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Deformations on the Ship Blocks During Fabrication: Cause and Remedies

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ABSTRACT

In building activity, the material is affected and this is likely to occur because of many factors such as heat in steel cutting, welds brings deformations, lifting and turning of ship blocks, technological stiffening and many possible changes of ship blocks. Lifting brings deformation and it is the main cause of modifications that highly disturb the production cost and quality. The purpose is to determine the main causes of deformations into the ship blocks during building and to determine in detail the lifting and turning operations of ship block using the Finite Element Method (FEM). A strength check with FEM is done on the ship block to find the deformations and stresses in some different loading conditions. Firstly, the block was checked without technological stiffening for lifting in front of during turning and final lifting after turning. Secondly: It was analyzed a case by means of technological stiffening, according to the lifting drawing. Different parameters that determine the lifting drawing were checked such as the sling angle – it affects the deformation charac-teristics. It was determined that the addition of technological stiffening is important for minimizing the deformations and maintaining the level of stress less than the yield point.

1. INTRODUCTION

The shipbuilding activity looks to three major targets: quality, costs, duration. When the ship quality is high and costs are low as well as the duration is not exceeded, the parties involved in the contract (client and shipyard) are happy. Consequenly, a nice reputation of the shipyards is won and more new ships orders are expected to be received.

During building activities, material deformations are likely to occur because of many factors such as heat in steel cutting, welds bring deformations (transverse & longitudinal deflection, angle distortion), transport or turning of the ship blocks, technological stiffening of ship blocks during assembling and modifications of ship blocks.

A big ship block is formed by assembling two or more small blocks, while a small block is made by assembling prefabricated steel panels. The dimensions accuracy of each built steel panel is essential for the overall dimensions accuracy of the ship block. Welds deformations result in wrong appearance and poor quality. For example, welds bring shrinkage which can make a mismatch in the dimensions of the ship panels creating significant challenges in the structural fit and assembly . Appropriate shrinkage allowance must be used to decrease the shrinkage during the building step.

Due to the welding activity during the fabrication of the ship block, the two effects, namely distortion & shrinkage produce results in the general modification of the ship dimensions The cumulative effect of shrinkage brings the reduction of the height and breadth of the ship block : see Fig.1.

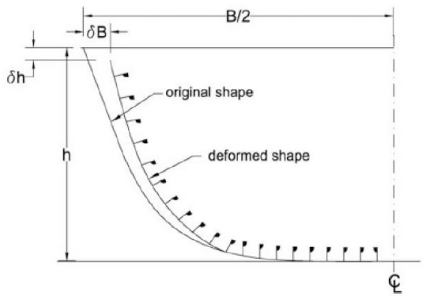

Fig. 1 Shrinkage of ship block (Mandal, 2017).

In normal shipbuilding, the split of the ship parts will be large, and the structure is more and more complicated. Therefore, the difficulty of lifting is higher. The rationality and feasibility of a lifting drawing is necessary because it determines if the lifting work can be performed safely and efficiently.

The ship blocks with lifting drawing are developed based on the normal situation of the shipyard and its lifting capabilities. The purpose is to give the intelligent and effective procedures, which will speed up the lifting activities.

The lifting drawing is usually done starting bydetermining the location of the lifting devices related to the weight, centre of gravity and structural characteristics of the ship block, combined with the specifications of the lifting position and lifting devices. Next, choose the proper lifting lug and sling specifications. At the end, a strength check must be done to determined if the block needs technological stiffening or not.

The positions of the lifting devices must be optimal for assembly and welds. In this analysis , two cases were studied. Firstly, the block was analysed without technological stiffening in three load scenarios: lifting in front of turning, worst-case scenario during turning and lifting after turning. Identically, the second: a case analysis was studied but with the technological stiffening placed according to the lifting drawing.

Before unning the analysis, some checks were done to ensure that the FE model is well set up such as checking the free edge elements, coincident nodes check the mass of the structure to make sure that it meets the actual weight, running modal analysis to check and inspect possible deformation modes of the structure.

The lifting simulation was carried out using the Finite Element Method to investigate the deformations that occur during the lifting activity. The structural model was generated in Simcentre FEMAP and solved for a linear static stress analysis using Simcentre.

The model was created based on the 2D drawings of a block from a cargo ship. According to the lifting drawing, technological stiffeners were placed to the model for comparing the results of deformations and stress with the original model. The blocks are built upside down to avoid the overhead welds, to fasten the fabrication activity and reduce the cost of fabrication. The block is to be lifted using a crane, with four slings of eight meters long each.

Lift the Block In front of Turn

The stresses throughout the analyzed model remain less than the allowable level for a stress of 280 MPa, indeed the majority remains under 25 MPa, increasing to a peak value of 110 MPa in the case of the lifting devices. The maximum stress is indicated in Fig. 2. The solving time is not very long because of the involvement of the bar element in incorporating all the stiffeners.

The block experienced a maximum value of deflection = 17 mm, represented in Fig. 3. Supporting stiffeners must be fitted at the position of the maximum translation. The maximum translation in the X, Y, and Z directions is –7 mm, - 10 mm and 16 mm.

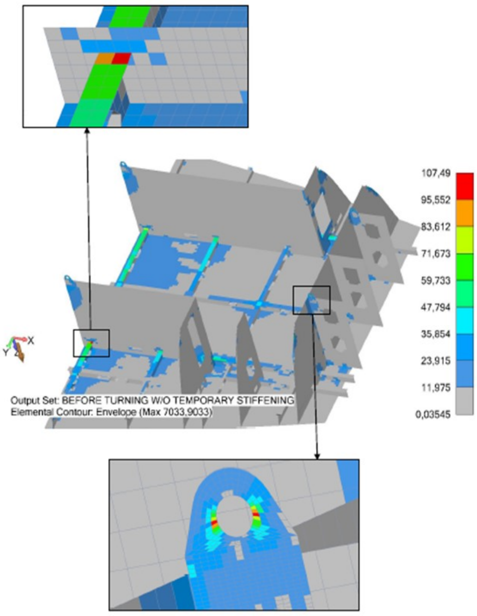

Fig. 2 Maximum of Plate top/Plate bottom Von Mises stress – lifting in front of turning without technological stiffening

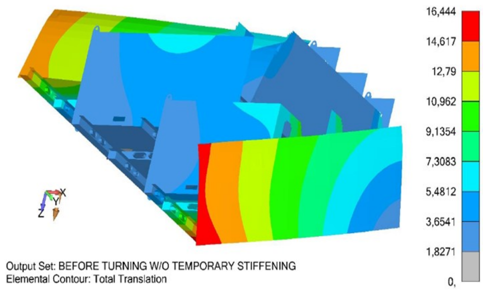

Fig. 3 Total translation – lifting in front of turning without technological stiffening

Turn the Block

The block is suspended only by two lifting devices and using only two slings, which is the worst-case during the turning activity. The stresses remain less than the fine mesh allowable stress of 285 MPa, the majority remains under 25 MPa, increasing to a peak value of 210 MPa in way of the two lifting devices. The contour plot of the maximum Von Mises stress for the plate top and bottom are indicated in Fig. 4.

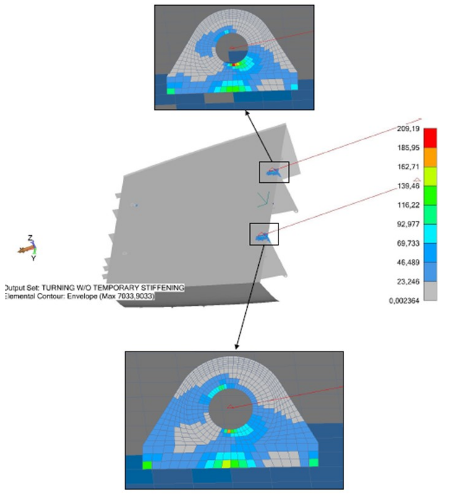

Fig. 4 Maximum of Plate top/Plate bottom Von Mises stress –turning case without technological stiffening

The block experienced a total maximum deflection of 7 mm as indicated in Fig. 5. It must be noted that supporting stiffeners must be fitted longitudinally at the position of the maximum translation. The maximum translation in the X, Y, and Z directions are 6, -5 mm and -6 mm.

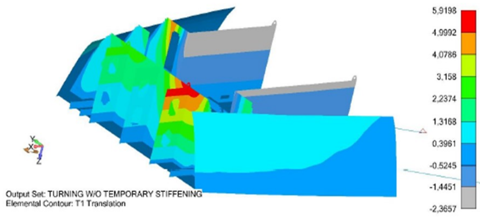

Fig. 5 Total translation – turning without technological stiffening

Lift the Block After Turn

The stresses remain less than the fine mesh allowable stress of 280 MPa, indeed the majority remains under 30 MPa, increasing to a peak value of 280 MPa in way of the lifting devices. The contour plot of the maximum Von Mises stress for the plate top and bottom are indicated in Fig. 6.

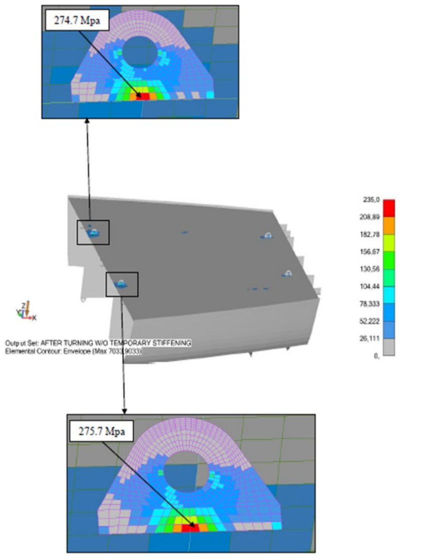

Fig. 6 Maximum of Plate top/Plate bottom Von Mises stress – lifting after turning without technological stiffening

The total maximum deflection is 17 mm in way of the aft boundary of the block as indicated in Fig.7. It must be noted that supporting stiffeners must be fitted transversely and vertically at the position of the maximum deformation. The maximum translation in the X , Y, and Z directions are 5 mm, 10 mm and 15 mm respectively.

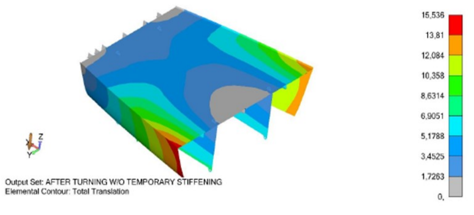

Fig. 7 Total translation – lifting after turning without technological stiffening

Lift the Block In front of Turn

After adding the technological stiffening according to the lifting drawing, the stresses also remain less than the fine mesh allowable stress of 280 MPa increasing to a peak value of 106 MPa in way of the lifting devices. The contour plot of the maximum Von Mises stress for the plate top and bottom are indicated in Fig. 8. It must be noted that the stress has slightly lowered compared to the same lifting activity without technological stiffening.

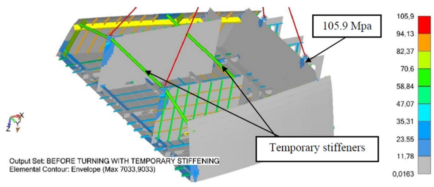

Fig. 8 Maximum of Plate top/Plate bottom Von Mises stress – lifting in front of turning with technological stiffening

The block at the position of the technological stiffeners as indicated in Fig. 9. It must be noted that the technological stiffeners have significantly affected the deformation characteristics of the block. The maximum translation in the X, Y, and Z directions are 5 mm, 10 mm and 15 mm respectively.

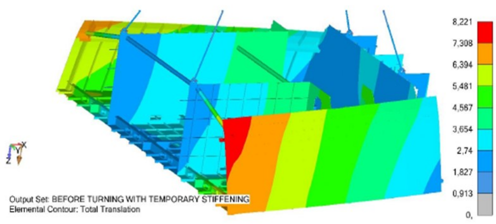

Fig. 9 Total translation – lifting in front of turning with technological stiffening

Turn the Block

In the worst-case during turning after adding the technological stiffening according to the lifting drawing, the stresses remained less than the fine mesh allowable stress of 280 MPa, increasing to a peak value of 185 MPa in way of the two lifting devices. The contour plot of the maximum Von Mises stress for the plate top and bottom are indicated in Fig. 10.

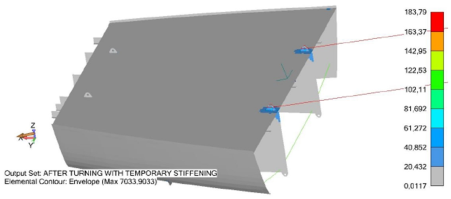

Fig. 10 Maximum of Plate top/Plate bottom Von Mises stress –turning case with technological stiffening

In this case, the obtained total maximum deflection is 7 mm as indicated in Fig. 11. It must be noted that the technological stiffeners have no influence on the deformation characteristics of the block. The maximum translation in the X , Y, and Z directions are 4 mm, -1 mm and -7 mm.

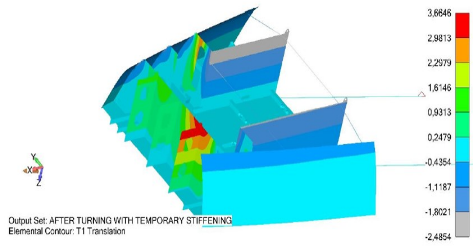

Fig. 11 Total translation – turning with technological stiffening

Lift the Block After Turn

As for the case of lifting after turning with the technological stiffening, the stresses remained less than the fine mesh allowable stress of 280 MPa, increasing to a peak value of 125 MPa in way of the lifting devices. The contour plot of the maximum Von Mises stress for the plate top and bottom are indicated in Fig. 12.

In this case, the obtained total maximum deflection is 8 mm as indicated in Fig. 13. It must be noted that the technological stiffeners have a significant influence on the deformation characteristics of the block. The maximum translation in the X, Y, and Z directions are 2 mm, -2.5 mm and -7 mm respectively.

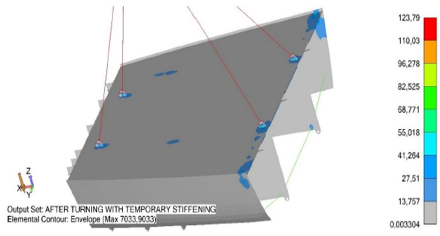

Fig. 12 Maximum of Plate top/Plate bottom Von Mises stress – lifting after turning with technological stiffening

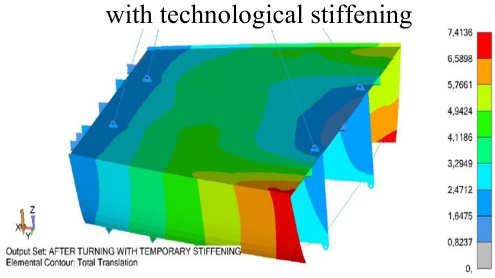

Fig. 13 Total translation – lifting after turning with technological stiffening

4. COMPARISON OF LOAD CASES

Fig. 14 compares the maximum Von Mises stress values of all the six load cases. It must be noted that the technological stiffening has a negligible effect on reducing stresses while lifting the block in front of turning. In the worst-case during turning the technological stiffening slightly improved the stress field by reducing the peak stress by 12 % (25 MPa). However, for lifting after turning, the technological stiffening has a significant influence on mitigating the maximum stresses by 55 % (150 MPa). Accordingly, stress-wise, this demonstrates the importance of adding the technological stiffening in the final stage of lifting.

Regarding the total deflection, not only the technological stiffening significantly improved the lifting after turning operation but also improved the lifting in front of turning operation. However, the turning operation has not been affected by the existence of the technological stiffening. This is justified because the technological stiffeners are needed for resisting deformations in the longitudinal direction as indicated in Fig. 5. which has a minimum effect on the turning load path. Fig. 15 shows a comparison of maximum deformation for all the six loading cases.

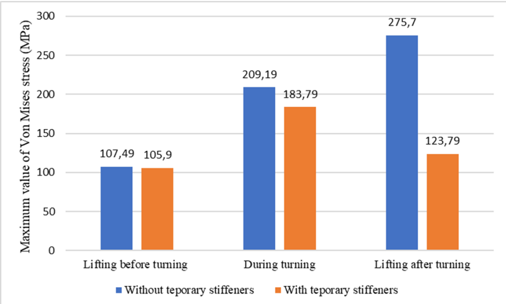

Fig. 14 Comparison of maximum Von Mises stress

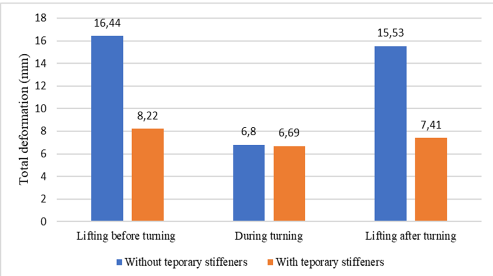

Fig. 15 Comparison of maximum deformation

5. SLING ANGLE ANALYSIS

The hook position must be placed above the center of gravity. Otherwise, the block will tilt until the hook and the center of gravity get to the same vertical line. The uneven stable position could lead to different sling angles and therefore different structural behaviour. Tilting the block might break the sling and/ or the weld of the lug. Also, it might cause more deformations on the block.

The sling angle is the angle between the sling and the horizontal line of the ship block deck. Different sling angles were studied to investigate the sling angle effect on the stress levels and deformations during the lifting of the ship block with the technological stiffening. It was observed that the stress is inversely proportional to the increase of the sling angle. However, the stress reduction is from 85 MPa at 30 degrees to 83 MPa at 75 degrees. Therefore, the stress variation is negligible. Fig. 16 shows the sling angle – maximum Von Mises stress relationship.

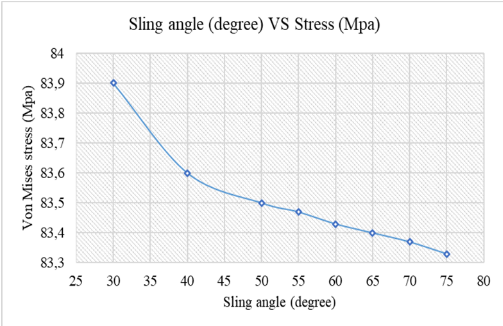

Fig. 16 Sling angle - Maximum Von Mises stress

Sling length is mainly dependent on the optimized sling angle which maintains the stress less than the yield limit to remain in the elastic deformation zone of the structure. Also, the crane specification is important for the determination of the distance between two adjacent lifting devices . For a given position of the lifting devices, the length of the fore and aft lifting slings is determined to ensure that there is no trim angle during the lifting activity.

The best sling angle would lay between 55 and 65 degrees as indicated from the results in Fig. 17, to compromise the sling tension force after resolving it, the horizontal component of the sling force decreases as the sling angle increases. Consequenly, it reduces the probability of buckling. However, the vertical component of the sling force increases as the sling angle increases. Consequenly, the structure will experience more bending load.

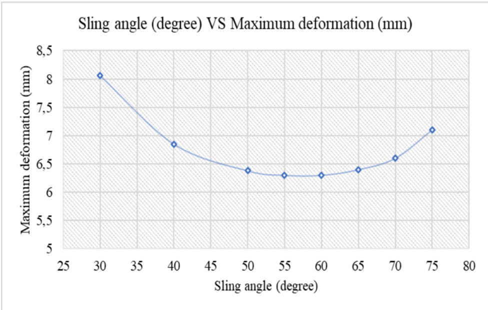

Fig. 17 Sling angle - Maximum deformation

The lifting and turning of block were simulated in FEMAP software. A linear static analysis was carried out using Simcenter Nastran solver to investigate the deformations and stresses for six different loading cases. One, the block was analysed without technological stiffening in three load scenarios: lifting in front of turning, worst-case scenario during turning and lifting after turning. Identically, the block was analysed after adding the technological stiffening according to the lifting drawing. The following conclusions are withdrawn:

• As expected, the stress hotspots are located in way of the lifting devices. The majority of the stresses remained under the yield stress of 240 MPa. Also, the addition of technological stiffening is essential to minimize the deformations and to maintain the stress levels less than the yield point.

• The lifting drawing design requires a high technical level of engineers. The engineer needs to consider the characteristics of the selected block, the site conditions, crane lifting capacity, lifting devices reusability and other constraints (each case might have special requirements) will be required to complete the design of the lifting drawing.

• When the hull blocks are assembled, if the length of slings is properly selected, the free angle of the block after lifting can be exactly adjusted to meet the inclination of the hull by using the selected crane under the condition that the crane load is allowed. Consequently, it is advantageous to reduce the labour intensity and the assembly time.

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