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MASTER THESIS

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DESIGN ANALYSIS AND OPTIMIZATION OF OFFSHORE MODULE

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FORWARD

This report is written by Zelalem Teshome Hika, and submitted as part of the requirements for completion of Master degree in Offshore Structural Engineering at University of Stavanger department of construction techniques and material technology. The terms of the assignment is from January to June 2012

Offshore structures may be defined as structures that have no fixed access to dry land. Such structures are highly exposed to environmental loadings, and required to withstand and overcome all conditions.

The main purpose of offshore structural analysis is to ensure that all offshore operations shall be performed in safe manner with respect to safety environment and economical risk.

The purpose of this thesis work is:-

- Learn to use SESAM GeniE for modelling the geometry and loads of the topside module.
- Learn to use SESAM Presel, Prepost, Framework and Xtract for structural analysis and reporting.
- Evaluation and implementation of relevant rules for offshore construction.
- Design and analysis of a module for relevant loads and control Phases such as transport, installation and operation.
- Optimize the frame/trusses configuration and selection of profile types to achieve optimal design with respect to weight considering, inplace, lift and transport condition.
- Local design of joints, lifting point and lifting pad eyes.

This master thesis has been carried out under the supervision of Rolf A. Jakobsen and Associate professor Siriwardane, S.A.Sudath C at university of Stavanger.

I would like to express my gratitude to my principal supervisors Rolf A. Jakobsen and Associate professor Siriwardane, S.A.Sudath C for their inspiration, follow-up and great advices.

I would like to thank Aker Solutions for giving me the opportunity to work on my master thesis with them and particularly I would like to express my deepest gratitude to my assistant supervisor Johan Christian Brun for his support and wonderful inspiration throughout, in such a way that I feel that I have gained greater understanding of this discipline.

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Finally I would like to thank my parents, brothers, sisters and friends for their support and inspiration during my study.

Stavanger 14.06.2012

Zelalem Teshome Hika

SUMMARY

The structural analysis of a topside module presents many technical challenges that have to be designed to overcome in efficient manner to meet a proper weight and strength control with respect to all conditions

The primary purpose and goal of the structural design analysis and optimization of this master thesis is to maintain proper weighed structure that has sufficient capacity and strength with respect to transportation, installation and operation. Apart from that the design analysis and optimization of this topside structure is to achieve a structure that has high safety with respect to life, environment and economic risk.

On preparation of analysis hand calculation of wind load, center of gravity and barge acceleration load were prepared.

During modeling, design analysis and optimization the following software tools were learned and utilized.

- SESAM GeniE for modeling the geometry and loads of the topside module
- SESAM Presel, Prepost, Framework and X-tract for structural analysis and reporting

In addition the following issues were considered.

- Evaluation and implementation of relevant rules for offshore construction;
- Optimize the frame/trusses configuration and selection of profile types to achieve optimal design with respect to weight considering, transport, inplace and lifting conditions;
- Design and analysis of the topside structure for relevant loads and control Phases;
- Local design of joints, lifting point and lifting pad eyes.

The structural design and analysis are performed considering the inplace as the basic and first stage of the process. Transport condition was second stage, considering barge accelerations, wind and sea fastening. Failing members could indicate a need for temporary reinforcements. All temporary reinforcements considered to be removed after the installation.

Lifting condition was the final stage. During lifting all temporary reinforcements will naturally be present.

Local design and analysis of lifting padeyes was performed for padeye loading capacity of 1500 tons.

Local analysis of joints for selected critical joints for inplace and lift conditions are detailed analysed and joints which had insufficient capacity were reinforced and analysed.

The results from the analysis reveal that the module has sufficient capacity to all design conditions.

The local analysis results for lifting padeyes show that the lifting padeye has sufficient capacity with respect to stresses in pin and eye, tensile stress next to the eye, shear stress in the pad eye plate and weld strength. The local analyses of critical joints results reveal that all critical joints have sufficient capacity with respect to design criteria and rules.

ABBREVIATIONS

ALS	Accidental Limit State
CoG	Centre of Gravity
CoGE	Centre of Gravity Envelope
CND	Operational, Storm or earthquake condition
DAF	Dynamic Amplification Factor
DC	Design Class
DNV	Det Norske Veritas
FLS	Fatigue Limit State
HSE	Health Safety and Environmental
IR	Interaction Ratio
IDC	Inter Discipline Check
LC	Load Case
Lbuck	Length between lateral support of compression flange
MEL	Master Equipment List
MSF	Module Support Frame
MTO	Material take-off
NS	Norsk Standard
PSA	Petroleum Safety Authority Norway
SDOF	Single Degree of Freedom
SOP	Swinging Object Protection
SI	System International
SKL	Skew Load Factor
SLS	Serviceability limit state
SMYS	Specified Minimum Yield Strength
SWL	Still Water Level
UF	Utility Factor
UFL	Unsupported Flange Length
ULS	Ultimate Limit State
V Mises	Equivalent stress used in von Mises stress check
WLL	Working Limit Load
WCF	Weight Contingency Factor

TABLE OF CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

An offshore structure may be defined as a structure that has no fixed access to dry land and is required to stay in position in all weather conditions. Major offshore structures support the exploration and production of oil and gas from beneath the seafloor.

The design, analysis and construction of these structures are one of the most demanding sets of tasks faced by engineering profession.

Offshore structures may be fixed to the seabed or may be floating. Floating structures may be moored to the seabed, dynamically positioned by thrusters or may be allowed to drift freely. Offshore structures should experience minimal movement to provide a stable work station for operations such as drilling and production of oil and gas. Offshore structures are typically built out of steel, concrete or a combination of steel and concrete, commonly referred to as hybrid construction.

The environment as well as financial aspects offshore requires that a high degree of prefabrication be performed onshore. It is desirable to design so that offshore work is kept to a minimum.

The overall cost of an offshore man-hour is approximately five times that of an onshore man-hour. The cost of construction equipment required to handle loads, and the cost for logistics are also much higher in offshore. These factors combined with the size and weight of a structure requires that the design must carefully consider all construction activities between shop fabrication and offshore installation. Ref. [23]

This master thesis presents the global design analysis and optimization of an offshore topside module which has a dimension of 40m x 20m x 20m length, width and height respectively.

The main goal of this master thesis is Optimization of structural member profiles and this thesis illustrates the strategy and procedure of performing a design optimization of a topside offshore module considering all the construction phases and design conditions.

Inplace, lifting and transport design analysis are performed using SESAM software package for global analysis of the topside module.

Local analysis of lifting padeyes, lifting points and joints are also performed with hand calculation and Excel software tools. The global and local analysis covers ULS and ALS condition are carried out in accordance with prevailing design rules and standards.

The design of offshore structures has to consider various requirements of construction relating to:

- Weight
- Load-out
- Sea transport
- Offshore lifting operations
- Hook-up
- Commissioning

The work performed in this report will be limited and concentrate on weight control, capacity and optimizations of member for transportation, lifting and operating phases and local analysis of lifting padeyes, lifting points and critical joints.

1.2 SCOPE

- Learn to use SESAM GeniE for modelling the geometry and loads of the topside module.
- Learn to use SESAM Presel, Prepost, Framework and Xtract for structural analysis and reporting.
- Evaluation and implementation of relevant rules for offshore construction.
- Optimize the frame/trusses configuration and selection of profile types to achieve optimal design with respect to weight considering, transport, lifting and operating conditions.
- Design and analyse the module for relevant loads and control phases such as transport, installation and operation.
- Local design and analysis of lifting padeyes, lifting point and critical joints.

1.3 REPORT STRUCTURE

The structure must be designed to resist static and dynamic loads. Chapter 2 discusses the general requirement of relevant techniques with respect to offshore structural design consideration. Chapter 3 presents the systematic approach to model the structure. Chapter 4 presents all the basic loads on the module. Chapter 5 presents action combination and structural analysis for inplace, lift and transport phases and global analysis the structure for all construction phases. Chapter 6 presents the local lifting padeye analysis. Chapter 7 considers methods of determining the static strength of local joint and analysis is performed and presented. In chapter 8 the discussion part of the analysis and optimization are presented and chapter 9 will presents the conclusion part of this thesis. References and Appendixes are presented at the end of this report.

2 DESIGN CONSIDERATIONS

2.1 ANALYSIS METHOD

The module shall be analysed by use of the SESAM suit of programs, and includes the following:

- GeniE for geometry and load modelling

Pre-processor for modelling beam/shell/plate structure
Pre-processor for applying equipment loads and actions

- Presel for super element assembly and load combining

Supper element and load assembly pre-processor
Use first level super elements created by GeniE to create higher order super elements
Assembles loads/actions from GeniE and create load combinations

- SESTRA for stiffness calculations

Solve the finite element equations

- Prepost for combining stiffness matrices and final load combinations

Conversion of finite element model, loads and results in to postprocessor data base elements

- Framework for code checks

Code check unit and post processor for finite element analysis

- Xtract for post processing

A post –processor for presentation of results from static structural analyses

2.2 DESIGN REQUIREMENTS AND CRITERIA

Governing law and regulations is the PSA, Ref. [2]. The structural checks will be carried out in accordance with NORSOK, Ref. [9] and [11], and Euro-code 3, Ref. [15].
The modules shall be code checked for following limit states:

ULS: Limit states that generally correspond to the resistance to maximum applied actions.

Action factors and action combinations with emphasis on ULS are given in chapter 5.

SLS: Limit states that correspond to the criteria governing normal functional use.
If not more stringent functional requirements specified otherwise, the following requirements for vertical deflection should apply:

Deck beams: $Max_{deflection} \leq L/200$ Beams supporting plaster or other brittle finish $Max_{deflection} \leq L/250$ Reference is also made to section 7.2.4 of NORSOK N-001, Ref. [9]. For the analyses performed, maximum deflection of L/250 is applied.

2.3 MATERIAL PROPERTIES

The steel qualities used in the analysis are presented and the strength reduction due to larger thicknesses (>40mm) shall be according to prevailing standards.

In general, the structural steels applied have the following steel properties and qualities:

Yield strength

Plates	420 MPa	
Sections	420 MPa	(Welded profiles)
	355 MPa	(Standard profiles

Further reference is made to [6], [7] and [8]

Any new steel shall comply with requirements set out in the NORSOK standards.

The design resistance shall be determined based on the characteristic values of material strength reduced by the material factor in accordance with section 7.2 of NORSOK N-001, Ref. [9]

The following material properties are considered for all steel profiles:

Young's modulus	E = 210000 N/mm2
Shear modulus	G = 80000 N/mm2
Density	ρ= 7850 kg/ m3
Poisson's ratio	υ = 0.3

MATERIAL FACTOR

Values of material factors can be taken as 1.0 except for ULS in which the following value is applied:

- 1.15 for Structural Steel detail

2.4 CROSS SECTIONS

Loading orientation on the structural member usually influence the selection of section profile types of the structural members. For this topside structural module, HEB and Square hollow sections with hot rolled and cold welded profile will be considered.

HEB profile type is most widely used for floor beams and columns because these profiles have great efficiency in transverse loading.

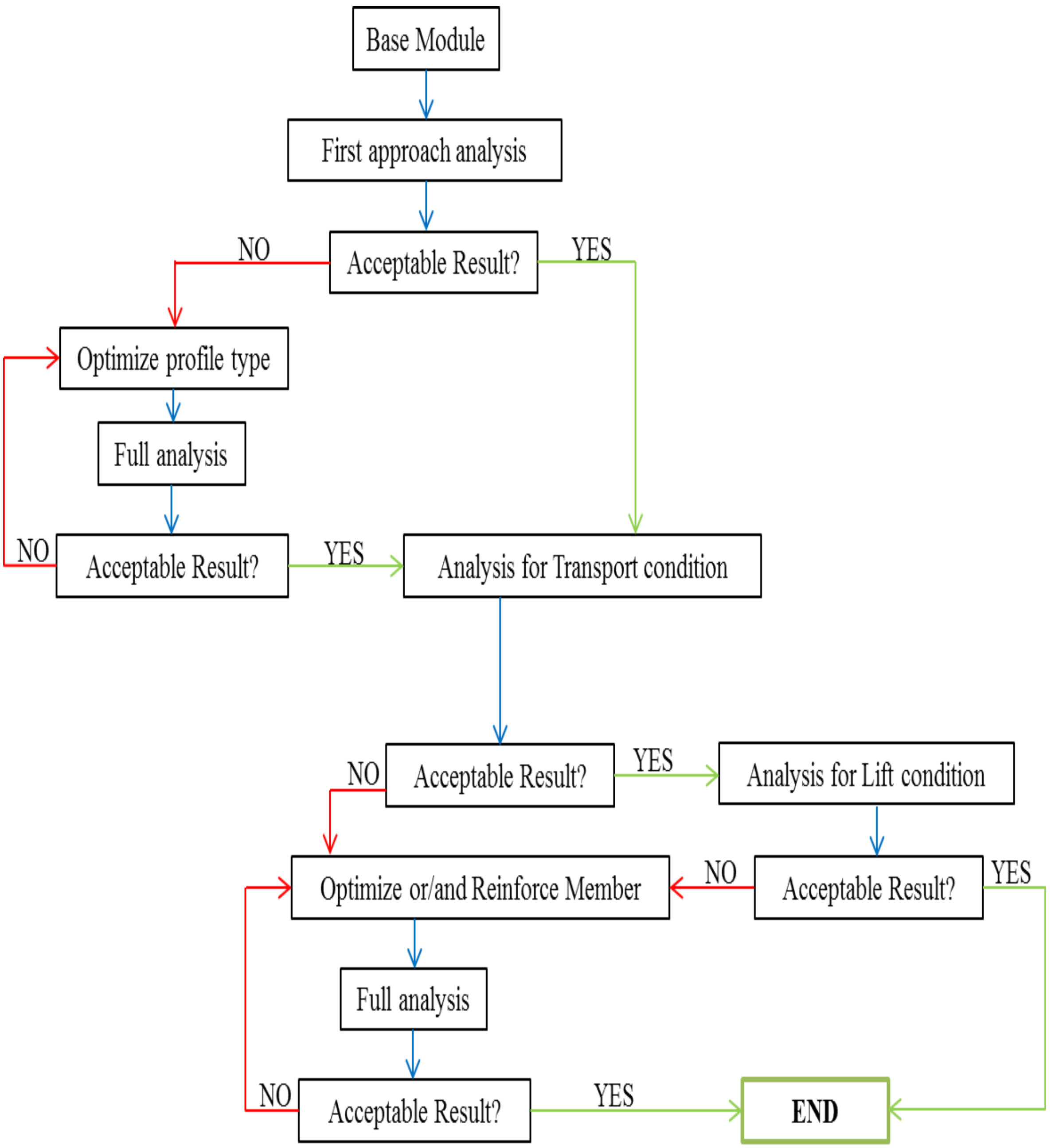
Rectangular tubes designed as rectangular hollow section widely used for column members because of their efficiency in axial compression and torsion. Selection of the structural member is considered the theory behind the structural member responses during transvers loading and axial loading.

Global analysis of the topside structure will be performed and member utilization factors are checked. Optimizations are performed for all construction phases. The final selected section properties of profile types are presented in Table 5-15

The general geometry and member names of the module is presented in Appendix A, joints names in Appendix B and all sections applied are presented in Appendix C

2.5 DESIGN ANALYSIS AND OPTIMIZATION PLAN

The analysis and optimization plan presented below shows the strategy to overcome optimized and well-integrated structure for inplace, lifting and transport condition.



3 COMPUTER MODELLING

3.1 GENERAL

The module is modeled and analyzed by use of SESAM suit of programs.

3.2 COORDINATE SYSTEM

The coordinate system is used is such that Y is pointing North, X is pointing East, Z is pointing upwards.

3.3 UNITS

The fundamental units (database unites) that used in the analyses are the following SI unites or multiples of:

Length: meter (m)
Mass: tonne (T) (10^3kg)
Time: seconds (s)

The resulting force and stresses will then be Mega Newton (MN) and MN/m^2 (MPa)
Input units to SESAM GeniE (pre-processor) are as follows:

Length: meter (m)
Mass tonene (T)
Time: second (s)
Force: kilo Newton (kN)

3.4 MEMBER, JOINTS AND DECK PLATE MODELING

A systematic approach to member and joint names will be adopted in the SESAM analyses.

Joint/Point names

Structural joints will have names starting with the letter J for joints and P for points, plus a six digit number system as follows:

Jxxyyzz (joint)
Pxxyyzz (point)

Where xx,yy and zz are numbers in the range between 00 and 99 indicating the position of the joint/point in the module's coordinate system.

Member names

Member names will start with the letter M and used the following notation:

Mαxxyyzz

Where: xx, yy and zz are numbers in the ranger between 00 and 99 corresponding to end 1 joint number. D may be used for dummy elements instead of M. α is a letter according to the direction of the member:

X- x-direction
Y- y-direction
Z- z-direction

A -Brace in the xy-plane running in the positive x-and positive y-direction
B -Brace in the xy-plane running in the positive x-and negative y-direction
C -Brace in the xz-plane running in the positive x-and positive z-direction
D -Brace in the xz-plane running in the positive x-and negative y-direction
E -Brace in the yz-plane running in the positive y-and positive y-direction
F -Brace in the yz-plane running in the positive y-and negative z-direction

Deck members and columns running in the parallel with the axis system shall always run in the positive direction. Direction of braces shall be such that the x-direction predominate the y-direction, which again predominates the z-direction. I.e. braces in xy- and xz–plane shall always run in positive x-direction, while braces in the yz-plane shall run in positive y-direction.

Plate names

Deck plates will have the following notation:

PLxxyyzz

Where: xx,yy and zz corresponds to the start joint of the plate. The start joint shall be the lower left corner of the plate with the following joints defined in the counter clockwise direction.

Joint modeling

Increased stiffness inside joint will in general be neglected, for large prefabricated nodes (e.g. support nodes) the joint stiffness may be simulated by use of separate elements with increased stiffness (dummy members). The stiffness of the dummy element shall be evaluated in each case.

Plate modeling

4- noded quadrilateral shell elements is used to simulate the in-plane shear stiffness of the deck structures. The plate elements shall not contribute to the strong axis bending stiffness of the deck girder and will therefore be modeled at the center of the deck girders (the system lines)

Only the shear stiffness of the plate is accounted for in the global module analyses. This is achieved by use of anisotropic shell element formulation and dividing the x-and y-components of the elements stiffness matrix by a large number (100 is used).

3.5 BOUNDARY CONDITIONS

The module is subjected to a two-step analysis.

Step one

Comprise dead load only, representing the condition at installation. The boundary conditions at this stage is statically determined; i.e., no constraint forces will be a strain on the structure

Step two

Step two represents the boundary conditions in operating and transport phases. This means that all the module supports are pinned, i.e. fixed for translation in all three directions. All live-, variable- and environmental loads are applied in this step.

3.6 CODE CHECK PARAMETERS

Code check of members is performed for ULS-a/b by use of SESAM Framework. Member checks (yield and stability) are performed according to NS3472, NORSOK N-004 and Euro-code 3.

Material Factor

The material factor (γ_m) for structural steel members is 1.15 for ordinary ULS analysis.

Buckling Length Factor(Ly, Lz)

All members will be given default buckling length factor 1.0. However, booking may be set manually if considered relevant.

Buckling Length

The default buckling length (Ly, Lz) is equal to the member length.
For members being modeled by several elements, the buckling lengths (Ly and Lz) may be adjusted to the distance between the actual restraints. For deck beams with top flange being restrained by the deck plate the buckling length for in-plane buckling can be set to a small length, i.e. 0.1L

Unsupported Flange Length (UFL)

The unsupported length of the compression flanges shall be modeled for lateral buckling checks of beams and girders. The default UFL is equal to the length of the element. For deck beams with top flanges being supported by a deck plate and where it can be demonstrated that the bottom flanges are in tension for all design cases, the UFL may be set to a small length to suppress the lateral buckling check

4 ACTION AND ACTION EFFECTS

A load numbering system is common for this topside module, and applied to first level super elements. The outline of numbering system is presented in Table 4-1

Load case	Description
1-10	Permanent loads representing steel weight
20-27	Permanent loads present at all control phases
31-34	Content weight (mechanical, piping, HVAC, etc.)
50-55	Wind loads
101-134	Horizontal acceleration loading, x-direction
201-234	Horizontal acceleration loading, y-direction

Table 4-1 Outline of the numbering system

4.1 DEAD LOADS

The dead loads include weight of structure, equipment, bulk and other items which form a permanent part of the installation.

Dead load or permanent load can usually be determined with high degree of precision. Hence, the characteristics value of a permanent load is usually taken as the expected average based on actual data of material density and volume and material.
The weight contingency of 1.10 is applied to all permanent loads included as part of the permanent weight.

The structural weight comprises primary, secondary and outfitting steel. Secondary and out fitting steel will be a percentage of the primary steel weight, unless a specific weight is defined.

On preparation of load modeling the total module weight was estimated to be about 2000T. The module ended up with a total un-factored weight of 1609.30T, split into various disciplines and deviations of the expected weight are listed in Table 4-2 below.

Basic dead load and live load generated from GeniE input data and SESTRA output are presented in Appendix D. the dead loads distribution is presented in Table 4-1.

Discipline	Relative	Actual	Deviation
Various equipment	20.9 %	336	1.994378
Electrical Dry Weight	3.9 %	62	-0.59895
Instrumental Dry Weight	1.5 %	24	0.726758
Piping Dry Weight	12.4 %	200	-0.28868
HVAC	1.7 %	28	-0.55598
Safety Dry Weight	1.7 %	28	-0.40797
Surface Dry Weight	0.7 %	12	-0.65465
Architectural Dry weight	3.0 %	48	-0.56831
Self Generated Dead Weight	36.1 %	580.9	
Secondary Steel	14.4 %	232.3	-0.27476
Outfitting Steel	3.6 %	58.1	-0.47408
	100.0 %	**1609.3**	

Table 4-2 Load distribution

4.2 LIVE LOADS

Live loads or variable functional loads are associated with use and normal operation of the structure
The live loads that usually must be considered are

- Weight of people and furniture
- Equipment and bulk content weights
- Pressure of contents in storage tanks
- Laydown area and live load on deck

The choice of the characteristic values of live load is a matter of structure. In general inventory and Equipment Live Loads shall be taken from the Master Equipment List and/or Weight Report and be distributed according to reported CoG coordinates but on this report the weight distribution is taken from Aker solutions list of weight report.

There is always be a possibility that live load will be exceeded during life time of the structure. The probability for this to happen depends on the life time and the magnitude of the specified load. In general during the course of the life of the platform, generally all floor and roof areas can be expected to support loads additional to the known permanent loads.

Variable deck area actions are applied in the structural check to account for loose items like portable equipment, tools, stores, personnel, etc. Deck area actions are applied in accordance with NORSOK, N-001 Ref. [9]

4.3 ENVIRONMENTAL LOADS

Environmental loads, is associated with loads from wind, snow, ice and earthquake. Within the design of offshore structures wave and current loads also belongs to this group.

For wind and snow statistical data are available in many cases. In connection with the determination of characteristic load, the term mean return value is often used. This is the expected number of years between a given seasonal maximum to occur.

Offshore structures are highly exposed to environmental loads and these loads can be characterized by:

- Wind speed and air temperature
- Waves, tide and storm surge, current
- Ice (fixed, floes, icebergs)
- Earthquake

4.3.1 WIND ACTIONS

The wind load which is applied on the structure is based on static wind load and basic information is presented below.

Reference wind speed applied on a module is the 1-hour, all year Omni directional wind speed at 10m above LAT:

U1h, 10m, 1y = 25.5 m/s
U1h, 10m, 10y = 29.5 m/s
U1h, 10m, 100y = 34.0 m/s

The global ULS inplace analyses will be based on the 3-second gust wind (L < 50m). Local checks, if applicable, of stair towers, crane, wind cladding, etc. should be based on the 3-sec gust wind.

For simplicity the wind load in the module analyses will be based on a constant wind speed at an elevation located ¾ of the module height.

The static wind load is calculated in accordance to NORSOK N-003 section 6.3.3. For extreme conditions, variation of the wind velocity as a function of height and the mean period is calculated by use of the following formulas:

The wind loads are calculated by the following formula:

$$F = ½ \cdot \rho \cdot Cs \cdot A \cdot U_m^2 \cdot \sin(\alpha)$$

Where:

ρ =1.225 kg/m3	mass density of air
Cs	shape coefficient shall be obtained from DNV-RP-C205,
A	area of the member or surface area normal to the direction of the force
U_m^2	wind speed
α	angle between wind and exposed area

The characteristic wind velocity u (z,t)(m/s) at a height z(m) above sea level and corresponding averaging time period t less than or equal to t_0 = 3600 s may be calculated as:

$$U(z,t) = U_z [1-0.41 I_u(z) \ln (t/t_0)]$$

Where, the 1 h mean wind speed U(z)(m/s) is given by

$$U(z) = U_0[1+C \ln(z/10)]$$

$$C = 5.73 * 10^{-2} (1 + 0.15 U_0)^{0,5}$$

Where, the turbulence intensity factor Iu (z) is given by

$$I_u(z) = 0.061[1+0.043U_0](z/10)^{-0.22}$$

Where, U_0 (m/s) is the 1 h mean wind speed at 10m

The wind load calculations performed for operational and transport phases are presented in Appendix D.

4.3.2 WAVE ACTIONS

Wave load is not relevant for structures positioned higher than 25 meter above sea level. It is considered that the module presented on this report has sufficient height above sea level to avoid direct wave loading.

4.3.3 EARTHQUAKE LOADS

Structures shall resist accelerations due to earthquake. The 100 year earthquake accelerations for this topside structure are 0.051g horizontal and 0.020g vertical. Ref. [18]
Accidental earthquake condition is also considered for inplace design and the values are presented in Table 4-3 below.

Earthquake load	100 years	10000 years
X direction	0.051g	0.245g
Y direction	0.051g	0.255g
-Z direction	0.020g	0.061g

Table 4-3 Earthquake acceleration

Earthquake with annual probability of 10^{-2} can be disregarded according to NORSOK N-003 Section 6.5.2 Ref. [10]

4.3.4 TRANSPORT ACCELERATION

The transport analysis will consider ULS-a/b load conditions with module dry weight (including temporary reinforcement), CoG shift factor, transport accelerations and wind. Wind loads and accelerations are applied in eight directions at 45 degrees interval covering the complete rosette, and is presented in Figure 4-1.

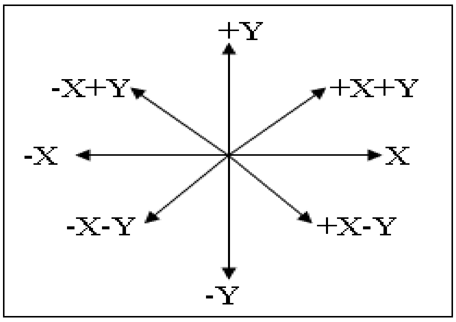


Figure 4-1 Directions of horizontal accelerations and wind

The barge acceleration is calculated according to Noble Denton Ref. [20] and detail calculation is presented in appendix D. Result are presented in Table 4-4

DIRECTION	ACCELERATION
X	1.054g
Y	0.662g
Z	0.200g
Z	-0.200g

Table 4-4 Barge motion acceleration

5 GLOBAL STRUCTURAL ANALYSIS AND OPTIMIZATION

The aim of structural design analysis is to obtain a structure that will be able to withstand all loads and deformations to which it is likely to be subjected throughout its expected life with a suitable margin of safety. The structure must also fit the serviceability requirements during normal use.
The various performance and use requirements are normally specified in terms of *LIMIT STATES.* For steel structures the limit states may be categorized as follows:

- Ultimate limit states (ULS), corresponding to the maximum load carrying capacity.
- Fatigue limit states (FLS), related to the damaging effect of repeated loading.
- Serviceability limit states (SLS), related to criteria governing normal use and durability.
- Accidental limit states (ALS), corresponding to accidental moments during operation.

The design of structure may be divided into three stages. These are:

<u>Functional planning</u>
This problem in design is the development of a plan that will enable the structure to fulfill the purpose for which it is built.

<u>Cost estimate</u>
Tentative cost estimate are developed for several structural layout

<u>Structural analysis</u>
Selection of the arrangement and sizes of the structural elements are decided so that the service loads may be carried with a reasonably factor of safety.

Offshore structures are not fabricated in their final in-service position. Therefore, a detail design must consider the following stages:

- Fabrication and erection
- Load out from fabrication yard to barge
- Transportation from yard to offshore site on a barge
- Lift from barge to final position
- Inplace operating and accidental conditions

It is necessary to consider all accidental stages as different members may be critical in different cases. In practice, the first two cases will be checks of the structure whereas the transport, lifting and operating conditions are governing for the design and final lay-out. This is because the fabrication, erection and load out methodology can be varied to suit the structure, but the other load cases are fundamental in the structure design. Analyses were therefore carried out for three primary load conditions, inplace, lift and transportation.

A brief discussion of the various load effects on the topside structure will be given in the present chapter. Finally, the Ultimate limit state check for all conditions will be illustrated. All loads that may influence the dimensioning are to be considered in the design analysis. Linear elastic design techniques have been applied almost exclusively to design structural steel work in offshore topside modules.

Structural analysis shall include all design conditions that required to cover the design limit states as specified by the PSA Ref.[1], and NORSOK N-001 Ref.[9]. Actions shall be combined in accordance with NORSOK N-003.

The combinations applied in the analysis are presented in Table 5-1below. Wave and current are not applicable for this module.

Ice only to be combined with 10^{-1} wind and due to the small loads it is considered negligible.

Snow loads are assumed to have minimal effect on this, and are therefore considered negligible

Limit states	Wind	Wave	Ice	Snow	Earthquake
ULS	100	100	-	-	-
	-	-	-	-	100
SLS	100	100	-	-	-
ALS	-	-	-	-	10000

Table 5-1 Environmental action combinations

ALS 10 000-year wind is not governing due to reduced load- and material factors, and for these analyses, it will be neglected.
The action factors to be used for the various limit states are presented in Table 5-2 below.

Load combination	P	L	E	D	A
ULS-a	1.3	1.3	0.7	1.0	-
ULS-b	1.0	1.0	1.3	1.0	-
SLS	1.0	1.0	1.0	-	-
ALS	1.0	1.0	-	-	1.0

Table 5-2 Action factors

Where:

P = Permanent loads
L = Variable functional loads (Live loads)
E = Environmental loads
D = Deformation loads
A = Accidental loads

5.1 INPLACE CONDITION

Inplace load combinations shall consider ULS – a/b load conditions with contribution from relevant load types as defined in chapter 4. Load combinations are established to give maximum footing reactions at the interface between the modules and the Main Support Frame (MSF).

Environmental loads wind, earthquake and barge accelerations shall be considered acting from eight different directions at 45 degrees interval covering the complete rosette.

However, the wind load applied on inplace storm condition is considered East/West only. Wind load from North and South directions are ignored because of shielding effects. The module is analysed for wind with average recurrence period of 100 years.

The 100-year ice loads shall be combined with 10-year wind action. Considering the modules height above water level, Ice load is neglected in the global analysis.

Snow loads shall not be combined with any other environmental loads. Considering the small load magnitude of 0.5 KN/m^2 it is concluded that the snow load can be neglected in the global analyses.

Maximum deck beam deflections in the SLS condition shall be analysed combining all permanent loads and variable functional loads. No other environmental loads will be included, but horizontal displacements at selected spots on the weather deck are reported for 100-year wind.

The super nodes applied for the boundary conditions for inplace condition are:

- S(301005)
- S(304005)
- S(701005)
- S(704005)

The support points for the inplace condition is to prevent constraint forces, a statically determined support system (3-2-1-1) is applied on all dead loads.

Action combinations for inplace analysis are performed in Presel. Both Presel load combinations comprise 3 levels, allowing combining and factoring loads up to a level for final ULS/SLS/ALS load combination in SESAM Prepost

Basic load cases modeled in SESAM GeniE listed in Table 5-3, Table 5-4 Table 5-5, Table 5-6 and Table 5-7below

Load Case	Description	Direction
1	Self Generated Dead Weight	(-Z)
2	Secondary Steel	(-Z)
3	Outfitting Steel	(-Z)
20	Various Equipment	(-Z)
21	Electrical Dry Weight	(-Z)
22	Instrumental Dry Weight	(-Z)
23	Piping Dry Weight	(-Z)
24	HVAC	(-Z)
25	Safety Dry Weight	(-Z)
26	Surface Dry Weight	(-Z)
27	Architectural Dry weight	(-Z)
31	Personnel Load	(-Z)
32	Weight of gas and liquid in the pipe	(-Z)
33	Stored liquids and goods (Tanks)	(-Z)
34	Lay-down area	(-Z)

Table 5-3 Dead loads and live loads (-Z) direction

Load Case	Description	Direction
101	Self Generated Dead Weight	(+X)
102	Secondary Steel	(+X)
103	Outfitting Steel	(+X)
120	Various Equipment	(+X)
121	Electrical Dry Weight	(+X)
122	Instrumental Dry Weight	(+X)
123	Piping Dry Weight	(+X)
124	HVAC	(+X)
125	Safety Dry Weight	(+X)
126	Surface Dry Weight	(+X)
127	Architectural Dry weight	(+X)
131	Personnel Load	(+X)
132	Weight of gas and liquid in the pipe	(+X)
133	Stored liquids and goods (Tanks)	(+X)
134	Lay-down area	(+X)

Table 5-4 Dead and live loads (+X) direction

Load Case	Description	Direction
201	Self Generated Dead Weight	(+Y)
202	Secondary Steel	(+Y)
203	Outfitting Steel	(+Y)
220	Various Equipment	(+Y)
221	Electrical Dry Weight	(+Y)
222	Instrumental Dry Weight	(+Y)
223	Piping Dry Weight	(+Y)
224	HVAC	(+Y)
225	Safety Dry Weight	(+Y)
226	Surface Dry Weight	(+Y)
227	Architectural Dry weight	(+Y)
231	Personnel Load	(+Y)
232	Weight of gas and liquid in the pipe	(+Y)
233	Stored liquids and goods (Tanks)	(+Y)
234	Lay-down area	(+Y)

Table 5-5 Local Dead and live loads (+Y) direction

Load Case	Description	Direction
50	Wind load from west	(+X)
51	Wind load from East	(-X)

Table 5-6 Wind loads

Load case	Description	Direction
101	Earthquake 10^{-2}	(-Z)
102	Earthquake 10^{-2}	(+X)
103	Earthquake 10^{-2}	(+Y)
201	Earthquake 10^{-4}	(-Z)
202	Earthquake 10^{-4}	(+X)
203	Earthquake 10^{-4}	(+Y)

Table 5-7 Earthquake loads

Model geometry, load geometry and load footprint are presented on Figure 5:1, 5:2 and 5:3 respectively and detail model geometry for inplace operational state is presented in Appendix:-A

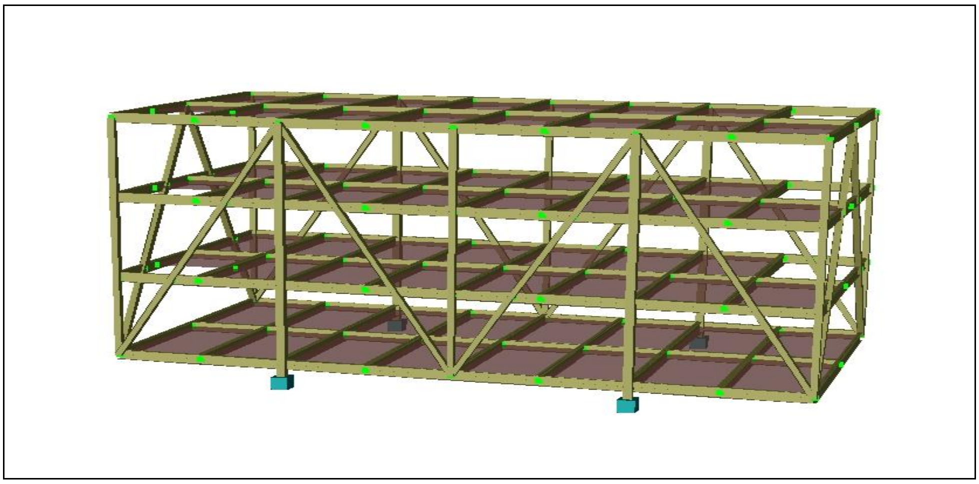


Figure 5-1 Numerical model of the module

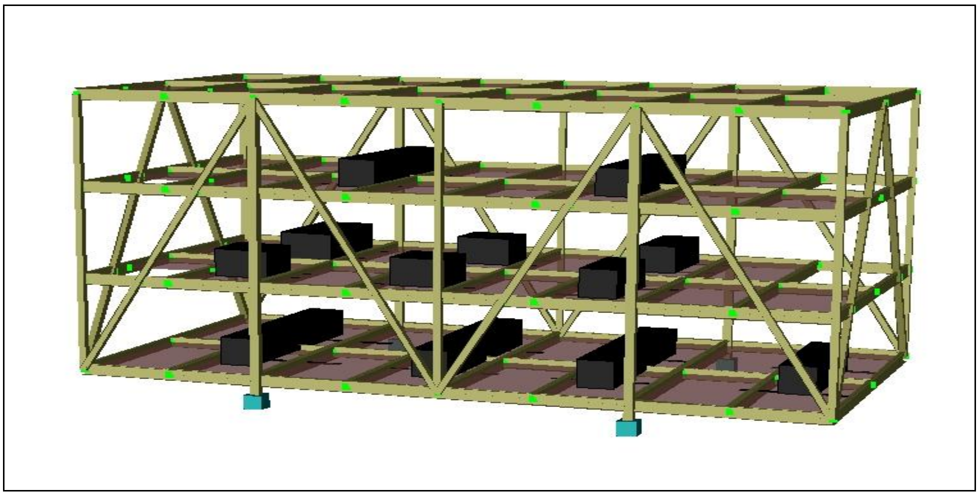


Figure 5-2 Numerical model of the load

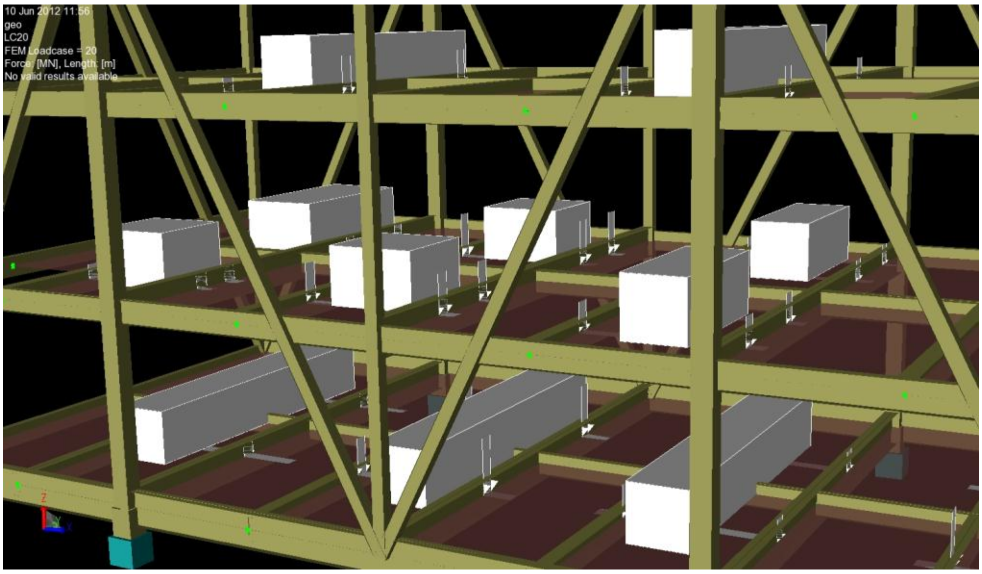


Figure 5-3 Numerical model of load and footprints

ULS DESIGN CHECK

The objective of structural analysis is to determine load effects on the structure such as displacement, deformation, stress and other structural responses. These load effects define the sizing of structural components and are used for checking resistance strength of these components comply with limit state criteria defined by design rules and codes.

The structural analysis of the module for inplace condition is based on the linear elastic behavior of the structure. As mentioned earlier the module is exposed to different loads. The structural weight and permanent loads are considered as time-independent loads. Further, the environmental loads are considered as time-dependent loads. Different wind durations are calculated and 3seconed wind gust is selected and applied to compute the static wind load for 100 year return period.

These analyses are performed and results presented for each condition and. The Framework member check for inplace conditions shows that except MY302030 all members of the structure have utilization factor less than one for the applied loads in inplace operational condition. This means that the members have sufficient capacity to withstand the applied loads.

MY302030 fails the initial code check in Framework. However, the beam is reassessed and found to be have sufficient capacity. Refer to Appendix E for further details

Yield, stability and deflection checks are performed as applicable for the relevant design conditions according to criteria given in Section 2.3. Framework results for members with utilization factor greater than 0.80 are presented in Table 5-8 below.

Member	**Load case**	**Outcome**	**Utility Factor**	**Reassessment**
MY302020	543	Failure StaL	**1.024**	**0.61**
MY702020	543	StaL	0.994	**-**
MY301020	545	StaL	0.934	-
MY701020	546	StaL	0.925	-
MY702020	543	StaL	0.885	-
MY302010	543	StaL	0.883	-

Table 5-8 Utilization factor inplace condition

The maximum displacements of the topside structure result from Xtract shows that the structural deformation for worst load combinations is within the criteria, $Max_{deformation}$ <L/250.

SLS DESIGN CHECK

The objective of this analysis is to satisfy the serviceability limit criteria of the topside structure and to make sure that the structure remains functional for its intended use.

The topside structure has sufficient capacity under ULS design check and the analysis is conservative. This result indicates that the structure has sufficient capacity under service limit state too. Because the SLS criteria states that the load and material factors is 1.0 for dead and live load and no environmental load will be included. Therefore the SLS criteria are satisfied during normal use.

5.2 LIFTING CONDITION

The purpose of lifting analysis is to ensure that lifting operation offshore shall be performed in safe manner and in accordance with the regulations in force.

In preparation of offshore lifting analysis structure the following questions play a role:

- Which weather condition?
- What type of lifting?
- What is the best approach?

These questions need to be considered carefully analysis at an early stage of the project. Good communication between the engineers and operational people is a key factor for success.

Heavy lifting offshore is a very important aspect in a project, and needs attention from start and throughout the project. Weather windows, i.e. periods of suitable weather conditions, are required for this operation. Lifting of heavy loads offshore requires use of specialized crane vessels.

The selected lifting method will impact the design consideration. There are several lifting methods such as single hook, multiple hooks, spreader bar, no spreader, lifting frame, three part sling arrangement, four part sling arrangement etc.

Lifting arrangement with spreader bar primarily is used to minimize the axial compression force on members between the lifting points. In this master thesis the lifting arrangement used is steel wire with four-sling arrangement which is directly hooked on to a single hook on the crane vessel as shown in Figure 5:4 and Figure 5-5. The thickest sling currently available now has a diameter of approximately 500 mm.

For lift condition USL-a is the governing load combination. Additional load factors such as CoG factor, Dynamic amplification factor, Skew load factor, Design factor and Center of Gravity envelop factor must be calculated and applied to get the total lifting weight. The calculation of center of gravity is performed and presented in Appendix D.

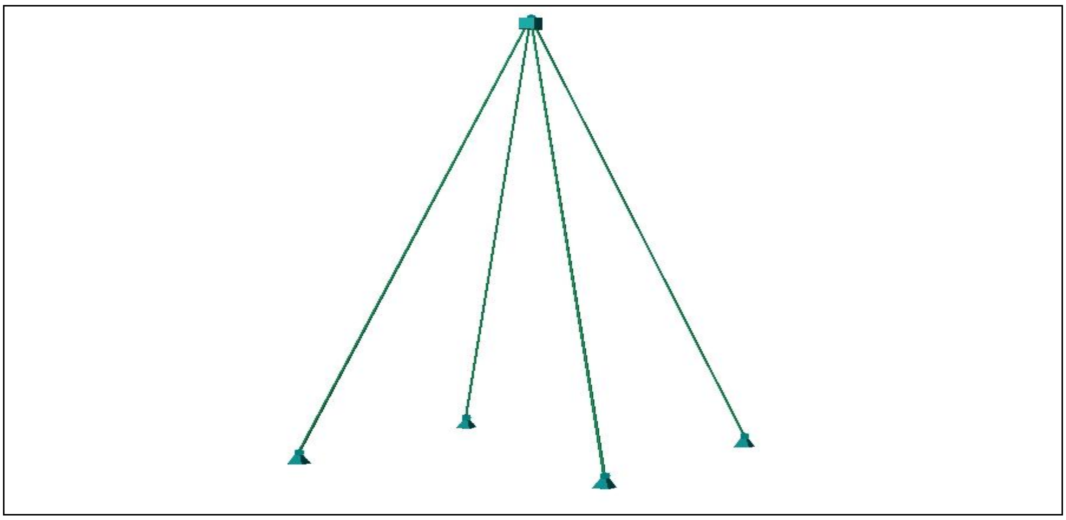


Figure 5-4 Numerical model of sling

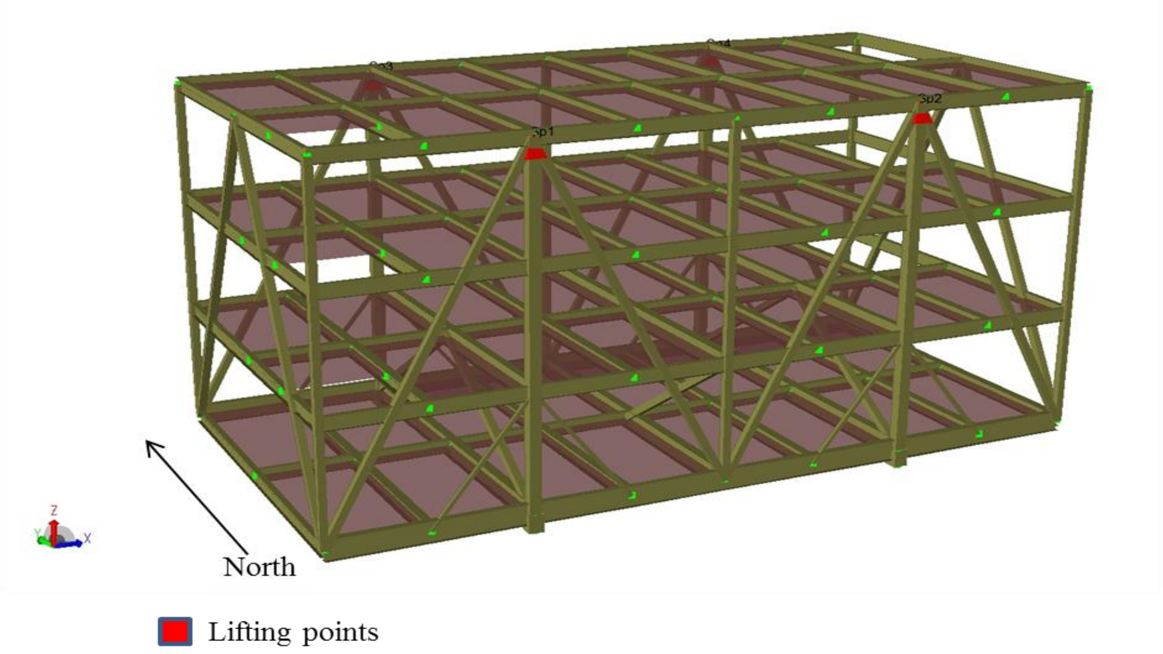


Figure 5-5 Numerical model of lifting

Lifting Design Load Factors

Load factors relevant for lifting design are summarized and presented as follows:

Dynamic Amplification Factor (DAF)
Offshore lifting is exposed to significant dynamic effects that shall be taken into account by applying an appropriate dynamic amplification factor According to DNV .Ref. [21] resulting DAF comes to 1.30for this module.

Skew Load Factor (SKL)
Skew loads are additional loads from redistribution due to equipment and fabrication tolerances and other uncertainties with respect to force distribution in the rigging arrangement.
Single crane four point lift without spreader bar the skew load factor can be taken 1.25

Design Factor (DF)

Design load factor DF defined as: $DF = \gamma_F * \gamma_C$
Where

γ_F = load factor

γ_C =consequence factor

Center of Gravity envelope factor (WCOG)
Center of Gravity envelope factor is calculated according Aker solutions working instruction and presented in appendix D.

ULS DESIGN CHECK

As mentioned before the purpose of lifting analysis is to ensure that the lifting operation offshore shall be performed in safe manner and in accordance with rules and regulations.

During preparation of lifting design analysis, weather window and lifting arrangement with best approach had to be decided. Global design analysis of the critical members of the topside module as shown in Figure 5-6

The members are categorized in three groups.

Single critical members, these are members connected to the lifting point and are assigned a consequence factor of 1.30.
Reduced critical members, these are main members nor connected to the lifting points, and assigned factor of 1.15.
None critical members, these are members considered to have no impact on the lifting operation, and are assigned a consequence factor of 1.00

Figure 5-6 depicts the single critical members on the structure. The load factors are applied as appropriate in Table 5-9 below.

Description	**Load factor**
Weight inaccuracy factor	1.03
Center of gravity inaccuracy factor	1.02
CoG factor	1.10
Skew load factor	1.25
Dynamic amplification factor	1.30
ULS-a load factor	1.30
Consequence factor Lift member	1.30
Lift member reduced consequence	1.15
Non-lift members No consequence	1.00

Table 5-9 Load factors applicable for lifting operation

The super nodes applied for the boundary conditions for lift condition are:

- S(301040)
- S(304040)
- S(701040)
- S(704040)

The tip of the hook is placed at (20m,10m,59m) in x-,y-and z-direction respectively.

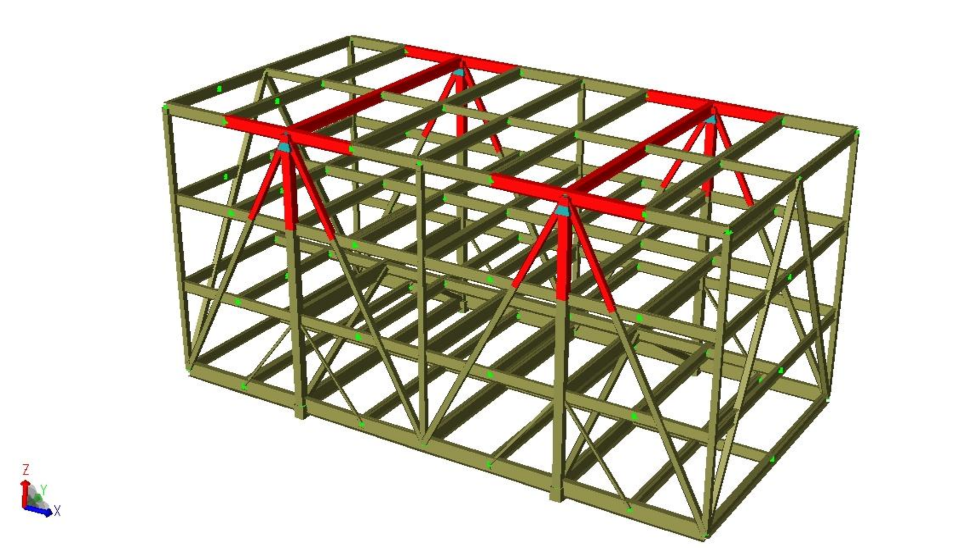


Figure 5-6 Members at lifting points

Global analysis of the topside structure are performed and presented. The Framework member check results shows that critical members at lifting point and have sufficient capacity with respect to structural design criteria.

MY302030 fails the initial code check in Framework. However, the beam is reassessed and found to be have sufficient capacity. Refer to Appendix E for further details

Members failing the Framework code check are reassessed. Ref. Appendix E

Utilization factors larger than 0.80 are presented in Table 5-10 below. UFs > 0.40 for single critical members are listed in Table 5-11

Member	Load case	Outcome	Utility Factor	Reassessment
MY302030	1	Lbck	**1.014**	**0.62**
MY301030	1	Lbck	0.914	-
MY501020	1	StaL	0.909	-
MY701030	1	Lbck	0.887	-
MY702030	1	Lbck	0.863	-
MY302040	1	StaL	0.845	-
MY301040	1	StaL	0.810	-
MY702040	1	StaL	0.800	-

Table 5-10 Utilization factor lifting condition

Member	Load case	Outcome	Utility Factor
MX601040	2	StaL	0.676
MX301040	2	StaL	0.660
MX304040	2	StaL	0.611
MX604040	2	StaL	0.542
MX651030	2	AxLd	0.444
MD301040	2	AxLd	0.430

Table 5-11 Utilization factor lifting condition for critical members

5.3 TRANSPORT CONDITION

Transportation in open sea is a challenging phase in offshore projects. This phase need careful planning analysis and solutions to achieve a safe transport.

Transporting can be done on a flattop barge or on the deck of the heavy lift vessel [HLV]. This thesis is based on a standard North Sea barge, 300ft x 90ft, for the transport phase. However, if transported on a known vessel or a HLV, the barge acceleration could be reduced considerably.

Barge accelerations
Barge accelerations are action loads which will be applied on the module in transportation condition. The intention with barge acceleration calculation is to identify applicable accelerations for the barge tow and to calculate the acceleration load that will be applied on the structure. These acceleration loads will be calculated and applied according to Nobel Denton, Guidelines for marine transportations Ref. [20]

Calculations of barge acceleration loads for transport on the deck of a North Sea barge are based on the Noble Denton criteria; refer to section 7.9, Table 7-2 Default Motion Criteria. Transport accelerations are calculated based on the parameters; L>76m and B>23 as shown in Table 5-1 below, and assuming the most unfavourable position on deck. These parameters are considered to be conservative.

The physical size of a barge is important with regards to the operational weather window because this can give a possibility to change the position of the structure and vessel coordinate system is presented shown in Figure 5-6 below.

Barge motions are loads that influence the structural stability and strength capacity. Refer to Appendix E for calculation details of barge accelerations.

Vessel type	**T** **Full cycle period (all categories)**	**Single amplitude**		**Heave acceleration**
		Roll	**Pitch**	
Standard North Sea barge	10 secs	20º	12.5º	0.2g

Table 5-12 Applied Noble Denton Criteria

Weather window needs to be suitable during transportation. The module will be analysed for wind with average recurrence period of 1 year in combination with barge accelerations. Both wind and accelerations are applied I eight directions with 45^{o} intervals, completing the entire rosette as showed in Figure 5-8. Wind load cases and directions are presented in Table 5-13 below.

Load Case	Description	Direction
52	Wind load from west	(+X)
53	Wind load from south	(+Y)
54	Wind load from East	(-X)
55	Wind load from North	(-Y)

Table 5-13 Basic wind loads

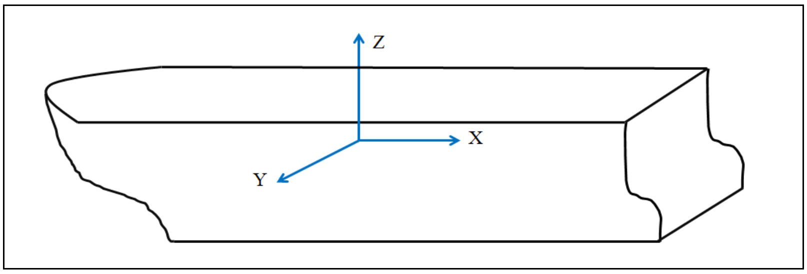


Figure 5-7 Vessel coordinate system

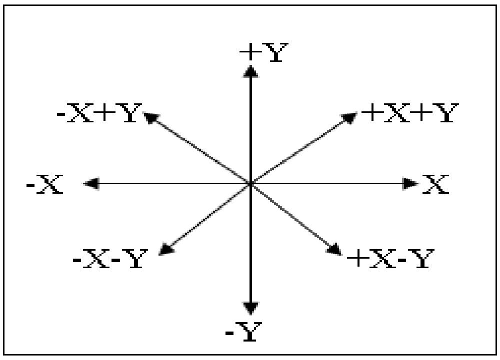


Figure 5-8 Direction of wind load

The transportation and installation of the large topside modules offshore is unique. The reserve capacity built in to the design provides additional safety in the critical components of the structure. The support points for the transport condition is chosen as the same as for the in-place. To prevent constraint forces, a statically determined support system (3-2-1-1) is applied on all dead loads. The support points are same as for inplace analysis.

During transport the module will be subjected to wind and acceleration loads. The module will have a (2-2-2-2) support system in the same supports as above. In addition, sea fastening in each corner will restrain horizontal movements.
The boundary conditions applied during transportation is presented in Figure 5-9 below.

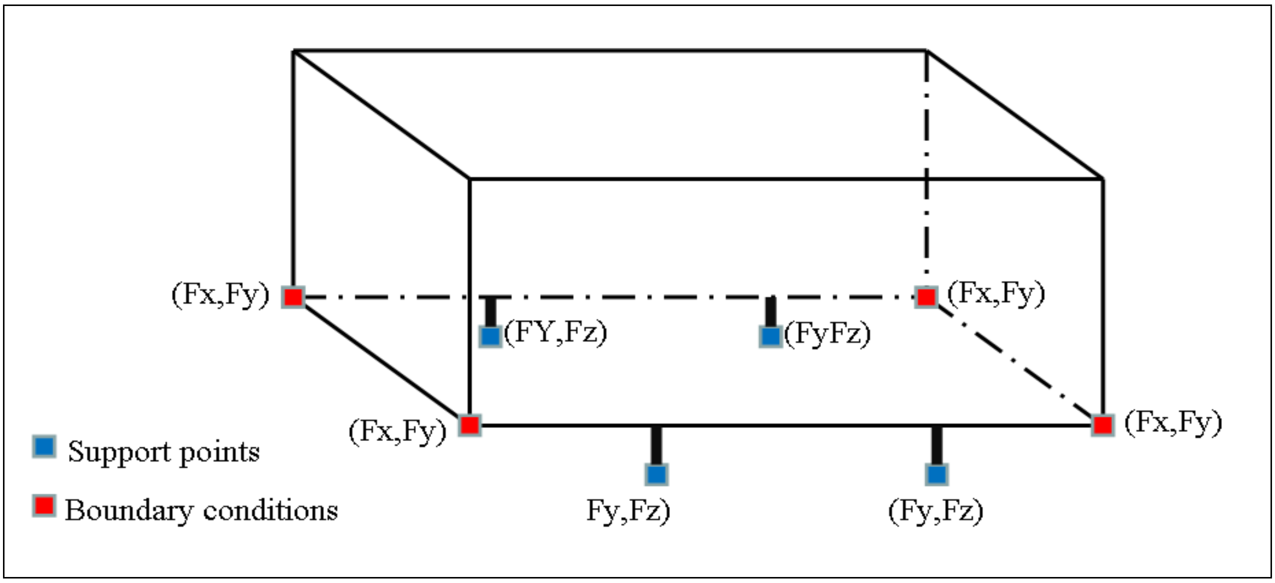


Figure 5-9 Boundary conditions for during transportation

ULS DESIGN CHECK

Several members failed the initial Framework code check. To overcome this it was necessary to either change the profile or introduce some temporary transportation reinforcements. During the process of optimization, the solution was a combination of both. These temporary reinforcements are shown in Figure 5-10 and Figure 5-11 below and shall be removed after installation.

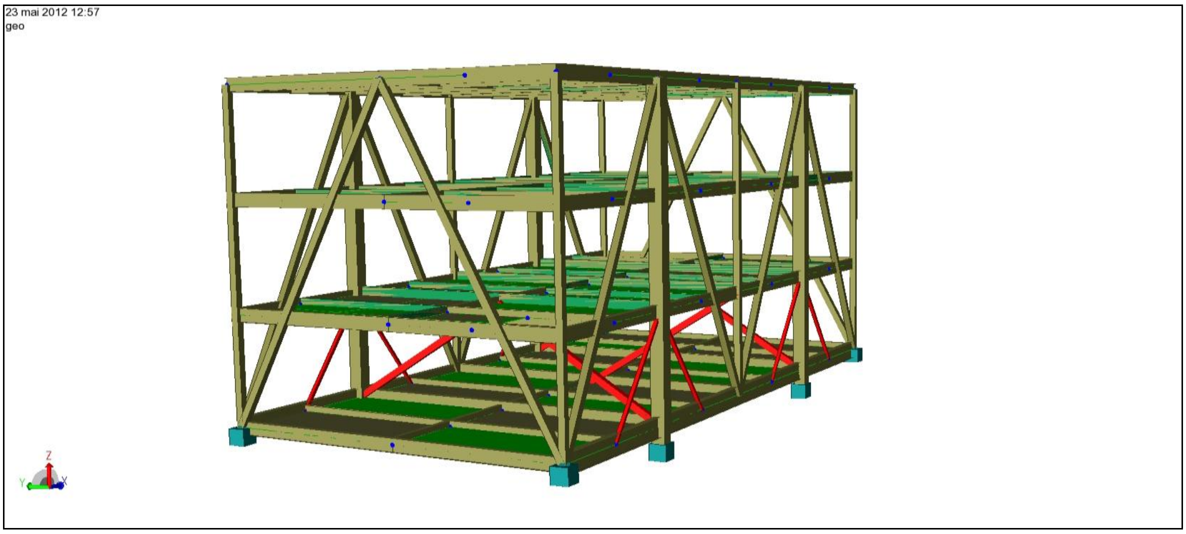


Figure 5-10 Reinforcement members for transport condition

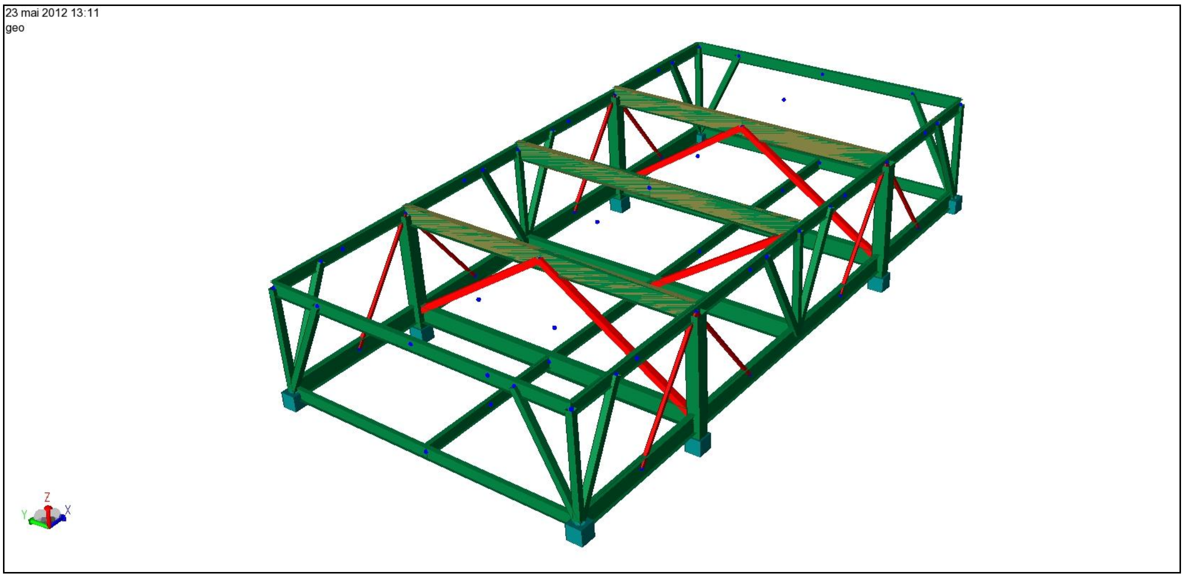


Figure 5-11 Reinforcement members for transport condition

After temporary reinforcement and upgrading some members still failed the initial code check in Framework. However, the beams are reassessed and found to be having sufficient capacity. Ref. Appendix E for details.
Members with UF > 0.90 are listed in Table 5-14

Member	**Load case**	**Outcome**	**Utility Factor**	**Reassessed**
MX601020	601	Fail StaL	**1.029**	**0.59**
MX301020	609	Fail StaL	**1.029**	**0.59**
MX304020	609	Fail StaL	**1.013**	**0.59**
MD454020	617	Fail StaL	**0.997**	**-**
MX604020	601	StaL	0.994	-
MC504010	625	StaL	0.985	-
MD304020	617	StaL	0.968	-
MD451020	617	StaL	0.967	-
MC501010	625	StaL	0.955	-
MC604010	625	StaL	0.941	-
MD301020	601	StaL	0.911	-

Table 5-14 Utilization factor transport condition

To achieve sufficient capacity to withstand the worst load cases during inplace, lift and transport conditions, the following cross sections have been selected as shown Table 5-15 below.
.

Member	Description	Type	Height [mm]	Width [mm]	t-flange [mm]	t-web [mm]
B020216	Hot rolled	Box	200	200	16	16
B040420	Hot rolled	Box	400	400	20	20
B040430	Welded	Box	400	400	30	30
B040440	Welded	Box	400	400	40	40
B060640	Welded	Box	600	600	40	40
HE600B	Hot rolled	HEB	600	300	155	30
HE800B	Hot rolled	HEB	800	300	175	33
HE1000B	Hot rolled	HEB	1000	300	190	36
I08402035	Welded	I-girder	800	400	35	20
I11042035	Welded	I-girder	1000	400	35	20
I11242035	Welded	I-girder	1200	400	35	20
I11252035	Welded	I-girder	1200	500	35	20
SUPP	Support dummy members		850	850	60	60

Table 5-15 Cross sections of the structure

6 DESIGN PADEYES

6.1 LOCAL ANALYSIS OF PADEYES

Padeyes are applied on lift attaching the sling for lifting operation. Several calculation methods are available, but in this report Aker Solutions Working instruction for Padeye design and strength assessment of padeyes is used.

The following stresses are evaluated and presented:

- Pin hole stress
- Main plate stress
- Cheek plate stress
- welds

Padeye plate structures are designed to sustain actions of the heaviest loaded lifting point. In order to guarantee structural safety as well as economic design of padeyes, comprehensive analysis should be performed.

Padeye body is usually welded to main structure. In some occasion main body may be welded to a plate and bolted to main structure for easier removal. Stress check shall be done on body and welded connection.

All loads are to be transferred from main structure to the padeye structures. The magnitude of this load or force will be generated from framework analysis result and the padeye will be designed according to relevant rules and design premises, Aker Solutions working instruction for padeye design.

On preparation of designing the lifting padeye the following factors needs to be taken into account:

- Dynamic Amplification Factors
- Skew load factor
- CoG inaccuracy factor
- Weight inaccuracy factor
- Consequence factor

6.2 DESIGN CHECK OF PADEYES

The lifting slings must have sufficient length so that angle of the slings meets the criteria set.

To avoid transverse loading on the padeyes, these may be tilted to match the angles of slings.

The geometry of lifting pad eye is shown in
Figure 6-1below and the dimension of padeye hole will be calculated with respect to the shackle dimension.

Shackle dimensions are taken from Green Pin shackle dimension data sheet Ref.[24] and presented in Table 6-1.

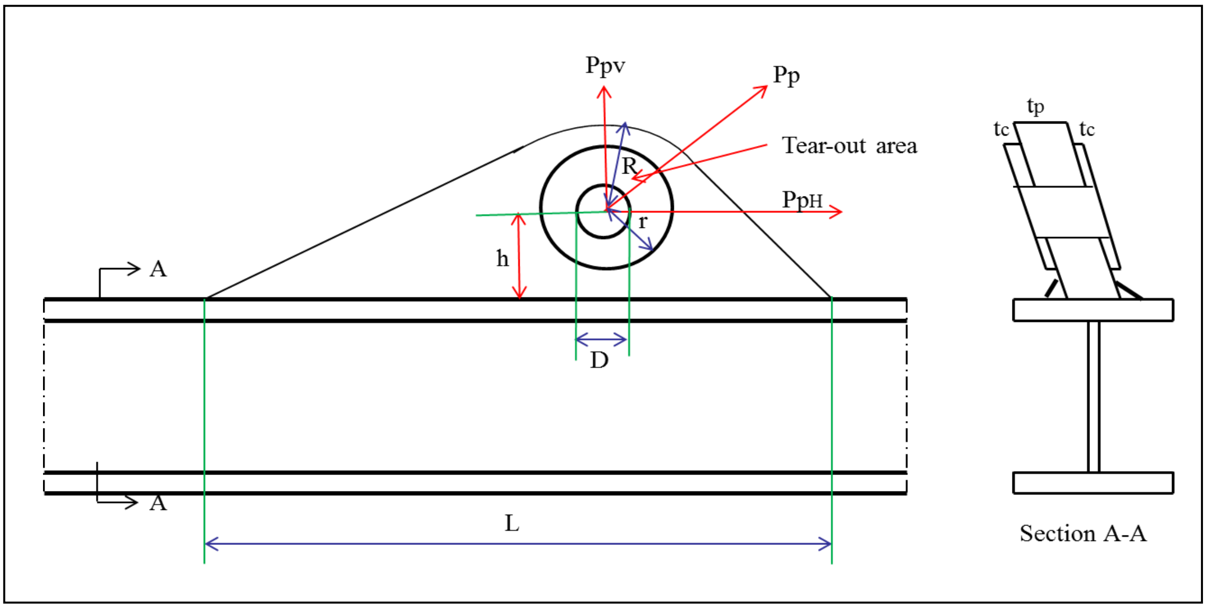


Figure 6-1 Lifting padeye geometry

Pad eye are frequently applied for use of lifting point, and should be designed to match the relevant standard shackle dimensions.

Figure 6-1 above depicts the different forces to be considered. In addition, a transverse load equaling 3% of the sling load should be considered.

According to Aker solutions working instruction Ref. [19] the following criteria should fulfill during design analysis of lifting padeyes.

Padeye hole diameter is calculated as

D=1.03d' +2mm…………………….….Eq. (6:1)
The clearance between shackle bolt and pad eye hole should not exceed 4% of the shackle bolt diameter

Pad eye plate thickness.
Total pad eye thickness T shall fulfill the following criterion: the padeye thickness at the hole should not be less than 60% of the inside width of the joining shackle.

$T > 0.6a'$ …………………………….….... Eq. (6:2)
Where: - a' is the shackle jaw

Increasing of clearance between the pin and the holes result in a decrease in the ultimate capacity of the pad eye.

The clearance between the pad eye and the shackle jaw should be in the range of 2 to 4mm. a set of spacer plate should be added if this cannot be achieved by the pad eye thickness with or without cheek plates.

Pad eye radius
Pad eye radius(R) should be derived by addressing the tear out capacity. In addition, it is checked towards shackle and sling geometry in terms of sufficient space.
Limits are described by the following formula: -
$1.3D < R < 2d'$ …………………………... Eq. (6:3)
Where: - D = pad eye hole diameter d' = shackle bolt diameter
R = minimum radius from center of hole to pad eye edge.

Pad eye Height and Length
Pad eye height and length should be decided on the basis of a load distribution perspective and an operational judgment.

Determination of pad eye geometry and formulas below shows methods to calculate pad eye height and strength.
Load angle 135deg. > β >45deg.
Where: t_c - cheek plate thickness
t_p- pad eye plate thickness
R -minimum radius from center of hole to pad eye edge
D=1.03d`+2mm
1.3D < R< 2d`
$R=r+t_c$ .... Eq. (6:4)

$$t_p = 0.85\left(\frac{a'}{2}\right)$$ .... Eq. (6:5)

$$t_c = 0.85\left(\frac{a'}{4}\right)$$ .... Eq. (6:6)

Height (h) =2r………………......……..... Eq. (6:7)

Length (l) = 1.8h...................................... Eq. (6:8)

The detailed lifting padeye analysis is performed according to the rules and design premises. The complete analysis and results are presented in Appendix F

The selected shackle has to house both pad eye and the selected sling. The selected shackle and pin are presented in Figure 6-2 and Table 6-1.

WLL [tons]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	F [mm]	G [mm]	H [mm]	J [mm]	L [mm]
1500	280	290	640	225	360	460	450	1480	1010	1060

Table 6-1 Shackle and pin dimensions

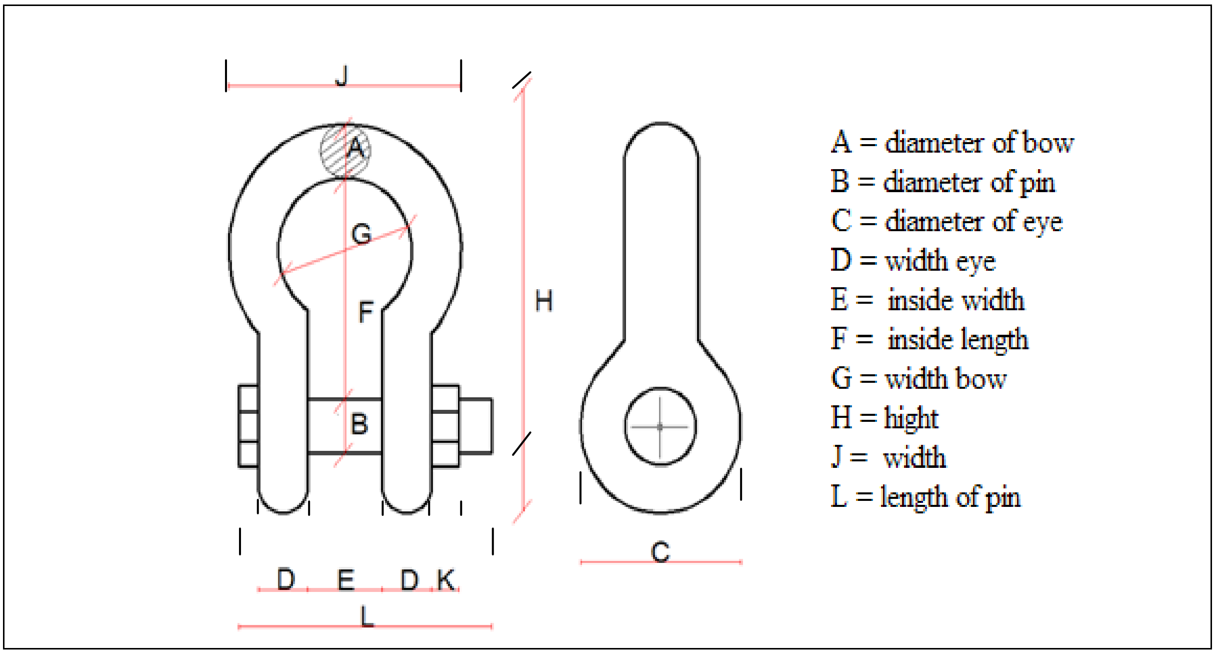


Figure 6-2 Shackle geometry

7 DESIGN OF JOINTS

7.1 LOCAL ANALYSIS OF JOINTS

Local joint analysis is an important structural analysis to ensure structural integrity.

The mode of failure of a statically loaded joint depends on the type of joint, the loading conditions and the joint geometrical parameters.

The procedure for stress checks of welded joints are given in documenting the relevant nodes. The procedure is briefly repeated as follows;

In order to separate and get the proper view of utilization level in different phases, each analysis condition is treated separately. The method could also be utilized further to combine all analysis in SESAM, and just check the most critical condition for each node.

First, a yield check of each member ends was performed in Framework, in order to establish the possible dimensioning load cases for each node. By this, the maximum number of load combinations to check for is limited by the number of members connected to the node.
Then, joint reaction forces (in the global axis system) are extracted from FRAMEWORK for the defined load combinations.

A screening was then performed based on a conservative combination of the maximum yield UF for each member connected at each node, in order to find the most critical node. For nodes indicated by the screening to be highly utilized, detail calculation was performed in order to find more correct node UF. Different hot spot in the node were checked towards the Von Mises criterion, utilizing the correct sign for stresses. In general, conservative combination of normal and shear stresses are used, giving some conservatism. I.e. Joints that have UF less than 1.05 are acceptable.

Local stability check of stiffeners and web is not performed for the actual nodes. The nodes are in general robustly stiffened, and local buckling is not considered relevant.

7.2 DESIGN CHECK OF JOINTS

All joints shall be checked for all critical load conditions. Care shall be taken to cover eccentricities in incoming members if this is not included in the computer analysis. Any additional moments shall be added to the member forces extracted from the existing analysis.
The following procedure is established to ease the selection of critical load combinations. Excel spreadsheets will in general be used to process the analysis results and perform detailed node checks. In order to reduce the required work, several analysis results may be combined by use of SESAM Prepost prior to the local calculations.

- Perform an ordinary Von Mises check at each member ends and by use of Framework extract utilization ratios and corresponding load combination, sorted on nodes, and import into Excel. The number of dimensioning load cases will then be less or equal the number of incoming members for each node.
- Joint reaction forces are extracted by use of Framework for all joints for identified dimensioning load cases.

- Calculate stresses in critical sections in the node.

- Calculate (multidirectional) equivalent stresses based on the Von Mises yield criterion and compare with design criteria. For class 1 and 2 sections the stresses may be calculated based on the plastic moment of inertia. It must then be verified that repeated yielding does not lead to failure of joints.

- Calculate the local stability usage factor, where considered relevant, based on the stress calculation from the Von Mises yield check.

The general 3D Von Mises stress calculation formulas as given below is used in order to find the equivalent stress:

$$\sigma_j = \sqrt{\frac{1}{2}\left[\left(\sigma_x - \sigma_y\right)^2 + \left(\sigma_y - \sigma_x\right)^2 + \left(\sigma_x - \sigma_z\right)^2 + 3\tau_{xy}^{\ 2} + 3\tau_{yz}^{\ 2} + 3\tau_{xz}^{\ 2}\right]} \quad \text{........Eq. (7:1)}$$

For simplicity reason, the indexing used for shear stresses deviates some from the normal definition, as e.g. τ_{xy} donates shear stress acting in the xy-plane.

A conservative combination of utilization factors may be done as screening, in order to identify the most critical nodes. The screening results may also be used as an upper limit for the actual node utilization. The screening may be done by picking the worst UF from transverse beams(x-direction, longitudinal beams(y-direction) and vertical beams (z-direction including inclined braces), respectively, and by assuming the worst possible sign combination, the equivalent Von Mises utilization can be calculated by the following expression;

$$UF_{.screening} = \sqrt{\frac{1}{2}\left[\left(UF_{.max} - UF_{.med}\right)^2 + \left(UF_{.med} - UF_{.min}\right)^2 + \left(UF_{.min} - UF_{.max}\right)^2\right]} \quad \text{Eq. (7:2)}$$

Where:

$UF_{max} \geq UF_{med} \geq UF_{min}$, which indicates that the worst situation is found if the maximum stress is of opposite sign than the two other components

It should be noted that the screening method described above, may not give a conservative estimate of the node utilization if the incoming member connection are not full strength connections or if large shear forces are to be transferred inside the node. Nevertheless, the screening may be used as a basis for critical node selection also in such cases.

The local joint analyses are performed on selected nodes based o screening results all three conditions are considered and assessed. The analysis is performed according to Aker solutions working instructions for joints. Analyses of these selected joints are performed and the calculation and results are presented on Appendix G

8 DISCUSSION

Optimization of the structural designed layout of a topside module with respect to structural integrity, weight safety and strength capacity is the main task of this master thesis.

As mentioned in previous chapters, the structure is exposed for different types of loads. These load actions have different effects on the structural behavior of the topside module. The structural capacity of the module for inplace condition was one of the main issues. It took much time to achieve optimized structural profiles with respect to intended inplace operation. However, I learnt that optimizing of the structural profiles has to consider all phases such as transport and lifting operation, in addition to the inplace operating phase.

To achieve the sufficient capacity and structural integrity, members are carefully selected based on their strength capacity. Inplace condition is considered as the basis for these selections.

To facilitate transport and/or lifting temporary reinforcements may be used. The main reason behind this this idea is that inplace operation phase represents a long lasting period. All conditions need to be considered and the structure will be designed and analyzed with respect to life, environmental and economic risk. After the analyses and optimizing structural members for inplace condition, transportation condition is considered and analyzed.

During transport analysis the structure will be analyzed as is (inplace condition) with transport load combinations and the structural capacity will be studied carefully using Framework member check result and Xtract for stress and deformation result. These results indicate the utilization factors, the stress concentrations and deformations of the structural members. This will lead us to find which part of the structure are most utilized, stressed and deformed. Studying these structural responses carefully and finding the best engineering solution, the structure can be modified reinforced to achieve the intended and required results.

The optimized structure for inplace condition was analyzed with the transport load cases. The result from Framework member check indicated that the structure had insufficient capacity to withstand these load combinations. The solution was to introduce some temporary reinforcements to facilitate the transport condition. All temporary reinforcements shall be removed before operating phase commences.

The last step of the global structural analysis will be lift condition. Lifting will not take place if there is wind and/or waves. No environmental loads are applicable for lifting analysis. Only dead loads are included, multiplied by an appropriate factor.

The analysis results of Framework show that the critical member at lifting points have sufficient capacity to withstand the subjected load during this operation. However, some members failed the initial code check in SESAM Framework. These beams have been reassessed and found ok.

Global structural analysis and optimization for inplace, lift and transport conditions are performed according to rules, codes and design premises. The analysis results show that each condition has its own influence on how the structural members behave. As we mentioned earlier, structural members must have a sufficient capacity to withstand all worst load cases and it must be designed for worst load cases and conditions.

Optimizing or upgrading the structural member section property to achieve sufficient capacity during transport condition reduced the utilization factors of these members for the inplace condition. However, oil companies are frequently evaluating extension of operational life and modifications. The extra capacity gained can be considered as a reserve for future modifications.

The modification of a structure might be necessary in future aspect. This concept indicates that the reserve capacity of structural strength is an advantage.

In preparation of local lifting padeye analysis of offshore structure, the loads which will be applied on the padeye structure needs to be evaluated carefully.

Small sling angles will results in undesirable axial loads on members between lifting points. However, this problem can be reduced by increasing the sling length. This method will increase the vertical load and reduce the axial compression load on the exposed structural members. Using spreader bar is another option that can be implemented during lifting arrangement. This method will eliminate the axial compression loads on the structural members between lifting points.

Time is a limiting factor for this thesis, and the lifting arrangement selected is a four point single hook arrangement.

Design and analysis of lifting padeye are performed and presented in appendix F.

However, time limitation the analysis performed on this master thesis considered only four-sling wire that connected with lifting padeyes and local analyses lifting padeyes are performed and presented in on Appendix F

Local joint analyses are performed on selected nodes based on screening results. The analyses and detailed calculations are done in Excel, and presented in Appendix G.

The topside structure has sufficient capacity under ULS design check and the analysis is conservative. This result indicates that the structure has sufficient capacity under service limit state too. Because the SLS criteria states that the load and material factors is 1.0 for dead and live load and no environmental load will be included. Therefore the SLS criteria are satisfied during normal use.

9 CONCLUSIONS

Structural design is very interesting, creative and challenging segment in engineering. Structures should be designed such a way that they can resist applied forces and do not exceed certain deformations. Moreover, structures should be economical. The best design is to design a structure that satisfies the stress and displacement constraints, and results in the least cost of construction. Although there are many factors that may influence the construction cost, the first and most obvious one is the amount of material used to build the structure. Therefore, minimizing the weight of the structure is usually the main goal of structural optimization.

The primary concern of the structural design analysis and optimization of this master thesis was to obtain a proper weighed structure that has sufficient capacity and strength, with respect to transportation, installation and operation. Apart from that the design analysis and optimization of this structure is to achieve a structure that has high safety with respect to life, environment and economic risk.

In preparation of the structural analyses the basis for the geometry and member properties were selected for operational phase. However, the topside structure will be exposed for different conditions before it reaches to the operational state. Lift and transportation phases were studied and detail analyses were performed. Offshore structures are exposed for different conditions and it is vital that the structure have sufficient strength and integrity to withstand these loads and phases.

Strength capacity of a structure can be achieved by different approaches. One approach can be constructing temporary reinforcement for members to facilitate temporary conditions such as transport and lifting.

The modeling, design analysis and optimization are performed based on elastic behavior of structural members. This linear elastic analysis is applied to find the structural members that have less and high interaction ratio (IR).

The global analysis results have been evaluated and the structure has sufficient integrity and capacity for all construction phases.

The global analysis of the topside structure shows that the structure at operational phase has sufficient capacity to withstand the load at operational state, and the utilization factor indicates the structure has reserve capacity. Oil companies are frequently evaluating extension of operational life, and/or modifications to enable further facilities and developments. The reserve capacity of the structure can be used in future modification of the structure.

Finally the global design analyses for inplace, lift and transport phases are performed and presented. The results imply that the designed structure has sufficient capacity to withstand all construction phases with respect to design criteria.

Padeye plate structures are designed to sustain actions of the heaviest loaded lift point. In order to guarantee structural safety as well as economic design of padeyes, comprehensive analysis is performed analysis result shows that the lifting padeyes have a sufficient capacity to withstand the loads during lifting operation with respect to design criteria.

Local joint analysis is an important analysis in order to guarantee structural safety, comprehensive local design analyses of selected joints are performed for inplace and lift conditions. The results show that one joint needs reinforcement. The rest of the selected joints have sufficient capacity strength to withstand the subjected loads with respect to design criteria and rules.

The structure must remain functional for its intended use and SLS design check shows that the structure fit the serviceability requirements during normal use.

Further studying in some areas will be interesting in this master thesis. However, time limitation and scope of the thesis is too comprehensive to be dealt with in this period.

Areas that could be of interest to look into are:

- Design and analysis of other lifting arrangement that can reduce axial compression loads.
- Calculating reserve plastic capacity of padeye.
- Further Finite-element analysis of stress concentration in padeyes
- Local analysis of joints for transport condition.

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APPENDIXES

A. GEOMETRY

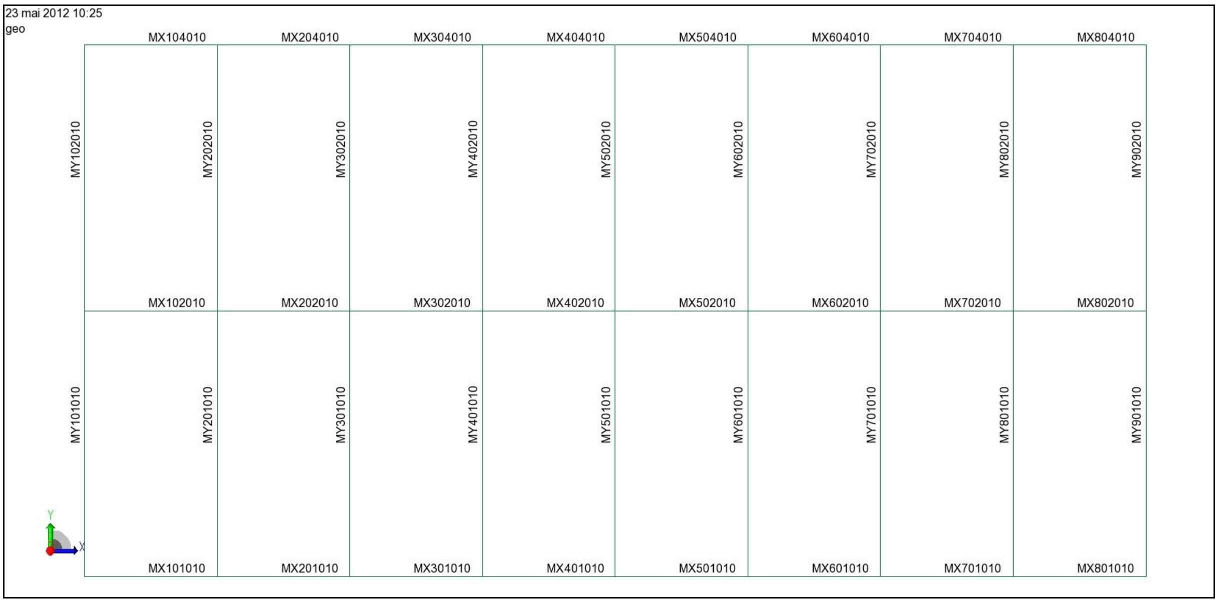


Figure A- 1 Member names, main deck

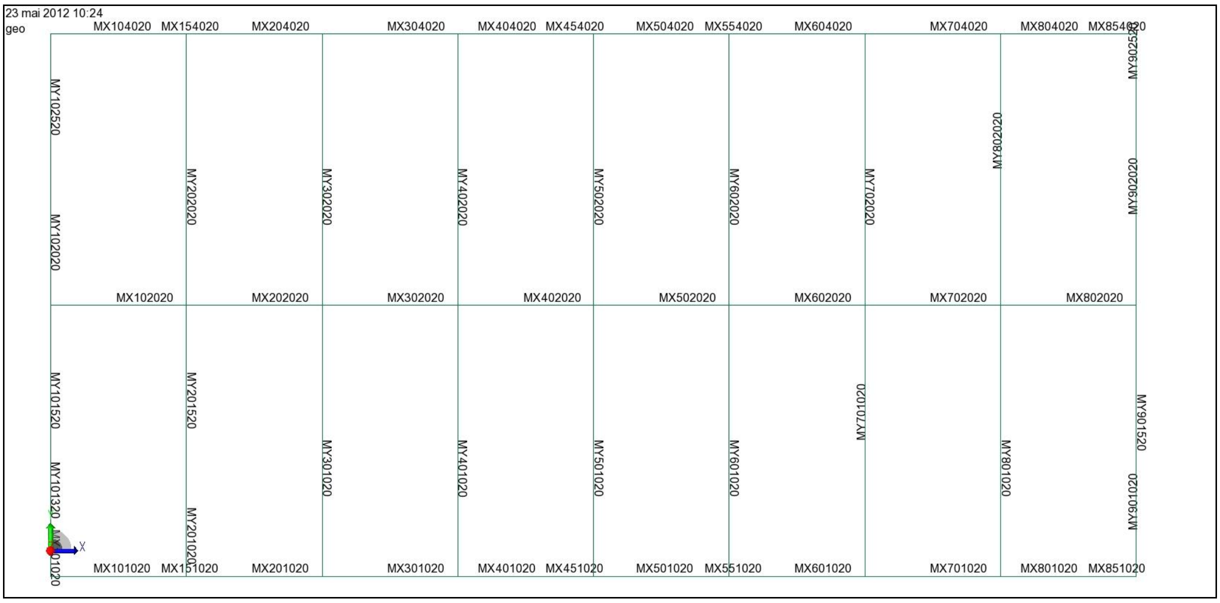


Figure A- 2 Member names, lower mezzanine deck

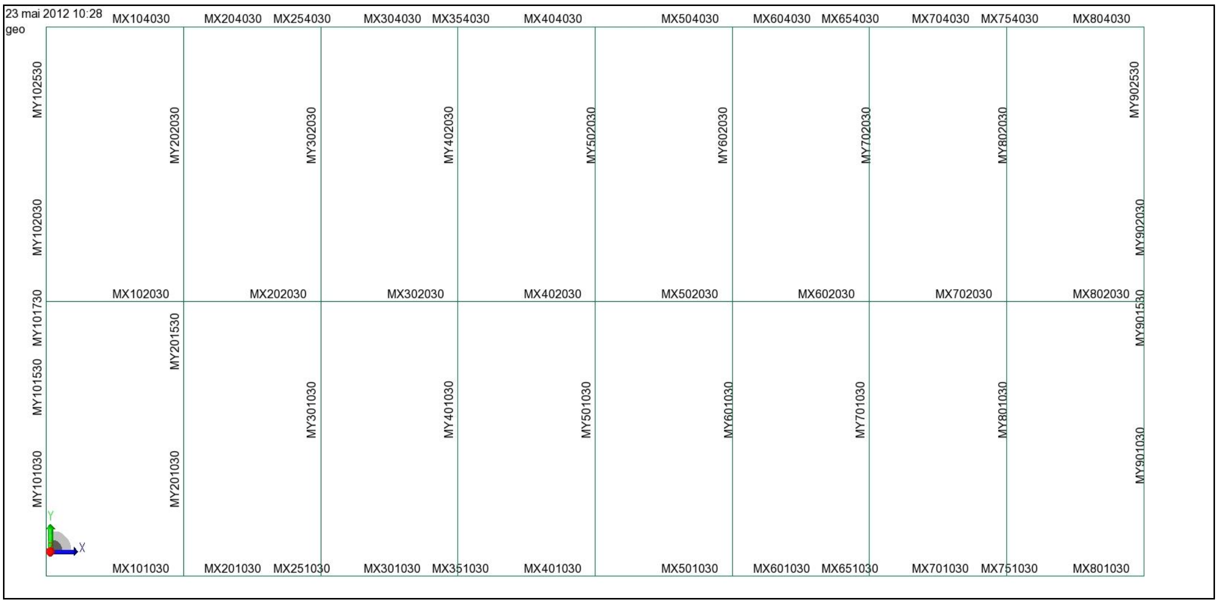


Figure A- 3 Member names, upper mezzanine deck

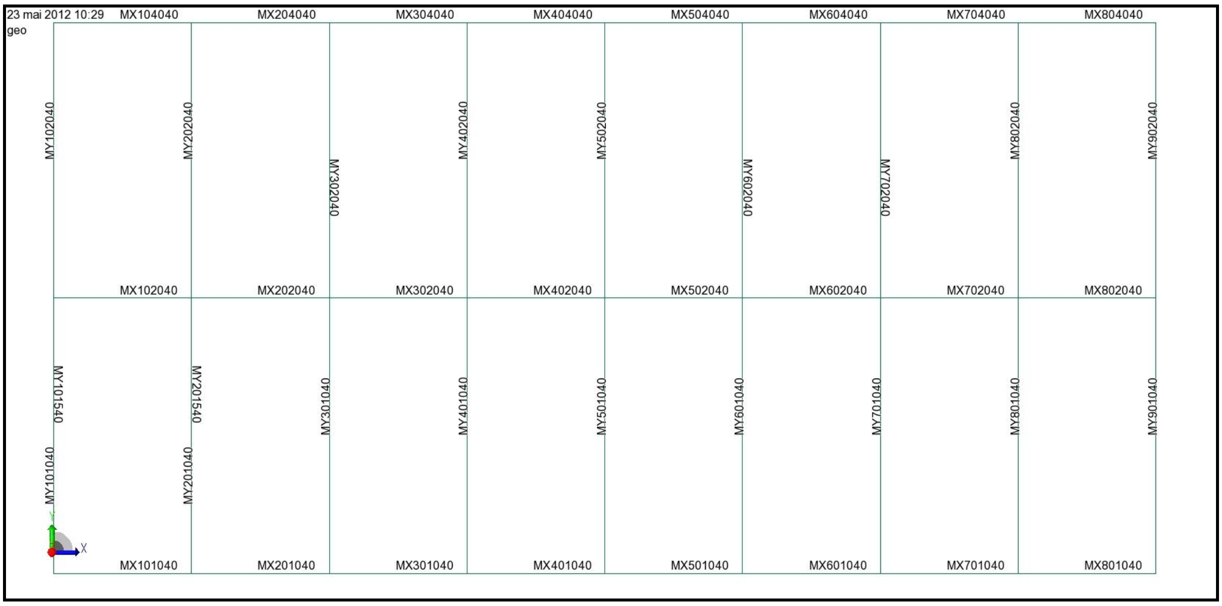


Figure A- 4 Member names, weather deck

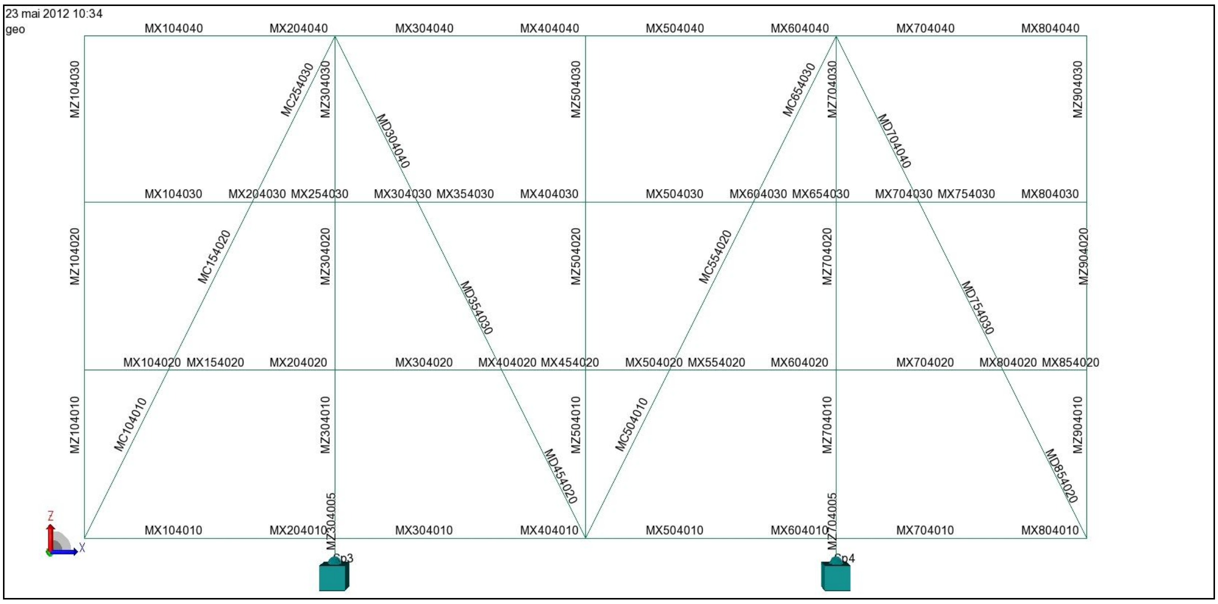


Figure A- 5 Member names North face

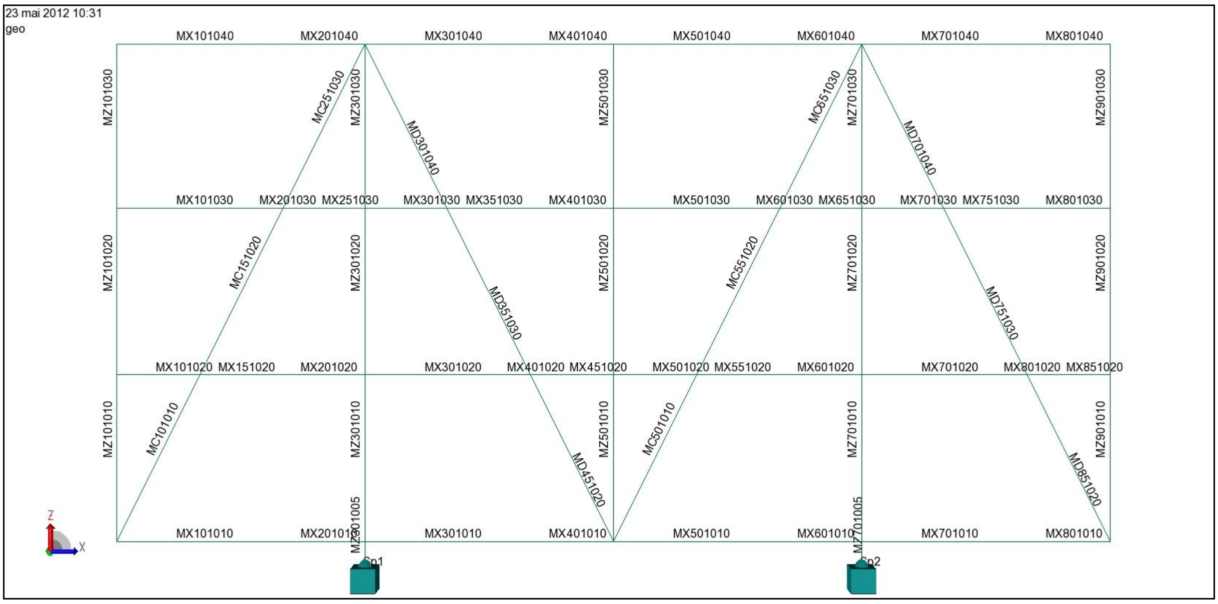


Figure A- 6 Member names South face

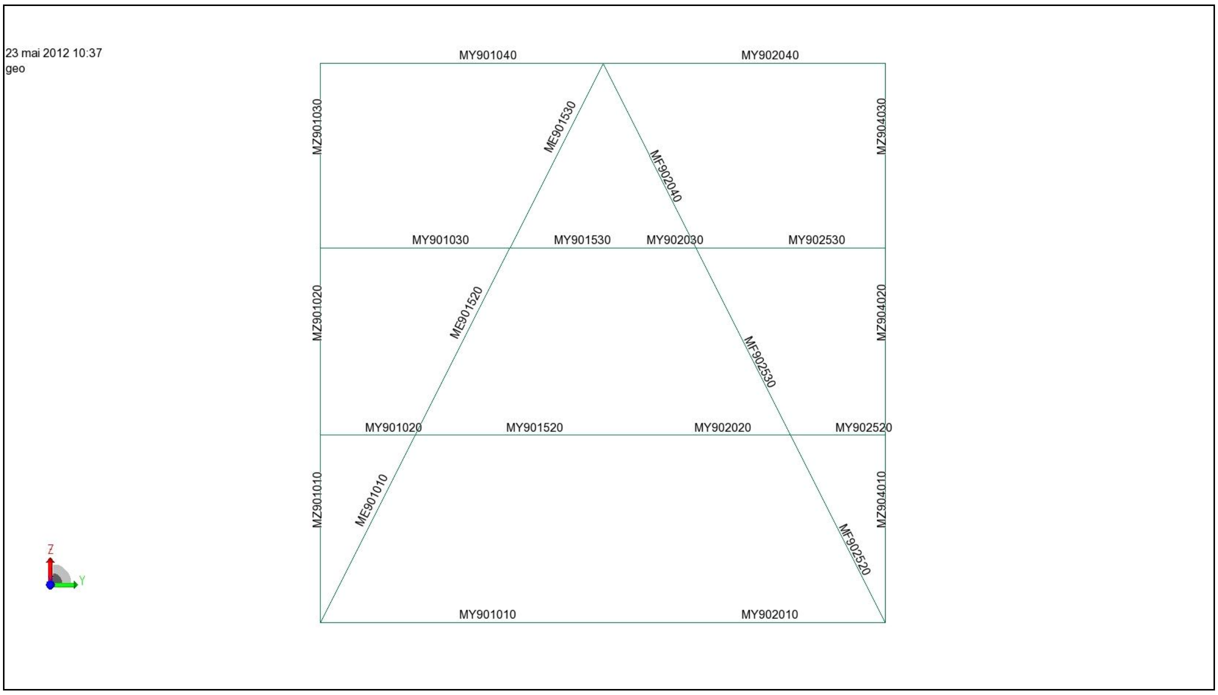


Figure A- 7 Member names East face

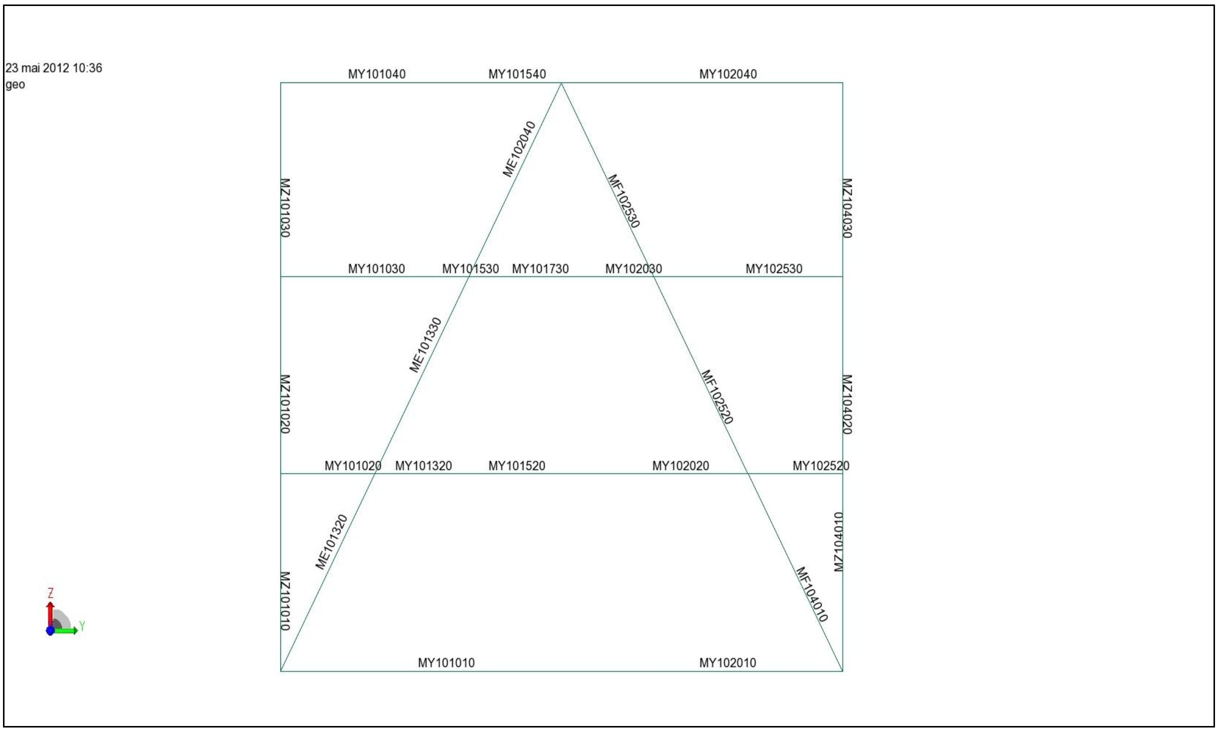


Figure A- 8 Member names West face

B. JOINTS

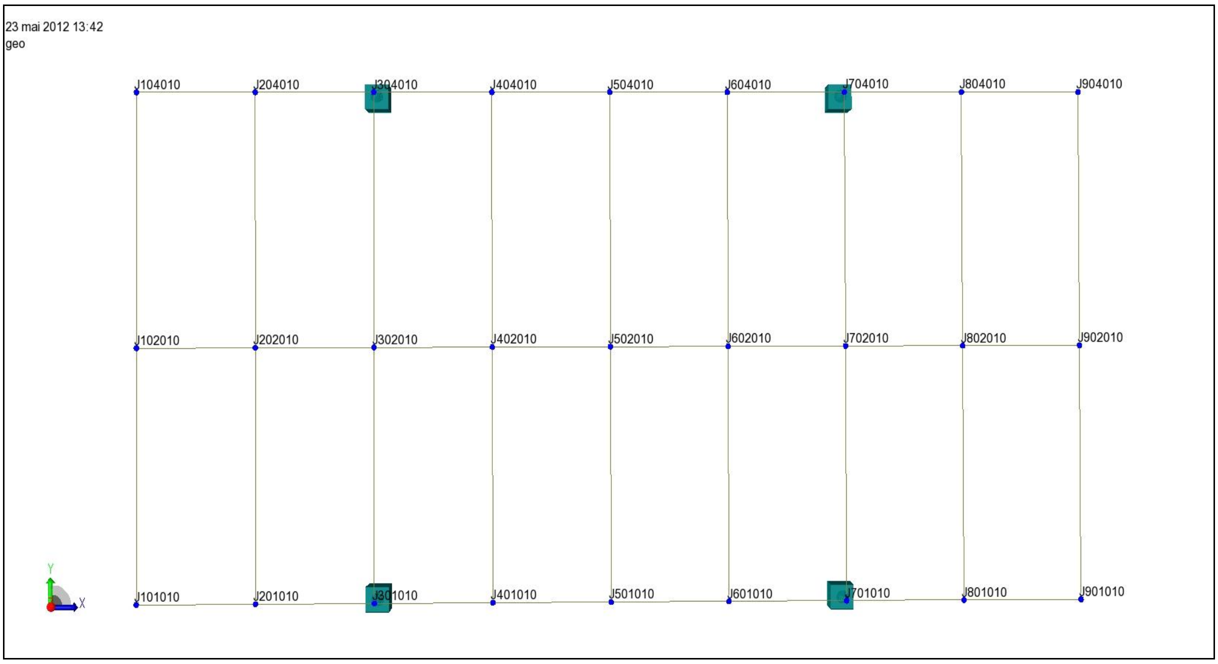


Figure B- 1 Joint names

Figure B- 2 Joint names

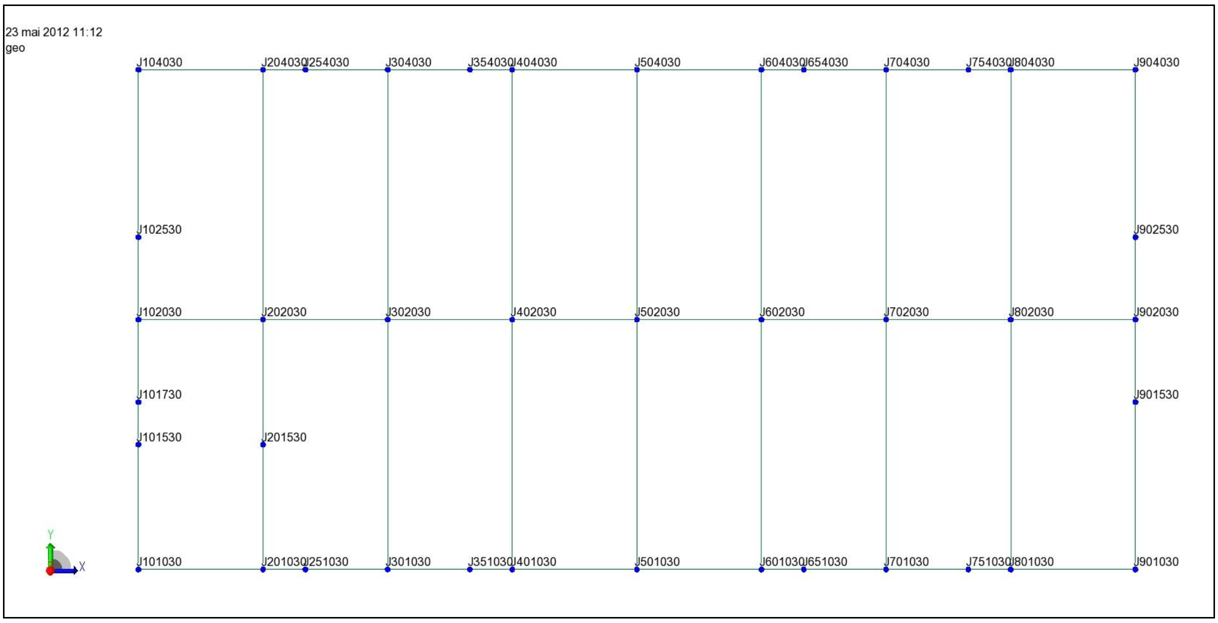


Figure B- 3 Joint names

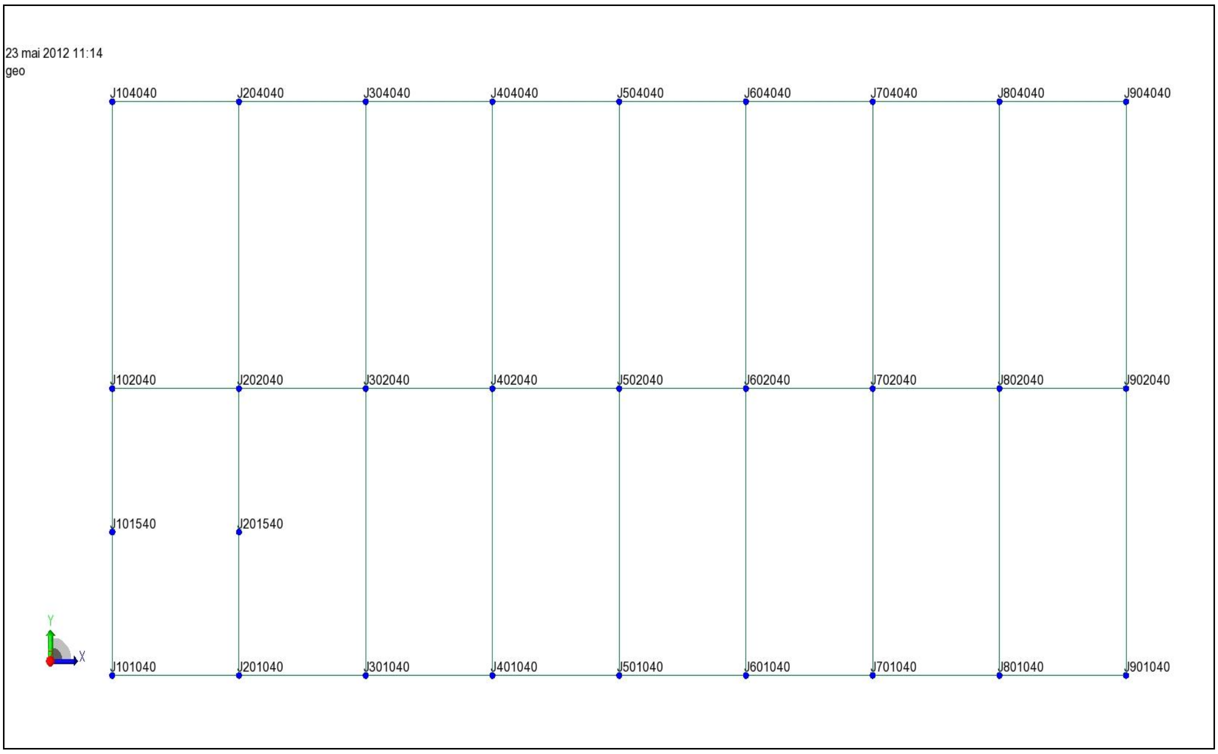


Figure B- 4 Joint names

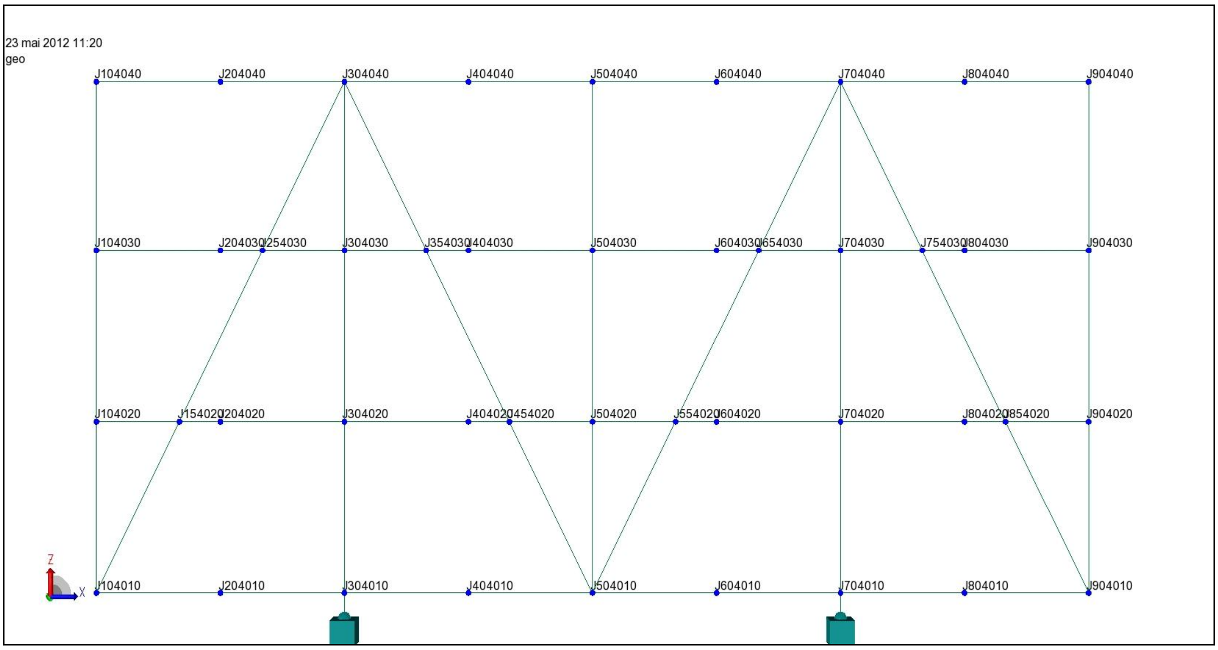


Figure B- 5 Joint names

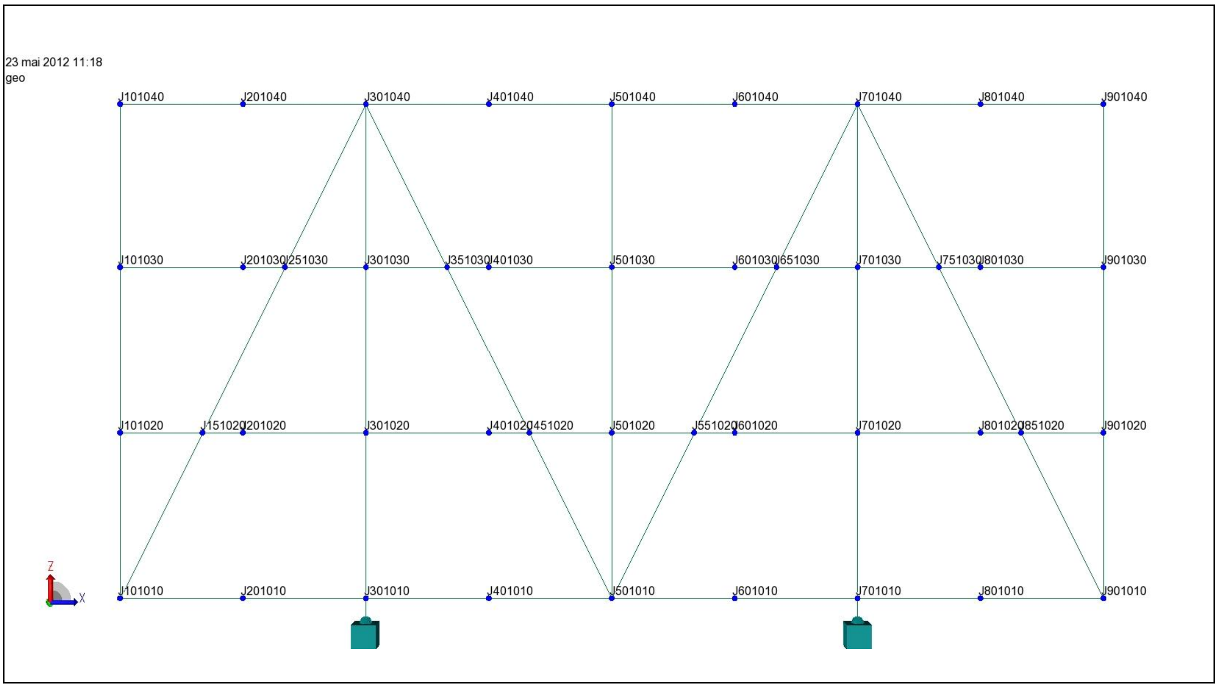


Figure B- 6 .Joint names

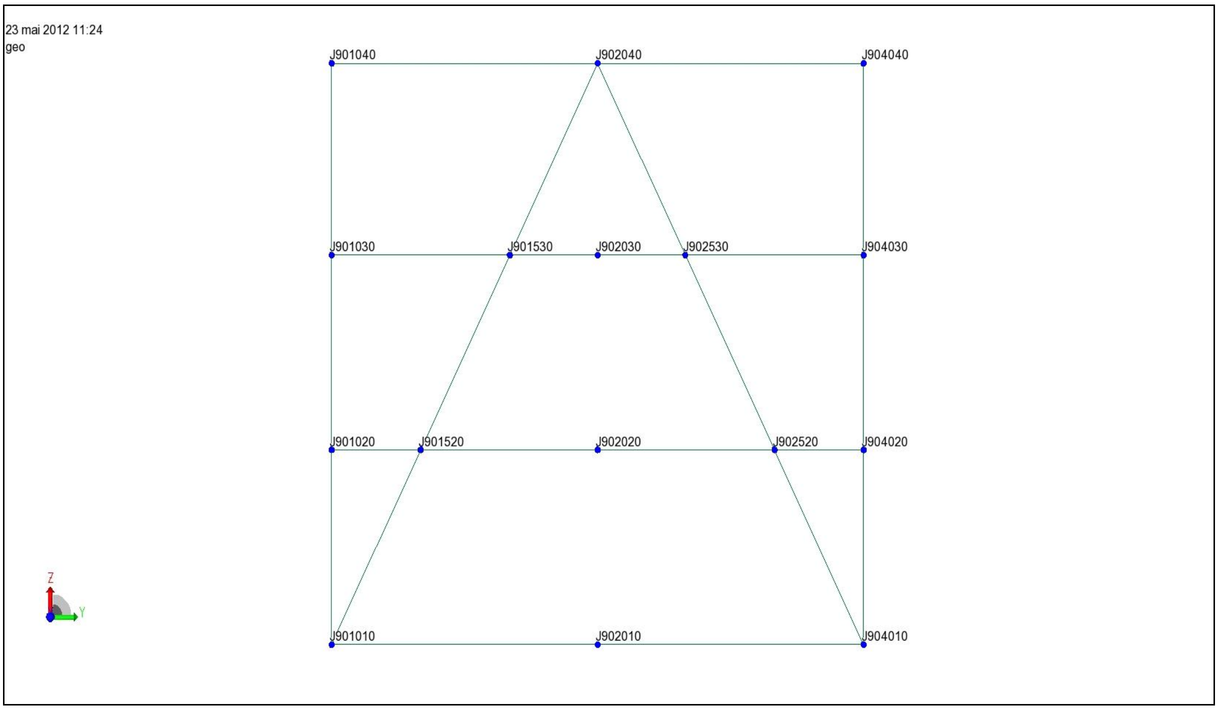


Figure B- 7 Joint names

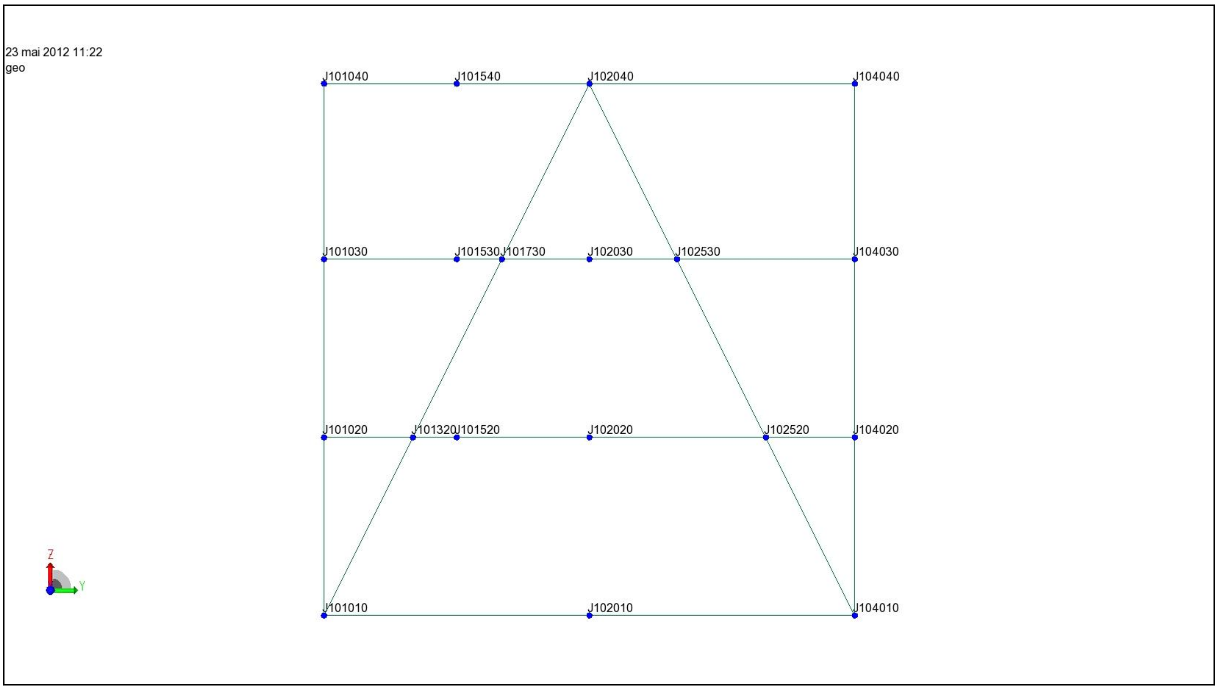


Figure B- 8 .Joint names

C. SECTION PROPERTIES

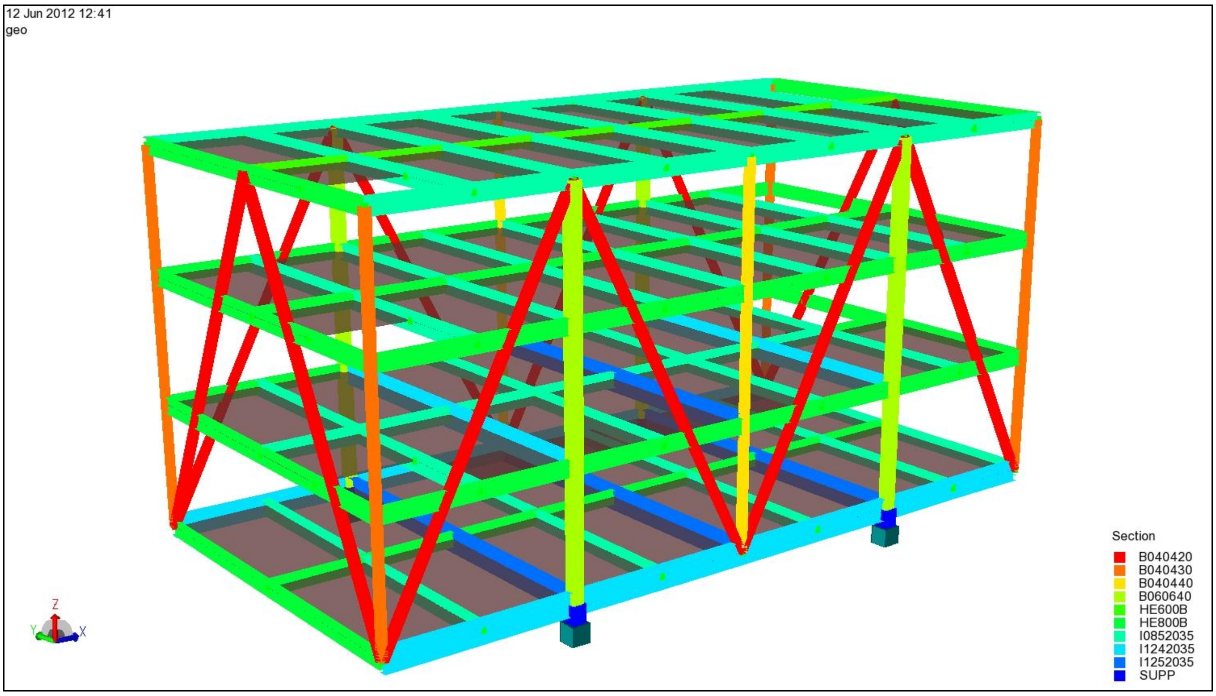


Figure C- 1 Sections of module

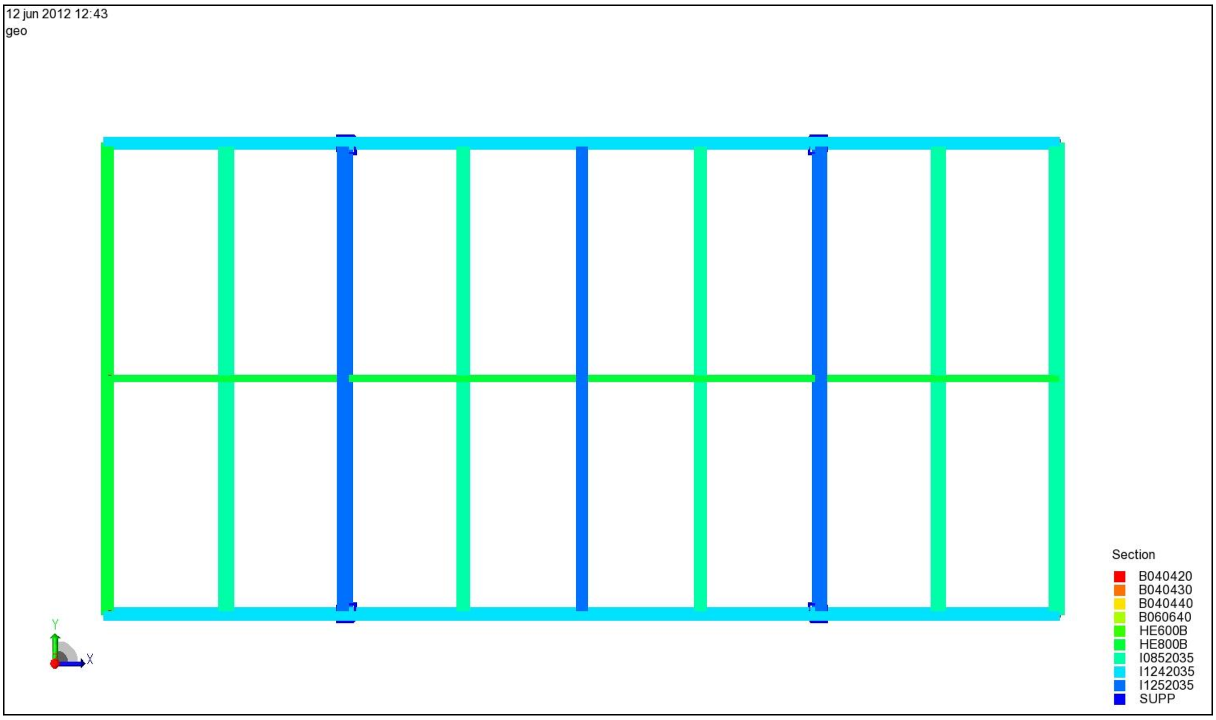


Figure C- 2 Sections on main deck

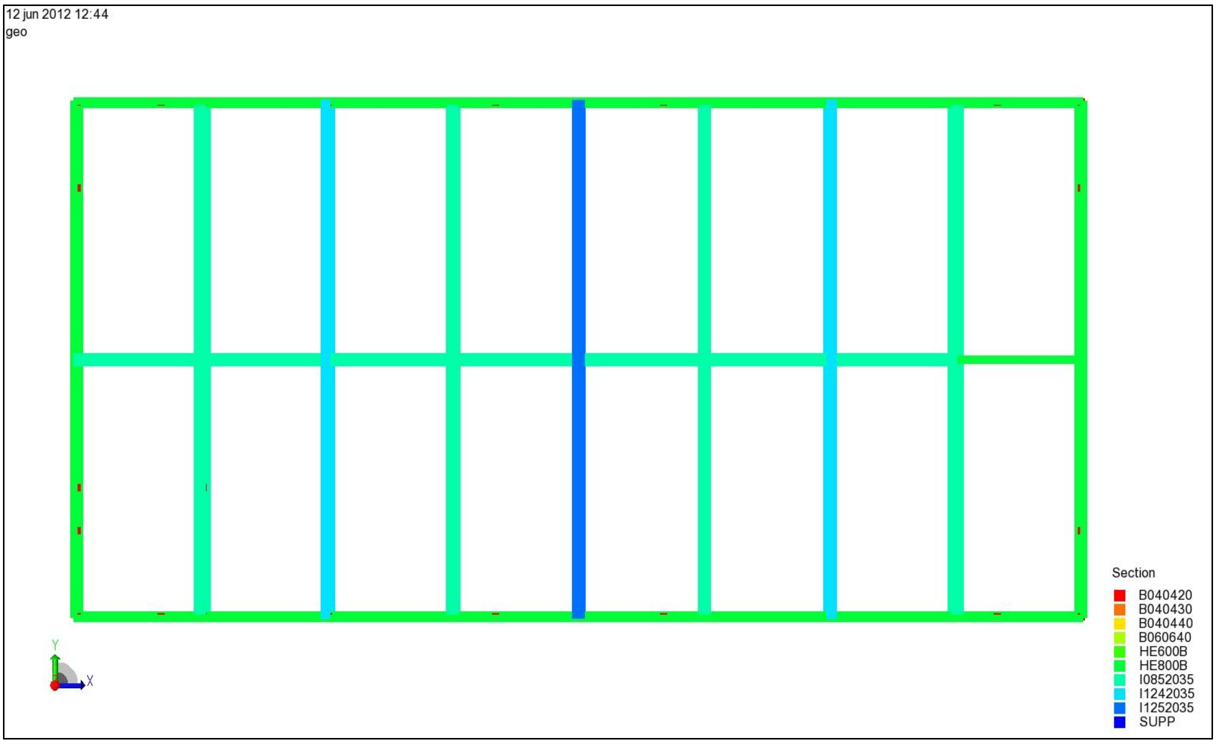


Figure C- 3 Sections on lower mezzanine deck

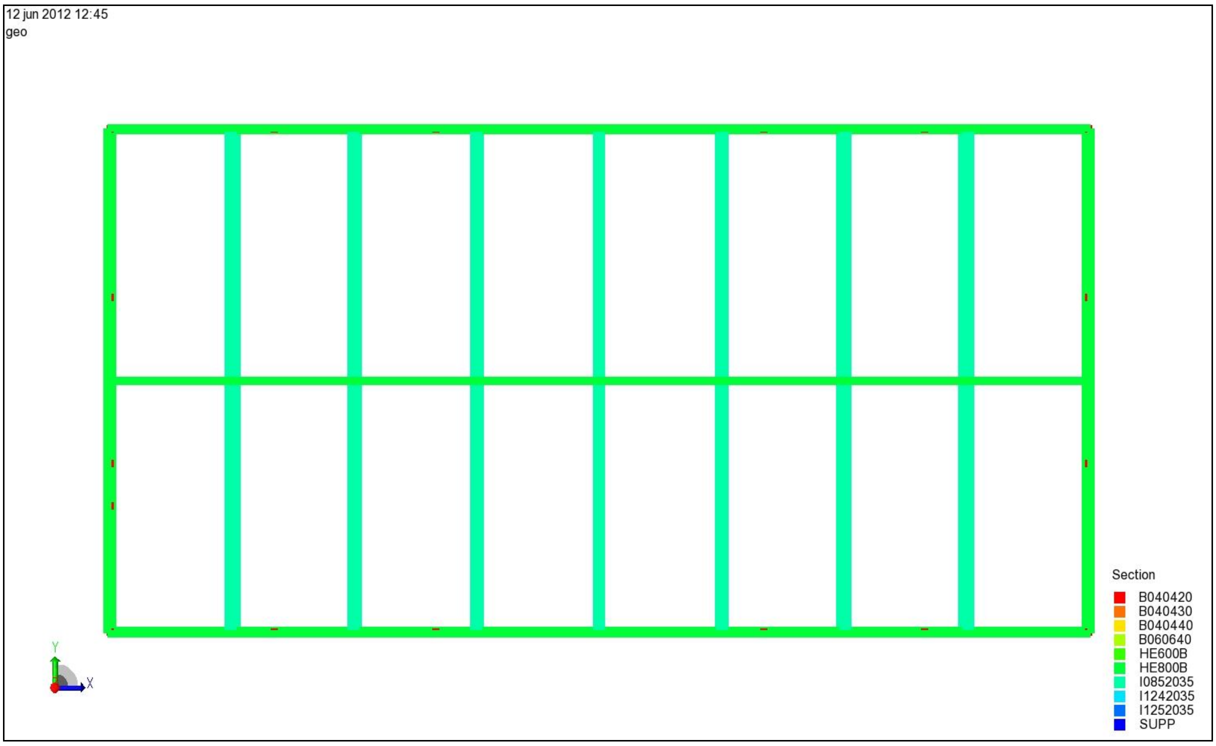


Figure C- 4 Sections on upper mezzanine deck

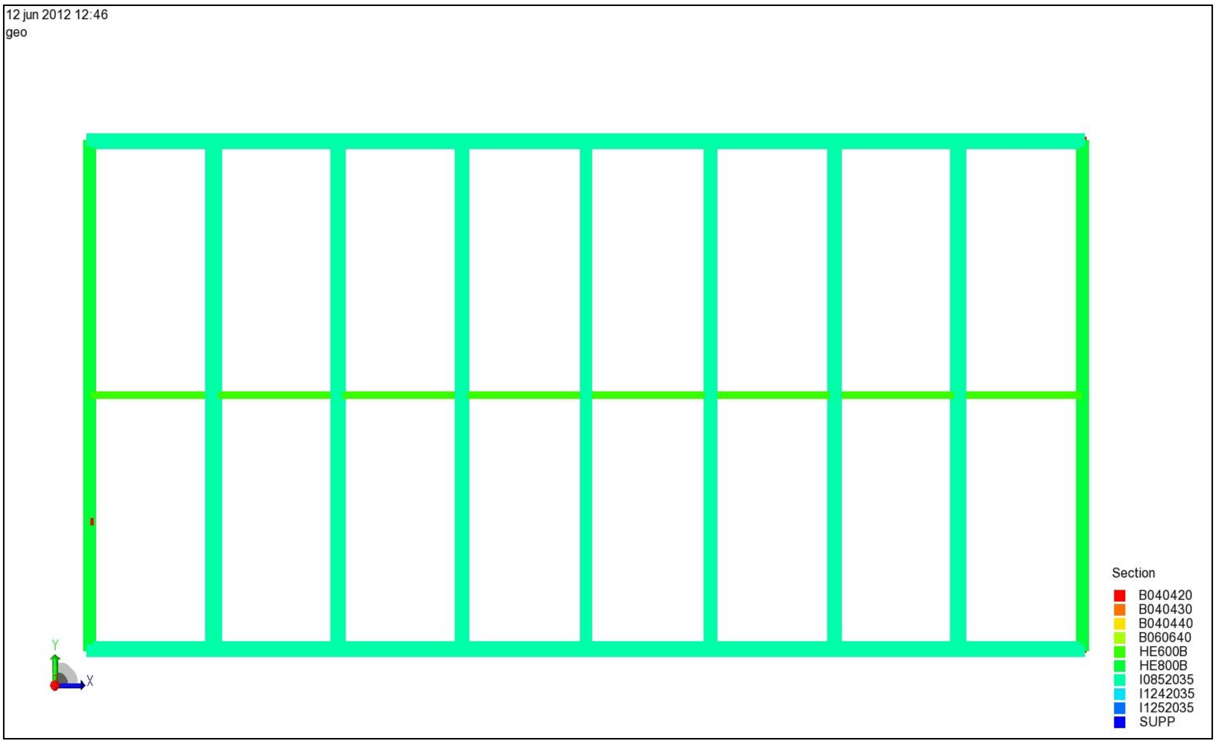


Figure C- 5 Sections on weather deck

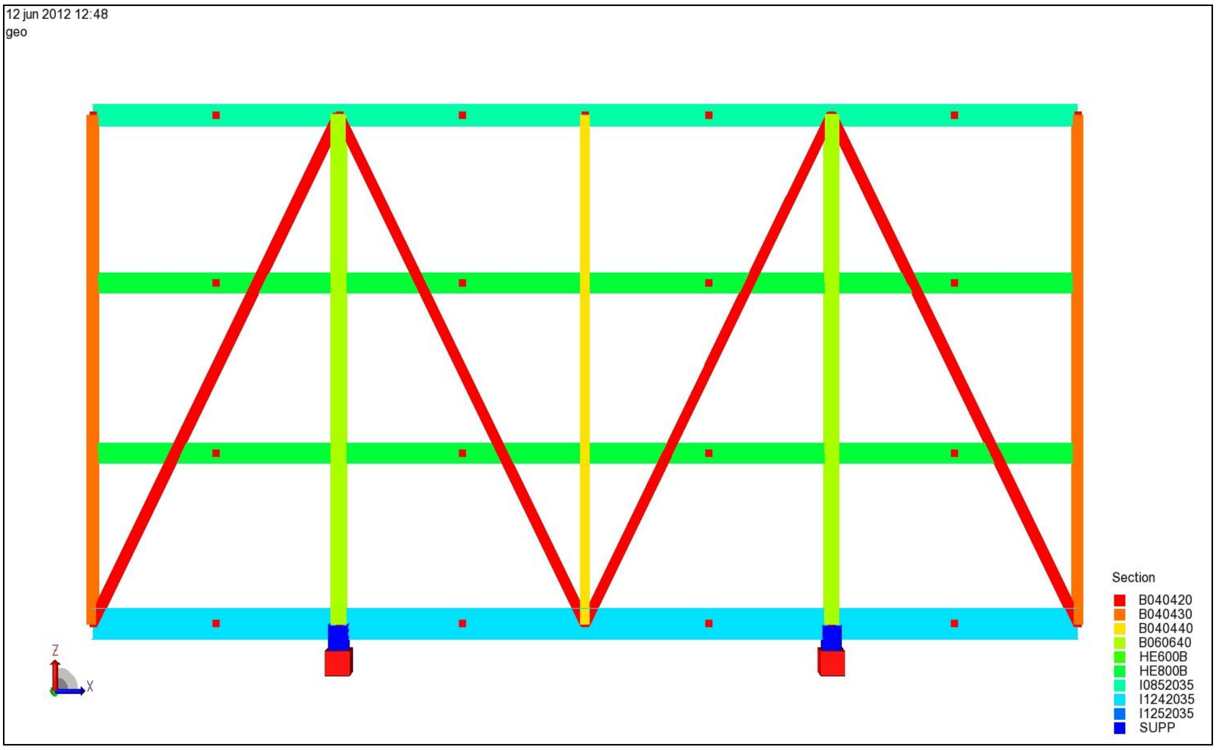


Figure C- 6 Sections on North face

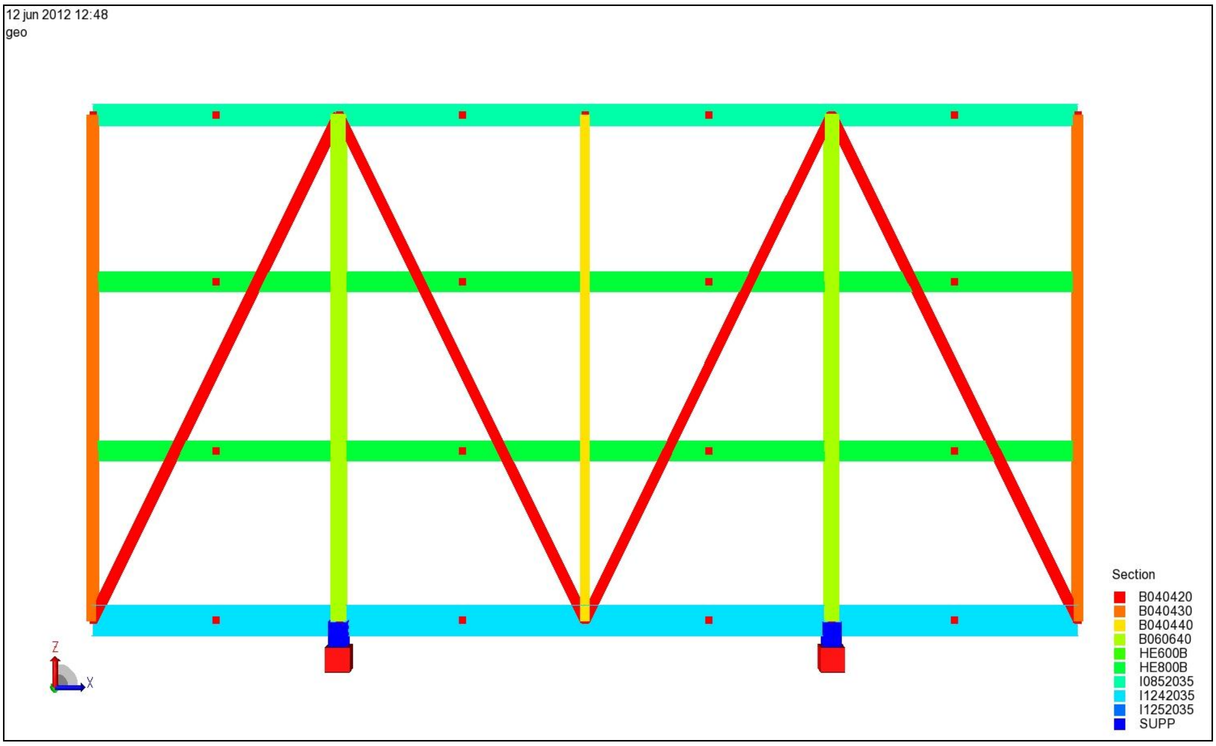


Figure C- 7 Sections on South face

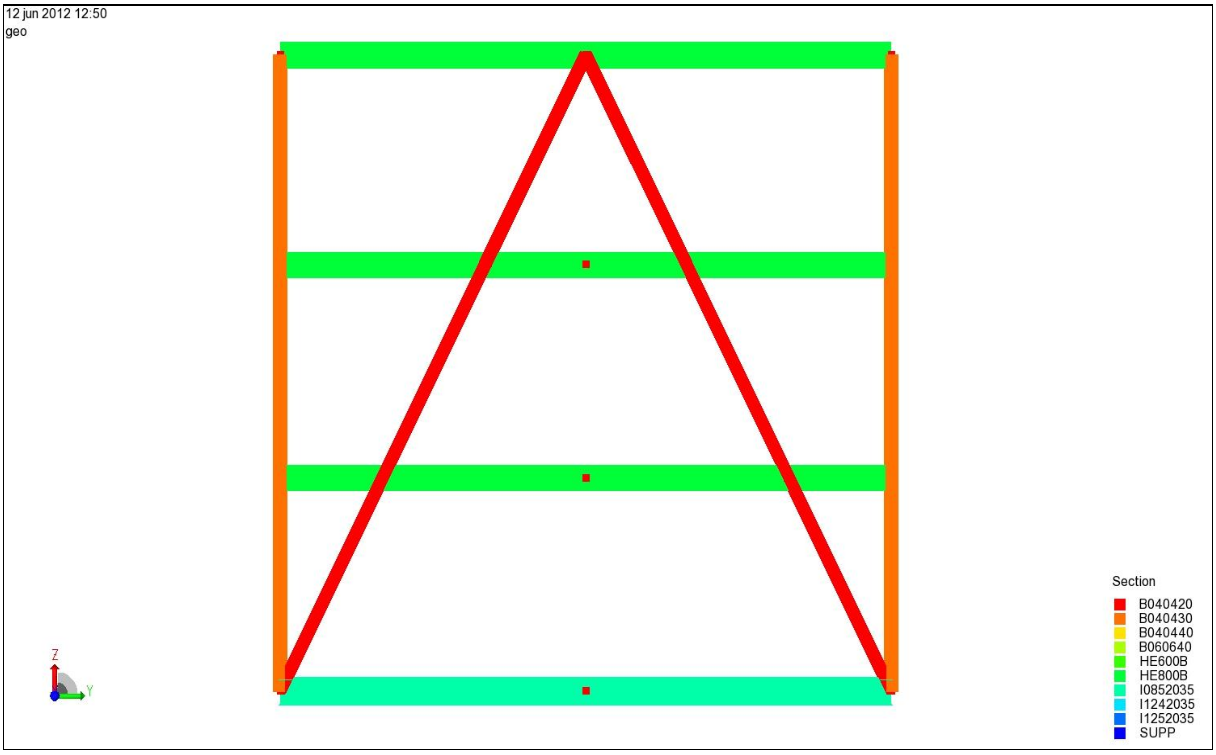


Figure C- 8 Sections on East face

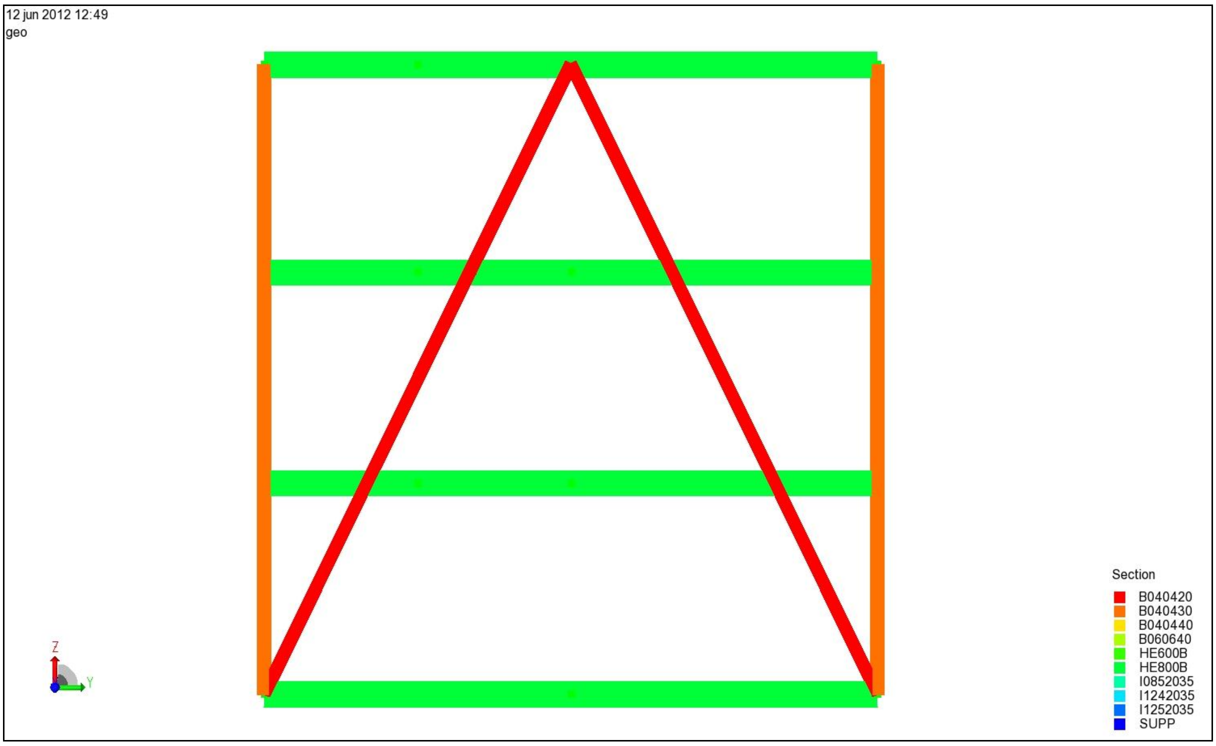


Figure C- 9 Sections on West face

D. ACTIONS

Basic dead and live load

Load cases and factor

- Inplace condition
- Lift condition
- Transport condition

Load combination Presel

- Inplace condition
- Lift Condition
- Transport condition

Load combination Prepost

- Inplace condition
- Transport condition

Wind Load Calculation

Barge acceleration

Center of Gravity check

BASIC DEAD LOAD WEIGHT SESTRA 100

		WEIGHT REPORT							SESTRA 100		
LC	**Description**	**X**	**Y**	**Z**	**X**	**Y**	**Z**	**LC**	**X**	**Y**	**Z**
		TONNE			**kN**						
1	Self Generated Dead Weight			580.9			5 699.0	1	0.0	0.0	-5 699.0
2	Secondary Steel			232.4			2 279.6	2	0.0	0.0	-2 279.6
3	Outfitting Steel			58.1			569.9	3	0.0	0.0	-569.9
20	Various Equipment			336.0			3 296.2	20	0.0	0.0	-3 296.2
21	Electrical Dry Weight			62.0			608.2	21	0.0	0.0	-608.0
22	Instrumental Dry Weight			24.0			235.4	22	0.0	0.0	-235.4
23	Piping Dry Weight			200.0			1 962.0	23	0.0	0.0	-1 962.0
24	HVAC			28.0			274.7	24	0.0	0.0	-274.7
25	Safety Dry Weight			28.0			274.7	25	0.0	0.0	-274.7
26	Surface Dry Weight			12.0			117.7	26	0.0	0.0	-117.7
27	Architectural Dry weight			48.0			470.9	27	0.0	0.0	-470.9
101	Self Generated Dead Weight	580.9			5 699.0			101	5 699.0	0.0	0.0
102	Secondary Steel	232.4			2 279.6			102	2 279.6	0.0	0.0
103	Outfitting Steel	58.1			569.9			103	569.9	0.0	0.0
120	Various Equipment	336.0			3 296.2			120	3 296.2	0.0	0.0
121	Electrical Dry Weight	62.0			608.2			121	608.0	0.0	0.0
122	Instrumental Dry Weight	24.0			235.4			122	235.4	0.0	0.0
123	Piping Dry Weight	200.0			1 962.0			123	1 962.0	0.0	0.0
124	HVAC	28.0			274.7			124	274.7	0.0	0.0
125	Safety Dry Weight	28.0			274.7			125	274.7	0.0	0.0
126	Surface Dry Weight	12.0			117.7			126	117.7	0.0	0.0
127	Architectural Dry weight	48.0			470.9			127	470.9	0.0	0.0
201	Self Generated Dead Weight		580.9			5 699.0		201	0.0	5 699.0	0.0
202	Secondary Steel		232.4			2 279.6		202	0.0	2 279.6	0.0
203	Outfitting Steel		58.1			569.9		203	0.0	569.9	0.0
220	Various Equipment		336.0			3 296.2		220	0.0	3 296.2	0.0
221	Electrical Dry Weight		62.0			608.2		221	0.0	608.0	0.0
222	Instrumental Dry Weight		24.0			235.4		222	0.0	235.4	0.0
223	Piping Dry Weight		200.0			1 962.0		223	0.0	1 962.0	0.0
224	HVAC		28.0			274.7		224	0.0	274.7	0.0
225	Safety Dry Weight		28.0			274.7		225	0.0	274.7	0.0
226	Surface Dry Weight		12.0			117.7		226	0.0	117.7	0.0
227	Architectural Dry weight		48.0			470.9		227	0.0	470.9	0.0

Figure D-1 Basic Load case SESTRA 100

BASIC DEAD WEIGHT LOAD SESTRA 150

WEIGHT REPORT								SESTRA 150		
			Factor	X	Y	Z		X	Y	Z
Z Direction	Load Cas	Description		kN			kN			
	1	Self Generated Dead Weight	1.1	0.0	0.0	-6 268.9				
	2	Secondary Steel	1.1	0.0	0.0	-2 507.6				
	3	Outfitting Steel	1.1	0.0	0.0	-626.9				
						-9 403.4	**1**	**0.0**	**0.0**	**-9 403.3**
	20	Various Equipment	1.1	0.0	0.0	-3 625.8				
	21	Electrical Dry Weight	1.1	0.0	0.0	-668.8				
	22	Instrumental Dry Weight	1.1	0.0	0.0	-259.0				
	23	Piping Dry Weight	1.1	0.0	0.0	-2 158.2				
	24	HVAC	1.1	0.0	0.0	-302.1				
	25	Safety Dry Weight	1.1	0.0	0.0	-302.1				
	26	Surface Dry Weight	1.1	0.0	0.0	-129.5				
	27	Architectural Dry weight	1.1	0.0	0.0	-518.0				
						-7 963.6	**2**	**0.0**	**0.0**	**-7 963.5**
X Direction										
	101	Self Generated Dead Weight	1.1	6 268.9	0.0	0.0				
	102	Secondary Steel	1.1	2 507.6	0.0	0.0				
	103	Outfitting Steel	1.1	626.9	0.0	0.0				
				9 403.4			**11**	**9 403.3**	**0.0**	**0.0**
	120	Various Equipment	1.1	3 625.8	0.0	0.0				
	121	Electrical Dry Weight	1.1	668.8	0.0	0.0				
	122	Instrumental Dry Weight	1.1	259.0	0.0	0.0				
	123	Piping Dry Weight	1.1	2 158.2	0.0	0.0				
	124	HVAC	1.1	302.1	0.0	0.0				
	125	Safety Dry Weight	1.1	302.1	0.0	0.0				
	126	Surface Dry Weight	1.1	129.5	0.0	0.0				
	127	Architectural Dry weight	1.1	518.0	0.0	0.0				
				7 963.6			**12**	**7 963.5**	**0.0**	**0.0**
Y Direction										
	201	Self Generated Dead Weight	1.1	0.0	6 268.9	0.0				
	202	Secondary Steel	1.1	0.0	2 507.6	0.0				
	203	Outfitting Steel	1.1	0.0	626.9	0.0				
					9 403.4		**21**	**0.0**	**9 403.3**	**0.0**
	220	Various Equipment	1.1	0.0	3 625.8	0.0				
	221	Electrical Dry Weight	1.1	0.0	668.8	0.0				
	222	Instrumental Dry Weight	1.1	0.0	259.0	0.0				
	223	Piping Dry Weight	1.1	0.0	2 158.2	0.0				
	224	HVAC	1.1	0.0	302.1	0.0				
	225	Safety Dry Weight	1.1	0.0	302.1	0.0				
	226	Surface Dry Weight	1.1	0.0	129.5	0.0				
	227	Architectural Dry weight	1.1	0.0	518.0	0.0				
					7 963.6		**22**	**0.0**	**7 963.5**	**0.0**

Figure D-2 Basic Load case SESTRA 150

BASIC DEAD WEIGHT LOAD SESTRA 200

		WEIGHT REPORT					SESTRA 200			
	LC	DESCRIPTIONS	Factor	X	Y	Z	LC	X	Y	Z
Z Direction				kN						
	1	Self Generated Dead Weight	1.1	0.0	0.0	-6 268.9				
	2	Secondary Steel	1.1	0.0	0.0	-2 507.6				
	3	Outfitting Steel	1.1	0.0	0.0	-626.9				
	20	Various Equipment	1.1	0.0	0.0	-3 625.8				
	21	Electrical Dry Weight	1.1	0.0	0.0	-668.8				
	22	Instrumental Dry Weight	1.1	0.0	0.0	-259.0				
	23	Piping Dry Weight	1.1	0.0	0.0	-2 158.2				
	24	HVAC	1.1	0.0	0.0	-302.1				
	25	Safety Dry Weight	1.1	0.0	0.0	-302.1				
	26	Surface Dry Weight	1.1	0.0	0.0	-129.5				
	27	Architectural Dry weight	1.1	0.0	0.0	-518.0				
						-17 366.9	**397**	**0.0**	**0.0**	**-17 367.0**
X Direction										
	101	Self Generated Dead Weight	1.1	6 268.9	0.0	0.0				
	102	Secondary Steel	1.1	2 507.6	0.0	0.0				
	103	Outfitting Steel	1.1	626.9	0.0	0.0				
	120	Various Equipment	1.1	3 625.8	0.0	0.0				
	121	Electrical Dry Weight	1.1	668.8	0.0	0.0				
	122	Instrumental Dry Weight	1.1	259.0	0.0	0.0				
	123	Piping Dry Weight	1.1	2 158.2	0.0	0.0				
	124	HVAC	1.1	302.1	0.0	0.0				
	125	Safety Dry Weight	1.1	302.1	0.0	0.0				
	126	Surface Dry Weight	1.1	129.5	0.0	0.0				
	127	Architectural Dry weight	1.1	518.0	0.0	0.0				
				17 366.9			**398**	**17 367.0**	**0.0**	**0.0**
Y Direction										
	201	Self Generated Dead Weight	1.1	0.0	6 268.9	0.0				
	202	Secondary Steel	1.1	0.0	2 507.6	0.0				
	203	Outfitting Steel	1.1	0.0	626.9	0.0				
	220	Various Equipment	1.1	0.0	3 625.8	0.0				
	221	Electrical Dry Weight	1.1	0.0	668.8	0.0				
	222	Instrumental Dry Weight	1.1	0.0	259.0	0.0				
	223	Piping Dry Weight	1.1	0.0	2 158.2	0.0				
	224	HVAC	1.1	0.0	302.1	0.0				
	225	Safety Dry Weight	1.1	0.0	302.1	0.0				
	226	Surface Dry Weight	1.1	0.0	129.5	0.0				
	227	Architectural Dry weight	1.1	0.0	518.0	0.0				
					17 366.9		**399**	**0.0**	**17 367.0**	**0.0**

Figure D-3 Basic Load case SESTRA 200

BASIC LIVE LOADS SESTRA 100

	WEIGHT REPORT									**SESTRA 100**		
LC	**Description**	**X**	**Y**	**Z**	**X**	**Y**	**Z**		**LC**	**X**	**Y**	**Z**
		TONNE			**kN**				**kN**			
31	Persons Load			412.0			4 041.7		31	0.0	0.0	-4 041.7
32	Weight of gas and liquid in the pipe			40.0			392.4		32	0.0	0.0	-392.4
33	Stored liquid and goods			80.0			784.8		33	0.0	0.0	-784.8
34	Layout Area			125.0			1 226.3		34	0.0	0.0	-1 226.2
131	Persons Load	412.0			4 041.7				131	4 041.7	0.0	0.0
132	Weight of gas and liquid in the pipe	40.0			392.4				132	392.4	0.0	0.0
133	Stored liquid and goods	80.0			784.8				133	784.8	0.0	0.0
134	Layout Area	125.0			1 226.3				134	1 226.2	0.0	0.0
231	Persons Load		412.0			4 041.7			231	0.0	4 041.7	0.0
232	Weight of gas and liquid in the pipe		40.0			392.4			232	0.0	392.4	0.0
233	Stored liquid and goods		80.0			784.8			233	0.0	784.8	0.0
234	Layout Area		125.0			1 226.3			234	0.0	1 226.2	0.0

Figure D-4 Basic Load SESTRA 100

BASIC LIVE LOAD SESTRA 150

		WEIGHT REPORT						**SESTRA 150**		
	LC	**DESCRIPTIONS**	**X**	**Y**	**Z**		**LC**	**X**	**Y**	**Z**
Z Direction			kN				kN			
	31	Persons Load	0.0	0.0	4 041.7					
	32	Weight of gas and liquid in the pipe	0.0	0.0	392.4					
	33	Stored liquides and goods (Tanks)	0.0	0.0	784.8					
	34	Laydown area	0.0	0.0	1 226.3					
					6 445.2		**1**	**0.0**	**0.0**	**-6 445.2**
X Direction										
	131	Persons Load	4 041.7	0.0	0.0					
	132	Weight of gas and liquid in the pipe	392.4	0.0	0.0					
	133	Stored liquides and goods (Tanks)	784.8	0.0	0.0					
	134	Laydown area	1 226.3	0.0	0.0					
			6 445.2				**2**	**6 445.2**	**0.0**	**0.0**
Y Direction										
	231	Persons Load	0.0	4 041.7	0.0					
	232	Weight of gas and liquid in the pipe	0.0	392.4	0.0					
	233	Stored liquides and goods (Tanks)	0.0	784.8	0.0					
	234	Laydown area	0.0	1 226.3	0.0					
				6 445.2			**3**	**0.0**	**6 445.2**	**0.0**

Figure D-5 Basic Live load SESTRA 150

INPLACE LOAD COMBINATIONS, PRESEL

BLC SEL. 10		Load-Name	Self generated dead weight	Secondary steel	Outfitting steel	Equipment	Electrical	Instrument	Piping	HVAC	Safety	Surface protection	Architectural
-z			1	2	3	20	21	22	23	24	25	26	27
+x			101			120			123			126	
+y			201			220			223			226	
Intermediate Level comb. SEL. 100	-z	1	1.0										
		2		1.0									
		3			1.0								
		20				1.0							
		21					1.0						
		22						1.0					
		23							1.0				
		24								1.0			
		25									1.0		
		26										1.0	
		27											1.0
	+x	101	1.0										
		102		1.0									
		103			1.0								
		120				1.0							
		121					1.0						
		122						1.0					
		123							1.0				
		124								1.0			
		125									1.0		
		126										1.0	
		127											1.0
	+y	201	1.0										
		202		1.0									
		203			1.0								
		220				1.0							
		221					1.0						
		222						1.0					
		223							1.0				
		224								1.0			
		225									1.0		
		226										1.0	
		227											1.0

Figure D-6 Presel load combination, static loads, run 1

Note. Static load cases are the same for Inplace and Transport conditions

BLC SEL. 100		Load-Name	Self generated dead weight	Secondary steel	Outfitting steel	Equipment	Electrical	Instrument	Piping	HVAC	Safety	Surface protection	Architectural
-z			1	2	3	20	21	22	23	24	25	26	27
+x			101	102	103	120	121	122	123	124	125	126	127
+y			201	202	203	220	221	222	223	224	225	226	227
Intermediate Level comb. SEL. 150	-z	1	1.1	1.1	1.1								
		2				1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	+x	11	1.1	1.1	1.1								
		12				1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	+y	21	1.1	1.1	1.1								
		22				1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

Figure D-7 Presel load combination, static loads, run 2

BLC SEL. 150		Load-Name	Structural dead weights	Equipment dead load
-z			1	2
+x			11	12
+y			21	22
Intermediate Level comb. SEL. 200	-z	397	1.0	1.0
	+x	398	1.0	1.0
	+y	399	1.0	1.0

Figure D-8 Presel load combination, static loads, run 3

BLC SEL. 10		Load-name	Self generated dead weight	Secondary steel	Outfitting steel	Equipment	Electrical	Instrument	Piping	HVAC	Safety	Surface protection	Architectural	Persons load	weight of gas and liquid	Stored liquides and goods	Laydown area	Wind from West	Wind from East
	-z		1	2	3	20	21	22	23	24	25	26	27	31	32	33	34		
	+x		2	102	103	120	121	122	123	124	125	126	127	131	132	133	134	50	51
	+y		3	202	203	220	221	222	223	224	225	226	227	231	232	233	234		
Intermediate Level comb. SEL. 100	-z	1	1.0																
		2		1.0															
		3			1.0														
		20				1.0													
		21					1.0												
		22						1.0											
		23							1.0										
		24								1.0									
		25									1.0								
		26										1.0							
		27											1.0						
		31												1.0					
		32													1.0				
		33														1.0			
		34															1.0		
	+x	101	1.0																
		102		1.0															
		103			1.0														
		120				1.0													
		121					1.0												
		122						1.0											
		123							1.0										
		124								1.0									
		125									1.0								
		126										1.0							
		127											1.0						
		131												1.0					
		132													1.0				
		133														1.0			
		134															1.0		
		50																1.0	
		51																	1.0
	+y	201	1.0																
		202		1.0															
		203			1.0														
		220				1.0													
		221					1.0												
		222						1.0											
		223							1.0										
		224								1.0									
		225									1.0								
		226										1.0							
		227											1.0						
		231												1.0					
		232													1.0				
		233														1.0			
		234															1.0		

Figure D-9 Presel load combination, live loads, run 1

BLC SEL. 100		Load-name	Self generated dead weight	Secondary steel	Outfitting steel	Equipment	Electrical	Instrument	Piping	HVAC	Safety	Surface protection	Architectural	Persons load	weight of gas and liquid	Stored liquides and goods	Laydown area	Wind from West	Wind from East
-z			1	2	3	20	21	22	23	24	25	26	27	31	32	33	34		
+x			101	102	103	120	121	122	123	124	125	126	127	131	132	133	134	50	51
+y			201	202	203	220	221	222	223	224	225	226	227	231	232	233	234		
Intermediate Level comb. SEL. 150	-z	1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1						
		31												1.0	1.0	1.0	1.0		
	+x	2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1						
		32												1.0	1.0	1.0	1.0		
		50																1.0	
		51																	1.0
	+y	3	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1						
		33												1.0	1.0	1.0	1.0		

Figure D-10 Presel load combination, live loads, run 2

BLC SEL. 150		Load-Name	Dead	Live	Wind from West	Wind from East
-z			1	31	50	51
+x			2	32		
+y			3	33		
Intermediate Level comb. SEL. 197	-z	101	0.020	0.020		
		31		1.000		
		201	0.061	0.061		
	+x	102	0.051			
		202	0.245	0.245		
		32		0.510		
		150			1.000	
		151				1.000
	+y	103	0.051			
		203	0.255	0.255		
		33		0.510		

Figure D-11 Presel load combination, live loads, run 3

LIFTING LOAD COMBINATIONS, PRESEL

BLC SEL. 11	**Direction**	Load-Name	Self generated dead weight	Secondary steel	Outfitting steel	Equipment	Electrical	Instrument	Piping	HVAC	Safety	Surface protection	Architectural
			1	2	3	20	21	22	23	24	25	26	27
Intermediate Level comb. SEL. 100	-z	1	1.0										
		2		1.0									
		3			1.0								
		20				1.0							
		21					1.0						
		22						1.0					
		23							1.0				
		24								1.0			
		25									1.0		
		26										1.0	
		27											1.0

Figure D-12 Presel load combination, static loads, run 1

BLC SEL. 100		Load-Name	Self generated dead weight	Secondary steel	Outfitting steel	Equipment	Electrical	Instrument	Piping	HVAC	Safety	Surface protection	Architectural
			1	2	3	20	21	22	23	24	25	26	27
Intermediate Level comb. SEL. 150	-z	1	1.1	1.1	1.1								
		2				1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

Figure D-13 Presel load combination, static loads, run 2

BLC SEL. 150	Direction	Load-Name	Structural dead weights	Equipment dead load
			1	2
Intermediate Level comb. SEL. 200	-z	397	1.0	1.0

Figure D-14 Presel load combination, static loads, run 3

BLC SEL. 200	Direction	Load-Name	Dead load
			397
Top Level comb. SEL. 201	-z	1	2.808
	-z	2	3.174

Figure D-15 Presel load combination, static loads, run 4

TRANSPORT LOAD COMBINATION, PRESEL

BLC SEL. 10		Load-name	Self generated dead weight	Secondary steel	Outfitting steel	Equipment	Electrical	Instrument	Piping	HVAC	Safety	Surface protection	Architectural	Persons load	weight of gas and liquid	Stored liquides and goods	Laydown area	Wind from West	Wind from East	Wind from South	Wind from North
-z			1	2	3	20	21	22	23	24	25	26	27	31	32	33	34				
+x			2	102	103	120	121	122	123	124	125	126	127	131	132	133	134	52	53	54	55
+y			3	202	203	220	221	222	223	224	225	226	227	231	232	233	234				
Intermediate Level comb. SEL. 100	-z	1	1.0																		
		2		1.0																	
		3			1.0																
		20				1.0															
		21					1.0														
		22						1.0													
		23							1.0												
		24								1.0											
		25									1.0										
		26										1.0									
		27											1.0								
		31												1.0							
		32													1.0						
		33														1.0					
		34															1.0				
	+x	101	**1.0**																		
		102		**1.0**																	
		103			**1.0**																
		120				**1.0**															
		121					**1.0**														
		122						**1.0**													
		123							**1.0**												
		124								**1.0**											
		125									**1.0**										
		126										**1.0**									
		127											**1.0**								
		131												**1.0**							
		132													**1.0**						
		133														**1.0**					
		134															**1.0**				
		52																**1.0**			
		53																	**1.0**		
		54																		**1.0**	
		55																			**1.0**
	+y	201	1.0																		
		202		1.0																	
		203			1.0																
		220				1.0															
		221					1.0														
		222						1.0													
		223							1.0												
		224								1.0											
		225									1.0										
		226										1.0									
		227											1.0								
		231												1.0							
		232													1.0						
		233														1.0					
		234															1.0				

Figure D-16 Presel load combination, live loads, run 1

BLC SEL. 100		Load-name	Self generated dead weight	Secondary steel	Outfitting steel	Equipment	Electrical	Instrument	Piping	HVAC	Safety	Surface protection	Architectural	Wind from West	Wind from East	Wind from East	Wind from East
-z			1	2	3	20	21	22	23	24	25	26	27				
+x			101	102	103	120	121	122	123	124	125	126	127	52	53	54	55
+y			201	202	203	220	221	222	223	224	225	226	227				
Intermediate Level comb. SEL. 150	+y	1	1.100	1.100	1.100												
		2				1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100				
		101	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200				
		104	-0.200	-0.200	-0.200	-0.200	-0.200	-0.200	-0.200	-0.200	-0.200	-0.200	-0.200				
	+x	11	1.100	1.100	1.100												
		12				1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100				
		102	1.054	1.054	1.054	1.054	1.054	1.054	1.054	1.054	1.054	1.054	1.054				
		152												1.000			
		153												0.707	0.707		
		154													1.000		
		155													0.707	0.707	
		156													1.000		
		157														0.707	0.707
		158													1.000		
		159												0.71			0.707
	+y	21	1.100	1.100	1.100												
		22				1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100				
		103	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530				

Figure D-17 Presel load combination, live loads, run 2

BLC SEL. 150		Load-Name	Self generated weight	Equipment dead load	Barge acceleration	Barge acceleration	Barge acceleration	Barge acceleration	Wind	Wind	Wind	Wind	Wind	Wind	Wind	Wind
-z			1	2	101			104								
+x			11	12		102			152	153	154	155	156	157	158	159
+y			21	22			103									
Intermediate Level comb. SEL. 197	-z	1	1.000	1.000												
	+x	2	1.000	1.000												
		52							1.000							
		53								1.000						
		54									1.000					
		55										1.000				
		56											1.000			
		57												1.000		
		58													1.000	
		59														1.000
	+y	3	1.000	1.000												
		201			1.000											
		202				1.000										
		203				0.707	0.707									
		204						1.000								
		205				-0.707	0.707									
		206				-1.000										
		207				-0.707	-0.707									
		208					-1.000									
		209				0.707	-0.707									
		210						1.000								

Figure D-18 Presel load combination, live loads, run 3

PREPOST LOAD COMBINATIONS, INPLACE

LOAD COMBINATIONS											
	LOAD CASE	Dead Load (-Z)	Live Load (-Z)	Wind load (+X)	Wind load (-X)	Earthquake load 10^-2 (Z)	Earthquake load 10^-2 (X)	Earthquake load 10^-2 (Y)	Earthquake load 10^-4 (Z)	Earthquake load 10^-4 (X)	Earthquake load 10^-4 (Y)
		397	31	150	151	101	102	103	201	202	203
ULS a	501	1.3	1.3	0.7							
	502	1.3	1.3		0.7						
	521	1.3	1.3			1.3	1.3				
	523	1.3	1.3			1.3		1.3			
	525	1.3	1.3			0.7	0.495	0.495			
	527	1.3	1.3			0.7	-0.495	0.495			
	529	1.3	1.3			0.7	-0.495	-0.495			
	531	1.3	1.3			0.7	0.495	-0.495			
ULS b	503	1.0	1.0	1.3							
	504	1.0	1.0		1.3						
	522	1.0	1.0			1.3	1.3				
	524	1.0	1.0			1.3		1.3			
	526	1.0	1.0			1.3	0.919	0.919			
	528	1.0	1.0			1.3	0.919	0.919			
	530	1.0	1.0			1.3	-0.919	-0.919			
	532	1.0	1.0			1.3	0.919	-0.919			
ALS	541	1.0	1.0						1.0	1.0	
	542	1.0	1.0						1.0	0.707	0.707
	543	1.0	1.0						1.0		1.0
	544	1.0	1.0						1.0	-0.707	0.707
	545	1.0	1.0						1.0	-0.707	-0.707
	546	1.0	1.0						1.0	0.707	-0.707

Figure D-19 Prepost load combination, inplace

LOAD COMBINATION

LOAD COMBINATIONS		
	Load Name	Dead Load (-Z)
		397
ULS a	1	2.808
	2	3.174

Figure D-20 Load combination lift

PREPOST LOAD COMBINATIONS, TRANSPORT

LOAD COMBINATIONS

	LOAD CASE	Dead Load (-Z)	Live Load (-Z)	Wind load (+X)	Wind load (-X+Y)	Wind load (+Y)	Wind load (-X+Y)	Wind load (-X)	Wind load (-X-Y)	Wind load (-Y)	Wind load (+X-Y)	Barge acceleration (-Z)	Barge acceleration (+X)	Barge acceleration (+X+Y)	Barge acceleration (+Y)	Barge acceleration (-X+Y)	Barge acceleration (-X)	Barge acceleration (-X-Y)	Barge acceleration (+X-Y)	Barge acceleration (-Z)
		397	52	53	54	55	56	57	58	59	201	202	203	204	205	206	207	208	209	210
ULS a	601	1.3	0.7								1.3	1.3								
	603	1.3		0.7							1.3		1.3							
	605	1.3			0.7						1.3			1.3						
	607	1.3				0.7					1.3				1.3					
	609	1.3					0.7				1.3					1.3				
	611	1.3						0.7			1.3						1.3			
	613	1.3							0.7		1.3							1.3		
	615	1.3								0.7	1.3								1.3	
	617	1.3	0.7									1.3								1.3
	619	1.3		0.7									1.3							1.3
	621	1.3			0.7									1.3						1.3
	623	1.3				0.7									1.3					1.3
	625	1.3					0.7									1.3				1.3
	627	1.3						0.7									1.3			1.3
	629	1.3							0.7									1.3		1.3
	631	1.3								0.7									1.3	1.3
ULS b	602	1.0	1.3								1.0	1.0								
	604	1.0		1.3							1.0		1.0							
	606	1.0			1.3						1.0			1.0						
	608	1.0				1.3					1.0				1.0					
	610	1.0					1.3				1.0					1.0				
	612	1.0						1.3			1.0						1.0			
	614	1.0							1.3		1.0							1.0		
	616	1.0								1.3	1.0								1.0	
	618	1.0	1.3									1.0								1.0
	620	1.0		1.3									1.0							1.0
	622	1.0			1.3									1.0						1.0
	624	1.0				1.3									1.0					1.0
	626	1.0					1.3									1.0				1.0
	628	1.0						1.3									1.0			1.0
	630	1.0							1.3									1.0		1.0
	532	1.0								1.3									1.0	1.0

Figure D-21 Prepost load combination, transport

WIND LOAD CALCULATION

WIND LOAD CALCULATION

According to the Norsok standard N-003 section 6.3.2 the wind speed U(z,t) at height z(m) above sea level and corresponding avaraging period t(s) lessthan or equal to t_0 =3600 s corresponding to annual probability of exceedance of 10^{-2} may be calculated as:

$U_{1y} := 25.5\frac{m}{s}$ Wind speed at a reference elevation z_r =10 m and return period of 1-year omnidirectional

$U_{10y} := 29.5\frac{m}{s}$ Wind speed at a reference elevation z_r =10 m and return period of 10-year omnidirectional

$U_{100y} := 34.0\frac{m}{s}$ Wind speed at a reference elevation z_r =10 m and return period of 100-year omnidirectional

$h_{58} := 58.3m$

$h_r := 10.0m$ Reference elevation

$t_0 := 3600.0s$

$t_{gust} := 3sec$

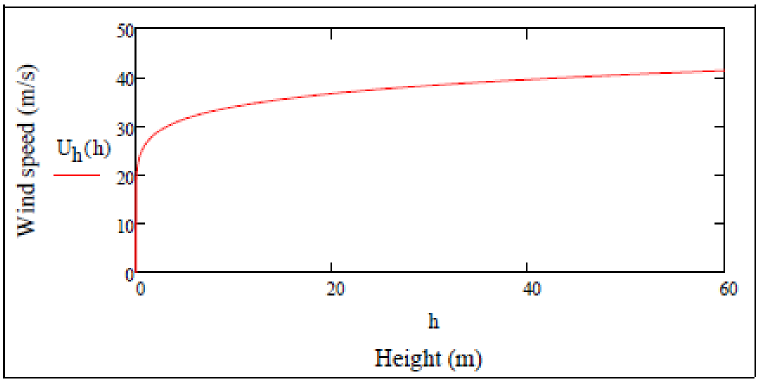
Duration greater than 1 hour

U_h. Wind speed (m/s) at 58 m above mean sea level (MSL)

$U_h(h)$ Wind speed at height (z) in meter

$$U_h := U_{100y}\left(\frac{h_{58}}{h_r}\right)^{0.11} \qquad U_h = 41.276\frac{m}{s}$$

$$U_h(h) := U_{100y}\left(\frac{h}{h_r}\right)^{0.11}$$



Graph D-1, Wind speed vs. height , 100-year return period

The graph above shows the relation between wind speed and height

Duration of 1 hour

1hour wind speeds at 58.3 meters above sea level (MSL) is given by:

U_h Hourly wind speed (m/s) at height h in meter

$$C := 5.73\cdot 10^{-2}\left(1 + 0.15\cdot\frac{s}{m}\cdot U_{100y}\right)^{0.5} \qquad C = 0.142$$

$$U_h := U_{100y}\left[1 + \left(C\cdot\ln\left(\frac{h_{58}}{h_r}\right)\right)\right] \qquad U_h = 42.483\,\frac{m}{s}$$

Duration shorter than 1 hour

Wind gusts have three-dimensional spatial scales related to their duration, e.g. 3 s gusts are coherent over shorter distances and therefore affect smaller structural elements than 15 s gust. Wind actions on different substructures are normally specified by a given averaging time for the wind speed and assuming full coherence over the entire substructure. Specific information about averaging time is given in Norsok N003 section 6.3.3 for static and in 6.3.4 for dynamic analysis.

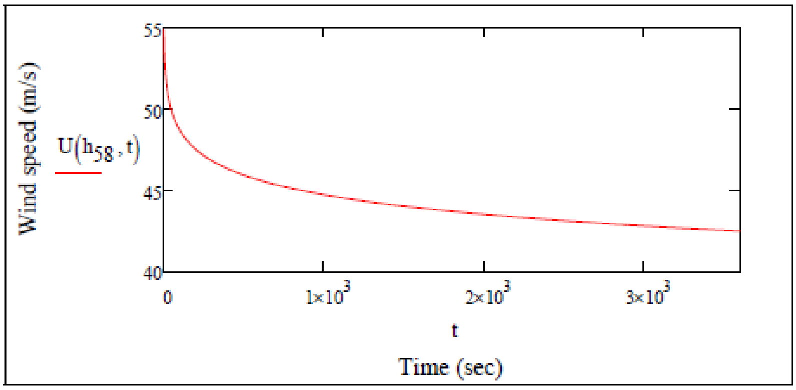
Wind speed for duration less than 1 hour at 58,3 m above (MSL) is given by:

$U_h = 42.483\,\frac{m}{s}$ Hourly mean wind speed ate height of 58.3m above (MSL)

$$I_u(h) := 0.06\left(1 + 0.043\cdot\frac{s}{m}\cdot U_{100y}\right)\cdot\left(\frac{h}{h_r}\right)^{-0.22} \qquad I_u(h_{58}) = 0.1$$

$$U(h,t) := U_h \cdot \left(1 - 0.41 \cdot I_u(h_{58}) \cdot \ln\left(\frac{t_{gust}}{t_0}\right)\right) \qquad U(h_{58}, t_{gust}) = 54.861 \frac{m}{s}$$

$$U(h,t) := U_h \cdot \left(1 - 0.41 \cdot I_u(h_{58}) \cdot \ln\left(\frac{t}{t_0}\right)\right)$$



Graph D-2, Wind speed vs. time 100-year return period

The graph above shows the relation between wind speed and time

Note

In case of structure or structural parts where the maximum length is greater than 50m, 15 second mean wind speed may be used when calculating static wind action. 3 second gust has been used and gives somewhat more conservative values. Ref.[10]

The wind mean action

The static wind action is calculated in accordance with NORSOK N-003, Ref.[10]. For extreme conditions, variation of the wind velocity as a function of the height and mean period is calculated by use of the formulas in NORSOK N003 Standard.
The wind load in global analysis will conservatively be based on a constant wind speed at the location 3/4 of the topside model height i.e. 58.3m
Structures or structural components that are not sensetive to wind gust may be calculated by considering the wind action as static.

In the case of structure or structural parts where the maximum dimension is less than approximately 50.m wind gest may be used when calculating static wind action but when the maximum length is greater than 50m, the mean period of wind may be increased to 15 seconds.

When design actions due to wind need to be combined with extreme actions due to waves and current, the mean wind speed over a 1 min period can be used. A longer averaging period may be used if properly documented.

The mean wind action,P, on a structural member or surface, acting normal to the member axes or surface, should be calculated by:

where

P pressure = N/mm^2

$\rho := 1.225 \frac{kg}{m^3}$ Mass density of air

$C_s := 1.0$ Shape coefficent

The shape coefficient are obtained from Ref.[17] which is set to 1,0 which should give a wind pressure:

$$P := \frac{\rho \cdot C_s \cdot U(h_{58}, t_{gust})^2}{2} \qquad P = 1.84 \cdot \frac{kN}{m^2}$$

WIND LOAD FOR TRANSPORATION

For a short term condition the wind may be described by means of an average wind velocity and a superimposed fluctuating wind gust with a mean value equal to zero, as well as a mean direction.

Unless a more detailed assessment is made, the average wind velocity at 10 m above sea level the characteristic value with an annual probability of exceedance of 10^{-2} can be chosen as 41m/s (10 min average) or 38 m/s (1 h average) for the whole continental shelf. The characteristic value with an annual probability of exceedance of 10^{-4} can be chosen as 48 m/s (10 min average) or 44 m/s (1 h average).

The characteristic wind velocity u(z,t)(m/s) at a height h(m) above sea level and corresponding averaging time period t less than or equal to t_0 = 3600 s may be calculated as:

$t := 3sec$ Duration of guest wind

$h_{30} := 30m$

U_h Hourly wind speed (m/s) at height h in meter

$$C := 5.73\cdot 10^{-2}\left(1 + 0.15\cdot\frac{s}{m}\cdot U_{1y}\right)^{0.5} \qquad C = 0.13$$

$$U_h := U_{1y}\cdot\left[1 + \left(C\cdot\ln\left(\frac{h_{30}}{h_r}\right)\right)\right] \qquad U_h = 29.03\frac{m}{s}$$

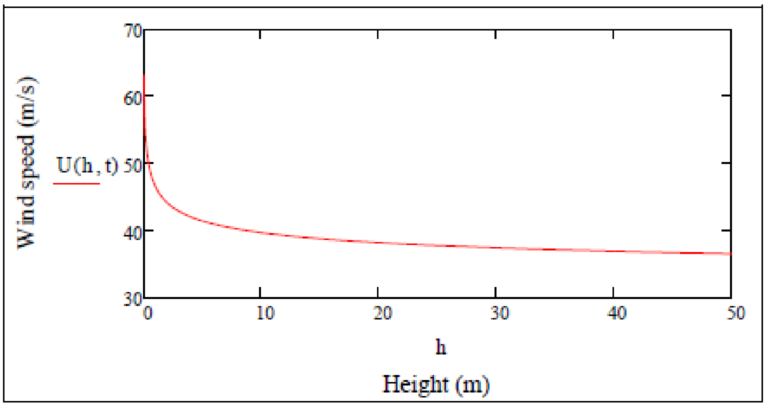
$U_h = 29.026\frac{m}{s}$ Hourly mean wind speed ate height of 30,0 m above (MSL)

$$I_u(h_{30}) := 0.06\left(1 + 0.043\cdot\frac{s}{m}\cdot U_{1y}\right)\cdot\left(\frac{h_{30}}{h_r}\right)^{-0.22} \qquad I_u(h_{30}) = 0.12$$

$$U(h,t) := U_h\cdot\left(1 - 0.41\cdot I_u(h_{30})\cdot\ln\left(\frac{t_{gust}}{t_0}\right)\right)$$

$$U(h_{30}, t_{gust}) = 37.4\frac{m}{s}$$

$$U(h,t) := U_h\cdot\left(1 - 0.41\cdot I_u(h)\cdot\ln\left(\frac{t}{t_0}\right)\right)$$



Graph D-3, Wind speed vs. time 1-year return period

$$P := \frac{\rho \cdot C_s \cdot U\left(h_{30}, t_{gust}\right)^2}{2}$$

$$P = 0.85 \cdot \frac{kN}{m^2}$$

BARGE ACCELERATION

Noble Denton default motion criteria

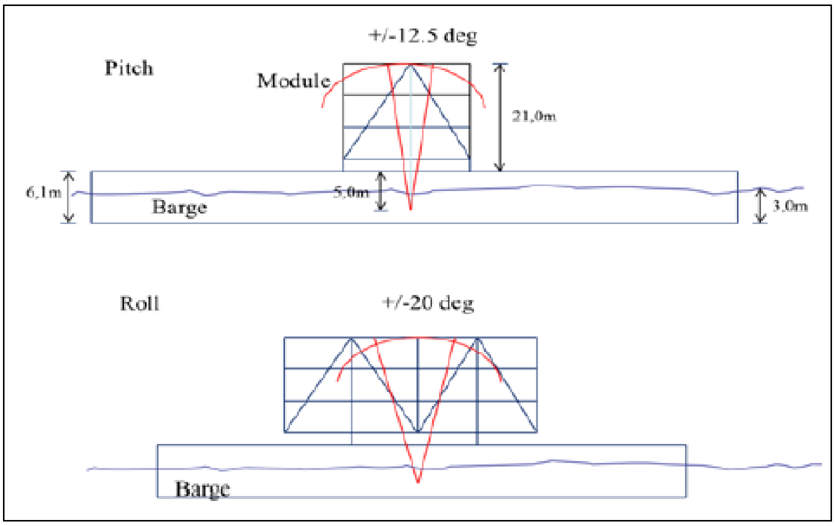


Figure D-22 Barge motion

Module to be transported on a standard North Sea barge.

Height:	$h_m := 21.0m$
Width:	$b_m := 20.0 \cdot m$
Length:	$l_m := 40.0 \cdot m$

Standard North Sea barge:

Length:	$L_b := 100m$
Width:	$B_b := 50 \cdot m$
Depth:	$D_b := 6.1m$
Draft:	$D_{b1} := 3.5m$

Radius from center of roll to top of module:

$$r := h_m + D_b - \frac{1}{2} \cdot D_{b1} \qquad r = 25.4\,m$$

Noble Denton "Guidelines for Marine Transportations", Section 7.9 - Default Motion Criteria:

Heave accelerations: $a_{heave} := 0.200 \cdot g$

Roll & Pitch accelerations are based on a full cycle period of 10 seconds.

Full cycle period for both roll & pitch: $P := 10 \cdot s$

Roll angles: +/- 20 degrees $\alpha_{roll} := 20 \cdot deg$

Pitch angles: +/- 12.5 degrees $\alpha_{pitch} := 12.5 \cdot deg$

Amplitude roll: $A_{roll} := 2 \cdot \pi \cdot r \cdot \frac{\alpha_{roll} \cdot 2}{360 \cdot deg}$ $A_{roll} = 17.698\,m$

Amplitude pitch: $A_{pitch} := 2 \cdot \pi \cdot r \cdot \frac{\alpha_{pitch} \cdot 2}{360 \cdot deg}$ $A_{pitch} = 11.061\,m$

$\omega := \frac{2 \cdot \pi}{P}$ $\omega = 0.628 \cdot s^{-1}$

Accelerations

Roll: $a_{roll} := \left| -A_{roll} \cdot \omega^2 \right| + g \cdot \sin(\alpha_{roll})$ $a_{roll} = 1.054 \cdot g$

Pitch: $a_{pitch} := \left| -A_{pitch} \cdot \omega^2 \right| + g \cdot \sin(\alpha_{pitch})$ $a_{pitch} = 0.662 \cdot g$

COG ENVELOPE

Input SESTRA listing

LOADCASE	X-LOAD	Y-LOAD	Z-LOAD	X-MOM	Y-MOM	Z-MOM	X-RMOM	Y-RMOM	Z-RMOM
397	1.46E-17	-1.19E-18	-1.73E+01	2.52E-01	0.00E+00	0.00E+00	-1.74E+02	3.46E+02	-1.69E-16
398	1.73E+01	0.00E+00	1.66E-10	-1.01E-03	-1.81E-04	3.89E-01	5.19E-10	1.61E+02	-1.74E+02
399	0.00E+00	1.73E+01	-2.30E-08	-3.31E-01	1.26E-22	-5.96E-19	-1.61E+02	4.32E-07	3.45E+02

Figure D-22 SESTRA output

CoG check

FROM SESTRA LISTING

		[KiloNewton]			[MegaNewton*Meter]			**CoG (Local Coord.)**				Weight (T)
		X-LOAD	Y-LOAD	Z-LOAD	X-RMOM	Y-RMOM	Z-RMOM	**X**	**Y**	**Z**		
Acceleratio	LoadCase											
-Z	397	0.0	0.0	17,300.0	174.0	346.0	0.0	20.001	10.060			1763.5
x	398	17,300.0	0.0	0.0	0.0	160.7	174.0		10.060	9.288		1763.5
y	399	0.0	17,300.0	0.0	160.7	0.0	345.1	19.947		9.288		1763.5

	Weight	x	y	
Length between support points		20.000	20.000	
Geometric middle		20.000	10.000	10.000
CoG, "as is" analysis	1,603.2	19.974	10.060	9.288
		Δx	Δy	
		0.026	0.060	
CoG shift = $((L_x+\Delta x)/L_x)*((L_y+\Delta y)/L_y)$			1.0043	
Original weight report	3451.8	299.290	155.460	525.210

From GeniE		Weight [ton]	Load [kN]	x-cog [m]	y-cog [m]	z-cog [m]	Check: Load	Check: x-cog	Check: y-cog	Check: z-cog
LC397	Self generated weight	1,763.51	1,763.5	20.001	10.060		**OK**	**OK**	**OK**	
LC398	Self generated weight	1,763.51	1,763.5		10.060	9.288	**OK**		**OK**	**OK**
LC399	Self generated weight	1,763.51	1,763.5	19.947		9.288	**OK**	**OK**		**OK**
						Max diff:	0.800 %	0.500 %	0.500 %	0.500 %

As of: **5/31/2012**

Figure D-23 CoG calculation

E. GLOBAL ANALYSIS

FRAMEWORK MEMBER CHECK RESULT

- Inplace condition
- Lift condition
- Transport condition

MEMBER ASSESMENT

- Inplace condition
- Lift condition
- Transport condition

FRAMEWORK MEMBER CHECK RESULT, INPLACE

```
  ******      ******      ******      ******     ** ***  ****
 ********    ********    ********    ********    *************
**      **  **      **  **      **  **      **   **    **    **
**          **      **  **                  **   **    **    **
 *******    **********   *******     *********   **    **    **
  *******   *********     *******   **********   **    **    **
        **  **                  **  **      **   **    **    **
**      **  **      **  **      **  **      **   **    **    **
 ********    ********    ********    *********   **    **    **
  ******      ******      ******      ****** **  **    **    **


*********************************************************************************************
*********************************************************************************************
**                                                                                         **
**                                                                                         **
**     *******  ******    *****   *     *  *******  *     *   *****   ******   *     *     **
**     *        *     *  *     *  **   **  *        *     *  *     *  *     *  *    *      **
**     *        *     *  *     *  * * * *  *        *     *  *     *  *     *  *   *       **
**     *****    ******   *******  *  *  *  *****    *  *  *  *     *  ******   ***         **
**     *        *   *    *     *  *     *  *        *  *  *  *     *  *   *    *  *        **
**     *        *    *   *     *  *     *  *        *  *  *  *     *  *    *   *   *       **
**     *        *     *  *     *  *     *  *******   ** **    *****   *     *  *     *     **
**                                                                                         **
**                                                                                         **
**                            Postprocessing of Frame Structures                           **
**                                                                                         **
**                                                                                         **
*********************************************************************************************
*********************************************************************************************
```

Marketing and Support by DNV Software

```
Program id   : 3.6-02                          Computer         : 586
Release date :  7-JUN-2011                     Impl. update     :
Access time  : 12-JUN-2012 09:17:05            Operating system : Win NT 6.1 [7601]
User id      : 123333                          CPU id           : 0476028815
                                               Installation     : , EURW120334
```

```
DATE: 12-JUN-2012 TIME: 09:17:05   PROGRAM: SESAM    FRAMEWORK 3.6-02   7-JUN-2011                 PAGE:
1

                                  MEMBER check: EC3/NS3472 ENV 1993-1-1/Ed 3
                                  Run:      Superelement:     Loadset:
                                  ULS       T197              INPLACE
                                  Priority....: Worst Loadcase
                                  Usage factor: Above   0.50                                        SUB PAGE:
1
```

NOMENCLATURE:

```
Member       Name of member
LoadCase     Name of loadcase
CND          Operational, storm or earthquake condition
Type         Section type
Joint/Po     Joint name or position within the member
Outcome      Outcome message from the code check
UsfTot       Total usage factor: UsfTot = UsfAx + UsfMy + UsfMz
UsfAx        Usage factor due to axial stress
N            Acting axial force
Ndy(Nkdy)    Axial (buckling) force capacity about y-axis
My*ky        Design bending moment used for bending about y-axis
Mdy          Moment capacity for bending about y-axis
Ky           Effective length factor for bending about y-axis
Ly           Buckling length for bending about y-axis
Phase        Phase angle in degrees
SctNam       Section name
EleNum       Element number
UsfMy        Usage factor due to bending about y-axis
Fy           Yield strength
Ndz(Nkdy)    Axial (buckling) force capacity about z-axis
Mz*kz        Design bending moment used for bending about z-axis
Mdz          Moment capacity for bending about z-axis
Kz           Effective length factor for bending about z-axis
Lz           Buckling length for bending about z-axis
UsfMz        Usage factor due to bending about z-axis
Gamma-m      Material factor, gamma-M1
vMises       Equivalent stress used in von Mises stress check
Lbuck        Length between lateral support of compression flange
C1           Lateral buckling factor
BCrv y,z     Buckling curve for bending about y,z-axes
Class w,f    Cross section class for web, flange
```

```
Member   LoadCase CND Type     Joint/Po Outcome  UsfTot   UsfAx      N     Ndy(Nkdy)   My*ky      Mdy        Ky         Ly
          Phase       SctNam   EleNum                     UsfMy      Fy    Ndz(Nkdy)   Mz*kz      Mdz        Kz         Lz
                                                          UsfMz   Gamma-m   vMises     Lbuck      C1      BCrv y,z  Class w,f
----------------------------------------------------------------------------------------------------------------------------
MY302020 543          I        0.50     *Fa StaL  1.024   0.027 -1.35E-01  1.76E+01 -3.22E+00  3.23E+00    1.000   1.00E+01
                      I1242035 229                        0.997  4.20E+02  4.97E+00  9.71E-05  1.06E+00    1.000   1.00E+01
                                                          0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 1

MY702020 543          I        0.50         StaL  0.994   0.027 -1.36E-01  1.76E+01 -3.12E+00  3.23E+00    1.000   1.00E+01
                      I1242035 371                        0.965  4.20E+02  4.97E+00 -1.02E-03  1.06E+00    1.000   1.00E+01
                                                          0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 1

MY301020 545          I        0.50         StaL  0.934   0.018 -8.77E-02  1.76E+01 -2.91E+00  3.23E+00    1.000   1.00E+01
                      I1242035 221                        0.902  4.20E+02  4.97E+00  1.53E-02  1.06E+00    1.000   1.00E+01
                                                          0.014     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 1

MY701020 546          I        0.50         StaL  0.925   0.015 -7.39E-02  1.76E+01 -2.87E+00  3.23E+00    1.000   1.00E+01
                      I1242035 363                        0.889  4.20E+02  4.97E+00 -2.27E-02  1.06E+00    1.000   1.00E+01
                                                          0.021     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 1

MY702010 543          I        0.50         StaL  0.885   0.073 -6.23E-01  2.01E+01 -3.84E+00  4.75E+00    1.000   1.00E+01
                      I1252035 369                        0.808  4.20E+02  8.50E+00 -3.34E-03  1.07E+00    1.000   1.00E+01
                                                          0.003     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 2

MY302010 543          I        0.50         StaL  0.883   0.078 -6.63E-01  2.01E+01 -3.82E+00  4.75E+00    1.000   1.00E+01
                      I1252035 227                        0.804  4.20E+02  8.50E+00  1.20E-03  1.07E+00    1.000   1.00E+01
                                                          0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 2

MY301010 545          I        0.50         StaL  0.782   0.061 -5.19E-01  2.01E+01 -3.19E+00  4.75E+00    1.000   1.00E+01
                      I1252035 219                        0.671  4.20E+02  8.50E+00  5.32E-02  1.07E+00    1.000   1.00E+01
                                                          0.050     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 2

MY701010 546          I        0.50         StaL  0.779   0.057 -4.85E-01  2.01E+01 -3.20E+00  4.75E+00    1.000   1.00E+01
                      I1252035 361                        0.674  4.20E+02  8.50E+00 -5.14E-02  1.07E+00    1.000   1.00E+01
                                                          0.048     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 2

MZ304010 544          BOX      0.50         Stab  0.665   0.274 -7.98E+00  2.91E+01 -2.18E+00  6.88E+00    1.000   6.70E+00
                      B060640  234                        0.316  4.20E+02  2.91E+01  5.11E-01  6.88E+00    1.000   6.70E+00
                                                          0.074     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MY302030 527          I        0.50         Lbck  0.661   0.000  1.24E-01  1.81E+01  2.23E+00  3.38E+00    1.000   1.00E+01
                      I0852035 231                        0.659  4.20E+02  1.81E+01 -3.50E-03  1.62E+00    1.000   1.00E+01
                                                          0.002     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MF104010 543          BOX      0.50         Stab  0.660   0.333 -2.39E+00  7.20E+00  3.41E-01  1.34E+00    1.000   7.49E+00
                      B040420  160                        0.255  3.55E+02  7.20E+00  9.70E-02  1.34E+00    1.000   7.49E+00
                                                          0.072     1.150  0.00E+00  7.49E+00    0.000   C , C    1 , 1

MF902520 543          BOX      0.50         Stab  0.660   0.272 -1.96E+00  7.20E+00  4.59E-01  1.34E+00    1.000   7.49E+00
                      B040420  450                        0.343  3.55E+02  7.20E+00  5.97E-02  1.34E+00    1.000   7.49E+00
                                                          0.045     1.150  0.00E+00  7.49E+00    0.000   C , C    1 , 1

MY302040 529          I        0.50         StaL  0.640   0.031 -2.50E-01  1.61E+01 -2.04E+00  3.38E+00    1.000   1.00E+01
                      I0852035 232                        0.602  4.20E+02  8.09E+00  1.11E-02  1.62E+00    1.000   1.00E+01
                                                          0.007     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MZ301010 545          BOX      0.50         Stab  0.637   0.253 -7.36E+00  2.91E+01  2.14E+00  6.88E+00    1.000   6.70E+00
                      B060640  216                        0.311  4.20E+02  2.91E+01  4.99E-01  6.88E+00    1.000   6.70E+00
                                                          0.072     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MY701030 531          I        0.33         StaL  0.624   0.001 -5.37E-03  1.61E+01 -2.11E+00  3.38E+00    1.000   1.00E+01
                      I0852035 365                        0.623  4.20E+02  8.09E+00 -5.68E-04  1.62E+00    1.000   1.00E+01
                                                          0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MX204010 542          I        0.50         StaL  0.618   0.141 -1.68E+00  1.85E+01 -2.43E+00  5.44E+00    1.000   5.00E+00
                      I1242035 208                        0.446  4.20E+02  1.19E+01  2.05E-02  6.83E-01    1.000   5.00E+00
                                                          0.030     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 1

MY702030 525          I        0.50         Lbck  0.613   0.000  1.21E-03  1.81E+01  2.07E+00  3.38E+00    1.000   1.00E+01
                      I0852035 373                        0.612  4.20E+02  1.81E+01 -2.13E-03  1.62E+00    1.000   1.00E+01
                                                          0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MZ704010 542          BOX      0.50         Stab  0.612   0.228 -6.64E+00  2.91E+01 -2.09E+00  6.88E+00    1.000   6.70E+00
                      B060640  376                        0.304  4.20E+02  2.91E+01 -5.48E-01  6.88E+00    1.000   6.70E+00
                                                          0.080     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MX201010 546          I        0.50         StaL  0.610   0.138 -1.64E+00  1.85E+01 -2.39E+00  5.44E+00    1.000   5.00E+00
                      I1242035 200                        0.439  4.20E+02  1.19E+01 -2.25E-02  6.83E-01    1.000   5.00E+00
                                                          0.033     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 1

MZ701010 546          BOX      0.50         Stab  0.609   0.230 -6.70E+00  2.91E+01  2.05E+00  6.88E+00    1.000   6.70E+00
                      B060640  358                        0.298  4.20E+02  2.91E+01 -5.57E-01  6.88E+00    1.000   6.70E+00
                                                          0.081     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MY301030 529          I        0.33         Lbck  0.607   0.000  4.89E-02  1.81E+01  2.05E+00  3.38E+00    1.000   1.00E+01
                      I0852035 223                        0.606  4.20E+02  1.81E+01  1.01E-03  1.62E+00    1.000   1.00E+01
                                                          0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MY102040 545          I        0.50         StaL  0.603   0.165 -3.45E-01  9.04E+00  2.80E-01  1.17E+00    1.000   1.00E+01
                      HE800B   158                        0.240  3.55E+02  2.09E+00  9.39E-02  4.76E-01    1.000   1.00E+01
                                                          0.197     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 1
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Member   LoadCase CND Type     Joint/Po Outcome  UsfTot   UsfAx      N      Ndy(Nkdy)   My*ky      Mdy        Ky         Ly
          Phase       SctNam   EleNum                     UsfMy      Fy     Ndz(Nkdy)   Mz*kz      Mdz        Kz         Lz
                                                          UsfMz   Gamma-m   vMises      Lbuck      C1      BCrv y,z  Class w,f
----------------------------------------------------------------------------------------------------------------------------
ME101320 546          BOX      0.50          Stab   0.583   0.280 -2.01E+00  7.20E+00  2.89E-01  1.34E+00    1.000   7.49E+00
                      B040420  141                          0.216  3.55E+02  7.20E+00  1.17E-01  1.34E+00    1.000   7.49E+00
                                                            0.088     1.150  0.00E+00  7.49E+00    0.000   C , C    1 , 1

MY301040 529          I        0.50          StaL   0.576   0.013 -1.09E-01  1.61E+01  1.89E+00  3.38E+00    1.000   1.00E+01
                      I0852035 226                          0.560  4.20E+02  8.09E+00  4.61E-03  1.62E+00    1.000   1.00E+01
                                                            0.003     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MX604010 541          I        0.50          StaL   0.569   0.087 -1.03E+00  1.85E+01 -2.46E+00  5.44E+00    1.000   5.00E+00
                      I1242035 350                          0.452  4.20E+02  1.19E+01  2.06E-02  6.83E-01    1.000   5.00E+00
                                                            0.030     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 1

MX601010 541          I        0.50          StaL   0.565   0.084 -9.99E-01  1.85E+01 -2.44E+00  5.44E+00    1.000   5.00E+00
                      I1242035 342                          0.449  4.20E+02  1.19E+01  2.22E-02  6.83E-01    1.000   5.00E+00
                                                            0.032     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 1

MX704010 544          I        0.50          StaL   0.564   0.125 -1.49E+00  1.85E+01 -2.21E+00  5.44E+00    1.000   5.00E+00
                      I1242035 391                          0.405  4.20E+02  1.19E+01  2.29E-02  6.83E-01    1.000   5.00E+00
                                                            0.034     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 1

MX701010 545          I        0.50          StaL   0.562   0.123 -1.47E+00  1.85E+01 -2.20E+00  5.44E+00    1.000   5.00E+00
                      I1242035 383                          0.404  4.20E+02  1.19E+01 -2.42E-02  6.83E-01    1.000   5.00E+00
                                                            0.035     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 1

ME901010 545          BOX      0.50          Stab   0.561   0.204 -1.46E+00  7.20E+00  3.89E-01  1.34E+00    1.000   7.49E+00
                      B040420  432                          0.291  3.55E+02  7.20E+00  8.92E-02  1.34E+00    1.000   7.49E+00
                                                            0.067     1.150  0.00E+00  7.49E+00    0.000   C , C    1 , 1

MX602010 521          I        0.50          StaL   0.560   0.028 -1.56E-01  1.01E+01 -1.10E+00  2.07E+00    1.000   5.00E+00
                      HE800B   345                          0.532  3.55E+02  5.62E+00 -6.02E-05  4.76E-01    1.000   5.00E+00
                                                            0.000     1.150  0.00E+00  5.00E+00    1.000   C , C    1 , 1

MY102010 501          I        0.50          Lbck   0.557   0.000  4.56E-01  1.01E+01  5.71E-01  1.17E+00    1.000   1.00E+01
                      HE800B   157                          0.488  3.55E+02  1.01E+01 -3.26E-02  4.76E-01    1.000   1.00E+01
                                                            0.068     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 1

MY101010 501          I        0.50          Lbck   0.552   0.000  4.83E-01  1.01E+01  5.66E-01  1.17E+00    1.000   1.00E+01
                      HE800B   146                          0.484  3.55E+02  1.01E+01 -3.24E-02  4.76E-01    1.000   1.00E+01
                                                            0.068     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 1

MY502020 527          I        0.50          StaL   0.547   0.006 -4.85E-02  2.01E+01  2.70E+00  5.01E+00    1.000   1.00E+01
                      I1252035 300                          0.539  4.20E+02  8.50E+00  3.50E-03  1.64E+00    1.000   1.00E+01
                                                            0.002     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 2

MX702010 525          I        0.50          StaL   0.547   0.008 -4.35E-02  1.01E+01 -1.11E+00  2.07E+00    1.000   5.00E+00
                      HE800B   386                          0.535  3.55E+02  5.62E+00  1.88E-03  4.76E-01    1.000   5.00E+00
                                                            0.004     1.150  0.00E+00  5.00E+00    1.000   C , C    1 , 1

MY501020 529          I        0.50          StaL   0.544   0.002 -1.80E-02  2.01E+01  2.70E+00  5.01E+00    1.000   1.00E+01
                      I1252035 292                          0.539  4.20E+02  8.50E+00  3.69E-03  1.64E+00    1.000   1.00E+01
                                                            0.002     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 2

MZ504010 544          BOX      0.50          Stab   0.542   0.084 -1.33E+00  1.60E+01 -1.05E+00  2.85E+00    1.000   6.70E+00
                      B040440  304                          0.370  4.20E+02  1.60E+01 -2.54E-01  2.85E+00    1.000   6.70E+00
                                                            0.089     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MZ501010 545          BOX      0.50          Stab   0.536   0.081 -1.30E+00  1.60E+01  1.05E+00  2.85E+00    1.000   6.70E+00
                      B040440  287                          0.367  4.20E+02  1.60E+01 -2.50E-01  2.85E+00    1.000   6.70E+00
                                                            0.088     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MF102530 543          BOX      0.50          Stab   0.533   0.192 -1.39E+00  7.25E+00  1.73E-01  1.34E+00    1.000   7.38E+00
                      B040420  154                          0.129  3.55E+02  7.25E+00  2.83E-01  1.34E+00    1.000   7.38E+00
                                                            0.211     1.150  0.00E+00  7.38E+00    0.000   C , C    1 , 1

MX304010 544          I        0.50          StaL   0.520   0.094 -1.12E+00  1.85E+01 -2.14E+00  5.44E+00    1.000   5.00E+00
                      I1242035 249                          0.393  4.20E+02  1.19E+01  2.25E-02  6.83E-01    1.000   5.00E+00
                                                            0.033     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 1

MY102020 543          I        0.50          StaL   0.516   0.037 -1.47E-01  9.74E+00 -7.94E-01  1.69E+00    1.000   6.65E+00
                      HE800B   155                          0.471  3.55E+02  3.97E+00  4.11E-03  4.76E-01    1.000   6.65E+00
                                                            0.009     1.150  0.00E+00  6.65E+00    1.000   C , C    1 , 1

MX301010 545          I        0.50          StaL   0.514   0.094 -1.12E+00  1.85E+01 -2.10E+00  5.44E+00    1.000   5.00E+00
                      I1242035 241                          0.386  4.20E+02  1.19E+01 -2.29E-02  6.83E-01    1.000   5.00E+00
                                                            0.033     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 1

MX604020 541          I        0.50          StaL   0.508   0.013 -7.34E-02  1.01E+01 -9.95E-01  2.07E+00    1.000   5.00E+00
                      HE800B   351                          0.482  3.55E+02  5.62E+00  6.22E-03  4.76E-01    1.000   5.00E+00
                                                            0.013     1.150  0.00E+00  5.00E+00    1.000   C , C    1 , 1

MX601020 541          I        0.50          StaL   0.505   0.013 -7.19E-02  1.01E+01 -9.93E-01  2.07E+00    1.000   5.00E+00
                      HE800B   343                          0.480  3.55E+02  5.62E+00 -5.47E-03  4.76E-01    1.000   5.00E+00
                                                            0.012     1.150  0.00E+00  5.00E+00    1.000   C , C    1 , 1

MX302010 529          I        0.50          StaL   0.502   0.029 -1.63E-01  1.01E+01 -9.75E-01  2.07E+00    1.000   5.00E+00
                      HE800B   244                          0.472  3.55E+02  5.62E+00 -7.00E-04  4.76E-01    1.000   5.00E+00
                                                            0.001     1.150  0.00E+00  5.00E+00    1.000   C , C    1 , 1
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FRAMEWORK MEMBER CHECK LIFT MEMBERS

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**                                                                                         **
**                                                                                         **
**                           Postprocessing of Frame Structures                            **
**                                                                                         **
**                                                                                         **
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                         Marketing and Support by DNV Software


   Program id   : 3.6-02                                  Computer         : 586
   Release date :  7-JUN-2011                             Impl. update     :
   Access time  : 12-JUN-2012 09:22:13                    Operating system : Win NT 6.1 [7601]
   User id      : 123333                                  CPU id           : 0476028815
                                                          Installation     : , EURW120334
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DATE: 12-JUN-2012 TIME: 09:22:13   PROGRAM: SESAM    FRAMEWORK 3.6-02   7-JUN-2011                PAGE:
1

                                    MEMBER check: EC3/NS3472 ENV 1993-1-1/Ed 3
                                    Run:      Superelement:     Loadset:
                                    LIFT_1    T201              LIFT
                                    Priority....: Worst Loadcase
                                    Usage factor: Above   0.05                                      SUB PAGE:


 NOMENCLATURE:

 Member       Name of member
 LoadCase     Name of loadcase
 CND          Operational, storm or earthquake condition
 Type         Section type
 Joint/Po     Joint name or position within the member
 Outcome      Outcome message from the code check
 UsfTot       Total usage factor: UsfTot = UsfAx + UsfMy + UsfMz
 UsfAx        Usage factor due to axial stress
 N            Acting axial force
 Ndy(Nkdy)    Axial (buckling) force capacity about y-axis
 My*ky        Design bending moment used for bending about y-axis
 Mdy          Moment capacity for bending about y-axis
 Ky           Effective length factor for bending about y-axis
 Ly           Buckling length for bending about y-axis
 Phase        Phase angle in degrees
 SctNam       Section name
 EleNum       Element number
 UsfMy        Usage factor due to bending about y-axis
 Fy           Yield strength
 Ndz(Nkdy)    Axial (buckling) force capacity about z-axis
 Mz*kz        Design bending moment used for bending about z-axis
 Mdz          Moment capacity for bending about z-axis
 Kz           Effective length factor for bending about z-axis
 Lz           Buckling length for bending about z-axis
 UsfMz        Usage factor due to bending about z-axis
 Gamma-m      Material factor, gamma-M1
 vMises       Equivalent stress used in von Mises stress check
 Lbuck        Length between lateral support of compression flange
 C1           Lateral buckling factor
 BCrv y,z     Buckling curve for bending about y,z-axes
 Class w,f    Cross section class for web, flange
DATE: 12-JUN-2012 TIME: 09:22:13   PROGRAM: SESAM    FRAMEWORK 3.6-02   7-JUN-2011                PAGE:
                                    MEMBER check: EC3/NS3472 ENV 1993-1-1/Ed 3
                                    Run:      Superelement:     Loadset:
                                    LIFT_1    T201              LIFT
                                    Priority....: Worst Loadcase
                                    Usage factor: Above   0.05                                      SUB PAGE:
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Member   LoadCase CND Type     Joint/Po Outcome  UsfTot   UsfAx      N      Ndy(Nkdy)   My*ky       Mdy        Ky          Ly
           Phase        SctNam   EleNum                     UsfMy      Fy     Ndz(Nkdy)   Mz*kz       Mdz        Kz          Lz
                                                            UsfMz   Gamma-m    vMises     Lbuck       C1     BCrv y,z  Class w,f
-------------------------------------------------------------------------------------------------------------------------------
 MY302030 1             I        0.45    *Fa Lbck   1.014   0.000  8.07E-02  1.81E+01  3.43E+00  3.38E+00    1.000   1.00E+01
                        I0852035 3644                       1.014  4.20E+02  1.81E+01 -4.54E-04  1.62E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

 MY301030 1             I        0.45        Lbck   0.914   0.000  6.72E-02  1.81E+01  3.09E+00  3.38E+00    1.000   1.00E+01
                        I0852035 3601                       0.914  4.20E+02  1.81E+01 -1.10E-03  1.62E+00    1.000   1.00E+01
                                                            0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

 MY501020 1             I        0.45        StaL   0.909   0.119 -1.01E+00  2.01E+01  3.75E+00  4.75E+00    1.000   1.00E+01
                        I1252035 3901                       0.789  4.20E+02  8.50E+00 -5.78E-05  1.07E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 2

 MY701030 1             I        0.45        Lbck   0.887   0.000  9.11E-02  1.81E+01  3.00E+00  3.38E+00    1.000   1.00E+01
                        I0852035 4222                       0.887  4.20E+02  1.81E+01  5.44E-04  1.62E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

 MY702030 1             I        0.45        Lbck   0.863   0.000  1.08E-01  1.81E+01  2.92E+00  3.38E+00    1.000   1.00E+01
                        I0852035 4265                       0.862  4.20E+02  1.81E+01  5.25E-04  1.62E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

 MY302040 1             I        0.50        StaL   0.845   0.248 -2.00E+00  1.61E+01 -1.84E+00  3.20E+00    1.000   1.00E+01
                        I0852035 3655                       0.575  4.20E+02  8.09E+00  2.42E-02  1.07E+00    1.000   1.00E+01
                                                            0.023     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 2

 MY301040 1             I        0.50        StaL   0.810   0.214 -1.73E+00  1.61E+01 -1.83E+00  3.20E+00    1.000   1.00E+01
                        I0852035 3612                       0.572  4.20E+02  8.09E+00  2.53E-02  1.07E+00    1.000   1.00E+01
                                                            0.024     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 2

 MY702040 1             I        0.50        StaL   0.800   0.246 -1.99E+00  1.61E+01  1.83E+00  3.38E+00    1.000   1.00E+01
                        I0852035 4276                       0.540  4.20E+02  8.09E+00 -2.22E-02  1.62E+00    1.000   1.00E+01
                                                            0.014     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 2

 MY701010 1             I        0.50        Lbck   0.788   0.000  6.79E-01  2.10E+01  3.95E+00  5.01E+00    1.000   1.00E+01
                        I1252035 4200                       0.787  4.20E+02  2.10E+01  1.77E-03  1.64E+00    1.000   1.00E+01
                                                            0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 2

 MY701040 1             I        0.50        StaL   0.767   0.212 -1.71E+00  1.61E+01  1.83E+00  3.38E+00    1.000   1.00E+01
                        I0852035 4233                       0.540  4.20E+02  8.09E+00 -2.40E-02  1.62E+00    1.000   1.00E+01
                                                            0.015     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

 MY502020 1             I        0.45        StaL   0.766   0.014 -1.21E-01  2.01E+01  3.77E+00  5.01E+00    1.000   1.00E+01
                        I1252035 3943                       0.751  4.20E+02  8.50E+00 -2.14E-04  1.64E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 2

 MX402010 1             I        0.40        StaL   0.765   0.031 -1.71E-01  9.42E+00 -1.35E+00  1.90E+00    1.000   5.00E+00
                        HE800B   3838                       0.713  3.55E+02  5.44E+00  6.13E-03  3.06E-01    1.000   5.00E+00
                                                            0.020     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1

 MY501030 1             I        0.45        Lbck   0.757   0.000  9.72E-03  1.81E+01  2.56E+00  3.38E+00    1.000   1.00E+01
                        I0852035 3912                       0.757  4.20E+02  1.81E+01 -3.65E-04  1.62E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

 MY502030 1             I        0.45        Lbck   0.757   0.000  1.03E-02  1.81E+01  2.56E+00  3.38E+00    1.000   1.00E+01
                        I0852035 3954                       0.757  4.20E+02  1.81E+01  2.79E-04  1.62E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

 MY702010 1             I        0.50        Lbck   0.745   0.000  1.25E+00  2.10E+01  3.73E+00  5.01E+00    1.000   1.00E+01
                        I1252035 4243                       0.745  4.20E+02  2.10E+01 -3.85E-04  1.64E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

 MF302020 1             BOX      0.50        Stab   0.702   0.509 -2.54E+00  4.99E+00 -2.58E-01  1.34E+00    1.000   1.20E+01
                        B040420  3627                       0.193  3.55E+02  4.99E+00  9.89E-19  1.34E+00    1.000   1.20E+01
                                                            0.000     1.150  0.00E+00  1.20E+01    0.000   C , C    1 , 1

 MX502010 1             I        0.40        StaL   0.701   0.034 -1.90E-01  1.01E+01 -1.35E+00  2.07E+00    1.000   5.00E+00
                        HE800B   4000                       0.655  3.55E+02  5.62E+00  6.09E-03  4.76E-01    1.000   5.00E+00
                                                            0.013     1.150  0.00E+00  5.00E+00    1.000   C , C    1 , 1

 MY102010 1             I        0.50        Lbck   0.690   0.000  4.95E-01  1.01E+01  7.64E-01  1.17E+00    1.000   1.00E+01
                        HE800B   3334                       0.653  3.55E+02  1.01E+01  1.75E-02  4.76E-01    1.000   1.00E+01
                                                            0.037     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 1

 MY101010 1             I        0.50        Lbck   0.685   0.000  4.92E-01  1.01E+01  7.65E-01  1.17E+00    1.000   1.00E+01
                        HE800B   3293                       0.654  3.55E+02  1.01E+01  1.50E-02  4.76E-01    1.000   1.00E+01
                                                            0.032     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 1

 MY301010 1             I        0.50        Lbck   0.684   0.000  8.03E-01  2.10E+01  3.42E+00  5.01E+00    1.000   1.00E+01
                        I1252035 3579                       0.683  4.20E+02  2.10E+01 -1.21E-03  1.64E+00    1.000   1.00E+01
                                                            0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 2

 MF702020 1             BOX      0.50        Stab   0.672   0.456 -2.27E+00  4.99E+00 -2.89E-01  1.34E+00    1.000   1.20E+01
                        B040420  4248                       0.216  3.55E+02  4.99E+00  3.32E-18  1.34E+00    1.000   1.20E+01
                                                            0.000     1.150  0.00E+00  1.20E+01    0.000   C , C    1 , 1

 MX702010 1             I        0.40        StaL   0.656   0.091 -4.94E-01  9.42E+00  1.07E+00  1.90E+00    1.000   5.00E+00
                        HE800B   4313                       0.564  3.55E+02  5.44E+00  3.91E-04  3.06E-01    1.000   5.00E+00
                                                            0.001     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1
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```
Member   LoadCase CND Type     Joint/Po Outcome  UsfTot   UsfAx      N      Ndy(Nkdy)   My*ky      Mdy        Ky         Ly
          Phase       SctNam   EleNum                      UsfMy     Fy      Ndz(Nkdy)   Mz*kz      Mdz        Kz         Lz
                                                           UsfMz   Gamma-m   vMises      Lbuck      C1      BCrv y,z  Class w,f
-----------------------------------------------------------------------------------------------------------------------------
MX302020 1            I        0.40        StaL   0.642     0.010 -1.50E-01  1.80E+01 -3.06E+00  4.89E+00    1.000   5.00E+00
                      I0852035 3697                         0.626  4.20E+02  1.44E+01  9.99E-03  1.62E+00    1.000   5.00E+00
                                                            0.006     1.150  0.00E+00  5.00E+00    1.000   C , C    1 , 2

MY302010 1            I        0.50        Lbck   0.641     0.000  1.37E+00  2.10E+01  3.21E+00  5.01E+00    1.000   1.00E+01
                      I1252035 3622                         0.641  4.20E+02  2.10E+01  4.08E-04  1.64E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MX202020 1            I        0.40        StaL   0.638     0.008 -1.13E-01  1.80E+01 -3.05E+00  4.89E+00    1.000   5.00E+00
                      I0852035 3530                         0.625  4.20E+02  1.44E+01  8.87E-03  1.62E+00    1.000   5.00E+00
                                                            0.005     1.150  0.00E+00  5.00E+00    1.000   C , C    1 , 2

MZ501010 1            BOX      0.50        Stab   0.633     0.226 -3.60E+00  1.60E+01  1.14E+00  2.85E+00    1.000   6.70E+00
                      B040440  3882                         0.399  4.20E+02  1.60E+01  2.12E-02  2.85E+00    1.000   6.70E+00
                                                            0.007     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MY902010 1            I        0.50        Lbck   0.625     0.000  6.21E-01  1.81E+01  1.96E+00  3.38E+00    1.000   1.00E+01
                      I0852035 4548                         0.578  4.20E+02  1.81E+01 -7.64E-02  1.62E+00    1.000   1.00E+01
                                                            0.047     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MY901010 1            I        0.50        Lbck   0.624     0.000  6.30E-01  1.81E+01  1.95E+00  3.38E+00    1.000   1.00E+01
                      I0852035 4511                         0.578  4.20E+02  1.81E+01 -7.51E-02  1.62E+00    1.000   1.00E+01
                                                            0.046     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MY701020 1            I        0.45        StaL   0.622     0.070 -3.49E-01  1.76E+01 -1.69E+00  3.10E+00    1.000   1.00E+01
                      I1242035 4211                         0.545  4.20E+02  4.97E+00 -4.38E-03  6.83E-01    1.000   1.00E+01
                                                            0.006     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 1

MZ504010 1            BOX      0.50        Stab   0.620     0.150 -2.39E+00  1.60E+01 -1.32E+00  2.85E+00    1.000   6.70E+00
                      B040440  3970                         0.462  4.20E+02  1.60E+01  2.20E-02  2.85E+00    1.000   6.70E+00
                                                            0.008     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MY501040 1            I        0.50        StaL   0.603     0.088 -7.13E-01  1.61E+01  1.74E+00  3.38E+00    1.000   1.00E+01
                      I0852035 3923                         0.515  4.20E+02  8.09E+00  5.52E-05  1.62E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MY301020 1            I        0.45        StaL   0.603     0.071 -3.53E-01  1.76E+01 -1.63E+00  3.10E+00    1.000   1.00E+01
                      I1242035 3590                         0.525  4.20E+02  4.97E+00  4.31E-03  6.83E-01    1.000   1.00E+01
                                                            0.006     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 1

MX601040 1            I        0.40        StaL   0.596     0.216 -3.10E+00  1.80E+01 -1.28E+00  4.47E+00    1.000   5.00E+00
                      I0852035 4141                         0.287  4.20E+02  1.44E+01 -9.89E-02  1.07E+00    1.000   5.00E+00

MZ504020 1            BOX      0.50        Stab   0.594     0.103 -1.65E+00  1.60E+01  1.39E+00  2.85E+00    1.000   6.70E+00
                      B040440  3971                         0.487  4.20E+02  1.60E+01 -9.17E-03  2.85E+00    1.000   6.70E+00
                                                            0.003     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MY502040 1            I        0.50        StaL   0.591     0.076 -6.17E-01  1.61E+01  1.74E+00  3.38E+00    1.000   1.00E+01
                      I0852035 3965                         0.515  4.20E+02  8.09E+00 -5.52E-05  1.62E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MX301040 1            I        0.40        StaL   0.581     0.212 -3.04E+00  1.80E+01 -1.25E+00  4.47E+00    1.000   5.00E+00
                      I0852035 3687                         0.280  4.20E+02  1.44E+01 -9.56E-02  1.07E+00    1.000   5.00E+00
                                                            0.090     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 2

MZ501020 1            BOX      0.50        Stab   0.578     0.099 -1.57E+00  1.60E+01 -1.36E+00  2.85E+00    1.000   6.70E+00
                      B040440  3883                         0.477  4.20E+02  1.60E+01 -5.95E-03  2.85E+00    1.000   6.70E+00
                                                            0.002     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MX602010 1            I        0.40        StaL   0.565     0.099 -5.40E-01  9.42E+00 -8.80E-01  1.90E+00    1.000   5.00E+00
                      HE800B   4146                         0.464  3.55E+02  5.44E+00 -5.05E-04  3.06E-01    1.000   5.00E+00
                                                            0.002     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1

MY401030 1            I        0.45        Lbck   0.558     0.000  2.48E-02  1.81E+01  1.89E+00  3.38E+00    1.000   1.00E+01
                      I0852035 3759                         0.557  4.20E+02  1.81E+01  9.32E-04  1.62E+00    1.000   1.00E+01
                                                            0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MY402030 1            I        0.45        Lbck   0.548     0.000  2.69E-02  1.81E+01  1.85E+00  3.38E+00    1.000   1.00E+01
                      I0852035 3801                         0.547  4.20E+02  1.81E+01 -5.55E-04  1.62E+00    1.000   1.00E+01
                                                            0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MY801010 1            I        0.50        Lbck   0.541     0.000  4.14E-01  1.81E+01  1.82E+00  3.38E+00    1.000   1.00E+01
                      I0852035 4359                         0.539  4.20E+02  1.81E+01  3.36E-03  1.62E+00    1.000   1.00E+01
                                                            0.002     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MY302020 1            I        0.45        Lbck   0.539     0.000  3.10E-02  1.85E+01  1.74E+00  3.23E+00    1.000   1.00E+01
                      I1242035 3633                         0.538  4.20E+02  1.85E+01 -1.37E-03  1.06E+00    1.000   1.00E+01
                                                            0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 1

MY702020 1            I        0.45        StaL   0.536     0.007 -3.58E-02  1.76E+01 -1.70E+00  3.23E+00    1.000   1.00E+01
                      I1242035 4254                         0.528  4.20E+02  4.97E+00  1.16E-03  1.06E+00    1.000   1.00E+01
                                                            0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 1

MX802010 1            I        0.40        StaL   0.534     0.017 -9.63E-02  1.01E+01  1.07E+00  2.07E+00    1.000   5.00E+00
                      HE800B   4458                         0.517  3.55E+02  5.62E+00 -1.44E-04  4.76E-01    1.000   5.00E+00
                                                            0.000     1.150  0.00E+00  5.00E+00    1.000   C , C    1 , 1
```

```
Member   LoadCase CND Type     Joint/Po Outcome  UsfTot   UsfAx      N      Ndy(Nkdy)   My*ky      Mdy        Ky         Ly
          Phase       SctNam   EleNum                      UsfMy     Fy     Ndz(Nkdy)   Mz*kz      Mdz        Kz         Lz
                                                           UsfMz  Gamma-m  vMises      Lbuck      C1     BCrv y,z  Class w,f
 ---------------------------------------------------------------------------------------------------------------------------
 MY802010 1           I        0.50        Lbck   0.531   0.000  3.96E-01  1.81E+01  1.79E+00  3.38E+00    1.000   1.00E+01
                      I0852035 4401                       0.529  4.20E+02  1.81E+01  3.29E-03  1.62E+00    1.000   1.00E+01
                                                          0.002     1.150  0.00E+00  1.00E+01     1.000   C , C    1 , 2

 MX402040 1           I        0.40        StaL   0.530   0.308 -1.48E+00  7.89E+00  2.78E-01  1.25E+00    1.000   5.00E+00
                      HE600B   3854                       0.222  3.55E+02  4.81E+00 -1.26E-04  2.78E-01    1.000   5.00E+00
                                                          0.000     1.150  0.00E+00  5.00E+00     1.000   C , C    3 , 1

 MX502040 1           I        0.40        StaL   0.526   0.308 -1.48E+00  7.89E+00  2.73E-01  1.25E+00    1.000   5.00E+00
                      HE600B   4016                       0.217  3.55E+02  4.81E+00 -1.62E-04  2.78E-01    1.000   5.00E+00
                                                          0.001     1.150  0.00E+00  5.00E+00     1.000   C , C    3 , 1

 MY402020 1           I        0.45        StaL   0.524   0.025 -2.01E-01  1.61E+01  1.68E+00  3.38E+00    1.000   1.00E+01
                      I0852035 3790                       0.497  4.20E+02  8.09E+00 -3.05E-03  1.62E+00    1.000   1.00E+01
                                                          0.002     1.150  0.00E+00  1.00E+01     1.000   C , C    1 , 2

 MX602020 1           I        0.40        StaL   0.520   0.008 -1.08E-01  1.80E+01 -2.47E+00  4.89E+00    1.000   5.00E+00
                      I0852035 4151                       0.506  4.20E+02  1.44E+01  1.09E-02  1.62E+00    1.000   5.00E+00
                                                          0.007     1.150  0.00E+00  5.00E+00     1.000   C , C    1 , 2

 MY601040 1           I        0.50        StaL   0.516   0.129 -1.05E+00  1.61E+01  1.29E+00  3.38E+00    1.000   1.00E+01
                      I0852035 4075                       0.382  4.20E+02  8.09E+00  7.96E-03  1.62E+00    1.000   1.00E+01
                                                          0.005     1.150  0.00E+00  1.00E+01     1.000   C , C    1 , 2

 MX702020 1           I        0.40        StaL   0.514   0.002 -3.33E-02  1.80E+01 -2.47E+00  4.89E+00    1.000   5.00E+00
                      I0852035 4318                       0.505  4.20E+02  1.44E+01  9.78E-03  1.62E+00    1.000   5.00E+00
                                                          0.006     1.150  0.00E+00  5.00E+00     1.000   C , C    1 , 2

 MY401040 1           I        0.50        StaL   0.513   0.128 -1.04E+00  1.61E+01  1.28E+00  3.38E+00    1.000   1.00E+01
                      I0852035 3770                       0.379  4.20E+02  8.09E+00 -7.89E-03  1.62E+00    1.000   1.00E+01
                                                          0.005     1.150  0.00E+00  1.00E+01     1.000   C , C    1 , 2

 MY601030 1           I        0.45        Lbck   0.508   0.000  2.77E-02  1.81E+01  1.72E+00  3.38E+00    1.000   1.00E+01
                      I0852035 4064                       0.508  4.20E+02  1.81E+01 -8.36E-04  1.62E+00    1.000   1.00E+01
                                                          0.001     1.150  0.00E+00  1.00E+01     1.000   C , C    1 , 2
```

FRAMEWORK MEMBERCHECK LIFT SINGLE CRITICAL MEMBER

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  ******      ******      ******      ******     ** ***  ****
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**      **  **      **  **      **  **      **   **    **    **
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**                                                                                          **
**                                                                                          **
**                         Postprocessing of Frame Structures                               **
**                                                                                          **
**                                                                                          **
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Marketing and Support by DNV Software

```
Program id   : 3.6-02                                  Computer         : 586
Release date :  7-JUN-2011                             Impl. update     :
Access time  : 12-JUN-2012 09:22:14                    Operating system : Win NT 6.1 [7601]
User id      : 123333                                  CPU id           : 0476028815
                                                       Installation     : , EURW120334
```


DATE: 12-JUN-2012 TIME: 09:22:14   PROGRAM: SESAM   FRAMEWORK 3.6-02   7-JUN-2011   PAGE:

```
MEMBER check: EC3/NS3472 ENV 1993-1-1/Ed 3
Run:      Superelement:     Loadset:
LIFT_2    T201              LIFT
Priority....: Worst Loadcase
Usage factor: Above   0.05                                      SUB PAGE:
```

NOMENCLATURE:

```
Member       Name of member
LoadCase     Name of loadcase
CND          Operational, storm or earthquake condition
Type         Section type
Joint/Po     Joint name or position within the member
Outcome      Outcome message from the code check
UsfTot       Total usage factor: UsfTot = UsfAx + UsfMy + UsfMz
UsfAx        Usage factor due to axial stress
N            Acting axial force
Ndy(Nkdy)    Axial (buckling) force capacity about y-axis
My*ky        Design bending moment used for bending about y-axis
Mdy          Moment capacity for bending about y-axis
Ky           Effective length factor for bending about y-axis
Ly           Buckling length for bending about y-axis
Phase        Phase angle in degrees
SctNam       Section name
EleNum       Element number
UsfMy        Usage factor due to bending about y-axis
Fy           Yield strength
Ndz(Nkdy)    Axial (buckling) force capacity about z-axis
Mz*kz        Design bending moment used for bending about z-axis
Mdz          Moment capacity for bending about z-axis
Kz           Effective length factor for bending about z-axis
Lz           Buckling length for bending about z-axis
UsfMz        Usage factor due to bending about z-axis
Gamma-m      Material factor, gamma-M1
vMises       Equivalent stress used in von Mises stress check
Lbuck        Length between lateral support of compression flange
C1           Lateral buckling factor
BCrv y,z     Buckling curve for bending about y,z-axes
Class w,f    Cross section class for web, flange
```

```
MEMBER check: EC3/NS3472 ENV 1993-1-1/Ed 3
Run:      Superelement:     Loadset:
LIFT_2    T201              LIFT
Priority....: Worst Loadcase
Usage factor: Above   0.05
```

Member	LoadCase	CND	Type	Joint/Po	Outcome	UsfTot	UsfAx	N	Ndy(Nkdy)	My*ky	Mdy	Ky	Ly
	Phase		SctNam	EleNum			UsfMy	Fy	Ndz(Nkdy)	Mz*kz	Mdz	Kz	Lz
							UsfMz	Gamma-m	vMises	Lbuck	C1	BCrv y,z	Class w,f
MX601040	2		I	0.40	StaL	0.676	0.244	-3.50E+00	1.80E+01	-1.45E+00	4.47E+00	1.000	5.00E+00
			I0852035	4141			0.325	4.20E+02	1.44E+01	-1.14E-01	1.07E+00	1.000	5.00E+00
							0.107	1.150	0.00E+00	5.00E+00	1.000	C , C	3 , 2
MX301040	2		I	0.40	StaL	0.660	0.239	-3.44E+00	1.80E+01	-1.42E+00	4.47E+00	1.000	5.00E+00
			I0852035	3687			0.317	4.20E+02	1.44E+01	-1.11E-01	1.07E+00	1.000	5.00E+00
							0.104	1.150	0.00E+00	5.00E+00	1.000	C , C	3 , 2
MX304040	2		I	0.40	StaL	0.611	0.216	-3.10E+00	1.80E+01	-1.31E+00	4.47E+00	1.000	5.00E+00
			I0852035	3724			0.292	4.20E+02	1.44E+01	1.10E-01	1.07E+00	1.000	5.00E+00
							0.103	1.150	0.00E+00	5.00E+00	1.000	C , C	3 , 2
MX604040	2		I	0.40	StaL	0.542	0.211	-3.03E+00	1.80E+01	-1.33E+00	4.89E+00	1.000	5.00E+00
			I0852035	4178			0.271	4.20E+02	1.44E+01	9.71E-02	1.62E+00	1.000	5.00E+00
							0.060	1.150	0.00E+00	5.00E+00	1.000	C , C	2 , 2
MC651030	2		BOX	J701040	AxLd	0.444	0.444	4.17E+00	9.38E+00	2.36E-02	1.34E+00	1.000	7.38E+00
			B040420	4185			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
							0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MD301040	2		BOX	J301040	AxLd	0.430	0.430	4.04E+00	9.38E+00	3.06E-02	1.34E+00	1.000	7.38E+00
			B040420	3668			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
							0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MC254030	2		BOX	J304040	AxLd	0.368	0.368	3.46E+00	9.38E+00	-8.17E-03	1.34E+00	1.000	7.38E+00
			B040420	3569			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
							0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MC654030	2		BOX	J704040	AxLd	0.359	0.359	3.37E+00	9.38E+00	-6.66E-03	1.34E+00	1.000	7.38E+00
			B040420	4190			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
							0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MD704040	2		BOX	J704040	AxLd	0.354	0.354	3.32E+00	9.38E+00	-4.00E-03	1.34E+00	1.000	7.38E+00
			B040420	4294			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
							0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MD304040	2		BOX	J304040	AxLd	0.353	0.353	3.31E+00	9.38E+00	6.87E-03	1.34E+00	1.000	7.38E+00
			B040420	3673			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
							0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MD701040	2		BOX	J701040	AxLd	0.343	0.343	3.22E+00	9.38E+00	-2.39E-02	1.34E+00	1.000	7.38E+00
			B040420	4289			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
							0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MX701040	2		I	0.40	StaL	0.340	0.007	-1.08E-01	1.80E+01	-1.41E+00	4.89E+00	1.000	5.00E+00
			I0852035	4308			0.288	4.20E+02	1.44E+01	-7.16E-02	1.62E+00	1.000	5.00E+00
							0.044	1.150	0.00E+00	5.00E+00	1.000	C , C	1 , 2
MX201040	2		I	0.40	StaL	0.328	0.009	-1.24E-01	1.80E+01	-1.35E+00	4.89E+00	1.000	5.00E+00
			I0852035	3520			0.277	4.20E+02	1.44E+01	-6.93E-02	1.62E+00	1.000	5.00E+00
							0.043	1.150	0.00E+00	5.00E+00	1.000	C , C	1 , 2
MX704040	2		I	0.40	StaL	0.324	0.009	-1.24E-01	1.80E+01	-1.33E+00	4.89E+00	1.000	5.00E+00
			I0852035	4345			0.273	4.20E+02	1.44E+01	6.90E-02	1.62E+00	1.000	5.00E+00
							0.042	1.150	0.00E+00	5.00E+00	1.000	C , C	1 , 2
MX204040	2		I	0.40	StaL	0.320	0.010	-1.46E-01	1.80E+01	-1.29E+00	4.89E+00	1.000	5.00E+00
			I0852035	3557			0.265	4.20E+02	1.44E+01	7.25E-02	1.62E+00	1.000	5.00E+00
							0.045	1.150	0.00E+00	5.00E+00	1.000	C , C	1 , 2
MC251030	2		BOX	J301040	AxLd	0.319	0.319	2.99E+00	9.38E+00	-3.27E-02	1.34E+00	1.000	7.38E+00
			B040420	3564			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
							0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MZ304030	2		BOX	J304040	AxLd	0.209	0.209	6.83E+00	3.27E+01	-2.10E+00	6.88E+00	1.000	6.60E+00
			B060640	3663			0.000	4.20E+02	3.27E+01	1.00E-10	6.88E+00	1.000	6.60E+00
							0.000	1.150	0.00E+00	6.60E+00	0.000	C , C	1 , 1
MZ704030	2		BOX	J704040	AxLd	0.198	0.198	6.49E+00	3.27E+01	-2.08E+00	6.88E+00	1.000	6.60E+00
			B060640	4284			0.000	4.20E+02	3.27E+01	1.00E-10	6.88E+00	1.000	6.60E+00
							0.000	1.150	0.00E+00	6.60E+00	0.000	C , C	1 , 1
MZ701030	2		BOX	J701040	AxLd	0.186	0.186	6.10E+00	3.27E+01	2.08E+00	6.88E+00	1.000	6.60E+00
			B060640	4194			0.000	4.20E+02	3.27E+01	1.00E-10	6.88E+00	1.000	6.60E+00
							0.000	1.150	0.00E+00	6.60E+00	0.000	C , C	1 , 1
MZ301030	2		BOX	J301040	AxLd	0.184	0.184	6.03E+00	3.27E+01	2.09E+00	6.88E+00	1.000	6.60E+00
			B060640	3573			0.000	4.20E+02	3.27E+01	1.00E-10	6.88E+00	1.000	6.60E+00
							0.000	1.150	0.00E+00	6.60E+00	0.000	C , C	1 , 1

FRAMEWORK MEMBER CHECK, TRANSPORT

1

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 **                         Postprocessing of Frame Structures                              **
 **                                                                                         **
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Marketing and Support by DNV Software

```
Program id   : 3.6-02                                          Computer         : 586
Release date :  7-JUN-2011                                     Impl. update     :
Access time  : 12-JUN-2012 09:23:46                            Operating system : Win NT 6.1 [7601]
User id      : 123333                                          CPU id           : 0476028815
                                                               Installation     : , EURW120334
```



```
DATE: 12-JUN-2012 TIME: 09:23:46   PROGRAM: SESAM    FRAMEWORK 3.6-02   7-JUN-2011                                       1

                                   MEMBER check: EC3/NS3472 ENV 1993-1-1/Ed 3
                                   Run:      Superelement:     Loadset:
                                   ULS       T197              INPLACE
                                   Priority....: Worst Loadcase
                                   Usage factor: Above   0.50                                                 SUB PAGE:
```

NOMENCLATURE:

```
Member       Name of member
LoadCase     Name of loadcase
CND          Operational, storm or earthquake condition
Type         Section type
Joint/Po     Joint name or position within the member
Outcome      Outcome message from the code check
UsfTot       Total usage factor: UsfTot = UsfAx + UsfMy + UsfMz
UsfAx        Usage factor due to axial stress
N            Acting axial force
Ndy(Nkdy)    Axial (buckling) force capacity about y-axis
My*ky        Design bending moment used for bending about y-axis
Mdy          Moment capacity for bending about y-axis
Ky           Effective length factor for bending about y-axis
Ly           Buckling length for bending about y-axis
Phase        Phase angle in degrees
SctNam       Section name
EleNum       Element number
UsfMy        Usage factor due to bending about y-axis
Fy           Yield strength
Ndz(Nkdy)    Axial (buckling) force capacity about z-axis
Mz*kz        Design bending moment used for bending about z-axis
Mdz          Moment capacity for bending about z-axis
Kz           Effective length factor for bending about z-axis
Lz           Buckling length for bending about z-axis
UsfMz        Usage factor due to bending about z-axis
Gamma-m      Material factor, gamma-M1
vMises       Equivalent stress used in von Mises stress check
Lbuck        Length between lateral support of compression flange
C1           Lateral buckling factor
BCrv y,z     Buckling curve for bending about y,z-axes
Class w,f    Cross section class for web, flange
```

```
DATE: 12-JUN-2012 TIME: 09:23:46   PROGRAM: SESAM    FRAMEWORK 3.6-02   7-JUN-2011


                                   MEMBER check: EC3/NS3472 ENV 1993-1-1/Ed 3
                                   Run:      Superelement:     Loadset:
                                   ULS       T197              INPLACE
                                   Priority....: Worst Loadcase
```

```
Member   LoadCase CND Type     Joint/Po Outcome  UsfTot   UsfAx      N      Ndy(Nkdy)   My*ky      Mdy        Ky         Ly
          Phase       SctNam   EleNum                     UsfMy     Fy      Ndz(Nkdy)   Mz*kz      Mdz        Kz         Lz
                                                          UsfMz  Gamma-m   vMises      Lbuck      C1      BCrv y,z  Class w,f
-------------------------------------------------------------------------------------------------------------------------
MX601020 601          I        0.50    *Fa StaL  1.029   0.105 -5.91E-01  1.01E+01 -1.84E+00  2.07E+00   1.000   5.00E+00
                      HE800B   351                        0.888  3.55E+02  5.62E+00 -1.71E-02  4.76E-01   1.000   5.00E+00
                                                          0.036    1.150   0.00E+00  5.00E+00   1.000   C , C    1 , 1

MX301020 609          I        0.50    *Fa StaL  1.029   0.102 -5.75E-01  1.01E+01 -1.85E+00  2.07E+00   1.000   5.00E+00
                      HE800B   247                        0.897  3.55E+02  5.62E+00 -1.40E-02  4.76E-01   1.000   5.00E+00
                                                          0.029    1.150   0.00E+00  5.00E+00   1.000   C , C    1 , 1

MX304020 609          I        0.50    *Fa StaL  1.013   0.078 -4.40E-01  1.01E+01 -1.84E+00  2.07E+00   1.000   5.00E+00
                      HE800B   256                        0.893  3.55E+02  5.62E+00  2.03E-02  4.76E-01   1.000   5.00E+00
                                                          0.043    1.150   0.00E+00  5.00E+00   1.000   C , C    1 , 1

MX604020 601          I        0.50        StaL  0.997   0.088 -4.96E-01  1.01E+01 -1.80E+00  2.07E+00   1.000   5.00E+00
                      HE800B   360                        0.869  3.55E+02  5.62E+00  1.92E-02  4.76E-01   1.000   5.00E+00
                                                          0.040    1.150   0.00E+00  5.00E+00   1.000   C , C    1 , 1

MD454020 617          BOX      0.50        Stab  0.990   0.617 -4.44E+00  7.20E+00  4.03E-01  1.34E+00   1.000   7.49E+00
                      B040420  291                        0.301  3.55E+02  7.20E+00  9.60E-02  1.34E+00   1.000   7.49E+00
                                                          0.072    1.150   0.00E+00  7.49E+00   0.000   C , C    1 , 1

MC504010 625          BOX      0.50        Stab  0.971   0.608 -4.37E+00  7.20E+00  3.97E-01  1.34E+00   1.000   7.49E+00
                      B040420  316                        0.297  3.55E+02  7.20E+00  8.94E-02  1.34E+00   1.000   7.49E+00
                                                          0.067    1.150   0.00E+00  7.49E+00   0.000   C , C    1 , 1

MD304020 617          BOX      0.50        Stab  0.971   0.877 -1.05E+00  1.20E+00  2.38E-02  2.51E-01   1.000   8.36E+00
                      B020216  255                        0.095  3.55E+02  1.20E+00  1.17E-18  2.51E-01   1.000   8.36E+00
                                                          0.000    1.150   0.00E+00  8.36E+00   0.000   C , C    1 , 1

MD451020 617          BOX      0.50        Stab  0.952   0.580 -4.17E+00  7.20E+00  4.12E-01  1.34E+00   1.000   7.49E+00
                      B040420  289                        0.308  3.55E+02  7.20E+00 -8.60E-02  1.34E+00   1.000   7.49E+00
                                                          0.064    1.150   0.00E+00  7.49E+00   0.000   C , C    1 , 1

MC604010 625          BOX      0.50        Stab  0.944   0.851 -1.02E+00  1.20E+00  2.36E-02  2.51E-01   1.000   8.36E+00
                      B020216  359                        0.094  3.55E+02  1.20E+00  4.08E-19  2.51E-01   1.000   8.36E+00
                                                          0.000    1.150   0.00E+00  8.36E+00   0.000   C , C    1 , 1

MC501010 625          BOX      0.50        Stab  0.941   0.579 -4.17E+00  7.20E+00  4.05E-01  1.34E+00   1.000   7.49E+00
                      B040420  314                        0.303  3.55E+02  7.20E+00 -7.89E-02  1.34E+00   1.000   7.49E+00
                                                          0.059    1.150   0.00E+00  7.49E+00   0.000   C , C    1 , 1

MD301020 617          BOX      0.50        Stab  0.915   0.826 -9.93E-01  1.20E+00  2.23E-02  2.51E-01   1.000   8.36E+00
                      B020216  246                        0.089  3.55E+02  1.20E+00 -1.19E-18  2.51E-01   1.000   8.36E+00
                                                          0.000    1.150   0.00E+00  8.36E+00   0.000   C , C    1 , 1

MC601010 625          BOX      0.50        Stab  0.900   0.811 -9.76E-01  1.20E+00  2.25E-02  2.51E-01   1.000   8.36E+00
                      B020216  350                        0.089  3.55E+02  1.20E+00 -1.32E-18  2.51E-01   1.000   8.36E+00
                                                          0.000    1.150   0.00E+00  8.36E+00   0.000   C , C    1 , 1

MX301010 609          I        0.50        StaL  0.877   0.235 -2.80E+00  1.85E+01 -2.81E+00  5.44E+00   1.000   5.00E+00
                      I1242035 245                        0.515  4.20E+02  1.19E+01  8.69E-02  6.83E-01   1.000   5.00E+00
                                                          0.127    1.150   0.00E+00  5.00E+00   1.000   C , C    3 , 1

MX304010 609          I        0.50        StaL  0.866   0.244 -2.91E+00  1.85E+01 -2.78E+00  5.44E+00   1.000   5.00E+00
                      I1242035 254                        0.512  4.20E+02  1.19E+01 -7.49E-02  6.83E-01   1.000   5.00E+00
                                                          0.110    1.150   0.00E+00  5.00E+00   1.000   C , C    3 , 1

MX601010 601          I        0.50        StaL  0.862   0.235 -2.80E+00  1.85E+01 -2.88E+00  5.44E+00   1.000   5.00E+00
                      I1242035 349                        0.529  4.20E+02  1.19E+01  6.62E-02  6.83E-01   1.000   5.00E+00
                                                          0.097    1.150   0.00E+00  5.00E+00   1.000   C , C    3 , 1

MX604010 601          I        0.50        StaL  0.852   0.247 -2.94E+00  1.85E+01 -2.87E+00  5.44E+00   1.000   5.00E+00
                      I1242035 358                        0.527  4.20E+02  1.19E+01 -5.38E-02  6.83E-01   1.000   5.00E+00
                                                          0.079    1.150   0.00E+00  5.00E+00   1.000   C , C    3 , 1

MF302020 605          BOX      0.50        Stab  0.851   0.759 -3.79E+00  4.99E+00 -1.24E-01  1.34E+00   1.000   1.20E+01
                      B040420  231                        0.092  3.55E+02  4.99E+00  3.12E-18  1.34E+00   1.000   1.20E+01
                                                          0.000    1.150   0.00E+00  1.20E+01   0.000   C , C    1 , 1

MX404010 609          I        0.50        StaL  0.841   0.207 -2.46E+00  1.85E+01 -2.78E+00  5.44E+00   1.000   5.00E+00
                      I1242035 286                        0.511  4.20E+02  1.19E+01  8.46E-02  6.83E-01   1.000   5.00E+00
                                                          0.124    1.150   0.00E+00  5.00E+00   1.000   C , C    3 , 1

MX504010 601          I        0.50        StaL  0.831   0.211 -2.52E+00  1.85E+01 -2.86E+00  5.44E+00   1.000   5.00E+00
                      I1242035 326                        0.526  4.20E+02  1.19E+01 -6.44E-02  6.83E-01   1.000   5.00E+00
                                                          0.094    1.150   0.00E+00  5.00E+00   1.000   C , C    3 , 1

MX401010 625          I        0.50        StaL  0.825   0.183 -2.18E+00  1.85E+01 -2.75E+00  5.44E+00   1.000   5.00E+00
                      I1242035 278                        0.506  4.20E+02  1.19E+01 -9.33E-02  6.83E-01   1.000   5.00E+00
                                                          0.137    1.150   0.00E+00  5.00E+00   1.000   C , C    3 , 1

MX304030 609          I        0.50        Lbck  0.809   0.000  9.03E-02  1.01E+01  1.86E+00  2.51E+00   1.000   3.30E+00
                      HE800B   243                        0.738  3.55E+02  1.01E+01  3.37E-02  4.76E-01   1.000   3.30E+00
                                                          0.071    1.150   0.00E+00  3.30E+00   1.000   C , C    1 , 1

MX501010 601          I        0.50        StaL  0.807   0.173 -2.06E+00  1.85E+01 -2.88E+00  5.44E+00   1.000   5.00E+00
                      I1242035 318                        0.529  4.20E+02  1.19E+01 -7.11E-02  6.83E-01   1.000   5.00E+00
                                                          0.104    1.150   0.00E+00  5.00E+00   1.000   C , C    3 , 1
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Member   LoadCase CND Type     Joint/Po Outcome  UsfTot   UsfAx      N      Ndy(Nkdy)   My*ky      Mdy        Ky          Ly
          Phase       SctNam   EleNum                     UsfMy      Fy     Ndz(Nkdy)   Mz*kz      Mdz        Kz          Lz
                                                          UsfMz   Gamma-m   vMises      Lbuck      C1     BCrv y,z  Class w,f
-------------------------------------------------------------------------------------------------------------------------------
MX651030 601          I        0.50        StaL   0.802   0.005 -3.78E-02  1.01E+01 -1.96E+00  2.51E+00    1.000   3.30E+00
                      HE800B   362                        0.779  3.55E+02  7.68E+00 -8.37E-03  4.76E-01    1.000   3.30E+00
                                                          0.018     1.150  0.00E+00  3.30E+00    1.000   C , C    1 , 1

MF702020 605          BOX      0.50        Stab   0.792   0.702 -3.50E+00  4.99E+00 -1.21E-01  1.34E+00    1.000   1.20E+01
                      B040420  380                        0.091  3.55E+02  4.99E+00  4.15E-18  1.34E+00    1.000   1.20E+01
                                                          0.000     1.150  0.00E+00  1.20E+01    0.000   C , C    1 , 1

MX654030 601          I        0.50        StaL   0.791   0.009 -7.02E-02  1.01E+01 -1.90E+00  2.51E+00    1.000   3.30E+00
                      HE800B   364                        0.756  3.55E+02  7.68E+00  1.26E-02  4.76E-01    1.000   3.30E+00
                                                          0.027     1.150  0.00E+00  3.30E+00    1.000   C , C    1 , 1

MX301030 609          I        0.50        StaL   0.788   0.006 -4.25E-02  1.01E+01 -1.93E+00  2.51E+00    1.000   3.30E+00
                      HE800B   241                        0.767  3.55E+02  7.68E+00 -7.12E-03  4.76E-01    1.000   3.30E+00
                                                          0.015     1.150  0.00E+00  3.30E+00    1.000   C , C    1 , 1

MX702010 601          I        0.50        StaL   0.780   0.345 -1.94E+00  1.01E+01 -8.11E-01  1.90E+00    1.000   5.00E+00
                      HE800B   398                        0.428  3.55E+02  5.62E+00  2.42E-03  3.06E-01    1.000   5.00E+00
                                                          0.008     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 1

MX202010 609          I        0.50        StaL   0.767   0.351 -1.97E+00  1.01E+01 -7.77E-01  1.90E+00    1.000   5.00E+00
                      HE800B   204                        0.409  3.55E+02  5.62E+00  1.93E-03  3.06E-01    1.000   5.00E+00
                                                          0.006     1.150  0.00E+00  5.00E+00    1.000   C , C    3 , 1

MY302030 607          I        0.50        Lbck   0.754   0.000  1.71E-02  1.81E+01  2.34E+00  3.38E+00    1.000   1.00E+01
                      I0852035 235                        0.691  4.20E+02  1.81E+01 -1.02E-01  1.62E+00    0.100   1.00E+01
                                                          0.063     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MY701010 603          I        0.50        StaL   0.746   0.035 -2.95E-01  2.01E+01  2.45E+00  4.75E+00    1.000   1.00E+01
                      I1252035 370                        0.516  4.20E+02  8.50E+00 -2.08E-01  1.07E+00    1.000   1.00E+01
                                                          0.195     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 2

MX804010 617          I        0.50        StaL   0.736   0.456 -4.84E+00  1.54E+01  8.82E-01  5.44E+00    1.000   5.00E+00
                      I1242035 435                        0.162  4.20E+02  1.06E+01  8.04E-02  6.83E-01    1.000   5.00E+00
                                                          0.118     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1

MX602010 601          I        0.50        StaL   0.734   0.337 -1.89E+00  1.01E+01 -8.11E-01  2.07E+00    1.000   5.00E+00
                      HE800B   353                        0.392  3.55E+02  5.62E+00 -2.06E-03  4.76E-01    1.000   5.00E+00
                                                          0.004     1.150  0.00E+00  5.00E+00    1.000   C , C    2 , 1

MX302010 609          I        0.50        StaL   0.727   0.341 -1.92E+00  1.01E+01 -7.88E-01  2.07E+00    1.000   5.00E+00
                      HE800B   249                        0.381  3.55E+02  5.62E+00 -2.00E-03  4.76E-01    1.000   5.00E+00
                                                          0.004     1.150  0.00E+00  5.00E+00    1.000   C , C    2 , 1

MY301030 613          I        0.33        StaL   0.724   0.012 -1.87E-01  1.61E+01 -2.41E+00  3.38E+00    1.000   1.00E+01
                      I0852035 226                        0.712  4.20E+02  1.81E+01  1.58E-03  1.62E+00    0.100   1.00E+01
                                                          0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MY702030 605          I        0.50        StaL   0.721   0.006 -9.76E-02  1.61E+01 -2.29E+00  3.20E+00    1.000   1.00E+01
                      I0852035 384                        0.715  4.20E+02  1.81E+01  3.86E-04  1.07E+00    0.100   1.00E+01
                                                          0.000     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 2

MX801010 617          I        0.50        StaL   0.708   0.453 -4.81E+00  1.54E+01  8.49E-01  5.44E+00    1.000   5.00E+00
                      I1242035 427                        0.156  4.20E+02  1.06E+01  6.75E-02  6.83E-01    1.000   5.00E+00
                                                          0.099     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1

ME301010 613          BOX      0.50        Stab   0.706   0.626 -3.12E+00  4.99E+00 -1.08E-01  1.34E+00    1.000   1.20E+01
                      B040420  222                        0.081  3.55E+02  4.99E+00 -2.90E-17  1.34E+00    1.000   1.20E+01
                                                          0.000     1.150  0.00E+00  1.20E+01    0.000   C , C    1 , 1

MX701010 601          I        0.50        StaL   0.701   0.318 -3.38E+00  1.54E+01 -1.39E+00  5.44E+00    1.000   5.00E+00
                      I1242035 394                        0.255  4.20E+02  1.06E+01 -8.68E-02  6.83E-01    1.000   5.00E+00
                                                          0.127     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1

MD354030 617          BOX      0.50        Stab   0.698   0.524 -3.77E+00  7.20E+00 -1.85E-01  1.34E+00    1.000   7.49E+00
                      B040420  261                        0.138  3.55E+02  7.20E+00 -4.72E-02  1.34E+00    1.000   7.49E+00
                                                          0.035     1.150  0.00E+00  7.49E+00    0.000   C , C    1 , 1

MY301010 607          I        0.50        StaL   0.694   0.026 -2.19E-01  2.01E+01  2.35E+00  4.75E+00    1.000   1.00E+01
                      I1252035 221                        0.495  4.20E+02  8.50E+00  1.85E-01  1.07E+00    1.000   1.00E+01
                                                          0.174     1.150  0.00E+00  1.00E+01    1.000   C , C    3 , 2

MY701030 613          I        0.33        StaL   0.692   0.007 -1.20E-01  1.61E+01 -2.31E+00  3.38E+00    1.000   1.00E+01
                      I0852035 375                        0.684  4.20E+02  1.81E+01  1.37E-03  1.62E+00    0.100   1.00E+01
                                                          0.001     1.150  0.00E+00  1.00E+01    1.000   C , C    1 , 2

MC554020 625          BOX      0.50        Stab   0.683   0.515 -3.70E+00  7.20E+00 -1.80E-01  1.34E+00    1.000   7.49E+00
                      B040420  346                        0.135  3.55E+02  7.20E+00 -4.46E-02  1.34E+00    1.000   7.49E+00
                                                          0.033     1.150  0.00E+00  7.49E+00    0.000   C , C    1 , 1

MX101010 625          I        0.50        StaL   0.678   0.444 -4.72E+00  1.54E+01  8.48E-01  5.44E+00    1.000   5.00E+00
                      I1242035 169                        0.156  4.20E+02  1.06E+01  5.34E-02  6.83E-01    1.000   5.00E+00
                                                          0.078     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1

MX104010 625          I        0.50        StaL   0.668   0.445 -4.73E+00  1.54E+01  8.69E-01  5.44E+00    1.000   5.00E+00
                      I1242035 177                        0.160  4.20E+02  1.06E+01 -4.33E-02  6.83E-01    1.000   5.00E+00
                                                          0.063     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1
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Member   LoadCase CND Type     Joint/Po Outcome  UsfTot   UsfAx      N     Ndy(Nkdy)  My*ky      Mdy        Ky         Ly
          Phase       SctNam   EleNum                     UsfMy     Fy     Ndz(Nkdy)  Mz*kz      Mdz        Kz         Lz
                                                          UsfMz  Gamma-m   vMises     Lbuck      C1      BCrv y,z  Class w,f
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MX201010 609          I        0.50         StaL   0.667   0.316 -3.35E+00  1.54E+01 -1.35E+00  5.44E+00    1.000   5.00E+00
                      I1242035 200                         0.249  4.20E+02  1.06E+01 -6.97E-02  6.83E-01    1.000   5.00E+00
                                                           0.102     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1

MX704010 601          I        0.50         StaL   0.664   0.318 -3.38E+00  1.54E+01 -1.30E+00  5.44E+00    1.000   5.00E+00
                      I1242035 403                         0.239  4.20E+02  1.06E+01  7.31E-02  6.83E-01    1.000   5.00E+00
                                                           0.107     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1

MZ701010 601          BOX      0.50         Stab   0.656   0.362 -1.05E+01  2.91E+01 -1.33E+00  6.88E+00    1.000   6.70E+00
                      B060640  367                         0.193  4.20E+02  2.91E+01 -6.97E-01  6.88E+00    1.000   6.70E+00
                                                           0.101     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MZ704010 601          BOX      0.50         Stab   0.656   0.346 -1.01E+01  2.91E+01  1.40E+00  6.88E+00    1.000   6.70E+00
                      B060640  387                         0.203  4.20E+02  2.91E+01 -7.29E-01  6.88E+00    1.000   6.70E+00
                                                           0.106     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MY702010 601          I        0.50         Lbck   0.648   0.000  1.08E-01  2.10E+01  2.41E+00  5.01E+00    1.000   1.00E+01
                      I1252035 379                         0.481  4.20E+02  2.10E+01 -2.75E-01  1.64E+00    1.000   1.00E+01
                                                           0.168     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 2

ME701010 613          BOX      0.50         Stab   0.646   0.566 -2.82E+00  4.99E+00 -1.07E-01  1.34E+00    1.000   1.20E+01
                      B040420  371                         0.080  3.55E+02  4.99E+00  3.14E-17  1.34E+00    1.000   1.20E+01
                                                           0.000     1.150  0.00E+00  1.20E+01    0.000   C , C    1 , 1

MX204010 609          I        0.50         StaL   0.643   0.314 -3.33E+00  1.54E+01 -1.30E+00  5.44E+00    1.000   5.00E+00
                      I1242035 209                         0.239  4.20E+02  1.06E+01  6.15E-02  6.83E-01    1.000   5.00E+00
                                                           0.090     1.150  0.00E+00  5.00E+00    1.000   C , C    4 , 1

MZ304010 609          BOX      0.50         Stab   0.639   0.350 -1.02E+01  2.91E+01  1.26E+00  6.88E+00    1.000   6.70E+00
                      B060640  238                         0.184  4.20E+02  2.91E+01  7.30E-01  6.88E+00    1.000   6.70E+00
                                                           0.106     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MD351030 617          BOX      0.50         Stab   0.634   0.483 -3.47E+00  7.20E+00 -1.71E-01  1.34E+00    1.000   7.49E+00
                      B040420  260                         0.128  3.55E+02  7.20E+00  3.15E-02  1.34E+00    1.000   7.49E+00
                                                           0.024     1.150  0.00E+00  7.49E+00    0.000   C , C    1 , 1

MZ504010 601          BOX      0.50         Stab   0.629   0.093 -1.49E+00  1.60E+01 -5.90E-01  2.85E+00    1.000   6.70E+00
                      B040440  311                         0.207  4.20E+02  1.60E+01  9.40E-01  2.85E+00    1.000   6.70E+00
                                                           0.330     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MC551020 601          BOX      J651030      AxLd   0.629   0.629  5.91E+00  9.38E+00  4.02E-01  1.34E+00    1.000   7.49E+00
                      B040420  345                         0.000  3.55E+02  9.38E+00  2.52E-02  1.34E+00    1.000   7.49E+00
                                                           0.000     1.150  0.00E+00  7.49E+00    0.000   C , C    1 , 1

MZ301010 609          BOX      0.50         Stab   0.627   0.354 -1.03E+01  2.91E+01 -1.19E+00  6.88E+00    1.000   6.70E+00
                      B060640  218                         0.173  4.20E+02  2.91E+01  6.92E-01  6.88E+00    1.000   6.70E+00
                                                           0.101     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MZ501010 601          BOX      0.50         Stab   0.625   0.132 -2.11E+00  1.60E+01  4.74E-01  2.85E+00    1.000   6.70E+00
                      B040440  293                         0.166  4.20E+02  1.60E+01  9.29E-01  2.85E+00    1.000   6.70E+00
                                                           0.326     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MZ701020 615          BOX      0.50         Stab   0.622   0.286 -8.32E+00  2.91E+01  1.36E+00  6.88E+00    1.000   6.70E+00
                      B060640  368                         0.198  4.20E+02  2.91E+01 -9.51E-01  6.88E+00    1.000   6.70E+00
                                                           0.138     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MZ301020 611          BOX      0.50         Stab   0.621   0.282 -8.21E+00  2.91E+01  1.43E+00  6.88E+00    1.000   6.70E+00
                      B060640  219                         0.208  4.20E+02  2.91E+01  8.95E-01  6.88E+00    1.000   6.70E+00
                                                           0.130     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MY302010 609          I        0.50         Lbck   0.618   0.000  1.75E-01  2.10E+01  2.34E+00  5.01E+00    1.000   1.00E+01
                      I1252035 230                         0.467  4.20E+02  2.10E+01  2.48E-01  1.64E+00    1.000   1.00E+01
                                                           0.151     1.150  0.00E+00  1.00E+01    1.000   C , C    2 , 2

MZ304020 607          BOX      0.50         Stab   0.611   0.280 -8.14E+00  2.91E+01 -1.44E+00  6.88E+00    1.000   6.70E+00
                      B060640  239                         0.209  4.20E+02  2.91E+01  8.37E-01  6.88E+00    1.000   6.70E+00
                                                           0.122     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MZ704020 603          BOX      0.50         Stab   0.602   0.274 -7.98E+00  2.91E+01 -1.32E+00  6.88E+00    1.000   6.70E+00
                      B060640  388                         0.192  4.20E+02  2.91E+01 -9.30E-01  6.88E+00    1.000   6.70E+00
                                                           0.135     1.150  0.00E+00  6.70E+00    0.000   C , C    1 , 1

MC204010 627          BOX      0.50         Stab   0.577   0.513 -6.17E-01  1.20E+00 -5.15E-03  2.51E-01    1.000   8.36E+00
                      B020216  210                         0.020  3.55E+02  1.20E+00  1.08E-02  2.51E-01    1.000   8.36E+00
                                                           0.043     1.150  0.00E+00  8.36E+00    0.000   C , C    1 , 1

MY901040 605          I        0.50         StaL   0.572   0.463 -9.55E-01  8.52E+00 -1.07E-01  1.12E+00    1.000   1.00E+01
                      HE800B   451                         0.095  3.55E+02  2.06E+00  4.46E-03  3.06E-01    1.000   1.00E+01
                                                           0.015     1.150  0.00E+00  1.00E+01    1.000   C , C    4 , 1

MC201010 623          BOX      0.50         Stab   0.567   0.504 -6.07E-01  1.20E+00 -4.96E-03  2.51E-01    1.000   8.36E+00
                      B020216  201                         0.020  3.55E+02  1.20E+00 -1.08E-02  2.51E-01    1.000   8.36E+00
                                                           0.043     1.150  0.00E+00  8.36E+00    0.000   C , C    1 , 1

MF902520 607          BOX      0.50         Stab   0.566   0.223 -1.61E+00  7.20E+00  2.48E-01  1.34E+00    1.000   7.49E+00
                      B040420  463                         0.186  3.55E+02  7.20E+00  2.11E-01  1.34E+00    1.000   7.49E+00
                                                           0.158     1.150  0.00E+00  7.49E+00    0.000   C , C    1 , 1
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Member	LoadCase CND	Type	Joint/Po	Outcome	UsfTot	UsfAx	N	Ndy(Nkdy)	My*ky	Mdy	Ky	Ly
	Phase	SctNam	EleNum			UsfMy	Fy	Ndz(Nkdy)	Mz*kz	Mdz	Kz	Lz
						UsfMz	Gamma-m	vMises	Lbuck	C1	BCrv y,z	Class w,f
MY501020	609	I	0.50	StaL	0.553	0.015	-3.00E-01	2.01E+01	1.96E+00	4.75E+00	1.000	1.00E+01
		I1252035	299			0.412	4.20E+02	2.10E+01	1.35E-01	1.07E+00	0.100	1.00E+01
						0.127	1.150	0.00E+00	1.00E+01	1.000	C , C	3 , 2
MD704020	631	BOX	0.50	Stab	0.553	0.489	-5.88E-01	1.20E+00	-5.26E-03	2.51E-01	1.000	8.36E+00
		B020216	404			0.021	3.55E+02	1.20E+00	1.08E-02	2.51E-01	1.000	8.36E+00
						0.043	1.150	0.00E+00	8.36E+00	0.000	C , C	1 , 1
MX204020	603	I	0.50	StaL	0.543	0.062	-3.50E-01	1.01E+01	-9.12E-01	2.07E+00	1.000	5.00E+00
		HE800B	211			0.441	3.55E+02	5.62E+00	1.87E-02	4.76E-01	1.000	5.00E+00
						0.039	1.150	0.00E+00	5.00E+00	1.000	C , C	1 , 1
ME901010	613	BOX	0.50	Stab	0.536	0.259	-1.86E+00	7.20E+00	2.63E-01	1.34E+00	1.000	7.49E+00
		B040420	445			0.197	3.55E+02	7.20E+00	1.08E-01	1.34E+00	1.000	7.49E+00
						0.081	1.150	0.00E+00	7.49E+00	0.000	C , C	1 , 1
MC651030	601	BOX	J701040	AxLd	0.535	0.535	5.03E+00	9.38E+00	-9.85E-02	1.34E+00	1.000	7.38E+00
		B040420	363			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
						0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MD301040	609	BOX	J301040	AxLd	0.532	0.532	4.99E+00	9.38E+00	-9.52E-02	1.34E+00	1.000	7.38E+00
		B040420	242			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
						0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MD701020	619	BOX	0.50	Stab	0.530	0.467	-5.62E-01	1.20E+00	-5.06E-03	2.51E-01	1.000	8.36E+00
		B020216	395			0.020	3.55E+02	1.20E+00	-1.08E-02	2.51E-01	1.000	8.36E+00
						0.043	1.150	0.00E+00	8.36E+00	0.000	C , C	1 , 1
MX302020	609	I	0.50	Lbck	0.528	0.000	2.29E-02	1.81E+01	2.57E+00	4.89E+00	1.000	5.00E+00
		I0852035	250			0.526	4.20E+02	1.81E+01	-3.46E-03	1.62E+00	1.000	5.00E+00
						0.002	1.150	0.00E+00	5.00E+00	1.000	C , C	1 , 2
MX202020	609	I	0.50	Lbck	0.527	0.000	3.76E-02	1.81E+01	2.55E+00	4.89E+00	1.000	5.00E+00
		I0852035	205			0.521	4.20E+02	1.81E+01	9.06E-03	1.62E+00	1.000	5.00E+00
						0.006	1.150	0.00E+00	5.00E+00	1.000	C , C	1 , 2
MX701020	611	I	0.50	StaL	0.522	0.061	-3.46E-01	1.01E+01	-8.76E-01	2.07E+00	1.000	5.00E+00
		HE800B	396			0.424	3.55E+02	5.62E+00	-1.74E-02	4.76E-01	1.000	5.00E+00
						0.037	1.150	0.00E+00	5.00E+00	1.000	C , C	1 , 1
MY101010	615	I	0.50	StaL	0.513	0.033	-2.99E-01	9.04E+00	4.56E-01	1.17E+00	1.000	1.00E+01
		HE800B	146			0.390	3.55E+02	1.01E+01	-4.30E-02	4.76E-01	0.100	1.00E+01
						0.090	1.150	0.00E+00	1.00E+01	1.000	C , C	1 , 1
MF102520	605	BOX	0.50	Stab	0.508	0.310	-2.23E+00	7.20E+00	-2.44E-01	1.34E+00	1.000	7.49E+00
		B040420	156			0.182	3.55E+02	7.20E+00	-2.03E-02	1.34E+00	1.000	7.49E+00
						0.015	1.150	0.00E+00	7.49E+00	0.000	C , C	1 , 1
MC654030	601	BOX	J704040	AxLd	0.502	0.502	4.71E+00	9.38E+00	-1.14E-01	1.34E+00	1.000	7.38E+00
		B040420	365			0.000	3.55E+02	9.38E+00	1.00E-10	1.34E+00	1.000	7.38E+00
						0.000	1.150	0.00E+00	7.38E+00	0.000	C , C	1 , 1
MY902010	609	I	0.50	Lbck	0.501	0.000	2.85E-01	1.81E+01	1.03E+00	3.38E+00	1.000	1.00E+01
		I0852035	460			0.303	4.20E+02	1.81E+01	3.21E-01	1.62E+00	0.100	1.00E+01
						0.197	1.150	0.00E+00	1.00E+01	1.000	C , C	1 , 2
MY901010	609	I	0.50	Lbck	0.501	0.000	2.76E-01	1.81E+01	1.03E+00	3.38E+00	1.000	1.00E+01
		I0852035	449			0.304	4.20E+02	1.81E+01	3.19E-01	1.62E+00	0.100	1.00E+01
						0.197	1.150	0.00E+00	1.00E+01	1.000	C , C	1 , 2

MEMBER ASSESSMENT

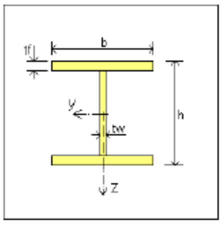
In place

COLBEAM EC3 - User defined	Project: MY302020		Page: 1/1
Version 1.0.6 Member Design Program incl updates until Apr 2009 Copyright (C) 2010 StruProg AB	Identification: 543	Date: 12.06.2012 Time: 16:7	
File: i:\master project\calculation\member assesment\my302020lc543.cec			

General:

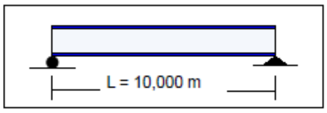
Material:	S420 N/NL	fy	=	420 MPa	E	=	210000,0 MPa
gm0/gm1 =	1,15/1,15	Cross Section Class 1-2: Elastic design					

Profile: I 1200x400x20x35



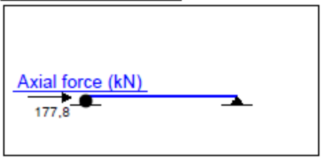
Dimensions and weight:			Section property:			Capacity:		
						Cross Section Class: 4/2/1 N/My/Mz		
h	=	1200,0 mm	A	=	50600 mm2	Nt,Rd	=	18480,0 kN
b	=	400,0 mm	Aeff	=	42323 mm2	Nc,Rd	=	15457,2 kN
tw	=	20,0 mm	Ix	=	1,445E+7 mm4	My,Rd	=	7248,5 kNm
tf	=	35,0 mm	Iy	=	1,191E+10 mm4	Mz,Rd	=	683,1 kNm
g	=	397,2 kg/m	Iz	=	3,741E+8 mm4	Vc,z,Rd	=	4704,5 kN
S	=	3,960 m2/m	Iw	=	1,267E+14 mm6	Vc,y,Rd	=	3936,0 kN
			Wel,y	=	1,985E+7 mm3			
			Weff,y	=	1,985E+7 mm3			
			Wpl,y	=	2,269E+7 mm3			
			Wel,z	=	1,870E+6 mm3			
			Weff,z	=	1,870E+6 mm3			
			Wpl,z	=	2,913E+6 mm3			

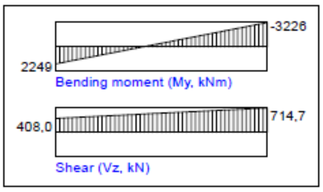
Geometry/Loading:



End Supports: Non-rigid

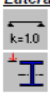
Endforces: (kN/kNm/m)





Buckling parameters:		Y-axis	Z-axis
Buckling length factor		1,00	1,00
Buckling Curve		b	c
Slenderness	lamda =	0,27	1,51
Interaction factors kij:	Method 1		

Lateral buckling parameters:



Mb,Rd = 5293,0 kNm (lateral torsional buckling) C1 = 2,547
Lateral torsional buckling curves: General Case (conservative, ch 6.3.2.2)

Governing Loadcase: EN1990 ULS: Eq 6.10a: LC = 1.35*G + 1.5*0,7*Q1 + 1.5*0,7*Q2

SECTION CONTROL:

IR = My,Ed/My,Rd = 3226,0/7248,5 = 0,45 < 1,0 (1,00L; Ch 6.2.5)
IR = My,Ed/MN,y,Rd = 3226,0/7248,5 = 0,45 < 1,0 (1,00L; Ch 6.2.9)
IR = Vz,Ed/Vz,Rd = 714,7/4704,5 = 0,15 < 1,0 (1,00L; Ch 6.2.6 Support stiffener recommended)

BUCKLING CONTROL: (incl Lateral Torsional Buckling)
No Buckling, ref ch 6.3.1.2 (4); lamdaby/lamdabz<=0.2 or Ned/Ncry<=0.04; Ned/Ncry<=0.04
IR = My,Ed/Mb,Rd = -3226,0/5293,0 = 0,61 < 1,0 (Ch 6.3.2.1/6.3.2.3)

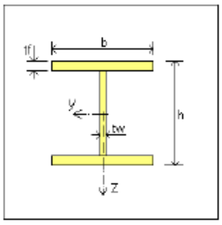
Lift

COLBEAM EC3 - User defined	Project: MY302030		Page: 1/1
Version 1.0.6 Member Design Program incl updates until Apr 2009 Copyright (C) 2010 StruProg AB	Identification: 1	Date: 12.06.2012 Time: 16:7	
File: i:\master project\calculation\member assesment\my302030lc1.cec			

General:

Material: S420 N/NL fy = 420 MPa E = 210000,0 MPa
gm0/gm1 = 1,15/1,15

Profile: I 800x500x20x35



Dimensions and weight:

h	=	800,0	mm
b	=	500,0	mm
tw	=	20,0	mm
tf	=	35,0	mm
g	=	389,4	kg/m
S	=	3,560	m2/m

Section property:

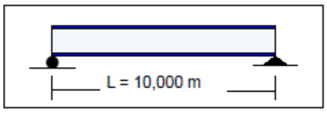
A	=	49600	mm2
Aeff	=	47754	mm2
Ix	=	1,624E+7	mm4
Iy	=	5,773E+9	mm4
Iz	=	7,297E+8	mm4
Iw	=	1,067E+14	mm6
Wel,y	=	1,443E+7	mm3
Weff,y	=	1,443E+7	mm3
Wpl,y	=	1,605E+7	mm3
Wel,z	=	2,919E+6	mm3
Weff,z	=	2,919E+6	mm3
Wpl,z	=	4,448E+6	mm3

Capacity:

Cross Section Class: 4/2/2 N/My/Mz

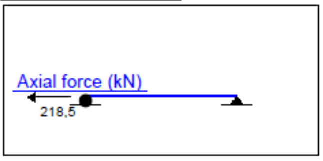
Nt,Rd	=	18114,8	kN
Nc,Rd	=	17440,8	kN
My,Rd	=	5862,5	kNm
Mz,Rd	=	1624,5	kNm
Vc,z,Rd	=	3694,2	kN
Vc,y,Rd	=	4920,0	kN

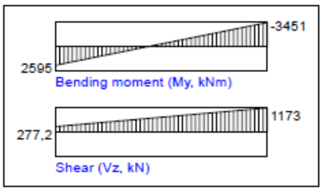
Geometry/Loading:

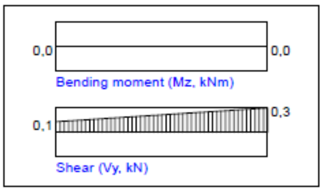


End Supports: Non-rigid

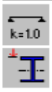
Endforces: (kN/kNm/m)







Lateral buckling parameters:



Mb,Rd = 5591,6 kNm (lateral torsional buckling) C1 = 2,600
Lateral torsional buckling curves: General Case (conservative, ch 6.3.2.2)

Governing Loadcase: Basic loads: G + Q1 + Q2

SECTION CONTROL:

IR = My,Ed/My,Rd = 3451,0/5862,5 = 0,59 < 1,0 (1,00L; Ch 6.2.5)
IR = My,Ed/MN,y,Rd = 3451,0/5862,5 = 0,59 < 1,0 (1,00L; Ch 6.2.9)
IR = Vz,Ed/Vz,Rd = 1173,3/3694,2 = 0,32 < 1,0 (1,00L; Ch 6.2.6)

BUCKLING CONTROL: (incl Lateral Torsional Buckling)
IR = My,Ed/Mb,Rd = -3451,0/5591,6 = 0,62 < 1,0 (Ch 6.3.2.1/6.3.2.3)

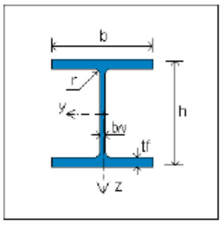
<u>Transport</u>

COLBEAM EC3 - User defined	Project: MX601020		Page: 1/1
Version 1.0.6 Member Design Program incl updates until Apr 2009 Copyright (C) 2010 StruProg AB	Identification: 609	Date: 12.06.2012 Time: 16:7	
File: i:\master project\calculation\member assesment\mx601020lc601.cec			

General:

Material:	S355	fy	=	355 MPa	E	=	210000,0 MPa
gm0/gm1 =	1,15/1,15						

Profile: HEB800



Dimensions and weight:

h	=	800,0 mm
b	=	300,0 mm
tw	=	17,5 mm
tf	=	33,0 mm
r	=	30,0 mm
g	=	262,3 kg/m
S	=	2,713 m2/m

Section property:

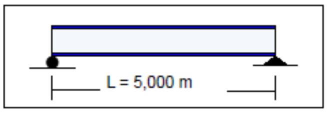
A	=	33420 mm2
Aeff	=	32042 mm2
Ix	=	9,490E+6 mm4
Iy	=	3,591E+9 mm4
Iz	=	1,490E+8 mm4
Iw	=	2,180E+13 mm6
Wel,y	=	8,978E+6 mm3
Weff,y	=	8,978E+6 mm3
Wpl,y	=	1,023E+7 mm3
Wel,z	=	9,933E+5 mm3
Weff,z	=	9,933E+5 mm3
Wpl,z	=	1,553E+6 mm3

Capacity:

Cross Section Class: 4/1/1 N/My/Mz

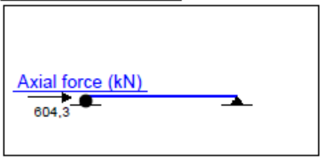
Nt,Rd	=	10316,6 kN
Nc,Rd	=	9891,2 kN
My,Rd	=	3157,6 kNm
Mz,Rd	=	479,4 kNm
Vc,z,Rd	=	2883,2 kN
Vc,y,Rd	=	2352,6 kN

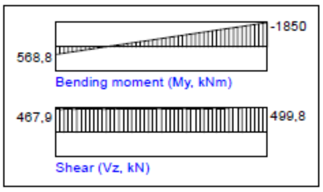
Geometry/Loading:

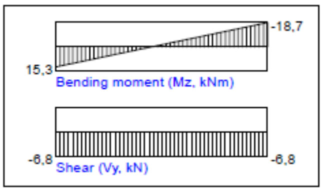


End Supports: Non-rigid

Endforces: (kN/kNm/m)



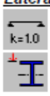




Buckling parameters:

		Y-axis	Z-axis
Buckling length factor		1,00	1,00
Buckling Curve		a	b
Slenderness	lamda =	0,20	0,96
Interaction factors kij:	Method 1		

Lateral buckling parameters:



Mb,Rd = 3153,1 kNm (lateral torsional buckling) C1 = 2,127
Lateral torsional buckling curves: General Case (conservative, ch 6.3.2.2)

Governing Loadcase: Basic loads: G + Q1 + Q2

SECTION CONTROL:

IR = My,Ed/My,Rd = 1850,0/3157,6 = 0,59 < 1,0 (1,00L; Ch 6.2.5)
IR = My,Ed/MN,y,Rd = 1850,0/3157,6 = 0,59 < 1,0 (1,00L; Ch 6.2.9)
IR = Vz,Ed/Vz,Rd = 499,8/2883,2 = 0,17 < 1,0 (1,00L; Ch 6.2.6)

BUCKLING CONTROL: (incl Lateral Torsional Buckling)

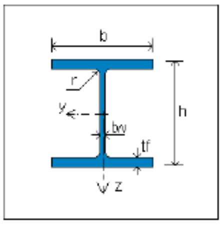
IR = NEd/Nb,y,Rd +kyy*My,Ed/(xLT*My,Ed) +kyz*Mz,Ed/Mz,Ed) = 604,3/9891,2+0,86*1850,0/(1,00*3157,6)+0,58*18,7/479,4 = 0,59 < 1,0 (Ch 6.3.1)
IR = NEd/Nb,z,Rd +kzy*My,Ed/(xLT*My,Ed) +kzz*Mz,Ed/Mz,Ed = 604,3/6160,5+0,46*1850,0/(1,00*3157,6)+0,61*18,7/479,4) = 0,39 < 1,0 (Ch 6.3.1)
IR = My,Ed/Mb,Rd = -1850,0/3153,1 = 0,59 < 1,0 (Ch 6.3.2.1

COLBEAM EC3 - User defined	Project: MX301020	Page: 1/1
Version 1.0.6 Member Design Program incl updates until Apr 2009 Copyright (C) 2010 StruProg AB	Identification: 609	Date: 12.06.2012 Time: 16:6
File: i:\master project\calculation\member assesment\mx301020lc609.cec		

General:

Material:	S355	fy	=	355 MPa	E	=	210000,0 MPa
gm0/gm1 =	1,15/1,15						

Profile: HEB800



Dimensions and weight:

h	=	800,0 mm
b	=	300,0 mm
tw	=	17,5 mm
tf	=	33,0 mm
r	=	30,0 mm
g	=	262,3 kg/m
S	=	2,713 m2/m

Section property:

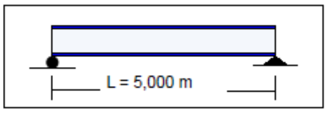
A	=	33420 mm2
Aeff	=	32042 mm2
Ix	=	9,490E+6 mm4
Iy	=	3,591E+9 mm4
Iz	=	1,490E+8 mm4
Iw	=	2,180E+13 mm6
Wel,y	=	8,978E+6 mm3
Weff,y	=	8,978E+6 mm3
Wpl,y	=	1,023E+7 mm3
Wel,z	=	9,933E+5 mm3
Weff,z	=	9,933E+5 mm3
Wpl,z	=	1,553E+6 mm3

Capacity:

Cross Section Class: 4/1/1 N/My/Mz

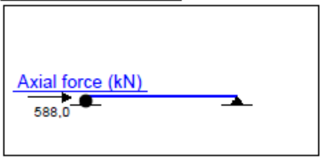
Nt,Rd	=	10316,6 kN
Nc,Rd	=	9891,2 kN
My,Rd	=	3157,6 kNm
Mz,Rd	=	479,4 kNm
Vc,z,Rd	=	2883,2 kN
Vc,y,Rd	=	2352,6 kN

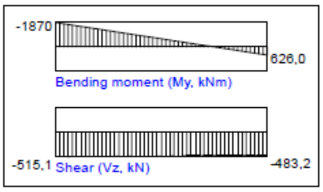
Geometry/Loading:

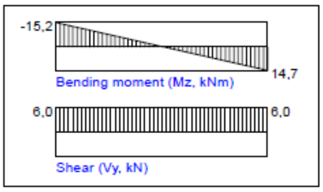


End Supports: Non-rigid

Endforces: (kN/kNm/m)

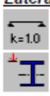






Buckling parameters:		Y-axis	Z-axis
Buckling length factor		1,00	1,00
Buckling Curve		a	b
Slenderness	lamda =	0,20	0,96
Interaction factors kij:	Method 1		

Lateral buckling parameters:



Mb,Rd = 3157,6 kNm (lateral torsional buckling) C1 = 2,158
Lateral torsional buckling curves: General Case (conservative, ch 6.3.2.2)

Governing Loadcase: Basic loads: G + Q1 + Q2

SECTION CONTROL:

IR = My,Ed/My,Rd = 1870,0/3157,6 = 0,59 < 1,0 (0,00L; Ch 6.2.5)
IR = My,Ed/MN,y,Rd = 1870,0/3157,6 = 0,59 < 1,0 (0,00L; Ch 6.2.9)
IR = Vz,Ed/Vz,Rd = 515,1/2883,2 = 0,18 < 1,0 (0,00L; Ch 6.2.6)

BUCKLING CONTROL: (incl Lateral Torsional Buckling)

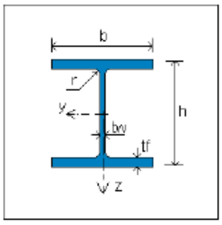
IR = NEd/Nb,y,Rd +kyy*My,Ed/(xLT*My,Ed) +kyz*Mz,Ed/Mz,Ed) = 588,0/9891,2+0,86*1870,0/(1,00*3157,6)+0,55*15,2/479,4 = 0,58 < 1,0 (Ch 6.3.1)
IR = NEd/Nb,z,Rd +kzy*My,Ed/(xLT*My,Ed) +kzz*Mz,Ed/Mz,Ed = 588,0/6160,5+0,46*1870,0/(1,00*3157,6)+0,57*15,2/479,4) = 0,38 < 1,0 (Ch 6.3.1)
IR = My,Ed/Mb,Rd = -1870,0/3157,6 = 0,59 < 1,0 (Ch 6.3.2.1

COLBEAM EC3 - User defined	Project: MX304020		Page: 1/1
Version 1.0.6 Member Design Program incl updates until Apr 2009 Copyright (C) 2010 StruProg AB	Identification: 609	Date: 12.06.2012 Time: 16:6	
File: i:\master project\calculation\member assesment\mx304020lc609.cec			

General:

Material:	S355	fy	=	355	MPa	E	=	210000,0 MPa
gm0/gm1 =	1,15/1,15							

Profile: HEB800



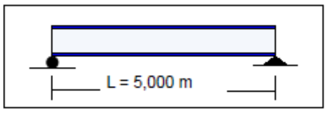
Dimensions and weight:			
h	=	800,0	mm
b	=	300,0	mm
tw	=	17,5	mm
tf	=	33,0	mm
r	=	30,0	mm
g	=	262,3	kg/m
S	=	2,713	m2/m

Section property:		
A	=	33420 mm2
Aeff	=	32042 mm2
Ix	=	9,490E+6 mm4
Iy	=	3,591E+9 mm4
Iz	=	1,490E+8 mm4
Iw	=	2,180E+13 mm6
Wel,y	=	8,978E+6 mm3
Weff,y	=	8,978E+6 mm3
Wpl,y	=	1,023E+7 mm3
Wel,z	=	9,933E+5 mm3
Weff,z	=	9,933E+5 mm3
Wpl,z	=	1,553E+6 mm3

Capacity:
Cross Section Class: 4/1/1 N/My/Mz

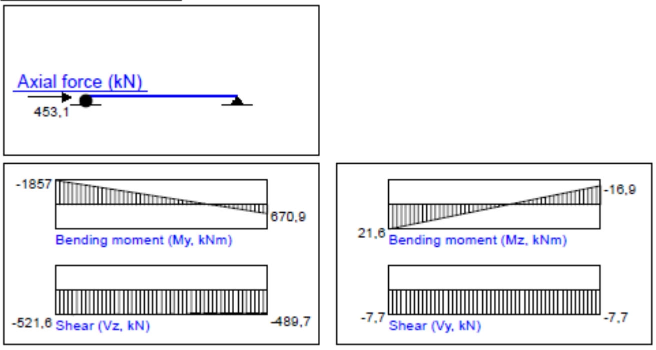
Nt,Rd	=	10316,6	kN
Nc,Rd	=	9891,2	kN
My,Rd	=	3157,6	kNm
Mz,Rd	=	479,4	kNm
Vc,z,Rd	=	2883,2	kN
Vc,y,Rd	=	2352,6	kN

Geometry/Loading:



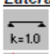
End Supports: Non-rigid

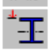
Endforces: (kN/kNm/m)



Buckling parameters:		Y-axis	Z-axis
Buckling length factor		1,00	1,00
Buckling Curve		a	b
Slenderness	lamda =	0,20	0,96
Interaction factors kij:	Method 1		

Lateral buckling parameters:





Mb,Rd = 3157,6 kNm (lateral torsional buckling) C1 = 2,189
Lateral torsional buckling curves: General Case (conservative, ch 6.3.2.2)

Governing Loadcase: Basic loads: G + Q1 + Q2

SECTION CONTROL:

IR = My,Ed/My,Rd = 1857,0/3157,6 = 0,59 < 1,0 (0,00L; Ch 6.2.5)
IR = My,Ed/MN,y,Rd = 1857,0/3157,6 = 0,59 < 1,0 (0,00L; Ch 6.2.9)
IR = Vz,Ed/Vz,Rd = 521,6/2883,2 = 0,18 < 1,0 (0,00L; Ch 6.2.6)

BUCKLING CONTROL: (incl Lateral Torsional Buckling)
No Buckling, ref ch 6.3.1.2 (4); lamdaby/lamdabz<=0.2 or Ned/Ncry<=0.04; Ned/Ncry<=0.04
IR = My,Ed/Mb,Rd = -1857,0/3157,6 = 0,59 < 1,0 (Ch 6.3.2.1/6.3.2.3)

F. DESIGN CHECK OF PADEYES

Padeye analysis

The Lifting design will be performed according to Aker Solutions working instruction.

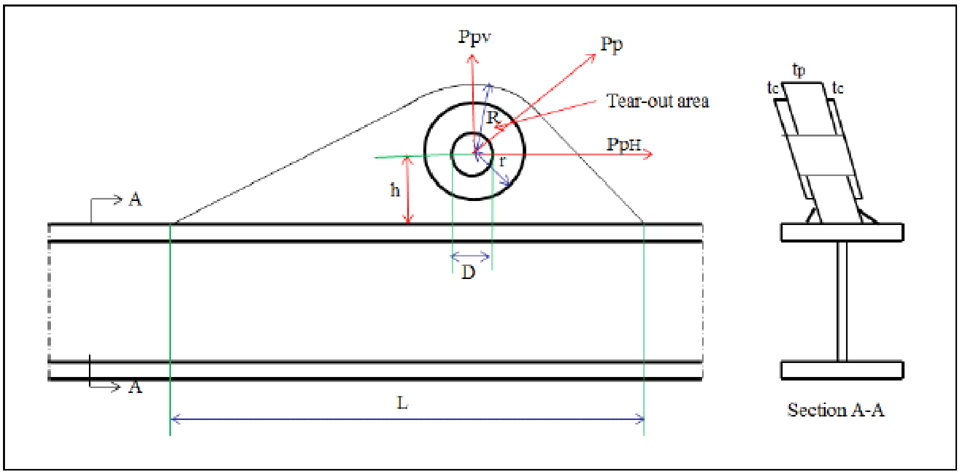


Figure F-1 Padeye geometry

Heaviest loaded lifting point normally be the point closest to CoG. This point have a maximum vertical reaction for design, P_{LP}, as illustrated by Figure F-1

Input data from drawing of existing padeye:

$d_{hole} := 301.0mm$ Padeye hole diameter

$d_{pin} := 290.0mm$ Pin diameter

$r_{cheek} := 577.0mm$ Cheek plate radius

$R_{plate} := 680.0mm$ Minimum radius from pin hole to padeye edge

$t_{plate} := 160.0mm$ Padeye thickness

$t_{cheek} := 80.0mm$ Cheek plate thickness

$a_{weld} := 32mm$ Nominal throat size of fillet weld

$\beta := 70deg$ Loading angle

$f_y := 420\frac{N}{mm^2}$ Yield strength $f_u := 520\frac{N}{mm^2}$ Ultimate tensile strength

$\gamma_m := 1.3$ Material factor for lifting padeye

$\gamma_F := 1.3$ Load factor, Ref. [19]

$\gamma_c := 1.3$ Consequence factor, Ref. [19]

$\gamma_{m2} := 1.3$ Material factor

$WCF := 1.1$ Weight contingency factor, Ref. [19]

$SKL := 1.250$ Skew load factor, Ref. [19]

$DAF := 1.30$ Dynamic Amplification factor Ref. [21]

$DF := \gamma_F \cdot \gamma_c$ Design factor, Ref. [19]

According to Aker Solution working instruction, the vertical reaction P_{LP} for 4 point lift can be computed as follows:

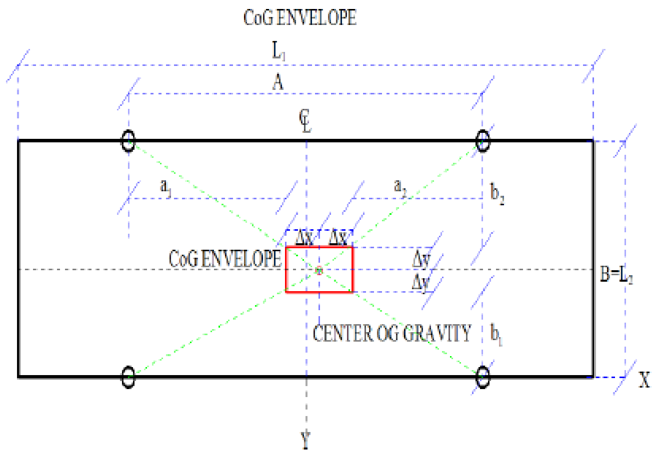


Figure F-2 Center of Gravity Envelope

The COG shift factor applicable in the analysis can be calculated independent as it presents in Figure F-2, on the actual location of the envelope location as follows:

$L_1 := 40.0m$ Length of Module

$L_2 := 20.0m$ Width of Module

$A := 20.0m$ Length between pad eye

$B := 20.0m$ Width between pad eye

$\Delta x := 2.5\% \cdot (L_1)$ $\Delta x = 1\,m$ 1/2 Length of Envelope

$\Delta y := 2.5\% \cdot (L_2)$ $\Delta y = 0.5\,m$ 1/2 Width of Envelope

$\gamma_{CoG} := \frac{A + \Delta x}{A} \cdot \frac{B + \Delta y}{B}$ Minimum := 1.05

$CoG_x := 20m$ Center of Gravity , x-axis (GeniE analysis)

$CoG_y := 9.9773m$ Center of Gravity , y-axis (GeniE analysis)

$a_1 := CoG_x - 10m$ $a_1 = 10\,m$

$b_1 := CoG_y$ $b_1 = 9.977\,m$

$a_2 := 40m - CoG_x$ $a_2 = 20\,m$

$b_2 := B - CoG_y$ $b_2 = 10.023\,m$

$\gamma_{CoG1} := \frac{(a_1 + \Delta x)}{a_1} \cdot \frac{(b_1 + \Delta y)}{b_1}$ $\gamma_{CoG1} = 1.155$

$\gamma_{CoG2} := \frac{(a_1 + \Delta x)}{a_1} \cdot \frac{(b_2 + \Delta y)}{b_2}$ $\gamma_{CoG2} = 1.155$

$\gamma_{CoG3} := \frac{(a_2 + \Delta x)}{a_2} \cdot \frac{(b_1 + \Delta y)}{b_1}$ $\gamma_{CoG3} = 1.103$

$\gamma_{CoG4} := \frac{(a_2 + \Delta x)}{a_2} \cdot \frac{(b_2 + \Delta y)}{b_2}$ $\gamma_{CoG4} = 1.102$

The maximum value of CoG envelope factor should be selected:

$\gamma_{cog} := \gamma_{CoG2}$ $\gamma_{cog} = 1.155$ CoG envelop factor WCOG

$P_P := 14.715MN$ Maximum unfactored vertical reaction force

$P_{LP} := P_P \cdot WCF \cdot \gamma_{cog} \cdot SKL \cdot DAF$

$P_{LP} = 30.4 \cdot MN$ Maximum sling Load

Load components

Main Padeye force:

$$P_p := \frac{P_{LP} \cdot DF}{\sin(\beta)} \qquad P_p = 54.6 \cdot MN \qquad \text{Sling Load}$$

$$P_{pv} := P_p \cdot \sin(\beta) \qquad P_{pv} = 51.3 \cdot MN \qquad \text{Vertical Load}$$

$$P_{PH} := P_p \cdot \cos(\beta) \qquad P_{PH} = 18.7 \cdot MN \qquad \text{Horizontal load}$$

Design Strength

$$f_d := \frac{f_y}{\gamma_m} \qquad f_d = 323.1 \cdot MPa$$

Tear out Stress

$$A_{sh} := \left(R_{plate} - \frac{d_{hole}}{2}\right) \cdot t_{plate} + 2 \cdot \left(r_{cheek} - \frac{d_{hole}}{2}\right) \cdot t_{cheek} \qquad A_{sh} = 1.53 \times 10^{5} \cdot mm^{2}$$

$$\tau_{ED} := \frac{P_p}{2A_{sh}} \qquad \tau_{ED} = 178.6 \cdot MPa$$

Shear Design strength

$$f_{d.} := \frac{f_y}{\sqrt{3} \cdot \gamma_m} \qquad f_{d.} = 186.5 \cdot MPa$$

$$UF_{tot} := \frac{\tau_{ED}}{f_{d.}}$$

$UF_{tot} = 0.55$ The Padeye has sufficient capacity

Load bearing strength at pin hole edge

Load Bearing Strength, Ref. [19]

$$\gamma_{m2} = 1.3$$

$$\sigma_{db} := 1.5 \cdot \frac{f_u}{\gamma_{m2}} \qquad \sigma_{db} = 600 \cdot MPa$$

Pin hole Bearing Stress:

$$t_{eff} := t_{plate} + 2t_{cheek}$$

$$\sigma_b := \frac{P_p}{t_{eff} \cdot d_{pin}} \qquad \sigma_b = 588.7 \cdot MPa$$

Bearing Stress Intersection Ratio:

$$IR := \frac{\sigma_b}{\sigma_{db}} \qquad IR = 0.98$$

Cheek Plate Fillet Weld

Effective weld strength:

$$L_{eff} := \frac{4}{3} \cdot \pi\, r_{cheek} \qquad L_{eff} = 2416.9 \cdot mm$$

Load through weld:

$$P_{cp} := \frac{P_p \cdot t_{cheek}}{\left(t_{plate} + 2t_{cheek}\right) \cdot L_{eff} \cdot a_{weld}}$$

$$f_{vd} := \frac{f_y}{\gamma_m \cdot \sqrt{3}} \qquad f_{vd} = 186.5 \cdot MPa$$

$$\tau_{ED.} := \frac{P_p \cdot t_{cheek}}{\left(t_{plate} + 2t_{cheek}\right) \cdot \frac{4}{3} \cdot r_{cheek} \cdot \pi \cdot a_{weld}} \qquad \tau_{ED} = 178.6 \cdot MPa$$

$$UF_{tot.} := \frac{\tau_{ED.}}{f_{vd}} \qquad UF_{tot.} = 0.95$$

G. DESIGN CHECK OF JOINTS

QuickNodeCheck - Screening - Inplace - Master module

- Joint UF based on a combination of incoming members UF's

- Check "Readme" sheet for explanations

(*) - The three highest UF's are used with the worst possible
sign combination of normal stresses in a 3D Von Mises check.

Joint	Translational (A,B,X)	Longitudinal (Y)	Vertical (C,D,E,F,Z)	UF (*)	
J101010	0.236	0.389	0.511	0.83	
J101020	0.119	0.104	0.184	0.30	
J101030	0.128	0.147	0.158	0.30	
J101040	0.055	0.115	0.135	0.23	
J101320	0.000	0.300	0.402	0.61	
J101520	0.000	0.168	0.000	0.17	
J101530	0.000	0.143	0.000	0.14	
J101540	0.000	0.044	0.000	0.04	
J101730	0.000	0.228	0.299	0.46	
J102010	0.054	0.414	0.000	0.44	
J102020	0.053	0.226	0.000	0.26	
J102030	0.075	0.125	0.000	0.18	
J102040	0.399	0.399	0.472	0.87	
J102520	0.000	0.323	0.454	0.68	
J102530	0.000	0.277	0.337	0.53	
J104010	0.257	0.407	0.565	0.91	
J104020	0.143	0.076	0.203	0.32	
J104030	0.126	0.136	0.189	0.32	
J104040	0.110	0.354	0.216	0.53	
J151020	0.163	0.000	0.408	0.51	
J154020	0.241	0.000	0.469	0.63	
J201010	0.171	0.088	0.000	0.23	
J201020	0.186	0.080	0.000	0.24	
J201030	0.142	0.071	0.000	0.19	
J201040	0.075	0.075	0.000	0.13	
J201520	0.000	0.151	0.000	0.15	
J201530	0.000	0.115	0.000	0.12	
J201540	0.000	0.141	0.000	0.14	
J202010	0.170	0.162	0.000	0.29	
J202020	0.132	0.064	0.000	0.17	
J202030	0.222	0.074	0.000	0.27	
J202040	0.386	0.173	0.000	0.50	
J204010	0.185	0.074	0.000	0.23	
J204020	0.176	0.077	0.000	0.22	
J204030	0.185	0.113	0.000	0.26	
J204040	0.149	0.137	0.000	0.25	
J251030	0.142	0.000	0.383	0.47	
J254030	0.196	0.000	0.462	0.59	
J301005	0.000	0.000	0.082	0.08	
J301010	0.446	0.427	0.577	1.01	Ref J304010
J301020	0.387	0.421	0.602	1.01	Ref J304020
J301030	0.363	0.407	0.380	0.78	
J301040	0.186	0.366	0.426	0.72	
J302010	0.380	0.312	0.000	0.60	
J302020	0.219	0.391	0.000	0.54	
J302030	0.168	0.304	0.000	0.41	
J302040	0.217	0.383	0.000	0.53	
J304005	0.000	0.000	0.087	0.09	
J304010	0.452	0.476	0.601	1.07	Checked
J304020	0.388	0.456	0.624	1.05	checked
J304030	0.392	0.458	0.409	0.86	
J304040	0.272	0.430	0.489	0.85	
J351030	0.195	0.000	0.400	0.53	
J354030	0.195	0.000	0.397	0.52	
J401010	0.161	0.071	0.000	0.21	
J401020	0.215	0.120	0.000	0.29	
J401030	0.150	0.084	0.000	0.21	
J401040	0.110	0.077	0.000	0.16	
J402010	0.160	0.147	0.000	0.27	
J402020	0.175	0.105	0.000	0.25	
J402030	0.161	0.131	0.000	0.25	
J402040	0.252	0.241	0.000	0.43	
J404010	0.158	0.068	0.000	0.20	
J404020	0.215	0.111	0.000	0.29	
J404030	0.155	0.082	0.000	0.21	
J404040	0.175	0.146	0.000	0.28	
J451020	0.257	0.000	0.464	0.63	
J454020	0.276	0.000	0.461	0.64	
J501010	0.236	0.203	0.588	0.81	
J501020	0.201	0.229	0.500	0.72	
J501030	0.075	0.257	0.314	0.51	

Joint	Translational (A,B,X)	Longitudinal (Y)	Vertical (C,D,E,F,Z)	UF (*)
J501040	0.070	0.173	0.333	0.46
J502010	0.065	0.258	0.000	0.30
J502020	0.059	0.312	0.000	0.35
J502030	0.110	0.260	0.000	0.33
J502040	0.121	0.251	0.000	0.33
J504010	0.242	0.203	0.588	0.81
J504020	0.201	0.246	0.504	0.73
J504030	0.075	0.252	0.314	0.50
J504040	0.065	0.166	0.337	0.46
J551020	0.267	0.000	0.449	0.63
J554020	0.267	0.000	0.464	0.64
J601010	0.136	0.069	0.000	0.18
J601020	0.215	0.107	0.000	0.28
J601030	0.155	0.085	0.000	0.21
J601040	0.103	0.066	0.000	0.15
J602010	0.121	0.145	0.000	0.23
J602020	0.120	0.115	0.000	0.20
J602030	0.151	0.142	0.000	0.25
J602040	0.061	0.153	0.000	0.19
J604010	0.133	0.065	0.000	0.17
J604020	0.212	0.104	0.000	0.28
J604030	0.161	0.082	0.000	0.21
J604040	0.095	0.067	0.000	0.14
J651030	0.171	0.000	0.398	0.51
J654030	0.172	0.000	0.426	0.53
J701005	0.000	0.000	0.076	0.08
J701010	0.420	0.425	0.570	0.99
J701020	0.394	0.420	0.581	0.99
J701030	0.332	0.412	0.379	0.77
J701040	0.172	0.258	0.316	0.54
J702010	0.424	0.345	0.000	0.67
J702020	0.166	0.347	0.000	0.45
J702030	0.128	0.309	0.000	0.39
J702040	0.213	0.242	0.000	0.39
J704005	0.000	0.000	0.075	0.08
J704010	0.423	0.477	0.575	1.03
J704020	0.397	0.444	0.584	1.01
J704030	0.339	0.404	0.384	0.77
J704040	0.168	0.247	0.311	0.52
J751030	0.172	0.000	0.351	0.46
J754030	0.163	0.000	0.371	0.47
J801010	0.148	0.097	0.000	0.21
J801020	0.145	0.064	0.000	0.19
J801030	0.123	0.070	0.000	0.17
J801040	0.074	0.064	0.000	0.12
J802010	0.277	0.214	0.000	0.43
J802020	0.169	0.075	0.000	0.22
J802030	0.227	0.102	0.000	0.29
J802040	0.285	0.115	0.000	0.36
J804010	0.145	0.095	0.000	0.21
J804020	0.195	0.056	0.000	0.23
J804030	0.113	0.063	0.000	0.15
J804040	0.064	0.060	0.000	0.11
J851020	0.220	0.000	0.387	0.53
J854020	0.187	0.000	0.409	0.53
J901010	0.225	0.297	0.537	0.80
J901020	0.122	0.091	0.203	0.31
J901030	0.118	0.122	0.156	0.28
J901040	0.050	0.099	0.143	0.22
J901520	0.000	0.208	0.366	0.50
J901530	0.000	0.216	0.207	0.37
J902010	0.074	0.330	0.000	0.37
J902020	0.094	0.298	0.000	0.35
J902030	0.098	0.264	0.000	0.32
J902040	0.266	0.159	0.316	0.54
J902520	0.000	0.270	0.438	0.62
J902530	0.000	0.326	0.265	0.51
J904010	0.215	0.292	0.557	0.81
J904020	0.228	0.287	0.210	0.51
J904030	0.137	0.146	0.145	0.29
J904040	0.063	0.159	0.128	0.26

Figure G-1 Screening Inplace condition

QuickNodeCheck - Screening - Lift - Master Module

- Joint UF based on a combination of incoming members UF's
- Check "Readme" sheet for explanations

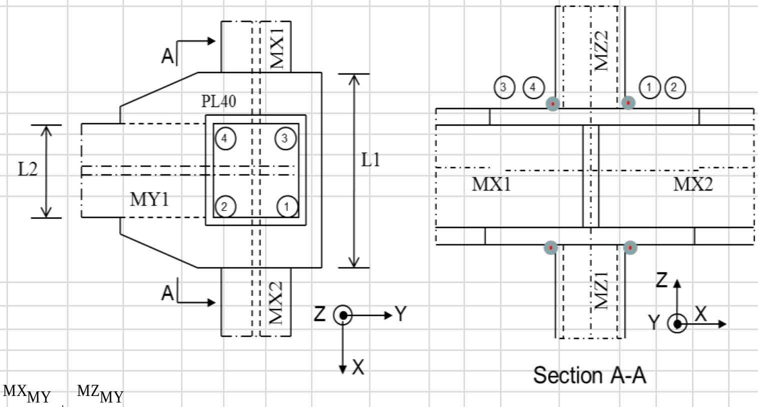
(*) - The three highest UF's are used with the worst possible
sign combination of normal stresses in a 3D Von Mises check.

Joint	Translational (A,B,X)	Longitudinal (Y)	Vertical (C,D,E,F,Z)	UF (*)		Joint	Translational (A,B,X)	Longitudinal (Y)	Vertical (C,D,E,F,Z)	UF (*)	
J101010	0.118	0.382	0.373	0.67		J501040	0.228	0.283	0.526	0.78	
J101020	0.088	0.088	0.155	0.24		J502010	0.603	0.177	0.468	0.96	
J101030	0.073	0.048	0.109	0.17		J502020	0.291	0.507	0.000	0.70	
J101040	0.040	0.063	0.111	0.16		J502030	0.207	0.552	0.000	0.68	
J101320	0.000	0.164	0.238	0.35		J502040	0.262	0.447	0.000	0.62	
J101520	0.000	0.073	0.000	0.07		J504010	0.214	0.190	0.518	0.72	
J101530	0.000	0.015	0.000	0.02		J504020	0.320	0.379	0.659	1.01	checked
J101540	0.000	0.053	0.000	0.05		J504030	0.077	0.497	0.595	0.95	
J101730	0.000	0.137	0.153	0.25		J504040	0.170	0.291	0.545	0.78	
J102010	0.097	0.433	0.000	0.49		J551020	0.287	0.000	0.522	0.71	
J102020	0.050	0.180	0.000	0.21		J554020	0.274	0.000	0.410	0.60	
J102030	0.090	0.124	0.000	0.19		J601010	0.114	0.113	0.369	0.48	
J102040	0.276	0.051	0.269	0.48		J601020	0.224	0.167	0.000	0.34	
J102520	0.000	0.189	0.271	0.40		J601030	0.289	0.151	0.000	0.39	
J102530	0.000	0.167	0.161	0.28		J601040	0.288	0.113	0.000	0.36	
J104010	0.122	0.415	0.382	0.70		J602010	0.255	0.144	0.000	0.35	
J104020	0.083	0.075	0.153	0.23		J602020	0.330	0.145	0.000	0.42	
J104030	0.057	0.020	0.055	0.10		J602030	0.285	0.304	0.000	0.51	
J104040	0.039	0.034	0.078	0.11		J602040	0.352	0.376	0.000	0.63	
J151020	0.181	0.000	0.309	0.43		J604010	0.146	0.104	0.325	0.45	
J154020	0.197	0.000	0.370	0.50		J604020	0.199	0.156	0.000	0.31	
J201010	0.081	0.123	0.229	0.33		J604030	0.263	0.142	0.000	0.36	
J201020	0.174	0.101	0.000	0.24		J604040	0.257	0.114	0.000	0.33	
J201030	0.194	0.108	0.000	0.27		J651030	0.312	0.000	0.547	0.75	
J201040	0.095	0.089	0.000	0.16		J654030	0.277	0.000	0.430	0.62	
J201520	0.000	0.163	0.000	0.16		J701005	0.000	0.000	0.000	0.00	
J201530	0.000	0.193	0.000	0.19		J701010	0.158	0.409	0.502	0.82	
J201540	0.000	0.186	0.000	0.19		J701020	0.266	0.291	0.349	0.63	
J202010	0.359	0.251	0.000	0.53		J701030	0.227	0.684	0.495	1.07	Ref J304030
J202020	0.231	0.150	0.000	0.33		J701040	0.594	0.623	0.527	1.18	Ref J304040
J202030	0.309	0.164	0.000	0.42		J702010	0.469	0.567	0.000	0.90	
J202040	0.262	0.152	0.000	0.36		J702020	0.571	0.092	0.453	0.90	
J204010	0.076	0.114	0.211	0.31		J702030	0.172	0.514	0.000	0.62	
J204020	0.122	0.089	0.000	0.18		J702040	0.313	0.450	0.000	0.66	
J204030	0.336	0.224	0.000	0.49		J704005	0.000	0.000	0.000	0.00	
J204040	0.097	0.090	0.000	0.16		J704010	0.163	0.477	0.559	0.92	
J251030	0.237	0.000	0.382	0.54		J704020	0.228	0.294	0.337	0.60	
J254030	0.375	0.000	0.457	0.72		J704030	0.163	0.667	0.508	1.05	Ref J304030
J301005	0.000	0.000	0.000	0.00		J704040	0.539	0.616	0.539	1.16	Ref J304040
J301010	0.144	0.378	0.458	0.75		J751030	0.252	0.000	0.415	0.58	
J301020	0.266	0.276	0.343	0.61		J754030	0.255	0.000	0.433	0.60	
J301030	0.208	0.700	0.503	1.09	Ref J304030	J801010	0.078	0.160	0.249	0.37	
J301040	0.580	0.620	0.526	1.17	Ref J304010	J801020	0.091	0.065	0.000	0.14	
J302010	0.343	0.509	0.000	0.74		J801030	0.201	0.109	0.000	0.27	
J302020	0.714	0.117	0.466	1.05		J801040	0.099	0.090	0.000	0.16	
J302030	0.211	0.558	0.000	0.69		J802010	0.478	0.307	0.000	0.69	
J302040	0.312	0.447	0.000	0.66		J802020	0.157	0.088	0.000	0.21	
J304005	0.000	0.000	0.000	0.00		J802030	0.240	0.185	0.000	0.37	
J304010	0.149	0.444	0.515	0.85		J802040	0.268	0.159	0.000	0.37	
J304020	0.231	0.291	0.315	0.58		J804010	0.089	0.151	0.225	0.35	
J304030	0.140	0.807	0.557	1.21	Checked	J804020	0.234	0.058	0.000	0.27	
J304040	0.543	0.626	0.552	1.17	Checked	J804030	0.193	0.098	0.000	0.26	
J351030	0.328	0.000	0.536	0.76		J804040	0.097	0.088	0.000	0.16	
J354030	0.304	0.000	0.432	0.64		J851020	0.238	0.000	0.390	0.55	
J401010	0.106	0.118	0.354	0.47		J854020	0.309	0.000	0.419	0.63	
J401020	0.250	0.185	0.000	0.38		J901010	0.136	0.435	0.599	0.92	
J401030	0.306	0.162	0.000	0.41		J901020	0.082	0.158	0.255	0.38	
J401040	0.288	0.113	0.000	0.36		J901030	0.077	0.036	0.111	0.17	
J402010	0.368	0.147	0.000	0.46		J901040	0.041	0.039	0.115	0.16	
J402020	0.479	0.189	0.000	0.60		J901520	0.000	0.121	0.317	0.39	
J402030	0.364	0.305	0.000	0.58		J901530	0.000	0.132	0.127	0.22	
J402040	0.355	0.374	0.000	0.63		J902010	0.123	0.500	0.000	0.57	
J404010	0.119	0.108	0.308	0.42		J902020	0.019	0.116	0.000	0.13	
J404020	0.265	0.201	0.000	0.40		J902030	0.072	0.231	0.000	0.27	
J404030	0.284	0.154	0.000	0.38		J902040	0.266	0.062	0.251	0.45	
J404040	0.261	0.113	0.000	0.33		J902520	0.000	0.133	0.334	0.42	
J451020	0.296	0.000	0.495	0.69		J902530	0.000	0.220	0.114	0.29	
J454020	0.301	0.000	0.369	0.58		J904010	0.131	0.443	0.585	0.91	
J501010	0.221	0.157	0.505	0.70		J904020	0.155	0.170	0.251	0.41	
J501020	0.481	0.446	0.644	1.11	Not Checked	J904030	0.118	0.055	0.101	0.20	
J501030	0.126	0.495	0.589	0.95		J904040	0.043	0.032	0.106	0.14	

Figure G-2 Screening Lift condition

Joint check - Inplace - Master module

Base deck



INPUT

Node					
J304010	MX1	MX2	MY	MZ1	MZ2
Member	MX204010	MX304010	MY302010	MZ304005	MZ304010
Section	I1242035	I1242035	I1252035	SUPP	B060640

RESULTS

UF_{max}	Dim LC
0.94	542

Material properties

γ_m	1.15	
f_y	355	MPa

Equations:

$$\sigma_{x.1T} = -\frac{FX_{MX2}}{A_{Mx}} + \frac{MY_{MX2}}{W_{y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.2T} = -\frac{FX_{MX2}}{A_{Mx}} + \frac{MY_{MX2}}{W_{y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.3T} = \frac{FX_{MX1}}{A_{Mx}} - \frac{MY_{MX1}}{W_{y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x.4T} = \frac{FX_{MX1}}{A_{Mx}} - \frac{MY_{MX1}}{W_{y.MX}} + \frac{MY_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.1B} = -\frac{FX_{MX2}}{A_{Mx}} - \frac{MY_{MX2}}{W_{y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.2B} = -\frac{FX_{MX2}}{A_{Mx}} - \frac{MY_{MX2}}{W_{y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.3B} = \frac{FX_{MX1}}{A_{Mx}} + \frac{MY_{MX1}}{W_{y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x.4B} = \frac{FX_{MX1}}{A_{Mx}} + \frac{MY_{MX1}}{W_{y.MX}} + \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{y.2T} = \frac{FY_{MY}}{A_{MY}} - \frac{MX_{MY}}{W_{y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.4T} = \frac{FY_{MY}}{A_{MY}} + \frac{MX_{MZ2}}{W_{y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.2B} = \frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.4B} = -\frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{z.1T} = -\frac{FZ_{MZ2}}{A_{Mz}} - \frac{MX_{MZ2}}{W_{y.MZ}} + \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.2T} = -\frac{FZ_{MZ2}}{A_{Mz}} + \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.3T} = -\frac{FZ_{MZ2}}{A_{Mz}} - \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.4T} = -\frac{FZ_{MZ2}}{A_{Mz}} + \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\tau_{xy.1.2.3.4.} = \frac{|FX_{MZ2}|}{2T_{w.MZ}B_{MZ}} + \frac{|FY_{MZ2}|}{2.T_{f.MZ} \cdot H_{MZ}} + \frac{|MZ_{MZ2}|}{(H_{MZ2} - T_{f.MZ2}) \cdot B_{MZ} \cdot T_{f.MZ}}$$

$$\tau_{xz.2.4.} = \frac{|FX_{MY}|}{2T_{f.MY}B_{MY}} + \frac{|MY_{MY}|}{(H_{MY} - T_{f.My}) \cdot B_{MY} \cdot T_{fMY}} + \frac{|FZ|}{H_{MY} \cdot t_{w.MY}}$$

$$\sigma_{yz.1.2.} = \frac{|FY_{MX2}|}{2T_{w.MY}B_{MX}} + \frac{|MY_{MX2}|}{(H_{MX} - T_{f.MX}) \cdot B_{MY} \cdot T_{f.MX}} + \frac{|FZ|}{H_{MX} \cdot t_{wMX}}$$

$$\sigma_{yz.3.4.} = \frac{|FY_{MX1}|}{2T_{w.MX}B_{MX}} + \frac{|MY_{MX2}|}{(H_{MX} - T_{f.MX}) \cdot B_{MX} \cdot T_{f.MX}} + \frac{|FZ|}{H_{MX} \cdot t_{w.MX}}$$

Incoming beam - y-dir

Section	I1252035	
H_{MY}	1200	mm
B_{MY}	500	mm
$T_{f\text{-}MY}$	35	mm
$T_{w\text{-}MY}$	20	mm
a	5.0	mm
A_{MY}	5.76E+04	mm^2
$W_{y\text{-}MY}$	2.38E+07	mm^3
$W_{z\text{-}MY}$	2.92E+06	mm^3

Continuous deck beam - x-dir

Section	I1242035	
H_{MX}	1200	mm
B_{MX}	400	mm
$T_{f\text{-}MX}$	35	mm
$T_{w\text{-}MX}$	20	mm
A_{MX}	5.06E+04	mm^2
$W_{x\text{-}MX}$	7.22E+05	mm^3
$W_{y\text{-}MX}$	1.98E+07	mm^3
$W_{z\text{-}MX}$	1.87E+06	mm^3

Incoming beam - column

Section	B060640	
H_{MZ}	600	mm
B_{MZ}	600	mm
$T_{f\text{-}MZ}$	40	mm
$T_{w\text{-}MZ}$	40	mm
A_{MZ}	8.96E+04	mm^2
$W_{x\text{-}MZ}$	2.51E+07	mm^3
$W_{y\text{-}MZ}$	1.57E+07	mm^3
$W_{z\text{-}MZ}$	1.57E+07	mm^3

Incoming beam - column

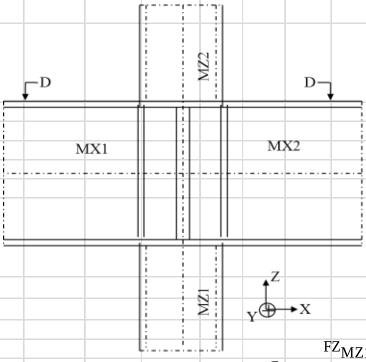
Section	SUPP	
H_{MZ}	850	mm
B_{MZ}	850	mm
$T_{f\text{-}MZ}$	60	mm
$T_{w\text{-}MZ}$	60	mm
A_{MZ}	1.46E+05	mm^2
$W_{x\text{-}MZ}$	2.92E+06	mm^3
$W_{y\text{-}MZ}$	4.67E+07	mm^3
$W_{z\text{-}MZ}$	1.45E+07	mm^3

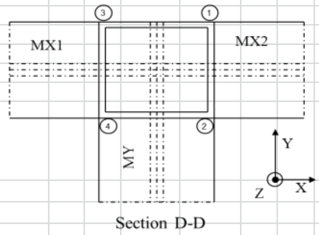
											Top flange			Bottom flange			Shear stresses			Von-Mises			
Member	LoadC	SctNam	Fx	Fy	Fz	Mx	My	Mz		Hot spot	$\sigma_{x\text{-}T}$	$\sigma_{y\text{-}T}$	$\sigma_{z\text{-}T}$	$\sigma_{x\text{-}B}$	$\sigma_{y\text{-}B}$	$\sigma_{z\text{-}B}$	τ_{yz}	τ_{xz}	$\tau_{xy\text{-}T}$	$\sigma_{j\text{-}T}$	$\sigma_{j\text{-}B}$	τ_{fill}	UF
			(kN)	(kN)	(kN)	(kNm)	(kNm)	(kNm)			(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	
MX204010	542	I1242035	-1687	-7	426	-1	2429	17		1	-13		-177	25		145	9		13	173	137		**0.94**
MX304010	542	I1242035	-21	2	214	-1	-372	10		2	-24	115	45	14	-152	-49	9	27	13	132	155		
MY302010	542	I1252035	-19	-476	644	-3170	0	-30		3	-165		-171	80		-156	18		13	172	211		
MZ304005	542	SUPP	2015	1522	-7176	1522	-2015	0		4	-147	135	45	98	-131	-221	18	27	13	257	291		
MZ304010	542	B060640	-66	-534	5889	1692	-46	3															
MX204010	543	I1242035	-1833	-2	402	-1	2285	5		1	-78		-189	45		111	14		14	168	102		**0.88**
MX304010	543	I1242035	644	-5	325	-1	-1213	-7		2	-70	149	55	52	-172	-140	14	30	14	200	219		
MY302010	543	I1252035	0	-689	714	-3830	0	1		3	-154		-219	76		-56	17		14	199	121		
MZ304005	543	SUPP	1312	1970	-8802	1970	-1312	0		4	-149	149	25	82	-173	-193	17	30	14	266	273		
MZ304010	543	B060640	43	-615	7357	1912	238	1															
MX204010	544	I1242035	-1264	4	315	-1	1655	-11		1	-141		-172	75		-12	19		14	164	92		**0.90**
MX304010	544	I1242035	1126	-10	443	-1	-2140	-20		2	-119	136	50	96	-133	-204	19	28	14	234	279		
MY302010	544	I1252035	19	-525	653	-3203	0	32		3	-103		-229	64		-6	13		14	201	76		
MZ304005	544	SUPP	-46	1506	-9433	1506	46	0		4	-114	115	-6	53	-155	-198	13	28	14	207	240		
MZ304010	544	B060640	139	-549	8018	1742	440	-1															

Figure G-3 Local analysis Joint 304010, inplace condition

Joint check - Inplace - Master module

Lower deck





INPUT

Node					
J304020	MX1	MX2	MY	MZ1	MZ2
Member	MX204020	MX304020	MY302020	MZ304010	MZ304020
Section	HE800B	HE800B	I1242035	B060640	B060640

RESULTS

UF_{max}	Dim LC
1.08	543

Material properties

γ_m	1.15	
f_y	355	MPa

Equations:

$$\sigma_{x.1T} = -\frac{FX_{MX2}}{A_{Mx}} - \frac{MY_{MX2}}{W_{y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.2T} = -\frac{FX_{MX2}}{A_{Mx}} - \frac{MY_{MX2}}{W_{y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.3T} = \frac{FX_{MX1}}{A_{Mx}} + \frac{MY_{MX1}}{W_{y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x.4T} = \frac{FX_{MX1}}{A_{Mx}} + \frac{MY_{MX1}}{W_{y.MX}} + \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x.1B} = -\frac{FX_{MX2}}{A_{Mx}} + \frac{MY_{MX2}}{W_{y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.2B} = -\frac{FX_{MX2}}{A_{Mx}} + \frac{MY_{MX2}}{W_{y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.3B} = \frac{FX_{MX1}}{A_{Mx}} - \frac{MY_{MX1}}{W_{y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x.4B} = \frac{FX_{MX1}}{A_{Mx}} - \frac{MY_{MX1}}{W_{y.MX}} + \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{y.2T} = \frac{FY_{MY}}{A_{MY}} - \frac{MX_{MY}}{W_{y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.4T} = \frac{FY_{MY}}{A_{MY}} - \frac{MX_{MZ2}}{W_{y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.2B} = \frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.4B} = \frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{z.1T} = -\frac{FZ_{MZ2}}{A_{Mz}} - \frac{MX_{MZ2}}{W_{y.MZ}} + \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.2T} = -\frac{FZ_{MZ2}}{A_{Mz}} + \frac{MX_{MZ2}}{W_{y.MZ}} + \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.3T} = -\frac{FZ_{MZ2}}{A_{Mz}} - \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.4T} = -\frac{FZ_{MZ2}}{A_{Mz}} + \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.1B} = \frac{FZ_{MZ1}}{A_{Mz}} + \frac{MX_{MZ1}}{W_{y.MZ}} - \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{z.2B} = \frac{FZ_{MZ1}}{A_{Mz}} - \frac{MX_{MZ1}}{W_{y.MZ}} - \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{z.3B} = \frac{FZ_{MZ1}}{A_{Mz}} + \frac{MX_{MZ1}}{W_{y.MZ}} + \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{z.4B} = \frac{FZ_{MZ1}}{A_{Mz}} - \frac{MX_{MZ1}}{W_{y.MZ}} + \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\tau_{xy.1.2.3.4.T.} = \frac{|FX_{MZ2}|}{2T_{f.MZ}B_{MZ}} + \frac{|FY_{MZ2}|}{2.T_{f.Mz} \cdot H_{MZ}} + \frac{|MZ_{MZ2}|}{(H_{MZ2} - T_{f.MZ2}) \cdot B_{MZ} \cdot T_{f.MZ}}$$

$$\tau_{xy.1.2.3.4.B.} = \frac{|FX_{MZ1}|}{2T_{f.MZ}B_{MZ}} + \frac{|FY_{MZ1}|}{2.T_{f.Mz} \cdot H_{MZ}} + \frac{|MZ_{MZ1}|}{(H_{MZ2} - T_{f.MZ1}) \cdot B_{MZ} \cdot T_{f.MZ}}$$

$$\tau_{xz.2.4.} = \frac{|FX_{MY}|}{2T_{f.MY}B_{MY}} + \frac{|MY_{MY}|}{(H_{MY} - T_{f.MY}) \cdot B_{MY} \cdot T_{fMY}} + \frac{|FZ_{MY}|}{H_{MY} \cdot t_{w.MY}}$$

$$\sigma_{yz.1.2.} = \frac{|FY_{MX2}|}{2T_{w.MY}B_{MX}} + \frac{|MX_{MX2}|}{(H_{MX} - T_{f.MX}) \cdot B_{MX} \cdot T_{f.MX}} + \frac{|FZ_{MX2}|}{H_{MX} \cdot t_{wMX}}$$

$$\sigma_{yz.3.4.} = \frac{|FY_{MX1}|}{2T_{w.MX}B_{MX}} + \frac{|MX_{MX2}|}{(H_{MX} - T_{f.MX}) \cdot B_{MX} \cdot T_{f.MX}} + \frac{|FZ_{MX1}|}{H_{MX} \cdot t_{w.MX}}$$

Incoming beam - y-dir

Section	I1242035	
H_{MY}	1200	mm
B_{MY}	400	mm
T_{f-MY}	35	mm (2)
T_{w-MY}	20	mm (1)
a	5.0	mm
A_{MY}	5.06E+04	mm^2
W_{y-MY}	1.98E+07	mm^3
W_{z-MY}	1.87E+06	mm^3

Continuous deck beam - x-dir

Section	HE800B	
H_{MX}	800	mm
B_{MX}	300	mm
T_{f-MX}	33	mm
T_{w-MX}	17.5	mm
A_{MX}	3.26E+04	mm^2
W_{x-MX}	4.86E+05	mm^3
W_{y-MX}	8.73E+06	mm^3
W_{z-MX}	9.92E+05	mm^3

Incoming beam - column

Section	B060640	
H_{MZ}	600	mm
B_{MZ}	600	mm
T_{f-MZ}	40	mm (2)
T_{w-MZ}	40	mm (2)
A_{MZ}	8.96E+04	mm^2
W_{x-MZ}	2.51E+07	mm^3
W_{y-MZ}	1.57E+07	mm^3
W_{z-MZ}	1.57E+07	mm^3

Note (1):
Weld at web is assumed to carry shear only
Note (2):
Part pen weld

										Top flange			Bottom flange			Shear stresses			Von-Mises			
Member	LoadC	SctNam	Fx	Fy	Fz	Mx	My	Mz	Hot spot	σ_{x-T}	σ_{y-T}	σ_{z-T}	σ_{x-B}	σ_{y-B}	σ_{z-B}	τ_{yz}	τ_{xz}	τ_{xy-T}	σ_{j-T}	σ_{j-B}	τ_{fill}	UF
			(kN)	(kN)	(kN)	(kNm)	(kNm)	(kNm)		(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	
MX204020	523	HE800B	-28	0	207	0	708	0	1	79		-152	-83		23	16		7	206	101		**0.95**
MX304020	523	HE800B	66	0	217	-1	-706	0	2	79	141	5	-83	141	-183	16	32	7	134	294		
MY302020	523	I1242035	0	-103	765	-2838	0	0	3	80		-145	-82		16	15		7	263	95		
MZ304010	523	B060640	-29	490	-7498	1623	57	-1	4	80	141	11	-82	141	-183	15	32	7	128	294		
MZ304020	523	B060640	-16	-337	6311	1230	-53	1														
MX204020	542	HE800B	91	-3	242	0	820	6	1	31		-135	-24		30	6		9	154	50		**1.01**
MX304020	542	HE800B	5	0	78	-1	-237	4	2	23	139	-2	-31	139	-204	6	28	9	140	302		
MY302020	542	I1242035	-9	-152	673	-2871	0	-5	3	91		-106	-97		75	18		9	231	153		
MZ304010	542	B060640	52	520	-5808	1841	-349	-3	4	103	145	27	-85	145	-204	18	28	9	119	313		
MZ304020	542	B060640	-99	-320	4816	1044	-231	-1														
MX204020	543	HE800B	82	-2	208	-1	750	2	1	72		-149	-74		59	14		8	197	118		**1.08**
MX304020	543	HE800B	-17	-2	188	-1	-637	-2	2	75	159	-9	-71	159	-215	14	30	8	157	332		
MY302020	543	I1242035	0	-178	715	-3226	0	0	3	86		-129	-85		52	15		8	261	124		
MZ304010	543	B060640	-43	596	-7276	2145	48	-1	4	90	159	11	-81	159	-215	15	30	8	141	333		
MZ304020	543	B060640	-50	-350	6167	1097	-157	0														
MX204020	544	HE800B	4	0	147	0	561	-3	1	108		-146	-120		60	21		8	224	163		**1.00**
MX304020	544	HE800B	7	-3	290	-1	-993	-6	2	119	149	-7	-108	149	-181	21	29	8	157	307		
MY302020	544	I1242035	9	-139	692	-2962	0	5	3	68		-145	-61		4	11		8	260	67		
MZ304010	544	B060640	-125	536	-7937	1892	444	1	4	61	144	-6	-67	144	-181	11	29	8	141	290		
MZ304020	544	B060640	23	-330	6810	1084	-7	2														

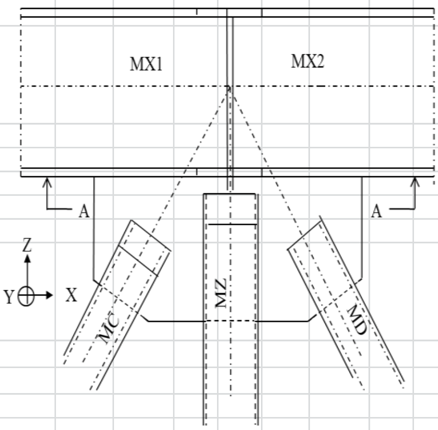
Figure G-4 Local analysis Joint 304020, inplace condition

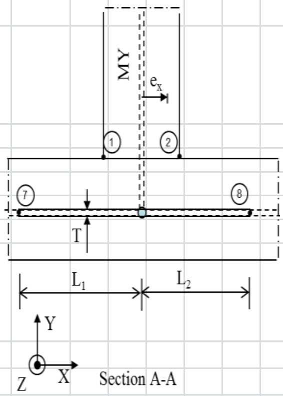
Joint check - Lift - Master Module

Weather deck

INPUT

Node						
J301040	MC	MD	MX1	MX2	MY	MZ
Member	MC251030	MD301040	MX201040	MX301040	MY301040	MZ301030
Section	B040420	B040420	I0852035	I0852035	I0852035	B060640





RESULTS

UF_{max}	Dim LC
0.87	2

Material properties

γ_m	1.15	
f_y	355	MPa

Equations:

$$\Sigma MY = MY_{MC} + MY_{MD} + MY_{MZ} + \left(FZ_{MC} + FZ_{MD} + FZ_{MZ}\right)\cdot e_X - \left(FX_{MC} + FX_{MD} + FX_{MZ}\right)\frac{H_{MX}}{2}$$

$$\tau_{XZ.1.2} = \frac{|FX_{MY}|}{2T_{f.MY}\cdot B_{MY}} + \frac{|MY_{MY}|}{\left(H_{MY} - T_{f.MY}\right)\cdot B_{MY}\cdot T_{f.MY}}$$

$$\sigma_{X.1T} = \frac{FX_{MX1}}{A_{MX}} + \frac{MY_{MX1}}{W_{Y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}} \qquad \sigma_{Y.1T} = -\frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{Y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\tau_{YZ.1} = \frac{|FY_{MX1}|}{2T_{f.MX}\cdot B_{MX}} + \frac{|MX_{MX1}|}{\left(H_{MX} - T_{f.MX}\right)\cdot B_{MX}\cdot T_{f.MX}}$$

$$\sigma_{X.2T} = -\frac{FX_{MX2}}{A_{MX}} - \frac{MY_{MX2}}{W_{Y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}} \qquad \sigma_{Y.2T} = -\frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{Y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\tau_{YZ.2} = \frac{|FY_{MX2}|}{2T_{f.MX}\cdot B_{MX}} + \frac{|MX_{MX2}|}{\left(H_{MX} - T_{f.MX}\right)\cdot B_{MX}\cdot T_{f.MX}}$$

$$\sigma_{X.1B} = \frac{FX_{MX1}}{A_{MX}} - \frac{MY_{MX1}}{W_{Y.MX}} + \frac{MZ_{MX1}}{W_{Z.MX}} \qquad \sigma_{Y.1B} = -\frac{FY_{MY}}{A_{MY}} - \frac{MX_{MY}}{W_{Y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\tau_{YZ.7} = \frac{|FY_{MX1}|}{2T_{f.MX}\cdot B_{MX}} + \frac{|FZ_{MX1}|}{T_{w.MX}\cdot H_{MX}} + \frac{|MX_{MX1}|}{\left(H_{MX} - T_{f.MX}\right)\cdot B_{MX}\cdot T_{f.MX}}$$

$$\sigma_{Y.2B} = -\frac{FY_{MY}}{A_{MY}} - \frac{MX_{MY}}{W_{Y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\tau_{YZ.8} = \frac{|FY_{MX2}|}{2T_{f.MX}\cdot B_{MX}} + \frac{|FZ_{MX2}|}{T_{w.MX}\cdot H_{MX}} + \frac{|MX_{MX2}|}{\left(H_{MX} - T_{f.MX}\right)\cdot B_{MX}\cdot T_{f.MX}}$$

$$\sigma_{X.2B} = -\frac{FX_{MX2}}{A_{MX}} + \frac{MY_{MX2}}{W_{Y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\tau_{XY.7.8B} = \frac{|FX_{MC} + FX_{MD} + FX_{MZ}|}{A_{weld}}$$

$$\sigma_{X.7B} = -\frac{FX_{MX1}}{A_{MX}} + \frac{MY_{MX1}}{W_{Y.MX}} \qquad \sigma_{Z.7B} = \frac{FZ_{MC} + FZ_{MD} + FZ_{MZ}}{A_{weld}} + \frac{\Sigma MY}{I_Y}\left(L_1 - e_X\right)$$

$$\sigma_{X.8B} = -\frac{FX_{MX2}}{A_{MX}} - \frac{MY_{MX2}}{W_{Y.MX}} \qquad \sigma_{Z.8B} = \frac{FZ_{MC} + FZ_{MD} + FZ_{MZ}}{A_{weld}} - \frac{\Sigma MY}{I_Y}\left(L_2 + e_X\right)$$

Incoming beam - y-dir

Section	I0852035	
H_{MY}	800	mm
B_{MY}	500	mm
T_{f-MY}	35	mm
T_{w-MY}	20	mm (1)
a	6.0	mm
A_{MY}	4.96E+04	mm^2
W_{y-MY}	1.44E+07	mm^3
W_{z-MY}	2.92E+06	mm^3

Continuous deck beam - x-dir

Section	I0852035	
H_{MX}	800	mm
B_{MX}	500	mm
T_{f-MX}	35	mm
T_{w-MX}	20	mm
A_{MX}	4.96E+04	mm^2
W_{x-MX}	8.12E+05	mm^3
W_{y-MX}	1.44E+07	mm^3
W_{z-MX}	2.92E+06	mm^3

Incoming beam - column

Section	B060640	
H_{MZ}	600	mm
B_{MZ}	600	mm
T_{f-MZ}	40	mm
T_{w-MZ}	40	mm
A_{MZ}	8.96E+04	mm^2
W_{x-MZ}	2.51E+07	mm^3
W_{y-MZ}	1.41E+07	mm^3
W_{z-MZ}	4.81E+06	mm^3

Incoming beam - braces

Section	B040420	
H_{MZ}	400	mm
B_{MZ}	400	mm
T_{f-MZ}	20	mm
T_{w-MZ}	20	mm
A_{MZ}	3.04E+04	mm^2
W_{x-MZ}	5.78E+06	mm^3
W_{y-MZ}	3.28E+06	mm^3
W_{z-MZ}	1.07E+06	mm^3

Section A-A (gusset)

L_1	750	mm	
L_2	680	mm	
T	50	mm	
s	30.0	mm	(Part. pen. w eld)
e_x	35.0	mm	
A	8.58E+04	mm^2	
I_y	1.46E+10	mm^4	

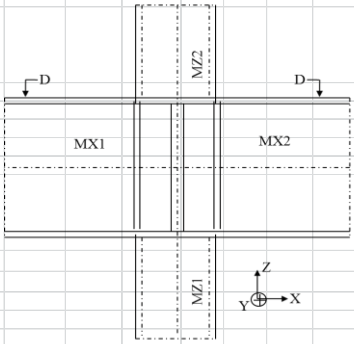
Figure G-5 Local analysis Joint 301040, lifting condition

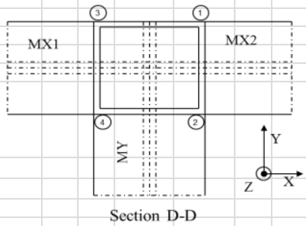
Joint check - Lift - Master Module

Intermediate deck

INPUT

Node					
J304030	MX1	MX2	MY	MZ1	MZ2
Member	MX254030	MX304030	MY302030	MZ304020	MZ304030
Section	HE800B	HE800B	I0852035	B060640	B060640





RESULTS

UF_{max}	Dim LC
1.00	2

Material properties

γ_m	1.15	
f_y	355	MPa

Equations:

$$\sigma_{x.1T} = -\frac{FX_{MX2}}{A_{Mx}} - \frac{MY_{MX2}}{W_{y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}} \qquad \sigma_{y.2T} = \frac{FY_{MY}}{A_{MY}} - \frac{MX_{MY}}{W_{y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}} \qquad \sigma_{z.1B} = \frac{FZ_{MZ1}}{A_{Mz}} + \frac{MX_{MZ1}}{W_{y.MZ}} - \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{x.2T} = -\frac{FX_{MX2}}{A_{Mx}} - \frac{MY_{MX2}}{W_{y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}} \qquad \sigma_{y.4T} = \frac{FY_{MY}}{A_{MY}} - \frac{MX_{MZ2}}{W_{y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}} \qquad \sigma_{z.2B} = \frac{FZ_{MZ1}}{A_{Mz}} - \frac{MX_{MZ1}}{W_{y.MZ}} - \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{x.3T} = \frac{FX_{MX1}}{A_{Mx}} + \frac{MY_{MX1}}{W_{y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}} \qquad \sigma_{y.2B} = \frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}} \qquad \sigma_{z.3B} = \frac{FZ_{MZ1}}{A_{Mz}} + \frac{MX_{MZ1}}{W_{y.MZ}} + \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{x.4T} = \frac{FX_{MX1}}{A_{Mx}} + \frac{MY_{MX1}}{W_{y.MX}} + \frac{MZ_{MX1}}{W_{Z.MX}} \qquad \sigma_{y.4B} = \frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}} \qquad \sigma_{z.4B} = \frac{FZ_{MZ1}}{A_{Mz}} - \frac{MX_{MZ1}}{W_{y.MZ}} + \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{x.1B} = -\frac{FX_{MX2}}{A_{Mx}} + \frac{MY_{MX2}}{W_{y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}} \qquad \sigma_{z.1T} = -\frac{FZ_{MZ2}}{A_{Mz}} - \frac{MX_{MZ2}}{W_{y.MZ}} + \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\tau_{xy.1.2.3.4.T.} = \frac{|FX_{MZ2}|}{2T_{f.MZ} B_{MZ}} + \frac{|FY_{MZ2}|}{2.T_{f.Mz} \cdot H_{MZ}} + \frac{|MZ_{MZ2}|}{(H_{MZ2} - T_{f.MZ2}) \cdot B_{MZ} \cdot T_{f.MZ}}$$

$$\sigma_{x.2B} = -\frac{FX_{MX2}}{A_{Mx}} + \frac{MY_{MX2}}{W_{y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}} \qquad \sigma_{z.2T} = -\frac{FZ_{MZ2}}{A_{Mz}} + \frac{MX_{MZ2}}{W_{y.MZ}} + \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\tau_{xy.1.2.3.4.B.} = \frac{|FX_{MZ1}|}{2T_{f.MZ} B_{MZ}} + \frac{|FY_{MZ1}|}{2.T_{f.Mz} \cdot H_{MZ}} + \frac{|MZ_{MZ1}|}{(H_{MZ2} - T_{f.MZ1}) \cdot B_{MZ} \cdot T_{f.MZ}}$$

$$\sigma_{x.3B} = \frac{FX_{MX1}}{A_{Mx}} - \frac{MY_{MX1}}{W_{y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}} \qquad \sigma_{z.3T} = -\frac{FZ_{MZ2}}{A_{Mz}} - \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\tau_{xz.2.4.} = \frac{|FX_{MY}|}{2T_{f.MY} B_{MY}} + \frac{|MY_{MY}|}{(H_{MY} - T_{f.MY}) \cdot B_{MY} \cdot T_{fMY}} + \frac{|FZ_{MY}|}{H_{MY} \cdot t_{w.MY}}$$

$$\sigma_{x.4B} = \frac{FX_{MX1}}{A_{Mx}} - \frac{MY_{MX1}}{W_{y.MX}} + \frac{MZ_{MX1}}{W_{Z.MX}} \qquad \sigma_{z.4T} = -\frac{FZ_{MZ2}}{A_{Mz}} + \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{yz.1.2.} = \frac{|FY_{MX2}|}{2T_{w.MY} B_{MX}} + \frac{|MX_{MX2}|}{(H_{MX} - T_{f.MX}) \cdot B_{MY} \cdot T_{f.MX}} + \frac{|FZ_{MX2}|}{H_{MX} \cdot t_{wMX}}$$

$$\sigma_{yz.3.4.} = \frac{|FY_{MX1}|}{2T_{w.MX} B_{MX}} + \frac{|MX_{MX2}|}{(H_{MX} - T_{f.MX}) \cdot B_{MX} \cdot T_{f.MX}} + \frac{|FZ_{MX1}|}{H_{MX} \cdot t_{w.MX}}$$

Incoming beam - y-dir

Section	I0852035	
H_{MY}	800	mm
B_{MY}	500	mm
$T_{f\text{-}MY}$	35	mm (2)
$T_{w\text{-}MY}$	20	mm (1)
a	5.0	mm
A_{MY}	4.96E+04	mm^2
$W_{y\text{-}MY}$	1.44E+07	mm^3
$W_{z\text{-}MY}$	2.92E+06	mm^3

Continuous deck beam - x-dir

Section	HE800B	
H_{MX}	800	mm
B_{MX}	300	mm
$T_{f\text{-}MX}$	33	mm
$T_{w\text{-}MX}$	17.5	mm
A_{MX}	3.26E+04	mm^2
$W_{x\text{-}MX}$	4.86E+05	mm^3
$W_{y\text{-}MX}$	8.73E+06	mm^3
$W_{z\text{-}MX}$	9.92E+05	mm^3

Incoming beam - column

Section	B060640	
H_{MZ}	600	mm
B_{MZ}	600	mm
$T_{f\text{-}MZ}$	40	mm (2)
$T_{w\text{-}MZ}$	40	mm (2)
A_{MZ}	8.96E+04	mm^2
$W_{x\text{-}MZ}$	2.51E+07	mm^3
$W_{y\text{-}MZ}$	1.57E+07	mm^3
$W_{z\text{-}MZ}$	1.57E+07	mm^3

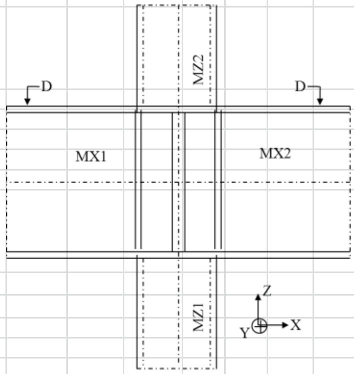
Note (1):
Weld at w eb is assumed to carry shear only
Note (2):
Part pen w eld

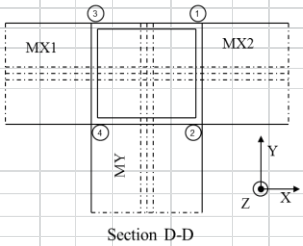
									Top flange			Bottom flange			Shear stresses			Von-Mises			
Member	LoadC	SctNam	Fx	Fy	Fz	Mx	My	Mz	Hot spot	$\sigma_{x\text{-}T}$	$\sigma_{y\text{-}T}$	$\sigma_{z\text{-}T}$	$\sigma_{x\text{-}B}$	$\sigma_{y\text{-}B}$	$\sigma_{z\text{-}B}$	τ_{yz}	τ_{xz}	$\tau_{xy\text{-}T}$	$\sigma_{j\text{-}T}$	$\sigma_{j\text{-}B}$	τ_{fill}	**UF**
			(kN)	(kN)	(kN)	(kNm)	(kNm)	(kNm)		(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	
MX254030	2	HE800B	-245	1	-70	0	208	-1	1	27		-65	-41		164	0		13	85	189		**1.00**
MX304030	2	HE800B	261	1	5	0	-298	1	2	25	275	212	-43	-265	-57	0	83	13	268	260		
MY302030	2	I0852035	0	247	1326	-3901	-1	0	3	17		-65	-30		176	5		13	308	194		
MZ304020	2	B060640	-24	377	5326	1733	93	0	4	15	275	212	-32	-265	-45	5	83	13	276	270		
MZ304030	2	B060640	0	-646	-6588	2169	0	0														

Figure G-6 Local analysis Joint 304020 , lifting condition

Joint check - Lift - Master Module

Lower deck





INPUT

Node					
J504020	MX1	MX2	MY	MZ1	MZ2
Member	MX454020	MX504020	MY502020	MZ504010	MZ504020
Section	HE800B	HE800B	I1252035	B040440	B040440

RESULTS

UF_{max}	Dim LC
1.07	2

Material properties

γ_m	1.15	
f_y	355	MPa

Equations:

$$\sigma_{x1T} = -\frac{FX_{MX2}}{A_{Mx}} - \frac{MY_{MX2}}{W_{y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x2T} = -\frac{FX_{MX2}}{A_{Mx}} - \frac{MY_{MX2}}{W_{y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x3T} = \frac{FX_{MX1}}{A_{Mx}} + \frac{MY_{MX1}}{W_{y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x4T} = \frac{FX_{MX1}}{A_{Mx}} + \frac{MY_{MX1}}{W_{y.MX}} + \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x1B} = -\frac{FX_{MX2}}{A_{Mx}} + \frac{MY_{MX2}}{W_{y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x2B} = -\frac{FX_{MX2}}{A_{Mx}} + \frac{MY_{MX2}}{W_{y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x3B} = \frac{FX_{MX1}}{A_{Mx}} - \frac{MY_{MX1}}{W_{y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x4B} = \frac{FX_{MX1}}{A_{Mx}} - \frac{MY_{MX1}}{W_{y.MX}} + \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{y.2T} = \frac{FY_{MY}}{A_{MY}} - \frac{MX_{MY}}{W_{y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.4T} = \frac{FY_{MY}}{A_{MY}} - \frac{MX_{MZ2}}{W_{y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.2B} = \frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.4B} = \frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{z.1T} = -\frac{FZ_{MZ2}}{A_{Mz}} - \frac{MX_{MZ2}}{W_{y.MZ}} + \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.2T} = -\frac{FZ_{MZ2}}{A_{Mz}} + \frac{MX_{MZ2}}{W_{y.MZ}} + \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.3T} = \frac{FZ_{MZ2}}{A_{Mz}} - \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.4T} = \frac{FZ_{MZ2}}{A_{Mz}} + \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.1B} = \frac{FZ_{MZ1}}{A_{Mz}} + \frac{MX_{MZ1}}{W_{y.MZ}} - \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{z.2B} = \frac{FZ_{MZ1}}{A_{Mz}} - \frac{MX_{MZ1}}{W_{y.MZ}} - \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{z.3B} = \frac{FZ_{MZ1}}{A_{Mz}} + \frac{MX_{MZ1}}{W_{y.MZ}} + \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{z.4B} = \frac{FZ_{MZ1}}{A_{Mz}} - \frac{MX_{MZ1}}{W_{y.MZ}} + \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\tau_{xy.1.2.3.4.T.} = \frac{|FX_{MZ2}|}{2T_{f.MZ} B_{MZ}} + \frac{|FY_{MZ2}|}{2.T_{f.Mz} \cdot H_{MZ}} + \frac{|MZ_{MZ2}|}{(H_{MZ2} - T_{f.MZ2}) \cdot B_{MZ} \cdot T_{f.MZ}}$$

$$\tau_{xy.1.2.3.4.B.} = \frac{|FX_{MZ1}|}{2T_{f.MZ} B_{MZ}} + \frac{|FY_{MZ1}|}{2.T_{f.Mz} \cdot H_{MZ}} + \frac{|MZ_{MZ1}|}{(H_{MZ2} - T_{f.MZ1}) \cdot B_{MZ} \cdot T_{f.MZ}}$$

$$\tau_{xz.2.4.} = \frac{|FX_{MY}|}{2T_{f.MY} B_{MY}} + \frac{|MY_{MY}|}{(H_{MY} - T_{f.MY}) \cdot B_{MY} \cdot T_{fMY}} + \frac{|FZ_{MY}|}{H_{MY} \cdot t_{w.MY}}$$

$$\sigma_{yz.1.2.} = \frac{|FY_{MX2}|}{2T_{w.MY} B_{MX}} + \frac{|MX_{MX2}|}{(H_{MX} - T_{f.MX}) \cdot B_{MY} \cdot T_{f.MX}} + \frac{|FZ_{MX2}|}{H_{MX} \cdot t_{wMX}}$$

$$\sigma_{yz.3.4.} = \frac{|FY_{MX1}|}{2T_{w.MX} B_{MX}} + \frac{|MX_{MX2}|}{(H_{MX} - T_{f.MX}) \cdot B_{MX} \cdot T_{f.MX}} + \frac{|FZ_{MX1}|}{H_{MX} \cdot t_{w.MX}}$$

Incoming beam - y-dir

Section	I1252035	
H_{MY}	1200	mm
B_{MY}	500	mm
T_{f-MY}	35	mm (2)
T_{w-MY}	20	mm (1)
a	5.0	mm
A_{MY}	5.76E+04	mm^2
W_{y-MY}	2.38E+07	mm^3
W_{z-MY}	2.92E+06	mm^3

Continuous deck beam - x-dir

Section	HE800B	
H_{MX}	800	mm
B_{MX}	300	mm
T_{f-MX}	33	mm
T_{w-MX}	17.5	mm
A_{MX}	3.26E+04	mm^2
W_{x-MX}	4.86E+05	mm^3
W_{y-MX}	8.73E+06	mm^3
W_{z-MX}	9.92E+05	mm^3

Incoming beam - column

Section	B040440	
H_{MZ}	400	mm
B_{MZ}	400	mm
T_{f-MZ}	40	mm (2)
T_{w-MZ}	40	mm (2)
A_{MZ}	5.76E+04	mm^2
W_{x-MZ}	1.04E+07	mm^3
W_{y-MZ}	6.30E+06	mm^3
W_{z-MZ}	6.30E+06	mm^3

Note (1):
Weld at w eb is assumed to carry shear only
Note (2):
Part pen w eld

										Top flange			Bottom flange			Shear stresses			Von-Mises			
Member	LoadC	SctNam	Fx	Fy	Fz	Mx	My	Mz	Hot spot	σ_{x-T}	σ_{y-T}	σ_{z-T}	σ_{x-B}	σ_{y-B}	σ_{z-B}	τ_{yz}	τ_{xz}	τ_{xy-T}	σ_{j-T}	σ_{j-B}	τ_{fill}	UF
			(kN)	(kN)	(kN)	(kNm)	(kNm)	(kNm)		(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	
MX454020	2	HE800B	504	1	-321	1	-670	-2	1	-61		-263	97		165	22		13	242	150		**1.07**
MX504020	2	HE800B	-504	1	-307	1	690	2	2	-66	116	193	92	-115	-251	22	54	13	253	317		
MY502020	2	I1252035	0	40	1304	-2755	0	0	3	-59		-260	94		161	23		13	330	147		
MZ504010	2	B040440	5	339	-2619	1311	-14	0	4	-64	117	196	90	-115	-256	23	54	13	253	319		
MZ504020	2	B040440	-3	-407	1943	1436	-8	0														

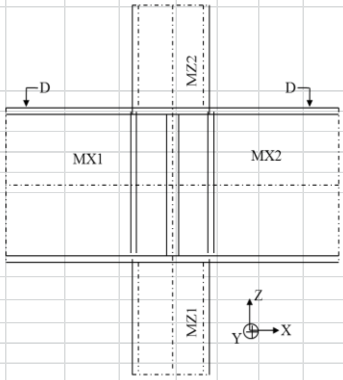
Figure G-7 Local analysis Joint 504020, lift condition

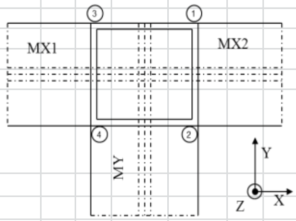
Joint check - Lift - Master Module

Intermediate deck

INPUT

Node					
J504030	MX1	MX2	MY	MZ1	MZ2
Member	MX404030	MX504030	MY502030	MZ504020	MZ504030
Section	HE800B	HE800B	I0852035	B040440	B040440





Section D-D

RESULTS

UF_{max}	Dim LC
1.07	2

Material properties

γ_m	1.15	
f_y	355	MPa

Equations:

$$\sigma_{x.1T} = -\frac{FX_{MX2}}{A_{Mx}} - \frac{MY_{MX2}}{W_{y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.2T} = -\frac{FX_{MX2}}{A_{Mx}} - \frac{MY_{MX2}}{W_{y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.3T} = \frac{FX_{MX1}}{A_{Mx}} + \frac{MY_{MX1}}{W_{y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x.4T} = \frac{FX_{MX1}}{A_{Mx}} + \frac{MY_{MX1}}{W_{y.MX}} + \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x.1B} = -\frac{FX_{MX2}}{A_{Mx}} + \frac{MY_{MX2}}{W_{y.MX}} + \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.2B} = -\frac{FX_{MX2}}{A_{Mx}} + \frac{MY_{MX2}}{W_{y.MX}} - \frac{MZ_{MX2}}{W_{Z.MX}}$$

$$\sigma_{x.3B} = \frac{FX_{MX1}}{A_{Mx}} - \frac{MY_{MX1}}{W_{y.MX}} - \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{x.4B} = \frac{FX_{MX1}}{A_{Mx}} - \frac{MY_{MX1}}{W_{y.MX}} + \frac{MZ_{MX1}}{W_{Z.MX}}$$

$$\sigma_{y.2T} = \frac{FY_{MY}}{A_{MY}} - \frac{MX_{MY}}{W_{y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.4T} = \frac{FY_{MY}}{A_{MY}} - \frac{MX_{MZ2}}{W_{y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.2B} = \frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{y.MY}} + \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{y.4B} = \frac{FY_{MY}}{A_{MY}} + \frac{MX_{MY}}{W_{y.MY}} - \frac{MZ_{MY}}{W_{Z.MY}}$$

$$\sigma_{z.1T} = -\frac{FZ_{MZ2}}{A_{Mz}} - \frac{MX_{MZ2}}{W_{y.MZ}} + \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.2T} = -\frac{FZ_{MZ2}}{A_{Mz}} + \frac{MX_{MZ2}}{W_{y.MZ}} + \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.3T} = -\frac{FZ_{MZ2}}{A_{Mz}} - \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.4T} = -\frac{FZ_{MZ2}}{A_{Mz}} + \frac{MX_{MZ2}}{W_{y.MZ}} - \frac{MY_{MZ2}}{W_{Z.MZ}}$$

$$\sigma_{z.1B} = \frac{FZ_{MZ1}}{A_{Mz}} + \frac{MX_{MZ1}}{W_{y.MZ}} - \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{z.2B} = \frac{FZ_{MZ1}}{A_{Mz}} - \frac{MX_{MZ1}}{W_{y.MZ}} - \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{z.3B} = \frac{FZ_{MZ1}}{A_{Mz}} + \frac{MX_{MZ1}}{W_{y.MZ}} + \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\sigma_{z.4B} = \frac{FZ_{MZ1}}{A_{Mz}} - \frac{MX_{MZ1}}{W_{y.MZ}} + \frac{MY_{MZ1}}{W_{Z.MZ}}$$

$$\tau_{xy.1.2.3.4.T.} = \frac{|FX_{MZ2}|}{2T_{f.MZ}B_{MZ}} + \frac{|FY_{MZ2}|}{2.T_{f.Mz} \cdot H_{MZ}} + \frac{|MZ_{MZ2}|}{(H_{MZ2} - T_{f.MZ2}) \cdot B_{MZ} \cdot T_{f.MZ}}$$

$$\tau_{xy.1.2.3.4.B.} = \frac{|FX_{MZ1}|}{2T_{f.MZ}B_{MZ}} + \frac{|FY_{MZ1}|}{2.T_{f.Mz} \cdot H_{MZ}} + \frac{|MZ_{MZ1}|}{(H_{MZ2} - T_{f.MZ1}) \cdot B_{MZ} \cdot T_{f.MZ}}$$

$$\tau_{xz.2.4.} = \frac{|FX_{MY}|}{2T_{f.MY}B_{MY}} + \frac{|MY_{MY}|}{(H_{MY} - T_{f.MY}) \cdot B_{MY} \cdot T_{fMY}} + \frac{|FZ_{MY}|}{H_{MY} \cdot t_{w.MY}}$$

$$\sigma_{yz.1.2.} = \frac{|FY_{MX2}|}{2T_{w.MY}B_{MX}} + \frac{|MX_{MX2}|}{(H_{MX} - T_{f.MX}) \cdot B_{MY} \cdot T_{f.MX}} + \frac{|FZ_{MX2}|}{H_{MX} \cdot t_{wMX}}$$

$$\sigma_{yz.3.4.} = \frac{|FY_{MX1}|}{2T_{w.MX}B_{MX}} + \frac{|MX_{MX2}|}{(H_{MX} - T_{f.MX}) \cdot B_{MX} \cdot T_{f.MX}} + \frac{|FZ_{MX1}|}{H_{MX} \cdot t_{w.MX}}$$

Incoming beam - y-dir

Section	I0852035	
H_{MY}	800	mm
B_{MY}	500	mm
T_{f-MY}	35	mm (2)
T_{w-MY}	20	mm (1)
a	5.0	mm
A_{MY}	4.96E+04	mm^2
W_{y-MY}	1.44E+07	mm^3
W_{z-MY}	2.92E+06	mm^3

Continuous deck beam - x-dir

Section	HE800B	
H_{MX}	800	mm
B_{MX}	300	mm
T_{f-MX}	33	mm
T_{w-MX}	17.5	mm
A_{MX}	3.26E+04	mm^2
W_{x-MX}	4.86E+05	mm^3
W_{y-MX}	8.73E+06	mm^3
W_{z-MX}	9.92E+05	mm^3

Incoming beam - column

Section	B040440	
H_{MZ}	400	mm
B_{MZ}	400	mm
T_{f-MZ}	40	mm (2)
T_{w-MZ}	40	mm (2)
A_{MZ}	5.76E+04	mm^2
W_{x-MZ}	1.04E+07	mm^3
W_{y-MZ}	6.30E+06	mm^3
W_{z-MZ}	6.30E+06	mm^3

Note (1):
Weld at w eb is assumed to carry shear only
Note (2):
Part pen w eld

										Top flange			Bottom flange			Shear stresses			Von-Mises			
Member	LoadC	SctNam	Fx	Fy	Fz	Mx	My	Mz	Hot spo	σ_{x-T}	σ_{y-T}	σ_{z-T}	σ_{x-B}	σ_{y-B}	σ_{z-B}	τ_{yz}	τ_{xz}	τ_{xy-T}	σ_{j-T}	σ_{j-B}	τ_{fill}	UF
			(kN)	(kN)	(kN)	(kNm)	(kNm)	(kNm)		(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	
MX404030	2	HE800B	-31	0	54	-1	-179	0	1	-21		-206	19		175	4		12	198	168		**1.07**
MX504030	2	HE800B	25	0	56	-1	176	0	2	-21	172	178	20	-173	-234	4	47	12	213	244		
MY502030	2	I0852035	0	-24	754	-2490	0	0	3	-22		-210	19		172	4		12	331	165		
MZ504020	2	B040440	3	407	-1787	1289	-9	0	4	-21	172	174	20	-173	-237	4	47	12	212	247		
MZ504030	2	B040440	3	-378	925	1209	11	0														

Figure G-8 Local analysis Joint 501030, lift condition