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STUDY ON QUAY MOORING CAPABILITIES OF A CLB

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Abstract: *When loading heavy payloads, during the several offshore operations, there is necessary to prove the capabilities and reliability of the envisaged systems for the activity itself. One of the biggest concerns that are considered by the Marine Warranty Surveyors is the mooring capability of a vessel supposed to receive and furthermore transport the offshore equipment.The present article is aiming to present a study on the quay mooring analysis of a cable laying barge, which is supposed to receive a 8km batch of submarine high voltage offshore cable.*
Keywords*: cable, laying, barge, mooring*

Introduction

Although the environmental loads experienced by a vessel / barge moored in a sheltered inshore location or alongside a quayside are likely to be significantly lower than those it may experience offshore, the risk profile of these types of mooring is high due to a combination of the following factors [1]:

a. Offshore mooring systems are generally designed for large deployed lengths of mooring wire or chain whereas inshore moorings will generally have short taut lines which can lead to very high tensions and can result in uplift on anchors

b. High consequence of failure given the proximity to shore, other assets and limited response time

c. Potential lack of suitable or degraded connection points on the vessel and onshore, e.g. quayside

d. Uncertainty in the calculation of environmental forces due to wind shear effects and shallow water blockage effects

e. Potential limitations on the ability to adjust moorings and balance the line tensions in adverse weather conditions

f. Potential difficulty in knowing the actual tensions in the lines, in other words, a lack of instrumentation

g. Potential for failures due to chafe points and abrasion (especially for quayside moorings).

Accordingly with the registry rules and MWS requirements, a mooring analysis shall be performed for each berthing system, to justify the safe berthing of the various deadweight capacities of vessels expected. The forces acting on a moored vessel shall be determined in accordance with the Warranty Surveyor requirements and accepted guidelines. Mooring line and breasting load combinations shall be in accordance with the maximum acceptable loads.

Two procedures, manual and numerical are available for performing mooring analyses. These procedures shall conform to either the OCIMF documents, "Mooring Equipment Guidelines" [2] and "Prediction of Wind and Current Loads on VLCCs" [3] or the Department of Defense "Mooring Design" document [4].

A new mooring assessment shall be performed whenconditions change, such as any modification in themooring configuration, vessel size or new informationindicating greater wind, current or other environmentalloads.

In general, vessels shall remain in contact with thebreasting or fendering system. Vessel motion (sway)of up to 2 feet off the breasting structure may beallowed under the most severe environmental loads,unless greater movement can be justified by anappropriate mooring analysis that accounts forpotential dynamic effects. The allowable movementshall be consistent with mooring analysis results,indicating that forces in the mooring lines and theirsupports are within the allowable safety factors. Also,

a check shall be made as to whether the movement iswithin the limitations of the cargo transfer equipment.

The most severe combination of the environmentalloads has to be identified for each mooring
component.

When the forces have been determined and thedistance between the bow and stern mooring points isknown, the yaw moment can be resolved into lateralloads at the bow and stern. The total environmentalloads on a moored vessel are comprised of the lateralload at the vessel bow, the lateral load at the vesselstern and the longitudinal load. Line pretension loadsmust be added.

A numericalprocedure is required to obtain mooring forces for the situations classified as moderate or high and for those that do not satisfy the requirementsfor using simplified calculations. Computerprogram(s) shall be based on mooring analysisprocedures that consider the characteristics of themooring system, calculate the environmental loadsand provide resulting mooring line forces and vesselmotions (surge and sway).

Study assumptions

The study below aims to emphasize the mooring analysis performed for a cable laying barge which is supposed to be the subject of cable loading operation while it is moored alongside a quay. The mooring analysis is carried to prove the mooring capabilities during the operation, accordingly to the weather conditions in the area.

Figure 1 presents the mooring setup developed for the operation.

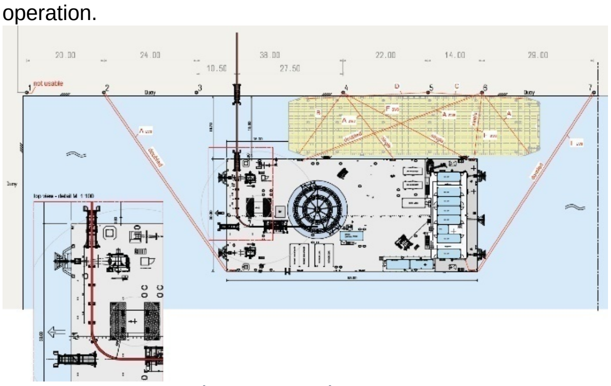

Figure 1. Mooring setup

According with reference [4], Nearshore Points 1 & 2 provide the relevant weather data for the berthing area. However, in order to follow a conservative approach, there was used the Offshore Point 1 data which provide far worse weather scenarios due to the unsheltered location; the annual wind extreme has a southwesterly direction but is below 20 m/s, thus, in order to stay on the safe side, there was considered to have a velocity of 25 m/s. Wave has been considered negligible in the port basin due to sheltered location and conservatively the current used in the design of the mooring is 0.5 m/s.

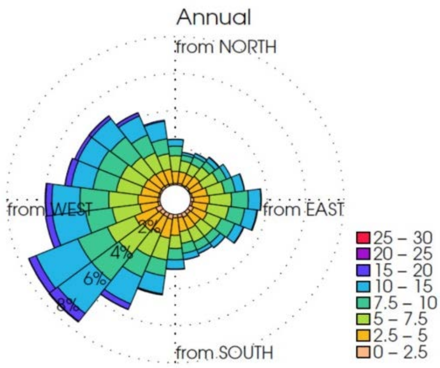

Figure 2. Wind speed in considered area [4]

Simulation setup

The fixed coordinate system has the origin in the CLB's Gravity Center (coordinates). It is located at the intersection of the water surface plan and the longitudinal plan, at 32.5 m from the aft line. The Ox axis is parallel to the barge's center line, pointing forward; the Oy axis is pointing to the Portside and the Oz axis is pointing upwards.

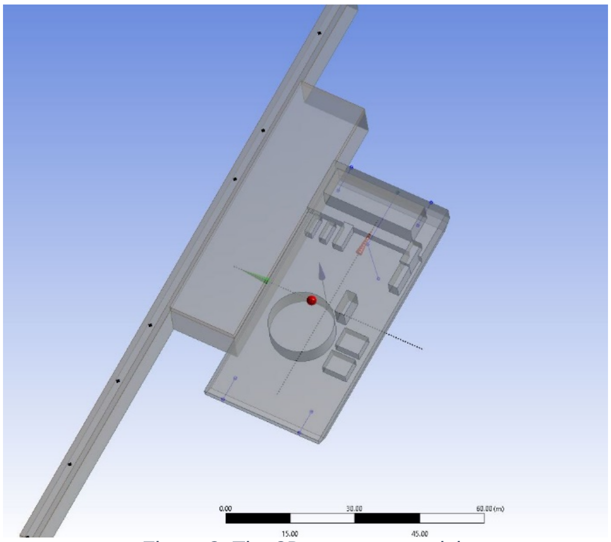

Figure 3. The 3D geometry model

The geometry was meshed by adopting a set defeaturing tolerance of 1.5 m, with a set maximum element size of 3 m. The general statistical data about the meshing is presented below:

Number of Nodes	6503
Number of Elements	6498
Number of Diffracting Nodes	2845
Number of Diffracting Elements	2485

The mooring is considered to be as a short term and weather unrestricted mooring with a pontoon between the barge and the quay

The mooring components are considered to be new or in a very god condition;

The mooringlines characteristics where assessed by considering an initial line pretention of 2.5 KN.

Mooring spread and definition of mooring lines and mooring points are presented in below representation.

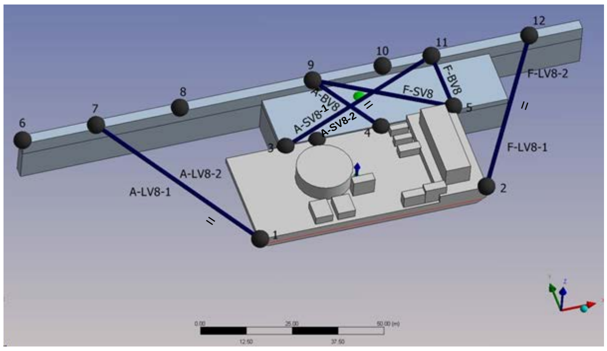

Figure 4. The simulation setup

The Hydrodynamic Diffraction analysis is the basis for the dynamic mooring analysis. During this step, the vessel motion response behavior to wave frequency (RAO's and QTF) is calculated. The loads resulting from wind, current are applied in the time – domain analysis. The CLB's RAOs and QTF values are used for calculating the barge's motions, line tensions and fairlead / bollard forces for the considered mooring spread.

The analysis setup was developed by considering a water depth of 15.5 m and a sea water density of 1025 kg/m^3. Table 1lists the inputs for the calculations:

Parameter	Symbol	Value
Wave frequency	ω [rad / s]	0.11 … 1.96
Wave period	T [s]	3.21 … 56.75
Angle of wave and wind incidence	μ [°]	-180 … 180
Increment	Δμ [°]	30
CLB forward speed	v_s [kn]	0

Table 1. Hydrodynamic Analysis input

Mooring lines loads have been analyzed by performing a time-domain analysis in Orcaflex software package. There were considered two intact Load Cases and three Redundancy checks.

	Load Case 1 (LC 1)	**Redundancy Checks for LC 1**	**Load Case 2 (LC 2)**	**3 Redundancy Checks for LC 2**
Start Time [s]	0	7200	0	7200
End time	7200	14400	7200	14400
Wind	25 m/s from quay	25 m/s from quay	25 m/s from forward	25 m/s from forward
Wind profile surface [m^2]	186.23	186.23	298.61	298.61
Wind induced force [N]	72753.13	72753.13	118753.9	118753.9
Current	0.5 m/s from forward	0.5 m/s from forward	0.5 m/s from forward	0.5 m/s from forward
Water depth	15.5 m	15.5 m	15.5 m	15.5 m

In order to follow a conservative approach, the environmental loads were determined by considering the high tide situation (Figure 5 and Figure 6); the mooring lines setup was developed by considering the lowest astronomical tide situation (Figure 7and Figure 8).

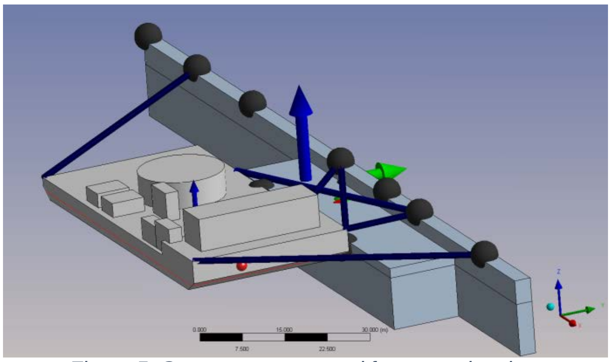

Figure 5. Geometry setup used for assessing the environmental loads – isometric view

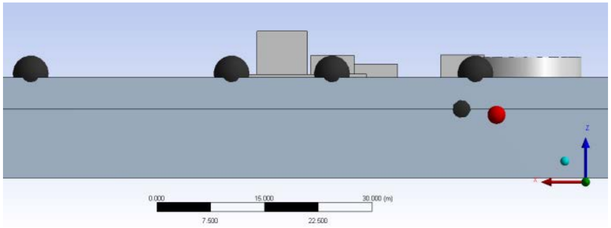

Figure 6. Geometry setup used for assessing the environmental loads – side view

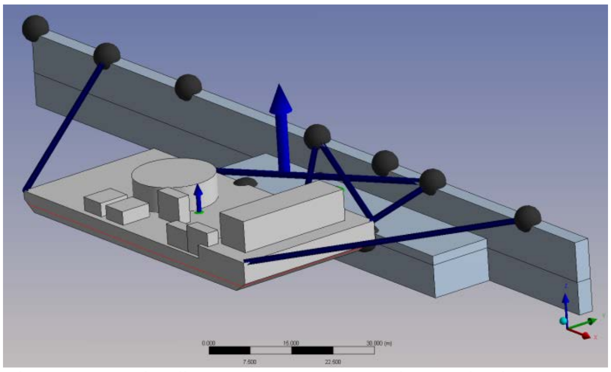

Figure 7. Mooring lines geometry setup – isometric view

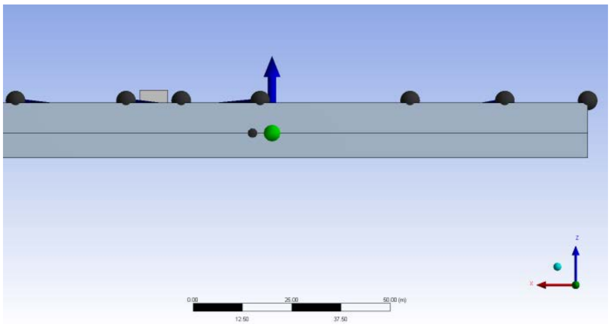

Figure 8. Mooring lines geometry setup – side view

Results

This section will present only the results obtained in the most loaded case with just one redundancy check result. The LC presented is LC1, with a 25 m/s wind velocity from beam.

	Min load [N]	Max load [N]	% MBL for Max Load	Mean load [N]	% MBL for Mean Load	Allowable %MBL
A-LV8-1	20334	20742	6.46	20499	6.39	60
A-LV8-2	20334	20742	6.46	20499	6.39	
F-LV8-1	16172	16450	5.12	16347	5.09	
F-LV8-2	16172	16450	5.12	16347	5.09	
A-SV8-1	8341	8578	2.67	8490	2.65	
A-BV8	3575	4261	1.33	3838	1.20	
F-SV8	4929	5481	1.71	5136	1.60	
F-BV8	14811	15081	4.70	14982	4.67	
A-SV8-2	8341	8578	2.67	8490	2.65	

Table 2. Mooring line Loads

No	Max load [N]	Mean load [N]	% SWL for Max Load	% SWL for Mean Load
1	41485	40998	51.86	51.25
2	32900	32695	41.13	40.87
3	17157	16981	21.45	21.23
4	4261	3838	5.33	4.80
5	20563	20118	25.70	25.15

Table 3. Barge bollards loads

No	Max load [N]	Mean load [N]	% SWL for Max Load	% SWL for Mean Load
7	41485	40998	13.83	13.67
9	9743	8974	3.25	2.99
11	23660	23473	7.89	7.82
12	32900	32695	10.97	10.90

Table 4. Quay bollards loads

For the redundancy check there was chosen the most loaded line, which is A-LV8-1, with a maximum of 20742 N. The resulted values are presented in Table 4.

	Min load [N]	Max load [N]	% MBL for Max Load	Mean load [N]	% MBL for Mean Load	Allowable %MBL
A-LV8-1	DAMAGED					80.00
A-LV8-2	20334	38006	11.84	31611	9.85	
F-LV8-1	11209	16450	5.13	13851	4.32	
F-LV8-	11209	16450	5.13	13851	4.32	

2						
A-SV8-1	8341	11251	3.51	10121	3.15	
A-BV8	2597	16530	5.15	10916	3.40	
F-SV8	2523	8046	2.51	5322	1.66	
F-BV8	6924	17089	5.32	14836	4.62	
A-SV8-2	8341	11251	3.51	10121	3.15	

Table 5. Mooring lines Loads

	Max load [N]	Mean load [N]	% SWL for Max Load	% SWL for Mean Load
1	38006	31611	47.51	39.51
2	32900	27702	41.13	34.63
3	22503	20243	28.13	25.30
4	16530	10916	20.66	13.65
5	25136	20159	31.42	25.20

Table 6. Barge bollards loads

	Max load [N]	Mean load [N]	% SWL for Max Load	% SWL for Mean Load
7	38006	31611	12.67	10.54
9	24577	16239	8.19	5.41
11	28341	24958	9.45	8.32
12	32900	27702	10.97	9.23

Table 7. Quay bollards loads

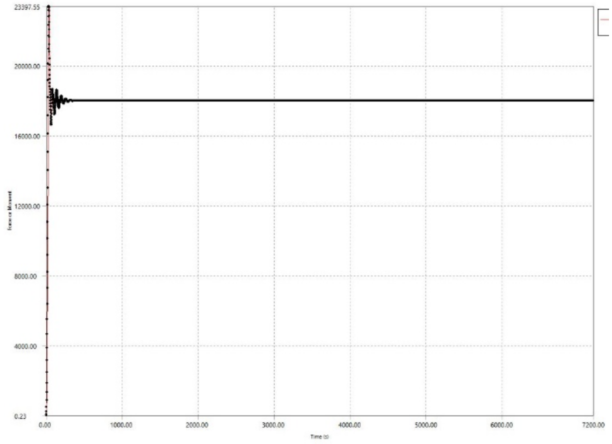

Figure 9. Loads for A-LV8-1 Line; intact condition

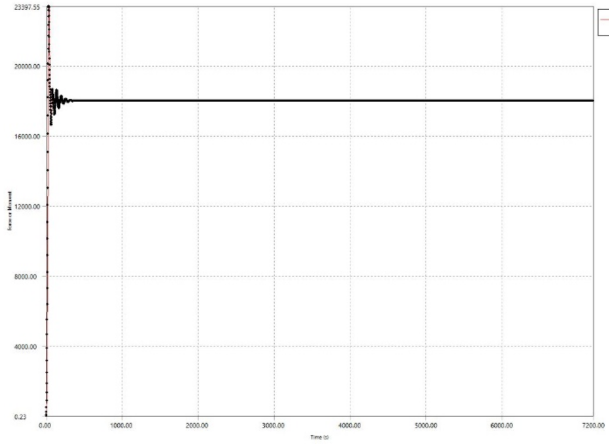

Figure 10. Loads for A-LV8-2 Line; intact condition

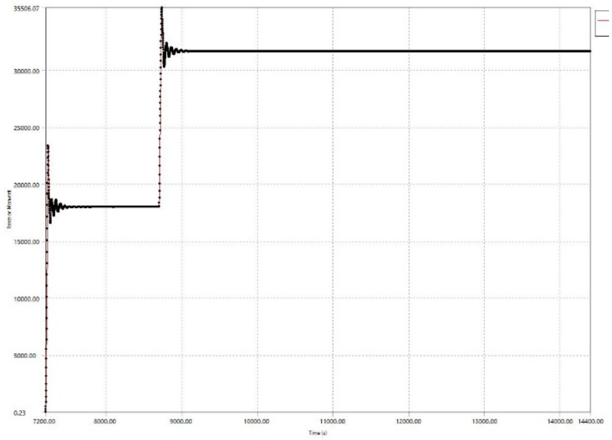

Figure 11. Loads for A-LV8-2 Line; A-LV8-1 line broken after 1500 seconds

Conclusions and further discussions

Considering the results presented in this study, the conclusion is that barges Loadout Spread, as developed and presented in Figure 1, provide sufficient mooring capability for the given environmental conditions (i.e. yearly extremes) when the configuration is implemented according to above mentioned figure. These checks have been performed as per below environmental data.

Wind Speed: 25 m/s
Current Speed: 0.5 m/s
Wave: Neglectable in the Basin

If the forecast issues weather warnings superior to above wind values, support tugs should be brought to keep the barge safely pressed onto the quay.

Acknowledgments

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