Boom Structural Design and Static Finite Element Analysis for a 1000tons Sheerleg Offshore Crane

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Abstract - ***Abstract Lifting equipment and structures, nowadays play a significant role in harbor and offshore heavy lift operations, offshore constructions and installation works of platforms, risers, modules, completing the service offer with heavy lift project management, in-house engineering of accurate lifting plans, comprehensive procedures, on-site coordination, heavy lift logistics, full loading, unloading, and rigging, as well as offshore work-scopes, from the supply of a shackle or rigging loft hire through to the complex installation of large pieces of equipment. In the present work, detailed design of a "welded box girder legs, coupled with cross beams" type boom structure for a 1000tons offshore "sheerleg" crane is presented. A finite element analysis, using the ANSYS program, is included. Results show reasonable structural resistance under the maximum lifting conditions. Wire-ropes calculations and selection of existing catalogues is involved as well.***

Key Words: *Key Offshore crane, Boom, Sheerleg, welded box girder legs, Head, Middle, Pivot, Finite Element, Wire-rope, Design, 1000tons*

1. INTRODUCTION

In recent decades, progressively heavy lifting crane operations in the offshore industry have been done, using floating vessels. From the establishment of the offshore industry, there are a huge number and variety types of floating cranes around the world for lifting services in subsea and offshore domains. Examples could be Pedestal cranes, Telescopic cranes, Knuckle boom cranes and Straight boom cranes. The offshore crane range involves advanced wire-luffing and ram-luffing cranes. The cranes are available in diverse geometries and sizes and are able to be modified for particular customer demands. Conducive to grow the usage and the operational range of floating crane vessels new ship designs have to be enhanced and the accuracy of the prediction of the operational proficiency for lifting operations has to be developed. A crane ship, floating crane or crane vessel is a ship with a crane specialized in lifting weighty loads. The greatest crane vessels are used for offshore semi-submersible deep-water construction vessels, for bridge construction and a various monohull offshore assembly or construction vessels. As installation of wind turbine foundations conventional monohulls are used, but the largest crane vessels are usually catamaran or semi-submersible categories as they have maximized stability.

In the majority of cases the crane and the vessel on which it is installed are designed autonomously from each other. This is for several reasons: Oftentimes, the crane and the vessel are designed by different companies or the crane has to be appropriate for the installation on a variety of ship types and vice versa. Therefore, the crane is many times incorporated into the ship design process only by its required space, weight and a load chart. [1]

There are a variety offshore cranes designed and constructed heretofore. In the early 20th century, the sheer hulk was used greatly as a floating crane for heavy lift tasks [2]. In 1920, the 1898-built battleship USS Kearsarge (BB-5) was converted to a crane ship when a crane with a capacity of 250 tons was installed. Later it was renamed Crane Ship No. 1. It was used, amongst other things, to place guns and other heavy items on battle ships under construction [3-5]. Another remarkable feat was the raising of the USS Squalus (SS-192) in 1939. In 1942, the Crane Ships aka "Heavy Lift Ships" SS Empire Elgar (PQ16), SS Empire Bard (PQ15), and SS Empire Purcell (PQ16) were sent to the Russian Arctic ports of Archangel, Murmansk and Molotovsk (Since renamed Sererodvinsk). Their role was to enable the unloading of the Arctic convoys where port installations were either destroyed by German bombers or were non-existent (as at Bakaritsa quay Archangel) [6]. In 1949, J. Ray McDermott had the Derrick Barge Four built, a barge that was outfitted with a 150 ton revolving crane. The arrival of this type of vessel changed the direction of the offshore construction industry. Instead of constructing oil platforms in parts, jackets and decks could be built onshore as modules. For use in the shallow part of the Gulf of Mexico, the cradle of the offshore industry, these barges sufficed [7, 8].

In 1963, Heerema converted a Norwegian tanker, the Sunnaas, into a crane vessel with a capacity of 300 tons, the first one in the offshore industry that was ship-

shaped. It was renamed Global Adventurer. This type of crane vessel was better adapted to the harsh environment of the North Sea [6, 7].
In 1978, Heerema had two semi-submersible crane vessels built, the Hermod and the Balder, each with one 2000 ton and one 3000 ton crane. Later, both were upgraded to a higher capacity. This type of crane vessel was much less sensitive to sea swell, so that it was possible to operate in the North Sea during the winter months. The high stability also allowed for heavier lifts than was possible with a monohull. The larger capacity of the cranes reduced the installation time of a platform from a whole season for a few weeks. Inspired by this success similar vessels were built [6, 7]. In 1985 the DB-102 was launched for McDermott, with two cranes with a capacity of 6000 tons each. Micoperi had the M7000 built in 1986 with two cranes of 7000 tons each. In 1984 a universal crane model was developed as part of the joint research and development project "Hook" for the ship design system E4 [8, 9]. The aim of the Hook project was to provide an integrated simulation tool for lifting operations with ships for the early ship design as well as the planning of lifting operations offshore and inshore [10, 11]. If the capabilities of a crane vessel shall be utilized to the maximum for a heavy lifting operation, simulations performed in beforehand must be as precise as possible. The second example is such a detailed crane model of a Sietas Type 183 heavy lift vessel [12] with two NMF DK IV Heavy cranes with 1000 t lifting capacity at 16 m outreach. Another representatives are the Dutch designed and built sheerlegs, which are capable to be lowered backwards for sailing the world oceans to faraway regions. On a sheerleg crane, the crane is fixed and cannot turn, and the vessel hence is maneuvered to place loads. There is a huge variety in sheerleg capacity. From 50 tons in lifting capacity, to the largest lifting capacity of over 4000 tons. The larger sheerlegs often have their own propulsion system and have a vast accommodation facility on board, while smaller ones are floating pontoons which require to be towed to their workplace zone by tugboats. Sheerlegs are routinely used for assistance in shipbuilding, salvaging ships, bridge building and loading/unloading large cargo onto ships. They have grown significantly bigger throughout the last decades owing to a marked increase in vessel, cargo, and element size (of ships, offshore oil rigs, and other large fabrications), evolving in heavier lifts both during construction and in salvage actions.
The Floating Sheerlegs 'Matador 3' (Bonn & Mees, Rotterdam) was originally designed for inshore lifts (2002), taking 1500 tons in the main tackles and 600 tons in the jib tackles. The new vessel called 'Rambiz 2' (2014), based on the already built and proven crane vessel 'Rambiz' (1996) was designed according to the order of Scaldis Salvage & Marine Contractors NV to Vuyk. The Rambiz 2 is a self-propelled DP2 crane vessel with two identical cranes, each with a lifting capacity of 1800 tons. The cranes can be skidded over 25 m longitudinal on the ship which allows the deck to be used to transport and then relocate cargo at a later stage. The width of the free deck space between the cranes has been maximized and the deck load capacity in this area is 50 ton/m2 [1].
Sadaf 3000 sheerleg crane barge was built in 1993 and modified in 2003, originally designed for offshore lifts, taking 3000 tons in the main tackles. SADAF-3000 crane barge and LB90 launch barge were due to load out, transportation and installation of the 890-ton topside in the oil layer of South Pars gas field in the Persian Gulf [15].
As there is no paper in designing procedure and details of sheerleg crane booms, in the present work we present boom structural design, finite element analysis and wire-ropes calculations and selecting from existing catalogues, for the Boom of a Sheerleg crane type 'welded box girder legs' with the maximum lifting capacity of 1000tons.

2. STRUCTURE DESIGN

2.1 Different Construction Types for the Crane Boom

To compare different construction types for the crane boom, an analysis has been made for some different designs. The following currently most common construction types have been considered [1]:
- Welded box girder legs, coupled with cross beams.
- Lattice construction legs, coupled with cross beams.
- Single lattice construction.

An optimized design has been made for each of these construction types, for three different material grades. The yield strengths of the considered materials are 355, 460 and 690N/mm2.

2.1.1 Lattice construction legs

The double lattice geometry is based on the (1st) Rambiz A-frame structure. It consists of two rectangular lattice columns. The columns are coupled with rectangular lattice cross beams. Only circular tubes are applied in this construction (example is "Rambiz").

2.1.2 Single lattice construction

The single lattice construction has a tapered rectangular cross section. Only circular tubes are applied in this construction (an example is USS Squalas (SS-192)).

2.1.3 Welded box girder legs

The A-frame consists of two continuous rectangular box

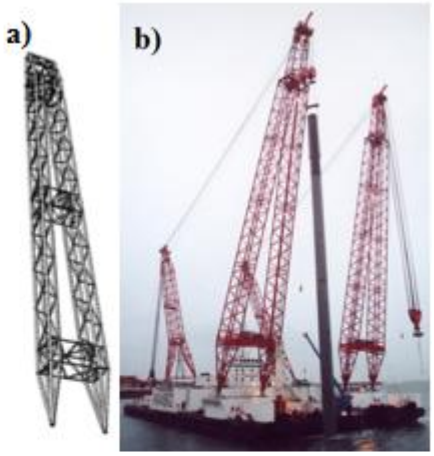


Fig -1: a) "Lattice construction legs" sheerleg crane boom b) Rambiz crane construction as an example

Fig -2: a) "Single lattice construction" sheerleg crane boom b) SS-192 crane construction as an example

sections running from bottom to top. The 4 outer plates are stiffened by diaphragms and longitudinal profiles (examples are 'Matador 3', Rambiz 2, Sadaf 3000). Two spreader bars have been used to regulate the distance between the two main hooks.

Fig -3: a) "Welded box girder legs" sheerleg crane boom b) Rambiz2 crane construction as an example

2.1.4 Basis for comparison

Some remarkable conclusions from these results [1]:
- A single lattice is the most material efficient construction type;
- A construction with 2 lattice legs is the most material inefficient construction type;
- The difference between a welded box construction and the single lattice construction is relative small.

More aspects than only the weight should be taken into account in the selection of the preferred construction type for a crane boom. Some of these aspects are:
- Fabrication costs: In general the fabrication of a lattice construction will cost significantly more per ton than for a plate construction.
- Material costs: tubes are more expensive than plates, higher grade steel is more expensive than lower grade steel;
- Fabrication facilities worldwide. Most construction companies are available for welding plated constructions than for lattice constructions;
- Inspection/ maintenance;
- Visibility: A box construction will block the visibility of the load more than a lattice construction will do;
- Damage resistance: A clash of the boom with the load or any obstacle could lead to failure of the boom. The chance for a fatal failure will be less for a box construction.

2.2 Boom Design

Figure 4 illustrates the general shape of a "welded box girder legs sheerleg floating crane". As it is seen from the Fig. 4, the boom structure of a Sheerleg offshore crane consists of three main parts: Head, Middle and Pivot. A general arrangement of the present designed crane structure (on a hypothetical vessel) is shown in the Fig. 5. As it is obvious, each side of the crane structure includes one lifting-block (named 'Upper lifting-blocks). The wires specialized for load lifting, are handled with two winches at each side. Considering the fact that, sheerleg crane boom should be fixed at an angle of 60 degrees for the present design (respect to horizontal direction), wire fixing method is supposed to be used. On each side, 2 pulleys are used to constraint fixing wire-ropes (Figs. 5 and 8).
Figure 6 shows a 3D view of the present design for the structure of the crane boom. In the Fig. 7, a 2D top-view illustration of the crane structure is presented to express boom main dimensions. The structure consists of 3 parts: Table 1 poses the structure dimensions for three main parts, Head, Middle and pivot. The additional costs per ton weight are less than the additional costs for heavier equipment; so, high tensile stainless-steel with the minimum yield of 690 N/mm2 is considered for the boom construction, to reduce the total weight.

Fig -4: Sheerleg crane, type Welded box girder legs

As it is clear from the Fig. 5, the longitudinal distance between the pivot-main deck connection point, and the A-frame (which is proposed to support lower pulleys), is 50m. Although this magnitude could be changed due to the ship/barge dimensions, here, all calculations (including wire-rope calculations and finite element analysis) are done with the 50m distance assumption. As well, the height of the A-frame is assumed to be 5m (Fig. 15). Two types of the wire-ropes are to be used; the first type is lifting wire-ropes (which pass through the lifting-blocks and are handled by winches), and the second type as fixing wire-ropes, which are supposed to be used to fix the boom structure in the 60 degree angle.

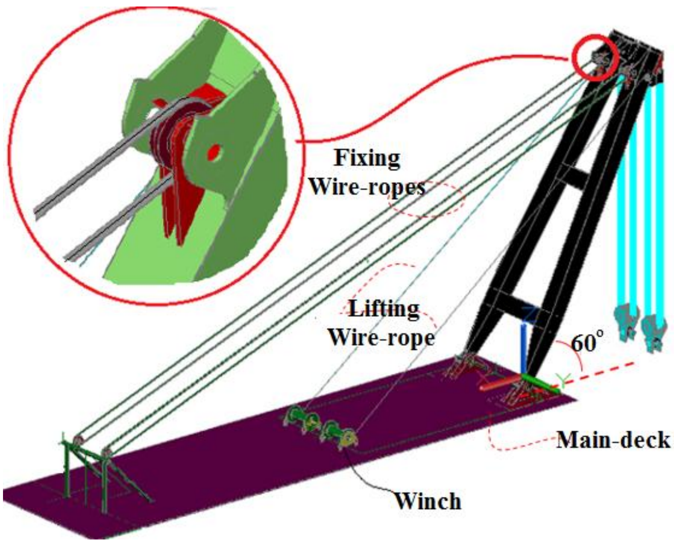


Fig -5: Schematic of General Arrangement

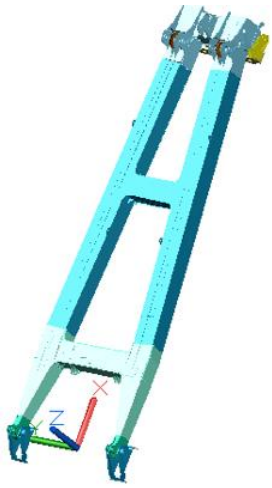


Fig -6: Present design for crane structure

2.2.1 Head Design

Figure 8 exhibits 3D drawing of the HEAD part design. As mentioned in the Table. 1, the length of the head part is equal to 4775mm. According to the Figs. 4 and 5, each sheerleg crane involve two types of lifting blocks: the first types are the Upper Lifting-Blocks which are jointed to the Head part on both sides, and Lower lifting blocks as the second type. Lower lifting blocks may be designed in variety models due to lifting projects or owner's demands. The HEAD part, includes facilities to support pulleys,

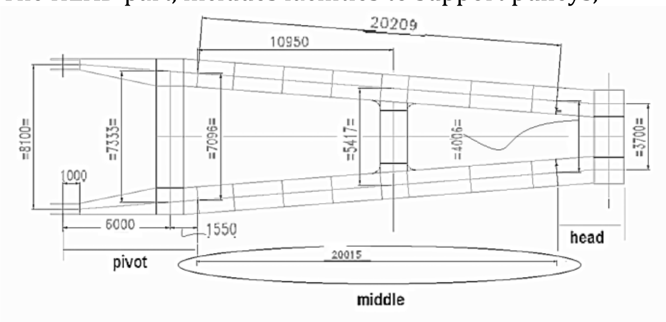


Fig -7: 2D top view of the designed crane structure

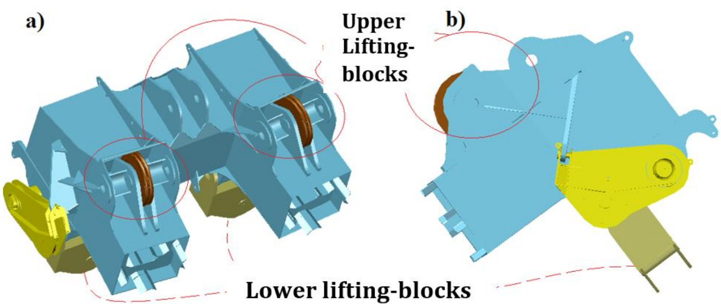


Fig. 8. 3D drawing of the head section a) Isometric view b) side view

(through which the lifting wire-ropes pass) and upper lifting-blocks. Cross sectional dimensions for the Head part are mentioned in the table 1 (w1, h1, w2 and h2). Figure 9(a) represents explosive 3D drawing of the HEAD part. Figure 9(b) illustrates marked part details, which are presented with magnification in the Fig. 10. Fig. 10 also shows associated plates' thicknesses.

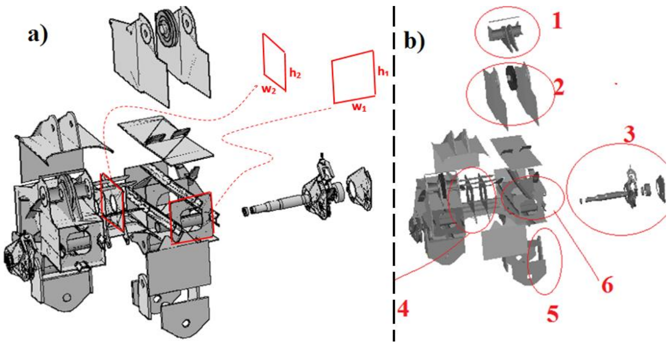


Fig -9: Explosive drawing for the head part of the crane structure, a) Indication of the dimensions presented in Table. 1 b) Numbered details, presented in the Fig. 10, one by one

2.2.2 Middle Design Characteristics

Figure 11 shows a 3D drawing of the MIDDLE part of the boom structure. The length of the MDDLE part is equal to 20015mm. Spout width at the widest section and slimmest section are 7096mm and 4006mm respectively (Fig. 7 and Table. 1).

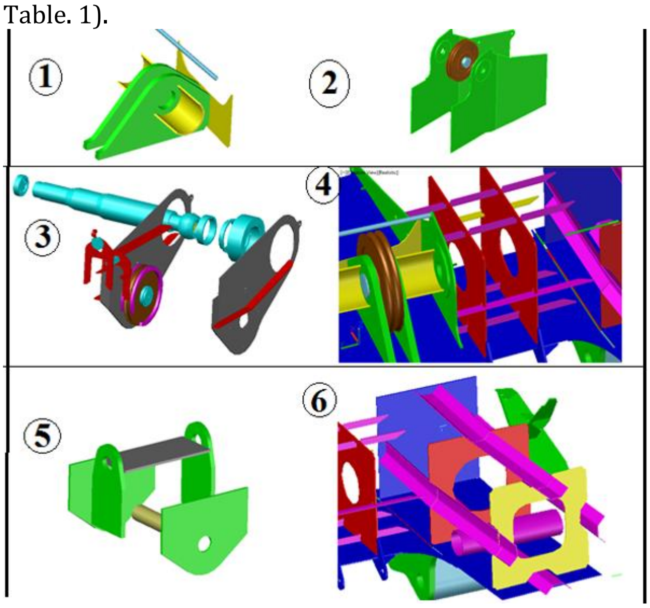


Fig -10: Part details of the HEAD part, for the reference detail numbers refer to the Fig. 9(b). Colors are thickness representation: Green: 80mm, Gray: 40mm, Dark blue: 25mm, Red: 20mm, Yellow: 15mm, Purple: 10mm, Light blue: pin

Figure 12, illustrates a 3D explosive drawing of the MIDDLE part with magnification on part details. Cross sectional dimensions for the middle part (w3, h3, w4 and h4 in Fig. 12) are presented in Table. 1. There are two types of inner stiffening plates: Longitudinal (filler-shape) and transversal. For all three boom main parts (head, middle and pivot) longitudinal stiffeners are similar to the thickness of 10mm. The cross section and thickness of the transversal stiffeners change in each part (which are indicated in corresponding figures). For the HEAD part, inner stiffener plates are displayed in Fig. 10, and for the MIDDLE part stiffener plates are revealed in Figs. 11 and 12.

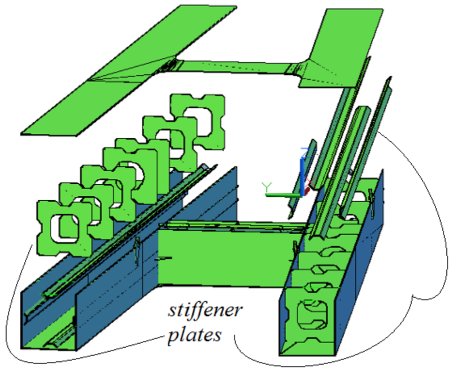


Fig -11: 3D representation of the Middle part of the crane structures, explosive view (colors do not represent thickness here)

2.2.3 Pivot Design Characteristics

Fig. 13 presents 3D view of the PIVOT part design. PIVOT part of the sheerleg crane boom structure is one of the most significant parts, due to handling the lifting and

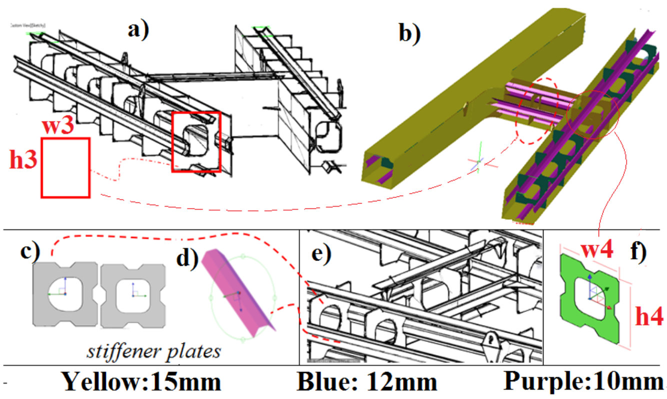


Fig -12: a, b and e) various explosive vies of the MIDDLE part of the crane structure; c, f) cross-sectional inner brackets; d) longitudinal inner brackets

crane weight load transition from MIDDLE and HEAD parts to the main-deck connection point. So, the thickness of the plates in this part is much more than the MIDDLE and HEAD parts. As it is seen in the Fig. 14, in the magnified part details of the bottom of the PIVOT, a huge pin undergoes the load transition and it suffers from a significant shear stress in contact with supporting plates. So, a series of rolled plates are used for preventing direct contact between the huge pin and supporting plates. Pin diameter is 600mm.

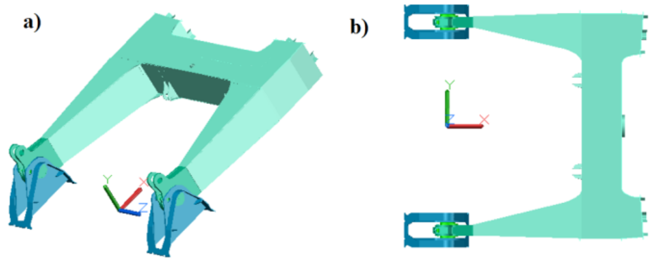


Fig -13: 3D drawing of the head section a) Isometric view b) side view (color do not represent thickness here)

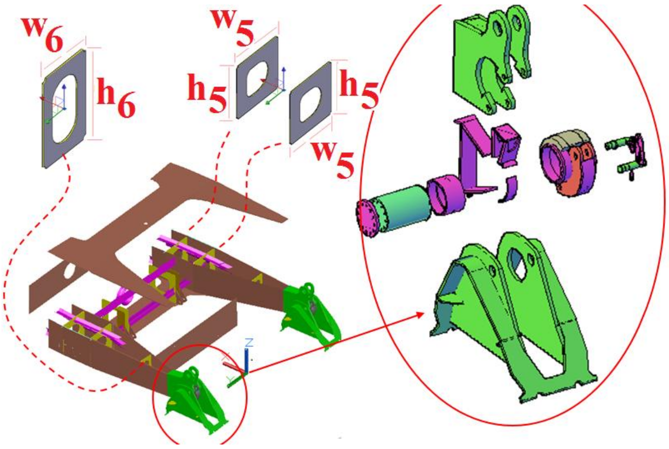


Fig -14: Explosive 3D illustration of the Pivot part of the designed crane structure

2.3 Wire-ropes Calculations

2.3.1 Fixing wire-ropes

- Calculations and selection

As it is presented in the Fig. 5 (as well as Fig. 15 and Fig. 19) 4 wire-ropes are used to fix the structure of the crane on each side, i.e. totally 8 wire-ropes fix the crane at the angle of 60° respect to the horizon. In addition, according to Fig. 5, an A-frame is supposed to be used in the distance of the 50m (respect to pivot fixing point on the main-deck) at the back side of the ship, with the height of the 5m. It provides more working place on the main deck, comparing the case in which the wire-ropes are fixed directly to the main-deck plate (with pulleys). The fixing wire ropes' geometry is displayed in the Fig. 15. In the calculations, the maximum lifted load is considered (1000tons).

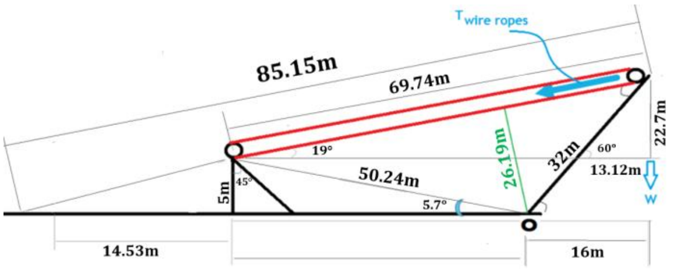


Fig -15: Geometry presentation of the fixing wire-rope dimensions

$$M_0 = 0 \Rightarrow w*16 = T_{fixing_{wire-ropes}} * 26.19 \Rightarrow$$
$$(w = 1000tons) \Rightarrow T_{fixing_{wire-ropes}} = 710.8tons \qquad (1)$$

M_0: Summation of the moment (in point O as reference)

$T_{fixing_{wire-ropes}}$: Total force of the fixing wire-ropes in half side of the boom

W: Maximum load in operation

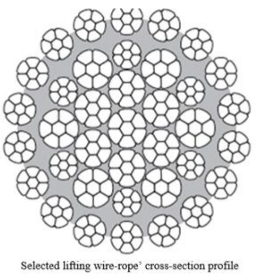
$T_{wire-ropes}$: Total applied force on fixing wire-ropes →

$$T_{each(fixing) wire-rope} = 710.8tons / 8 = 76.35tons \qquad (2)$$

$T_{each(fixing) wire-rope}$: Applied force on each fixing wire-rope in maximum loading operation condition

According to Eq. 2, each fixing wire-rope undergo a force equal to 76.35tons in maximum load lifting conditions. Considering GL1 appliance guidelines, maximum applied stress should not exceed from approximately 0.7 of the allowed stress. So, selected wire-rope should have an allowed maximum force equal to 127.25 tons. Fig. 16 represents a wire-rope catalogue2, in which a wire-rope with 36mm diameter and 131 tons of maximum allowed force is selected. As stated in the catalogue, selected wire-rope can be used for all cranes and high performance lifting applications where non-rotating and high MBL ropes are required. Recommended for offshore, deck cranes and marine environment. Figure 16 also shows the cross-sectional profile texture of the selected wire-rope. MBF (kN) and MBF (MT) are the maximum allowed force in kN and tons respectively.

[1] Rules for Classification and Construction, edition 2012
[2] Lankhorst ropes catalogue



Diameter (mm)	Metallic area (mm)	Weight (kg/m)	MBF (kN)	MBF (MT)
22	271	2,34	474	48,3
23	297	2,56	520	53,0
24	324	2,79	567	57,8
25	350	3,03	612	62,4
26	377	3,25	660	67,3
27	410	3,54	717	73,1
28	441	3,80	772	78,7
30	507	4,38	887	90,5
32	575	4,97	1006	103
34	647	5,59	1132	115
36	732	6,30	1281	131
38	811	7,01	1419	145
40	896	7,74	1568	160
42	987	8,52	1727	176
44	1092	9,40	1911	195

Fig -16: "Royal Lankhorst" wire-rope catalogue for fixing wire-ropes [18]

- *Wire termination*

Each fixing wire-rope is passed through each couple of pulleys (one pulley on the head part and its pair at the backside A-frame) (Figs. 5, 15 and 17a). It is crucial to utilize an appropriate wire termination method, because of high applied force on the wire-ropes (come from fixing the boom structure). One of the most common methods is using Fistgrip Clips for wire-rope termination (Fig. 17b). The number of required Clips, as well as wire turn-back length, is to be determined, depending on wire-rope diameter. As the wire-rope diameter is equal to 36mm (1.5 inches approximately), 7 clips are required at least. In addition, according to the catalogue table, a minimum length of 78 inches of the wire-rope is to be turned back (Fig. 18).

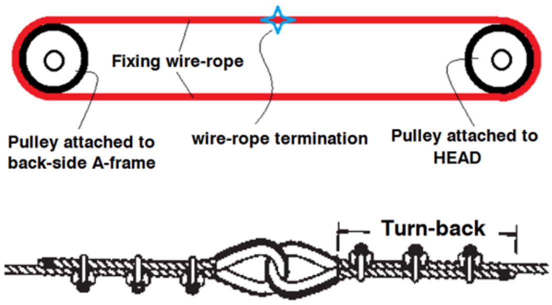


Fig -17: Wire-rope termination method for fixing wire-ropes

2.3.2 Lifting wire-ropes calculations and selection

There are three types of lifting blocks which involve pulleys: Lower lifting block, upper lifting block and frame lifting block with 7, 6 and 1 pulley respectively (Fig. 19). According to reeving diagram in Fig. 19, the total weight of the lifted load in each side is divided into 14 to obtain applied force on the lifting wire-ropes. Assuming 500tons load in each side (when lifting maximum load), the applied force on the lifting wire-rope is:

Table 1

Clip Size (Inches)	Rope Size (Inches)	Minimum No. of Clips	Amount of Rope to Turn Back in Inches	*Torque in Ft. Lbs.
3/16	3/16	2	4	30
1/4	1/4	2	4	30
1-3/8	1-3/8	6	62	500
1-1/2	1-1/2	7	78	500

If a pulley (sheave) is used for turning back the wire rope, add one additional clip. See Figure 4.

If a greater number of clips are used than show in the table, the amount of turnback should be increased proportionately.

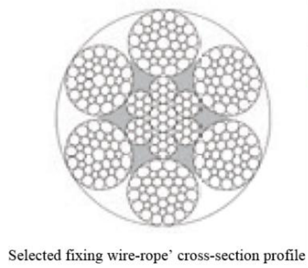
*The tightening torque values shown are based upon the threads being clean, dry, and free of lubrication.

Fig -18: Wire-termination requirements: minimum number of clips and minimum wire-rope turn back [17]

$$T_{lifting_{wire-ropes}} = {500tons}/{14} = 37.7tons \quad (3)$$

Same to fixing wire ropes, this value should not exceed 0.7 maximum allowable force. So, selected wire rope should have at least ${37.7tons}/{0.7} = 62.8tons$ maximum allowable force.

The selected wire-rope (Fig. 20) has 92.2 MBF with 36mm of diameter.



Diameter (mm)	Weight (kg/m)	MBF (kN)	MBF (MT)
32	4,19	715	72,9
34	4,73	807	82,3
36	5,30	904	92,2
38	5,91	1008	103
40	6,54	1116	114
42	7,22	1231	126
44	7,92	1351	138
46	8,65	1476	151
48	9,42	1608	164
50	10,2	1744	178
51	10,6	1815	185
52	11,1	1887	192
54	11,9	2030	207
56	12,8	2188	223
58	13,8	2350	240

Fig -20: Selection of the lifting wire-rope from the catalogue [16]

Figure 20 shows the cross-sectional profile texture of the selected lifting wire-rope, as well.

As declared in the catalogue, selected fixing wire-rope is a standard wire rope with higher breaking strength; used for all kinds of purposes, i.e. luffing, mooring, towing, anchoring and coupling push barges. The independent wire rope core provides more strength and stability to the wire rope compared to the fiber core.

3. Finite Element Analysis

3.1. Finite element model

Fig. 21 shows a 3D finite element model, provided in ANSYS program.

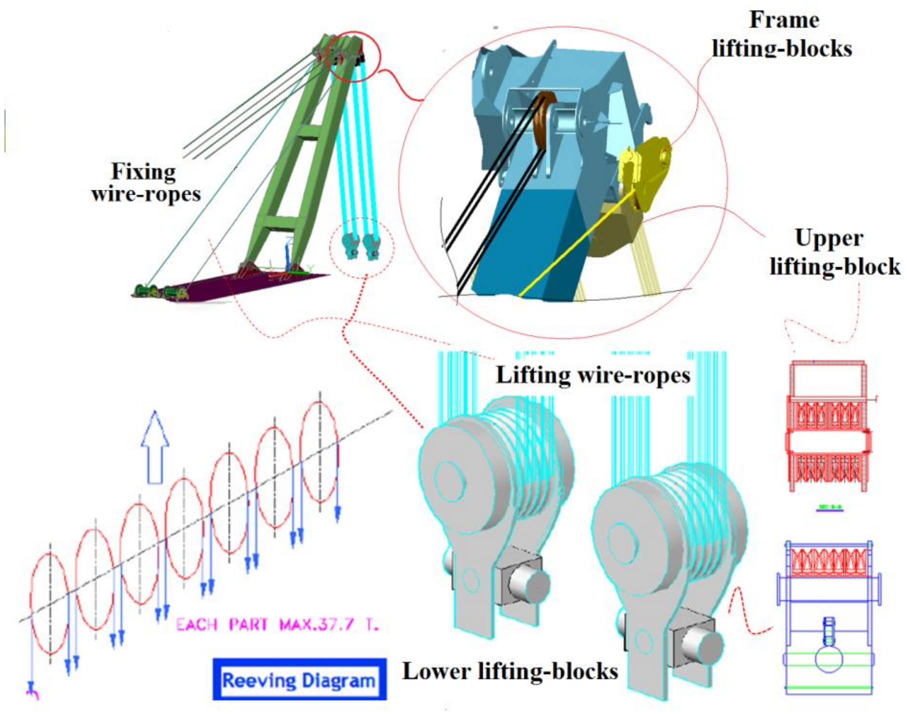


Fig -19: Details on lifting wire-rope

In the Fig. 22 details of the model in ANSYS are represented. Figure 22(a) illustrates HEAD part model details, in which fixing wire-ropes are modeled with lines; these wire-rope reorientation lines are meshed with BEAM elements and loading method would be expressed in the next section.

Figure 22(b) shows MIDDLE part model details. Transversal inner brackets are included in the ANSYS model of all HEAD, MIDDLE and PIVOT, and for the purpose of the model simplification, longitude inner brackets are not added to the model. Figure 22(c) and 22(d) represents a magnification of the pivot part. Taking this fact into account, that present design is flexible to be used in diverse ships and barges, we typically have modeled a limited part of hypothetical main-deck sheet (for the connection point of the pivot to main-deck) to apply displacement constraints.

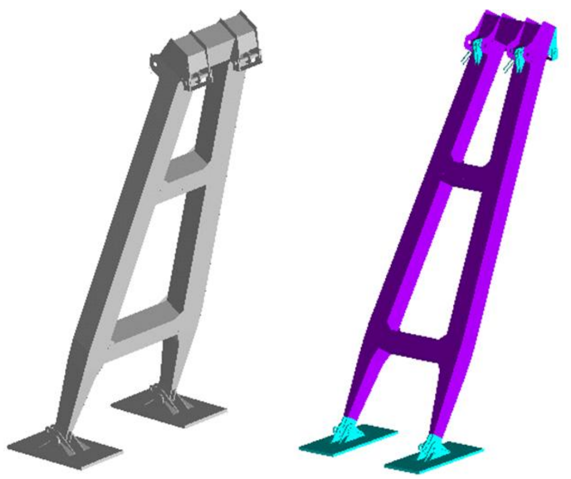


Fig -21: 3D finite element model provided in ANSYS

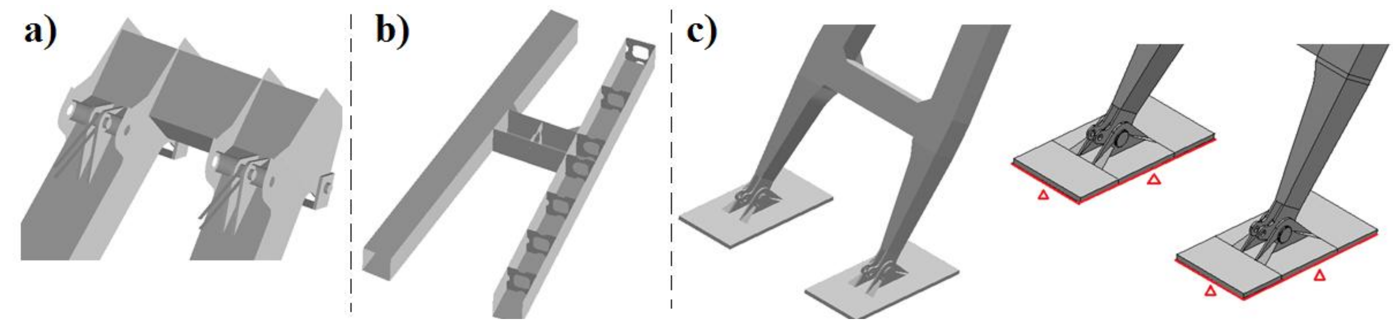


Fig -22: Finite element model details of the a) HEAD b) MIDDLE and c) PIVOT, in ANSYS

3.2 Loading

Figure 23 presents a simple schematic of external applied loads besides the boom constraint at pivot pin. As it is seen, LOAD represents the lifted load by the crane and, fixing wire-ropes undergo resulted forces to maintain the boom structure at fixes 60 degrees angle. The fixing wire-ropes are partially modeled with lines, meshed using 3D Beam elements with circular cross-section. The end side of the partially modeled fixing wire-ropes are fixed (Fig. 24). Lifted Load is distributed on the top plate of the Upper Lifting Block (Fig. 24). At the bottom of the boom, pivot's pin supports constraint of the boom structure to the main deck's supporting plates. Figure 25 shows fixed lines of the partially modeled plates of the main deck.

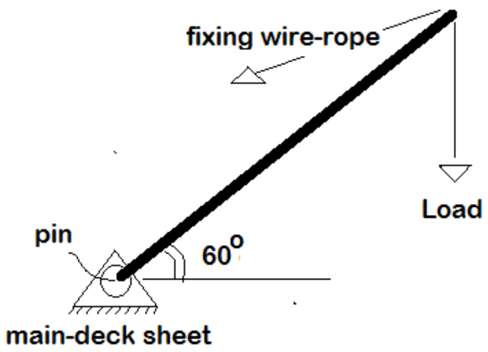


Fig -23: Simple schematic of the load vectors and constraints of the model

A sliding contact using penalty method is used for contact definition between the pivot pin and its supporting plates. It is so important the contact to be sliding. If else, a huge unreal momentum is produced, due to applying lifted loads at the tip of the boom, results in unconfirmed extensively high stress distribution at the pin zone. For the purpose of reducing the time of the calculations, only half of the crane boom is modeled and symmetric constraints are applied to the edged lines situated on the symmetry axes.

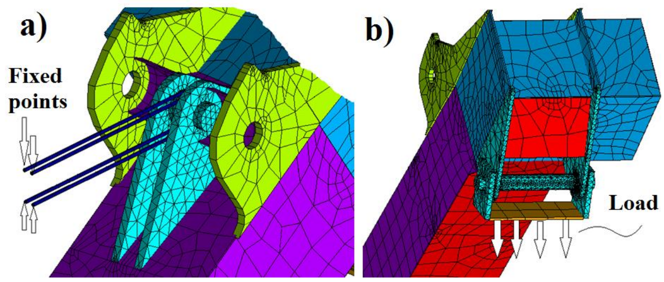


Fig -24: a) Method of the modeling of the fixing wire-ropes, b) Method of applying lifted load

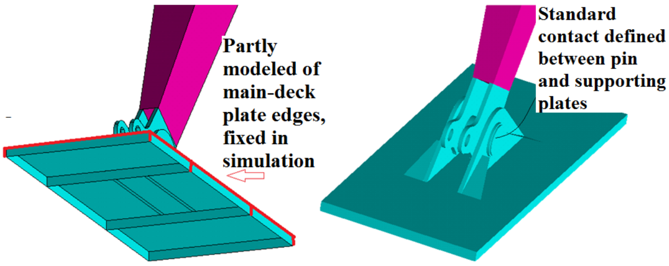


Fig -25: Fixed lines of the partially modeled of the main-deck plate

3.3 Results

Fig. 26 presents Von Misses stress contours of the whole boom structure, with the presentation of the maximum stress point. As it is illustrated, the maximum of 350 MPa stress occurred at the plates of the MIDDLE part of the boom structure, at the conjunction of the vertical boom's leg and horizontal connector box. Figures 27(a) and 27(b) show Von Misses stress distribution at the HEAD and PIVOT parts respectively. For the HEAD part, considering contour legend, maximum stress level is approximately 2702MPa, and for the pivot part, locally 350MPa stress is the maximum.
Figure 28 shows Von Misses stress contour at the inner stiffener plates which does not exceed 350MPa. Considering 690MPa high tensile steel supposed to be used for the construction, all results show reliability and high performance resistance of the designed structure under the maximum lifting conditions.

4. CONCLUSION

In the present work, a review on the history of the offshore crane designs is provided. A more currently considered type of the offshore cranes, named "Sheerleg" is described in continuing. Three models of the Sheerleg design are explained afterward. Designing procedure and 3D sketches of the boom structure, for a Sheerleg offshore crane, with the 1000tons maximum lifting capacity is provided. 3D detailed explosive drawings (using the AutoCAD program) are involved. A corresponding 3D finite element model is then, prepared in ANSYS program and analyzed under static loading conditions. The results show reasonable strength of the boom structure in the maximum load-lifting conditions. Altogether, as clearly an extensive lake of papers in the design process of the crane boom, for sheerleg type cranes is seen, this paper provides a good guideline for the boom structure design procedure of the Sheerleg type crane.

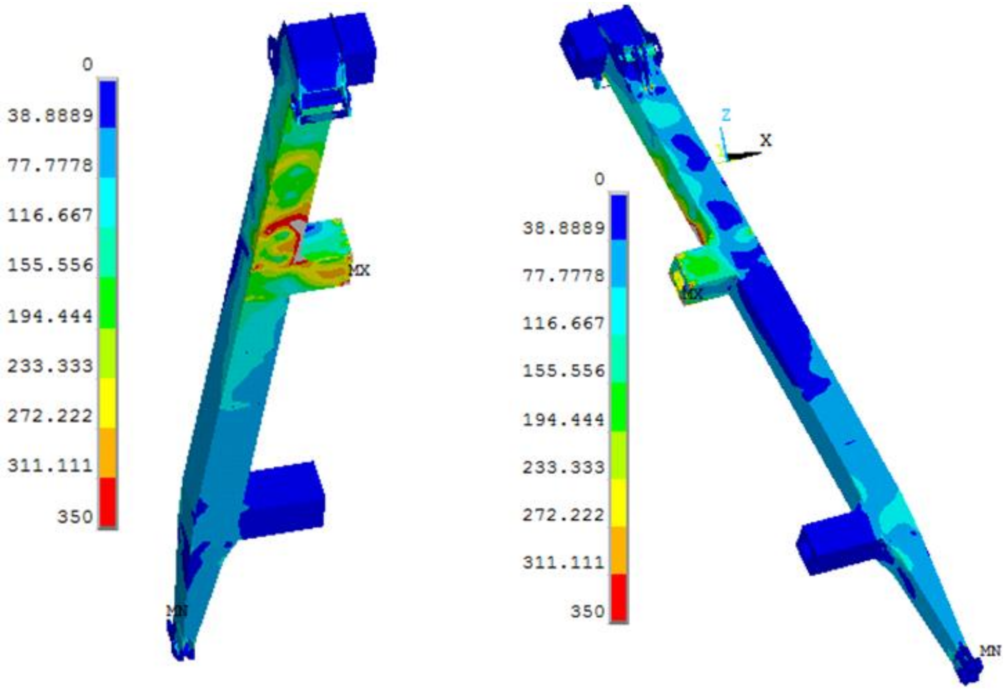


Fig -26: Von Misses stress distribution on the whole model

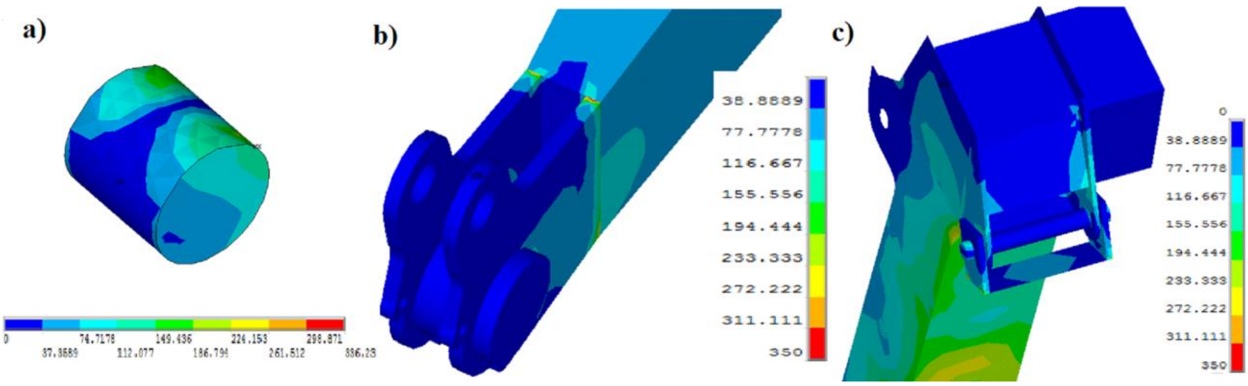


Fig -27: Von Misses stress distribution, a) Pin, b) PIVOT, c) HEAD

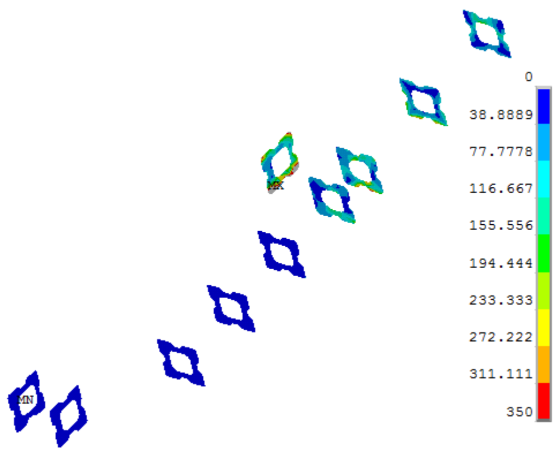


Fig -28: Von Misses stress distribution on inner stiffeners

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