The Assessment of CSR Regulations Implementation on the Midship Strength and Structural Weight of 77.500 DWT Bulk Carrier

Ahmad Fauzan Zakki

Abstract

Since April 1st 2006, all of the ships that built must comply with the common structural rules. As the consequences of this condition the scantling of the ship will be increased. This paper will explain about the influence of the CSR rules implementation to the midship strength and structural weight of 77.500 DWT Bulk Carrier. The comparisons of two finite element models will be made to distinguish the effect of scantling modifications to the midship strength and the weight of the ship structures. The results show that the steel weight has been increased 4.74 % higher than the prior ship. The critical condition is the harbor-1 condition with the maximum plate stress induced by SWBM is 96.6 MPa; The Maximum Bar Stress is 84.7 MPa. The conclusion states that the CSR regulations standard not significantly different with the DNV standard for the Midship Strength performance. It could be actually explains that the increment of the plate thickness only for the corrosion allowance.

Keywords: CSR Regulation, Steel Weight, Midship Strength

1. Introduction

More than 50 organizations worldwide define their activities as providing marine classification. Ten of those organizations form the International Association of Classification Societies (IACS). It is estimated that these ten societies, together with the additional society that has been accorded associate status by IACS, collectively class about 94 percent of all commercial tonnage involved in international trade worldwide.

In December 2005 the CSR Rules was created by the IACS. The main goal of the new regulation are to establish clear, demonstrable and verifiable to the effect that a properly built, operated and maintained ship remains safe and environmentally friendly for its whole life. The consequences of this goal, all of the ship have to be built comply with the CSR regulations. The new regulation that has been implementing in April 2006 has any tendency change the scantlings of ship structure. These changes make an escalation in the thickness of plates and profiles, which caused an increasing in the weight of the ship structure.

This paper will explain about the influence of the CSR regulations implementation to the strength of the midship section and structural weight of the Bulk Carrier 77.500 DWT. The methodology started from examining the dimension of the Bulk Carrier that previously has been built by the DNV Classifications with standard scantling of the CSR Regulation. The results of the conformity check will be used to modify the ship structure with the new scantling that complies with the CSR Regulations. Finally the two finite element models will be created for modeling the previous conditions and the new conditions. The comparisons will be makes to distinguish the effect of scantling modifications to the midship strength and the weight of the ship structure.

2. CSR Bulk Carriers

In June 2003, the IACS responded the IMO and Industry and decided to develop Common structural Rules for Bulk carrier. It was started in July 2004 the first draft of the regulation has launched. The 2834 comments respond from industry has accepted by the committee as a reference to improve the regulation. Finally in April 2006 the Common Structural rule is implemented effectively.

The CSR Rules are applicable to single and double side skin bulk carriers as defined in IACS URS 11.2 of 90 m in length and above with unrestricted worldwide navigation. All the requirements influencing the structural design, including SOLAS, Load Line and IACS, have been incorporated and the project is claimed by the JBP (Joint Bulker Project) based on the following objectives, [1]:

- To eliminate competition between class societies on scantling
- To embrace the intentions of the anticipated IMO requirement for goal based standards for new buildings
- To ensure that a ship complying with these rule will be recognized by the industry as being at least as safe, robust and fit for purpose as would have been required by any of existing rules
- To employ the combined experience of all class society to develop an agreed set of rules
- To use a net scantling approach throughout the new rules

The main changes of the CSR with the previous classification rules is implemented with the purpose of 25 years lifetime of ship building structure in a North Atlantic environment. Nowadays the shipping company used their ships only in 20 years for trading in a worldwide environment. The harsh environment standard and longer structural lifetime is expected to develop the new regulation with the increasing in structural scantling of Bulk Carrier. As a consequence of the increased scantling, the steel weight of ship structures will be increased.

The other factor that could increase the scantling is the corrosion allowance. The corrosion allowance was the main issues of concern with the industry. The new corrosion allowances is now a fixed figure regardless the original plate thickness. Previously, the percentage of the plate thickness is used to determine the allowance. This totally different approach corresponds to 95 % of the measured corrosion wastages after 25 years in services.

3. Research Methodology

The research methodology started from the conformity check of the prior scantling of Bulker to the CSR standard. Finally the FE model is analyzed for the global strength analysis. The Flowchart of the methodology can be seen in figure 3.1.

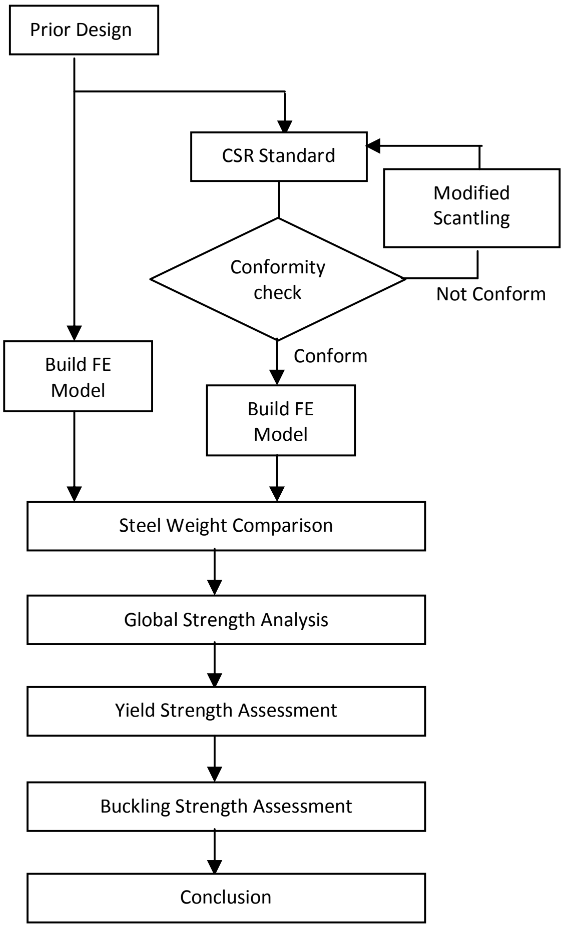


Figure 3.1 Flowchart of research methodology

3.1. Conformity Check

The implementation of the CSR rules has change the standard dimensions of the ship scantling. The previous ship that has been built by the DNV Rules in 2002 will be check with the CSR standard. The Sea Trust Version 3.3 will be used to check the conformity of the ship dimension to the CSR Standard. The results show that the scantling in the deck area and inner bottom shell has to be increased. It could be explain, with the new corrosion allowance standard the structure has to be increased 2-4 mm from the prior thickness.

According to the results of the conformity check by the Sea Trust, the prior scantling will be modified to have the new scantling of the Bulker that complies with the CSR. This new scantling was compared as an influence of the implementation of the CSR to the midship strength and steel weight of 77,500 DWT Bulk Carrier

3.2. Bulk Carrier FE Model

The FE model that will be used in the analysis must comply with the CSR standard for the global strength FE analysis. Based on the CSR standard the built FE models have the characteristics as followed:

- The FE model have three cargo holds and four transverse bulkhead
- All main structural members are to be presented in the FE Model
- Stiffeners are to be modeled by beam and bar element having axial, torsional, bi-directional shear and bending stiffness
- Plates are to be modeled by shell element having out-of-plane bending stiffness in addition to bi axial and in-plane stiffness
- Side shell frames and their end bracket are to be modeled by using shell elements for the web and beam elements for face plate

The Sea Trust Version 3.3 is used to create the FE model and then it will be improved using MSC Patran and Nastran to have the final result.

3.3. The Boundary Condition of FE Model

Based on the CSR Rules, both ends of the FE model are to be simply supported. The nodes on the longitudinal members at both end section are to be rigidly linked to independent points at neutral axis on centerline, see Tab 3.1. The independent points of the both ends are to be fixed, see Tab 3.2.

The detail of the loading condition can be seen in the chapter 4 appendix 2, [2]. The Hydrostatic and Cargo Load can be seen in Fig.3.2 and Fig 3.3.

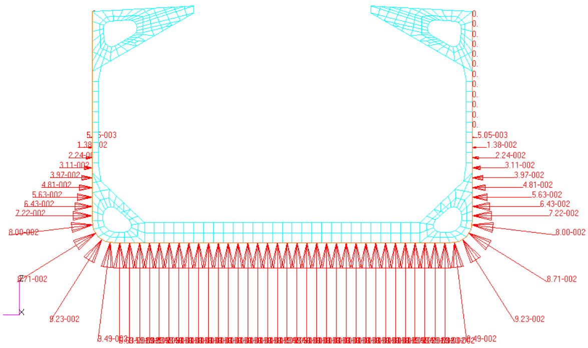


Figure 3.2 Hydrostatic Load Model

Table 3.1 Rigid-link of both ends

Nodes on longitudinal members at both ends of the model	Translational			Rotational		
	Dx	Dy	Dz	Rx	Ry	Rz
All longitudinal members	RL	RL	RL	-	-	-
RL means rigidly linked to the relevant degrees of freedom of the independent point						

Table 3.2 Support condition of the independent point

Location of the independent point	Translational			Rotational		
	Dx	Dy	Dz	Rx	Ry	Rz
Independent point on aft end of model	-	Fix	Fix	-	-	-
Independent point on fore end of model	Fix	Fix	Fix	Fix	-	-

3.4. The Loading Condition for Direct Strength analysis

The loading conditions that will be used in the analysis are based on the CSR standard. The CSR loading patterns for BC-C No Multi Port class as followed:

- Full Load in homogenous condition
- Slack load
- Deepest Ballast
- Heavy Ballast
- Harbor Condition 1
- Harbor Condition 2

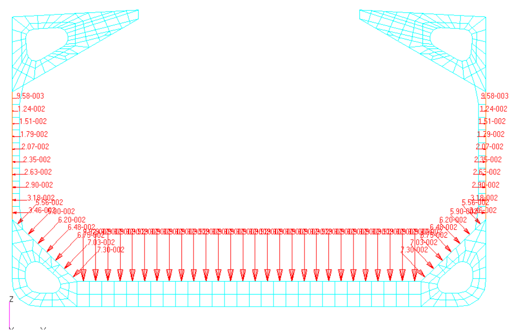


Figure 3.3 Bulk Cargo Load Model

3.5. Running the model

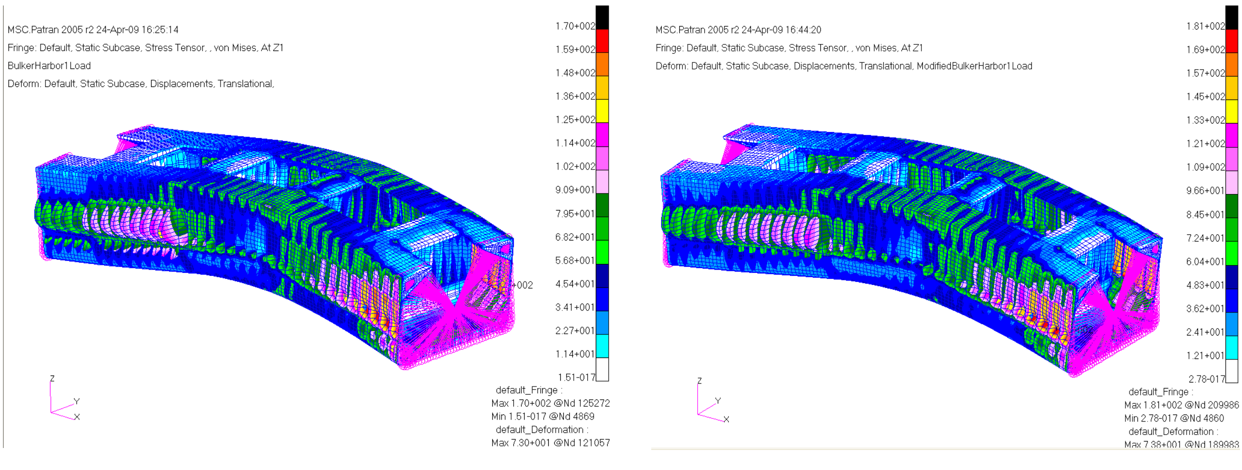
The model that has been defined with the loading and boundary condition will be analyzed by running the model with MSC Nastran. The static analysis has been chosen to solve this problem case. The result of this analysis was the plate and bar stress, the plate and bar deformation. The MSC Patran has been used for the steel weight calculation by using the mass properties calculation.

The steel weight calculation that has been made by the MSC Patran actually is the steel weight of the model that already built. The calculated model weight is used as an estimation of the steel weight changes in the entire body of the ship induced by the CSR implementation. The Results show that steel weight has been increased 4.74% from the prior ship.

4. Yield Strength Assessment

The first acceptance criterion of the global strength analysis is yield strength assessment. The reference stress that used in the assessment is Von Mises equivalent stress at center of a plane element (shell or membrane) or axial stress of a line element (Bar, Beam or Rod) obtained by FE analysis using the MSC Patran and Nastran that not exceed 235 MPa, where the material factor was chosen 1 for the normal material.

The result shows that maximum plate stress is 179 MPa, in Slack Loading Conditions. However, this maximum stress not induced by the still water bending moment. The stress induced by the lateral load from the full cargo hold in fore part area.



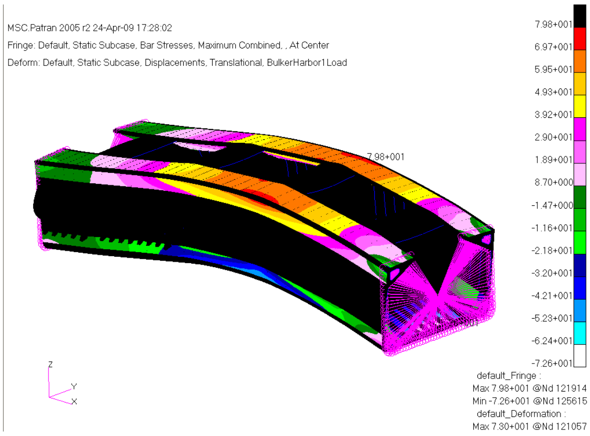
a) Prior 77,500 DWT Bulk Carrier

b) Modified 77,500 DWT Bulk Carrier

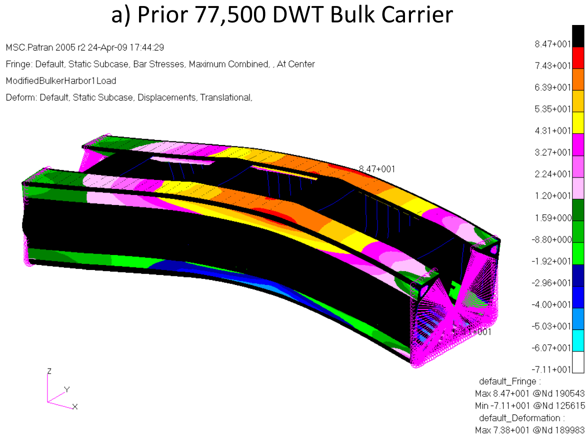
Figure 4.1 the Maximum Combine Von Mises plate stress Harbor-1 loading condition
Bulk Carrier 77,500 DWT

The maximum stress of the Bar Element is 84.7 MPa in Harbor 1 Condition. The bar maximum stress is induced by the still water bending moment. The Maximum Plate Stress that induced by the still water bending moment is 96.6 MPa, in the Harbor 1 condition.

Based on the results of the 6 loading condition, the critical conditions for the yield strength assessment induced by the still water bending moment is Harbor 1 condition. However, all of the maximum stress results still accepted by the CSR Regulations standard for yielding assessment.



a) Prior 77,500 DWT Bulk Carrier



b) Modified 77,500 DWT Bulk Carrier

Figure 4.2 the Maximum bar stress harbor-1 loading condition Bulk Carrier 77,500 DWT

5. Buckling and Ultimate Strength Assessment

Buckling and ultimate strength assessment is to be performed for the panels on primary supporting member. The acceptance criterion for the buckling assessment is the safety factor should be taken equal to 1.0 or less.

Based on the CSR standard the buckling and ultimate Strength assessment has been calculated by using SeaTrust Ver. 3.3. The result shows that the prior ship do not pass the buckling criterion, the bottom girders safety factor is 1.515 – 1.886 exceed the standard number, see fig 5.1. Otherwise, the modified bulker has been fixed; consequently the modified Bulk Carrier scantling has passed the Buckling safety factor criterion. The bottom girders safety factor as decreased as 0.933-0.953, see fig5.2.

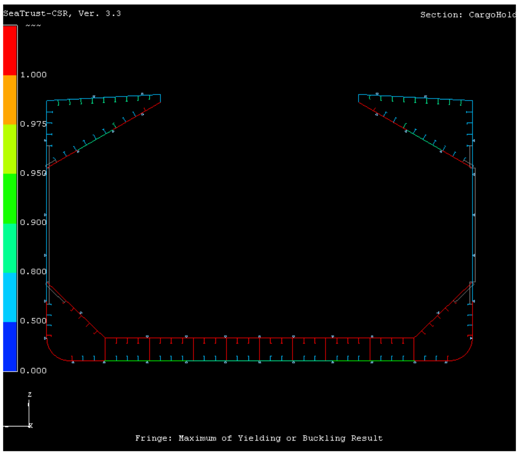


Figure 5.1 the Buckling Check of Bulk Carrier 77,500 DWT

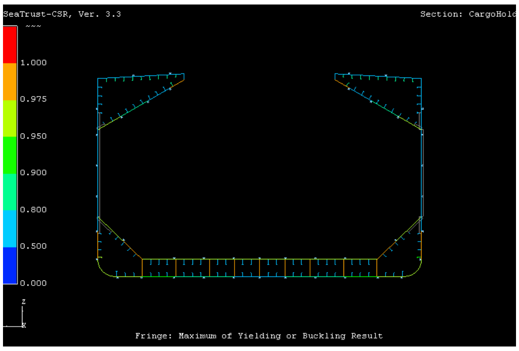


Figure 5.2 the Buckling Check of Modified Bulk Carrier 77,500 DWT

7. Conclusion

The influence of the implementing the CSR regulations standard has increases 77,500 DWT bulk carrier steel weight in 4.74%. This is caused by the corrosion allowance are based on 25 years, however the DNV regulations only for 20 years corrosion wastage.

The global strength analysis shows that the critical conditions is the harbor-1 loading condition, because the loading case give the maximum stress result than the other condition, however the maximum stress of both model still acceptable by the CSR Criteria. It is shows that the DNV Regulations still acceptable for the yield strength of the midship section.

Otherwise the prior model do not passed the buckling check; especially the side girder scantling safety factor criterion is 1.515 – 1.886, exceeding the CSR standard.

8. References

1. Varheim R, 2005. **"IACS Common Structural Rules for Bulk Carrier"**, DNV Bulk Carrier Update, DNV Maritime, Norway
2. JBP, 2005. **"Common Rules for Bulk Carriers to enter into force in 2006"**, Bulk Carrier Focus, technical news and information on bulk carrier, Lloyd Register, UK
3. Kendrick A, 2007. **"Comparative Study of Naval and Commercial Ship Structure Design Standards"**, BMT Fleet Technology Ltd, USA
4. IACS, 2006. **"Classification societies- What, Why and How?"**, www.iacs.org.
5. IACS, 2006. **"Common Structural Rules for Bulk Carriers"**, Published by Korean Register of Shipping, Korea