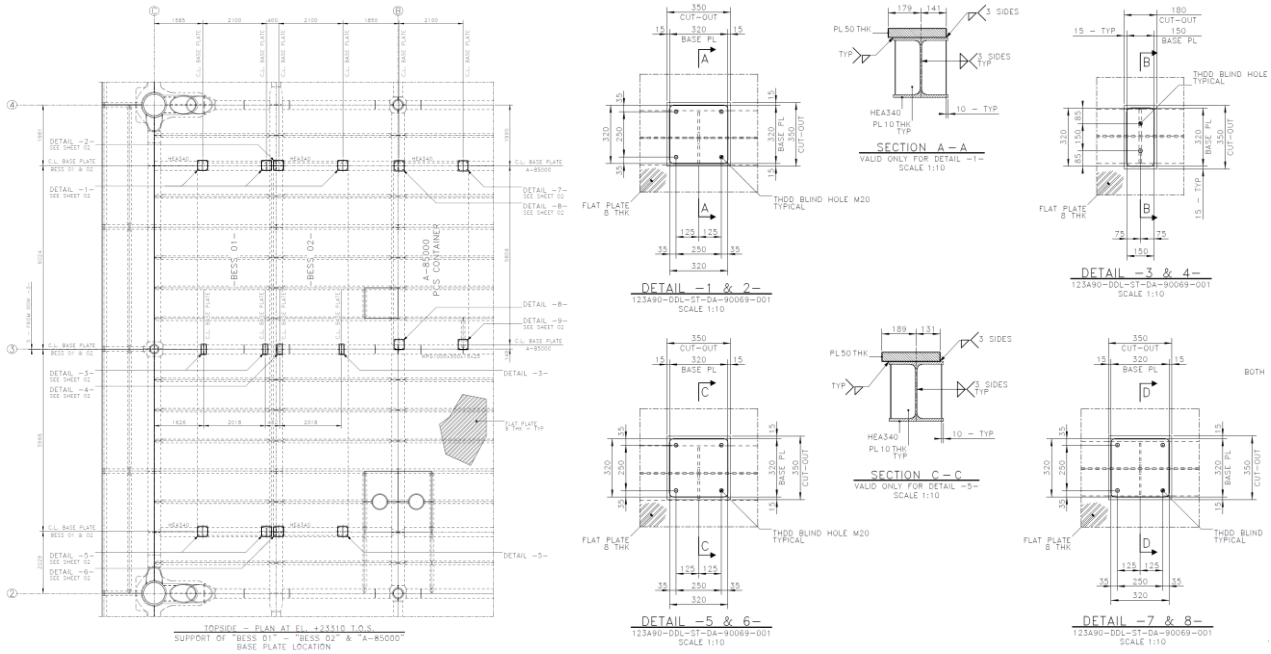


Figure 16.5 – BESS 01-02 support scheme

Checks according to EC3 ref./10/ are reported in the following table. Weight is according to WCR ref./22/.

BOLT CONNECTION CHECK - EC3			
Item:	BESS 01/02	**MAX UC =**	**0.45**
DATA			
Weight	W =	400	kN
Height	H =	3.4	m
Width	B =	2.1	m
Vertical Supports	nv =	6	
Horizontal Supports	nh =	4	
Bolts		M20	
Bolts per support	nb =	4	
Shear resistance	Fv,Rd =	94.1	kN
Tension resistance	Ft,Rd =	141.1	kN
FORCES			
Inertia load - Roll	V1 = 0.6W =	240	kN
Inertia load - Pitch	V2 = 0.4W =	160	kN
Inertia load - Heave	Fh = 0.5*W =	200	kN
Wind load	V3 = 0.7 kPa*36m2 =	25	kN
ULS Shear on support	fv,ed1 = 1.35*(V1+V3)/nh =	89.5	kN
	fv,ed2 = 1.35*V2/nh =	54	kN
ULS Heave on support	fh = 1.35*Fh / nh =	67.5	kN
ULS Tension on support	rt1 = 1.35*(V1+V3)*(H/2)/B/(nh/2) =	144.9	kN
due to Shear	rt2 = 1.35*V2*(H/2)/B/(nh/2) =	87.4	kN
ULS vertical load on suppor	N = 0.9*W/8 =	45	kN
SHEAR CHECK			
Shear on bolt	Fv,Ed = fv,ed1/nb =	22.4	kN
	Fv,Ed < Fv,Rd - UC =	0.24	≤ 1.0
TENSION CHECK			
Tension on bolt	Ft,ed = (rt2+fh-N) / nb =	41.9	kN
	Ft,Ed < Ft,Rd - UC =	0.30	≤ 1.0
SHEAR+TENSION CHECK			
	Fv,Ed = fv,ed1/nb =	22.4	kN
	Ft,ed = (rt1+fh-N) / nb =	41.9	kN
Fv,Ed / Fv,Rd + Ft,Ed / 1.4*Ft,Rd =		0.45	≤ 1.0

Calculation scheme

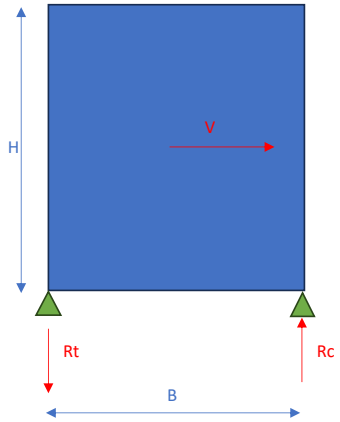


Table 16.2 – Bess 01-02 support check

16.2.2 PCS Container

PCS container support scheme is reported in the following figure. Supports are according to structural drawing ref. /37/. Weight is according to WCR ref./22/.

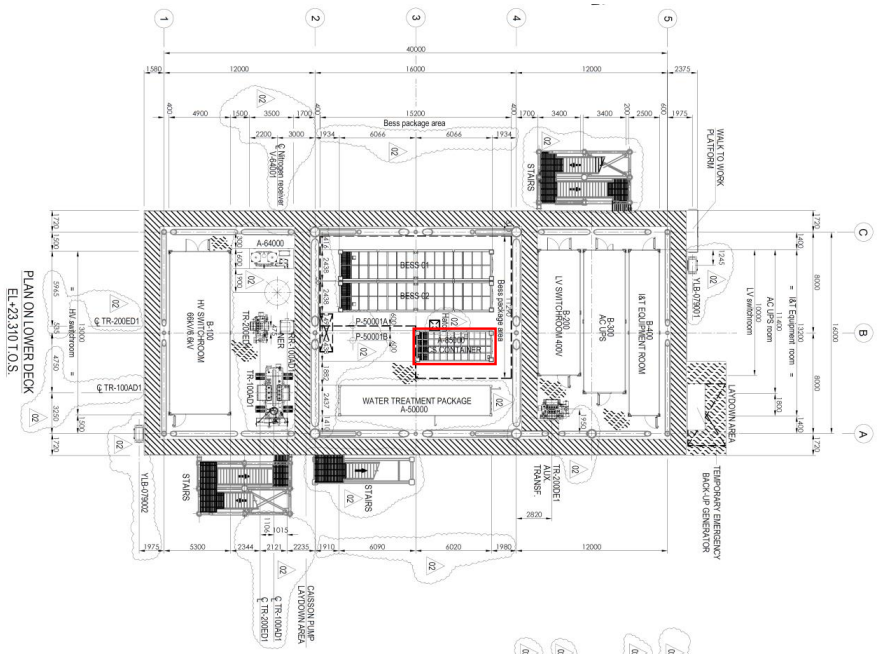


Figure 16.6 – PCS Container location

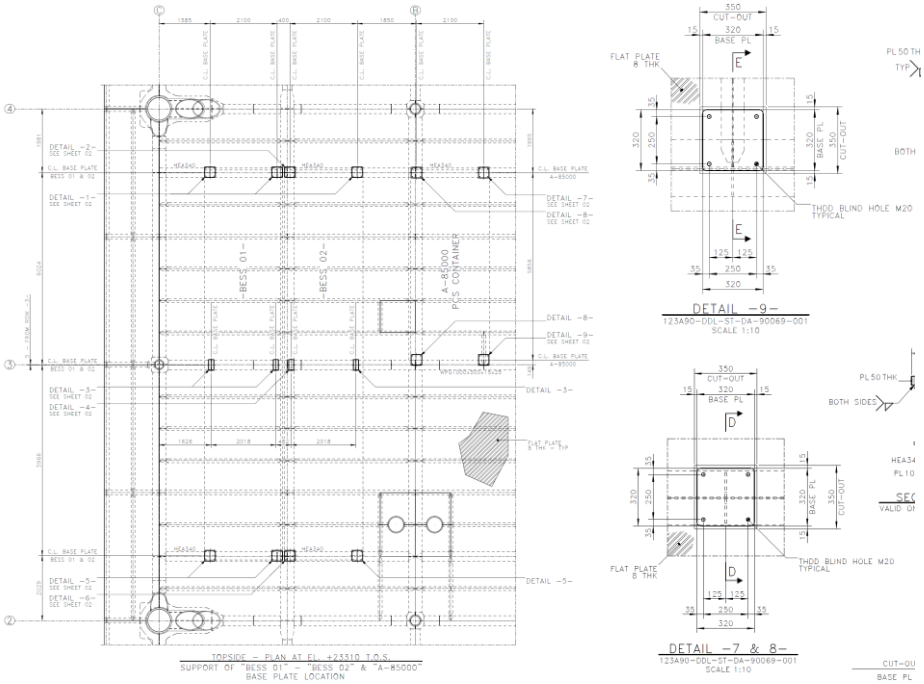


Figure 16.7 – PCS container support scheme

BOLT CONNECTION CHECK - EC3			
Item:	PCS CONTAINER	**MAX UC =**	**0.10**
DATA			
Weight	W =	170	kN
Height	H =	3.8	m
Width	B =	2.1	m
Vertical Supports	nv =	4	
Horizontal Supports	nh =	4	
Bolts		M20	
Bolts per support	nb =	4	
Shear resistance	Fv,Rd =	94.1	kN
Tension resistance	Ft,Rd =	141.1	kN
FORCES			
Inertia load - Roll	V1 = 0.6W =	102	kN
Inertia load - Pitch	V2 = 0.4W =	68	kN
Inertia load - Heave	Fh = 0.5*W =	85	kN
ULS Shear on support	fv,ed1 = 1.35*V1/nh =	34.425	kN
	fv,ed2 = 1.35*V2/nh =	22.95	kN
ULS Heave on support	fh = 1.35*Fh / nh =	28.7	kN
ULS Tension on support	rt1 = 1.35*V1*(H/2)/B/(nh/2) =	62.3	kN
due to Shear	rt2 = 1.35*V2*(H/2)/B/(nh/2) =	41.5	kN
ULS vertical load on support	N = 0.9*W/4 =	38.25	kN
SHEAR CHECK			
Shear on bolt	Fv,Ed = fv,ed1/nb =	8.6	kN
	Fv,Ed < Fv,Rd - UC =	0.09	≤ 1.0
TENSION CHECK			
Tension on bolt	Ft,ed = (rt2+fh-N) / nb =	8.0	kN
	Ft,Ed < Ft,Rd - UC =	0.06	≤ 1.0
SHEAR+TENSION CHECK			
	Fv,Ed = fv,ed2/nb =	5.7	kN
	Ft,ed = (rt2+fh-N) / nb =	8.0	kN
Fv,Ed / Fv,Rd + Ft,Ed / 1.4*Ft,Rd =		0.10	≤ 1.0

Calculation scheme

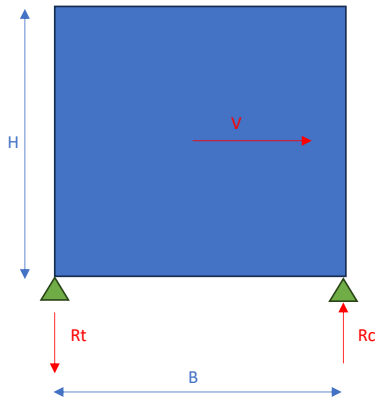


Table 16.3 – PCS container support check

16.2.3 Transformers

Transformer TR-100AD1 support scheme is reported in the following figure. Supports are according to structural drawing ref. /37/. Weight is according to WCR ref./22/. Checks cover other transformers' supports, since the selected one is the heavier and corresponds to the worst scenario.

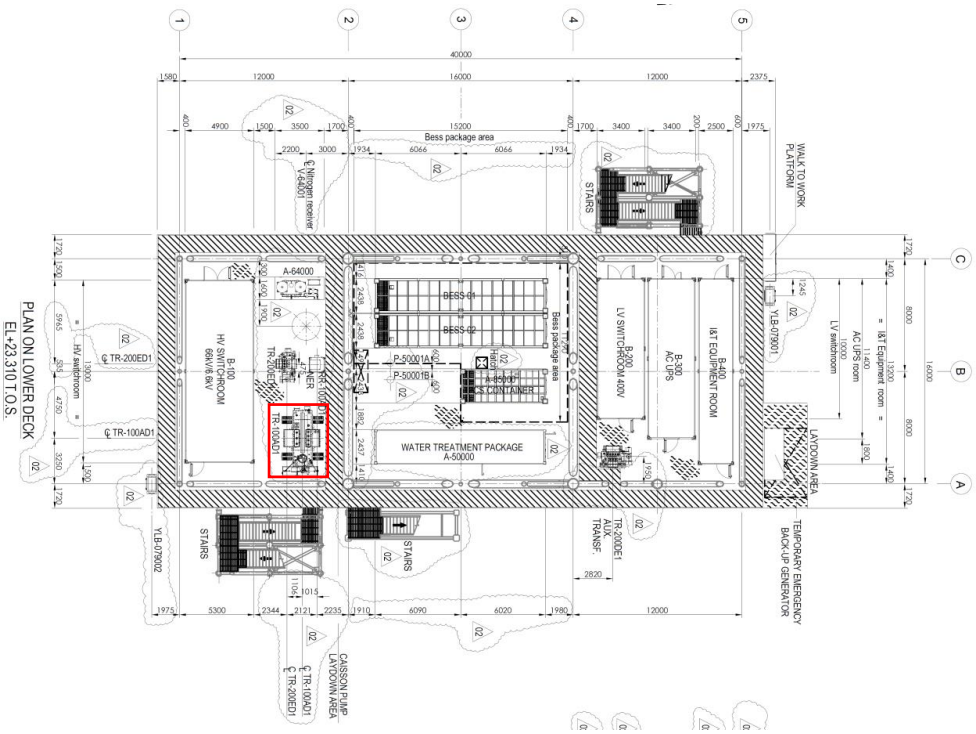


Figure 16.8 – Transformer location

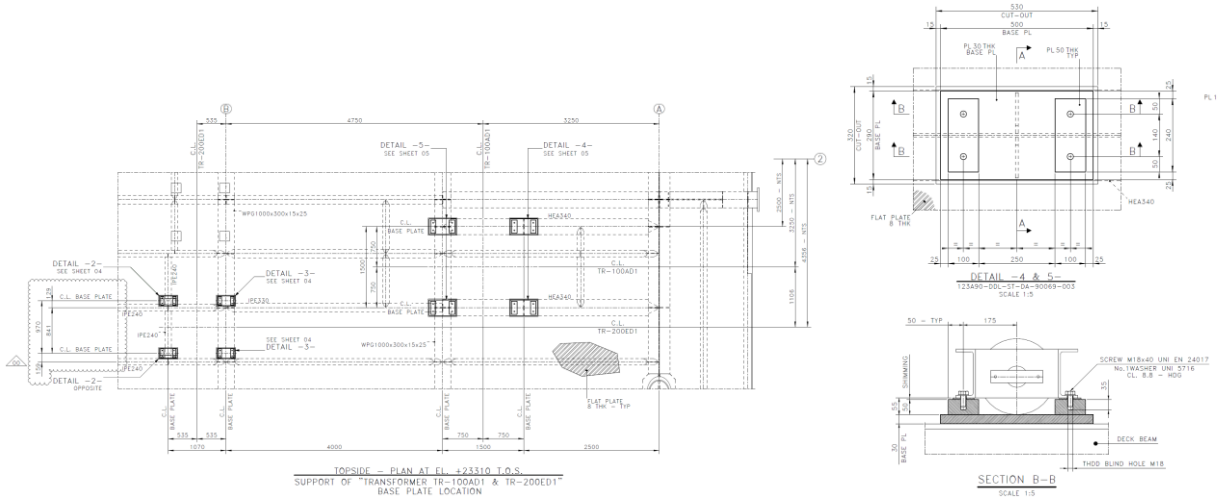


Figure 16.9 – Transformer support scheme

BOLT CONNECTION CHECK - EC3			
Module:	TR-100AD1	**MAX UC =**	**0.23**
DATA			
Weight	W =	265	kN
Height	H =	2.3	m
Width	B =	1.5	m
Vertical Supports	nv =	4	
Horizontal Supports	nh =	4	
Bolts		M18	
Bolts per support	nb =	4	
Shear resistance	Fv,Rd =	73.7	kN
Tension resistance	Ft,Rd =	110.6	kN
FORCES			
Inertia load - Roll	V1 = 0.6W =	159	kN
Inertia load - Pitch	V2 = 0.4W =	106	kN
Inertia load - Heave	Fh = 0.5*W =	132.5	kN
ULS Shear on support	fv,ed1 = 1.35*V1/nh =	53.6625	kN
	fv,ed2 = 1.35*V2/nh =	35.775	kN
ULS Heave on support	fh = 1.35*Fh / nh =	44.7	kN
ULS Tension on support	rt1 = 1.35*V1*(H/2)/B/(nh/2) =	82.3	kN
due to Shear	rt2 = 1.35*V2*(H/2)/B/(nh/2) =	54.9	kN
ULS vertical load on support	N = 0.9*W/8 =	29.8125	kN
SHEAR CHECK			
Shear on bolt	Fv,Ed = fv,ed1/nb =	13.4	kN
	Fv,Ed < Fv,Rd - UC =	0.18	≤ 1.0
TENSION CHECK			
Tension on bolt	Ft,ed = (rt2+fh-N) / nb =	17.4	kN
	Ft,Ed < Ft,Rd - UC =	0.16	≤ 1.0
SHEAR+TENSION CHECK			
	Fv,Ed = fv,ed2/nb =	8.9	kN
	Ft,ed = (rt2+fh-N) / nb =	17.4	kN
Fv,Ed / Fv,Rd + Ft,Ed / 1.4*Ft,Rd =		0.23	≤ 1.0

Calculation scheme

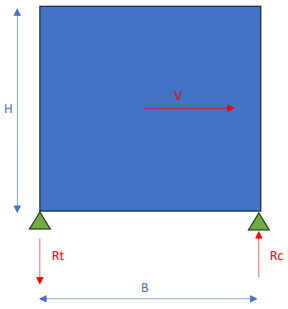


Table 16.4 – Transformer support check

16.2.4 Switchroom

HV Switchroom B-100 support scheme is reported in the following figure. Supports are according to structural drawings. Weight is according to WCR ref./22/.

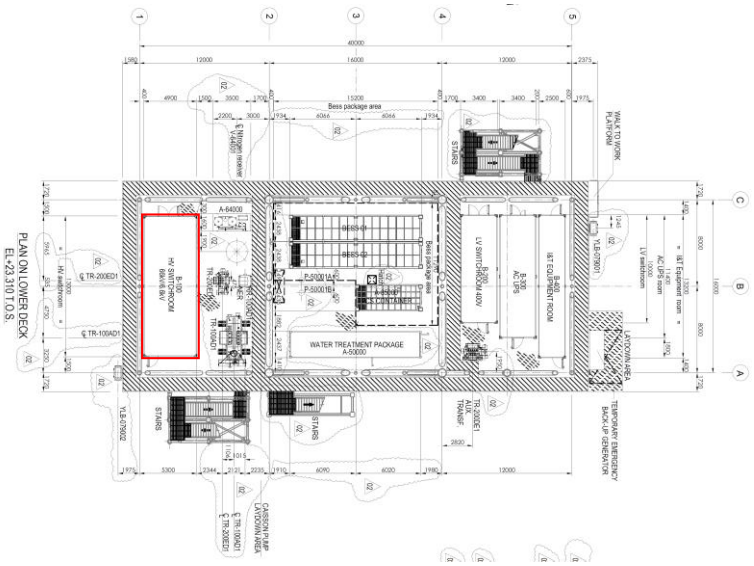


Figure 16.10 – Switchroom location

For this item, transport accelerations are computed specifically, at the item's CoG, as per following calculations.

TRANSPORT FORCES ON CARGO

In accordance with: DNVGL ST N001 2018-amended 2020

Barge data			Cargo barge		P-mak	
	Length	L =	91.50	m		
	Breadth	B =	27.40	m		
	Depth	D =	6.10	m		
	Draft	d =	2.70	m	from barge keel	
Cargo data						
	Weight	W =	1.00	kN		
	C.o.G.	x =	-2.00	m	from c.g. of barge	
		y =	2.35	m	from centerline	
		z =	5.75	m	from barge deck	
	distance from roll axis	d_t =	9.45	m	on water plane	
	d_t angle	α_t =	0.25	rad	from vertical	
	distance from pitch axis	d_l =	9.37	m	on water plane	
	d_l angle	α_l =	-0.22	rad	from vertical	
Motion data			(single amplitude, in 10 sec full cycle period)			
	Transportation duration		Unrestricted operations			
	Transportation area		Non-benign			
			Roll	Pitch	Heave	
	Maximum amplitude	a =	20.0	12.5		deg
	Max acceleration	ä =	0.138	0.086		rad/s^2
		ä =			0.2	g
Forces, per unit weight, due to:			Roll	Pitch	Heave	Gravity
	Inertia force = (W/g) d ä	F =	0.13	0.08	0.20	
	Transverse components	F_t =	0.13		0.07	0.34
	Vertical components	F_v =	0.03		0.19	0.94
	Longitudinal components	F_l =		0.08	0.04	0.22
	Vertical components	F_v =		-0.02	0.20	0.98
Accelerations at cargo c.o.g.			Transv.	Longit.	Vertical	
1	+ Roll + Heave		0.54		1.16	g
2	+ Roll - Heave		0.40		0.78	g
3	- Roll + Heave		-0.54		1.09	g
4	- Roll - Heave		-0.40		0.72	g
5	+ Pitch + Heave			0.34	1.15	g
6	+ Pitch - Heave			0.25	0.76	g
7	- Pitch + Heave			-0.34	1.19	g
8	- Pitch - Heave			-0.25	0.80	g

From the computation above, max inertia accelerations are the following:

- Roll: 0.55g
- Pitch: 0.35g
- Heave: ±0.3g

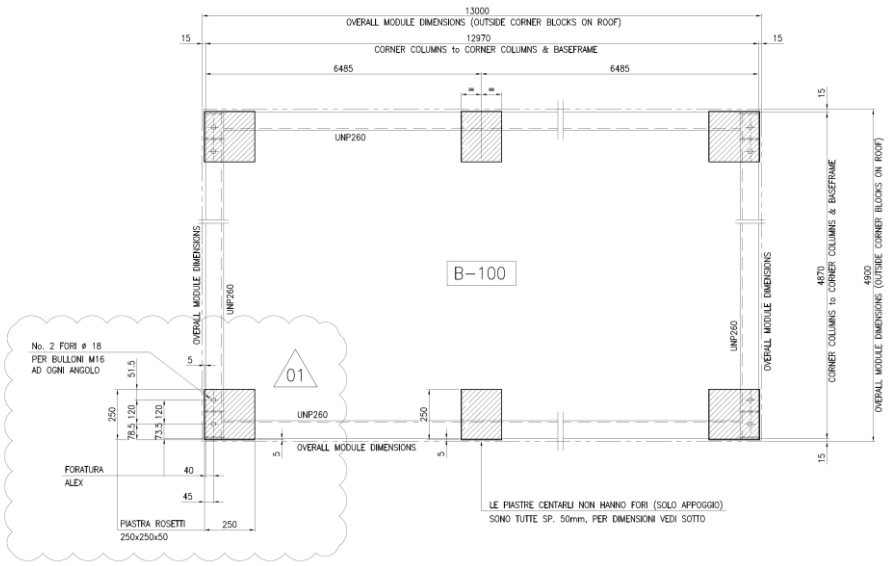


Figure 16.11 – B-100, B-200, B-300, B-400 support scheme

BOLT CONNECTION CHECK - EC3			
Item:	B-100	**MAX UC =**	**0.84**
DATA			
Weight	W =	480	kN
Height	H =	4.5	m
Width	B =	4.6	m
Vertical Supports	nv =	6	
Horizontal Supports	nh =	4	
Bolts		M16	
Bolts per support	nb =	2	
Shear resistance	Fv,Rd =	60.3	kN
Tension resistance	Ft,Rd =	90.4	kN
FORCES			
Inertia load - Roll	V1 = 0.55W =	264	kN
Inertia load - Pitch	V2 = 0.35W =	168	kN
Inertia load - Heave	Fh = 0.3*W =	144	kN
Wind load	V3 = 0.7 kPa*58.5m2 =	41	kN
ULS Shear on support	fv,ed1 = 1.35*V1/nh =	89.1	kN
	fv,ed2 = 1.35*(V2+V3)/nh =	70.5	kN
ULS Heave on support	fh = 1.35*Fh / nh =	48.6	kN
ULS Tension on support	rt1 = 1.35*V1*(H/2)/B/(nh/2) =	87.2	kN
due to Shear	rt2 = 1.35*(V2+V3)*(H/2)/B/(nh/2) =	69.0	kN
ULS vertical load on suppor	N = 0.9*W/8 =	54	kN
SHEAR CHECK			
Shear on bolt	Fv,Ed = fv,ed1/nb =	44.55	kN
	Fv,Ed < Fv,Rd - UC =	0.74	≤ 1.0
TENSION CHECK			
Tension on bolt	Ft,ed = (rt2+fh-N) / nb =	31.8	kN
	Ft,Ed < Ft,Rd - UC =	0.35	≤ 1.0
SHEAR+TENSION CHECK			
	Fv,Ed = fv,ed2/nb =	35.3	kN
	Ft,ed = (rt2+fh-N) / nb =	31.8	kN
Fv,Ed / Fv,Rd + Ft,Ed / 1.4*Ft,Rd =		0.84	≤ 1.0

Calculation scheme

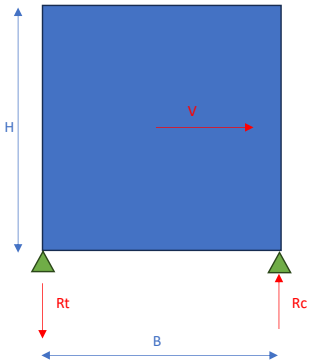


Table 16.5 – B-100 support check

16.2.1 AC UPS

AC UPS B-300 support scheme is reported in in Figure 16.11. Supports are according to structural drawings. Weight is according to WCR ref./22/. Checks cover B-200 supports, since the selected item is the heavier and the worst acceleration scenario has been considered.

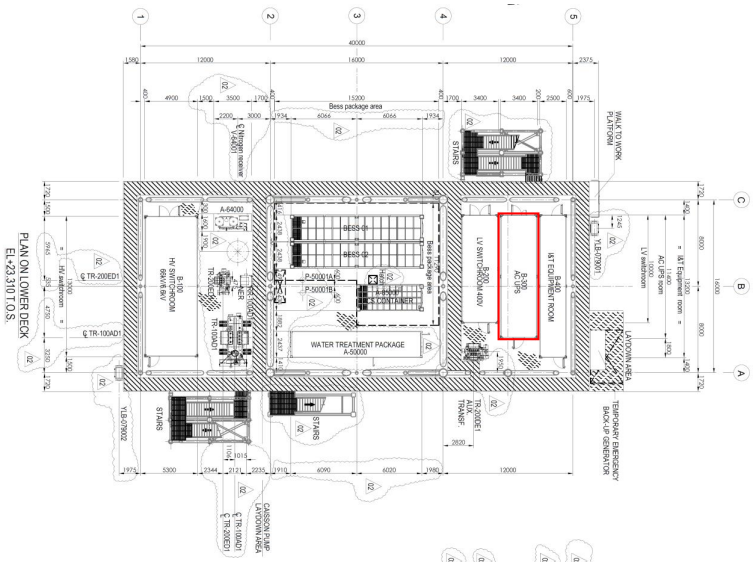


Figure 16.12 – AC UPS location

BOLT CONNECTION CHECK - EC3			
Item:	B-300	**MAX UC =**	**0.80**
DATA			
Weight	W =	430	kN
Height	H =	4.5	m
Width	B =	4.6	m
Vertical Supports	nv =	6	
Horizontal Supports	nh =	4	
Bolts		M16	
Bolts per support	nb =	2	
Shear resistance	Fv,Rd =	60.3	kN
Tension resistance	Ft,Rd =	90.4	kN
FORCES			
Inertia load - Roll	V1 = 0.6W =	258	kN
Inertia load - Pitch	V2 = 0.4W =	172	kN
Inertia load - Heave	Fh = 0.5*W =	215	kN
ULS Shear on support	fv,ed1 = 1.35*V1/nh =	87.075	kN
	fv,ed2 = 1.35*(V2)/nh =	58.1	kN
ULS Heave on support	fh = 1.35*Fh / nh =	72.6	kN
ULS Tension on support	rt1 = 1.35*V1*(H/2)/B/(nh/2) =	85.2	kN
due to Shear	rt2 = 1.35*(V2)*(H/2)/B/(nh/2) =	56.8	kN
ULS vertical load on suppor	N = 0.9*W/8 =	48.375	kN
SHEAR CHECK			
Shear on bolt	Fv,Ed = fv,ed1/nb =	43.5375	kN
	Fv,Ed < Fv,Rd - UC =	0.72	≤ 1.0
TENSION CHECK			
Tension on bolt	Ft,ed = (rt2+fh-N) / nb =	40.5	kN
	Ft,Ed < Ft,Rd - UC =	0.45	≤ 1.0
SHEAR+TENSION CHECK			
	Fv,Ed = fv,ed2/nb =	29.0	kN
	Ft,ed = (rt2+fh-N) / nb =	40.5	kN
Fv,Ed / Fv,Rd + Ft,Ed / 1.4*Ft,Rd =		0.80	≤ 1.0

Calculation scheme

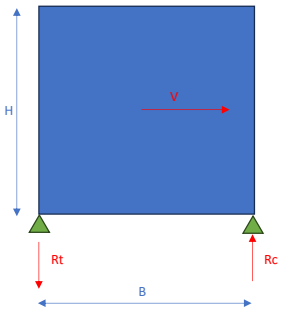


Table 16.6 – B-300 support check

16.2.2 Equipment Room

I&T Equipment Room B-400 support scheme is reported in Figure 16.11. Supports are according to structural drawings. Weight is according to WCR ref./22/.

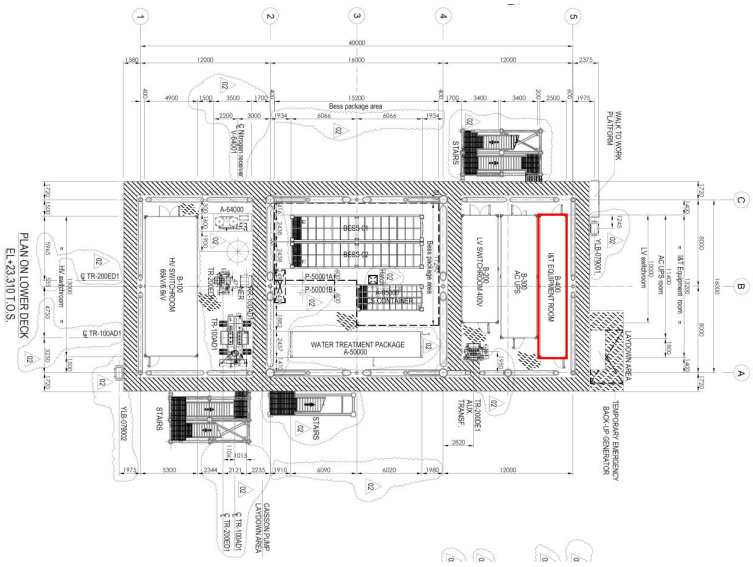


Figure 16.13 – Equipment Room location

BOLT CONNECTION CHECK - EC3			
Item:	B-400	**MAX UC =**	**0.83**
DATA			
Weight	W =	280	kN
Height	H =	4	m
Width	B =	2.2	m
Vertical Supports	nv =	6	
Horizontal Supports	nh =	4	
Bolts per support	nb =	2	
Bolts		M16	
Shear resistance	Fv,Rd =	60.3	kN
Tension resistance	Ft,Rd =	90.4	kN
FORCES			
Inertia load - Roll	V1 = 0.6W =	168	kN
Inertia load - Pitch	V2 = 0.4W =	112	kN
Inertia load - heave	Fh = 0.5*W =	140	kN
Wind load	V3 = 0.7 kPa*49m2 =	34	kN
ULS Shear on support	fv,ed1 = 1.35*V1/nh =	56.7	kN
	fv,ed2 = 1.35*(V2+V3)/nh =	49.4	kN
ULS Heave on support	fh = 1.35*Fh / nh =	47.3	kN
ULS Tension on support	rt1 = 1.35*V1*(H/2)/B/(nh/2) =	103.1	kN
due to Shear	rt2 = 1.35*(V2+V3)*(H/2)/B/(nh/2) =	89.8	kN
ULS vertical load on suppor	N = 0.9*W/8 =	31.5	kN
SHEAR CHECK			
Shear on bolt	Fv,Ed = fv,ed1/nb =	28.35	kN
	Fv,Ed < Fv,Rd - UC =	0.47	≤ 1.0
TENSION CHECK			
Tension on bolt	Ft,ed = (rt2+fh-N) / nb =	52.8	kN
	Ft,Ed < Ft,Rd - UC =	0.58	≤ 1.0
SHEAR+TENSION CHECK			
	Fv,Ed = fv,ed2/nb =	24.7	kN
	Ft,ed = (rt2+fh-N) / nb =	52.8	kN
Fv,Ed / Fv,Rd + Ft,Ed / 1.4*Ft,Rd =		0.83	≤ 1.0

Calculation scheme

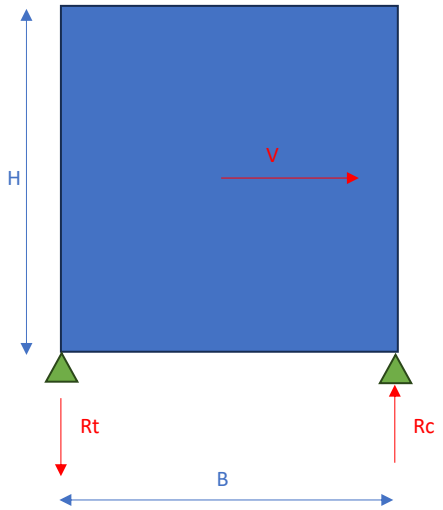


Table 16.7 – B-400 support check

16.2.3 Electrolyser

Electrolyser support scheme is reported in the following figures. Supports are according to structural drawings. Weight is according to WCR ref./22/.

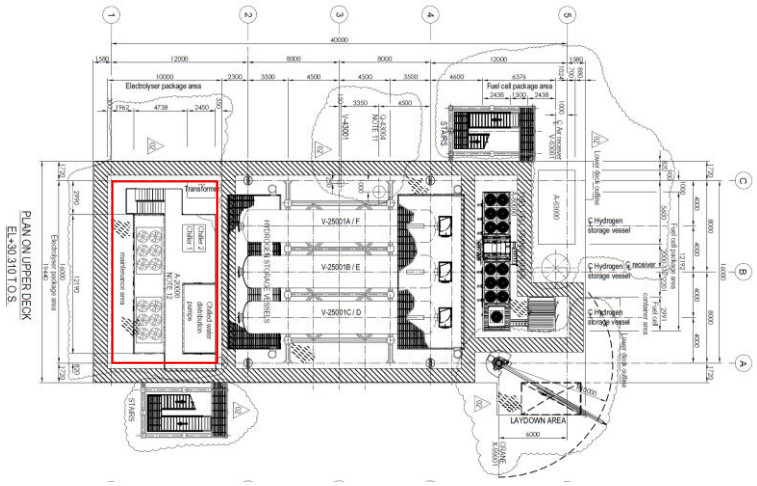


Figure 16.14 – Electrolyser location

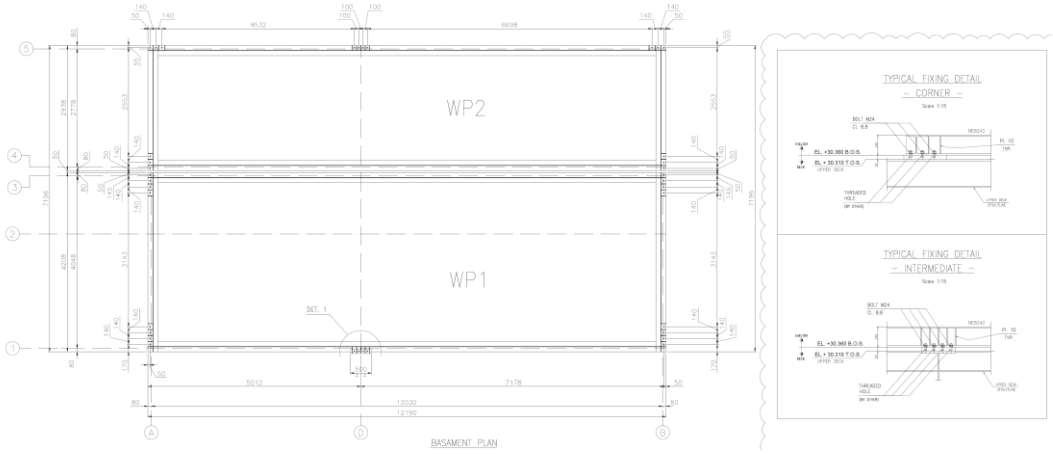


Figure 16.15 – Electrolyser support scheme

Loads on foundations are reported in Table 16.8, taken from drawing 224J10-DDL-ST-DG-00001.

Load combinations are performed according to sec.7.4. The envelope of the reactions for ULS checks are reported in Table 16.9.

Shear Resistance bolt M24: $F_{v,Rd}$ = 135.6 kN

Tension Resistance bolt M24: $F_{t,Rd}$ = 203.3 kN

NODE REACTION FORCES									
Node	Load	FX (kN)	FY (kN)	FZ (kN)	Node	Load	FX (kN)	FY (kN)	FZ (kN)
A1	G1	-3,67	-6,58	-81,71	B5	G1	6,44	6,46	-41,36
A1	G2 Eq.	-6,95	-4,12	-128,07	B5	G2 Eq.	10,32	3,21	-21,09
A1	G2	-2,00	-3,34	-39,97	B5	G2	3,64	3,44	-21,29
A1	Q	-6,08	-9,37	-91,57	B5	Q	9,98	8,85	-39,26
A1	Wx+	10,74	-0,09	6,82	B5	Wx+	5,35	2,17	-0,64
A1	Wx-	-8,59	0,95	-6,68	B5	Wx-	-6,84	-2,75	0,93
A1	Wy+	2,23	74,28	97,02	B5	Wy+	0,22	2,51	-6,45
A1	Wy-	-0,60	-60,94	-95,87	B5	Wy-	1,84	-25,97	88,71
A1	Ex(RS)	-41,02	-42,43	-40,78	B5	Ex(RS)	-30,96	-12,46	-20,34
A1	Ey(RS)	-14,28	-58,27	-65,18	B5	Ey(RS)	-17,79	-21,05	-43,96
A1	Evx(RS)	-6,62	-13,83	-42,63	B5	Evx(RS)	-8,42	-6,91	-16,90
A1	Evy(RS)	-11,03	-23,06	-71,05	B5	Evy(RS)	-14,03	-11,52	-28,17
A3	G1	-45,45	8,48	-86,77	A4	G1	-30,95	-0,63	-51,24
A3	G2 Eq.	-30,16	11,89	-68,99	A4	G2 Eq.	-24,73	-1,89	-63,87
A3	G2	-27,14	4,49	-49,05	A4	G2	-16,28	-0,36	-27,95
A3	Q	-90,20	11,20	-150,50	A4	Q	-48,94	-0,61	-78,63
A3	Wx+	34,30	-6,56	26,16	A4	Wx+	16,06	0,60	9,50
A3	Wx-	-32,81	5,88	-26,26	A4	Wx-	-14,38	0,05	-9,12
A3	Wy+	-42,38	50,51	-93,13	A4	Wy+	-2,42	3,27	-6,02
A3	Wy-	28,93	-34,55	85,96	A4	Wy-	-19,71	-3,80	-1,69
A3	Ex(RS)	-96,06	-36,49	-88,16	A4	Ex(RS)	-61,01	-9,44	-31,37
A3	Ey(RS)	-26,23	-38,30	-75,69	A4	Ey(RS)	-29,79	-22,00	-15,94
A3	Evx(RS)	-16,06	-9,87	-27,09	A4	Evx(RS)	-14,24	-6,01	-17,88
A3	Evy(RS)	-26,77	-16,45	-45,15	A4	Evy(RS)	-23,74	-10,02	-29,81
B1	G1	1,87	-8,88	-82,36	B4	G1	53,01	-9,07	-83,06
B1	G2 Eq.	2,10	-9,62	-126,81	B4	G2 Eq.	49,98	-7,74	-59,82
B1	G2	0,95	-4,90	-43,11	B4	G2	29,06	-4,97	-46,01
B1	Q	2,26	-13,17	-104,05	B4	Q	83,58	-12,21	-126,11
B1	Wx+	8,50	3,41	-4,60	B4	Wx+	12,95	-2,22	-13,03
B1	Wx-	-10,67	-2,63	4,56	B4	Wx-	-13,27	2,64	12,20
B1	Wy+	-3,43	74,31	188,60	B4	Wy+	-4,14	2,84	8,09
B1	Wy-	1,79	-52,77	-169,93	B4	Wy-	12,28	-26,76	-90,99
B1	Ex(RS)	-36,19	-44,49	-61,02	B4	Ex(RS)	-50,23	-14,04	-41,28
B1	Ey(RS)	-8,42	-45,74	-83,89	B4	Ey(RS)	-10,43	-20,00	-45,46
B1	Evx(RS)	-4,36	-9,27	-44,03	B4	Evx(RS)	-22,23	-6,96	-31,05
B1	Evy(RS)	-7,27	-15,45	-73,39	B4	Evy(RS)	-37,05	-11,60	-51,74
B3	G1	47,81	6,32	-84,96	D5	G1	-2,20	-4,07	-37,13
B3	G2 Eq.	37,01	9,31	-68,37	D5	G2 Eq.	0,40	-2,65	-25,58
B3	G2	28,27	3,43	-50,00	D5	G2	-1,31	-2,12	-19,59
B3	Q	92,58	9,16	-157,89	D5	Q	-3,12	-6,39	-53,04
B3	Wx+	34,53	6,66	-29,49	D5	Wx+	7,39	-0,23	0,64
B3	Wx-	-35,87	-7,38	29,45	D5	Wx-	-6,77	0,19	-0,80
B3	Wy+	40,62	57,99	-190,48	D5	Wy+	4,24	0,74	-9,33
B3	Wy-	-33,02	-38,80	175,41	D5	Wy-	-5,67	-1,56	18,32
B3	Ex(RS)	-92,00	-30,84	-77,04	D5	Ex(RS)	-60,47	-13,49	-10,25
B3	Ey(RS)	-25,61	-33,04	-96,85	D5	Ey(RS)	-18,44	-36,27	-12,68
B3	Evx(RS)	-14,99	-8,31	-22,96	D5	Evx(RS)	-10,11	-9,57	-11,91
B3	Evy(RS)	-24,98	-13,86	-38,27	D5	Evy(RS)	-16,85	-15,95	-19,85
A5	G1	-26,89	2,35	-42,60	D1	G1	0,04	5,61	-36,21
A5	G2 Eq.	-39,12	-0,76	-77,54	D1	G2 Eq.	1,16	2,38	-69,74
A5	G2	-15,13	1,09	-24,74	D1	G2	-0,07	3,24	-18,79
A5	Q	-39,81	3,10	-60,03	D1	Q	-0,25	9,43	-45,88
A5	Wx+	9,31	-3,63	4,21	D1	Wx+	11,13	-0,16	0,44
A5	Wx-	-7,61	2,90	-3,88	D1	Wx-	-11,08	0,09	-0,41
A5	Wy+	6,65	2,93	2,12	D1	Wy+	-1,60	41,76	9,59
A5	Wy-	-6,85	1,08	-1,67	D1	Wy-	0,59	-12,99	-8,26
A5	Ex(RS)	-57,74	-14,71	-36,84	D1	Ex(RS)	-67,70	-22,33	-5,77
A5	Ey(RS)	-12,04	-18,08	-14,16	D1	Ey(RS)	-15,71	-36,08	-6,07
A5	Evx(RS)	-14,60	-5,24	-24,06	D1	Evx(RS)	-8,30	-11,04	-16,91
A5	Evy(RS)	-24,33	-8,74	-40,10	D1	Evy(RS)	-13,84	-18,41	-28,19

NODE FOUNDATION LOADS									
Node	Load	FX (kN)	FY (kN)	FZ (kN)	Node	Load	FX (kN)	FY (kN)	FZ (kN)
A1	G1	3,67	6,58	81,71	B5	G1	-6,44	-6,46	41,36
A1	G2 Eq.	6,95	4,12	128,07	B5	G2 Eq.	-10,32	-3,21	21,09
A1	G2	2,00	3,34	39,97	B5	G2	-3,64	-3,44	21,29
A1	Q	6,08	9,37	91,57	B5	Q	-9,98	-8,85	39,26
A1	Wx+	-10,74	0,09	-6,82	B5	Wx+	-5,35	-2,17	0,64
A1	Wx-	8,59	-0,95	6,68	B5	Wx-	6,84	2,75	-0,93
A1	Wy+	-2,23	-74,28	-97,02	B5	Wy+	-0,22	-2,51	6,45
A1	Wy-	0,60	60,94	95,87	B5	Wy-	-1,84	25,97	-88,71
A1	Ex(RS)	41,02	42,43	40,78	B5	Ex(RS)	30,96	12,46	20,34
A1	Ey(RS)	14,28	58,27	65,18	B5	Ey(RS)	17,79	21,05	43,96
A1	Evx(RS)	6,62	13,83	42,63	B5	Evx(RS)	8,42	6,91	16,90
A1	Evy(RS)	11,03	23,06	71,05	B5	Evy(RS)	14,03	11,52	28,17
A3	G1	45,45	-8,48	86,77	A4	G1	30,95	0,63	51,24
A3	G2 Eq.	30,16	-11,89	68,99	A4	G2 Eq.	24,73	1,89	63,87
A3	G2	27,14	-4,49	49,05	A4	G2	16,28	0,36	27,95
A3	Q	90,20	-11,20	150,50	A4	Q	48,94	0,61	78,63
A3	Wx+	-34,30	6,56	-26,16	A4	Wx+	-16,06	-0,60	-9,50
A3	Wx-	32,81	-5,88	26,26	A4	Wx-	14,38	-0,05	9,12
A3	Wy+	42,38	-50,51	93,13	A4	Wy+	2,42	-3,27	6,02
A3	Wy-	-28,93	34,55	-85,96	A4	Wy-	19,71	3,80	1,69
A3	Ex(RS)	96,06	36,49	88,16	A4	Ex(RS)	61,01	9,44	31,37
A3	Ey(RS)	26,23	38,30	75,69	A4	Ey(RS)	29,79	22,00	15,94
A3	Evx(RS)	16,06	9,87	27,09	A4	Evx(RS)	14,24	6,01	17,88
A3	Evy(RS)	26,77	16,45	45,15	A4	Evy(RS)	23,74	10,02	29,81
B1	G1	-1,87	8,88	82,36	B4	G1	-53,01	9,07	83,06
B1	G2 Eq.	-2,10	9,62	126,81	B4	G2 Eq.	-49,98	7,74	59,82
B1	G2	-0,95	4,90	43,11	B4	G2	-29,06	4,97	46,01
B1	Q	-2,26	13,17	104,05	B4	Q	-83,58	12,21	126,11
B1	Wx+	-8,50	-3,41	4,60	B4	Wx+	-12,95	2,22	13,03
B1	Wx-	10,67	2,63	-4,56	B4	Wx-	13,27	-2,64	-12,20
B1	Wy+	3,43	-74,31	-188,60	B4	Wy+	4,14	-2,84	-8,09
B1	Wy-	-1,79	52,77	169,93	B4	Wy-	-12,28	26,76	90,99
B1	Ex(RS)	36,19	44,49	61,02	B4	Ex(RS)	50,23	14,04	41,28
B1	Ey(RS)	8,42	45,74	83,89	B4	Ey(RS)	10,43	20,00	45,46
B1	Evx(RS)	4,36	9,27	44,03	B4	Evx(RS)	22,23	6,96	31,05
B1	Evy(RS)	7,27	15,45	73,39	B4	Evy(RS)	37,05	11,60	51,74
B3	G1	-47,81	-6,32	84,96	D5	G1	2,20	4,07	37,13
B3	G2 Eq.	-37,01	-9,31	68,37	D5	G2 Eq.	-0,40	2,65	25,58
B3	G2	-28,27	-3,43	50,00	D5	G2	1,31	2,12	19,59
B3	Q	-92,58	-9,16	157,89	D5	Q	3,12	6,39	53,04
B3	Wx+	-34,53	-6,66	29,49	D5	Wx+	-7,39	0,23	-0,64
B3	Wx-	35,87	7,38	-29,45	D5	Wx-	6,77	-0,19	0,80
B3	Wy+	-40,62	-57,99	190,48	D5	Wy+	-4,24	-0,74	9,33
B3	Wy-	33,02	38,80	-175,41	D5	Wy-	5,67	1,56	-18,32
B3	Ex(RS)	92,00	30,84	77,04	D5	Ex(RS)	60,47	13,49	10,25
B3	Ey(RS)	25,61	33,04	96,85	D5	Ey(RS)	18,44	36,27	12,68
B3	Evx(RS)	14,99	8,31	22,96	D5	Evx(RS)	10,11	9,57	11,91
B3	Evy(RS)	24,98	13,86	38,27	D5	Evy(RS)	16,85	15,95	19,85
A5	G1	26,89	-2,35	42,60	D1	G1	-0,04	-5,61	36,21
A5	G2 Eq.	39,12	0,76	77,54	D1	G2 Eq.	-1,16	-2,38	69,74
A5	G2	15,13	-1,09	24,74	D1	G2	0,07	-3,24	18,79
A5	Q	39,81	-3,10	60,03	D1	Q	0,25	-9,43	45,88
A5	Wx+	-9,31	3,63	-4,21	D1	Wx+	-11,13	0,16	-0,44
A5	Wx-	7,61	-2,90	3,88	D1	Wx-	11,08	-0,09	0,41
A5	Wy+	-6,65	-2,93	-2,12	D1	Wy+	1,60	-41,76	-9,59
A5	Wy-	6,85	-1,08	1,67	D1	Wy-	-0,59	12,99	8,26
A5	Ex(RS)	57,74	14,71	36,84	D1	Ex(RS)	67,70	22,33	5,77
A5	Ey(RS)	12,04	18,08	14,16	D1	Ey(RS)	15,71	36,08	6,07
A5	Evx(RS)	14,60	5,24	24,06	D1	Evx(RS)	8,30	11,04	16,91
A5	Evy(RS)	24,33	8,74	40,10	D1	Evy(RS)	13,84	18,41	28,19

Table 16.8 – Electrolyser loads on foundations

LOAD	BASIC LOAD CASES															ENVELOPE		
COMB	G1	G2	Q	W	G1X	G2X	QX	G1Y	G2Y	QY	WX	WY	SX	SY	SZ	FX	FY	FZ
coeff	*1.3*	*1.3*	*1.5*	*1.22*	*1.3*	*1.3*	*1.5*	*1.3*	*1.3*	*1.5*	*1.22*	*1.22*	*0*	*0*	*0*			
ULS 1	113	65	237	-230	69	38	139	12	7	20	52	91	0	0	0	297	129	185
coeff	*1.3*	*1.3*	*1.05*	*1.5*	*1.3*	*1.3*	*1.05*	*1.3*	*1.3*	*1.05*	*1.5*	*1.5*						
ULS 2	113	65	166	-283	69	38	97	12	7	14	64	111	0	0	0	267	144	61
coeff	*1*	*1*	*0*	*1.5*	*1*	*1*	*0*	*1*	*1*	*0*	*1.5*	*1.5*						
ULS 3	87	50	0	-283	53	29	0	9	5	0	64	111	0	0	0	146	126	-146
coeff	*1*	*1*	*0.3*	*0*	*1*	*1*	*0.3*	*1*	*1*	*0.3*	*0*	*0*	*1*	*1*	*1*			
SEIS	87	50	47	0	53	29	28	9	5	4	0	0	96	58	97	110	18	281

Table 16.9 – Electrolyser loads on foundations – ULS Envelope

From the tables:

Max. Shear: $F_{v,Ed} = \sqrt{(297^2+144^2)}/3 = 110$ kN < $F_{v,Rd} = 135.6$ kN OK

Max. Tension = $F_{t,Ed} = \mathbf{146}/3 = 48.7$ kN < $F_{t,Rd} = 203.3$ kN OK

$F_{v,Ed} / F_{v,Rd} + F_{t,Ed} / 1.4\ F_{t,Rd} = 0.81 + 0.17 = 0.98 < 1.0$ OK

Checks are fulfilled. Nevertheless, gusset plates as seafastenings are added at the external corners of the two modules to prevent the uplift; bolts will work only for shear.

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16.2.4 PAU Hydrogen storage Vessels

Hydrogen Storage Vessel V-25001A/B/C/D/E/F support scheme is reported in the following figure. Supports are according to structural drawings. Weight is according to WCR ref./22/.

Checks are performed for V-25001A, which is the most stressed by transport accelerations (worst scenario), and they cover all the tanks.

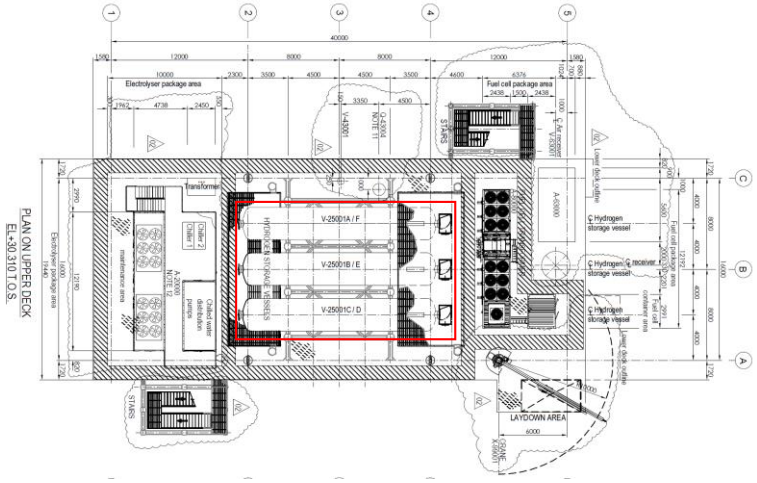


Figure 16.16 – Hydrogen Storage vessels location

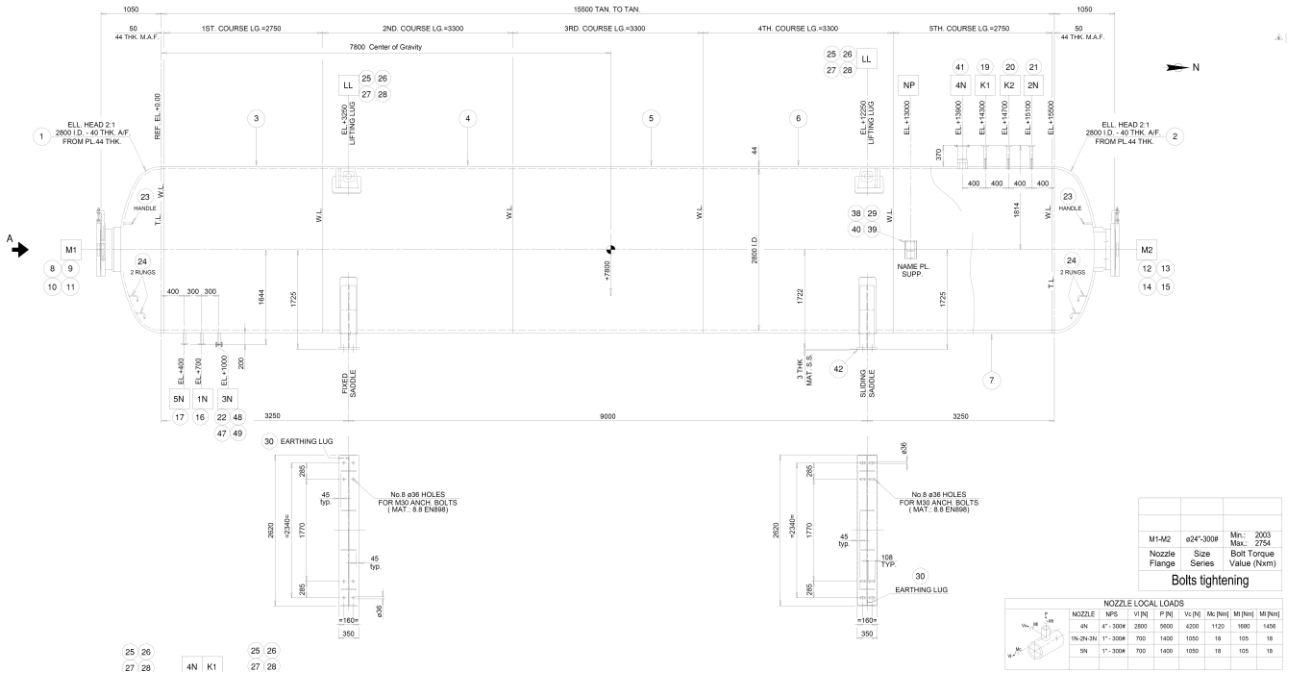


Figure 16.17 – Hydrogen Storage vessels support scheme

For this item, transportation inertia forces are computed specifically at the V-25001A CoG as per following calculation.

TRANSPORT FORCES ON CARGO

In accordance with: DNVGL ST N001 2018-amended 2020

Barge data			Cargo barge		P-mak		
	Length	L =	91.50	m			
	Breadth	B =	27.40	m			
	Depth	D =	6.10	m			
	Draft	d =	2.70	m	from barge keel		
Cargo data							
	Weight	W =	1.00	kN			
	C.o.G.	x =	15.38	m	from c.g. of barge		
		y =	5.15	m	from centerline		
		z =	17.00	m	from barge deck		
	distance from roll axis	d_t =	21.04	m	on water plane		
	d_t angle	α_t =	0.25	rad	from vertical		
	distance from pitch axis	d_l =	25.55	m	on water plane		
	d_l angle	α_l =	0.65	rad	from vertical		
Motion data			(single amplitude, in 10 sec full cycle period)				
	Transportation duration		Unrestricted operations				
	Transportation area		Non-benign				
			Roll	Pitch	Heave		
	Maximum amplitude	a =	20.0	12.5		deg	
	Max acceleration	ä =	0.138	0.086		rad/s^2	
		ä =			0.2	g	
Forces, per unit weight, due to:			Roll	Pitch	Heave	Gravity	
	Inertia force = (W/g) d ä	F =	0.30	0.22	0.20		
	Transverse components	F_t =	0.29		0.07	0.34	
	Vertical components	F_v =	0.07		0.19	0.94	
	Longitudinal components	F_l =		0.18	0.04	0.22	
	Vertical components	F_v =		0.13	0.20	0.98	
Accelerations at cargo c.o.g.			Transv.	Longit.	Vertical		
1	**+ Roll + Heave**		0.70		1.20	g	
2	**+ Roll - Heave**		0.56		0.82	g	
3	**- Roll + Heave**		-0.70		1.06	g	
4	**- Roll - Heave**		-0.56		0.68	g	
5	**+ Pitch + Heave**			0.44	1.31	g	
6	**+ Pitch - Heave**			0.35	0.92	g	
7	**- Pitch + Heave**			-0.44	1.04	g	
8	**- Pitch - Heave**			-0.35	0.65	g	

From the computation above, max inertia accelerations are the following:

- Roll: 0.7g
- Pitch: 0.5g
- Heave: ±0.4g

BOLT CONNECTION CHECK - EC3			
Item:	V-25001A	**MAX UC =**	**0.32**
DATA			
Weight	W =	660	kN
Height	H =	4	m
Width	B =	2.06	m
Vertical Supports	nv =	4	
Horizontal Supports y	nhy =	4	
Horizontal Supports x	nhx =	2	
Bolts per support	nb =	4	
Bolts		M30	
Shear resistance	Fv,Rd =	223.1	kN
Tension resistance	Ft,Rd =	334.7	kN
FORCES			
Inertia load - Roll	V1 = 0.7W =	462	kN
Inertia load - Pitch	V2 = 0.5W =	330	kN
Inertia load - heave	Fh = 0.4W =	264	kN
Wind load	V3 = 0.7 kPa*48m2 =	33.6	kN
ULS Shear on support	fv,ed1 = 1.35*(V1+V3)/nhy =	167.3	kN
	fv,ed2 = 1.35*V2/nhx =	222.8	kN
ULS Heave on support	fh = 1.35*Fh / nh =	89.1	kN
ULS Tension on support	rt1 = 1.35*V1*(H/2)/B/(nv/2) =	302.8	kN
due to Shear	rt2 = 1.35*V2*(H/2)/B/(nv/2) =	216.3	kN
ULS vertical load on support	N = 0.9*W/nv =	148.5	kN
SHEAR CHECK			
Shear on bolt	Fv,Ed = fv,ed2/nb =	55.7	kN
	Fv,Ed < Fv,Rd - UC =	0.25	≤ 1.0
TENSION CHECK			
Tension on bolt	Ft,ed = (rt2+fh-N) / nb =	60.8	kN
	Ft,Ed < Ft,Rd - UC =	0.18	≤ 1.0
SHEAR+TENSION CHECK			
	Fv,Ed = fv,ed1/nb =	41.8	kN
	Ft,ed = (rt1+fh-N) / nb =	60.8	kN
Fv,Ed / Fv,Rd + Ft,Ed / 1.4*Ft,Rd =		0.32	≤ 1.0

Calculation scheme

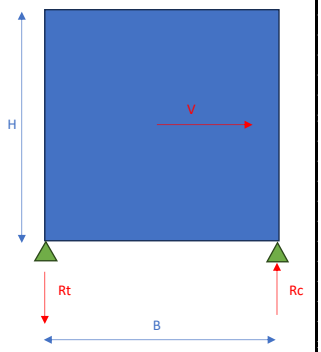


Table 16.10 – v-25001A support check

16.2.5 Instrument air package

Instrument Air Package A-63000 support scheme is reported in the following figure. Supports are according to structural drawings. Weight is according to WCR ref./22/.

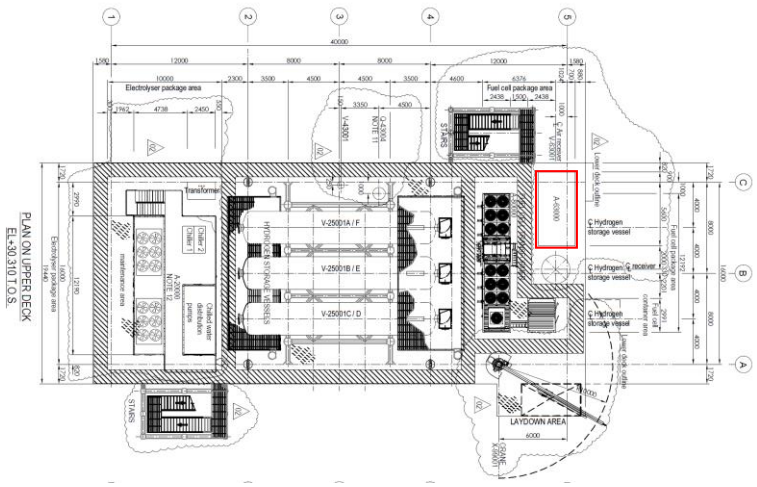


Figure 16.18 – Instrument air package location

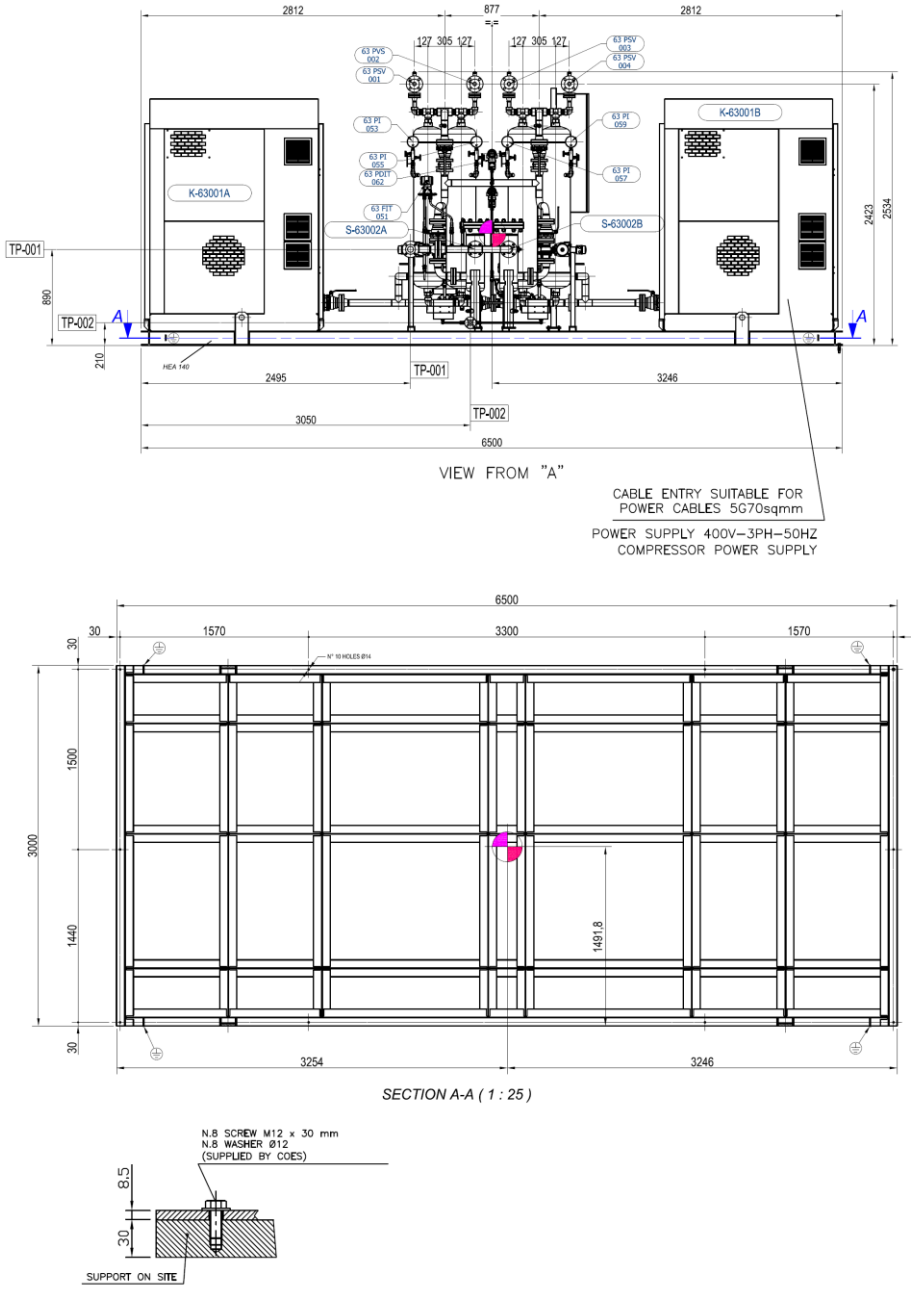


Figure 16.19 –Instrument Air Package support scheme

BOLT CONNECTION CHECK - EC3			
Item:	A-63000	**MAX UC =**	**0.50**
DATA			
Weight	W =	110	kN
Height	H =	2.1	m
Width	B =	2.94	m
Vertical Supports	nv =	8	
Horizontal Supports	nh =	8	
Bolts		M12	
Bolts per support	nb =	1	
Shear resistance	Fv,Rd =	32.4	kN
Tension resistance	Ft,Rd =	48.6	kN
FORCES			
Inertia load - Roll	V1 = 0.65W =	71.5	kN
Inertia load - Pitch	V2 = 0.45 =	49.5	kN
Inertia load - Heave	Fh = 0.55*W =	60.5	kN
ULS Shear on support	fv,ed1 = 1.35*V1/nh =	12.1	kN
	fv,ed2 = 1.35*V2/nh =	8.4	kN
ULS Heave on support	fh = 1.35*Fh / nh =	10.2	kN
ULS Tension on support	rt1 = 1.35*V1*(H/2)/B/(nh/2) =	8.6	kN
due to Shear	rt2 = 1.35*V2*(H/2)/B/(nh/2) =	6.0	kN
ULS vertical load on support	N = 0.9*W/8 =	12.38	kN
SHEAR CHECK			
Shear on bolt	Fv,Ed = fv,ed1/nb =	12.1	kN
	Fv,Ed < Fv,Rd - UC =	0.37	≤ 1.0
TENSION CHECK			
Tension on bolt	Ft,ed = (rt2+fh) / nb =	18.8	kN
	Ft,Ed < Ft,Rd - UC =	0.39	≤ 1.0
SHEAR+TENSION CHECK			
	Fv,Ed = fv,ed2/nb =	8.4	kN
	Ft,ed = (rt2+fh) / nb =	16.2	kN
Fv,Ed / Fv,Rd + Ft,Ed / 1.4*Ft,Rd =		0.50	≤ 1.0

Calculation scheme

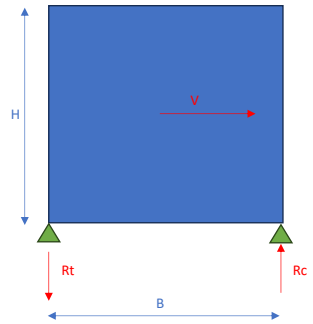


Table 16.11 – A-63000 support check

16.2.6 Air receiver

Air Receiver V-63001 support scheme is reported in the following figure. Supports are according to structural drawings. Weight is according to WCR ref./22/. Checks cover bolted connection of V-64001 receiver, which has the same base supporting scheme, tank being smaller and lighter.

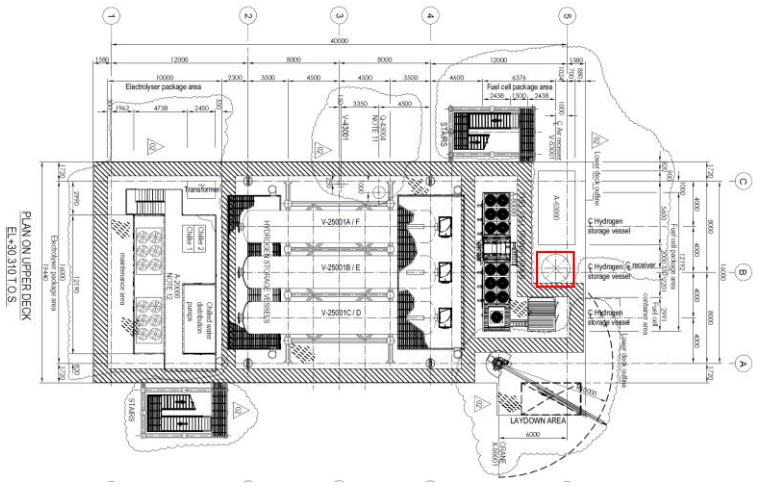


Figure 16.20 – Instrument air package location

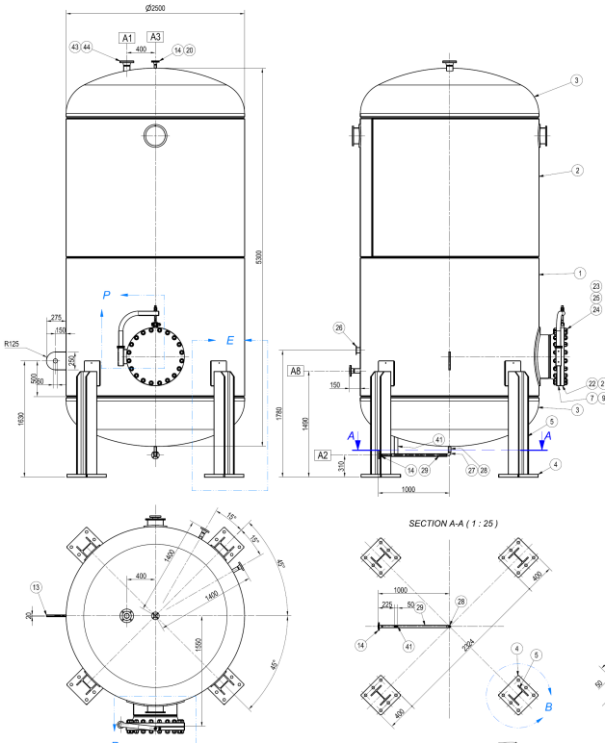


Figure 16.21 – Air Receiver support scheme

BOLT CONNECTION CHECK - EC3				Calculation scheme
Item:	V-63001	MAX UC =	0.03	
DATA				
Weight	W =	74.5	kN	
Height	H =	6	m	
Width	B =	1.9	m	
Vertical Supports	nv =	4		
Horizontal Supports	nh =	4		
Bolts		M33		
Bolts per support	nb =	6		
Shear resistance	Fv,Rd =	266.5	kN	
Tension resistance	Ft,Rd =	399.7	kN	
FORCES				
Inertia load - Roll	V1 = 0.65W =	48.4	kN	
Inertia load - Pitch	V2 = 0.45W =	33.5	kN	
Inertia load - Heave	Fh = 0.55*W =	41.0	kN	
Wind load	V3 = 0.7 kPa*13.25m2 =	9	kN	
ULS Shear on support	fv,ed1 = 1.35*(V1+V3)/nh =	19.5	kN	
	fv,ed2 = 1.35*(V2+V3)/nh =	14.4	kN	
ULS Heave on support	fh = 1.35*Fh / nh =	13.8	kN	
ULS Tension on support	rt1 = 1.35*(V1+V3)*(H/2)/B/(nh/2) =	60.7	kN	
due to Shear	rt2 = 1.35*(V2+V3)*(H/2)/B/(nh/2) =	45.0	kN	
ULS vertical load on support	N = 0.9*W/nv =	16.76	kN	
SHEAR CHECK				
Shear on bolt	Fv,Ed = fv,ed1/nb =	3.25	kN	
	Fv,Ed < Fv,Rd - UC =	0.01	≤ 1.0	
TENSION CHECK				
Tension on bolt	Ft,ed = (rt1+fh-N) / nb =	9.6	kN	
	Ft,Ed < Ft,Rd - UC =	0.02	≤ 1.0	
SHEAR+TENSION CHECK				
	Fv,Ed = fv,ed1/nb =	3.2	kN	
	Ft,ed = (rt1+fh-N) / nb =	9.6	kN	
Fv,Ed / Fv,Rd + Ft,Ed / 1.4*Ft,Rd =		0.03	≤ 1.0	

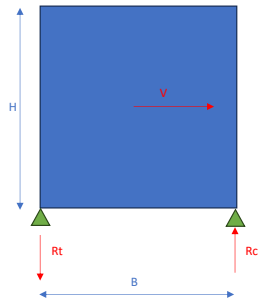


Table 16.12 – V-63001 support check

16.2.7 Nitrogen Package

Nitrogen Generation Package A-64000 support scheme is reported in the following figure. Supports are according to structural drawings. Weight is according to WCR ref./22/.

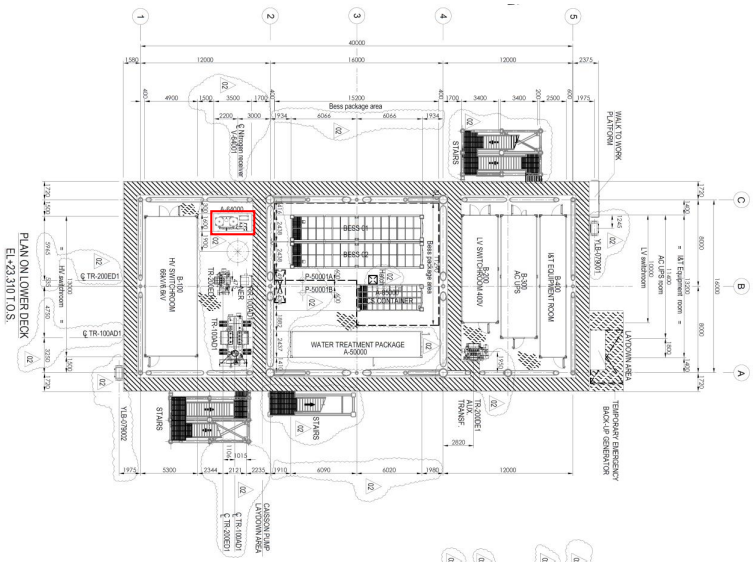
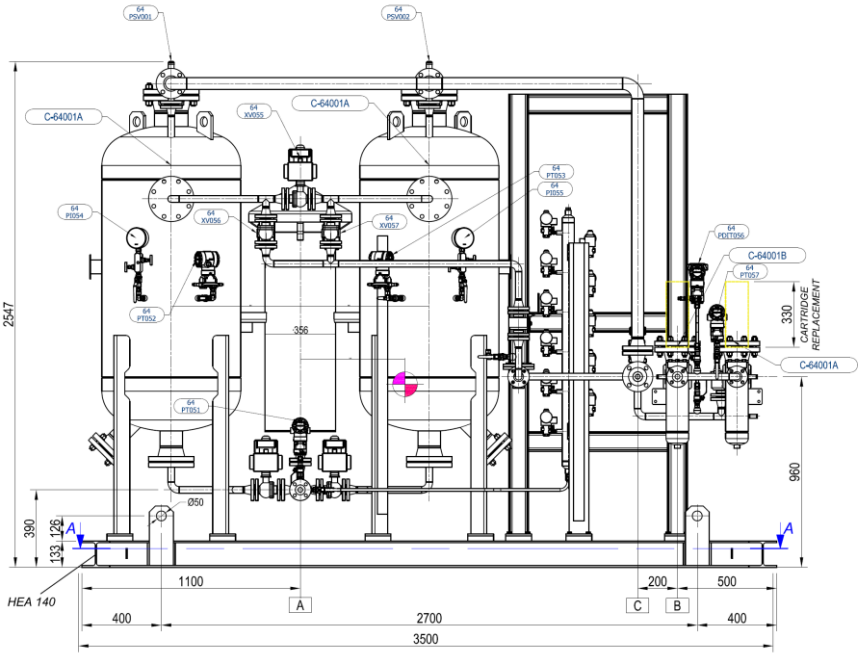


Figure 16.22 – Nitrogen package location



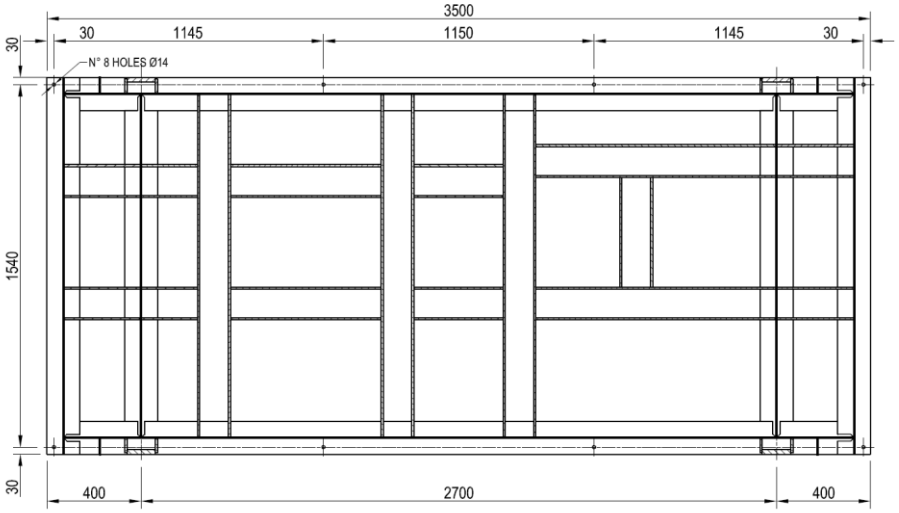


Figure 16.23 – Nitrogen Package support scheme

BOLT CONNECTION CHECK - EC3				Calculation scheme
Item:	A-63000	**MAX UC =**	**0.31**	
DATA				
Weight	W =	50	kN	
Height	H =	2	m	
Width	B =	1.54	m	
Vertical Supports	nv =	8		
Horizontal Supports	nh =	8		
Bolts		M12		
Bolts per support	nb =	1		
Shear resistance	Fv,Rd =	32.4	kN	
Tension resistance	Ft,Rd =	48.6	kN	
FORCES				
Inertia load - Roll	V1 = 0.6W =	30	kN	
Inertia load - Pitch	V2 = 0.4W =	20	kN	
Inertia load - Heave	Fh = 0.5*W =	25	kN	
ULS Shear on support	fv,ed1 = 1.35*V1/nh =	5.1	kN	
	fv,ed2 = 1.35*V2/nh =	3.4	kN	
ULS Heave on support	fh = 1.35*Fh / nh =	4.2	kN	
ULS Tension on support	rt1 = 1.35*V1*(H/2)/B/(nh/2) =	6.6	kN	
due to Shear	rt2 = 1.35*V2*(H/2)/B/(nh/2) =	4.4	kN	
ULS vertical load on support	N = 0.9*W/8 =	5.6	kN	
SHEAR CHECK				
Shear on bolt	Fv,Ed = fv,ed1/nb =	5.1	kN	
	Fv,Ed < Fv,Rd - UC =	0.16	≤ 1.0	
TENSION CHECK				
Tension on bolt	Ft,ed = (rt2+fh) / nb =	10.8	kN	
	Ft,Ed < Ft,Rd - UC =	0.22	≤ 1.0	
SHEAR+TENSION CHECK				
	Fv,Ed = fv,ed1/nb =	5.1	kN	
	Ft,ed = (rt1+fh) / nb =	10.8	kN	
Fv,Ed / Fv,Rd + Ft,Ed / 1.4*Ft,Rd =		0.31	≤ 1.0	

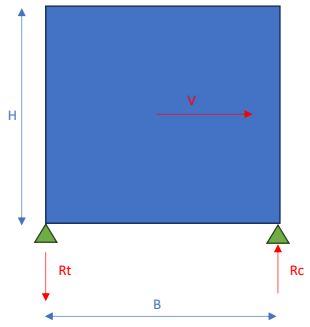


Table 16.13 – A-64000 support check

17 HANDRAILS

Handails are dimensioned according to the following live loads:

Area Use	Load
Service platforms	300 N/m, per max distance in m, between the axes of two successive stanchions, Ref. /19/
Escape routes	750 N/m, per max distance in m, between the axes of two successive stanchions, Ref. Client requirement (SHELL UK)
Laydown areas	1500 N/m, per max distance in m, between the axes of two successive stanchions, ref. FEED Ref. /38/

Table 17.1 – Loads for handrails Local Checks

Checks are performed according to ISO 19902 ref./7/.

17.1 STANDARD HANDRAILS

For standard handrails, considering 750 N/m linear load applied at the top rail, a cantilever calculation scheme is used.

Standard handrail is according to structural drawing ref./35/.

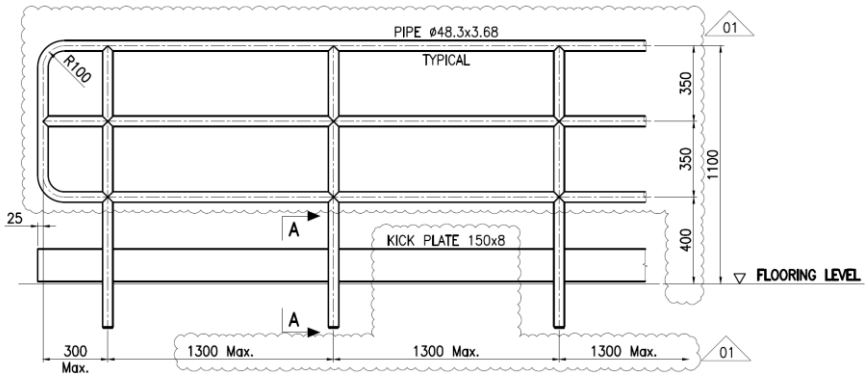


Figure 17.1 – Standard Handrail

Spacing between columns: 1.3m.

Total load applied to one column: 0.75*1.3 = 1.0 kN.

Resisting properties:

V_{Rd} = 0.5*A*fy/√3/1.05 = 0.5*516*355/√3/1.05 = 50 kN

M_{Rd} = W_{el}*f_y/1.05 = 5352*355 = 1.9 kNm

Internal forces ULS:

Shear Force V_{Ed} = 1.5*1 = 1.5 kN < V_{Rd} = 50 kN OK

Bending moment M_{Ed} = 1.5*1*1.1 = 1.65 kNm < M_{Rd} = 1.9 kNm OK

17.2 HEAVY DUTY HANDRAILS

For heavy duty handrails, considering 1500 N/m linear load applied at the top rail, a cantilever calculation scheme is used.

Heavy duty handrail is according to structural drawing ref./36/.

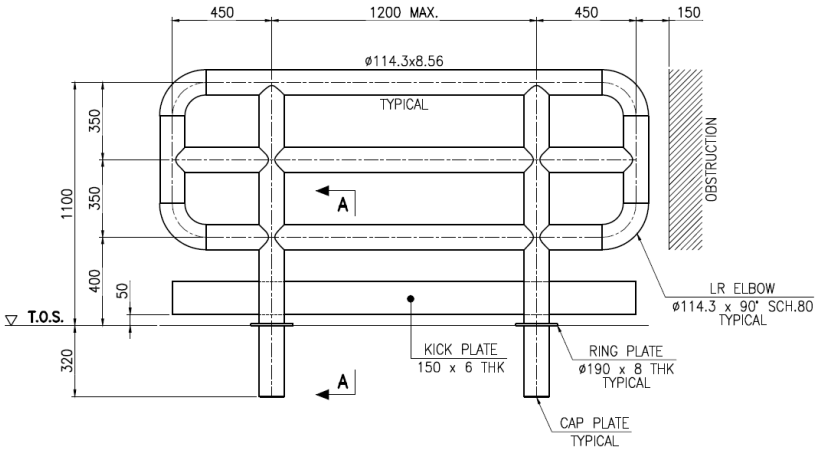


Figure 17.2 – Heavy Duty Handrail

Spacing between columns: 1.2m.

Total load applied to one column: 1.5*1.2 = 1.8 kN.

Resisting properties:

V_{Rd} = 0.5*A*fy/√3/1.05 = 0.5*2843.6*355/√3/1.05 = 277.5 kN

M_{Rd} = W_{el}*f_y/1.05 = 70000*355 = 24.85 kNm

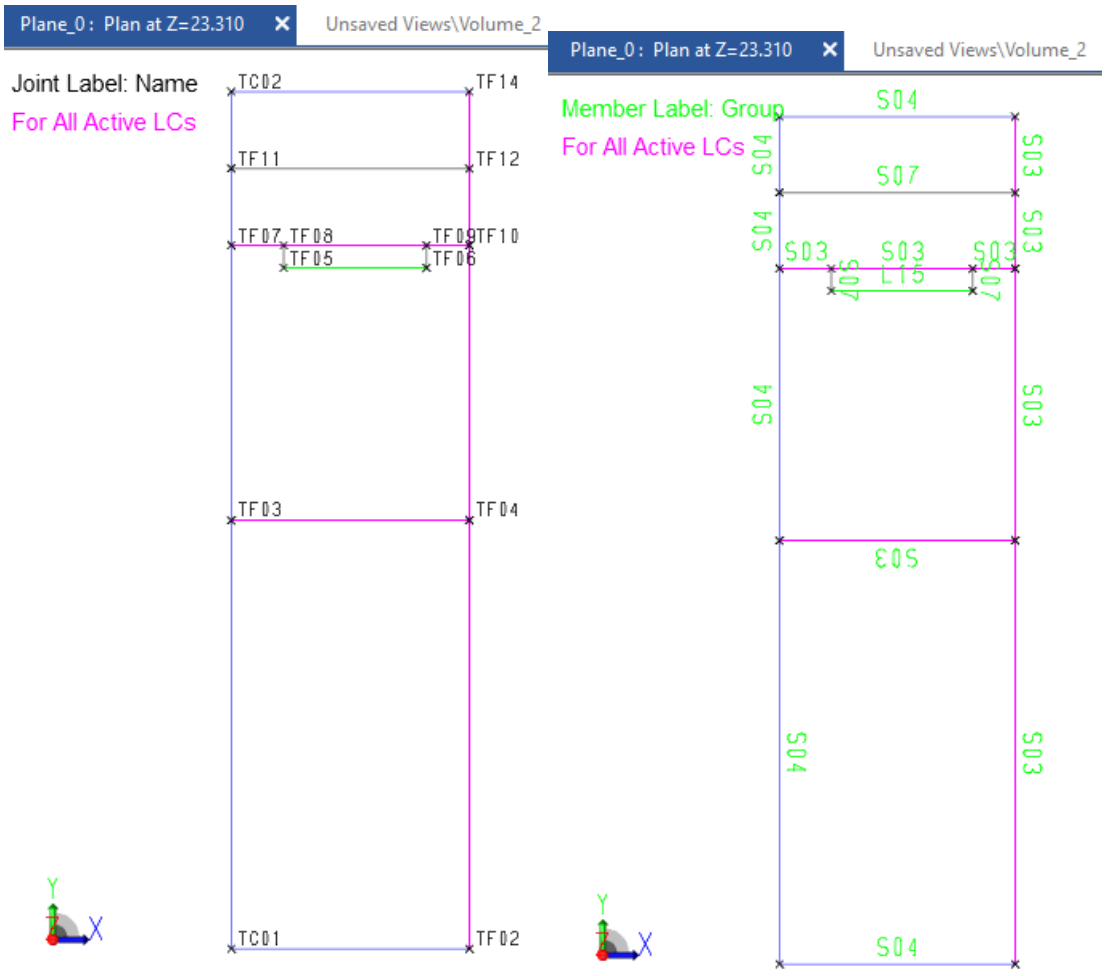
Internal forces ULS:

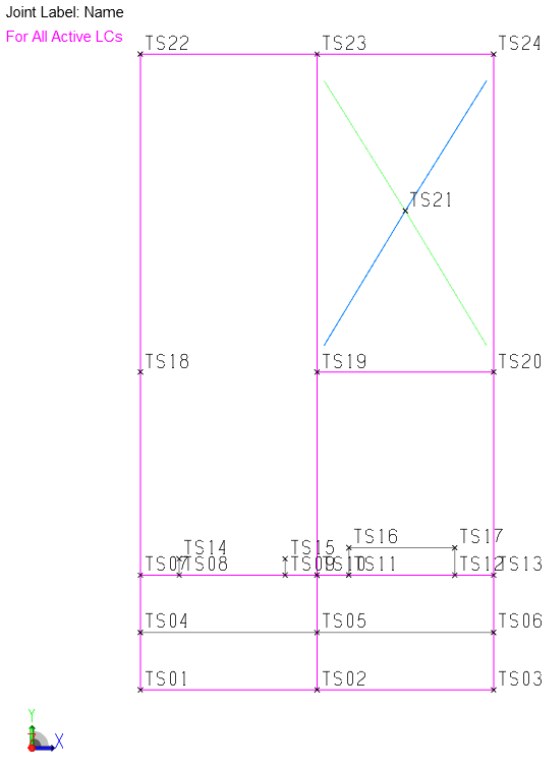
Shear Force V_{Ed} = 1.5*1.8 = 2.7 kN < V_{Rd} = 277.5 kN OK

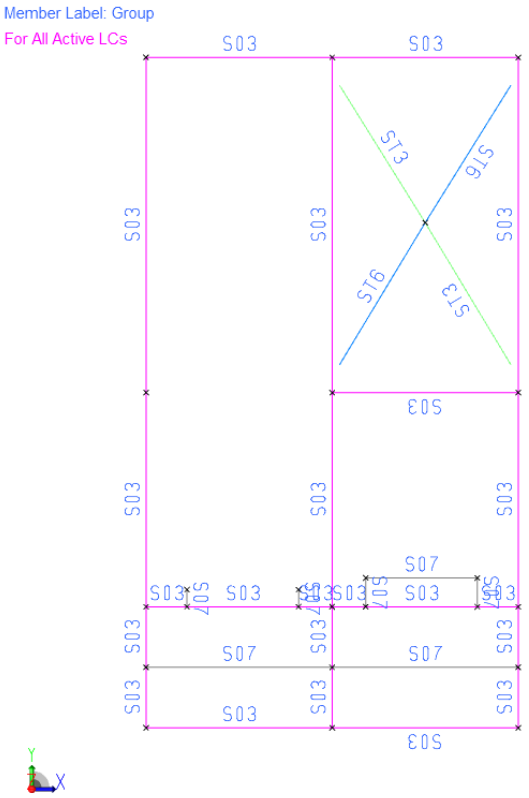
Bending moment M_{Ed} = 1.5*1.8*1.1 = 3.0 kNm < M_{Rd} = 24.85 kNm OK

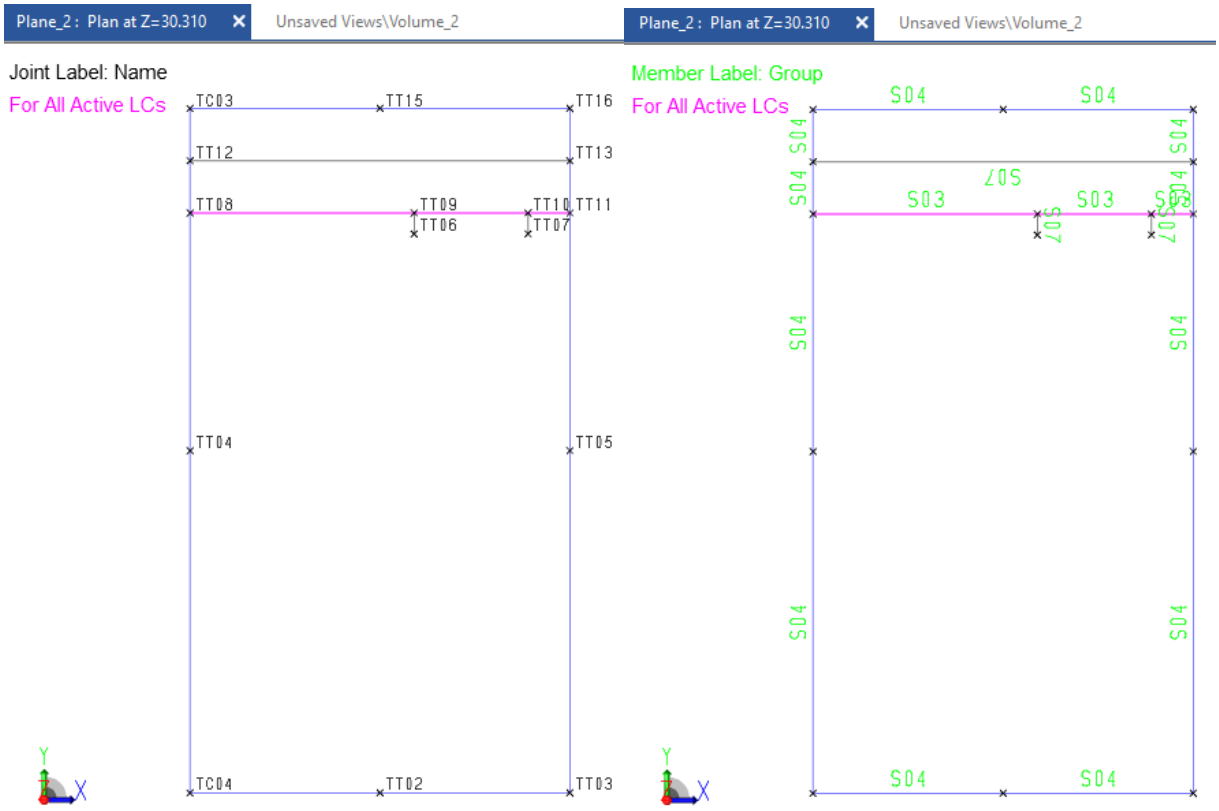
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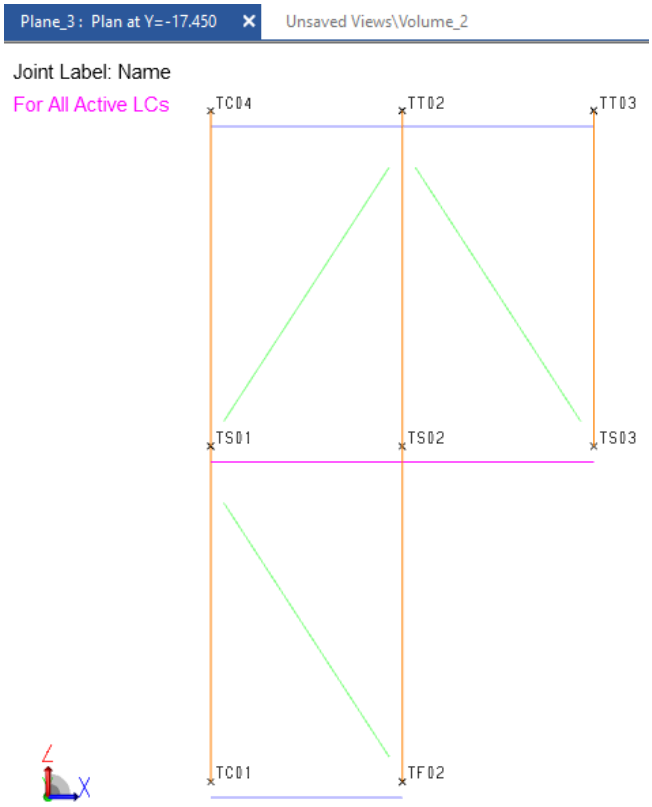
APPENDIX A – MEMBER AND JOINT LABELS FOR TOWER STAIRS

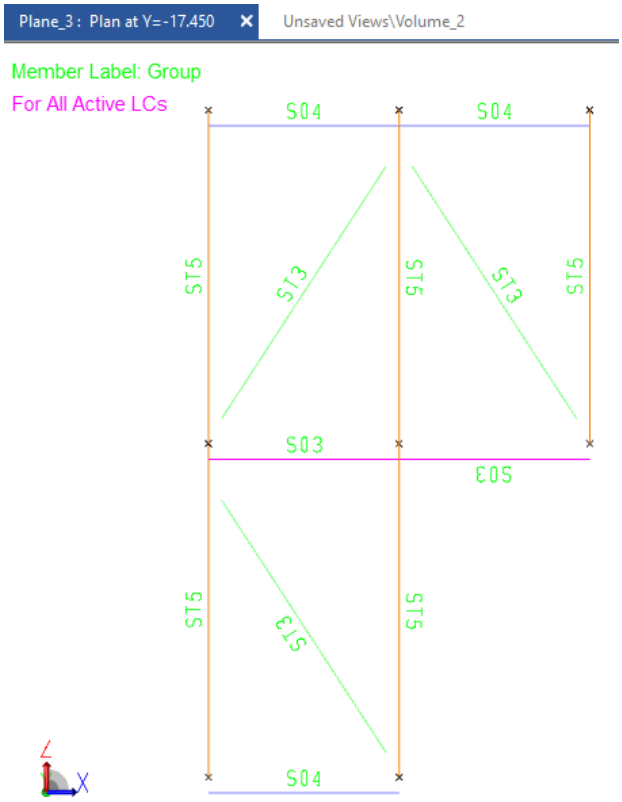


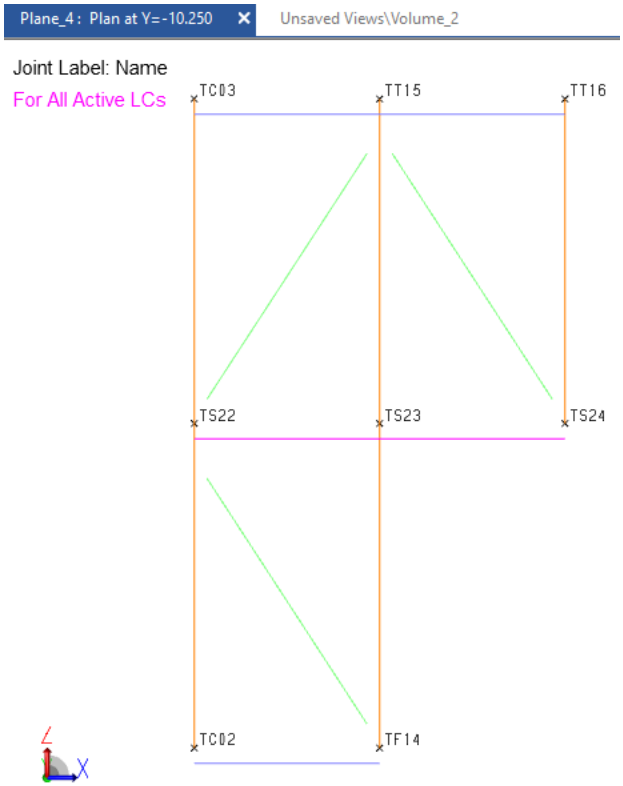

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TS23
TS24
TS21
TS18
TS19
TS20
TS14
TS15
TS16
TS17
TS07
TS08
TS09
TS10
TS11
TS12
TS13
TS04
TS05
TS06
TS01
TS02
TS03
Y
X

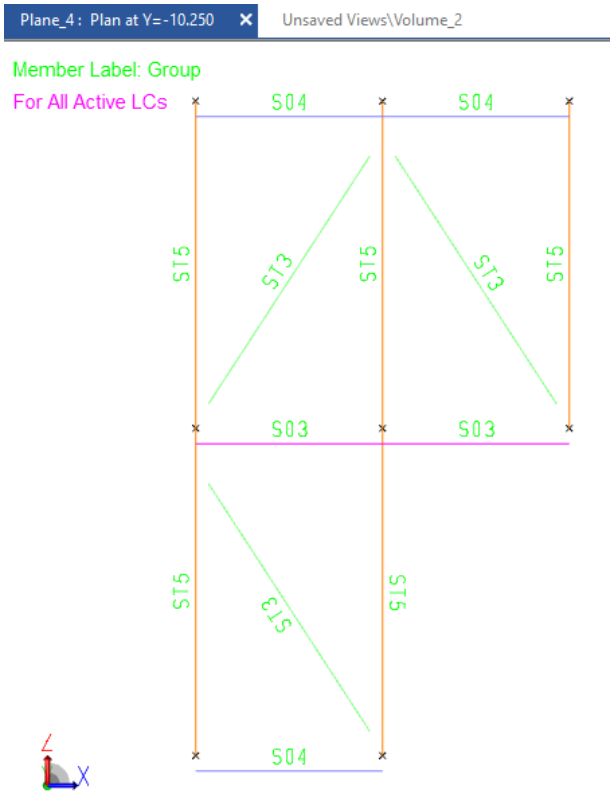

Member Label: Group
For All Active LCs
S03
S07
ST3
ST6
Y
X

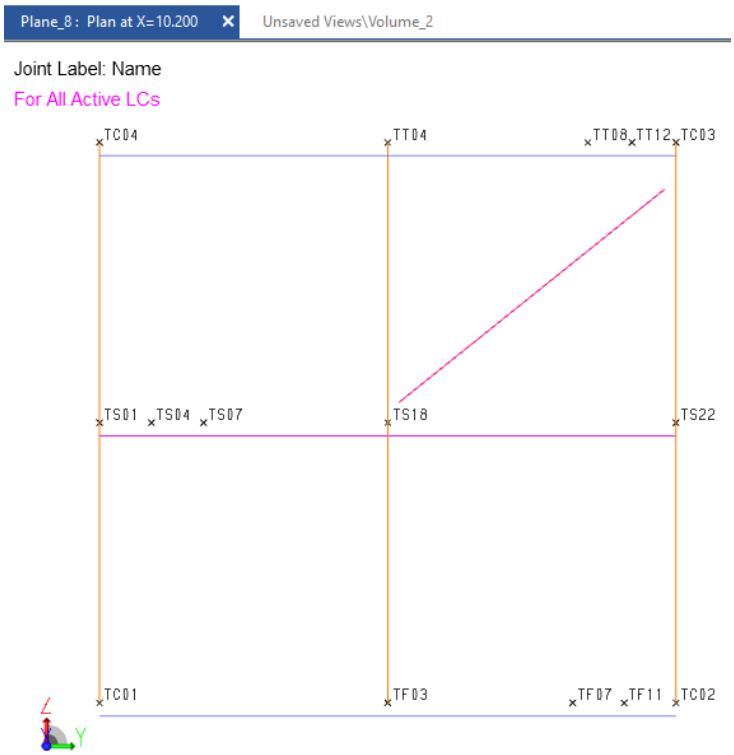

Plane_2 : Plan at Z=30.310
Unsaved Views\Volume_2
Joint Label: Name
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TT15
TT16
TT12
TT13
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TT09
TT10
TT11
TT06
TT07
TT04
TT05
TC04
TT02
TT03
Y
X
Plane_2 : Plan at Z=30.310
Unsaved Views\Volume_2
Member Label: Group
For All Active LCs
S04
S07
S03
Y
X

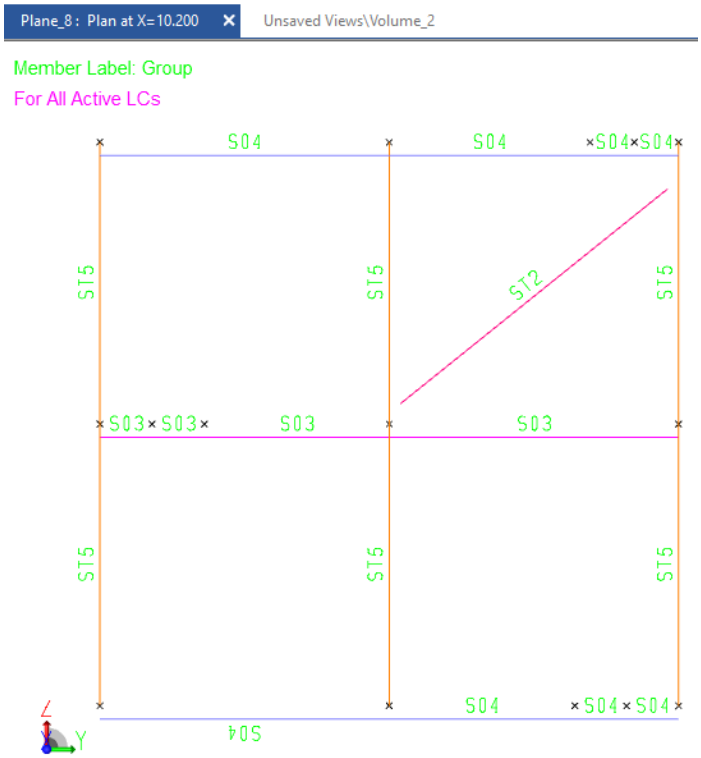

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TT03
TS01
TS02
TS03
TC01
TF02
Z
X

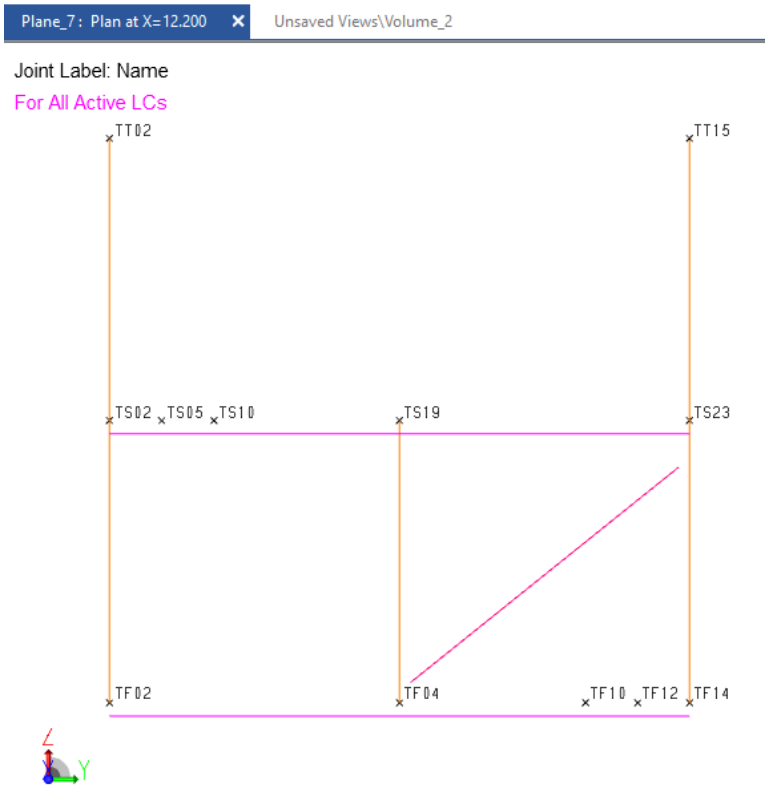

Plane_3 : Plan at Y=-17.450
Unsaved Views\Volume_2
Member Label: Group
For All Active LCs
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S04
ST5
ST3
ST5
ST3
ST5
S03
S03
ST5
ST3
ST5
S04
Z
X

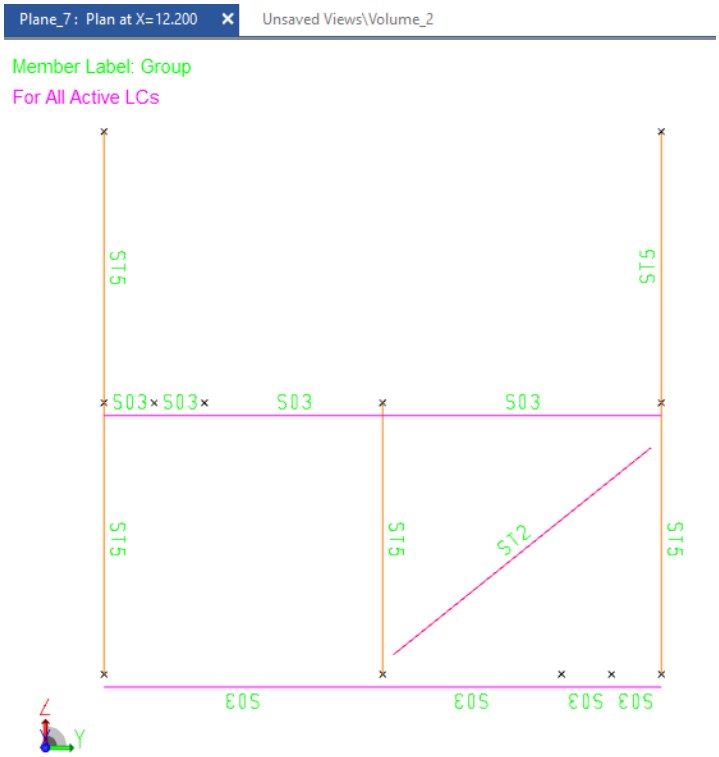

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TS23
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TC02
TF14
Z
X

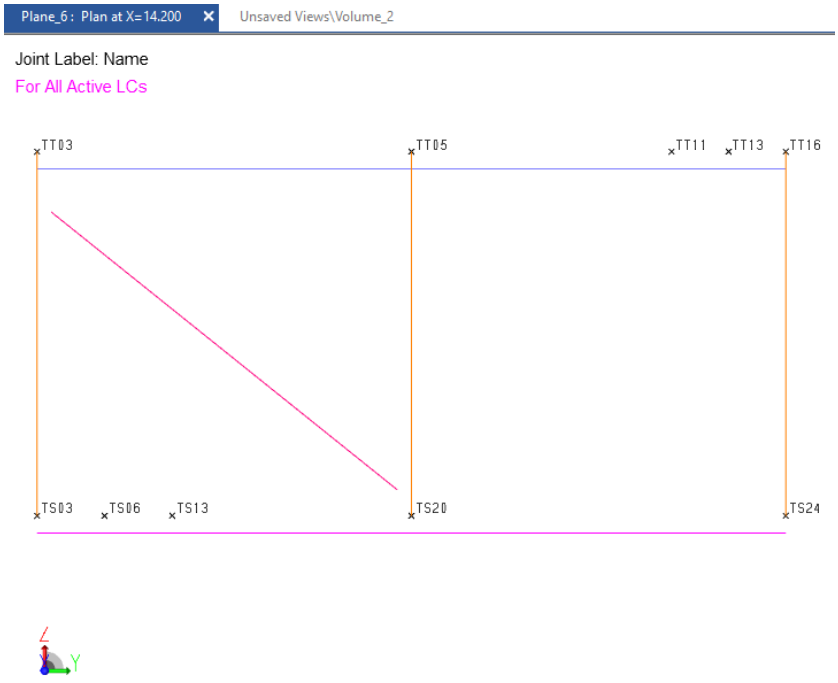

Plane_4 : Plan at Y=-10.250
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Member Label: Group
For All Active LCs
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ST5
ST3
ST5
ST3
ST5
S03
S03
ST5
ST3
ST5
S04
Z
X

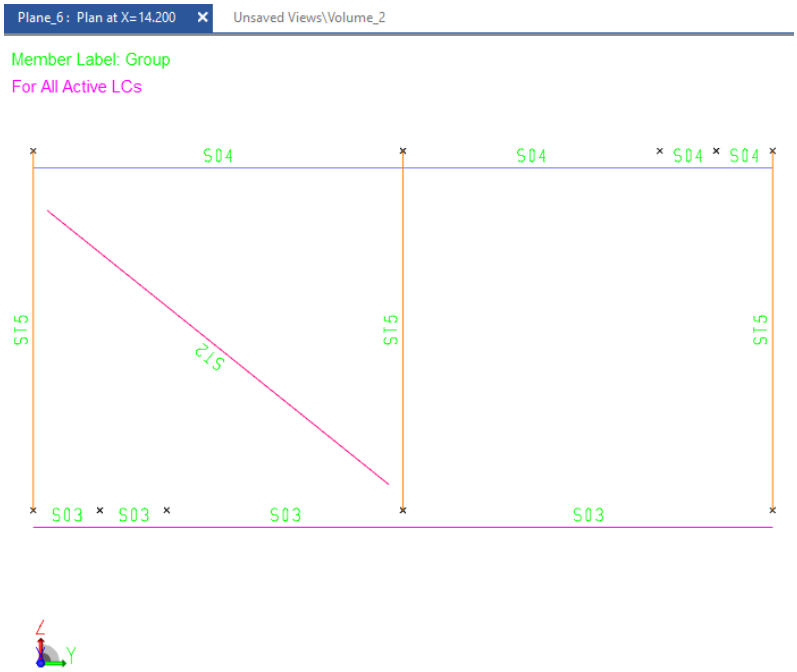

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TT08
TT12
TC03
TS01
TS04
TS07
TS18
TS22
TC01
TF03
TF07
TF11
TC02
Z
Y


Plane_8 : Plan at X=10.200
Unsaved Views\Volume_2
Member Label: Group
For All Active LCs
S04
S04
S04
S04
ST5
ST5
ST2
ST5
S03
S03
S03
S03
ST5
ST5
ST5
S04
S04
S04
S04
Z
Y

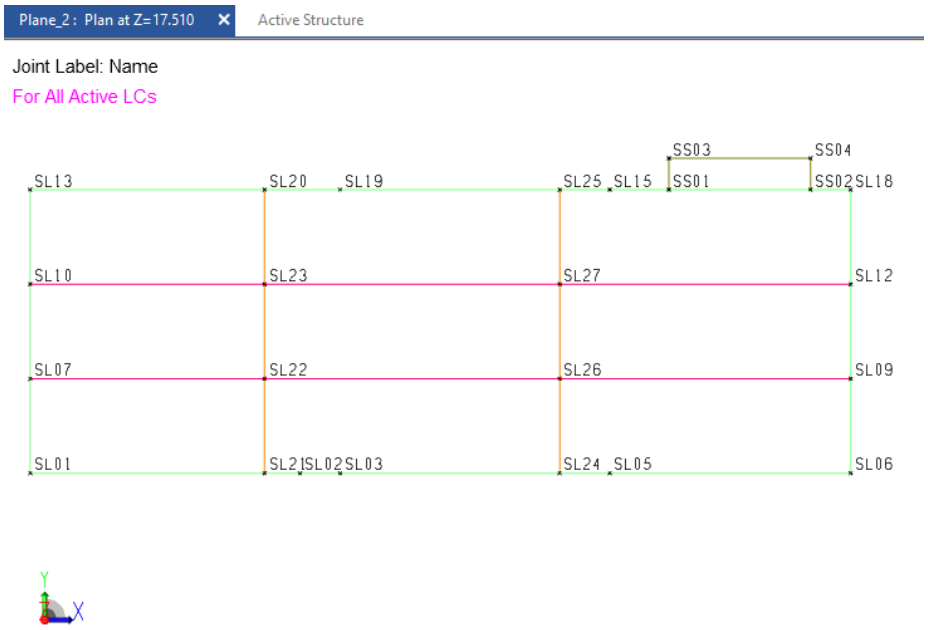

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TS23
TF02
TF04
TF10
TF12
TF14
Z
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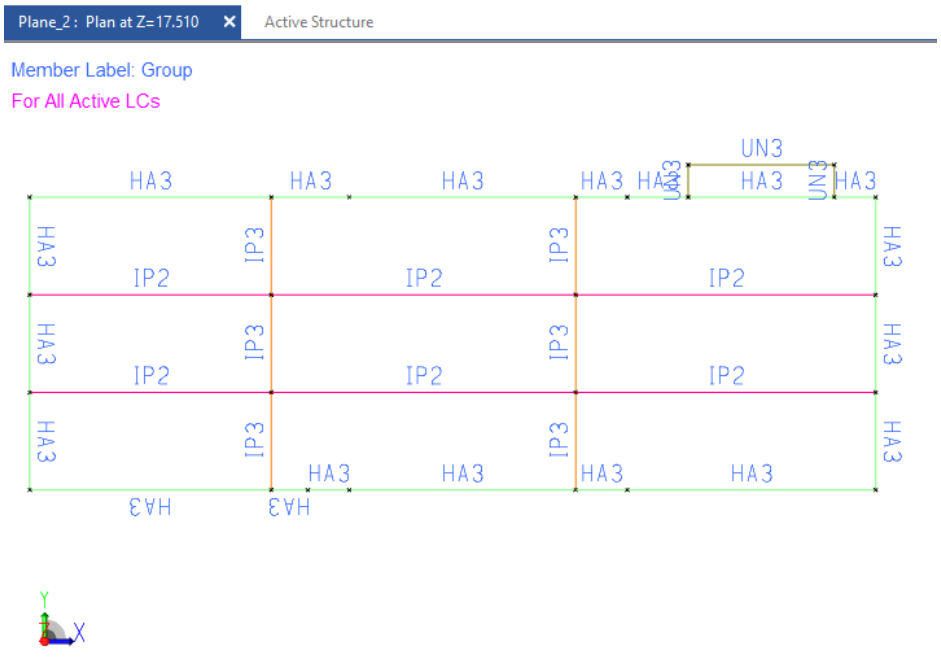

Plane_7 : Plan at X=12.200
Unsaved Views\Volume_2
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S03
S03
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ST5
ST2
ST5
S03
S03
S03
S03
Z
Y

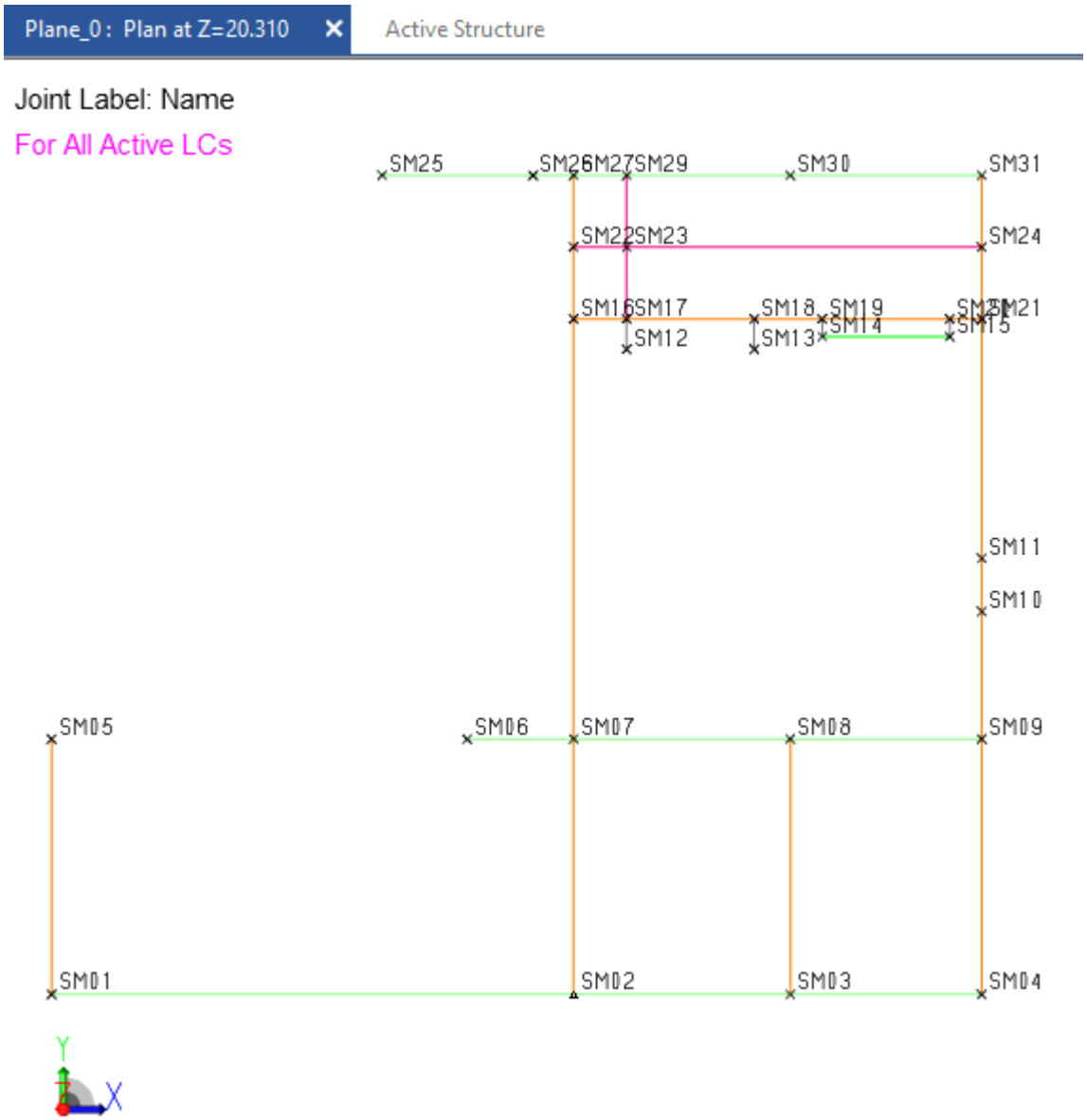

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TT05
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TT13
TT16
TS03
TS06
TS13
TS20
TS24
Z
Y

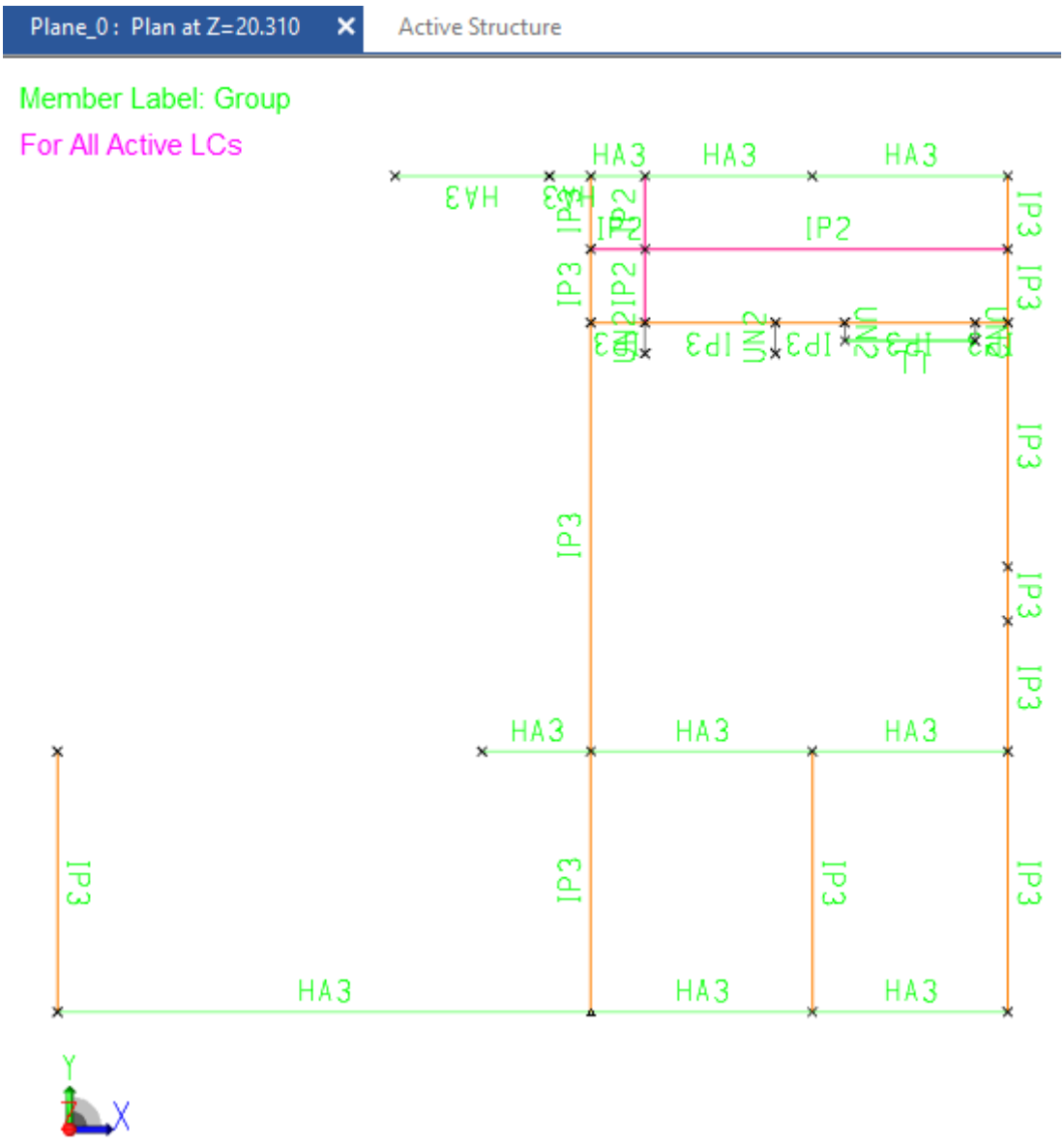

Plane_6 : Plan at X=14.200
Unsaved Views\Volume_2
Member Label: Group
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S04
S04
S04
ST5
ST5
ST5
ST2
S03
S03
S03
S03
Z
Y

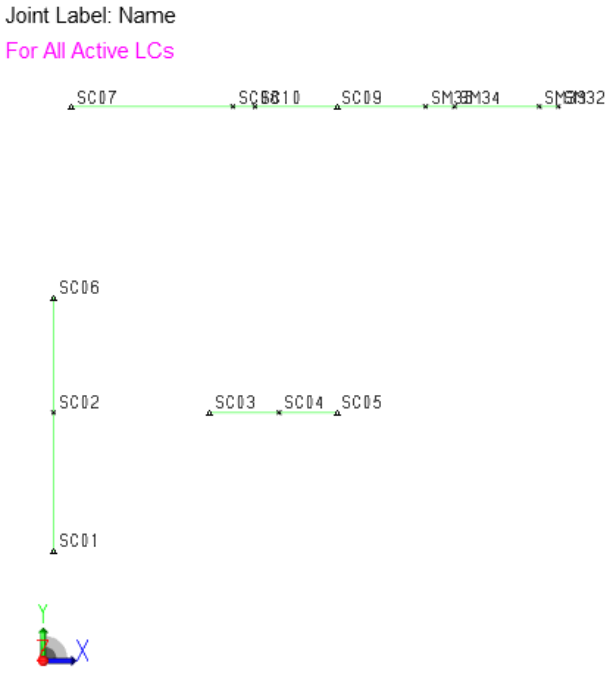
APPENDIX B – MEMBER AND JOINT LABELS FOR TP STAIRS

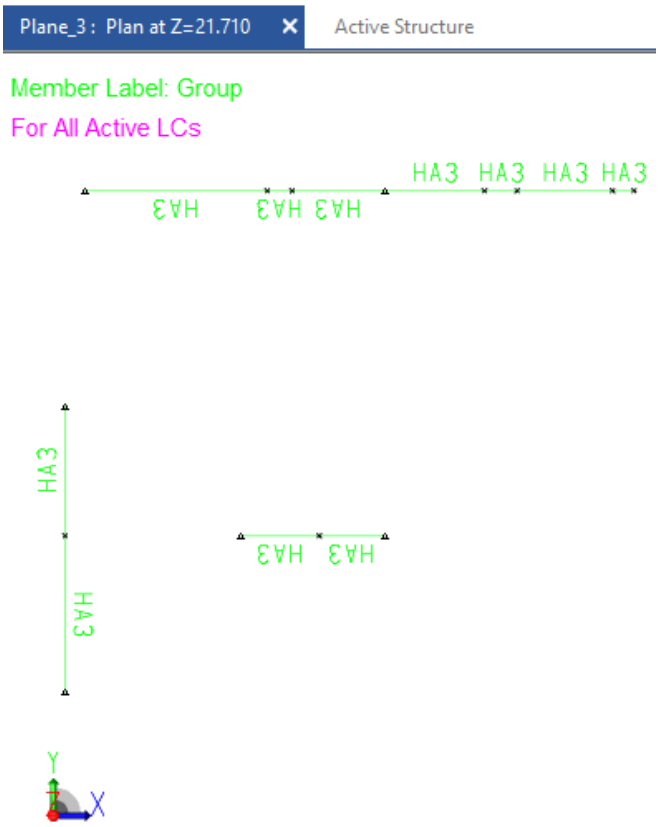


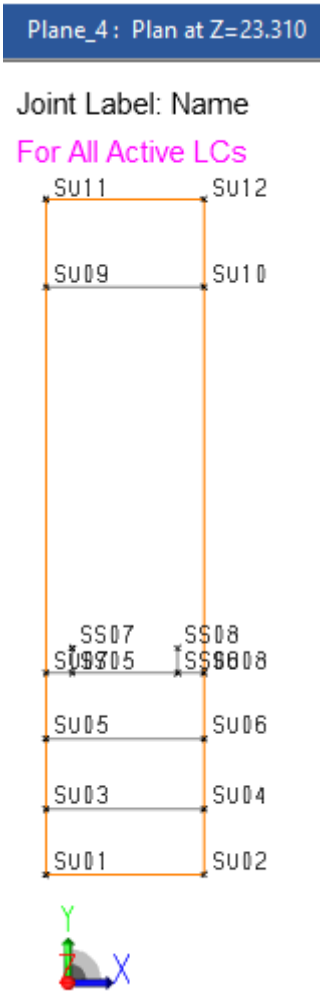


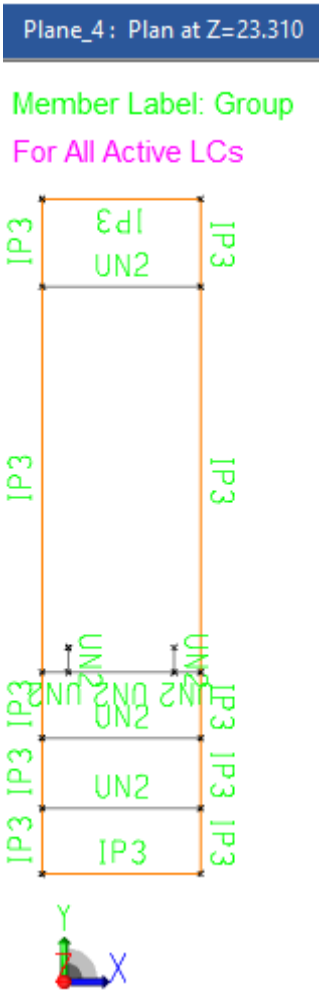

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Joint Label: Name
For All Active LCs
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SM26
SM27
SM29
SM30
SM31
SM22
SM23
SM24
SM16
SM17
SM18
SM19
SM21
SM12
SM13
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SM02
SM03
SM04
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X

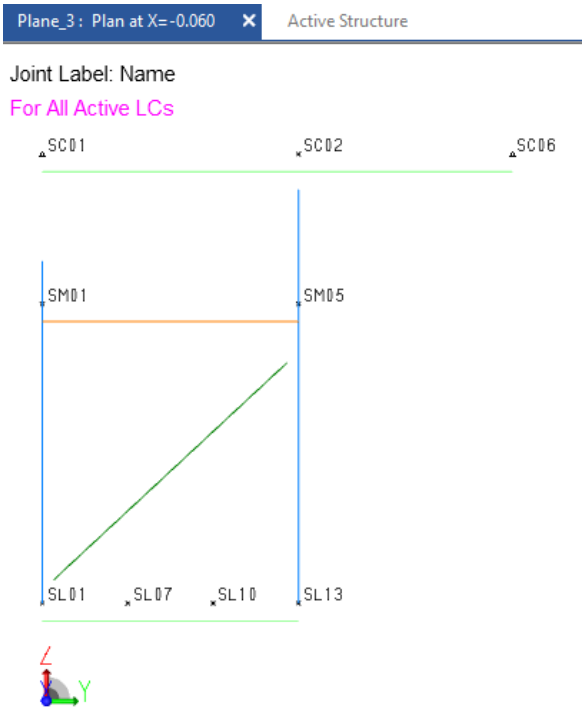

Plane_0 : Plan at Z=20.310
Active Structure
Member Label: Group
For All Active LCs
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IP2
IP3
UN2
Y
X

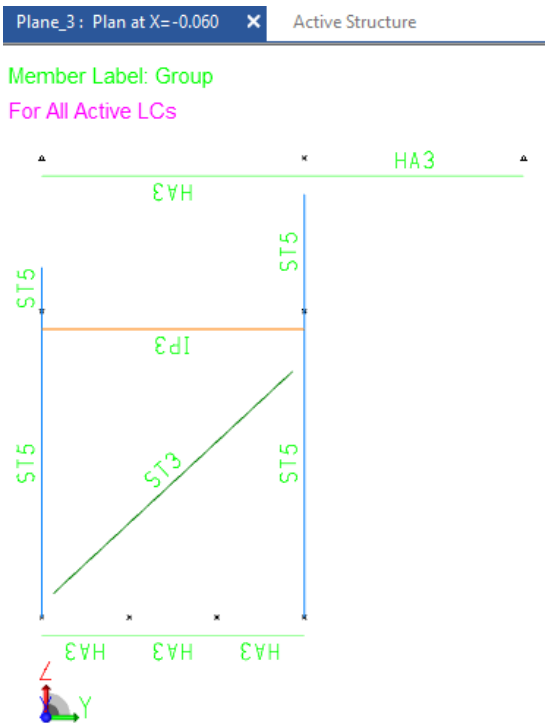

Joint Label: Name
For All Active LCs
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SC08
SC09
SC06
SC02
SC03
SC04
SC05
SC01
Y
X

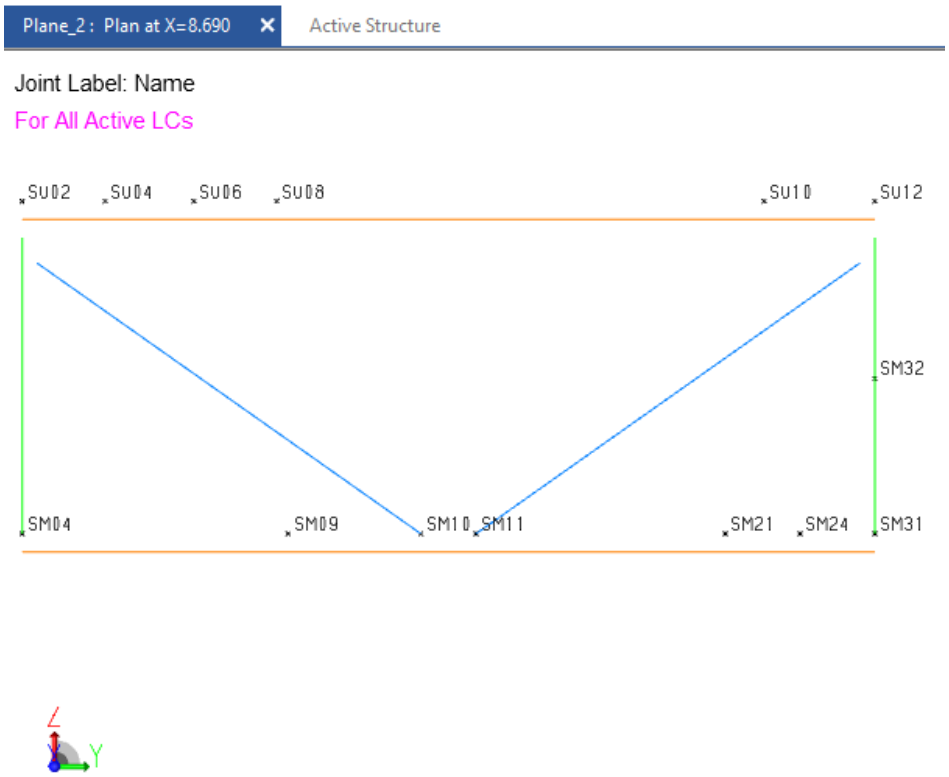

Plane_3 : Plan at Z=21.710
Active Structure
Member Label: Group
For All Active LCs
HA3 HA3 HA3 HA3
HA3 HA3 HA3
HA3
HA3
HA3 HA3
Y
X

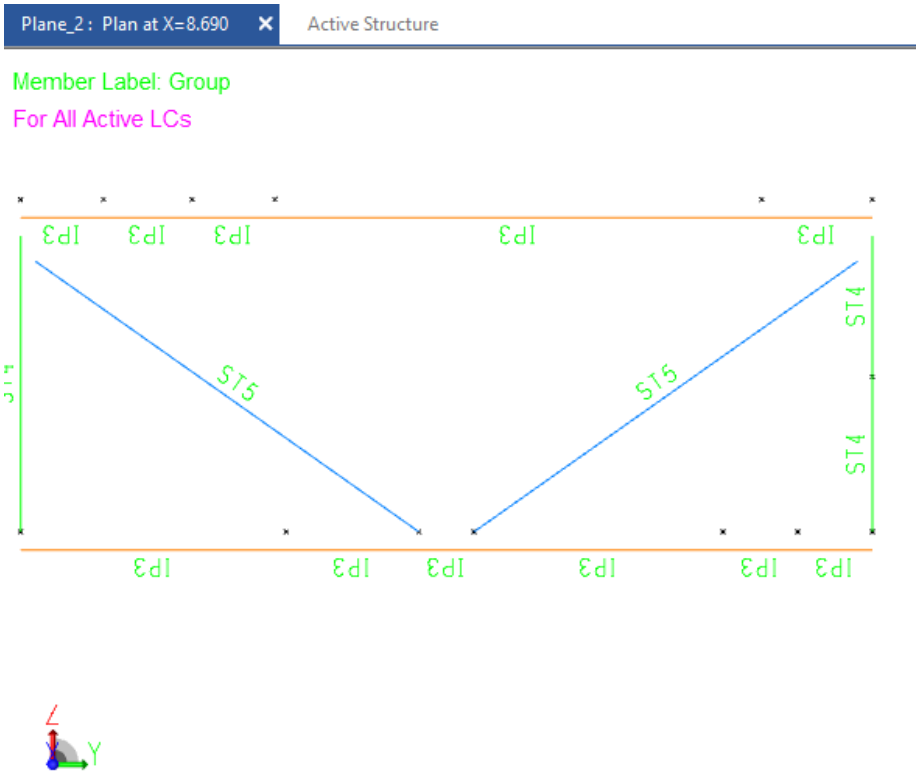

Plane_4 : Plan at Z=23.310
Joint Label: Name
For All Active LCs
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SU12
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SS07
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SU03
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SU01
SU02
Y
X

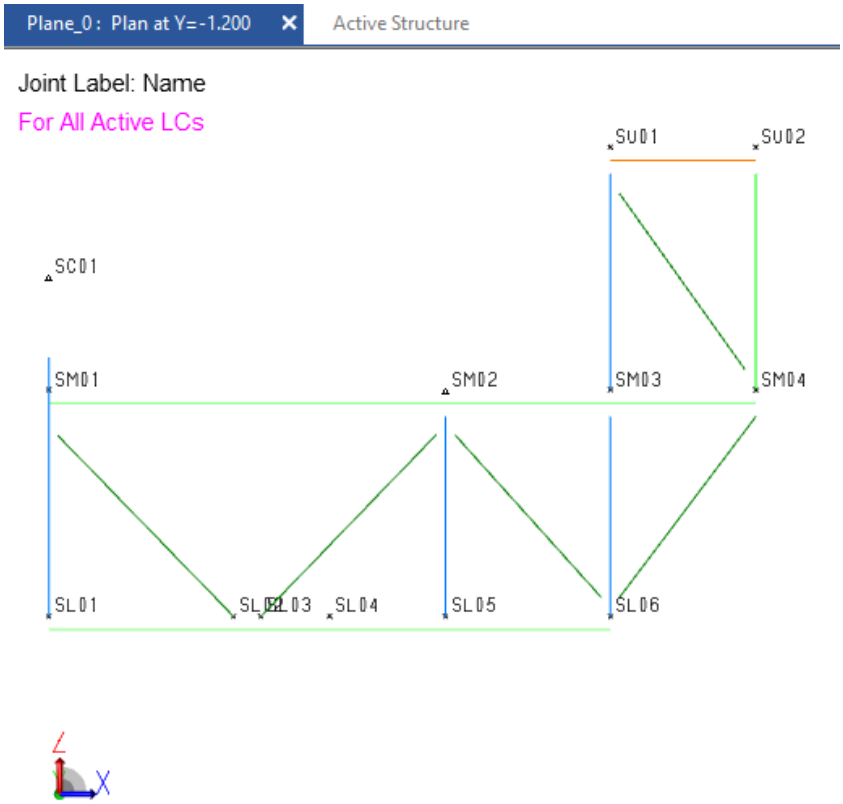

Plane_4 : Plan at Z=23.310
Member Label: Group
For All Active LCs
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UN2
Y
X

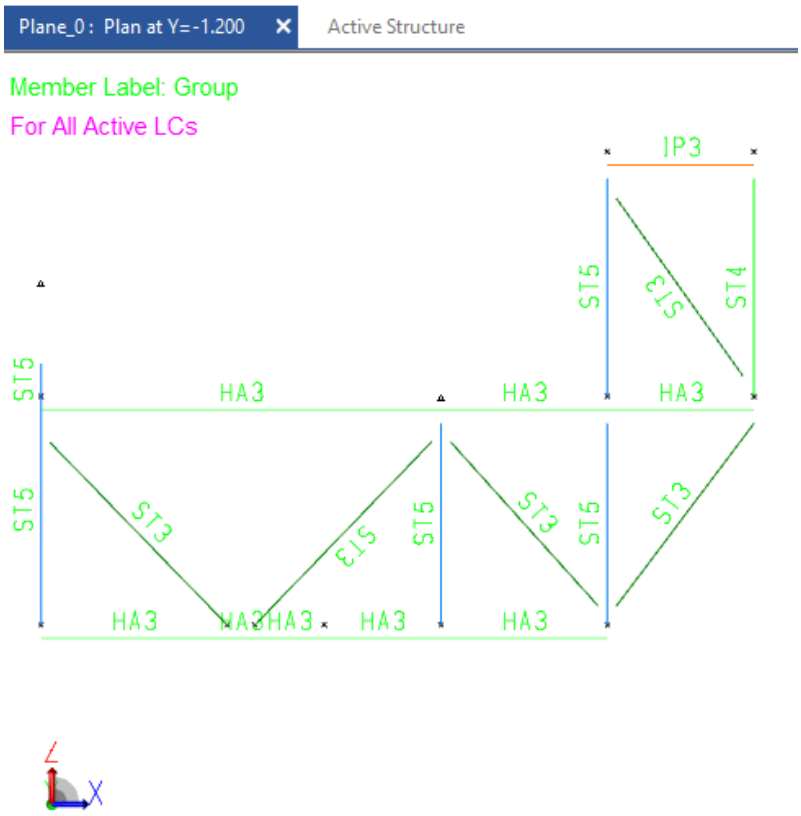

Plane_3 : Plan at X=-0.060
Active Structure
Joint Label: Name
For All Active LCs
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SC02
SC06
SM01
SM05
SL01
SL07
SL10
SL13
Z
Y

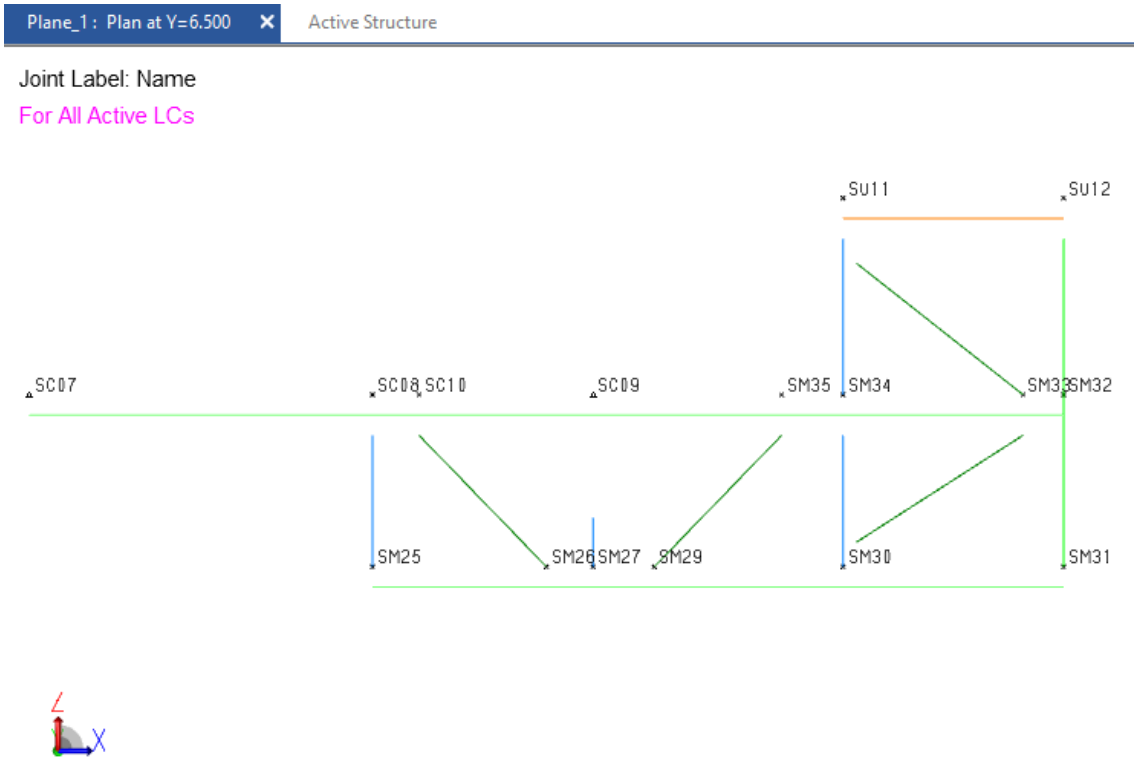

Plane_3 : Plan at X=-0.060
Active Structure
Member Label: Group
For All Active LCs
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ST5
ST5
IP3
ST5
ST3
ST5
HA3
HA3
HA3
Z
Y

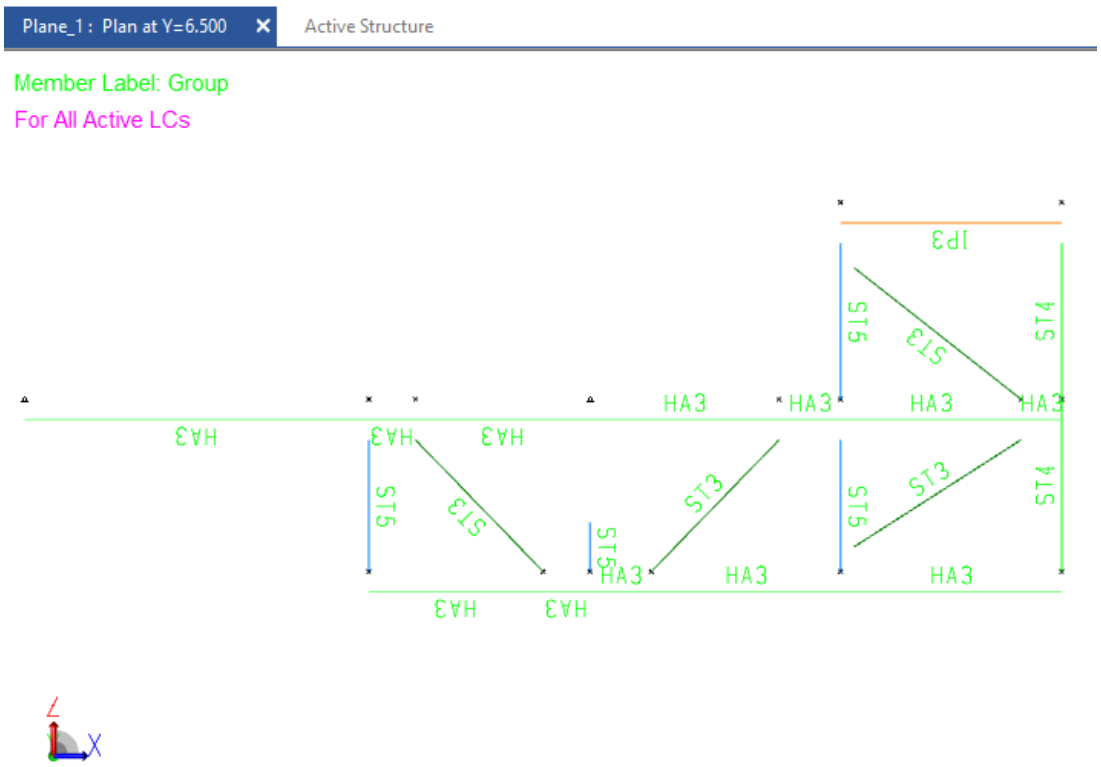

Plane_2 : Plan at X=8.690
Active Structure
Joint Label: Name
For All Active LCs
SU02
SU04
SU06
SU08
SU10
SU12
SM32
SM04
SM09
SM10
SM11
SM21
SM24
SM31
Z
Y

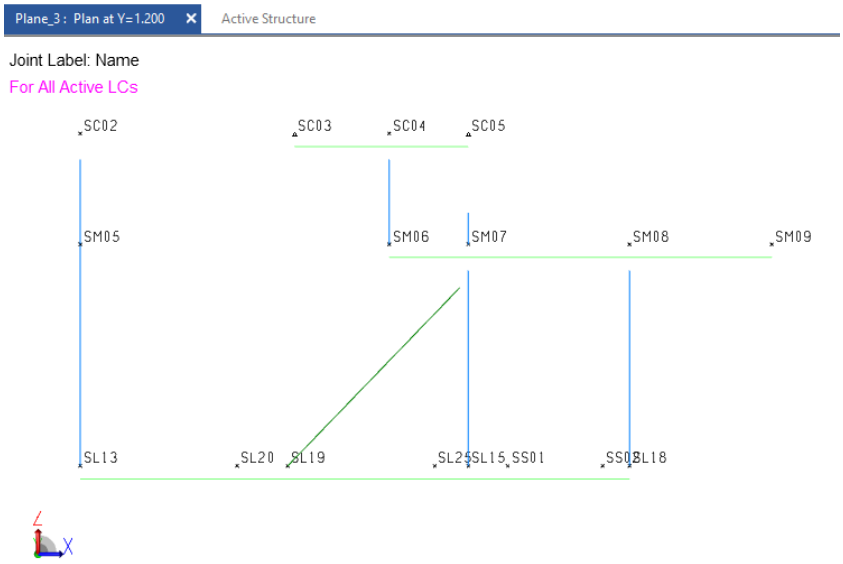

Plane_2 : Plan at X=8.690
Active Structure
Member Label: Group
For All Active LCs
ST5
ST5
ST4
ST4
Z
Y

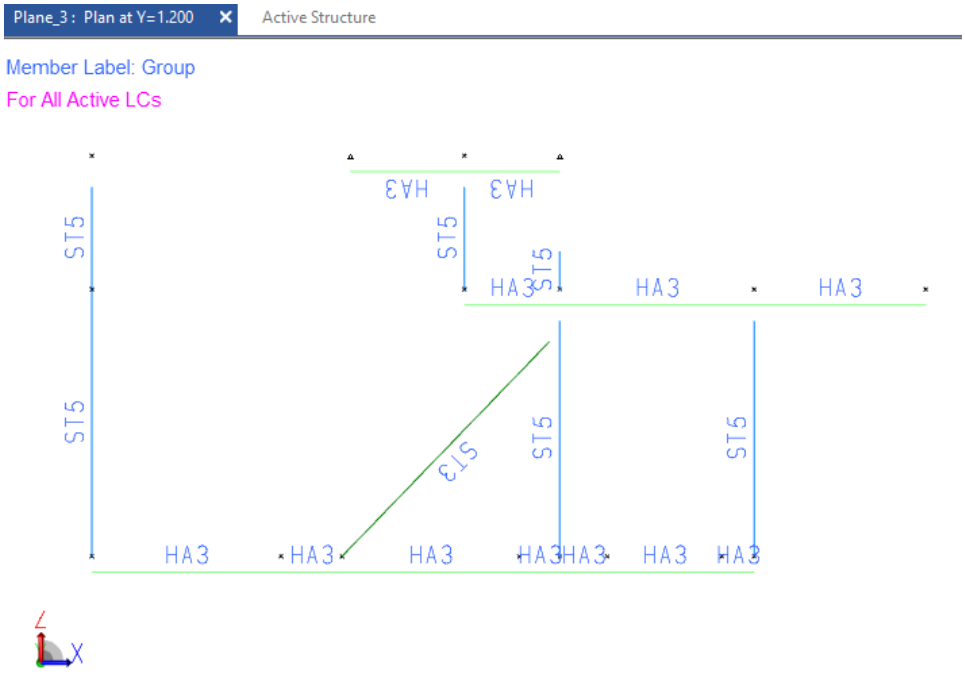

Plane_0 : Plan at Y=-1.200
Active Structure
Joint Label: Name
For All Active LCs
SU01
SU02
SC01
SM01
SM02
SM03
SM04
SL01
SL02
SL03
SL04
SL05
SL06
Z
X

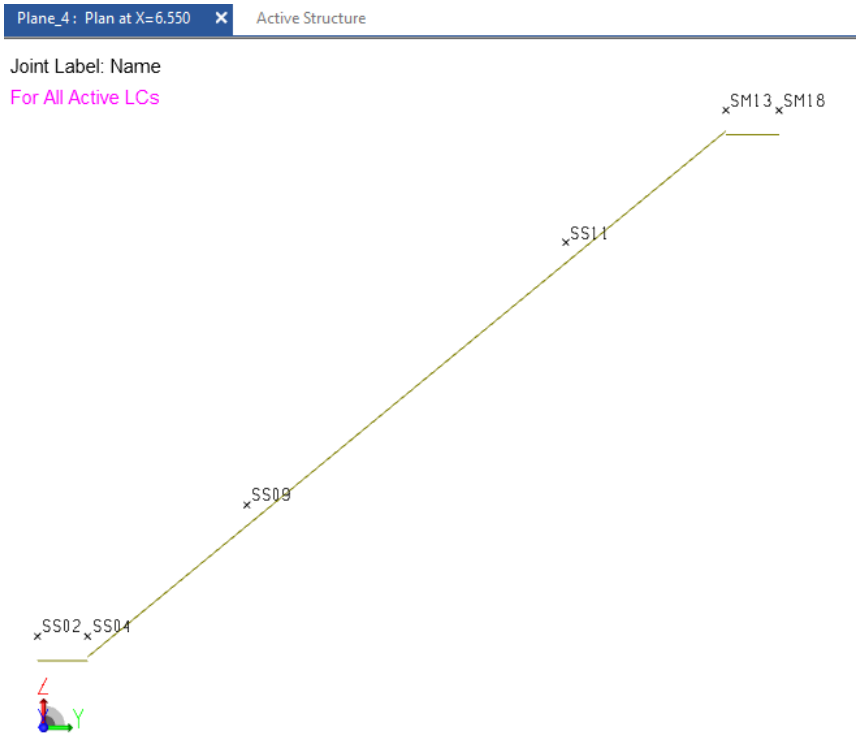

Plane_0 : Plan at Y=-1.200
Active Structure
Member Label: Group
For All Active LCs
IP3
ST5
ST3
ST4
HA3
ST5
ST5
ST3
ST3
ST5
ST5
ST3
HA3
HA3
HA3
HA3
HA3
Z
X

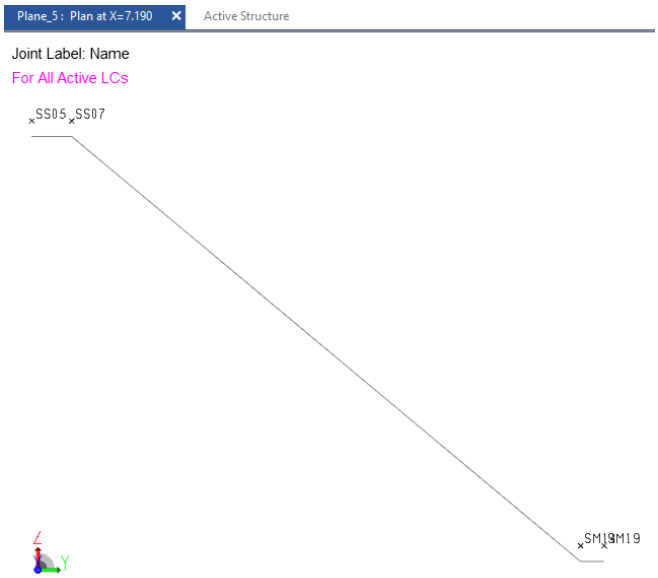

Plane_1 : Plan at Y=6.500
Active Structure
Joint Label: Name
For All Active LCs
SU11
SU12
SC07
SC08
SC10
SC09
SM35
SM34
SM33
SM32
SM25
SM26
SM27
SM29
SM30
SM31
Z
X

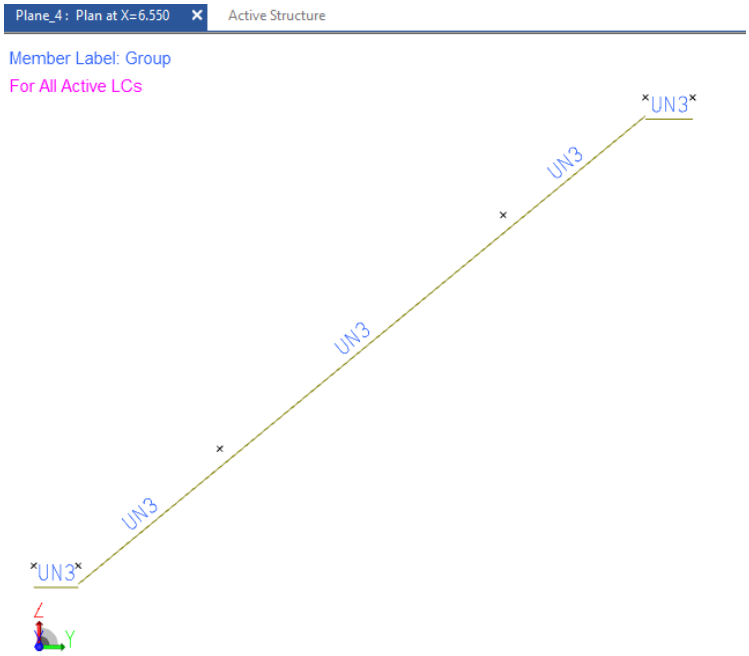

Plane_1 : Plan at Y=6.500
Active Structure
Member Label: Group
For All Active LCs
IP3
ST5
ST3
ST4
HA3
ST3
ST5
Z
X

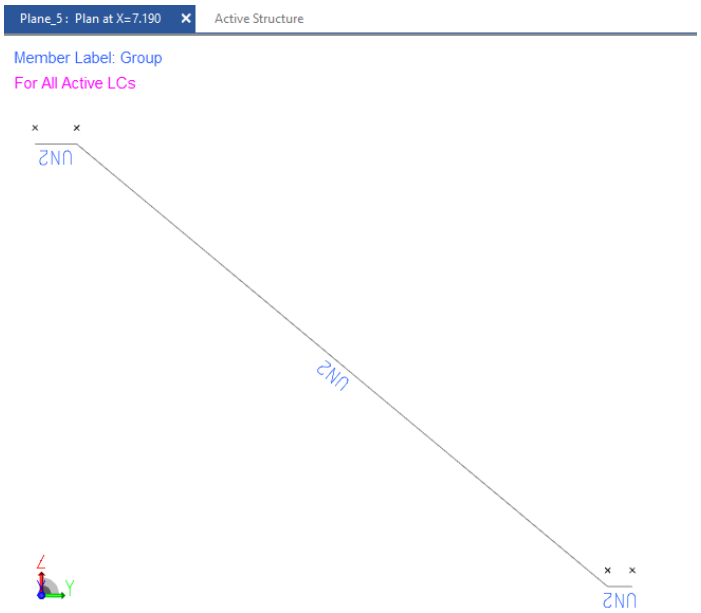

Plane_3 : Plan at Y=1.200
Active Structure
Joint Label: Name
For All Active LCs
SC02
SC03
SC04
SC05
SM05
SM06
SM07
SM08
SM09
SL13
SL20
SL19
SL25
SL15
SS01
SS02
SL18
X


Plane_3 : Plan at Y=1.200
Active Structure
Member Label: Group
For All Active LCs
HA3
ST5
ST3
X


Plane_4 : Plan at X=6.550
Active Structure
Joint Label: Name
For All Active LCs
SM13
SM18
SS11
SS09
SS02
SS04
Z
Y


Plane_5 : Plan at X=7.190
Active Structure
Joint Label: Name
For All Active LCs
SS05
SS07
SM19
Z
Y

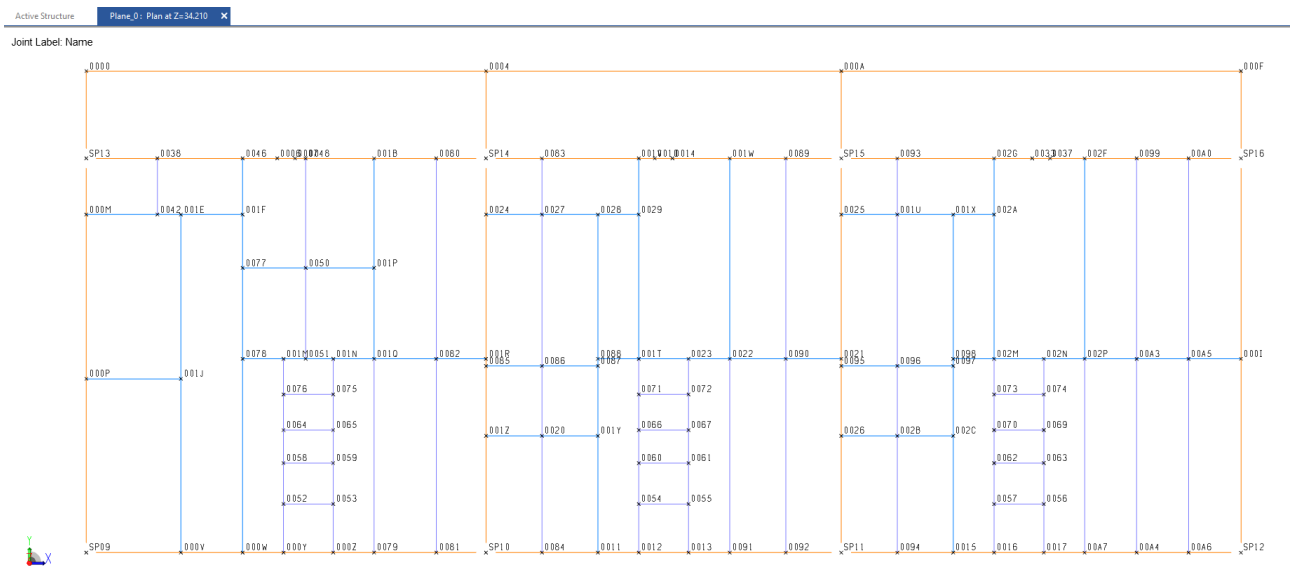

Plane_4 : Plan at X=6.550
Active Structure
Member Label: Group
For All Active LCs
UN3
UN3
UN3
UN3
Z
Y

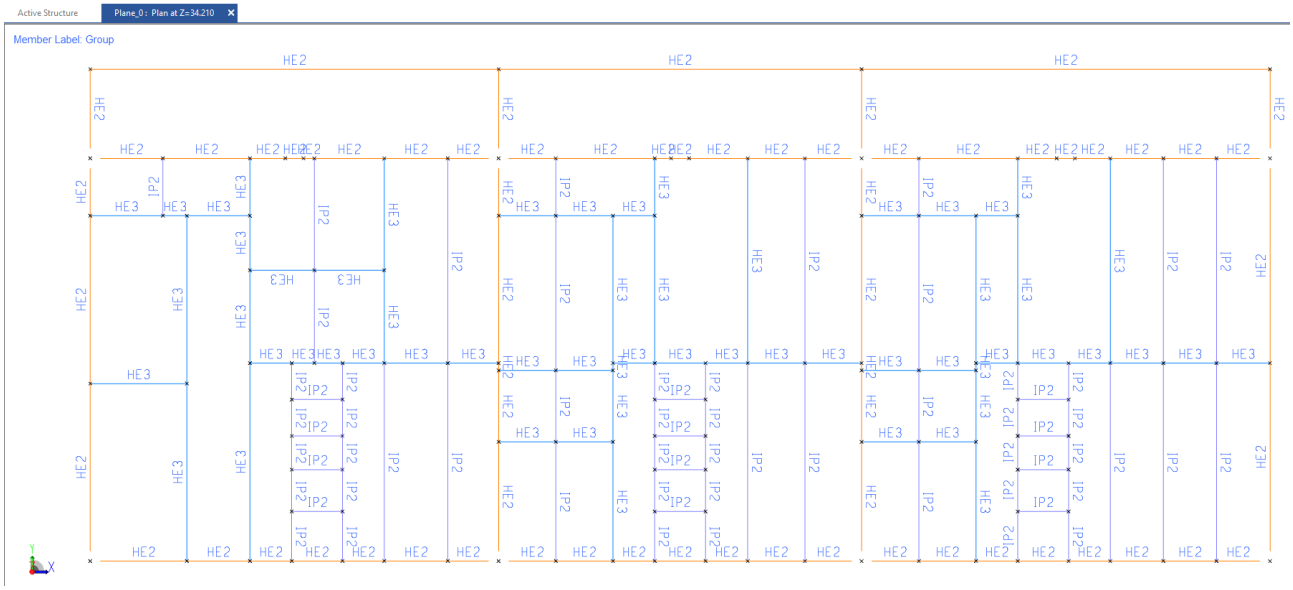

Plane_5 : Plan at X=7.190
Active Structure
Member Label: Group
For All Active LCs
UN2
UN2
UN2
Z
Y

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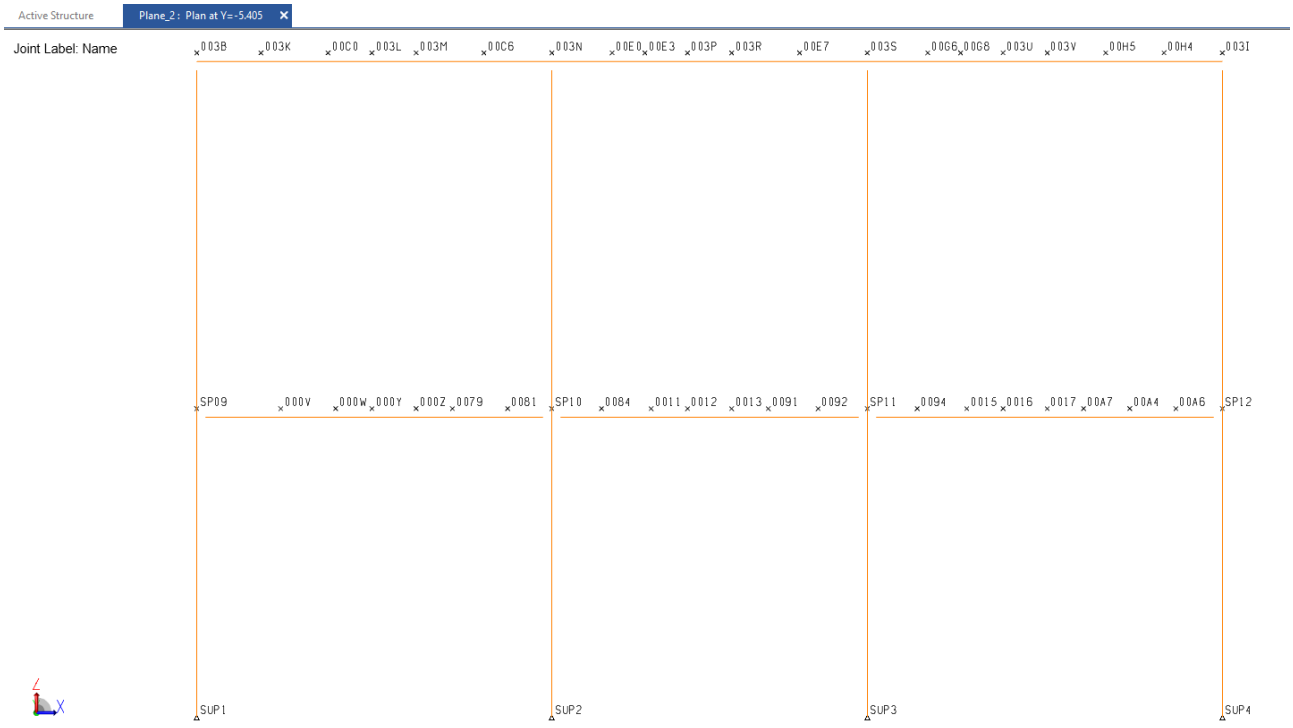
APPENDIX C – MEMBER AND JOINT LABELS FOR PAU STAIRS

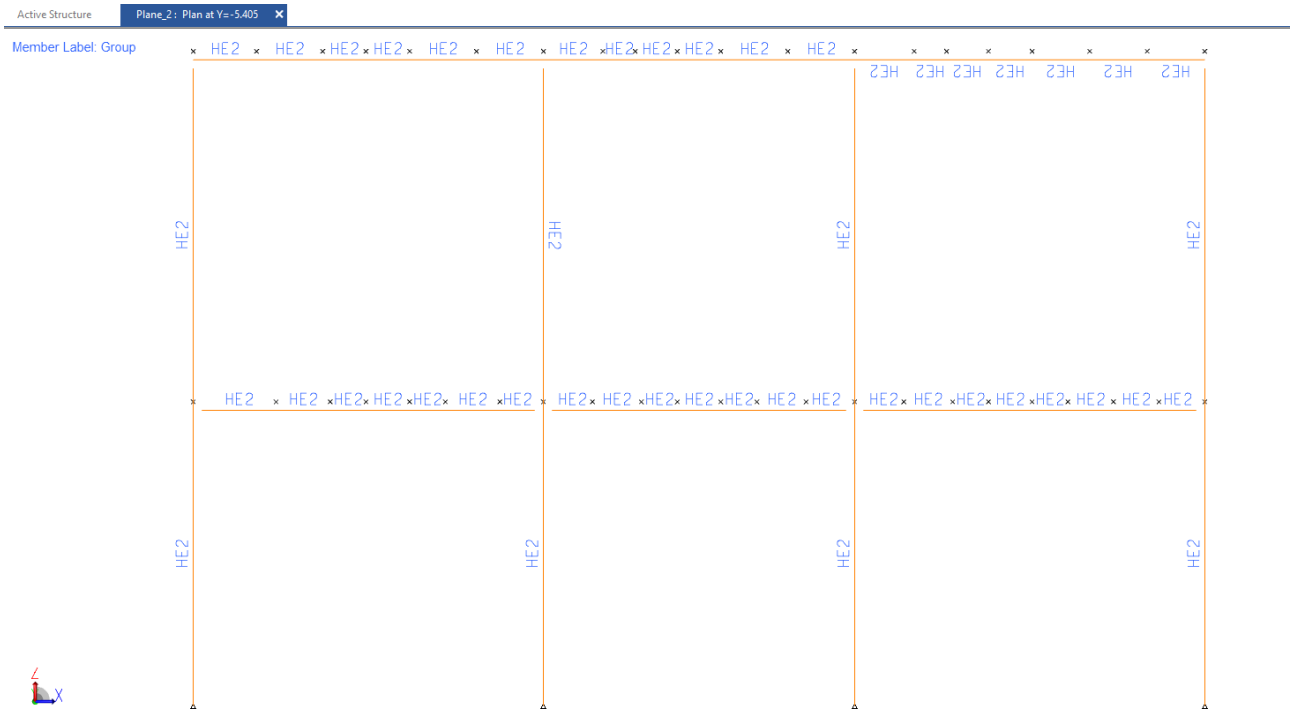
North Stairs

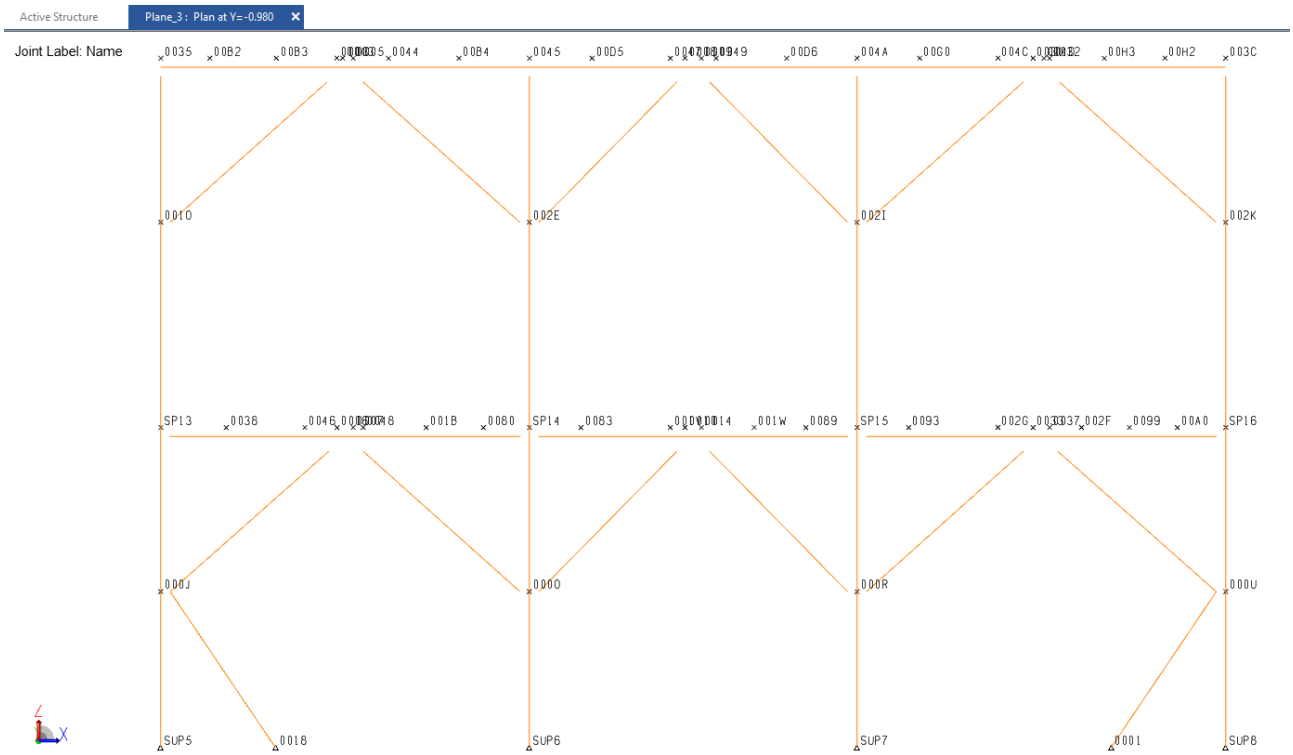


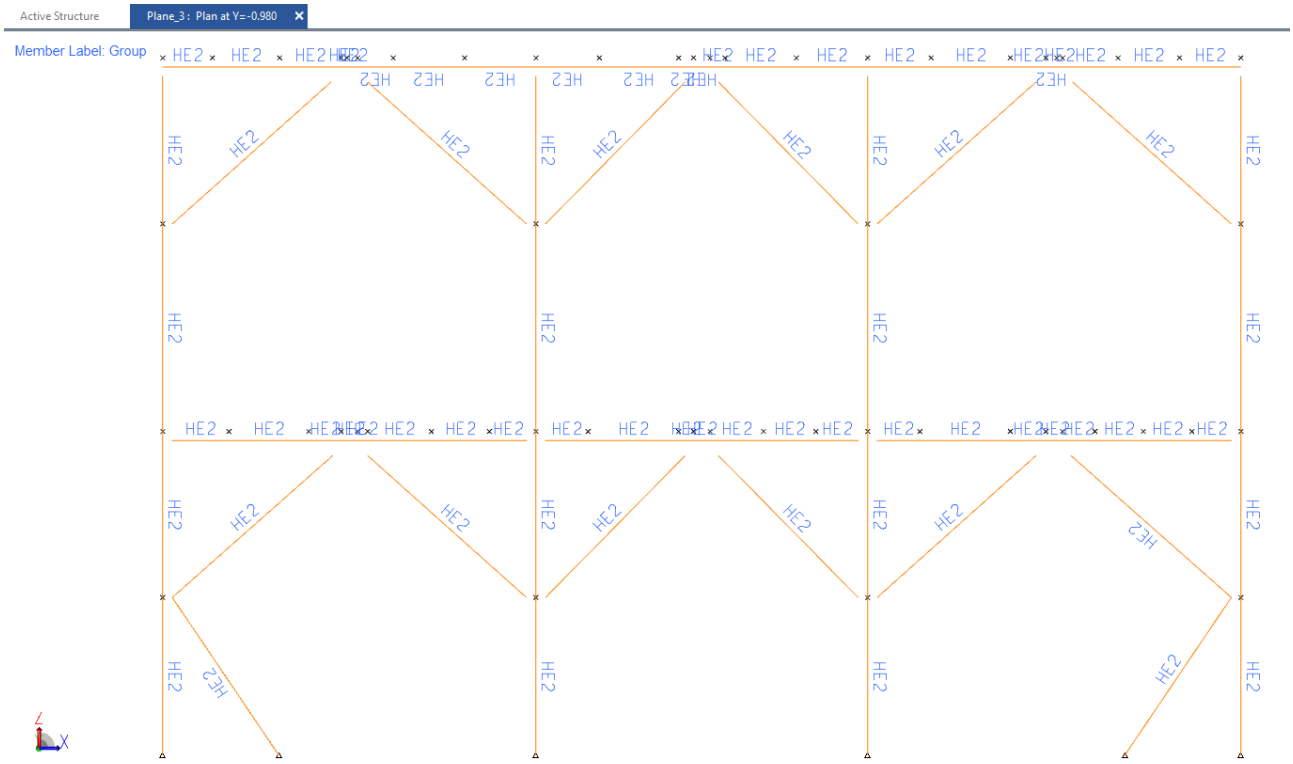


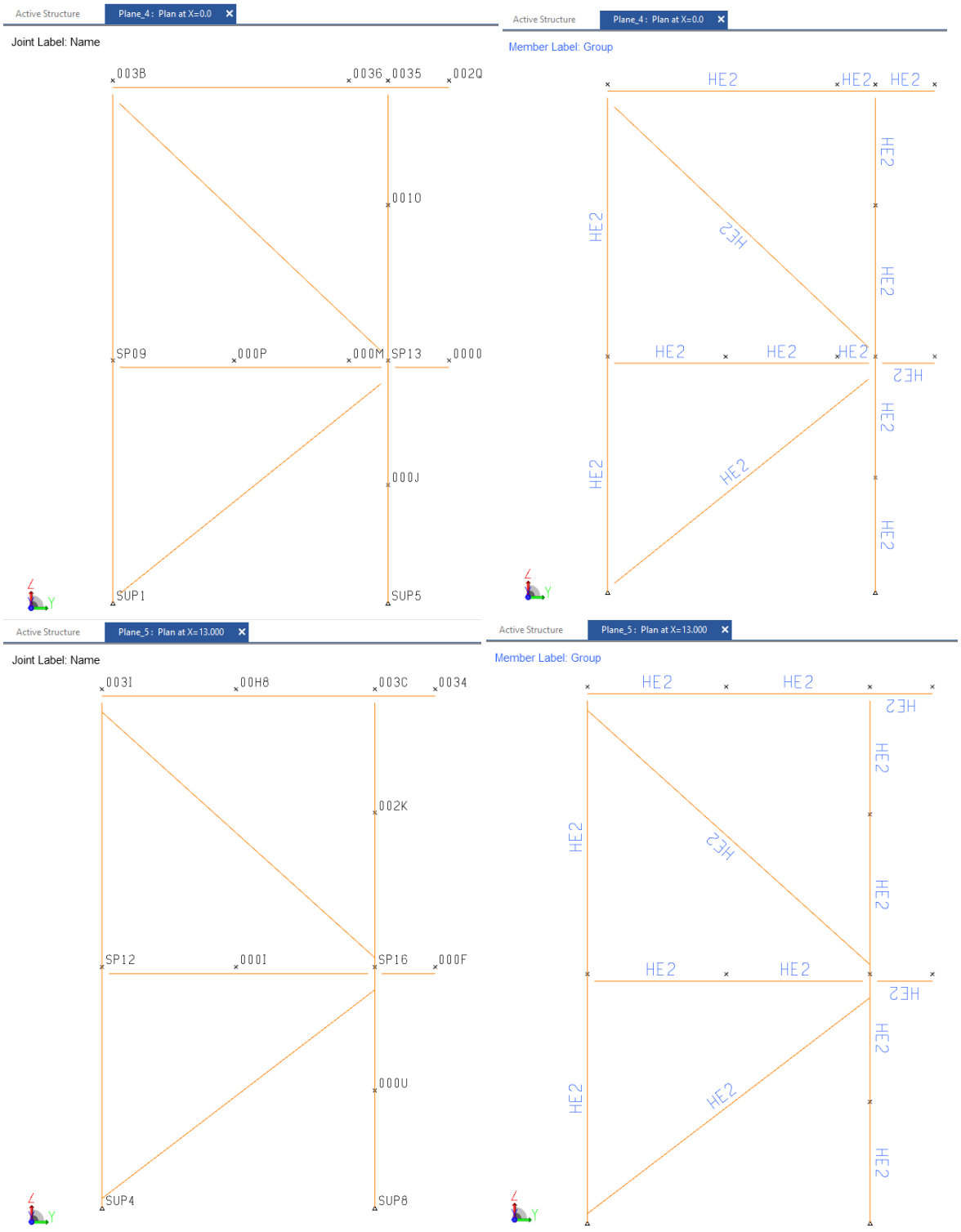

Active Structure
Plane_1 : Plan at Z=38.710
Joint Label: Name
Active Structure
Plane_1 : Plan at Z=38.710
Member Label: Group


Active Structure
Plane_2 : Plan at Y=-5.405
Joint Label: Name
SUP1
SUP2
SUP3
SUP4

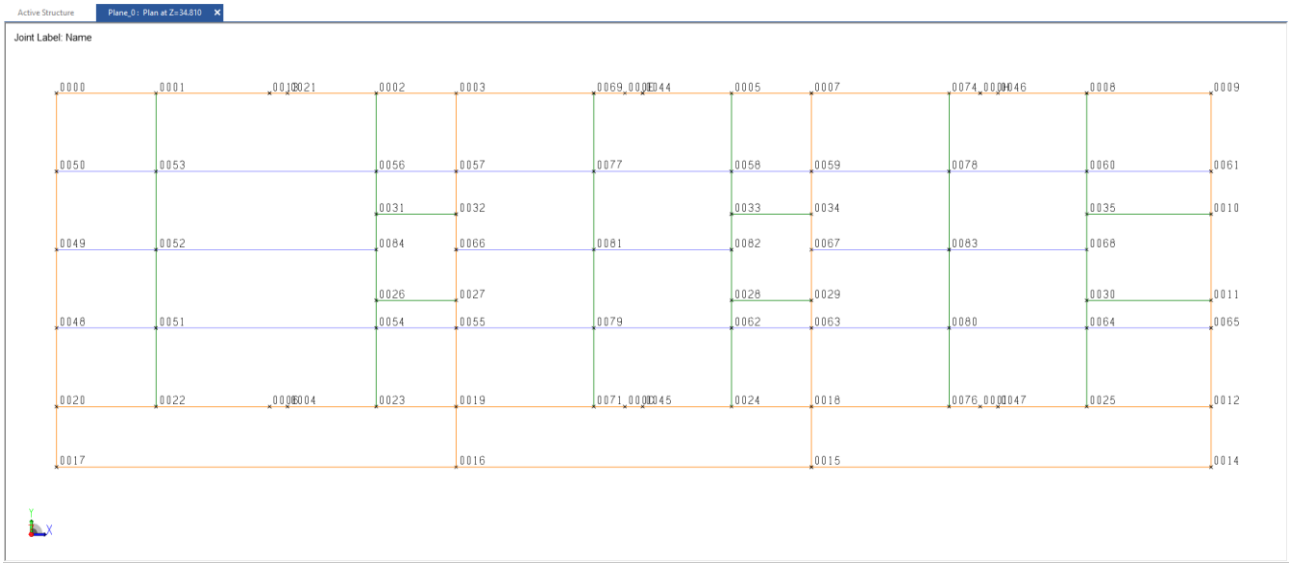

Active Structure
Plane_2 : Plan at Y=-5.405
Member Label: Group
HE2

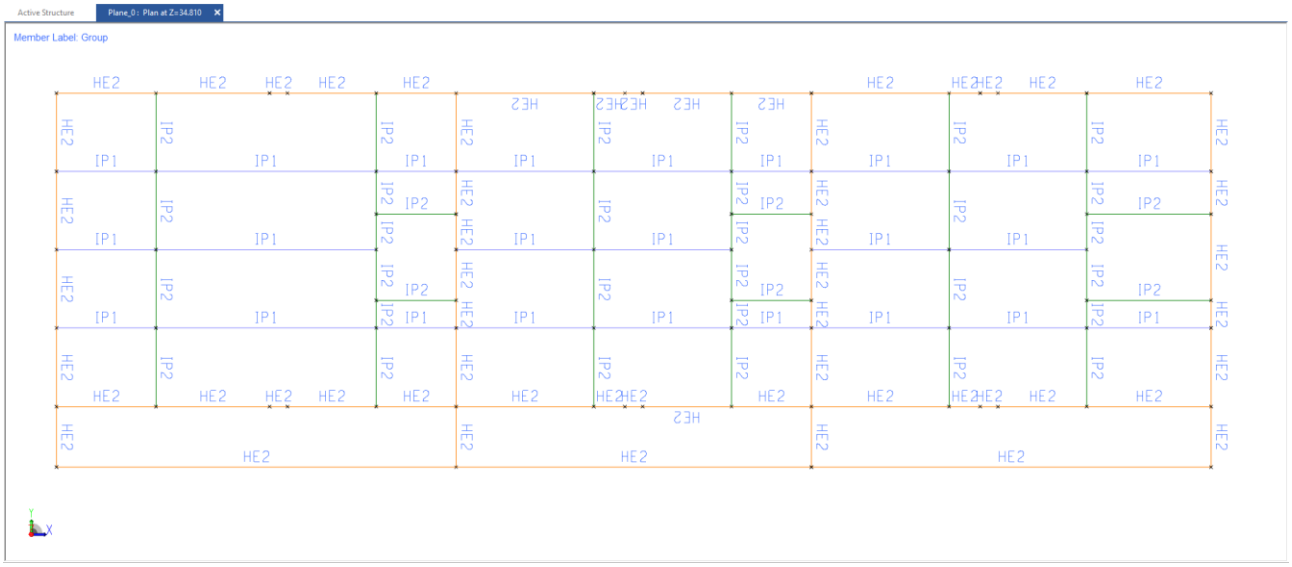

Active Structure
Plane_3 : Plan at Y=-0.980
Joint Label: Name
SP13
SP14
SP15
SP16
SUP5
SUP6
SUP7
SUP8

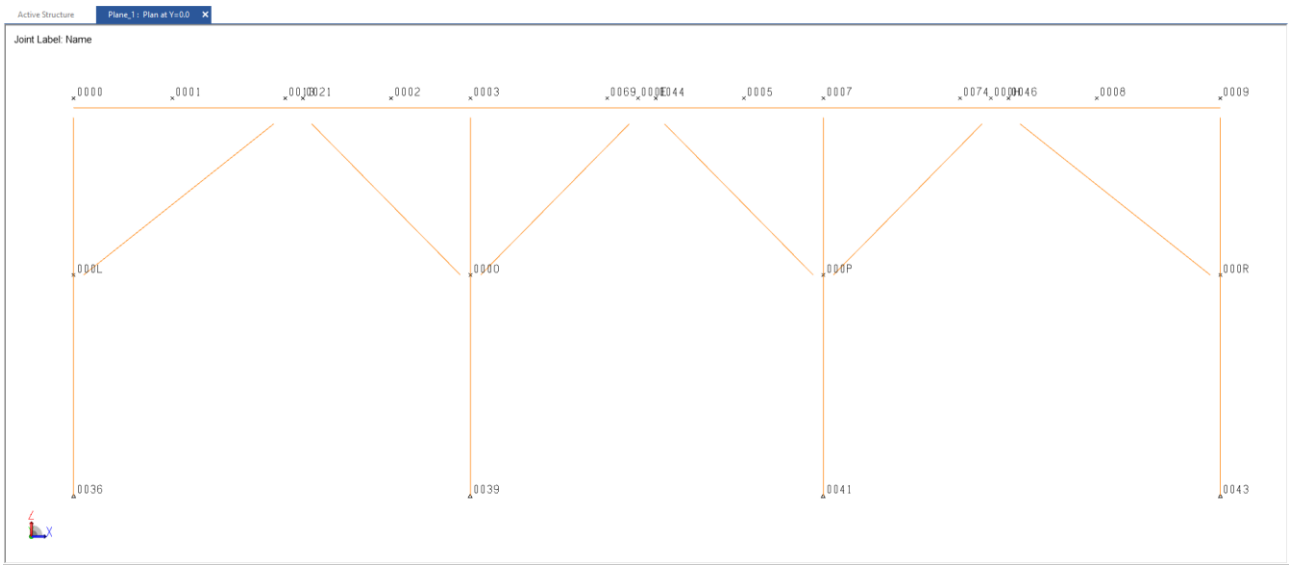

Active Structure
Plane_3 : Plan at Y=-0.980
Member Label: Group
HE2

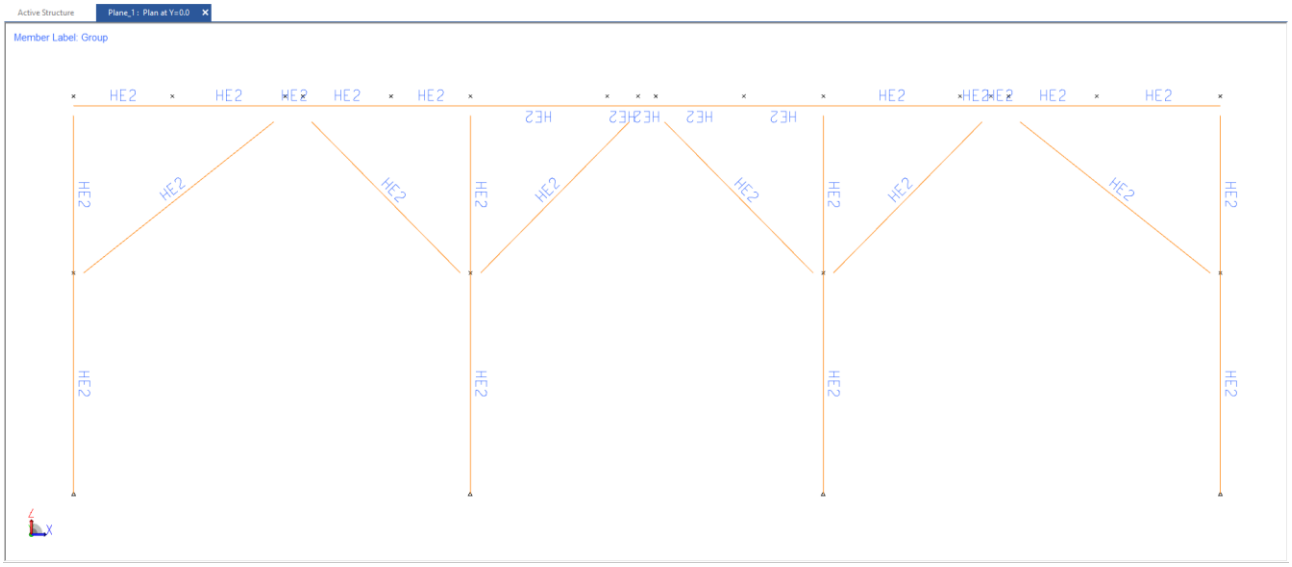

Active Structure
Plane_4 : Plan at X=0.0
Joint Label: Name
003B
0036
0035
002Q
0010
SP09
000P
000M
SP13
0000
000J
SUP1
SUP5
Active Structure
Plane_4 : Plan at X=0.0
Member Label: Group
HE2
Active Structure
Plane_5 : Plan at X=13.000
Joint Label: Name
0031
00H8
003C
0034
002K
SP12
0001
SP16
000F
000U
SUP4
SUP8
Active Structure
Plane_5 : Plan at X=13.000
Member Label: Group
HE2

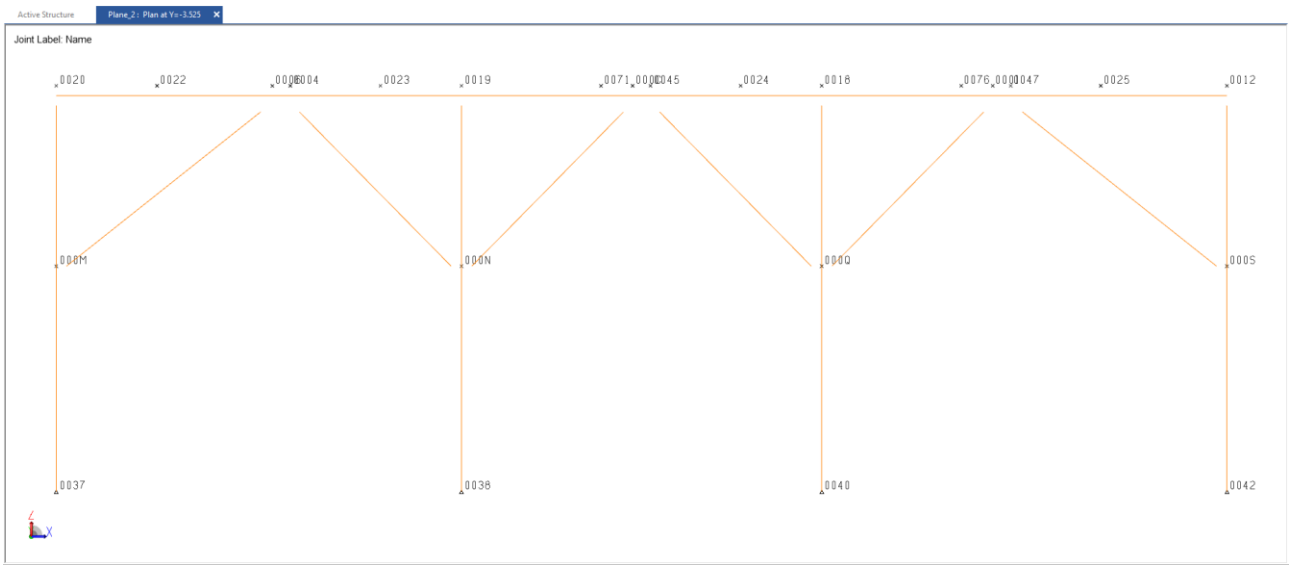
South Stairs

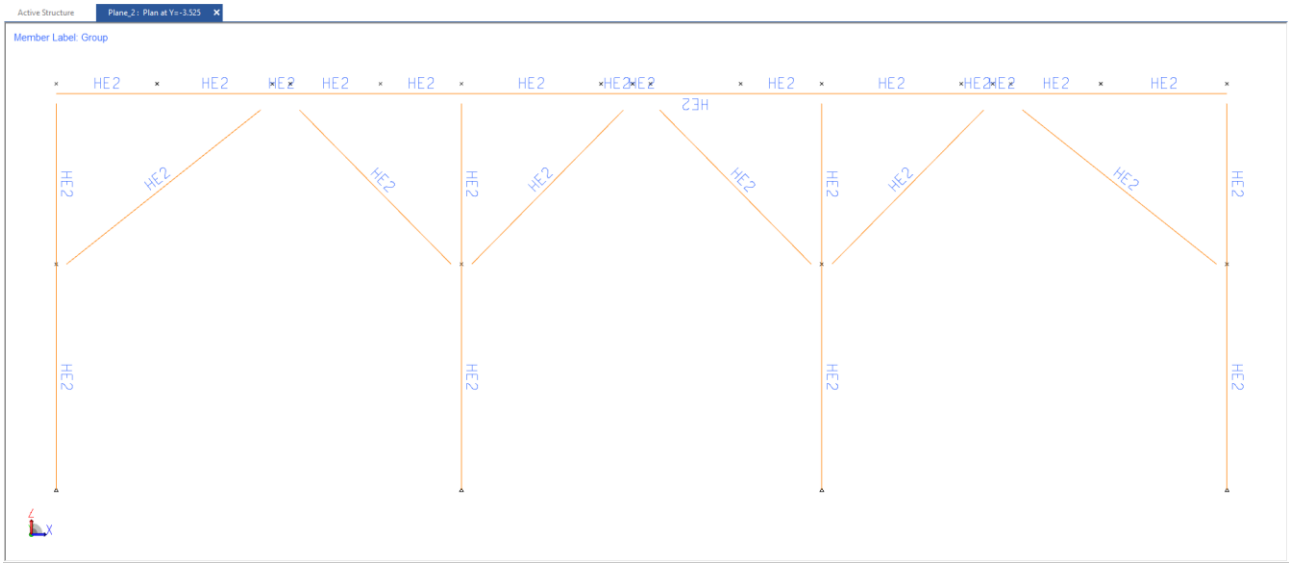


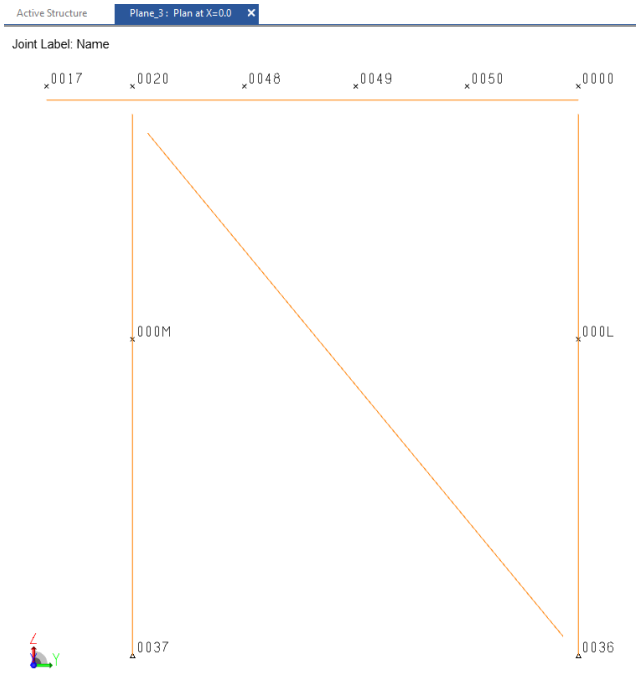


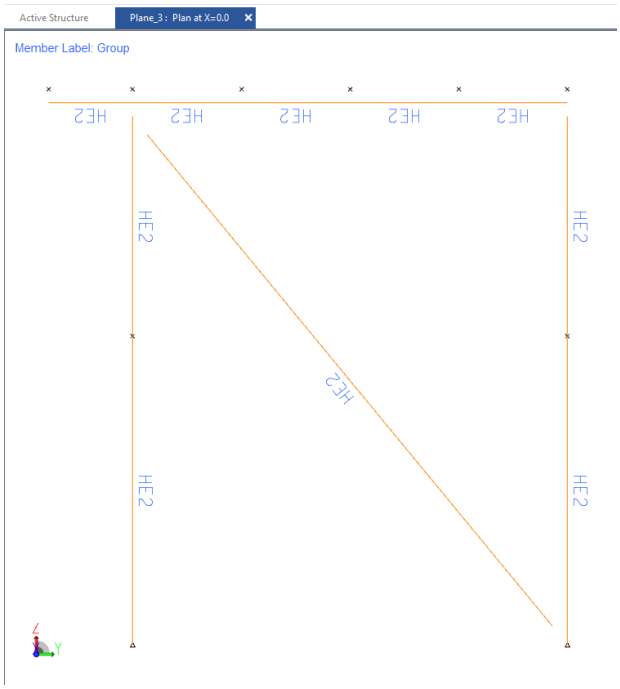

Active Structure
Plane_1 : Plan at Y=0.0
Joint Label: Name
0000
0001
0021
0002
0003
0044
0005
0007
0046
0008
0009
000L
0000
000P
000R
0036
0039
0041
0043

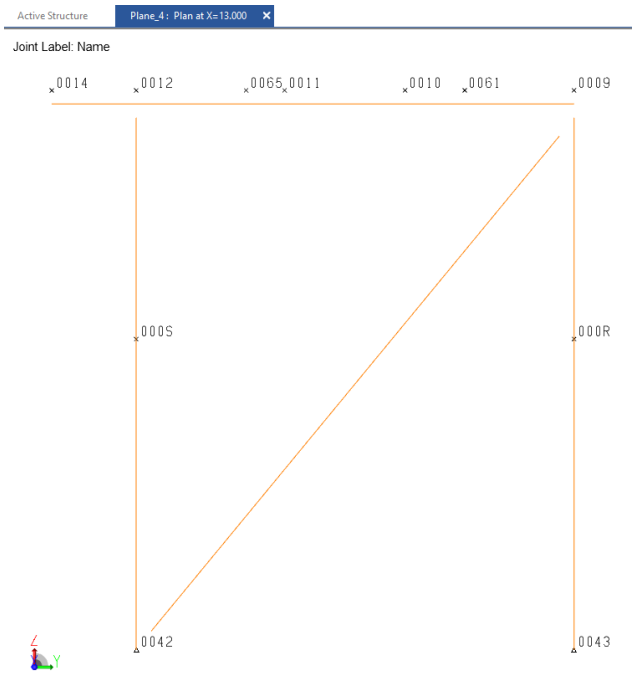

Active Structure
Plane_1 : Plan at Y=0.0
Member Label: Group
HE2

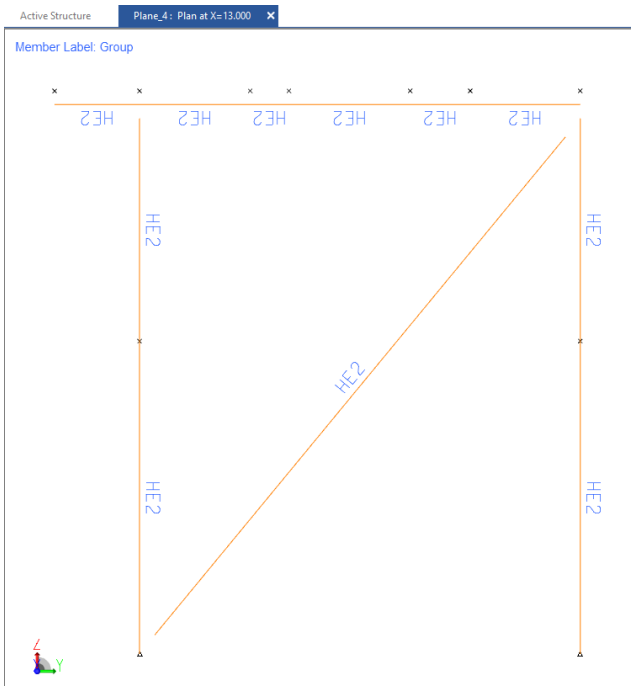

Active Structure
Plane_2 : Plan at Y=-3.525
Joint Label: Name
0020
0022
0004
0023
0019
0045
0024
0018
0047
0025
0012
0037
0038
0040
0042


Active Structure
Plane_2 : Plan at Y=-3.525
Member Label: Group
HE2


Active Structure
Plane_3 : Plan at X=0.0
Joint Label: Name
0017
0020
0048
0049
0050
0000
000M
000L
0037
0036


Active Structure
Plane_3 : Plan at X=0.0
Member Label: Group
HE2


Active Structure
Plane_4 : Plan at X=13.000
Joint Label: Name
0014
0012
0065
0011
0010
0061
0009
000S
000R
0042
0043


Active Structure
Plane_4 : Plan at X=13.000
Member Label: Group
HE2

APPENDIX D – EQUIPMENT SUPPORT DOCUMENTATION

Fuel Cell System reaction forces

40ft flatbed + 40ft container (CROSSWIND)							
Ultimate Limit State: LC15-LC18 - destination place (Offshore)							
40ft container + 40ft flatbed (max self-weight) LC15 MAX- Destination place - Offshore Wind X+				40ft container + 40ft flatbed (min self-weight) LC15 MIN - Destination place - Offshore Wind X+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-67	2	58	A	-61	3	48
B	-69	-4	99	B	-63	-4	83
C	-	-	84	C	-	-	63
D	-	-	102	D	-	-	78
E	1	10	71	E	-7	6	51
F	-23	-8	20	F	-27	-4	9
40ft container + 40ft flatbed (max self-weight) LC16 MAX- Destination place - Offshore Wind Y+				40ft container + 40ft flatbed (min self-weight) LC16 MIN - Destination place - Offshore Wind Y+			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	65	-95	-260	A	71	-95	-275
B	-115	-82	362	B	-108	-81	347
C	-	-	103	C	-	-	92
D	-	-	105	D	-	-	80
E	-4	-65	-38	E	-12	-69	-61
F	53	-95	158	F	50	-92	149
40ft container + 40ft flatbed (max self-weight) LC17 MAX- Destination place - Offshore Wind X-				40ft container + 40ft flatbed (min self-weight) LC17 MIN - Destination place - Offshore Wind X-			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	16	-7	26	A	21	-6	17
B	13	6	39	B	19	6	21
C	-	-	97	C	-	-	76
D	-	-	102	D	-	-	78
E	69	24	91	E	61	20	72
F	60	-24	78	F	56	-20	66
40ft container + 40ft flatbed (max self-weight) LC18 MAX- Destination place - Offshore Wind Y-				40ft container + 40ft flatbed (min self-weight) LC18 MIN - Destination place - Offshore Wind Y-			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-117	90	332	A	-111	91	323
B	60	83	-237	B	67	83	-257
C	-	-	98	C	-	-	76
D	-	-	119	D	-	-	106
E	73	98	189	E	65	94	172
F	-17	66	-72	F	-21	69	-88

40ft flatbed + 40ft container (CROSSWIND)							
Ultimate Limit State: LC7-LC14 - sea transport on barge							
40ft container + 40ft flatbed (max self-weight) LC7 MAX: Sea transport on the barge Head sea, bow down, Y+ [Pitch case 1]				40ft container + 40ft flatbed (min self-weight) LC7 MIN: Sea transport on the barge Head sea, bow down, Y+ [Pitch case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	39	-75	-158	A	65	-72	-217
B	-103	-63	300	B	-76	-63	234
C	-	-	113	C	-	-	53
D	-	-	130	D	-	-	24
E	11	-42	27	E	-24	-60	-70
F	53	-83	138	F	35	-67	93
40ft container + 40ft flatbed (max self-weight) LC8 MAX: Sea transport on the barge Quatering sea, bow down, X+ Y+ [Quatering 1]				40ft container + 40ft flatbed (min self-weight) LC8 MIN: Sea transport on the barge Quatering sea, bow down, X+ Y+ [Quatering 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-64	-39	-60	A	42	37	98
B	-153	-49	263	B	-131	-50	207
C	-	-	101	C	-	-	34
D	-	-	127	D	-	-	41
E	-45	-33	30	E	-74	-48	-42
F	-37	-44	85	F	-52	-30	21
40ft container + 40ft flatbed (max self-weight) LC9 MAX: Sea transport on the barge Beam sea, X+ [Roll case 1]				40ft container + 40ft flatbed (min self-weight) LC9 MIN: Sea transport on the barge Beam sea, X+ [Roll case 1]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-130	9	80	A	-111	10	48
B	-131	-12	141	B	-111	-13	90
C	-	-	99	C	-	-	31
D	-	-	124	D	-	-	47
E	-44	2	70	E	-70	-11	-10
F	-78	2	-4	F	-92	13	-41
40ft container + 40ft flatbed (max self-weight) LC10 MAX: Sea transport on the barge Quatering sea, stern down, X+ Y- [Quatering 2]				40ft container + 40ft flatbed (min self-weight) LC10 MIN: Sea transport on the barge Quatering sea, stern down, X+ Y- [Quatering 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-154	51	206	A	-132	53	172
B	-67	31	-6	B	-44	31	-65
C	-	-	105	C	-	-	30
D	-	-	126	D	-	-	49
E	-4	46	127	E	-32	32	61
F	-74	37	-39	F	-90	49	-82
40ft container + 40ft flatbed (max self-weight) LC11 MAX: Sea transport on the barge Head sea, stern down, Y- [Pitch case 2]				40ft container + 40ft flatbed (mix self-weight) LC11 MIN: Sea transport on the barge Head sea, stern down, Y- [Pitch case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	-104	68	265	A	-79	71	225
B	33	65	-126	B	61	64	-164
C	-	-	118	C	-	-	23
D	-	-	130	D	-	-	59
E	77	85	178	E	43	67	101
F	-6	43	-13	F	-26	59	-79
40ft container + 40ft flatbed (max self-weight) LC12 MAX: Sea transport on the barge Quatering sea, stern down, X- Y- [Quatering 3]				40ft container + 40ft flatbed (min self-weight) LC12 MIN: Sea transport on the barge Quatering sea, stern down, X- Y- [Quatering 3]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	0	33	161	A	22	35	129
B	88	51	-101	B	111	51	-166
C	-	-	118	C	-	-	41
D	-	-	120	D	-	-	51
E	129	75	164	E	101	61	99
F	81	6	60	F	66	19	10
40ft container + 40ft flatbed (max self-weight) LC13 MAX: Sea transport on the barge Beam sea, X- [Roll case 2]				40ft container + 40ft flatbed (min self-weight) LC13 MIN: Sea transport on the barge Beam sea, X- [Roll case 2]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	69	-14	19	A	88	-13	-13
B	66	14	9	B	87	13	-31
C	-	-	115	C	-	-	47
D	-	-	117	D	-	-	40
E	126	39	120	E	100	25	60
F	122	-38	120	F	107	-27	83
40ft container + 40ft flatbed (max self-weight) LC14 MAX: Sea transport on the barge Quatering sea, stern down, X- Y+ [Quatering 4]				40ft container + 40ft flatbed (min self-weight) LC14 MIN: Sea transport on the barge Quatering sea, stern down, X- Y+ [Quatering 4]			
Reactions	X [kN]	Y [kN]	Z [kN]	Reactions	X [kN]	Y [kN]	Z [kN]
A	92	-57	-108	A	113	-55	-150
B	1	-29	170	B	24	-30	116
C	-	-	113	C	-	-	53
D	-	-	120	D	-	-	35
E	88	-5	70	E	59	-20	-5
F	119	-74	154	F	104	-61	116

Twist Lock Certification

DNV

Certificate No:
TAS00003Z5

TYPE APPROVAL CERTIFICATE

This is to certify:

That the Cargo Securing Devices

with type designation(s)
Dovetail Twistlock 45° BD-D1

Issued to
General Lashing System (China) Co., Ltd.
Ningbo, China

is found to comply with
DNV rules for classification – Ships

Application :

Product(s) approved by this certificate is/are accepted for installation on all vessels classed by DNV.

SWL, tension (kN)	**250**
SWL, shear (kN)	**210**
SWL, compr. (kN)	**1000**

Issued at **Hamburg** on **2023-08-23**

This Certificate is valid until **2028-08-22**.
DNV local unit: **Ningbo FIS**

Approval Engineer: **Aadil Wafdi**

for **DNV**

DNV
Digitally Signed By: Abt, Daniel
Location: DNV Hamburg, Germany
Signing Date: 2023-08-25 , on behalf of

Andree Orth
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid.
The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

LEGAL DISCLAIMER: Unless otherwise stated in the applicable contract with the holder of this document, or following from mandatory law, the liability of DNV AS, its parent companies and their subsidiaries as well as their officers, directors and employees ("DNV") arising from or in connection with the services rendered for the purpose of the issuance of this document or reliance thereon, whether in contract or in tort (including negligence), shall be limited to direct losses and under any circumstance be limited to 300,000 USD.

DNV

Job Id: **262.1-028785-8**
Certificate No: **TAS00003Z5**

Product description

Dovetail Twistlock

Application/Limitation

Load	Tension [kN]	Shear [kN]	Compression [kN]
Test Load	313	263	1250
Breaking Load	500	420	2000

Tests to be carried out:

- Production testing: At least 2% of the items delivered are to be selected and subjected to the test load.
- Material tests are to be included energy testing at -20°C, with the impact energy requirements acc. to DNV-CP-0068. The material shall be according to the approved drawings. Material certificates shall be 3.1 acc. to ISO 10474:2013.

Type Approval documentation

Drawing No.	Rev.	Title
BD-D1/R		Dovetail Twistlock (45°)
BD-D1/L		Dovetail Twistlock (45°)
BD-D1/01		Slide Twistlock Base
BD-D1/E/03		Shaft
BD-D1/02		Handle
BD-D1/(04) (05)		Part

Drawing approval: Ref.No. 262.1-028785-8, dated 2023-08-16
Test report No.: DNV-CP-0068 dated 2023-07-20

Tests carried out

The prototype test was carried out in Nanjing, P.R. China, dated 2023-07-20 in accordance with the DNV-CP-0068.

Marking of product

Each item shall be marked by manufacturer for traceability.

Periodical Assessment

For retention of the Type Approval, a DNV surveyor shall perform a survey after 2 and 3.5 years, to verify that the Type Approval is complied with.

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