Base Load Power Hub (BLPH)

CAISSON FRAME – Grillage and Sea Fastening 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.

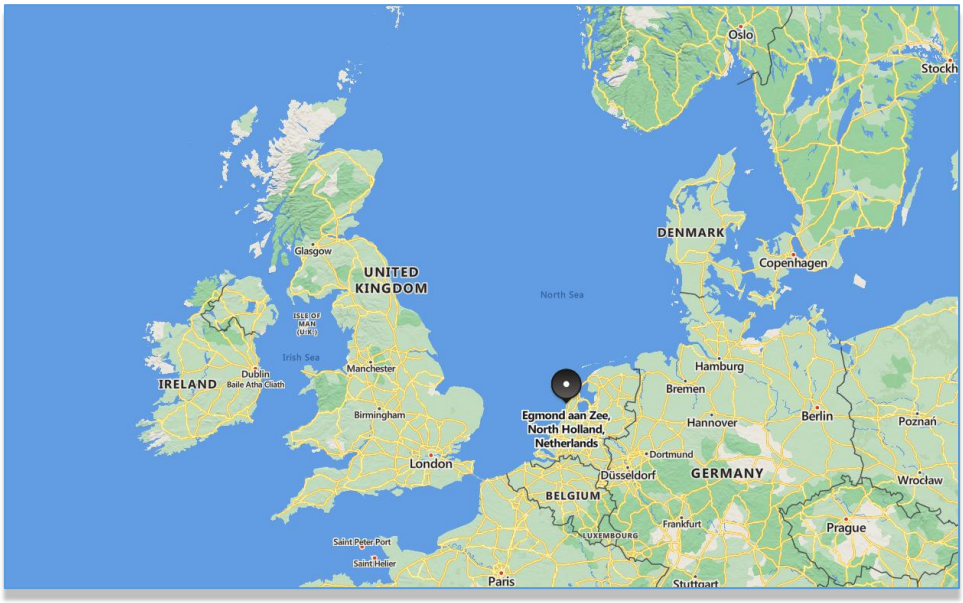


Figure 1.1 HOLLANDSE KUST NOORD WIND PARK Location Map

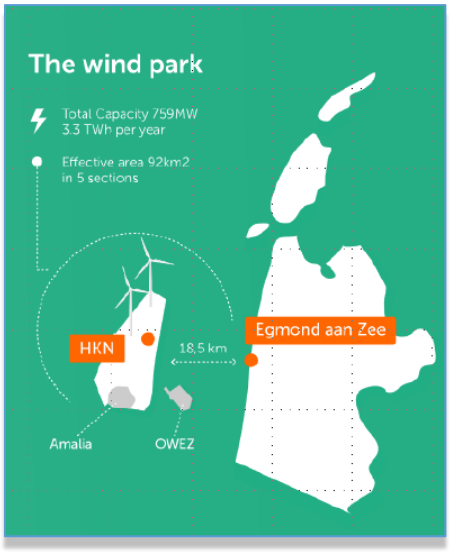


Figure 1.2 - Wind Park Details

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.

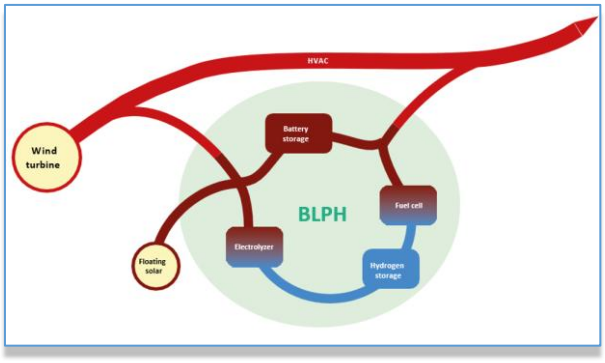


Figure 1.3 – BLPH Concept

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

The objective of this report is to present the results of the Grillage and Sea Fastening elements of the Caisson Frame (CF) of the BLPH platform during sea transportation to the installation site.

Structural checks of the CF during transportation are detailed in a separate report, ref./24/.

The CF will be loaded out on 300ft barge, by means of yard crane, with its longitudinal axis aligned with barge long. axis.

The analysis has been performed in compliance with the requirements, criteria and parameters reported in the Structural Design Premises, Ref./19/.

Transportation analysis is performed in accordance with DNV-ST-N001, Ref./9/ motion criteria for unrestricted tow.

Structural Code checks are performed according to EN ISO 19902 for tubular members and tubular joints, Ref./6/, and according to Eurocode 3 for non-tubular structural elements, Ref./8/.

All structural analyses have been carried out using the structural analysis program SACS, the proprietary software developed by Bentley, Ref. /32/.

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

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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 19901-3	Specific requirements for offshore structures – Part 3: Topsides structure - 2014
/4/ BS EN ISO 19901-5	Specific requirements for offshore structures – Part 5: Weight Management - 2021
/5/ BS EN ISO 19901-6	Specific requirements for offshore structures – Part 6: Marine Operations – 2009
/6/ BS EN ISO 19902	Petroleum and natural gas industries - Fixed steel offshore structures – 2020
/7/ ISO 19906:2019	Petroleum and natural gas industries – Arctic offshore structures
/8/ UNI EN 1993-1-1	Design of steel structures - Part 1-1: General rules and rules for buildings
/9/ DNV-ST-N001	DNV - Marine operation and marine warranty - 2021
/10/ DNV-ST-0145	DNV, Offshore substations
/11/ DNV-RP-C201	DNV, Buckling Strength of Plated Structures, October 2010.
/12/ DNV-RP-C203	DNV, Fatigue design of offshore steel structures, September 2019 and Amendment January 2020
/13/ DNV-RP-C204	DNV-RP-C204 Design against accidental loads – 2019
/14/ DNV-RP-C205	DNV - Environmental conditions and environmental loads - September 2019, amended September 2021.
/15/ DNV-ST-0126	Support structures for wind turbine, 2018

3.2 COMPANY SPECIFICATIONS

Doc. No.	Description
/16/ DEP 37.19.00.12	Gen - Offshore Topsides Structures
/17/ DEP 37.19.00.30	Gen - Fixed Steel Offshore Structures (Adoption of IOGP S-631-11, Amendments / Supplements to ISO 19902:2020).

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/18/ DEP 37.81.10.19	Gen - Marine Operations Requirements – Loadout, Transportation and Installation of Offshore Structures (Amendments / Supplements to ISO 19901-6)

3.3 PROJECT DOCUMENTS

Doc. No.	Description
/19/ 123A90-DDL-ST-SP-90017	Structural Design Basis
/20/ 123A90-DDL-MD-RE-01006	Monthly Weight Report – rev. 03 July '24
/21/ 123A90-DDL-ST-SP-90018	Structural Material Specification for Topside and TP
/22/ 123A90-DDL-TI-SP-99014	Specification for TP, Topside and Caissons Transportation and Installation
/23/ 123A90-DDL-ST-TN-90119	Evaluating ISO and DNV Approaches
/24/ 123A90-DDL-ST-RE-90015	Caisson Frame – In service, Lifting and transportation design report
/25/ 123A90-DDL-ST-RE-90014	Caisson Frame – Loadout Analysis
/26/ 123A90-DDL-ST-DD-90094	Caisson frame – Elevations
/27/ 123A90-DDL-ST-DD-90095	Caisson frame - Details
/28/ 123A90-DDL-ST-DD-90096	Caisson frame - Details
/29/ 123A90-DDL-TI-DD-99015	BLPH Platform – Barge Layout
/30/ 123A90-DDL-TI-DD-99047	CF – Grillage drawing
/31/ 123A90-DDL-TI-DD-99048	CF – Sea fastening drawing

3.4 SOFTWARE

Doc. No.	Description
/32/ 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
BLPH	Base Load Power Hub
BESS	Battery Energy Storage System
BHD	Bulkhead
BLPH	Base Load Power Hub
CF	Caisson Frame
CL	Concentrated Load
CoG	Centre of Gravity
CW	CrossWind
DAF	Dynamic Amplification Factor
DNV	Det Norske Veritas
El.	Elevation
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
PG	Plate Girder
T&I	Transport & Installation
ToS	Top of Steel

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TP	Transition Piece
UC	Unity Check
ULS	Ultimate Limit state
UDL	Uniformly Distributed Load
VIV	Vortex Induced Vibration

Table 4.1 - Definitions and Abbreviations

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5 SUMMARY AND CONCLUSIONS

The analyses performed show that the Grillage and Sea Fastening of Caisson Frame (CF) can withstand all possible combinations of environmental, operating and transient loads occurring during transportation, according to the applicable codes. The software SACS™, ref./32/, is used for all global analyses of the structures.

5.1 REACTION FORCES

Maximum and minimum base reaction forces for Grillage and Sea Fastening design in transportation conditions, are reported in the following table. Reactions are read in global reference system.

JOINT	Rx [kN]				Ry [kN]				Rz [kN]			
	MAX	LCOND	MIN	LCOND	MAX	LCOND	MIN	LCOND	MAX	LCOND	MIN	LCOND
XX1	25	C207	-20	C206	0	C101	0	C101	167	C101	33	C304
XX2	34	C205	-29	C208	0	C101	0	C101	167	C101	33	C304
XX3	36	C204	-44	C201	0	C101	0	C101	111	C101	7	C304
XX4	37	C204	-44	C201	0	C101	0	C101	110	C101	7	C304
XX5	0	C101	0	C101	34	C205	-32	C207	0	C101	0	C101
XX6	0	C101	0	C101	28	C205	-30	C207	0	C101	0	C101
XX7	0	C101	0	C101	57	C205	-55	C207	0	C101	0	C101
XX8	0	C101	0	C101	53	C205	-55	C207	0	C101	0	C101

Table 5.1 – CF base reaction forces in Transportation Conditions – STEP 3

5.2 MEMBER CHECKS

Structural members with maximum Unity Check (UC) are detailed in the following table.

MEMBER	GROUP	DESCRIPTION	SECTION	COMBINATION	UC
700- 702	TR3	Diagonal	168.3 x 14.27	C101	0.28
701- 702	TR3	Diagonal	168.3 x 14.27	C101	0.28
404- 402	TR3	Diagonal	168.3 x 14.27	C101	0.20

Table 5.2 – Member UC Summary – CF

5.3 LOCAL CHECKS

Maximum Unity Check for Grillage is UC = 0.28 < 1.00.

MEMBER	GROUP	DESCRIPTION	SECTION	COMBINATION	UC
0011-0013	GR1	Sea fastening ROLL	HE340A	C000	0.28
0006-0003	GR1	Long.Grillage	HE340A	C000	0.27
0011-0005	GR1	Transv.Grillage	HE340A	C000	0.22

Table 5.3 – Member UC Summary – Gr&SF

The max. reaction at grillage: F_{max} = 124.3 kN = 12.7 t (ULS) < 160 t at barge frame

6 CAISSON FRAME DESCRIPTION

The caisson frame is designed to structurally connect n.2 seawater lift caissons and n.1 brine discharge caisson to the Monopile CW70.

The monopile is supplied with N. 6 stubs for support of the caisson frame. These are arranged in pairs at N. 3 elevations (El. +14.5m LAT, El. +7m LAT and El. 0.00m LAT) and cannot be modified or moved as monopile CW70 is already installed in the wind farm. All the supports will be surveyed offshore prior to proceed with caisson loadout.

The support concept is that the CF form a structure similar to the boat landing frame, that has been successfully installed by Van Oord on monopile.

The brine caisson is "piggy-backed" off the CF. it is positioned on the outside of the CF and terminates 6m above the inlet to the seawater lift pump caissons. This to avoid, as far as possible, cross-contamination of waste brine water being dumped overboard with fresh seawater drawn for electrolysis.

The seawater lift caissons contain submersible pumps, so the caissons must be vertical.

As the caissons extend to the topside, dedicated caisson structure is foreseen welded to TP.

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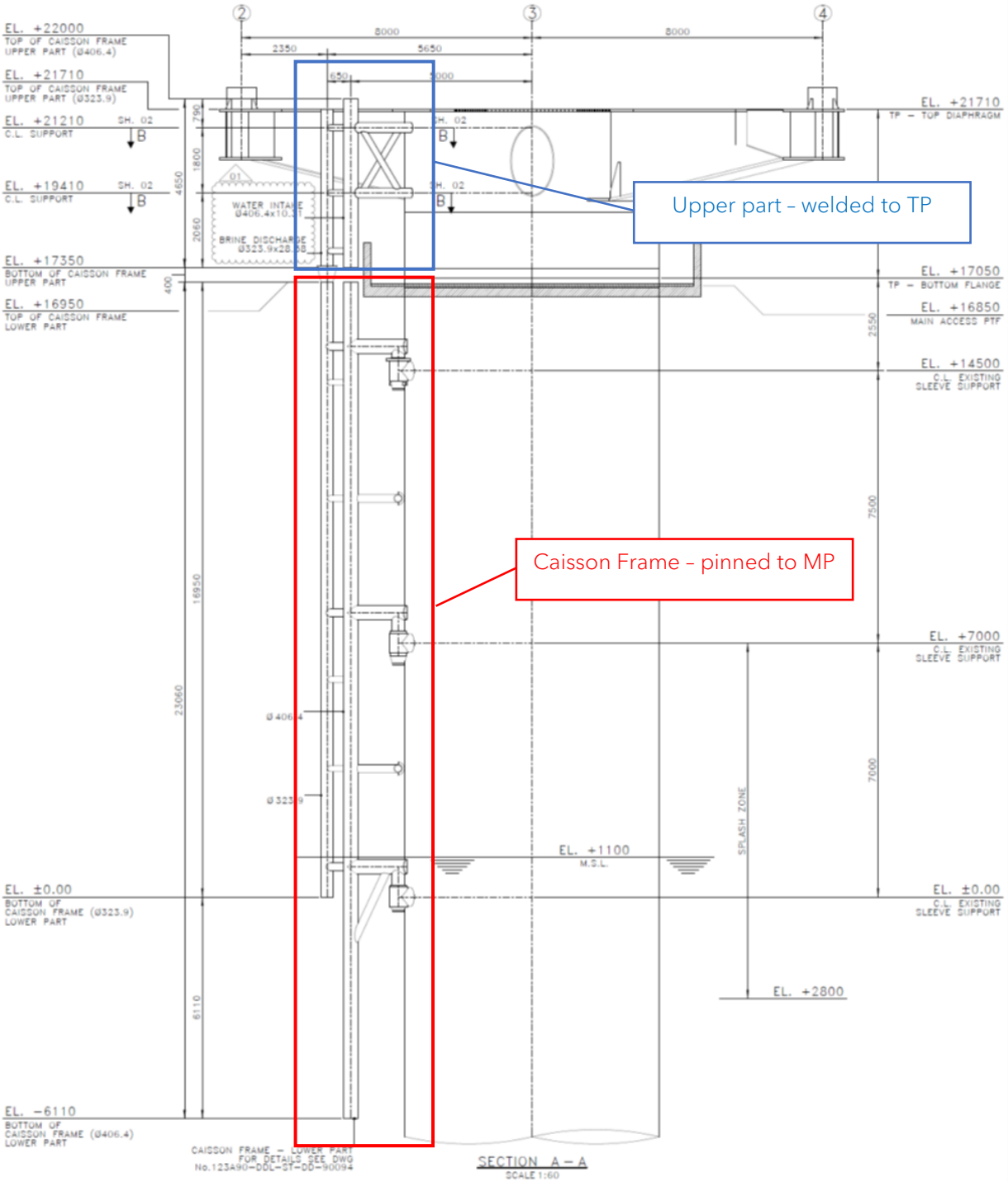


Figure 6.1 – CF assembly

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7 MATERIALS

7.1 STRUCTURAL STEEL PROPERTIES

For the structural analyses, steel types and grades to be used for the platform structures are summarised in Table 8.1 and specified in Ref./21/. 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 t > 50	-40 -40	DC1-I-420-40_Z	2, 7, 8, 11, 12, 17, 18
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 12 < t <= 25 25 < t <= 50 t > 50	0 -20 -40 -40	NA DC2-II-420-20 DC2-II-420-40	- 2, 7, 8, 11 17 for t > 40mm
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 12 < t <= 25 25 < t <= 50 t > 50	0 -20 -40 -40	DC3-II-355-0 / DC3-II-X52-0 DC3-II-355-20 / DC3-II-X52-20 DC3-II-355-40 / DC3-II-X52-40	2, 7, 8 11 for plate 17 for t > 40mm
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 12 < t <= 25	0 0	DC4-III-355-0 / DC4-III-X52-0 / DC4-III-X60-0	-
DC5 floor plating, grating, Walkw ays, 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 12 < t <= 25	10 10	DC5-IV-235-10 / DC5-IV-275-10 / DC5-IV-355-10 / DC5-IV-GRB-10	-

Table 7.1 - Material Selection, Ref /21/

Mechanical properties for structural materials are presented in Table 8-2, Table 8-3 and Table 8-4.

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

Thickness (mm)	Min. Tensile Strength (N/mm^2)	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 7.2 – Mechanical properties of Plates

Thickness (mm)	Min. Tensile Strength (N/mm^2)	Min. Yield Strength (N/mm2)	Steel Type
$t \leq 20$	460	355	III
$20 < t \leq 40$	460	345	III

Table 7.3 – Mechanical properties of Structural Seamless Tubulars

8 DESIGN CRITERIA AND REQUIREMENTS

8.1 GENERAL

Structures in SOW are designed in accordance with limit states approach of ISO codes 19901 and 19902, Refs./2/, /3/and /6/. For non-tubular sections, Eurocode, Ref./8/, is adopted. Member forces and moments derived from the global analyses are used for checking member strength and stability, and joint strength.

8.2 PARTIAL RESISTANCE FACTORS

8.2.1 Partial Resistance Factors for Tubular Sections

The partial resistance factors for tubular sections from ISO 19902, Ref./6/, 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 8.1- Resistance Factors for Tubular Sections

8.2.2 Partial Resistance Factors for Non-tubular Sections

Referring to ISO 19901-3, Ref./3/, section 8, to be consistent with ISO 19900 inherent the level of safety, a "building code correspondence factor" is to be applied to the AISC partial factors.

The partial resistance factors for non-tubular sections from Eurocode 3, Ref./8/, are listed below

Resistance factor	Value	Definition
Resistance of members and cross sections		
γ_{M0}	1.10	Cross-section resistance to excessive yield strain including local buckling
γ_{M1}	1.10	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

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$\gamma_{M6,SER}$	1.00	Resistance of pins at Serviceability Limit State
γ_{M7}	1.10	Preload of high strength bolts

Table 8.2- Resistance for Non Tubular Section

8.2.3 Partial Resistance Factors for Tubular Joints Check

The partial resistance factors for tubular joints checks are provided in following table according to ISO 19902, Ref./6/.

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 8.3 - Resistance Factors for Tubular Joints

8.3 LOAD CLASSIFICATIONS

Design loads are classified as either global or local within ISO 19901-3, Ref. /3/ and ISO 19902, Ref./6/ and summarized in Table 8.4.

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 CF
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
Environmental Transient	T_{Eo}	1-yr storm wind (wind in transportation conditions is assimilated to a Transient Load)
Transient	T	Transient Loads for Pre-Service Analyses (inertial loads from barge motion)

Table 8.4 - ISO Loads Classification

8.4 PARTIAL ACTION FACTORS

8.4.1 Partial Action Factors for Pre-Service Analysis

Partial Action Factors for Pre-Service analysis (e.g. Lifting, Transportation, Load-out) conditions are shown in Table 8.5 with reference to three design situations, according to ISO 19902, Ref./6/. where:

- G_T are the permanent actions during the transient situation;
- Q_T are the variable actions during the transient situation;
- T represents the actions from the transient situation being considered.

SITUATION	ACTION		
	Permanent (GT)	**Variable (QT)**	Transient (T)
1	1.3	1.3	1.0
2	1.1	1.1	1.35
3	0.95	0.9	1.35

Table 8.5 – Partial action factors for Pre-service Analyses

8.5 ACCEPTANCE CRITERIA

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

9 STRUCTURAL ANALYSIS

9.1 TRANSPORTATION ANALYSIS

The CF analysis in transportation conditions include permanent, variable and transient actions (as accelerations from barge motions), according to design data reported in ref. /24/.

The transportation analysis is performed considering a two steps analysis with different restraint conditions, to ensure that the whole mass is reacted by the grillages only and the dynamic loads by grillages and by sea-fastening suitably designed for horizontal loads.

Partial action factors for pre-service analyses as per Table 8.5 will be considered and sixteen (16) basic combinations of wind and inertia loads are therefore defined for each design situation (± Pitch ± Heave and ± R ± H).

The members and joints of the CF structure are checked in accordance with ISO 19902 and Eurocode 3, Ref./6/ and /8/, respectively for tubular and non-tubular elements.

9.2 TRANSPORTATION ARRANGEMENT

The CF is to be transported on 300ft cargo barge supported by grillages structures. The position of CF is shown in figure 9-1.

The 300ft barge is characterized by following main dimensions:

- Length: 91.5m
- Breadth: 27.40m
- Side height: 6.10m

The centre of rotation is assumed to be at the centre of the barge at water level.

The barge motion axes are defined as follows:

- the pitch axis (barge transverse axis) corresponds to the model Y-axis;
- the roll axis (barge longitudinal axis) corresponds to the model X-axis;
- along the x axis of CF model, the barge centre of motion is assumed at X=23.650 m;
- along the y axis of CF model, the barge centre of motion is assumed at Y=11.200 m;
- along the z axis of CF model, the barge centre of motion is assumed at Z= -3.0 m below the barge deck.

An overview of the transportation layout is shown in the following figure from Ref./29/.

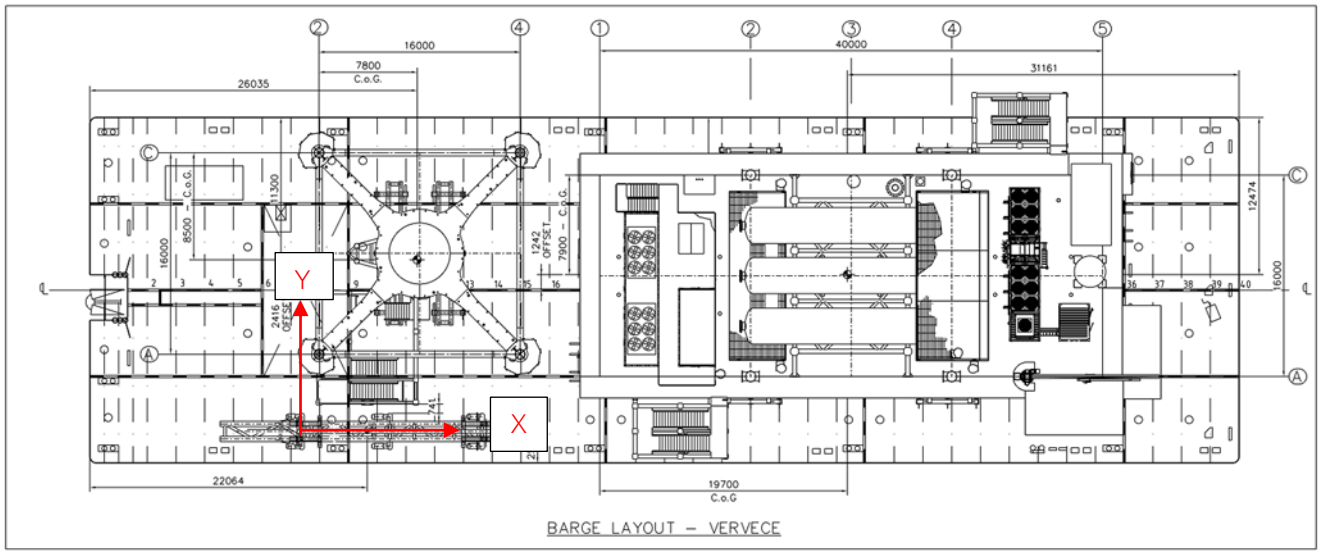


Figure 9.1 – Transportation Arrangement – Plan views

9.3 STRUCTURAL MODEL

The SACS structural model used for CF Transportation analysis (Ref./24/) is used for the Grillage and Sea Fastening checks. The same analyses are used for the checks, but the model has been updated according to the final grillage configuration, i.e. supporting points and stoppers.

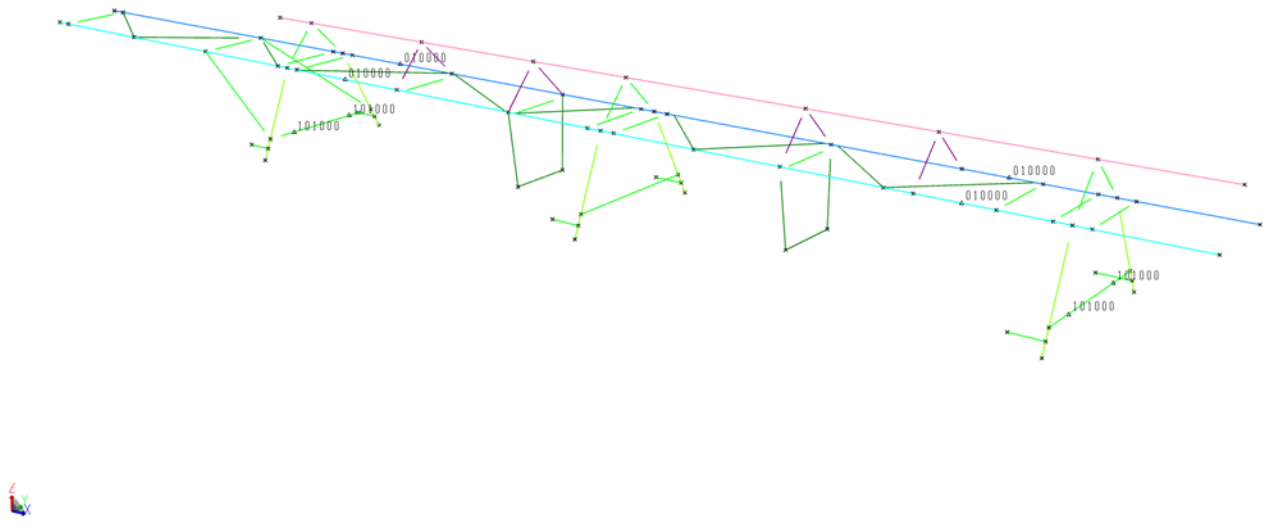


Figure 9.2 - CF structural model in Transportation Conditions

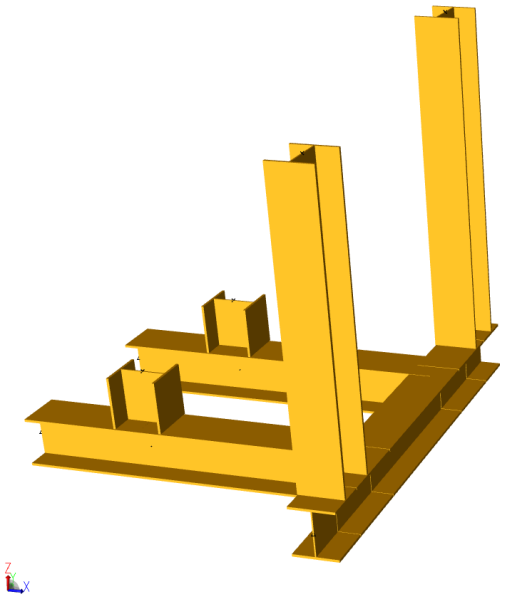


Figure 9.3 – CF structural model in Transportation Conditions – Grillage and Sea Fastening 3D view

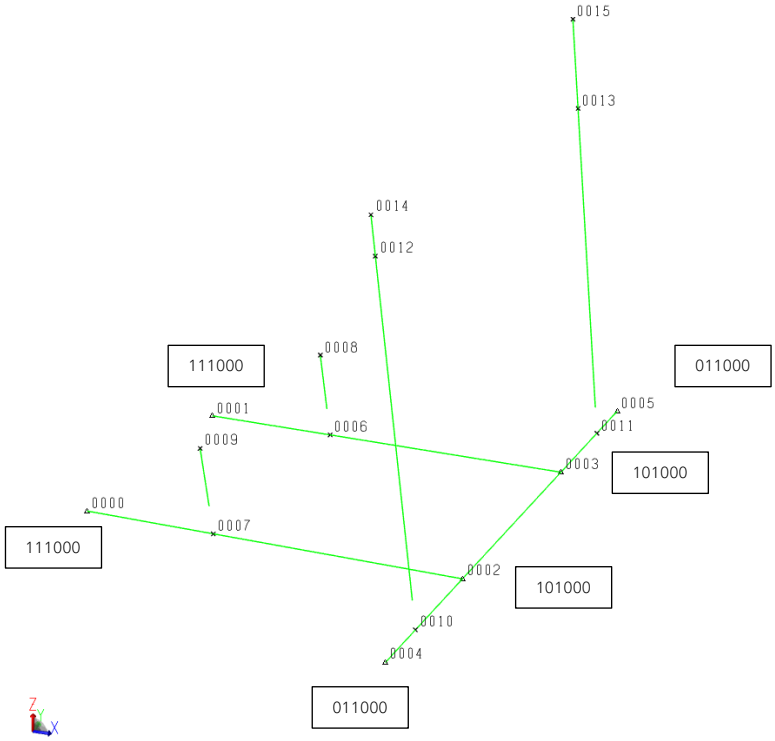


Figure 9.4 – CF structural model in Transportation Conditions – joints name and fixities

10 BASIC LOAD CASES & LOAD COMBINATIONS

All the design loads have defined according to the Weight Control Report, Ref./20/, in terms of weights, CoG position and contingency factors.

10.1 BASIC LOAD CASES

Basic load cases include:

- Permanent Actions (structural weight, secondary structures)
- Transportation Inertia forces

All the listed load cases are described in detail in the CF Transportation Analysis Report Ref./24/.

In the following SACS excerpt, basic load cases summary is reported.

LOAD CASE	LOAD LABEL	RELATIVE TO STRUCTURAL ORIGIN 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)
STEP 1													
1	DEAZ	0.00				0.00				-266.88	6.20	0.00	1.93
2	DEAC	0.00				0.00				-53.38	6.20	0.00	1.93
3	C000	0.00				0.00				-320.25	6.20	0.00	1.93
STEP 2													
1	CHCK	0.00				0.00				-320.26	6.20	0.00	1.93
2	+R+H	0.00				-126.64	6.19	0.00	1.94	-91.38	6.19	-0.02	1.93
3	+R-H	0.00				-82.83	6.19	0.00	1.95	29.00	6.20	0.05	1.93
4	-R+H	0.00				126.64	6.19	0.00	1.94	9.63	6.19	-0.17	1.93
5	-R-H	0.00				82.83	6.19	0.00	1.95	130.00	6.19	-0.01	1.93
6	+P+H	80.18	6.19	0.00	1.94	0.00				-138.75	7.00	0.00	1.93
7	+P-H	52.45	6.19	0.00	1.95	0.00				-13.68	14.39	0.00	1.93
8	-P+H	-80.18	6.19	0.00	1.94	0.00				28.86	10.08	0.00	1.93
9	-P-H	-52.45	6.19	0.00	1.95	0.00				153.93	6.92	0.00	1.93

10.2 TRANSPORTATION LOAD COMBINATIONS

Basic Load cases and load combinations, detailed in chapter 10, have been combined together to define the design Load Combinations to be used in the transportation analysis, according to Partial Action Factor as per sec. 8.4.1.

10.2.1 Design Load Combinations

A total of 48 load combinations, according to ISO 19902 Transportation Design Situations, have been defined as per following tables.

TRANSPORTATION LOAD COMBINATIONS - DESIGN SITUATION 1									
LOAD COMB.	LOAD CASES								
	C000	+P+H	+P-H	-P+H	-P-H	+R+H	+R-H	-R+H	-R-H
C101	1.30	1.00							
C102	1.30		1.00						
C103	1.30			1.00					
C104	1.30				1.00				
C105	1.30					1.00			
C106	1.30						1.00		
C107	1.30							1.00	
C108	1.30								1.00

Table 10.1- Transportation Load Combinations – Design situation 1

TRANSPORTATION LOAD COMBINATIONS - DESIGN SITUATION 2									
LOAD COMB.	LOAD CASES								
	C000	+P+H	+P-H	-P+H	-P-H	+R+H	+R-H	-R+H	-R-H
C201	1.10	1.35							
C202	1.10		1.35						
C203	1.10			1.35					
C204	1.10				1.35				
C205	1.10					1.35			
C206	1.10						1.35		
C207	1.10							1.35	
C208	1.10								1.35

Table 10.2 - Transportation Load Combinations – Design situation 2

TRANSPORTATION LOAD COMBINATIONS - DESIGN SITUATION 3									
LOAD COMB.	LOAD CASES								
	C000	+P+H	+P-H	-P+H	-P-H	+R+H	+R-H	-R+H	-R-H
C301	0.90	1.35							
C302	0.90		1.35						
C303	0.90			1.35					
C304	0.90				1.35				
C305	0.90					1.35			
C306	0.90						1.35		
C307	0.90							1.35	
C308	0.90								1.35

Table 10.3 - Transportation Load Combinations – Design situation 3

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10.2.2 Load Combinations Summary

Following excerpt from SACS output provides the Load Combinations resultants.

FORCES AND MOMENTS SUMMARY
*** MOMENTS SUMMED ABOUT ORIGIN ***

LOAD CASE	FORCE(X) KN	FORCE(Y) KN	FORCE(Z) KN	MOMENT(X) KN-M	MOMENT(Y) KN-M	MOMENT(Z) KN-M
C101	-80.180	0.000	555.073	-0.720	-3706.540	-0.108
C102	-52.455	0.000	430.009	-0.552	-2878.132	-0.071
C103	80.181	0.000	387.465	-0.548	-2132.594	0.108
C104	52.453	0.000	262.400	-0.380	-1411.435	0.071
C105	0.000	126.641	507.704	-248.228	-3145.249	784.474
C106	0.000	82.830	387.325	-163.333	-2399.487	513.066
C107	0.000	-126.643	406.702	247.002	-2519.617	-784.486
C108	0.000	-82.830	286.327	162.424	-1773.876	-513.058
C201	-108.244	0.000	539.584	-0.690	-3704.308	-0.146
C202	-70.814	0.000	370.747	-0.463	-2585.957	-0.096
C203	108.245	0.000	313.312	-0.458	-1579.481	0.146
C204	70.812	0.000	144.475	-0.231	-605.917	0.096
C205	0.000	170.965	475.635	-334.826	-2946.564	1059.040
C206	0.000	111.821	313.124	-220.217	-1939.786	692.639
C207	0.000	-170.968	339.283	333.735	-2101.962	-1059.056
C208	0.000	-111.820	176.776	219.554	-1095.211	-692.628
C301	-108.244	0.000	475.533	-0.604	-3307.507	-0.146
C302	-70.814	0.000	306.696	-0.377	-2189.157	-0.096
C303	108.245	0.000	249.262	-0.372	-1182.680	0.146
C304	70.812	0.000	80.425	-0.144	-209.116	0.096
C305	0.000	170.965	411.585	-334.739	-2549.764	1059.040
C306	0.000	111.821	249.074	-220.131	-1542.986	692.639
C307	0.000	-170.968	275.233	333.821	-1705.161	-1059.056
C308	0.000	-111.820	112.726	219.641	-698.410	-692.628

11 ANALYSIS RESULTS

This section presents the results of the Transportation analysis carried out in terms of:

- Reaction forces
- Structural checks of structural members;
- Local checks of grillage.
- Barge max. reaction checks.

11.1 REACTION FORCES

Maximum and minimum base reaction forces for CF in transportation condition are reported in the following tables. Reactions are read in correspondence of CF and grillage connections in global reference system.

An envelope of base reaction forces is also provided.

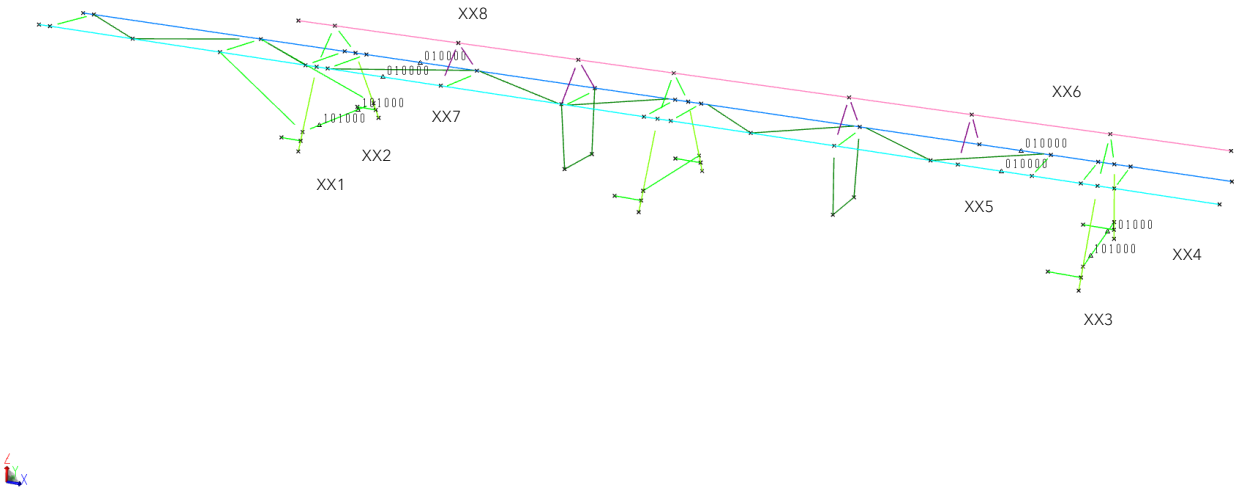


Figure 11.1 -CF joints fixities

JOINT	Rx [kN]				Ry [kN]				Rz [kN]			
	MAX	LCOND	MIN	LCOND	MAX	LCOND	MIN	LCOND	MAX	LCOND	MIN	LCOND
XX1	25	C207	-20	C206	0	C101	0	C101	167	C101	33	C304
XX2	34	C205	-29	C208	0	C101	0	C101	167	C101	33	C304
XX3	36	C204	-44	C201	0	C101	0	C101	111	C101	7	C304
XX4	37	C204	-44	C201	0	C101	0	C101	110	C101	7	C304
XX5	0	C101	0	C101	34	C205	-32	C207	0	C101	0	C101
XX6	0	C101	0	C101	28	C205	-30	C207	0	C101	0	C101
XX7	0	C101	0	C101	57	C205	-55	C207	0	C101	0	C101
XX8	0	C101	0	C101	53	C205	-55	C207	0	C101	0	C101

Table 11.1 – CF base reaction forces in Transportation Conditions – Summary Envelope

Base reaction forces for all load combinations are reported in following SACS excerpt with reference to STEP 3 analysis, final transportation configuration.

SACS-IV SYSTEM FIXED JOINTS REACTION FORCES AND MOMENTS

JOINT	LOAD	FORCE(X) KN	FORCE(Y) KN	FORCE(Z) KN	MOMENT(X) KN-M	MOMENT(Y) KN-M	MOMENT(Z) KN-M
				NUMBER CASE			
XX1	C101	-7.289	0.000	167.468	0.000	0.000	0.000
	C102	-8.938	0.000	129.213	0.000	0.000	0.000
	C103	15.294	0.000	128.628	0.000	0.000	0.000
	C104	-1.279	0.000	88.338	0.000	0.000	0.000
	C105	-12.725	0.000	156.684	0.000	0.000	0.000
	C106	-14.829	0.000	120.264	0.000	0.000	0.000
	C107	18.681	0.000	130.577	0.000	0.000	0.000
	C108	3.246	0.000	91.397	0.000	0.000	0.000
	C201	-9.840	0.000	160.181	0.000	0.000	0.000
	C202	-12.066	0.000	108.537	0.000	0.000	0.000
	C203	20.647	0.000	107.747	0.000	0.000	0.000
	C204	-1.727	0.000	53.355	0.000	0.000	0.000
	C205	-17.179	0.000	145.623	0.000	0.000	0.000
	C206	-20.020	0.000	96.456	0.000	0.000	0.000
	C207	25.219	0.000	110.379	0.000	0.000	0.000
	C208	4.382	0.000	57.485	0.000	0.000	0.000
	C301	-9.840	0.000	140.059	0.000	0.000	0.000
	C302	-12.066	0.000	88.415	0.000	0.000	0.000
	C303	20.647	0.000	87.625	0.000	0.000	0.000
	C304	-1.727	0.000	33.233	0.000	0.000	0.000
	C305	-17.179	0.000	125.501	0.000	0.000	0.000
	C306	-20.020	0.000	76.333	0.000	0.000	0.000
	C307	25.219	0.000	90.256	0.000	0.000	0.000
	C308	4.382	0.000	37.363	0.000	0.000	0.000
XX2	C101	-7.833	0.000	166.557	0.000	0.000	0.000
	C102	-8.904	0.000	128.489	0.000	0.000	0.000
	C103	15.274	0.000	127.853	0.000	0.000	0.000
	C104	-0.593	0.000	87.758	0.000	0.000	0.000
	C105	25.249	0.000	161.398	0.000	0.000	0.000
	C106	10.542	0.000	122.401	0.000	0.000	0.000
	C107	-19.713	0.000	124.221	0.000	0.000	0.000
	C108	-21.309	0.000	87.986	0.000	0.000	0.000
	C201	-10.575	0.000	159.334	0.000	0.000	0.000
	C202	-12.020	0.000	107.942	0.000	0.000	0.000
	C203	20.620	0.000	107.083	0.000	0.000	0.000
	C204	-0.801	0.000	52.955	0.000	0.000	0.000
	C205	34.086	0.000	152.369	0.000	0.000	0.000
	C206	14.232	0.000	99.723	0.000	0.000	0.000
	C207	-26.613	0.000	102.180	0.000	0.000	0.000
	C208	-28.767	0.000	53.262	0.000	0.000	0.000
	C301	-10.575	0.000	139.328	0.000	0.000	0.000
	C302	-12.020	0.000	87.937	0.000	0.000	0.000
	C303	20.620	0.000	87.078	0.000	0.000	0.000
	C304	-0.801	0.000	32.949	0.000	0.000	0.000
	C305	34.086	0.000	132.363	0.000	0.000	0.000
	C306	14.232	0.000	79.717	0.000	0.000	0.000
	C307	-26.613	0.000	82.175	0.000	0.000	0.000
	C308	-28.767	0.000	33.257	0.000	0.000	0.000
XX3	C101	-32.375	0.000	110.660	0.000	0.000	0.000
	C102	-17.241	0.000	86.245	0.000	0.000	0.000
	C103	24.711	0.000	65.555	0.000	0.000	0.000
	C104	27.023	0.000	43.175	0.000	0.000	0.000
	C105	-7.698	0.000	93.019	0.000	0.000	0.000
	C106	1.127	0.000	71.487	0.000	0.000	0.000

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	C107	1.996	0.000	77.933	0.000	0.000	0.000
	C108	9.963	0.000	54.423	0.000	0.000	0.000
	C201	-43.706	0.000	110.177	0.000	0.000	0.000
	C202	-23.276	0.000	77.217	0.000	0.000	0.000
	C203	33.360	0.000	49.285	0.000	0.000	0.000
	C204	36.481	0.000	19.072	0.000	0.000	0.000
	C205	-10.392	0.000	86.362	0.000	0.000	0.000
	C206	1.521	0.000	57.294	0.000	0.000	0.000
	C207	2.695	0.000	65.996	0.000	0.000	0.000
	C208	13.451	0.000	34.257	0.000	0.000	0.000
	C301	-43.706	0.000	98.204	0.000	0.000	0.000
	C302	-23.276	0.000	65.243	0.000	0.000	0.000
	C303	33.360	0.000	37.311	0.000	0.000	0.000
	C304	36.481	0.000	7.098	0.000	0.000	0.000
	C305	-10.392	0.000	74.388	0.000	0.000	0.000
	C306	1.521	0.000	45.321	0.000	0.000	0.000
	C307	2.695	0.000	54.022	0.000	0.000	0.000
	C308	13.451	0.000	22.283	0.000	0.000	0.000
XX4	C101	-32.683	-0.000	110.388	0.000	0.000	0.000
	C102	-17.372	-0.000	86.061	0.000	0.000	0.000
	C103	24.902	-0.000	65.429	0.000	0.000	0.000
	C104	27.303	-0.000	43.130	0.000	0.000	0.000
	C105	-4.826	-0.000	96.602	0.000	0.000	0.000
	C106	3.161	-0.000	73.173	0.000	0.000	0.000
	C107	-0.964	-0.000	73.971	0.000	0.000	0.000
	C108	8.099	-0.000	52.522	0.000	0.000	0.000
	C201	-44.123	-0.000	109.891	0.000	0.000	0.000
	C202	-23.452	-0.000	77.051	0.000	0.000	0.000
	C203	33.618	-0.000	49.197	0.000	0.000	0.000
	C204	36.859	-0.000	19.093	0.000	0.000	0.000
	C205	-6.515	-0.000	91.281	0.000	0.000	0.000
	C206	4.267	-0.000	59.652	0.000	0.000	0.000
	C207	-1.301	-0.000	60.729	0.000	0.000	0.000
	C208	10.934	-0.000	31.772	0.000	0.000	0.000
	C301	-44.123	-0.000	97.942	0.000	0.000	0.000
	C302	-23.452	-0.000	65.102	0.000	0.000	0.000
	C303	33.618	-0.000	37.248	0.000	0.000	0.000
	C304	36.859	-0.000	7.144	0.000	0.000	0.000
	C305	-6.515	-0.000	79.332	0.000	0.000	0.000
	C306	4.267	-0.000	47.703	0.000	0.000	0.000
	C307	-1.301	-0.000	48.780	0.000	0.000	0.000
	C308	10.934	-0.000	19.823	0.000	0.000	0.000
XX5	C101	0.000	6.577	0.000	0.000	0.000	0.000
	C102	0.000	3.224	0.000	0.000	0.000	0.000
	C103	0.000	-4.611	0.000	0.000	0.000	0.000
	C104	0.000	-5.734	0.000	0.000	0.000	0.000
	C105	0.000	24.952	0.000	0.000	0.000	0.000
	C106	0.000	14.734	0.000	0.000	0.000	0.000
	C107	0.000	-23.489	0.000	0.000	0.000	0.000
	C108	0.000	-17.579	0.000	0.000	0.000	0.000
	C201	0.000	8.879	0.000	0.000	0.000	0.000
	C202	0.000	4.353	0.000	0.000	0.000	0.000
	C203	0.000	-6.225	0.000	0.000	0.000	0.000
	C204	0.000	-7.741	0.000	0.000	0.000	0.000
	C205	0.000	33.685	0.000	0.000	0.000	0.000
	C206	0.000	19.892	0.000	0.000	0.000	0.000
	C207	0.000	-31.711	0.000	0.000	0.000	0.000
	C208	0.000	-23.732	0.000	0.000	0.000	0.000
	C301	0.000	8.879	0.000	0.000	0.000	0.000
	C302	0.000	4.353	0.000	0.000	0.000	0.000
	C303	0.000	-6.225	0.000	0.000	0.000	0.000
	C304	0.000	-7.741	0.000	0.000	0.000	0.000
	C305	0.000	33.685	0.000	0.000	0.000	0.000
	C306	0.000	19.892	0.000	0.000	0.000	0.000
	C307	0.000	-31.711	0.000	0.000	0.000	0.000
	C308	0.000	-23.732	0.000	0.000	0.000	0.000

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XX6	C101	0.000	-6.632	0.000	0.000	0.000	0.000
	C102	0.000	-3.236	0.000	0.000	0.000	0.000
	C103	0.000	4.630	0.000	0.000	0.000	0.000
	C104	0.000	5.792	0.000	0.000	0.000	0.000
	C105	0.000	20.392	0.000	0.000	0.000	0.000
	C106	0.000	14.957	0.000	0.000	0.000	0.000
	C107	0.000	-21.882	0.000	0.000	0.000	0.000
	C108	0.000	-12.059	0.000	0.000	0.000	0.000
	C201	0.000	-8.954	0.000	0.000	0.000	0.000
	C202	0.000	-4.368	0.000	0.000	0.000	0.000
	C203	0.000	6.250	0.000	0.000	0.000	0.000
	C204	0.000	7.819	0.000	0.000	0.000	0.000
	C205	0.000	27.529	0.000	0.000	0.000	0.000
	C206	0.000	20.192	0.000	0.000	0.000	0.000
	C207	0.000	-29.540	0.000	0.000	0.000	0.000
	C208	0.000	-16.280	0.000	0.000	0.000	0.000
	C301	0.000	-8.954	0.000	0.000	0.000	0.000
	C302	0.000	-4.368	0.000	0.000	0.000	0.000
	C303	0.000	6.250	0.000	0.000	0.000	0.000
	C304	0.000	7.819	0.000	0.000	0.000	0.000
	C305	0.000	27.529	0.000	0.000	0.000	0.000
	C306	0.000	20.192	0.000	0.000	0.000	0.000
	C307	0.000	-29.540	0.000	0.000	0.000	0.000
	C308	0.000	-16.280	0.000	0.000	0.000	0.000
XX7	C101	0.000	0.713	0.000	0.000	0.000	0.000
	C102	0.000	-0.646	0.000	0.000	0.000	0.000
	C103	0.000	1.041	0.000	0.000	0.000	0.000
	C104	0.000	-1.592	0.000	0.000	0.000	0.000
	C105	0.000	41.955	0.000	0.000	0.000	0.000
	C106	0.000	26.022	0.000	0.000	0.000	0.000
	C107	0.000	-40.651	0.000	0.000	0.000	0.000
	C108	0.000	-28.560	0.000	0.000	0.000	0.000
	C201	0.000	0.963	0.000	0.000	0.000	0.000
	C202	0.000	-0.873	0.000	0.000	0.000	0.000
	C203	0.000	1.405	0.000	0.000	0.000	0.000
	C204	0.000	-2.149	0.000	0.000	0.000	0.000
	C205	0.000	56.639	0.000	0.000	0.000	0.000
	C206	0.000	35.130	0.000	0.000	0.000	0.000
	C207	0.000	-54.879	0.000	0.000	0.000	0.000
	C208	0.000	-38.556	0.000	0.000	0.000	0.000
	C301	0.000	0.963	0.000	0.000	0.000	0.000
	C302	0.000	-0.873	0.000	0.000	0.000	0.000
	C303	0.000	1.405	0.000	0.000	0.000	0.000
	C304	0.000	-2.149	0.000	0.000	0.000	0.000
	C305	0.000	56.639	0.000	0.000	0.000	0.000
	C306	0.000	35.130	0.000	0.000	0.000	0.000
	C307	0.000	-54.879	0.000	0.000	0.000	0.000
	C308	0.000	-38.556	0.000	0.000	0.000	0.000
XX8	C101	0.000	-0.658	0.000	0.000	0.000	0.000
	C102	0.000	0.658	0.000	0.000	0.000	0.000
	C103	0.000	-1.059	0.000	0.000	0.000	0.000
	C104	0.000	1.534	0.000	0.000	0.000	0.000
	C105	0.000	39.342	0.000	0.000	0.000	0.000
	C106	0.000	27.116	0.000	0.000	0.000	0.000
	C107	0.000	-40.621	0.000	0.000	0.000	0.000
	C108	0.000	-24.631	0.000	0.000	0.000	0.000
	C201	0.000	-0.889	0.000	0.000	0.000	0.000
	C202	0.000	0.888	0.000	0.000	0.000	0.000
	C203	0.000	-1.430	0.000	0.000	0.000	0.000
	C204	0.000	2.071	0.000	0.000	0.000	0.000
	C205	0.000	53.112	0.000	0.000	0.000	0.000
	C206	0.000	36.607	0.000	0.000	0.000	0.000
	C207	0.000	-54.838	0.000	0.000	0.000	0.000
	C208	0.000	-33.252	0.000	0.000	0.000	0.000
	C301	0.000	-0.889	0.000	0.000	0.000	0.000

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C302	0.000	0.888	0.000	0.000	0.000	0.000
C303	0.000	-1.430	0.000	0.000	0.000	0.000
C304	0.000	2.071	0.000	0.000	0.000	0.000
C305	0.000	53.112	0.000	0.000	0.000	0.000
C306	0.000	36.607	0.000	0.000	0.000	0.000
C307	0.000	-54.838	0.000	0.000	0.000	0.000
C308	0.000	-33.252	0.000	0.000	0.000	0.000

Table 11.2 - Reaction Forces in Transportation Conditions

11.2 GLOBAL STRUCTURAL CHECKS

The results of the performed analysis in terms of structural elements' Unity Check (UC) are detailed in the following.

All members were checked according to ISO 19902 and Eurocode 3, Ref./6/and /8/, respectively for tubular and non-tubular elements. Members' code checks are reported in the following and show that the structure can withstand Transportation load combinations, with utilization factors below 1.0.

11.2.1 Caisson Frame

The maximum UC value is equal to 0.28 on member 700-702 for load combination C101. Maximum member UC are reported in following SACS excerpt.

* * * M E M B E R G R O U P S U M M A R Y * * *
ISO 19902:2020 / EC3:1992

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
CFA	FX21- S21	C101	0.00	0.5	-0.0	0.0	0.3	.3E+03	.3E+05	.4E+03	.4E+03	SHEAR	1.00	1.00	0.85	0.85
CFB	901- T01	C105	0.08	0.0	-2.1	33.4	1.1	283.9	4578.0	437.7	437.7	ACBI	2.80	1.22	0.85	0.85
CS1	800- 900	C105	0.11	0.2	1.2	5.3	-47.3	319.0	713.0	443.5	443.5	TN+BN	7.00	7.00	0.85	0.85
CS2	801- 901	C101	0.11	0.2	0.3	-6.2	-48.1	319.0	713.0	443.5	443.5	TN+BN	7.00	7.00	0.85	0.85
CS3	602- 652	C101	0.09	0.0	-13.2	0.3	26.0	288.1	6576.0	456.0	456.0	ACBI	1.84	1.84	0.85	0.85
TR1	XX3- T21	C201	0.15	0.5	0.4	-25.7	-63.4	328.6	2018.5	463.2	463.2	TN+BN	2.21	2.21	0.85	0.85
TR2	801- 700	C101	0.04	0.0	0.3	0.5	-20.2	328.6	1467.4	453.9	453.9	TN+BN	2.65	2.65	0.85	0.85
TR3	700- 702	C101	0.28	0.0	-2.8	-128.0	-0.6	.3E+03	.2E+05	.5E+03	.5E+03	ACBI	0.55	0.55	0.85	0.85

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

JOINT	ORIGINAL DIAMETER (CM)	ORIGINAL THICKNESS (CM)	ORIGINAL YLD STRS (N/MM2)	LOAD UC	STRN UC	LOAD DESIGN DIAMETER (CM)	LOAD DESIGN THICKNESS (CM)	LOAD DESIGN YLD STRS (N/MM2)	LOAD UC	STRN UC	STRENGTH ANALYSIS BRACE JOINT	LOAD CASE
1151	40.640	3.653	335.000	0.001	0.001	40.640	3.653	335.000	0.001	0.001	1150	C207
0037	21.910	1.826	345.000	0.001	0.001	21.910	1.826	345.000	0.001	0.001	0038	C205
S10	40.640	3.096	335.000	0.000	0.000	40.640	3.096	335.000	0.000	0.000	FX10	C201
S11	40.640	3.096	335.000	0.000	0.000	40.640	3.096	335.000	0.000	0.000	FX11	C201
S20	40.640	3.096	335.000	0.000	0.000	40.640	3.096	335.000	0.000	0.000	FX20	C201
S21	40.640	3.096	335.000	0.000	0.000	40.640	3.096	335.000	0.000	0.000	FX21	C201
S00	40.640	3.096	335.000	0.000	0.000	40.640	3.096	335.000	0.000	0.000	FX00	C201
S01	40.640	3.096	335.000	0.000	0.000	40.640	3.096	335.000	0.000	0.000	FX01	C201

11.3 LOCAL CHECKS

Starting from the maximum loads resulting from the transportation analysis and summarized in the previous section, the local checks of Grillage and Sea Fastenings are performed in the following sections, according to ISO 19902 and Eurocode 3, Ref./6/and /8/.

11.3.1 Grillage & SF

The max loads obtained by transport analyses, see Table 11.1, have been applied to grillage and SF structure. Joint fixities are shown on Fig. 9.4.

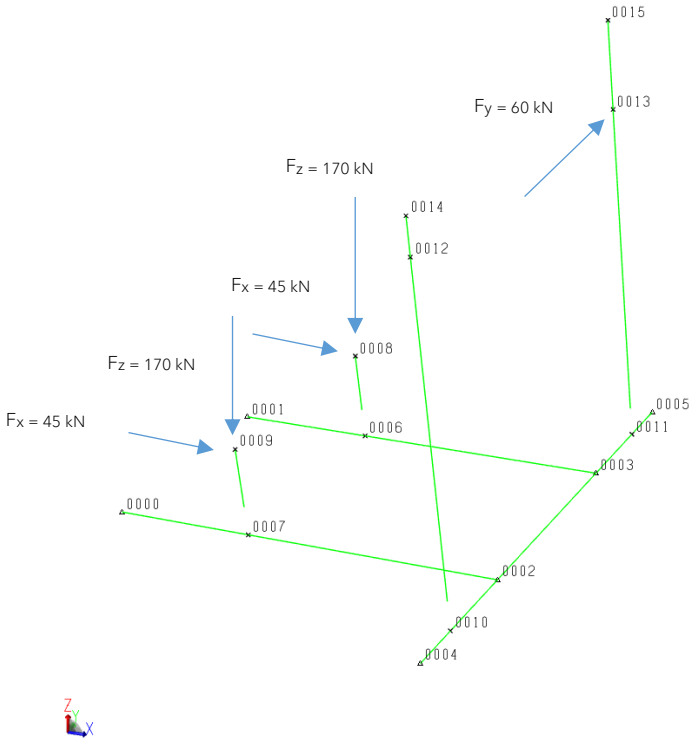


Figure 11.2 -CF Grillage & SF – Applied loads (ref. table 11.1)

BASE REACTIONS

SACS-IV SYSTEM FIXED JOINTS REACTION FORCES AND MOMENTS

JOINT NUMBER	LOAD CASE	FORCE(X) KN	FORCE(Y) KN	FORCE(Z) KN	MOMENT(X) KN-M	MOMENT(Y) KN-M	MOMENT(Z) KN-M
0000	C000	-29.252	-0.006	101.674	0.000	0.000	0.000
0001	C000	-29.252	-0.012	101.674	0.000	0.000	0.000
0002	C000	-15.784	0.000	54.351	0.000	0.000	0.000
0003	C000	-15.712	0.000	-31.027	0.000	0.000	0.000
0004	C000	0.000	-6.420	1.754	0.000	0.000	0.000
0005	C000	0.000	-53.561	124.300	0.000	0.000	0.000

MEMBER CHECKS

The maximum UC value is equal to 0.28 on member 0011-0013. Maximum member UC are reported in following SACS excerpt.

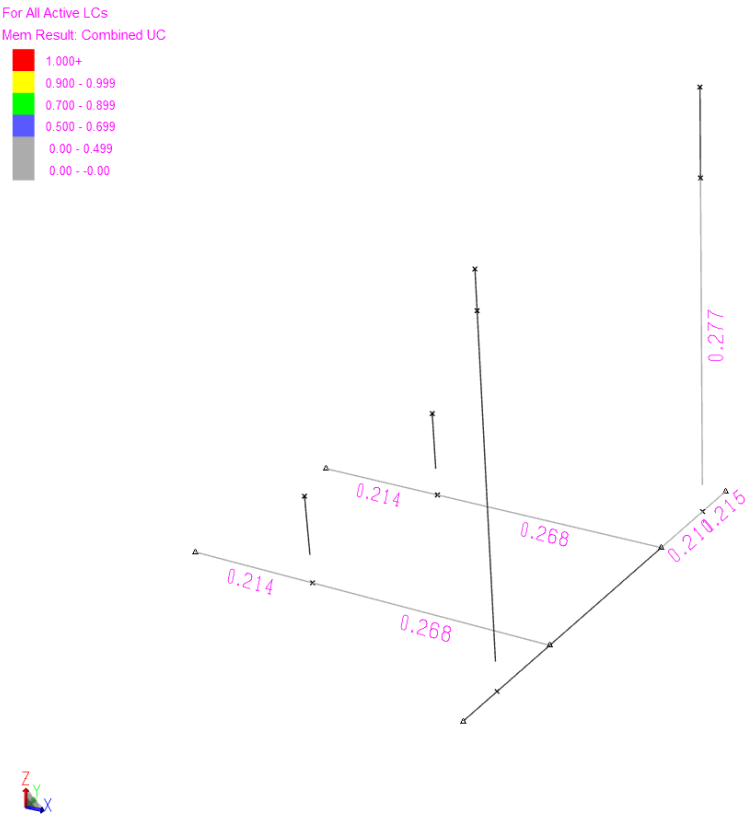


Figure 11.3 -CF Grillage & SF – Member UC

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 **

* * * 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
GR1	0011-0013	C000	0.28	0.0	-0.2	65.4	0.0	225.5	689.7	236.6	340.8	BN+AX	4.00	4.00	0.60	1.00

Checks are performed for max. reactions at the point connection with barge to design gusset plates and min. welds lengths.

Max Rx = 50 kN

Max Ry = 50 kN

Rz = 124.3 kN see 11.4

Check of Bottom weld of gusset plates:

A_V = 2*(15*0.7)*0.7*100 = 1470 mm^2

F_y = 235 MPa

fv = Rx (or Ry) / Av = 34 MPa < $Fy/\sqrt{3}/\gamma_{m2}$ = 109 MPa OK

11.4 BARGE DECK CHECK

Barge deck load plan indicates min. deck frame capacity = 160 ton/m.

The max. reaction at barge deck, as per sec.11.3.1, is 124.3 kN at ULS.

F_{max} = 12.5 t (ULS) < 160t.

APPENDIX A – CF MEMBER GROUP AND SECTION PROPERTIES

****** SEASTATE INITIAL GROUP DESCRIPTION ******

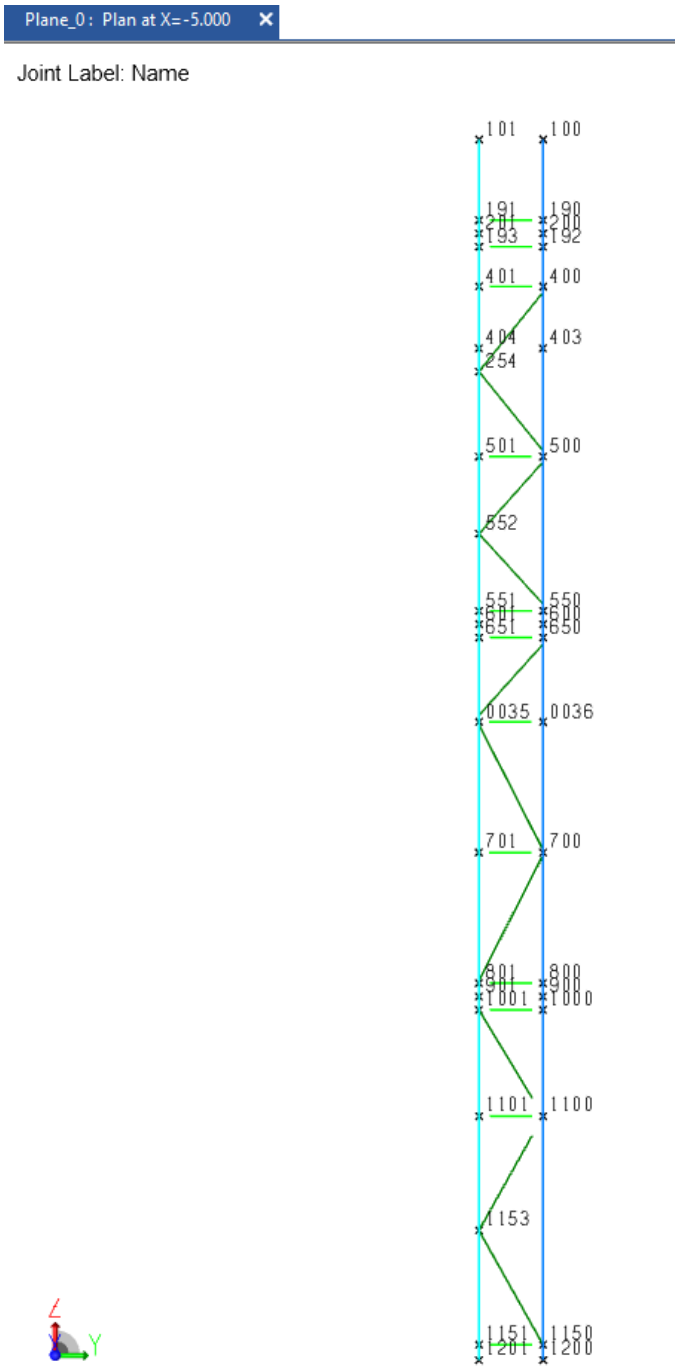
GROUP LABEL	SECTION LABEL	***** AREAS ***** CONST. (CM**2)	DISPL. (CM)	** DIAMETERS ** Y (CM)	Z (CM)	* SECTION * TYPE	* MATL. * LENGTH	* JOINT * DENSITY (TONNE/M**3)	FLOOD THICK (M.)	** DRAG AND INERTIA COEFFICIENTS ** CDY	CDZ	CMY	CMZ	CDT	CMT
CFA		285.67	989.80	35.50	35.50	TUB	7.849	0.000	NO	1.30	1.30	1.60	1.60	0.00	0.00
CFB		365.17	1297.17	40.64	40.64	TUB	7.849	0.000	NO	1.30	1.30	1.60	1.60	0.00	0.00
CS1		424.47	1297.17	40.64	40.64	TUB	7.849	0.000	YES	1.30	1.30	1.60	1.60	0.00	0.00
CS2		424.47	1297.17	40.64	40.64	TUB	7.849	0.000	YES	1.30	1.30	1.60	1.60	0.00	0.00
CS3		265.16	823.97	32.39	32.39	TUB	7.849	0.000	YES	1.30	1.30	1.60	1.60	0.00	0.00
TR1		141.75	377.03	21.91	21.91	TUB	7.849	0.000	NO	1.30	1.30	1.60	1.60	0.00	0.00
TR2		115.21	377.03	21.91	21.91	TUB	7.849	0.000	NO	1.30	1.30	1.60	1.60	0.00	0.00
TR3		69.05	222.46	16.83	16.83	TUB	7.849	0.000	NO	1.30	1.30	1.60	1.60	0.00	0.00

TUBULAR MEMBER PROPERTIES

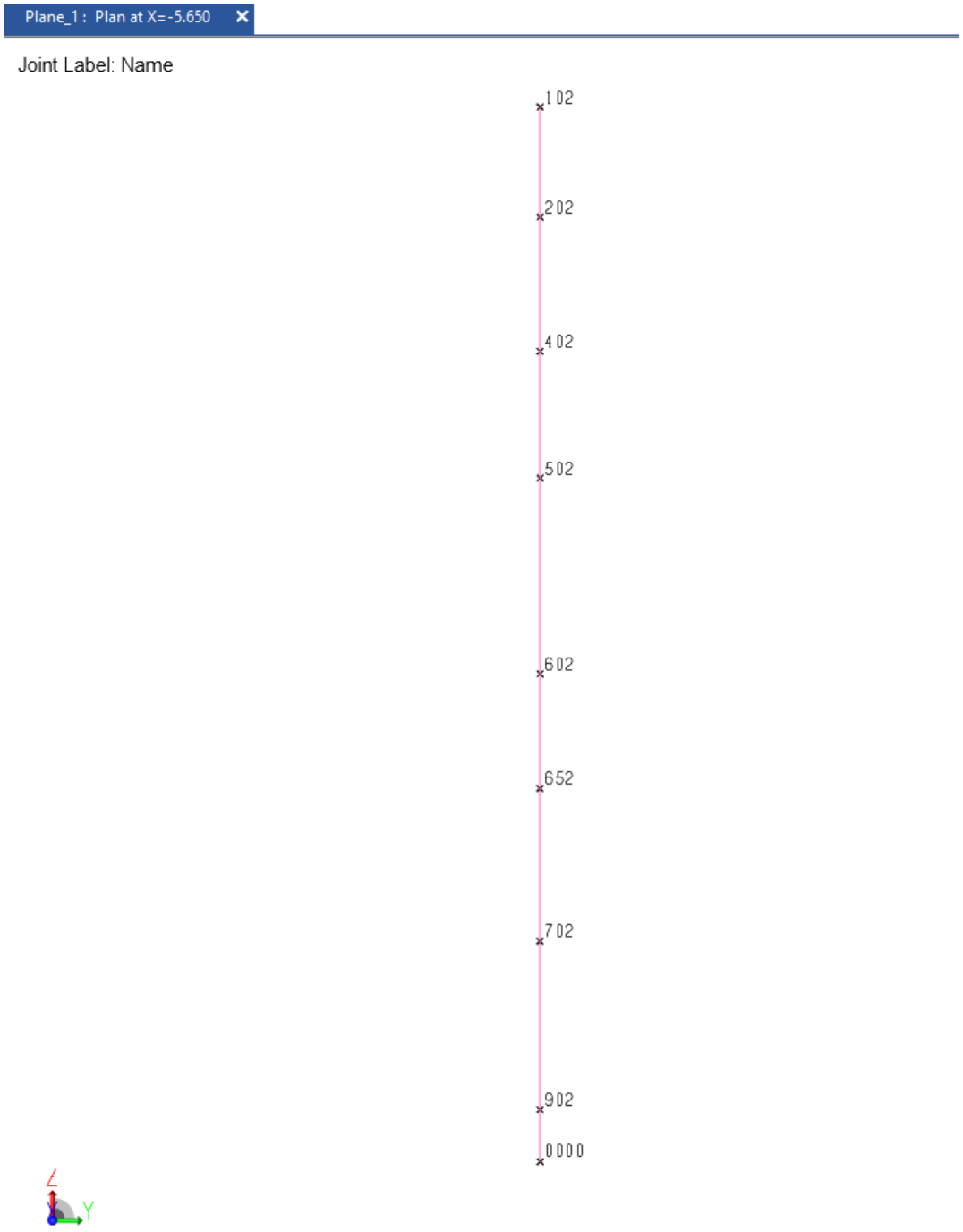
JOINT GRP	M/S	WALL THICK M	OUTSIDE THICK CM	E DIAM. CM	G 1000 KN/CM2	AXIAL 1000 KN/CM2	AREA CM**2	***** MOMENTS OF INERTIA **** X-X CM**4	Y-Y CM**4	Z-Z CM**4	YIELD STRESS KN/CM2	KY	KZ	SHEAR AREA CM**2	RING SPACE M	SECT TAPER LENG M
CFA	1	0.00	2.779	35.50	20.5	7.7	285.67	77016.	38508.	38508.	33.5	1.0	1.0	142.84	0.00	0.00
CFB	1	0.00	3.096	40.64	20.5	7.7	365.17	0.12956E+06	64778.	64778.	33.5	1.0	1.0	182.58	0.00	0.00
CS1	1	0.00	3.653	40.64	20.5	7.7	424.47	0.14659E+06	73295.	73295.	33.5	1.0	1.0	212.24	0.00	0.00
CS2	1	0.00	3.653	40.64	20.5	7.7	424.47	0.14659E+06	73295.	73295.	33.5	1.0	1.0	212.24	0.00	0.00
CS3	1	0.00	2.858	32.39	20.5	7.7	265.16	58356.	29178.	29178.	34.5	1.0	1.0	132.58	0.00	0.00
TR1	1	0.00	2.222	21.91	20.5	7.7	137.43	13488.	6743.9	6743.9	34.5	1.0	1.0	68.72	0.00	0.00
TR2	1	0.00	1.826	21.91	20.5	7.7	115.21	11714.	5857.2	5857.2	34.5	1.0	1.0	57.61	0.00	0.00
TR3	1	0.00	1.427	16.83	20.5	7.7	69.053	4130.9	2065.4	2065.4	34.5	1.0	1.0	34.53	0.00	0.00

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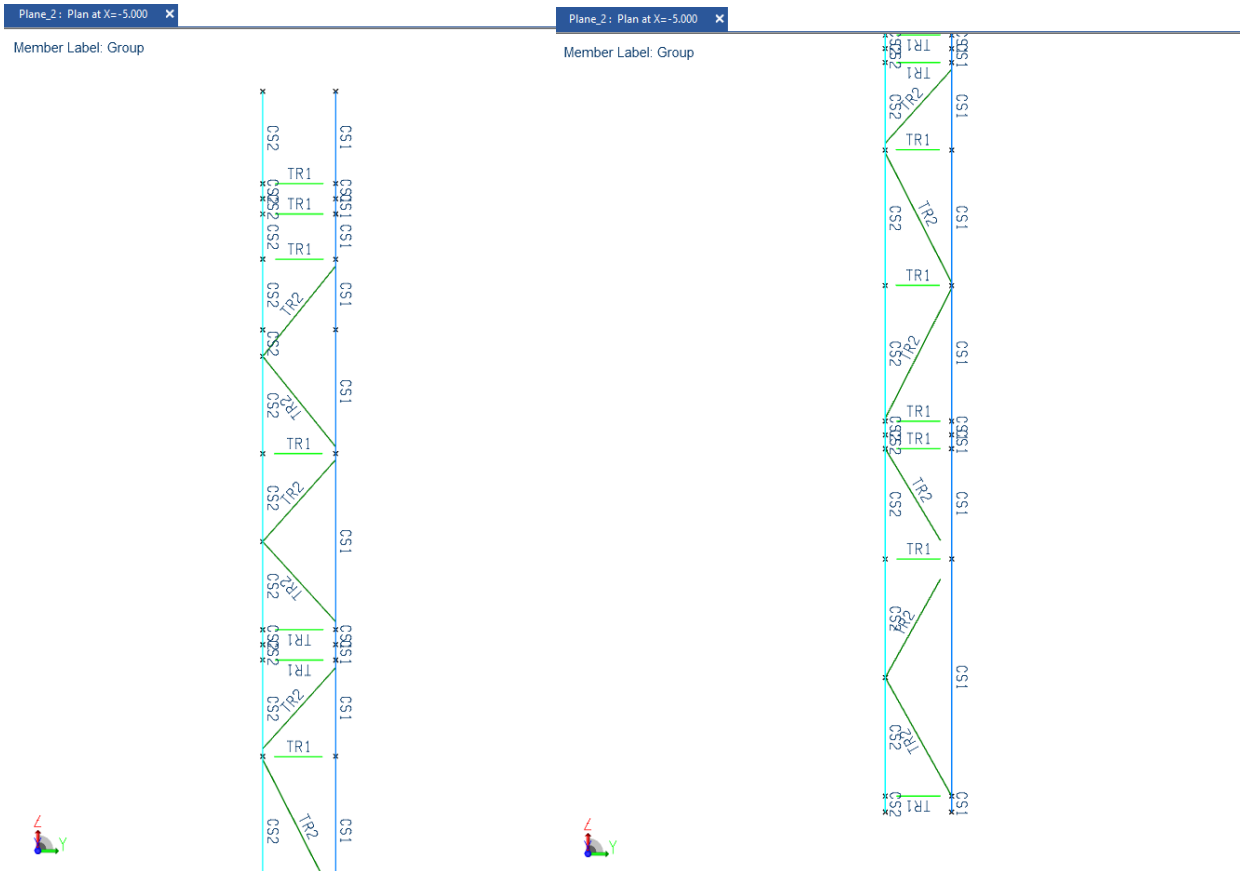
APPENDIX B – CF WIREFRAME SCHEMES



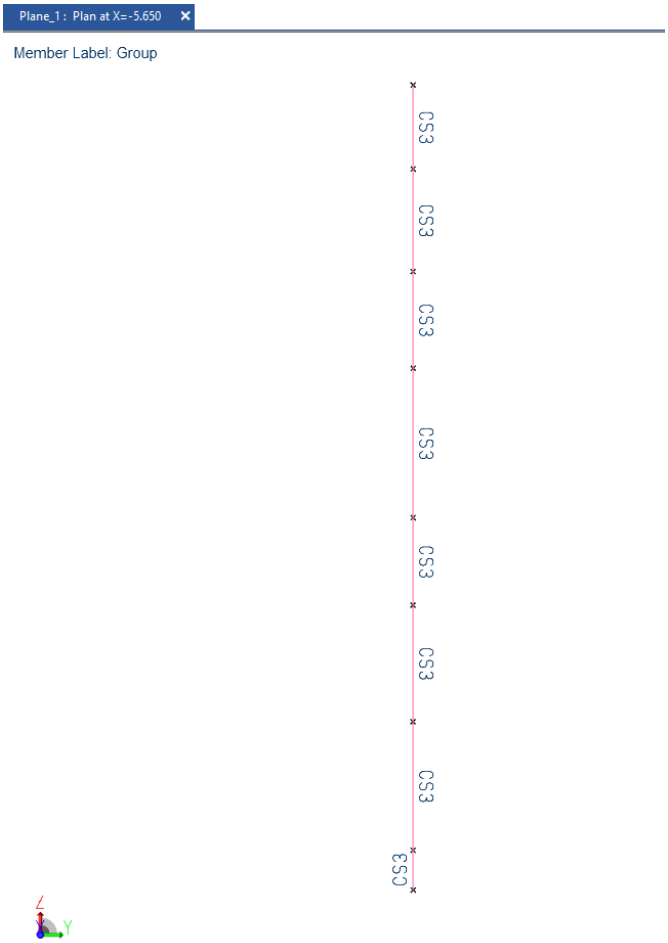
Seawater caissons frame – joints name



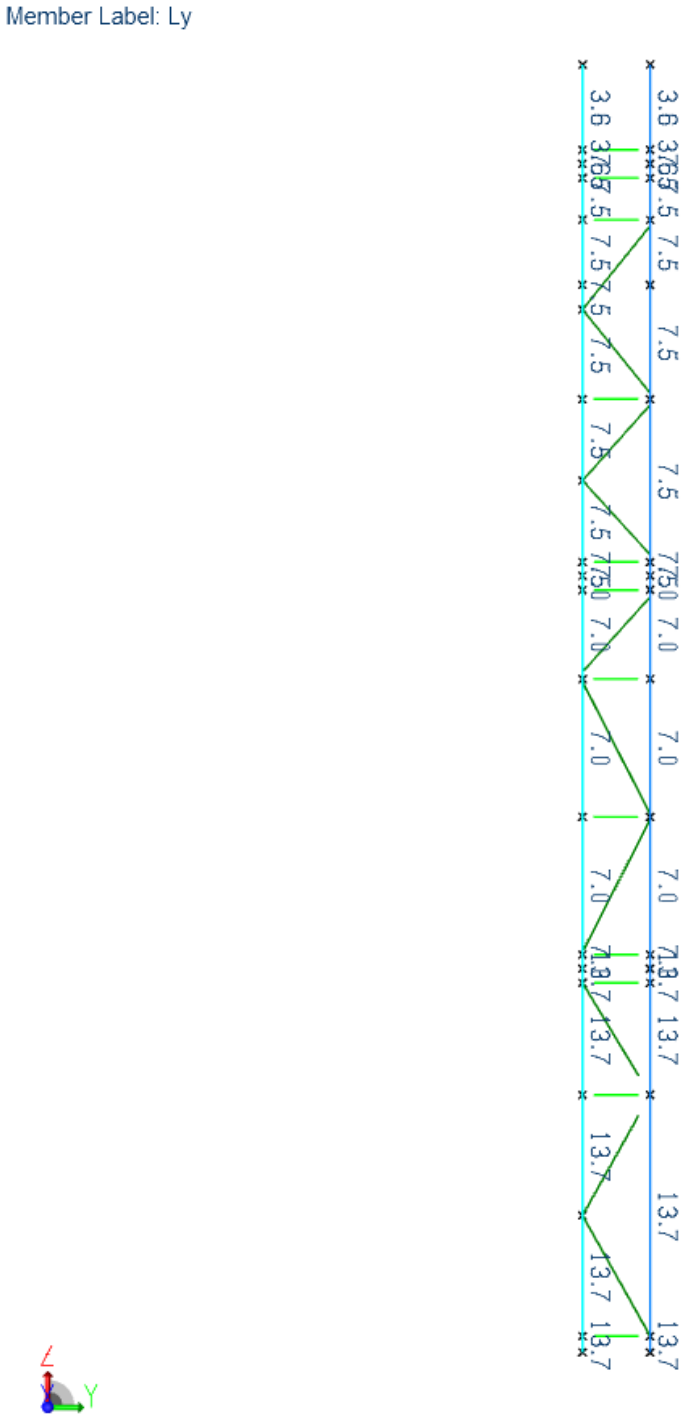
Brine discharge caisson – joints name



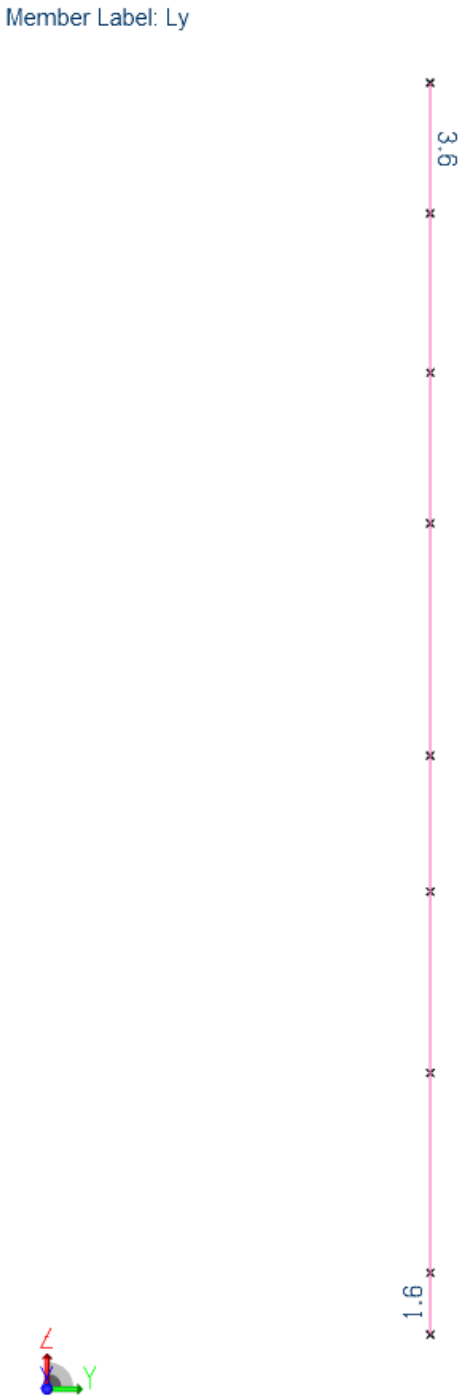
Seawater caissons frame – groups



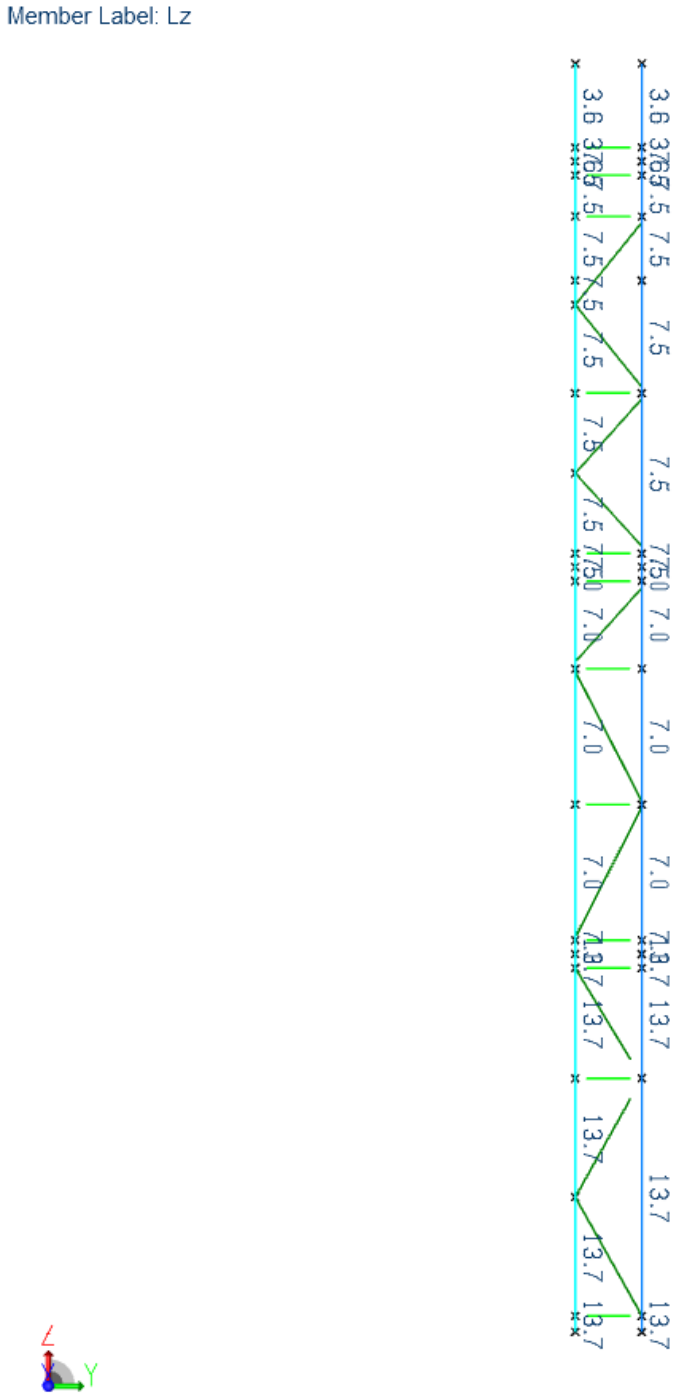
Brine discharge caisson – groups



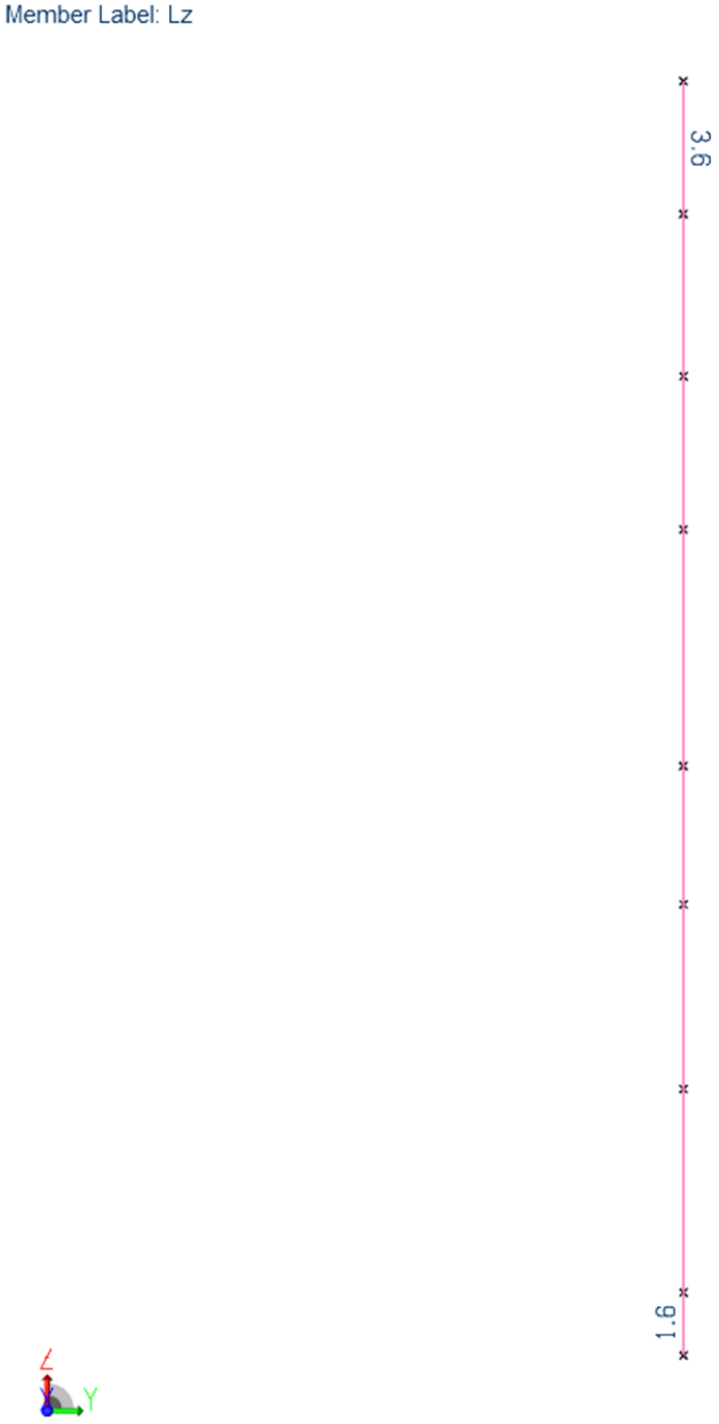
Seawater caissons frame – Ly



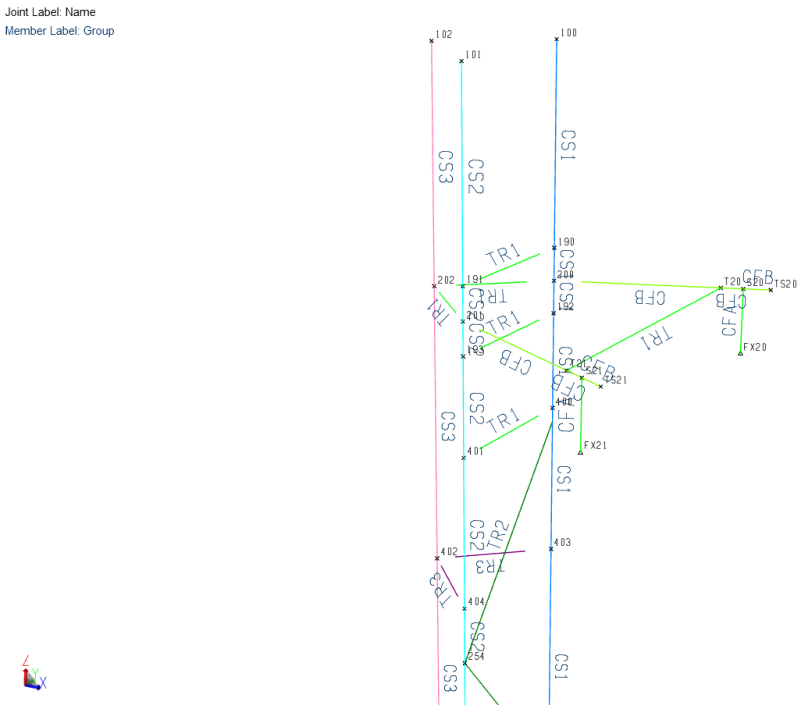
Brine discharge caisson – Ly



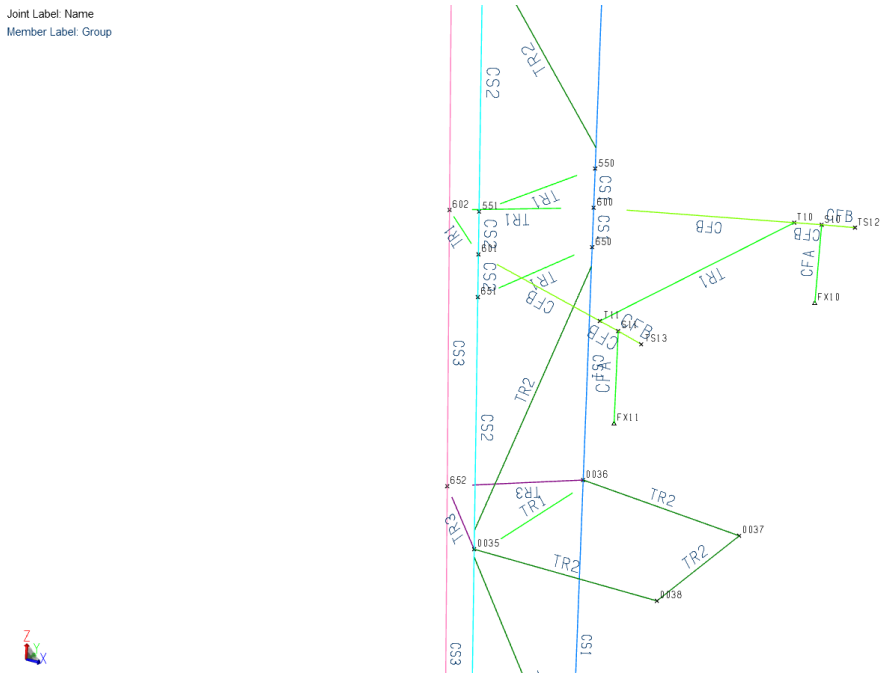
Seawater caissons frame – Lz



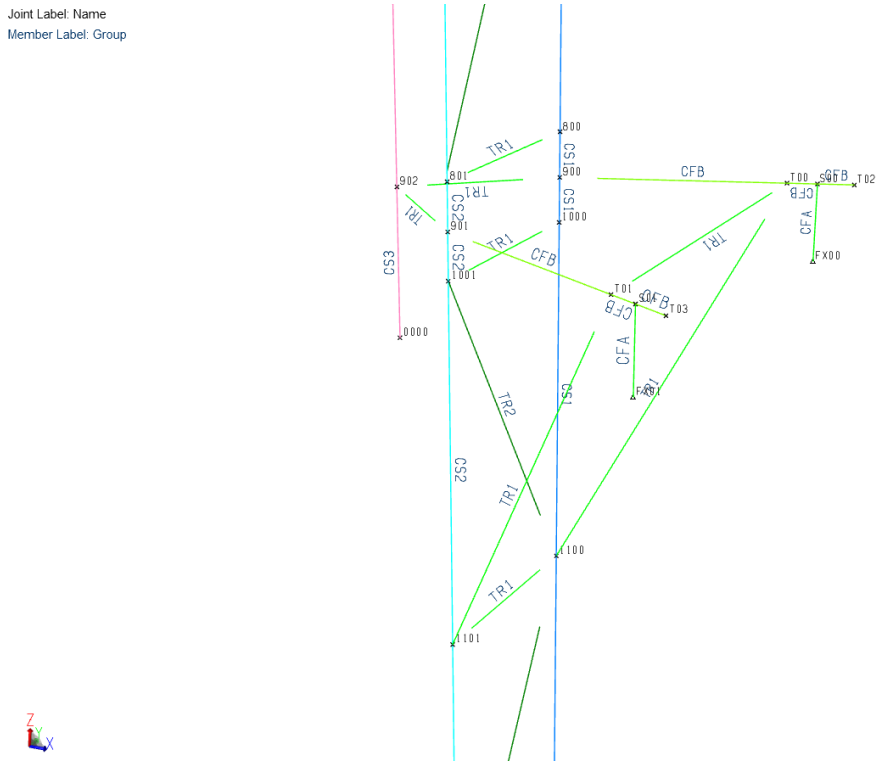
Brine discharge caisson – Lz



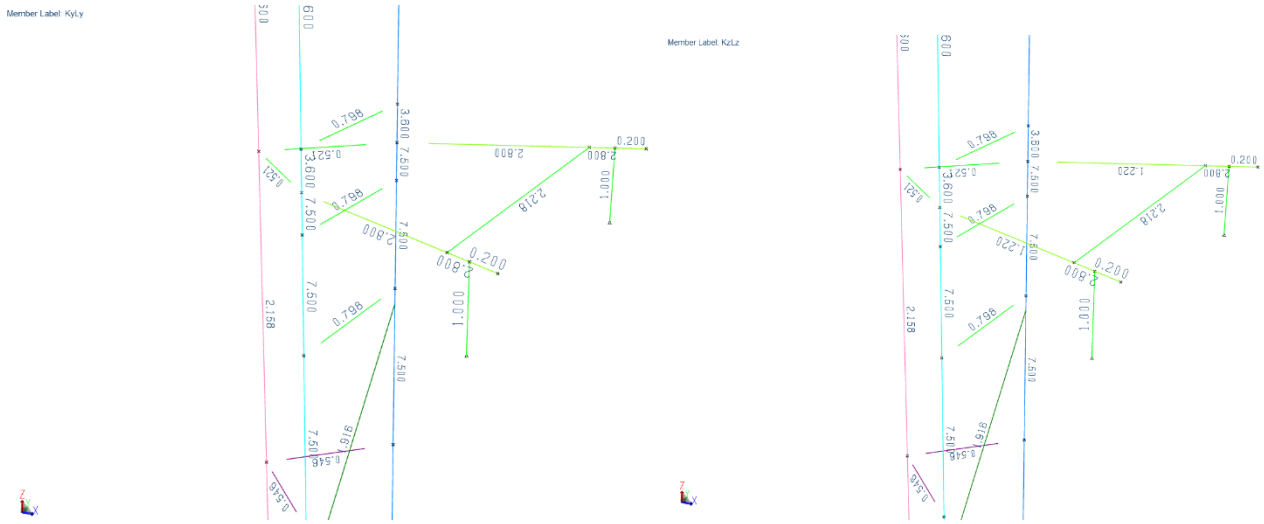
EL + 15.153m LAT – joins name and member groups



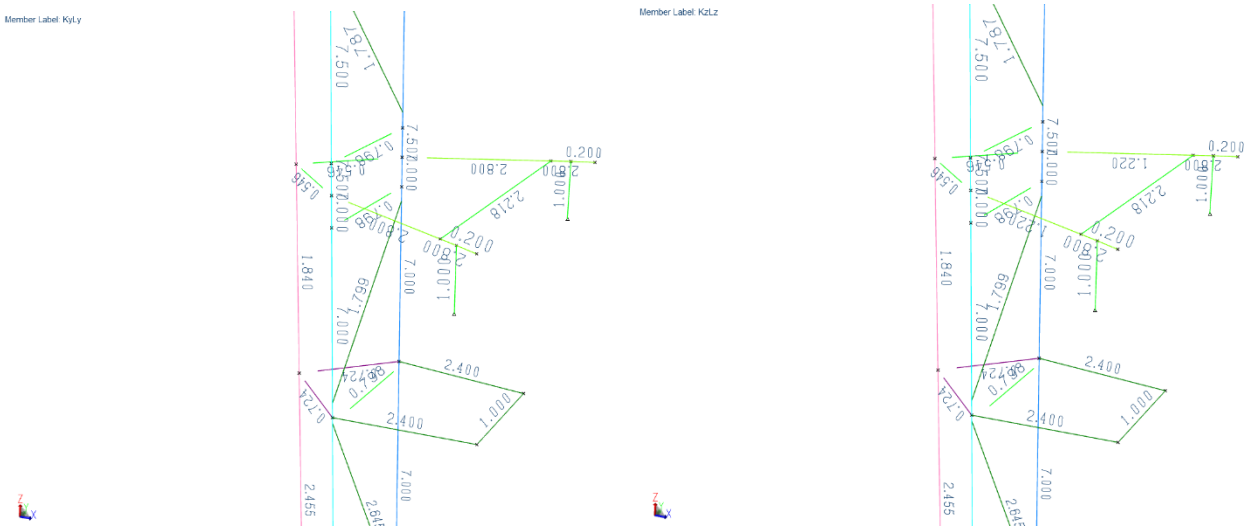
EL + 7.837m LAT – joins name and member groups



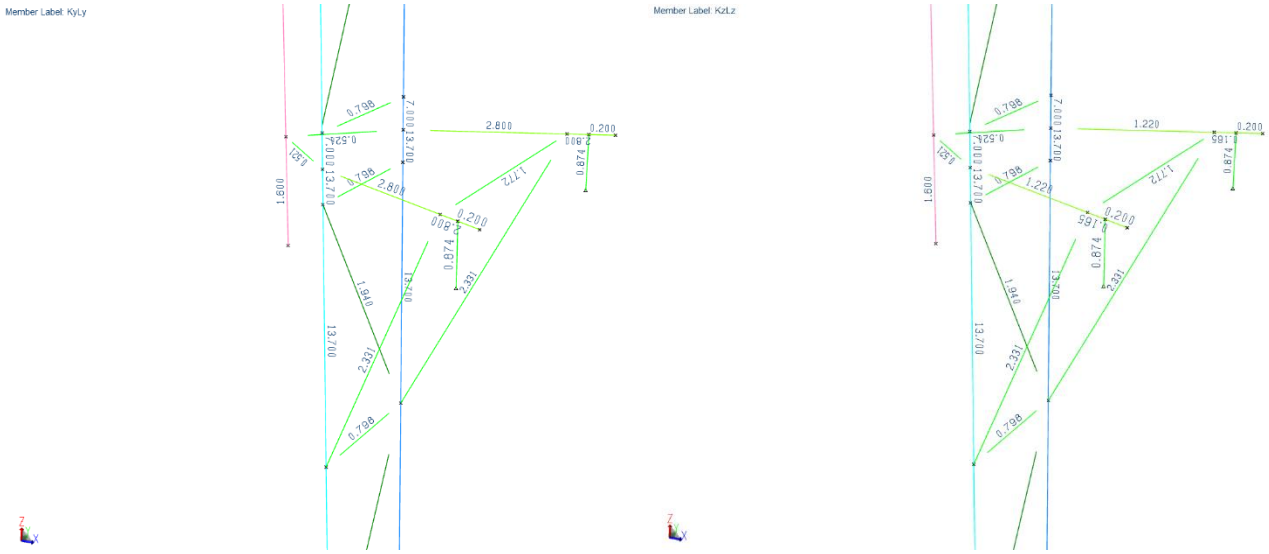
EL + 0.837m LAT – joins name and member groups



EL + 15.153m LAT – Ly & Lz



EL + 7.837m LAT – Ly & Lz



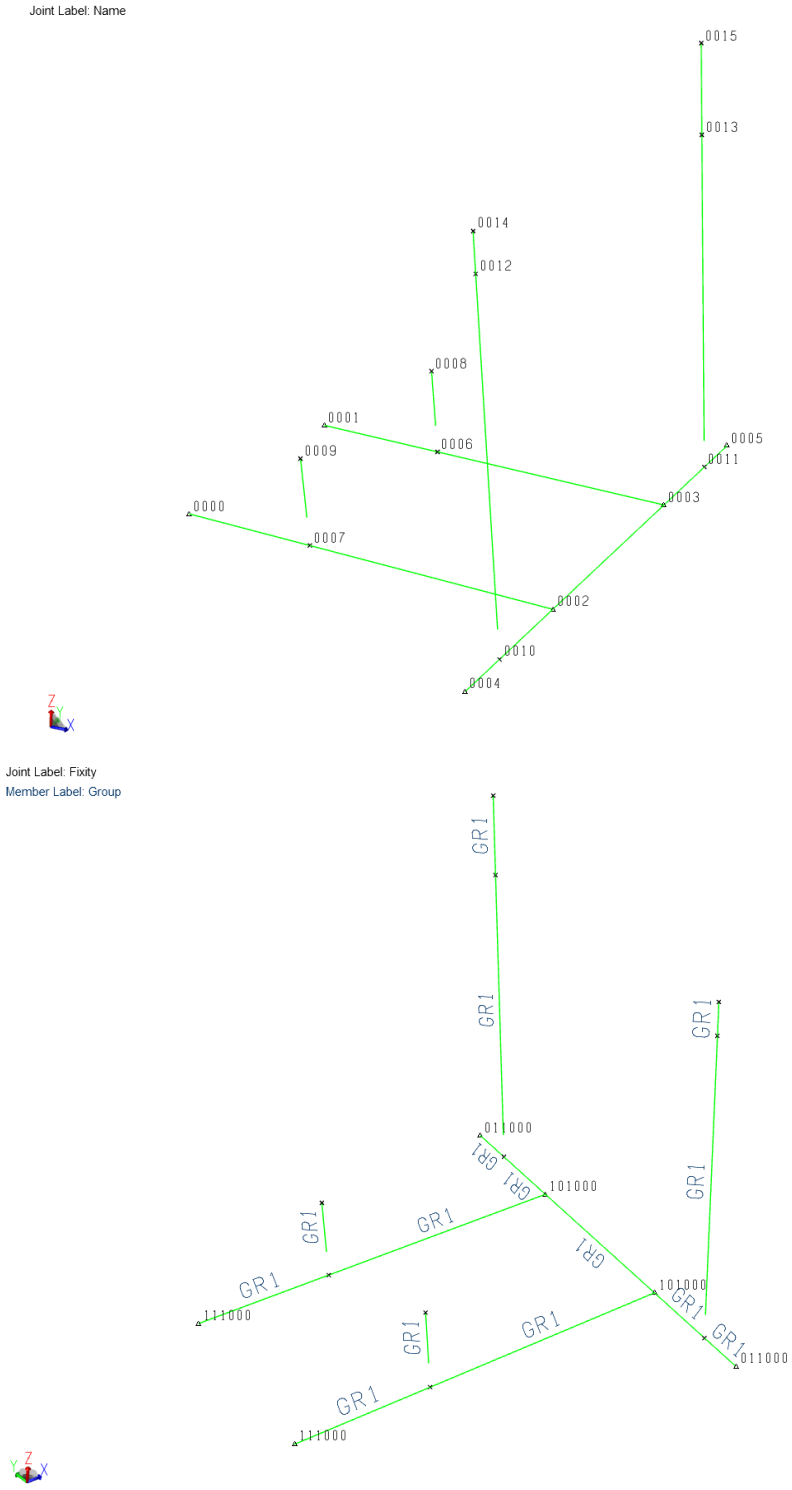
EL + 0.837m LAT – Ly & Lz

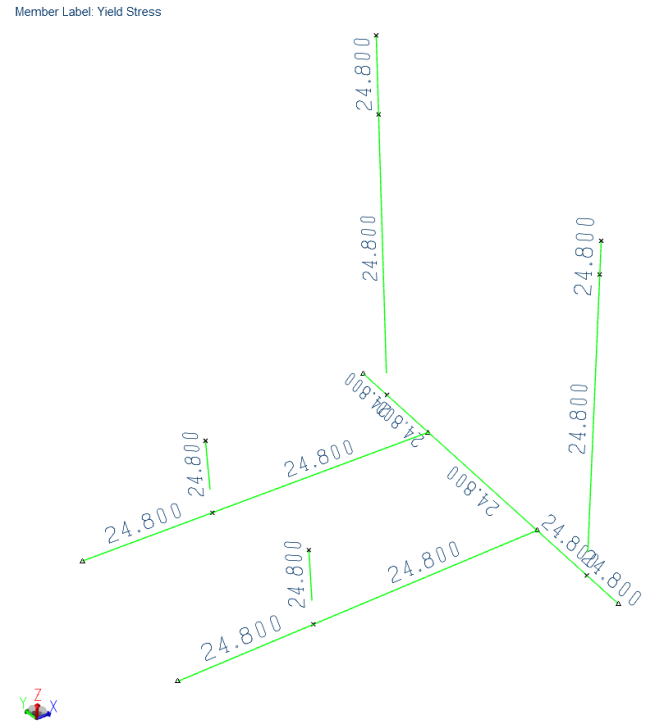
APPENDIX C – GR&SF MEMBER GROUP AND SECTION PROPERTIES

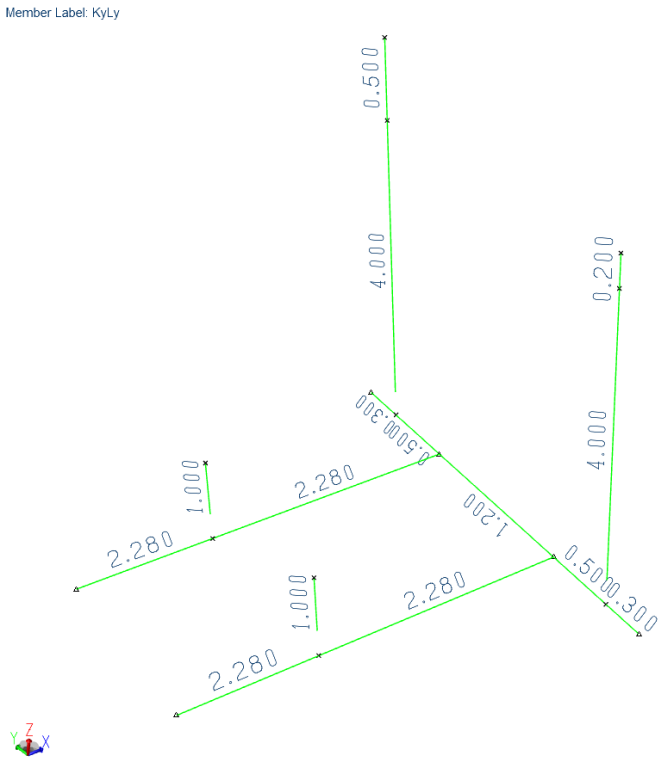
****** SEASTATE INITIAL GROUP DESCRIPTION ******

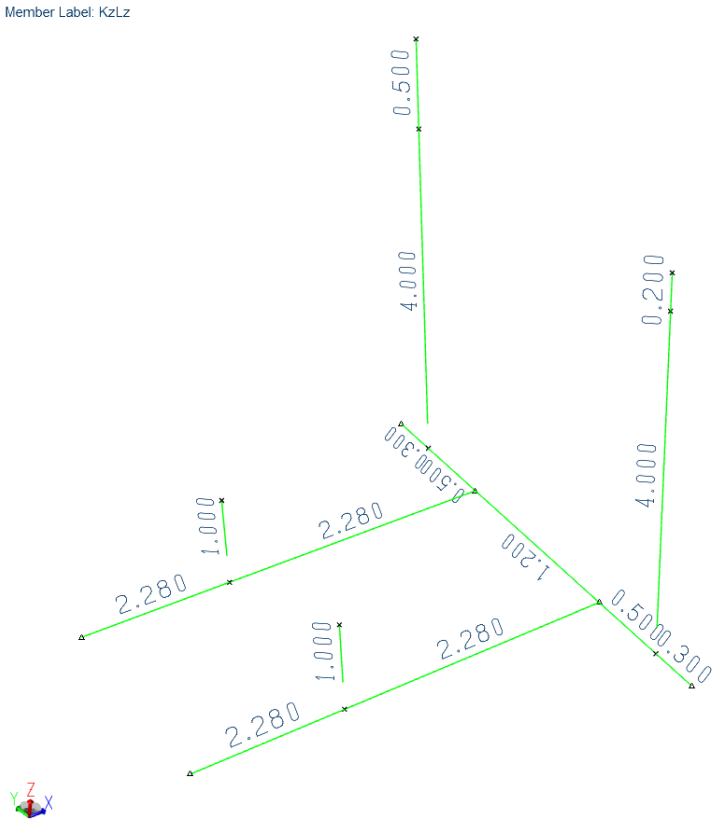
GROUP LABEL	SECTION LABEL	**** AREAS ***** CONST.	DISPL. (CM**2)	** DIAMETERS ** Y (CM)	Z	* SECTION * TYPE	LENGTH	* * MATL. * * DENSITY (TONNE/M**3)	JOINT * THICK (M.)	FLOOD	** DRAG AND INERTIA COEFFICIENTS ** CDY	CDZ	CMY	CMZ	CDT	CMT
GR1	HE340A	133.00	133.00	33.00	30.00	WF		7.849	0.000		0.61	0.61	1.39	1.39	0.00	0.00

APPENDIX D – GR&SF WIREFRAME SCHEMES




Member Label: Yield Stress
24.800
24.800
24.800
24.800
24.800
24.800
24.800
24.800
24.800
24.800
24.800
24.800
24.800


Member Label: KyLy
0.500
4.000
0.200
4.000
0.500
0.300
1.200
2.280
1.000
2.280
2.280
1.000
2.280
2.280


Member Label: KzLz
0.500
4.000
0.200
4.000
0.5000.300
1.200
0.5000.300
2.280
1.000
2.280
2.280
1.000
2.280