MR. Tanker with Harmonized CSR

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Abstract

HCSR(Harmonized CSR) which came into force since July 1, 2015 is working on its way. Many of builders have concerned about the weight increment and un-expectable long design time. HMD would build the tanker and it might be the first vessel which is designed in accordance with HCSR in the world.
In this paper, the result of the evaluation on the steel weight and design time consumed as well as some technical issues for 50K Class Product Chemical tanker are contained and discussed.

1 Introduction & Background

By the establishment of GBS(Goal base Standard), developments to harmonize the rule of Oil tanker and Bulk carrier have been carried out since 2011. As the result from the efforts, the HCSR(harmonized Common Structure Rule) was officially published in early 2014.

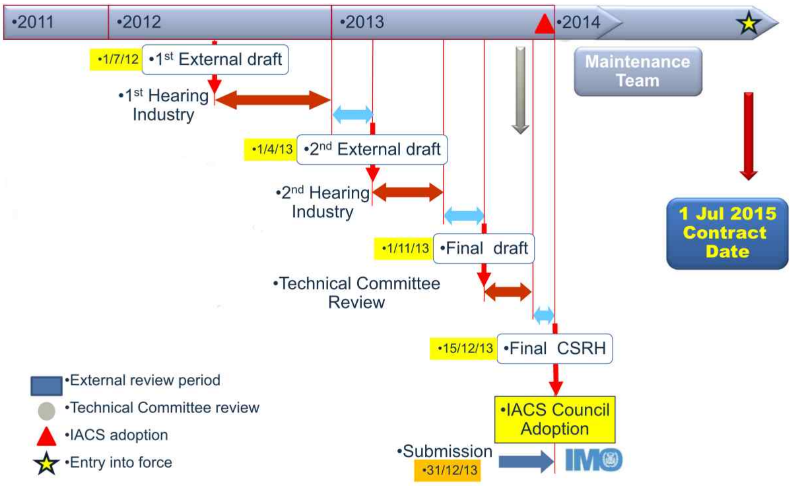


Fig.1.1 Schedule for development of HCSR

All tankers and bulk carriers which were contracted after first July 2015 should be complied with HCSR. During the developments of the rule, there are lots of rule changes. So not only builders and owners but also classification societies must know the effect on the changes.
This paper introduces the main effect about applying HCSR to MR sized Product & Chemical tankers and shows the investigation on the increment of steel weight in comparison with previous vessels which were already built.

The main dimension of vessel which has been investigated is as below

Fig.1.2 MR Product & Chemical Tanker

Main Dimension

LBP : 174.00m
B : 32.20 m
D : 19.10m
T : 13.30m

Table 1.1 Bending moment

	Hogging bending moment	Sagging bending moment
Seagoing	136,300Ton-m	182,900Ton-m
Harbour	81,400Ton-m	101,400Ton-m

2. Prescriptive Rule

2.1 Corrosion addition

The corrosion additions for CSR-OT and CSR-BC are unified. It is similar to that of previous rule at the most location. But there are little changes for the plates near the shear strake(4.0mm to 3.5mm) and upper most inner bhd including topside (4.0mm to 4.5mm). And the application region for the quay contact is changed in the direction of the ship length.

2.2 Minimum Thickness

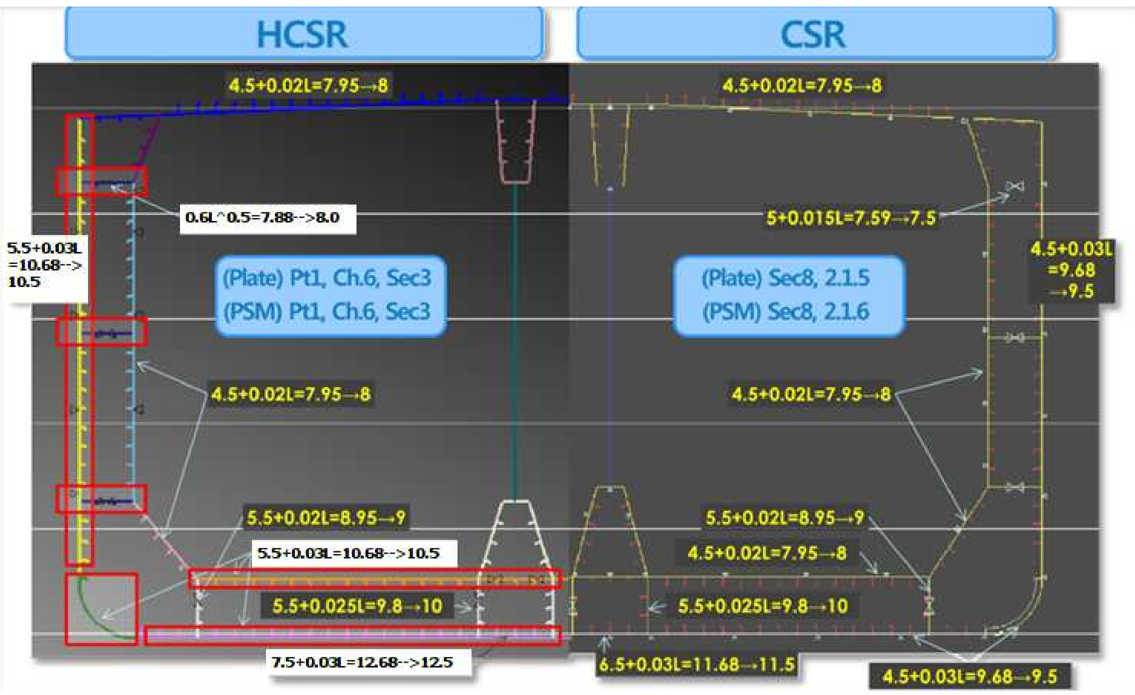


Fig. 2.1 Minimum requirement

Minimum thickness is defined according to the length of the vessel. The constants in the formula of minimum thickness have been increased. As a result, the thickness of side stringer, inner bottom and keel plates are increased 0.5mm to 1.0mm.

2.3 Loading

The loading set has been developed based on the loading pattern of the CSR-OT and CSR-BC. Among these loading sets, the flooding condition which is applied to the CSR-BC has been adopted in HCSR.

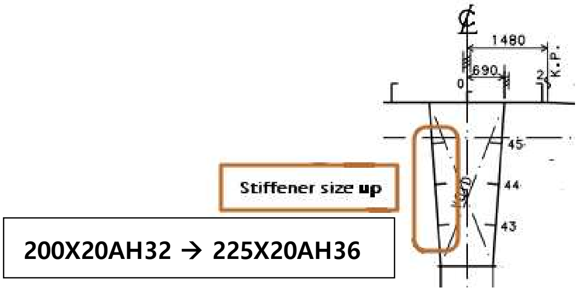


Fig.2.2 Longitudinal upper stool structure

It is the loading set which determines the scantling of members on the compartments which are not carrying liquids. So this adoption leads to the increase of the scantling for the members of upper stool.

Another effect from the loading change is the dynamic pressure on deck. It is increased due to the oblique sea condition. So the required section modulus for deck transverse member is also increased.

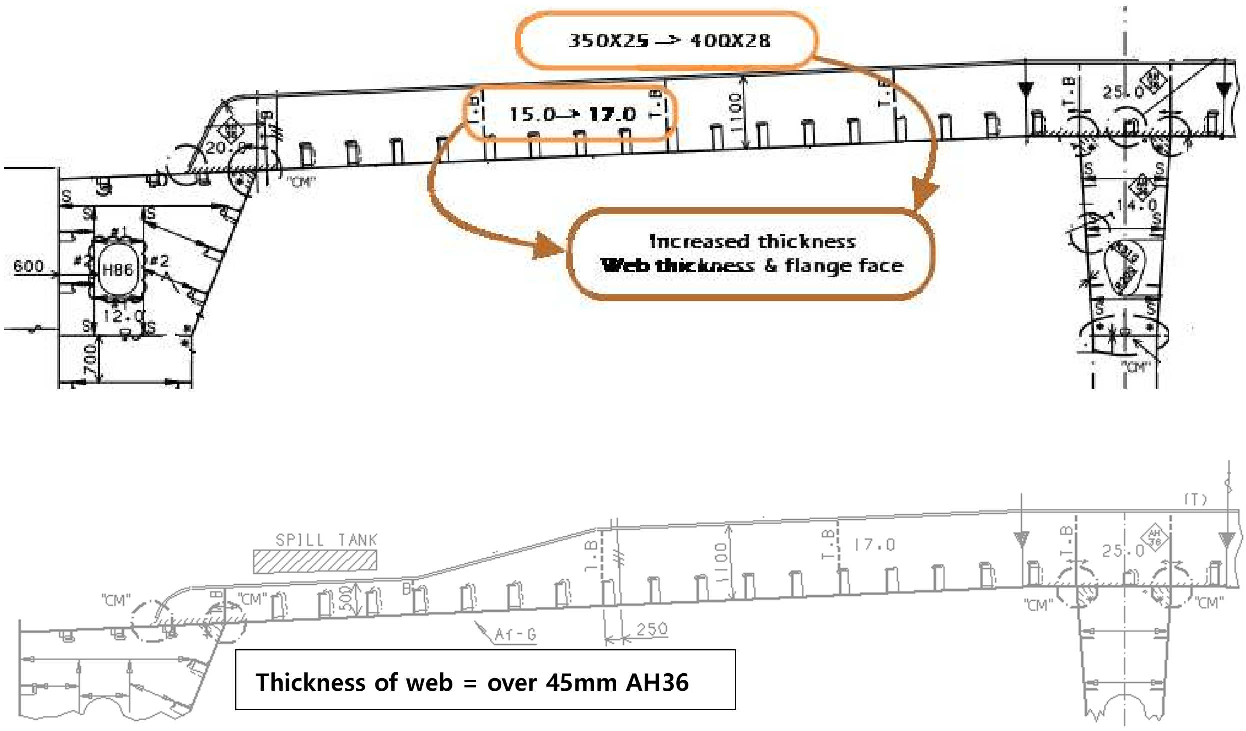


Fig.2.3 Deck transverse

As fig. 2.3 shows, the scantlings of web and face plate have been increased. In way of spill tank, reduction of the web height is inevitable. Accordingly the scantling change of web is required.
So there may be an alternative design that could reduce this scantling steel weigh increase.

3. Direct Structure Analysis

3.1 Analysis and Evaluation region

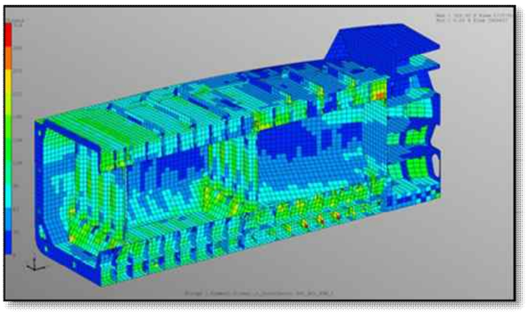
Main change is about the analysis and evaluation region. The CSR-OT and CSR-BC as well as all previous analysis procedure require 3 Cargo hold analysis for the Midship region. So assumptions for the scantling are unavoidable for the structures outside Midship region. Actually there is no official recommendation for analysis procedure about FWD & AFT region. However, HCSR announces useful analysis procedures for the region. And HCSR requires cargo hold analysis for whole cargo hold length.

3.2 Boundary Condition & Loading condition

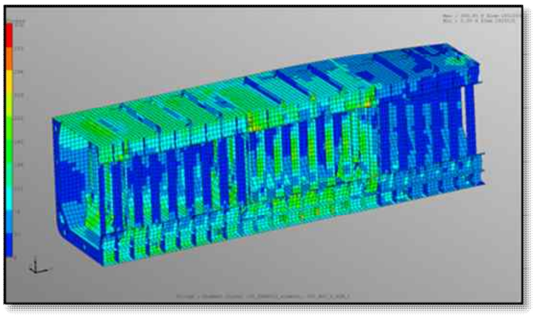
The boundary condition has been developed to apply the global load such as bending moment, shear force and torsional moment at each location. Especially to simulate the warping constraint under torsional moment from the cut-out structure, the end beams are applied at both ends of the cargo hold.

The loading conditions are developed based on EDW(equivalent design waves)load and essential cargo loading patterns.

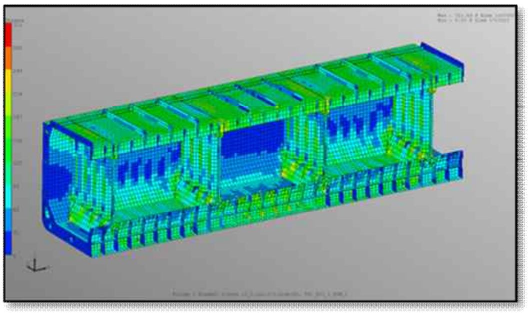
3.3 Yield evaluation



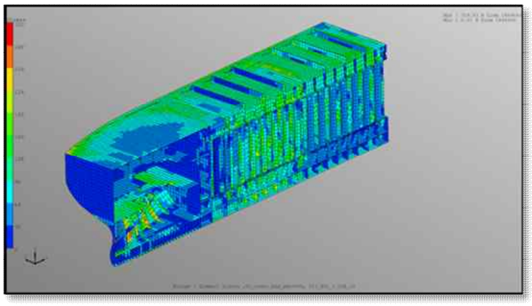
(a) No.1 hold



(b) No.2 hold



(c)No.3,4,5 hold



(d) No.6 hold

Fig.3.1 Stress plot at worse loading condition for each cargo hold

Table 3.1 Amendment position and Yield evaluation

(Unit : mm)

Cargo Hold	Structural member	Thickness (Prescriptive)	Thickness (FEM)
No1 hold(Foremost)	- Very foremost area of No.1 STR - Long' Upper stool near F.P BHD	11.0 14.0 AH36	12.0AH32 16.0AH36
No2 hold(Outside)	- Upper deck at upper stool cross joint area - Floor end(Ship side)	12.0AH 12.0AH	14.0AH 13.5AH

Mid hold(3,4,5hold)	- Upper deck at upper stool cross joint area - Floor end(Ship side) - Side web above No3 STR	12.0AH 12.0AH 12.0	14.0AH 13.5AH 13.5AH
No6 hold(Aftermost)	- double bottom side girder in way of trans stool(11730 off CL) - No.3 STR. End bracket In way of fr.40(O.T BHD)	12.5 19.5AH36	15.0 AH36 19.5 AH36

As a result of F.E analysis, we found that most of the structural members are satisfied with stress criteria requirements. But structural reinforcements are needed at foremost and aftmost cargo holds which are connected with FP BHD and E/R BHD. It is believed that the discontinuity of the longitudinal members caused high stress at the end of these structures.

3.4 Buckling evaluation

Table 3.2 Amendment position and Buckling evaluation

	Member	Action
No1 hold(Foremost)	- Upper deck - F.P BHD - C.L LONGI. STOOL(LOW) - Trans. Stool (LOW)	Buckling Stiffener Addition
No2 hold(Outside)	Similar to Midhold	-
Mid hold(3,4,5hold)	Same as CSR	-
No6 hold(Aftermost)	Similar to Midhold	-

The result for the buckling failure has similar tendency with the result complied with CSR-OT and CSR-BC at the Midship region.

With CSR-OT and CSR-BC, the designers or engineers only needed to carry out 3 Cargo hold and evaluated it. It means that scantlings were mainly calculated only for the Midship hold. On the other hand, HCSR is required the analysis for all cargo hold including extended area forward to engine room and Forebody area. However the buckling results are very similar to those from the CSR-OT and CSR-BC even the side shell buckling results for No1/No2 cargo hold which have non-prismatic shape of hull are satisfied with. Additional buckling stiffeners are not required given the allowable buckling usage factor in HCSR Chap.8.Sec.1.3.3.1.

3.5 Fine-mesh evaluation

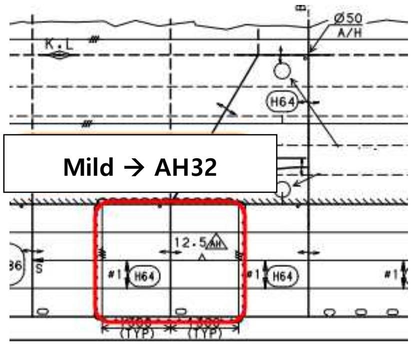
One of main changes in HCSR is the amount of Fine-mesh position. Basically mandatory positions at the Midship area are almost similar with CSR-OT. But every manhole and same position with the Midship area should be checked with screening for other cargo holds.

In this project, total fine-mesh positions are shown in the table as below and these positions are all checked by fine mesh analysis.

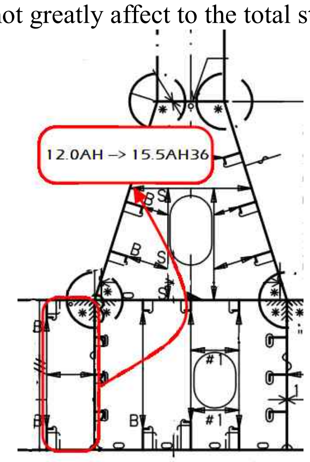
Table 3.3 Fine mesh positions (unit : EA)

No. of Hold	Mandatory	Screening	total
1		14	14
2		14	14
3	8	12	20
4	8	12	20
5	8	12	20
6		14	14
Total	24	78	102

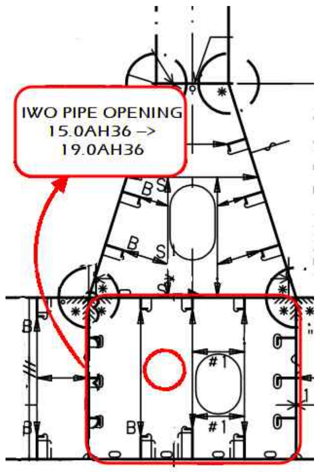
From the fine-mesh results, most of the positions are satisfied with requirement. But some positions fig. 3.2 are necessary to be improved. These modifications does not greatly affect to the total steel weight.



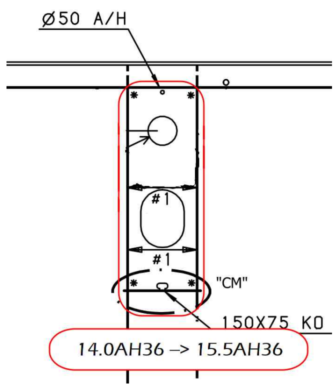
(a)Side girder joint with T lower stool



(b) Floor end joint with L lower stool



(c) iwo pipe opening and manhole



(d) Upper stool diaph.

Fig.3.2 Highlighted structure from Fine mesh analysis

4. Conclusion

The 50K Class PCs have been investigated and evaluated with HCSR which was newly issued. From the investigation, there is not a great change in FE analysis. Certain method has been introduced for FE analysis targeting outside Midship region. Consequently invisible areas for designer become more clear than before.

The main cause to increase hull weight comes from the local scantling requirements such as minimum requirement, corrosion addition and change of loading sets, etc.

Table 4.1 Summary of influence of HCSR application

Section in paper	Cause	Influence	
		Weight	Work hour
2.1	Corrosion margin	Small	-
2.2	Min. Thickness	Big	-
2.3	Deck pressure	Big	-
3.3	F.E (yield)	Medium	Big
3.4	F.E(buckling)	Small	Big
3.5	Fine-mesh	Small	Big

From our investigation of the application of HCSR to MR Tanker, we found that the increase in steel weight is not considerable, but the designer man hour required has increased significantly in F.E Modeling and evaluation. Efforts must be made to reduce this design time for builder.