# HEAVY LIFT & MARINE TRANSPORTATION ~EXPERIENCES SHARING

February 2025

# 重件吊裝與海運經驗分享

昱能海事股份有限公司

**Wynnergy Marine Co., Ltd**

# WYNNERGY MARINE 介紹

台灣離岸風電工作船與海事工程服務提供商:

- 船舶投資
  VESSEL INVESTMENT
- 船舶租賃
  VESSEL CHARTERING
- 船舶設備供應
  MARINE EQUIPMENT
- 海事工程服務
  MARINE ENGINEERING



# WYNNERGY MARINE IN TAIWAN

## 2020~2024 Track Records in Taiwan

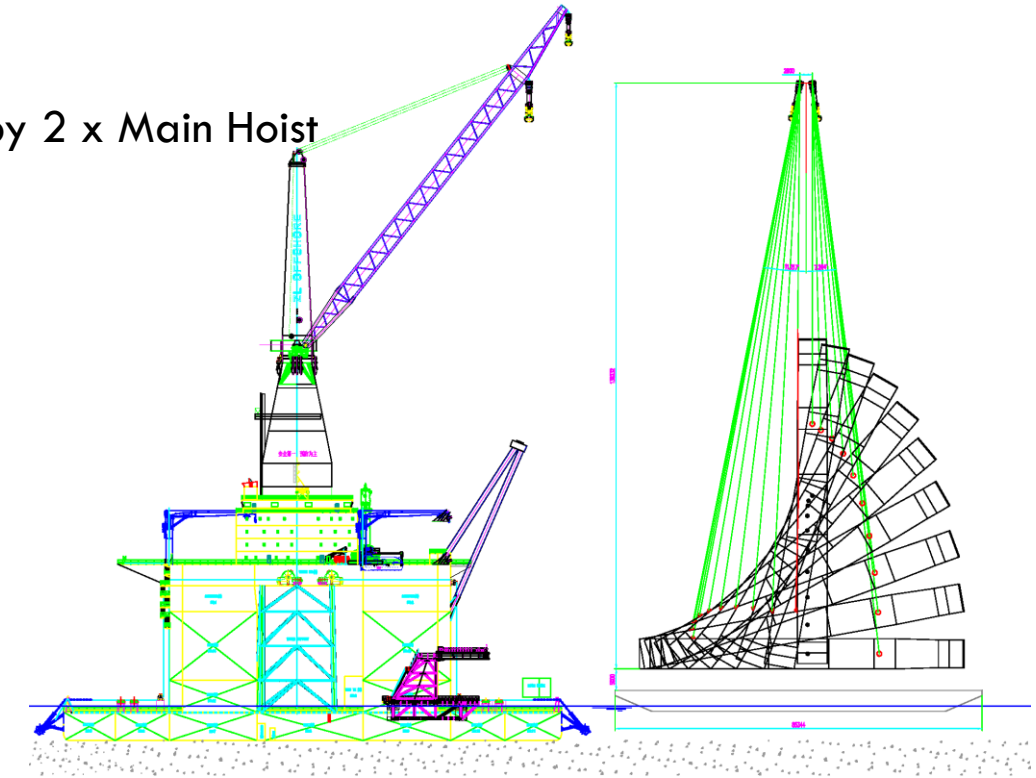
- PLGR,  BOUY DEPLOYMENT and SEA HOTEL
- UWNM, ANCHOR HANDLING, HEAVY TRANSPORTATION, ECOLOGICAL OBSERVATIONS
- RESCUE STANDBY, CABLE LAYING GUARD, PILING OPERARTION GUARD, DRILLING GUARD, SCOUR PROTECTION GUARD

# 重件吊裝與海運經驗分享

1. Heavy Lift 重件吊裝
2. Marine Transportation 重件海運
3. Roll-on Loadout Operation 重件裝船

# 1. Heavy Lift

## 1.1 Pile Up-right by 2 x Main Hoist



| Up-right Angle | Wire Angle - Holding (dgr) | Wire Angle - Hoist Up (dgr) | Vertical Load - Holding (MT) | Vertical Load - Hoist Up (MT) | Hori. Load - Holding (MT) | Hori. Load - Hoist Up (MT) | Hook Load - Holding | Hook Load - Hoisting |
|---|---|---|---|---|---|---|---|---|
| 0 | 79.081 | 83.312 | 372.371 | 612.629 | 71.835 | 71.835 | 379.237 | 616.826 |
| 10 | 78.783 | 82.920 | 379.335 | 605.665 | 75.226 | 75.226 | 386.722 | 610.319 |
| 20 | 78.861 | 82.736 | 387.088 | 597.912 | 76.216 | 76.216 | 394.520 | 602.750 |
| 30 | 79.330 | 82.821 | 394.648 | 590.352 | 74.357 | 74.357 | 401.592 | 595.016 |
| 40 | 80.189 | 83.240 | 400.594 | 584.406 | 69.274 | 69.274 | 406.539 | 588.498 |
| 50 | 81.422 | 84.044 | 402.736 | 582.264 | 60.750 | 60.750 | 407.292 | 585.425 |
| 60 | 82.995 | 85.252 | 397.298 | 587.702 | 48.818 | 48.818 | 400.286 | 589.726 |
| 70 | 84.861 | 86.821 | 376.078 | 608.922 | 33.824 | 33.824 | 377.596 | 609.861 |
| 80 | 86.980 | 88.599 | 312.035 | 672.965 | 16.460 | 16.460 | 312.469 | 673.166 |
| 90 | 90.000 | 90.000 | 0.000 | 985.000 | 0.000 | 0.000 | 0.000 | 985.000 |

Up-right Hook Load Calculation

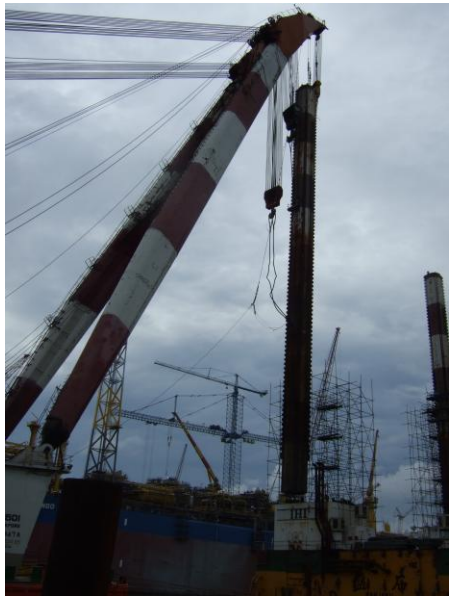
- ZPMC Crane on 'ShunYi-1600'.
- Total Lifting Capacity – 1600MT.
- Single Main Hoist Lifting Capacity 1200MT.
- Pile up-right by 2 x Main Hoist
- Pile Weight 985MT.

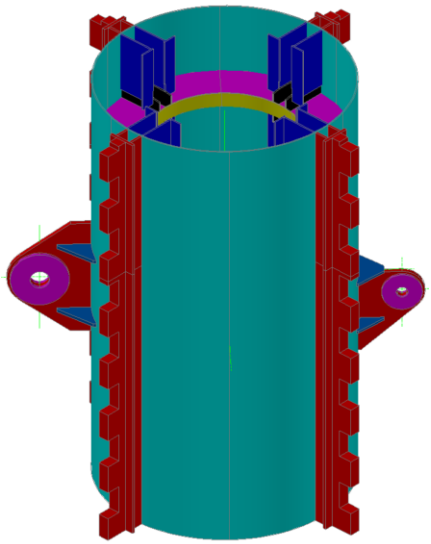
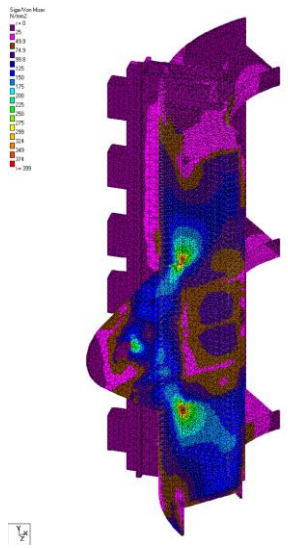
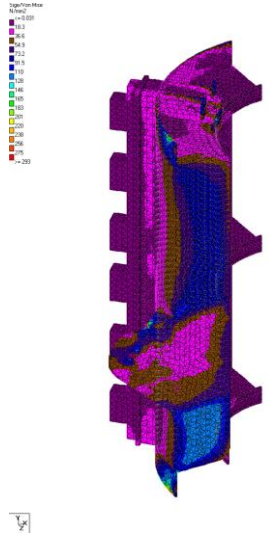
- Hook Load Calculations during up-righting to determine the following.

1. Max. Hook Load within 2 Main Hoist.
2. Max. hook open up angle, must be less than allowable open up angle, normally 15°.

# 1. Heavy Lift

## 1.2 Jack-up Barge Leg Removal



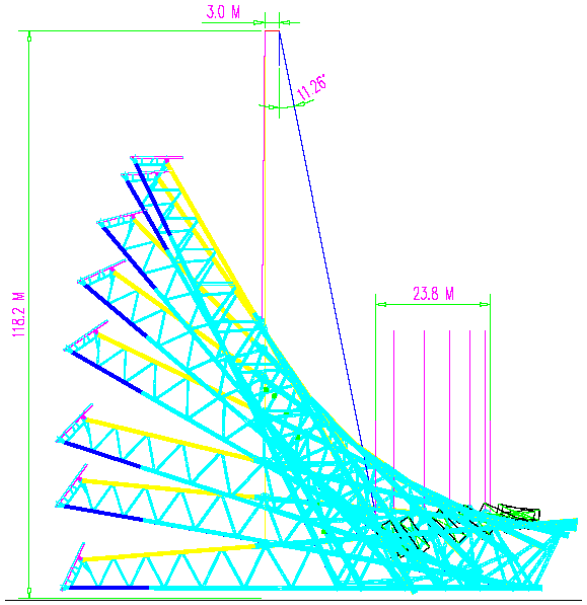
Padeye Design & FEM Analysis

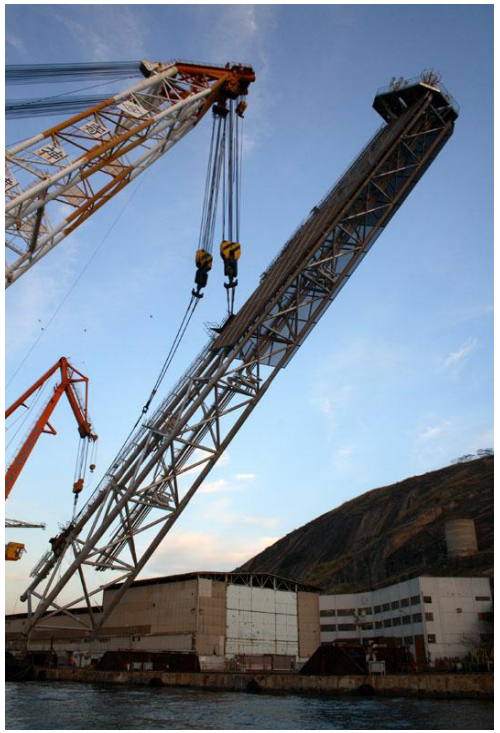
- 1 x Main Hoist + 1 x Aux. Hoist to pull out.
- 2 x Main Hoist to Turn the leg level.
- Make it feasible to lift with limited hook height.
- Leg Weight 360MT each.

- 1 x 400MT Padeye + 2 x 200MT Padeye.
- Padeye Strength Check by FEM Analysis.

# 1. Heavy Lift

## 1.3 FPSO P54 Flare Boom Installation



**P54 FLARE BOOM INSTALLATION BY SHEERLEG FLATING CRANE 'KAISEI'**

**Ming LI**, Morlinc Pte Ltd, Singapore

**SUMMARY**

The Flare Boom weighs 515 metric tons with a total height 93 meters from main deck at 65 degrees angle to horizontal, which is one of the largest and heaviest flare booms on FPSOs. It had been successfully installed in August, 2007 by a 2050 MT floating sheerleg crane named 'Kaisei', in Maua-Jurong Shipyard located at Rio de Janeiro, Brazil. There were 3 stages operation involved,

1. Horizontally shift from Slip Way, rotate 90 degrees and laid onto wharf.
   Problems: Lifting off starting with Flare Boom at 3.2 degrees tilt to horizontal in Slip Way;
   Hydrotest water remained in the pipes causing running C.O.G.;
   Foul weather condition;
   Landing on Supports with 4 degrees tilts.
2. Tandem Lift by 'Kaisei' & 'Piaui' (a 250T Revolving floating crane) to upright from 0 to 65.12 degrees.
   Problems: The C.O.G and padeyes locations were out of range for installation on board;
   If up-righting by 2 main hooks from 'Kaisei', the hook fleet angle is more than the limit 15 degrees;
   Manoeuvring of both floating cranes for tandem lift .
3. Install by 'Kaisei' using 2 main hooks.
   Problems: Mooring patterns for positioning 'Kaisei' 45 degrees to P54 vessel;
   Congested space on board 'P54' for manoeuvring during installation;

**1. INTRODUCTION**

P54 is a FPSO vessel owned by Petrobras which was completed construction in October, 2007, in Maua-Jurong Shipyard at Rio de Janeiro, Brazil. The flare Boom is one of the largest, heaviest and highest in the world so far among flare booms on FPSOs, semi-submersible rigs and fixed offshore platforms. The success of the Flare Boom installation on 2nd of Aug., 2007 was a milestone of completion of P54.

The final weight of the Flare Boom is 515 metric tons. It measures 108 meters in length when it was constructed on ground. It stands 91 meters tall from P54 main deck with 65 degrees slung to horizontal level.

The flare Boom was constructed inside the Slip Way in Maua-Jurong Shipyard. It was seated onto supports followed the tilt angle 3.2 degrees of the Slip Way. It was perpendicular to the Dock Gate with the bottom part to the sea. The 1st stage of the operation was to lift the Flare Boom out of the Slip Way, turn 90 degrees and place it parallel to the wharf at Quay 2, so that it could be up-righted at the 2nd stage.

There are 2 padeyes located on top of the Flare Boom for up-righting and installation. The initial plan was to up-right by 2 main hooks from 'Kaisei'. But study showed it was not possible because the port side Main Hook fleet angle is more than allowable 15 degrees. A 250T floating crane 'Piaui' was therefore called to assist for the operation.

The Flare Boom was installed successfully the following day at final stage. The mooring plan was well set up. The crane barge was manoeuvred under precise control.

Maua-Jurong Shipyard is located in Guanabara Bay. The swell from South West direction always affects a lot to the lifting operations. The installation date on 2nd of Aug., 2007 was selected in the good weather window period between the 2 storms.

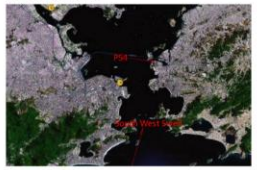


Figure 1.1: P54 Location in Guanabara Bay

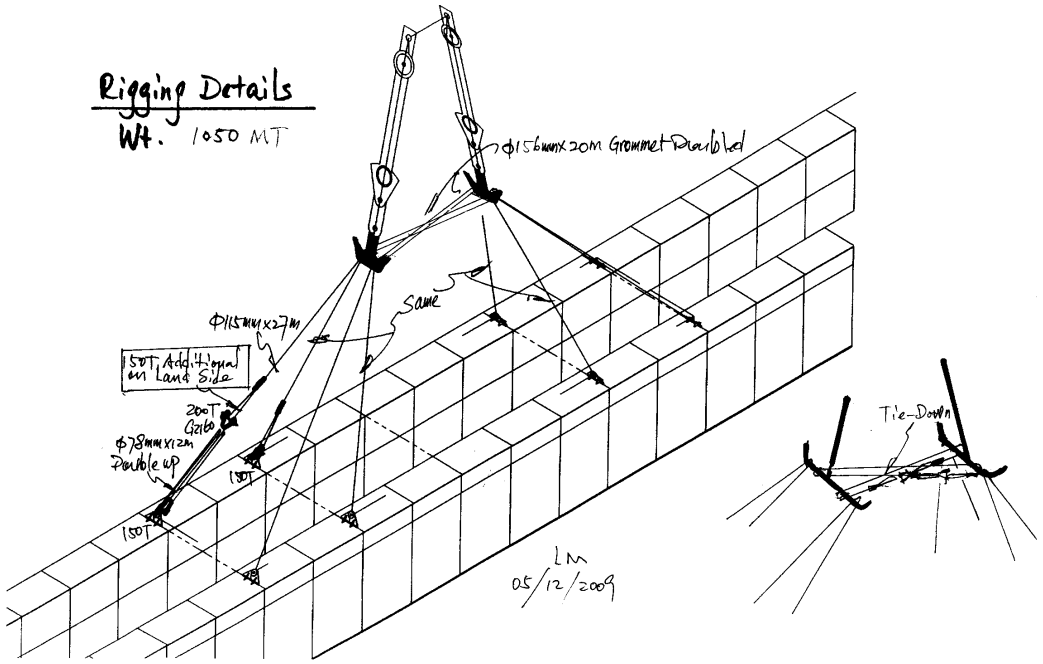
This paper will describe the problems and solutions during the lifting / installation process.

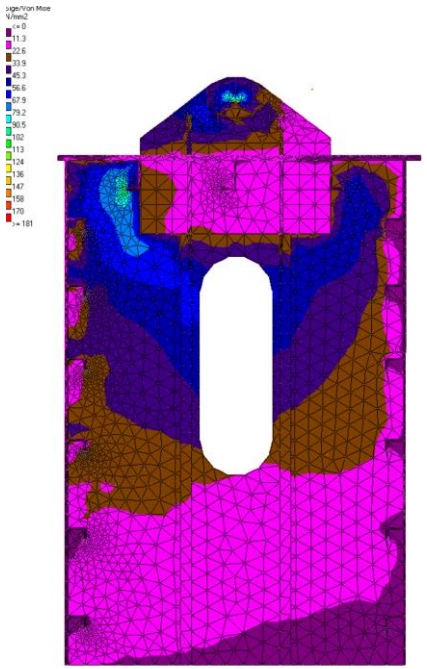
- Tandem Lift to lift and turn Flare Boom to 65°.
- 2 x Main Hoist to install Flare Boom to FPSO.
- Total Weight 515MT @93m High from main deck.

- The lifting operation was written in a report 'P54 Flare Boom Installation by Sheerleg Floating Crane 'Kaisei' and presented in RINA International Conference 'Marine Heavy Transport & Lift II – 2008'.

# 1. Heavy Lift

## 1.4 Kone Crane Girder Installation

- Limited Hook Height.
- 2 x Main Hoist to install.
- Total Weight 1050MT.

- Lifting Points Design for short rigging height.

# 1. Heavy Lift

## 1.5 FPSO P68 & P70 Module Lifting by ‘L-3602’ at EJA, Brazil

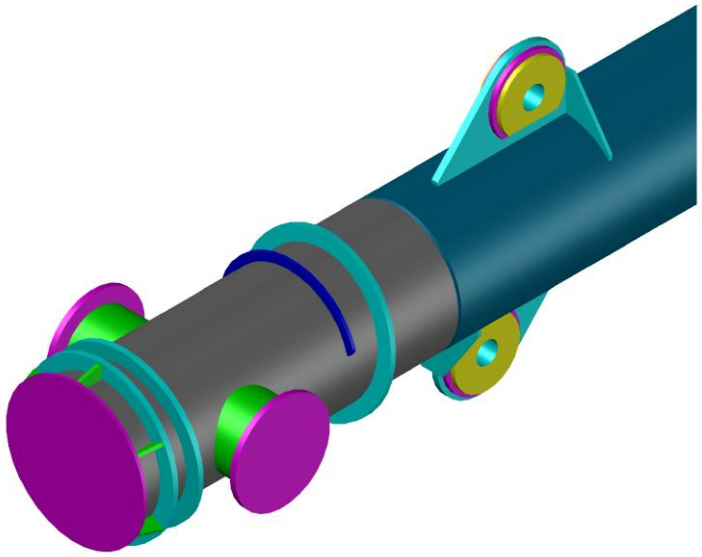
- 2 x spreader & 4 x Delta Plate by 4 x Main Hoist.

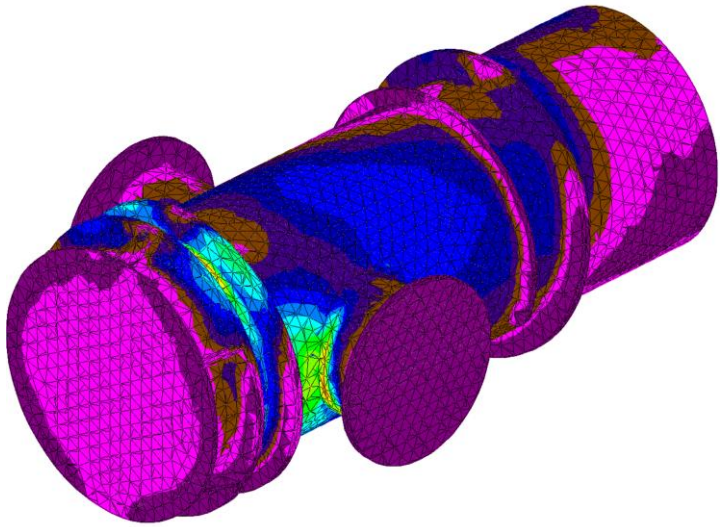
- Special designed rigging to make wire vertical to lifting points.

- Max. lifting Weight 2500MT for rigging design.

# 1. Heavy Lift

## 1.6 FPSO ‘Stybarrow’ Mega Module Lifting





- Mega Module incl. of Port Module, Center Piperack & Stb’d Module.

- 8 x Padeyes.

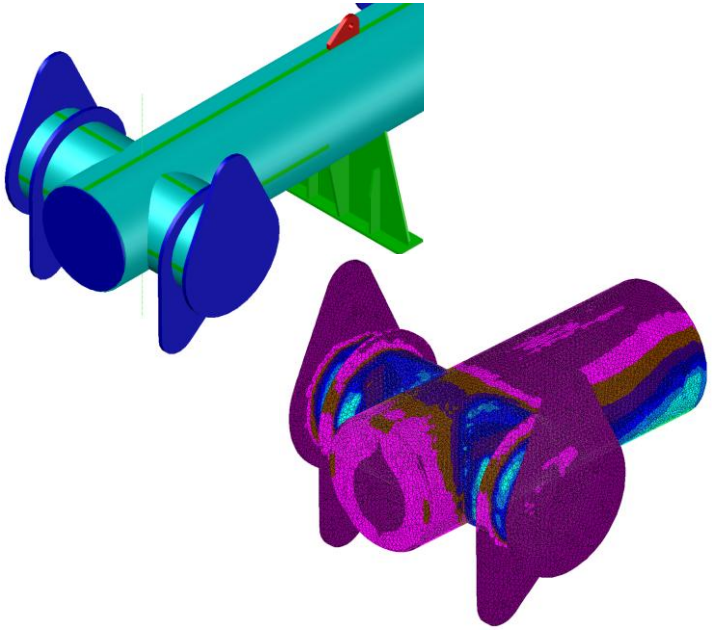
- Inner Padeye takes double load of Outer Padeye.

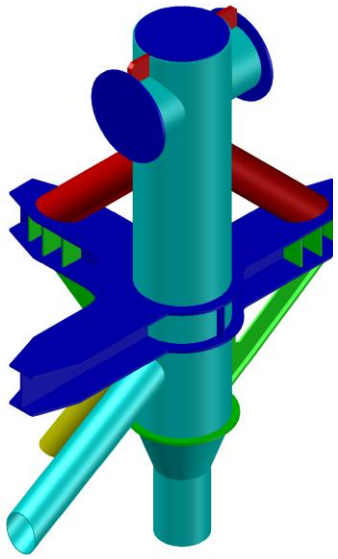
- Special designed spreader SWL 1250MT x 33m.

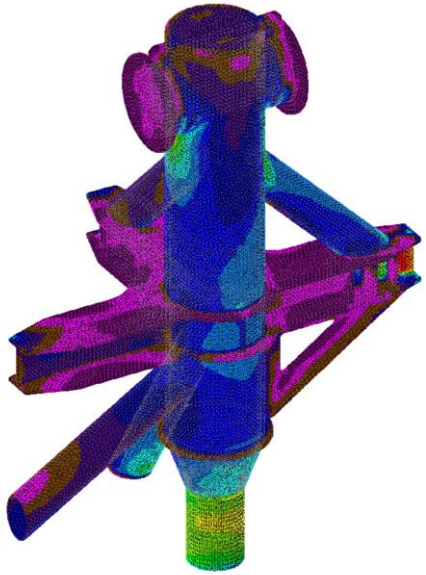
- Max. Module Weight 2000MT.

# 1. Heavy Lift

## 1.7 FPSO ‘Barossa’ Module Lifting







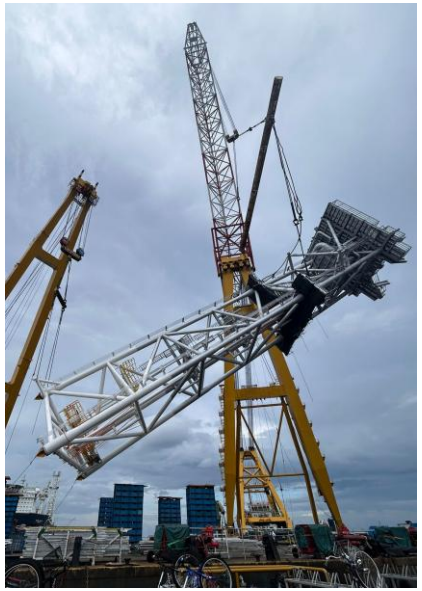
- 4 to 6 lifting points.
- Trunnion as lifting point for modules over 3000MT.
- Spreader SWL 2500MT x 25m.
- Max. Module Weight 3850T.

# 1. Heavy Lift

## 1.8 FPSO 'Barossa' Flare Tower Lifting

Up-right Lower Part

Up-right Middle Part



Up-right Top Part

Inst. Top Part

- Flare Tower in 3 parts, Lower, Middle & Upper.
- 4 lifting points at each part.
  1. Tailing
  2. 2 x Trunnion with Padeye
  3. Fixed
- Weight of each part.
  1. Lower Part - 655MT
  2. Middle Part - 217MT
  3. Upper Part - 280MT
- Total Height from Vessel Deck 153m.

Tailing Point

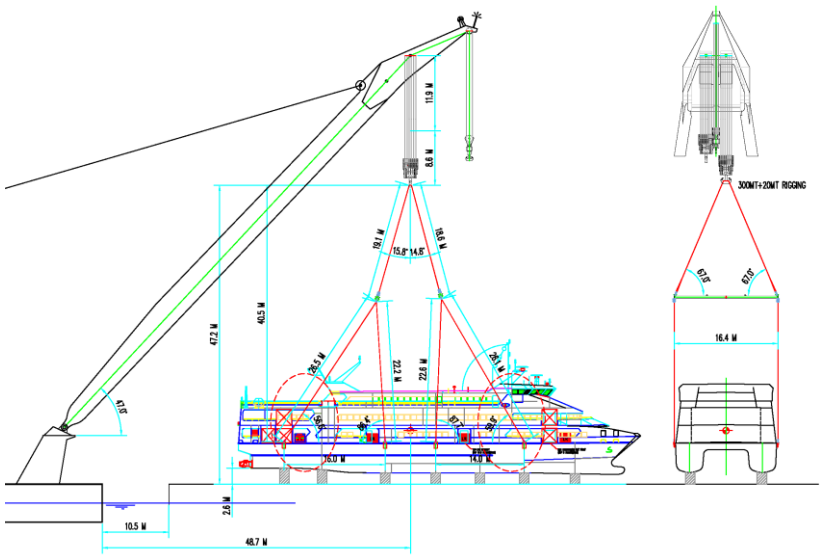
Trunnion with Padeye

Fixed Point

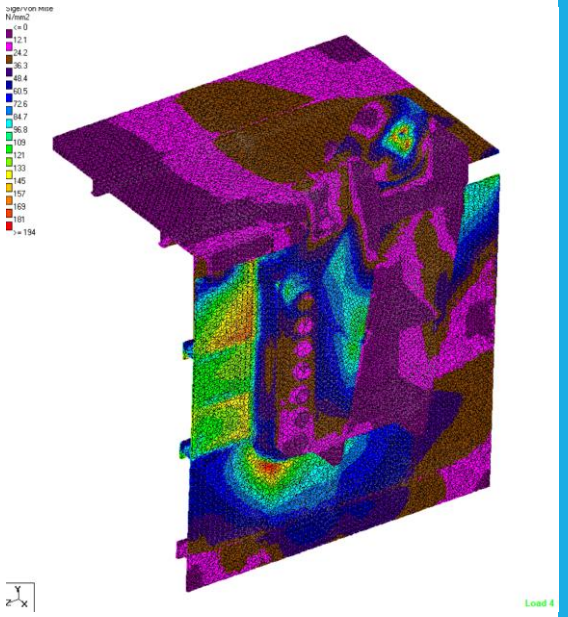
# 1. Heavy Lift

## 1.9 Catamaran Boat Lifting

- Lift Catamaran from yard to water.
- Tow to Jurong Port
- Tandem Lift by 2 x Vessel Cranes
- Transport to Argentina




Lifting Arrangement

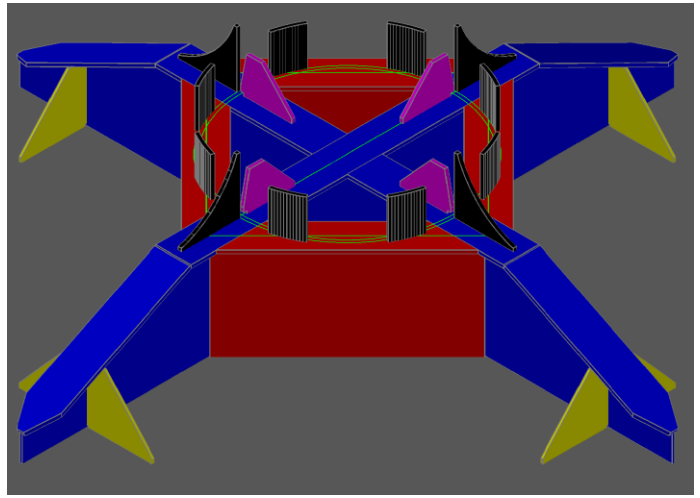


Padeye Local Strength Check

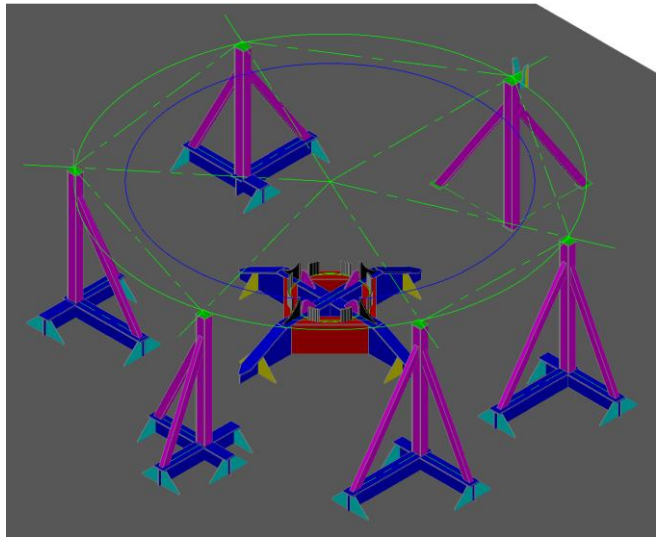
- Total Lifting Weight 300MT.

## 2. Marine Transportation

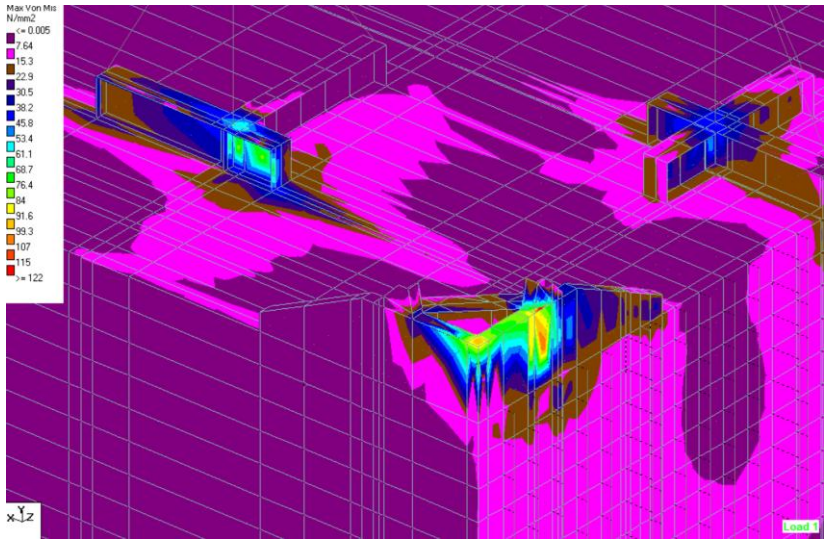
### 2.1 FPSO 'Pyrenees' Upper Turret Module (UTM)



Central Grillage Foundation



Overall View of Grillage




Deck Strength Check

- Only UTM central column supports the whole weight of UTM.

- The central grillage foundation is designed for.

1. Support the whole load from UTM central column.
2. Spread the load onto barge deck.
3. Lifting guides for installation of UTM
4. Lash down UTM to the top of foundation.

- The 6 x vertical supports are to stabilize UTM.

- No welding allowed between UTM Bottom and top of grillage.

- Total Weight of UTM 504MT.

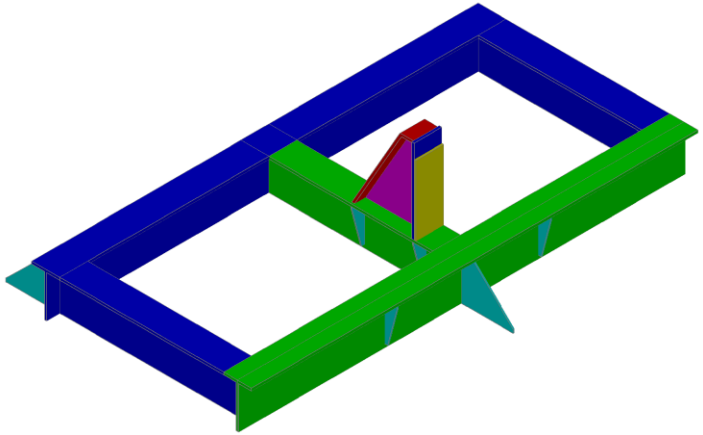
- Deck Strength Check by FEM analysis.

- Plate & Beam Model.

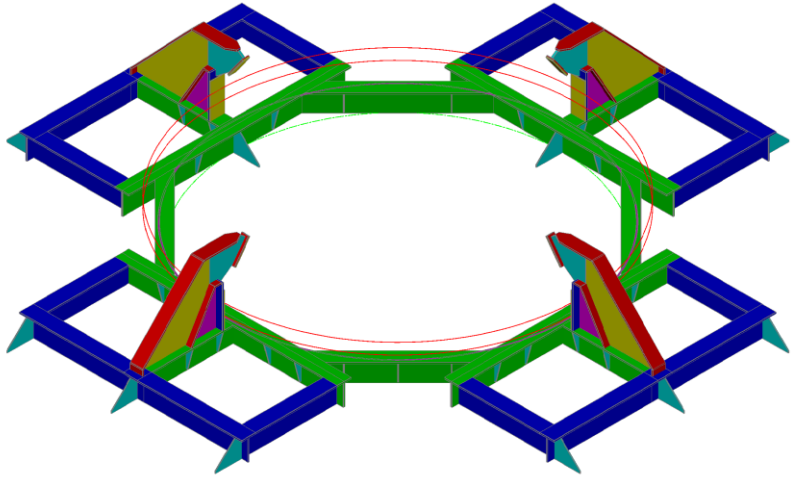
- FEM model incl. of barge structural members and grillage structure.

## 2. Marine Transportation

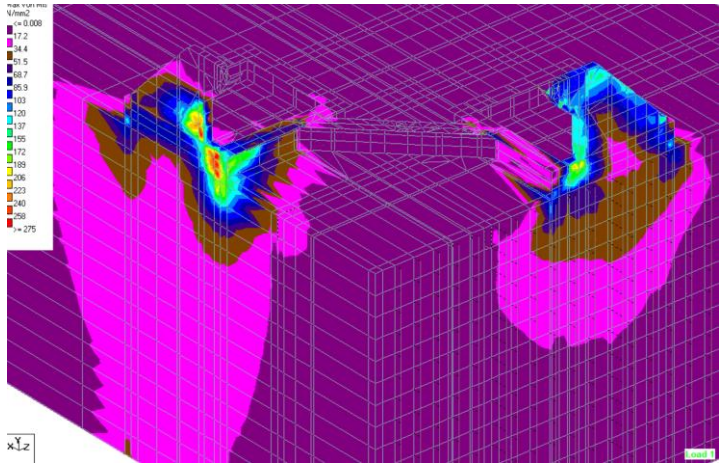
### 2.2 FPSO ‘Pyrenees’ Lower Turret Module (LTM)



Installation Guide



Grillage & Lashing



Deck Strength Check

- The grillage beams are in line with barge deck structural members.

- The grillage beams and installation guides are laid onto barge first to receive LTM by lifting.

- The lashing part will add on to the installation guide.

- Total Weight of LTM 503.5MT.

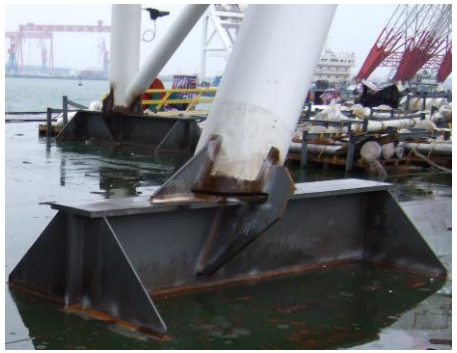
- Deck Strength Check by FEM analysis.

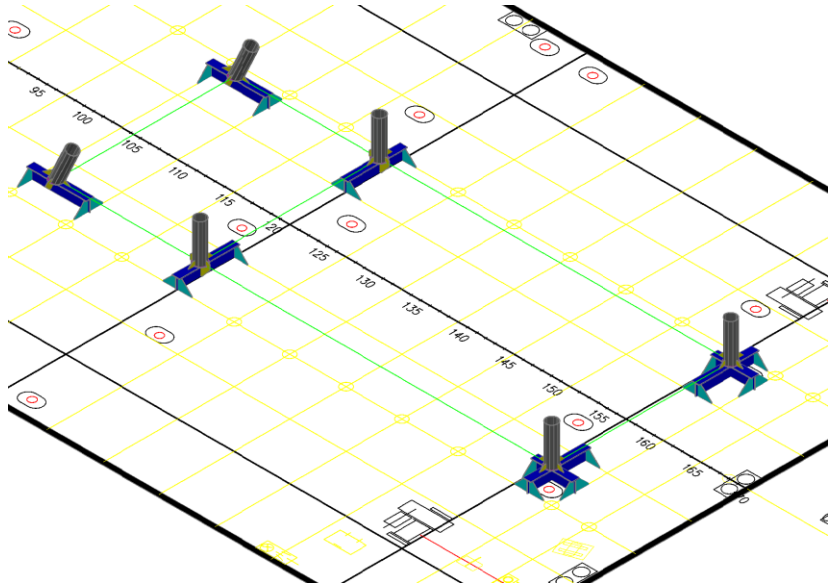
- Plate & Beam Model.

- FEM model incl. of barge structural members and grillage & lashing structure.

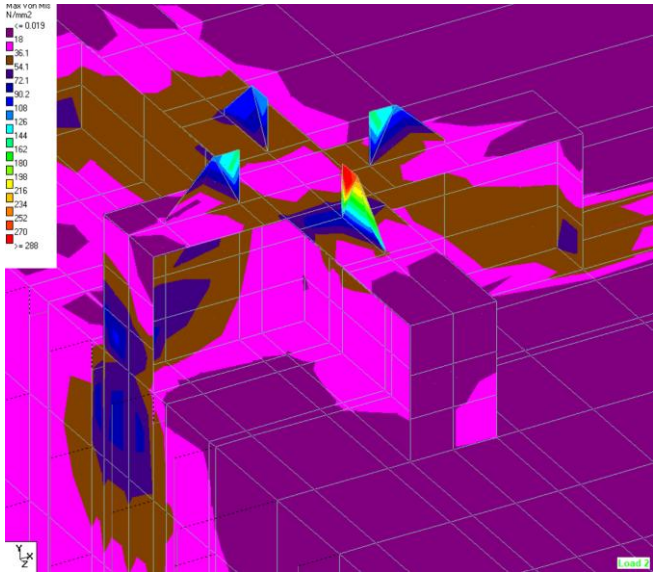
## 2. Marine Transportation

### 2.3 FPSO ‘Pyrenees’ Swivel Access Support (SAS)





Grillage & Lashing



Deck Strength Check

- The grillage beams are in line with barge deck structural members.

- Total Weight of SAS 312.9MT.

- Deck Strength Check by FEM analysis.

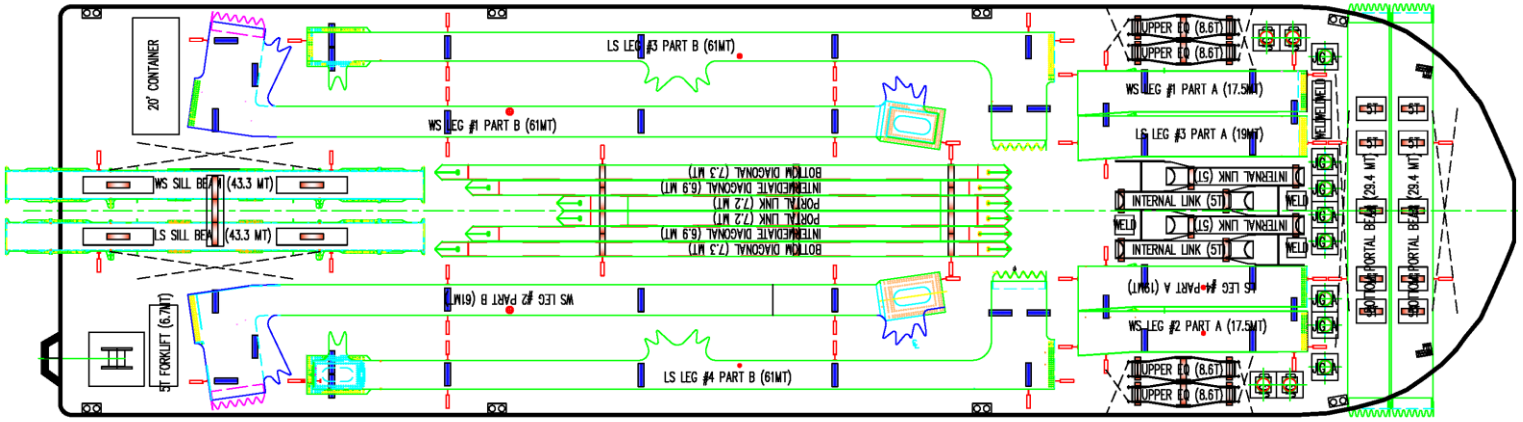
- Plate & Beam Model.

- FEM model incl. of barge structural members and grillage & lashing structure.

## 2. Marine Transportation

### 2.4 Impsa Container Quay Crane Lower Frame Transported in Loose


After fully erected at PTP




Stowage Plan of CQC Lower Frame Parts

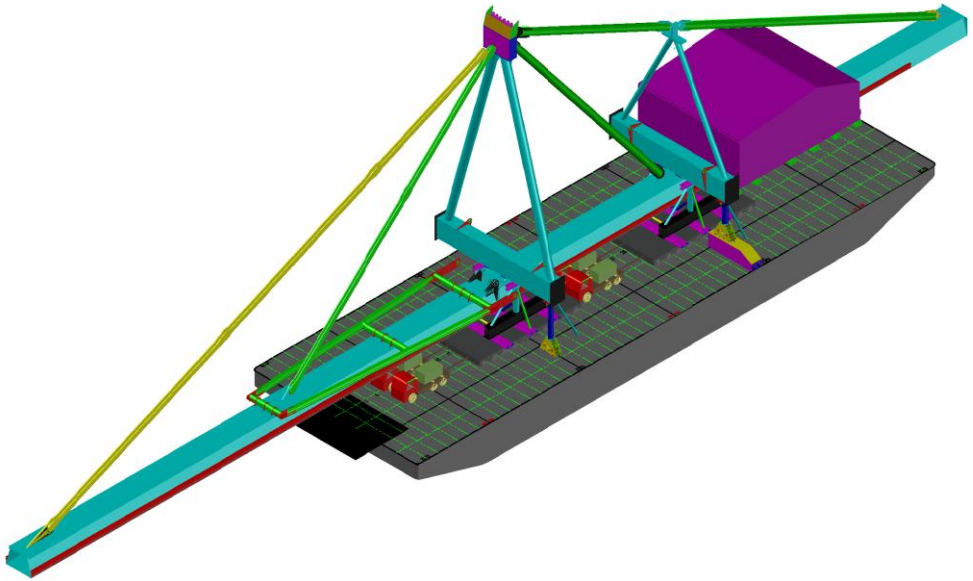
- One CQC Lower Frame Parts are well organized on one barge.

- One set of grillages and lashings for 3 x CQC Lower Parts in 3 shipments.

## 2. Marine Transportation

### 2.5 Impsa Container Quay Crane Upper Girger

Installed by Floating Crane



Stowage Plan of CQC Upper Girder

- CQC Upper Girder was roll-on to barge.

- It was measured 140m long, weighing 1200MT.

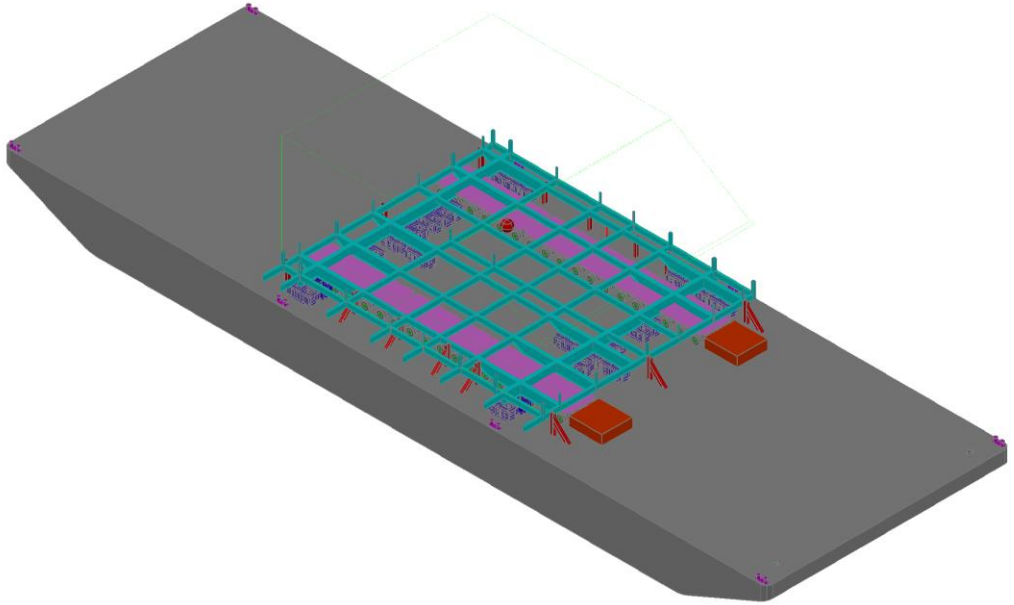
- Only pipe lashing.

- Stool supports on loadout beams.

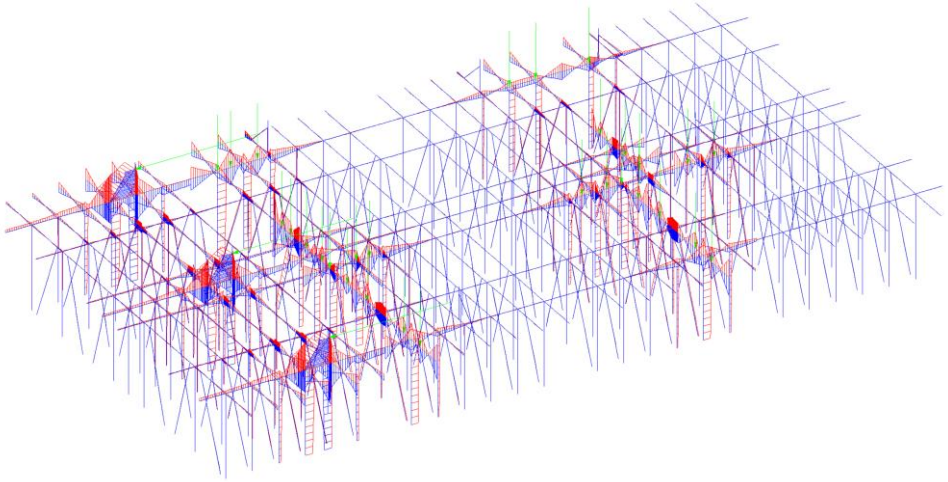
- CQC Girder was installed by 'Asian Hercules II'

## 2. Marine Transportation

### 2.6 Module Transportation Desian



Stowage Plan – E House Module



Deck Strength Check

**E-house Transportation Lashing Calculation**
**Guideline for Marine Transportations, Report No.0014/NDI, Noble Denton**

**1 Load Resulting from Vessel Motions**

**a General Information**

| | | |
|---|---|---|
| Cargo Barge Length OA | 76.200 | meters |
| Cargo Barge Beam | 24.320 | meters |
| Cargo Barge Depth | 4.877 | meters |
| Rolling Angle Applied | 10.0 | degrees in 10 seconds full cycle perioc |
| Pitching Angle Applied | 10.0 | degrees in 10 seconds full cycle perioc |
| Heave Acceleration (g) | 0.1 | m/s^2 |
| Draft of Cargo Barge | 1.51 | meters |
| Cargo Weight | 849.11 | MT |
| Trans. Dist to Barge CL (Y) | 0.000 | meters |
| Longi. Dist to barge CL (X) | 0.000 | meters |
| Cargo VCG to Deck (Z) | 6.100 | meters |
| Cargo Length in longitudinal Direction | 26.250 | meters |
| Cargo Width in Transververse Direction | 23.000 | meters |
| Cargo Height to Deck | 13.000 | meters |
| Uplift Lever in X | 10.050 | meters |
| Uplift Lever in Y | 9.652 | meters |

**b Condition A : Roll & Heave**

| | | Roll+Heave | celeration (g) | Roll-Heave | cceleration (g) |
|---|---|---|---|---|---|
| Vertical Load (KN) | : | 9023.543 | 1.08 | 7382.899 | 1.08 |
| Transverse Load (KN) | : | 2143.673 | 0.26 | 1854.383 | 0.26 |

**c Condition B : Pitch & Heave**

| | | Pitch+Heave | celeration (g) | Pitch-Heave | cceleration (g) |
|---|---|---|---|---|---|
| Vertical Load | : | 9023.543 | 1.08 | 7382.899 | 1.08 |
| Longitudinal Load | : | 2143.673 | 0.26 | 1854.383 | 0.26 |

Lashing Calculation

- The Marine Transportation design normally incl. of the following drawings and calculations.

1. Stowage Plan
2. Lashing Design & Lashing Strength Check
3. Vessel Deck Strength FEM Analysis
4. Intact & Damage Stability Calculation*
5. Towing Capacity Check*

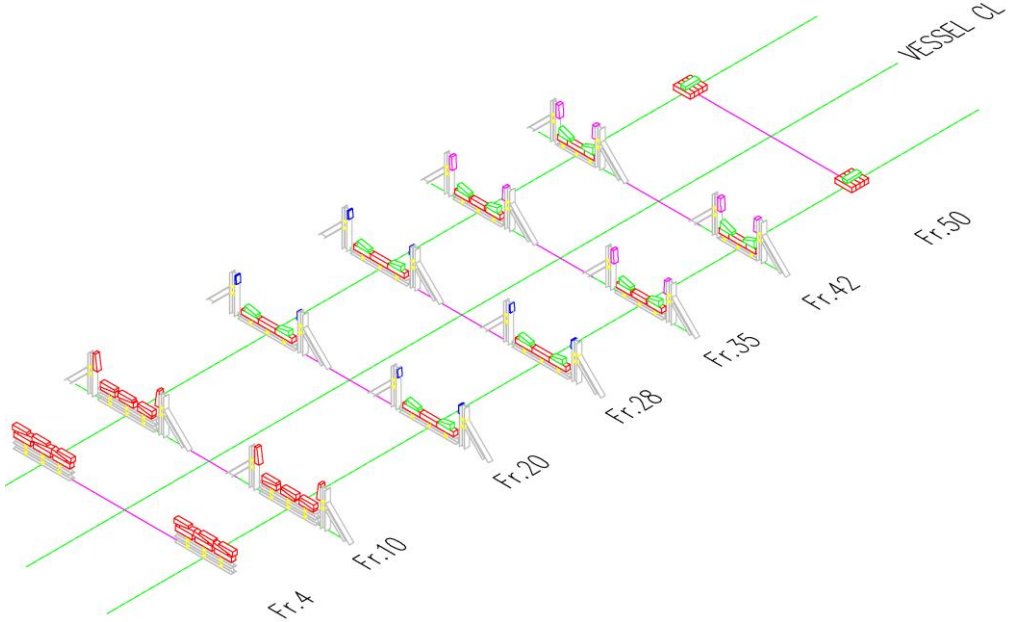
*4. One tank damage.

*5. In 2 weather conditions, severe condition for holding vessel in position, and normal condition for towing speed estimation.

## 2. Marine Transportation

### 2.7 Catamaran Grillage & Lashing Design

Grillage & Lashing on Deck




Grillage & Lashing Design

- Wooden grillage in line with vessel deck and catamaran strong structural members.

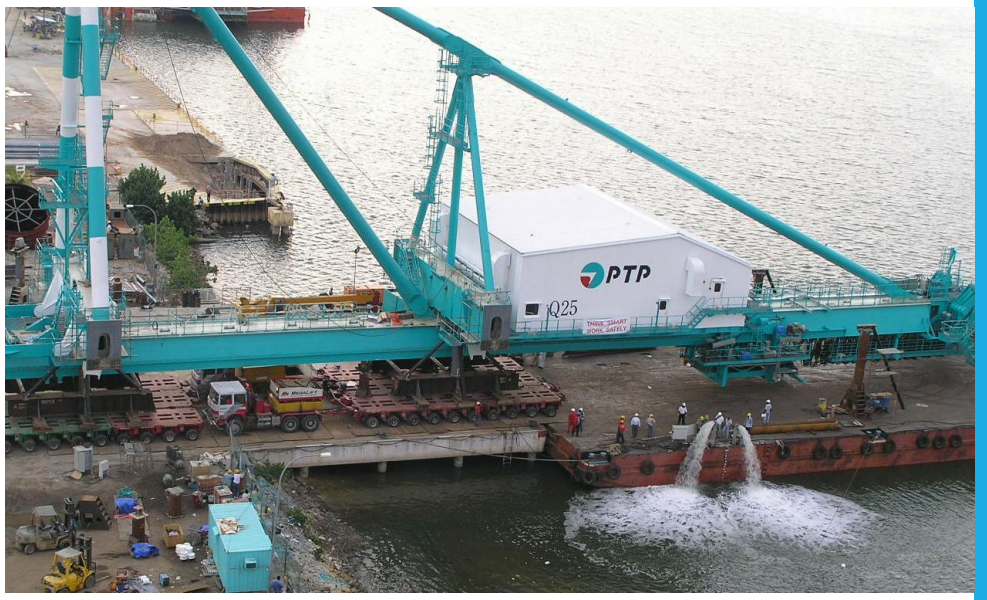
- Wooden grillage is adjustable to suit the shape of catamaran bottom.

- I Beam stanchions as lashing in vessel trans. direction.

- Crossed wire lashings added after Catamaran fully seated.

## 3. Roll-on Loadout Operation

### 3.1 Impsa CQC Upper Girder Loadout




Ballasting Tanks during Roll-on Operation

- In general the Roll-on operation design should consider the following.

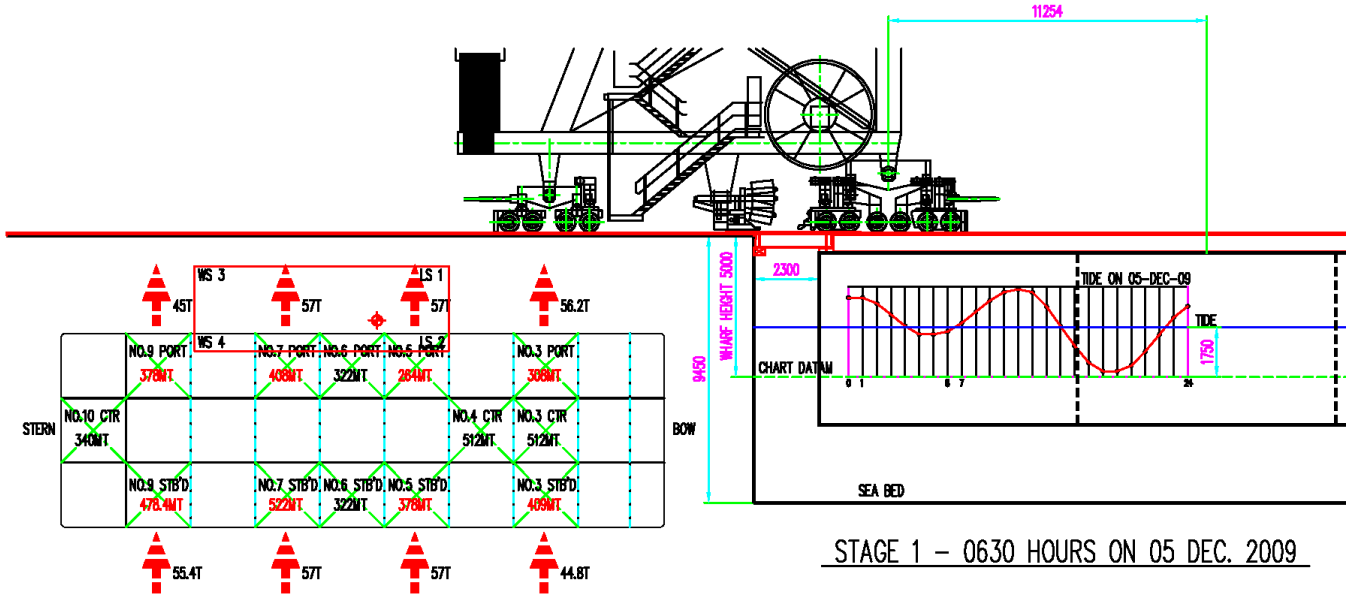
1. Roll-on operation normally at rising tide.
2. Mooring is crucial to secure the barge.
3. Water Depth, wharf height and local tide table be taken into account for roll-on stability calculation.
4. Ramp / Bridge is required for connecting shore to barge.
5. Barge ballasting tanks are for level up barge during roll-on and encounter the tideal difference.
6. Ballast pump capacities be sufficient for roll-on in planned period, and encounter tidal range within 24 hours daily if roll-on got stuck in halfway.
7. No. of pumps should be 50% more than working pumps for standby.
8. Electrical pumps need 2 independent power supplies.

# 3. Roll-on Loadout Operation

## 3.2 Coat Unloader Loadout

| TRIM - DRAFTS | | | | | |
|---|---|---|---|---|---|
| Displacement | = | 7359.205MT | TPC | = | 23.539MT/cm |
| Draft @ LCF | = | 3.527m | Draft @ Aft End | = | 3.523m |
| LCB from Aft End | = | 42.30m | Draft @ Midship | = | 3.527m |
| LCG from Aft End | = | 42.32m | Draft @ Fwd End | = | 3.531m |
| LCF from Aft End | = | 43.35m | Trim | = | -0.008m |
| MCT | = | 158.61MT-m/cm | List | = | 0.009deg |
| | | | Trim : By Bow | | |
| | | | List : To Starboard Side | | |

## Ballast Calculation




Ballast on Tanks when front Bogies Cross Over

- Barge port side alongside for side loading.

- Port tanks de-ballast out while stb'd tanks ballast in.

# CONCLUSION REMARKS

WYNNERGY

Design ability is crucial and we hope to introduce the design package to assist the local development of Taiwan offshore wind industry.

Not only the design tools but also the experienced engineering team to deal with the lifting(padeyes and spreaders design), roll on, loadout, sea fastening and marine transportation cases.

Meet the requirements from regulatory bodies and 3rd party and also provide the cost-effective design package.

# Thank you for listening

WYNNERGY
昱能海事

Heavy lifting & Marine transportation
Solution for Taiwan offshore wind industry

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02 Engineering & Analysis

03 Third-Party Veryfication

04 Manufacturing

05 Installation & Transportation

We have experienced industry experts and an engineering team with extensive experience and a thorough understanding of the standards set by regulatory regulatory authorities for Heavy lifting and Marine transportation, ensuring we meet the requirements of our clients and their principals.

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