Impact of Harmonized CSR for oil tanker

Un-Chul Choi <unch62@hhi.co.kr>
Hundai Heavy Industries Co., Ltd, Ulsan, Korea

Abstract

This paper covers the design experience for oil tankers designed by the Harmonized Common Structural Rules for Bulk Carriers and Oil Tankers (CSR-H).
There are two major changes in CSR-H compared to the Common Structural Rule (CSR). The first is the prescriptive rule changes including load cases, minimum thickness, tank pressure and so on. The second is the extended scope of FE analysis including fine mesh and fatigue analysis.
This paper provides a study on the design changes and weight increases due to the prescriptive rule change and FE analysis of the whole cargo hold.

1 Introduction

CSR-H brings some impact on the design of Oil Tankers due to the prescriptive rule change and extended scope of FE analysis. In this paper, through design experience of a 158K DWT crude oil carrier based on CSR-H, the impact of CSR-H is discussed in aspects of design change and weight increase.

Table 1 Main Dimension of Evaluation Vessel (158K DWT COT)

Length B. P.	267 m
Breadth	48 m
Depth	23.1 m
Draught (Design)	16 m
Draught (Scantling)	17.15 m

2 Prescriptive Rule Changes

Prescriptive rule changes which have impact on design change are discussed below.

2.1 Corrosion Addition of Shell Plate

The difference of corrosion addition is shown in table 2. In CSR-H, zone of 1.5 mm corrosion is extended to ends of whole ship. The relevant shell plate is increased by 0.5mm except in way of No.1 and 2 hold of which shell plates are extended with mid hold scantling.

Table 2 Difference in Corrosion Addition

Compartment type	CSR	CSR-H
Exposed to Seawater	Shell plating : 1.0 mm Quay contact region (refer to Fig.1) : 1.5 mm	Shell plating : 1.0 mm Between minimum design ballast draught and scantling draft : 1.5 mm

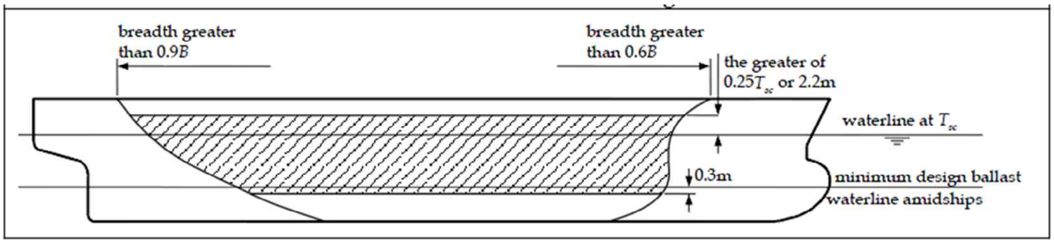

Fig.1 Quay contact region of CSR

2.2 Green Sea Load

The green sea load from CSR-H is about 47% more than CSR in mid hold area. Therefore, the web plate of the deck transverse is strengthened in the shear strength check.

Table 3 Difference in Green Sea Load for Deck Transverse Scantling

Position	CSR	CSR-H
Mid Hold	58 kN/m^2	73 kN/m^2

2.3 Internal Tank Pressure at Seagoing Condition

Internal tank pressure at seagoing condition is increased by 25 kN/m^2. This increases the scantlings of plates, stiffeners and primary support members in cargo tank boundary as shown in fig. 2.

Table 4 Difference in Internal Tank Pressure at Seagoing Condition

Position	CSR	CSR-H
Cargo Tank	Internal static pressure + Internal dynamic pressure + Relief valve pressure(25 kN/m^2) – 25 kN/m^2	Internal static pressure + Internal dynamic pressure + Relief valve pressure(25 kN/m^2)

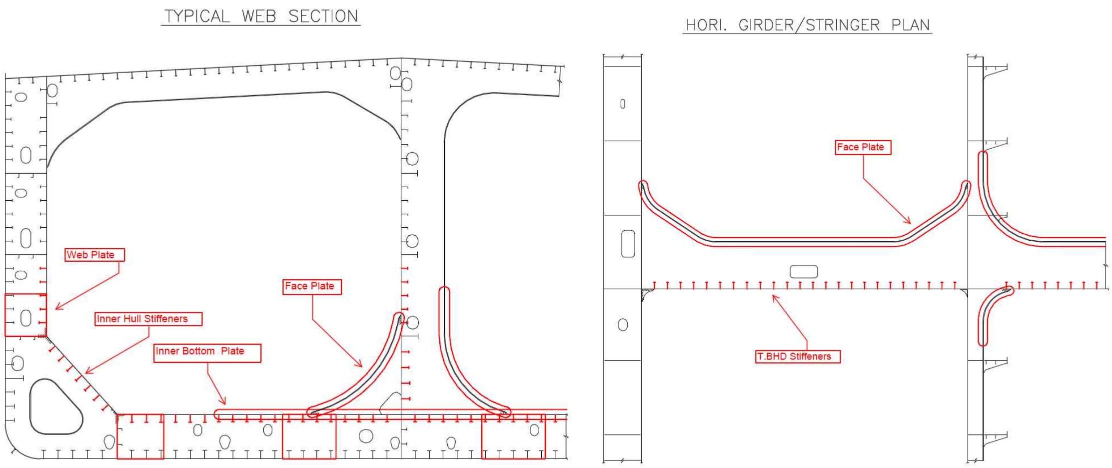

Fig.2 Positions to be reinforced due to increased tank pressure

2.4 Bottom Slamming Region

The region of maximum bottom slamming pressure is extended forward.

Table 5 Difference in Bottom Slamming Pressure

Position	CSR	CSR-H
Maximum Pressure Region	0.125L ~ 0.05L from F.P.	0.122L ~ 0L from F.P.

2.5 Minimum Thickness

Minimum thickness requirements are more severe in CSR-H than CSR as shown in Table 6. This increases the scantlings of plates in relevant locations as shown in fig. 3.

Table 6 Difference in Minimum Thickness

Position	CSR	CSR-H	Impact on design
Side Shell i.w.o ER and AFT Part	$4.5 + 0.03\ L_2$	$7.0 + 0.03\ L_2$	18.0 mm with corrosion addition of 3.0 mm
Inner Bottom	$4.5 + 0.02\ L_2$	$5.5 + 0.03\ L_2$	16.5 mm with corrosion addition of 3 mm
Stringer in WBT	$5.0 + 0.015\ L_2$	$0.6\ L_2^{1/2}$	12.5 mm with corrosion addition of 3 mm
Keel Plating	-	Not to be less than the adjacent plating	-
Bilge Plating	Not to be less than the adjacent bottom and side shell plating	Not to be less than the adjacent bottom and side shell plating	-
Sheer Strake	-	Not to be less than the adjacent side plating	-
Deck Stringer Plating	-	Not to be less than the adjacent deck plating	-

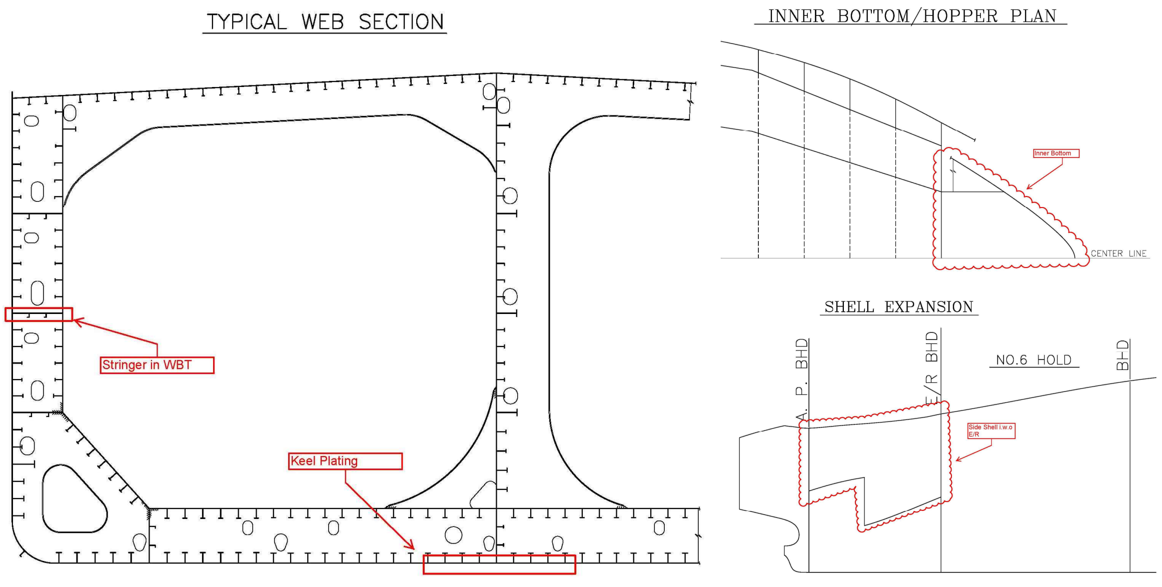

Fig.3 Positions to be reinforced due to minimum thickness requirement

3 Extended Scope of FE Analysis

The following analysis scope is extended in CSR-H.

- Cargo hold analysis
- Fine mesh analysis
- Fatigue analysis (very fine mesh analysis)

3.1 Cargo Hold Analysis

Nonparallel regions of cargo hold are included in cargo hold analysis in CSR-H as shown in Table 7 and Figure 4.

Table 7 Difference in Extent of Cargo Hold Analysis

Position		CSR	CSR-H
Mid hold region	No.3 ~ 5 Hold	O	O
Aft most cargo hold region	No. 6 Hold and Slop Tank	-	O
Aft cargo hold region	-	-	O
Forward cargo hold region	No.2 Hold	-	O
Forward most cargo hold region	No. 1 Hold	-	O

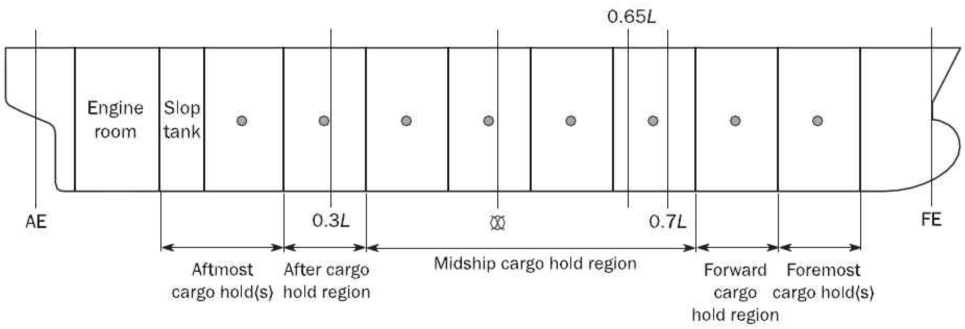

Fig.4 Definition of Cargo Hold Regions for FE Analysis

In the analysis of mid hold region, no significant impacts are found except thickness increases in cargo tank boundary due to increased cargo tank pressure.
In the analysis of aft most cargo hold region, buckling reinforcement at bottom shell plating forward of E/R BHD are required as shown in figure 5.
In other analysis, no significant impacts are found.

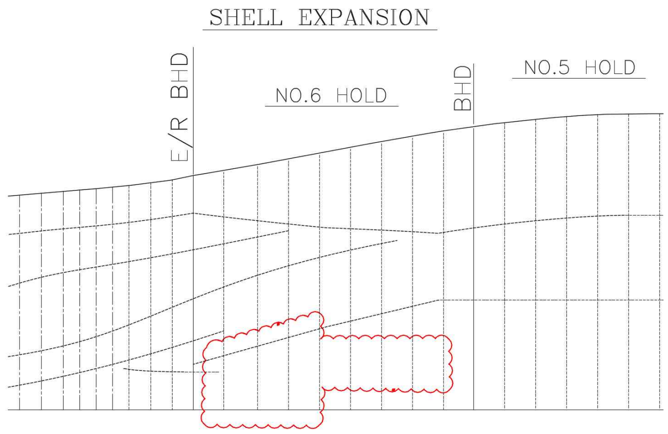

Fig.5 Buckling Reinforcement at Bottom Shell Plating forward of E/R BHD

3.2 Fine Mesh Analysis

The number of positions to be assessed by fine mesh analysis is increased as shown in Table 8. Positions required to be assessed for CSR are shown in blue circles and the additional positions for CSR-H are shown in red circles in Figure 6. There is no specific reinforcement in comparison with CSR except local reinforcements at toe ends due to the increase of cargo pressure.

Table 8 Difference in Extent of Fine Mesh Analysis

Position	CSR	CSR-H
Upper hopper knuckle	Mandatory	Mandatory
Lower hopper knuckle	-	Mandatory
Toe of PSM or large bracket	Mandatory	Screening
Heel of stringer	Mandatory	Screening
Opening	Large opening only (i.e. opening for inclined ladder)	Manhole (every opening) with screening
Connection between transverse BHD and double bottom and deck longitudinal	Mandatory	Mandatory
Extended Cargo Hold Analysis Region	-	Screening

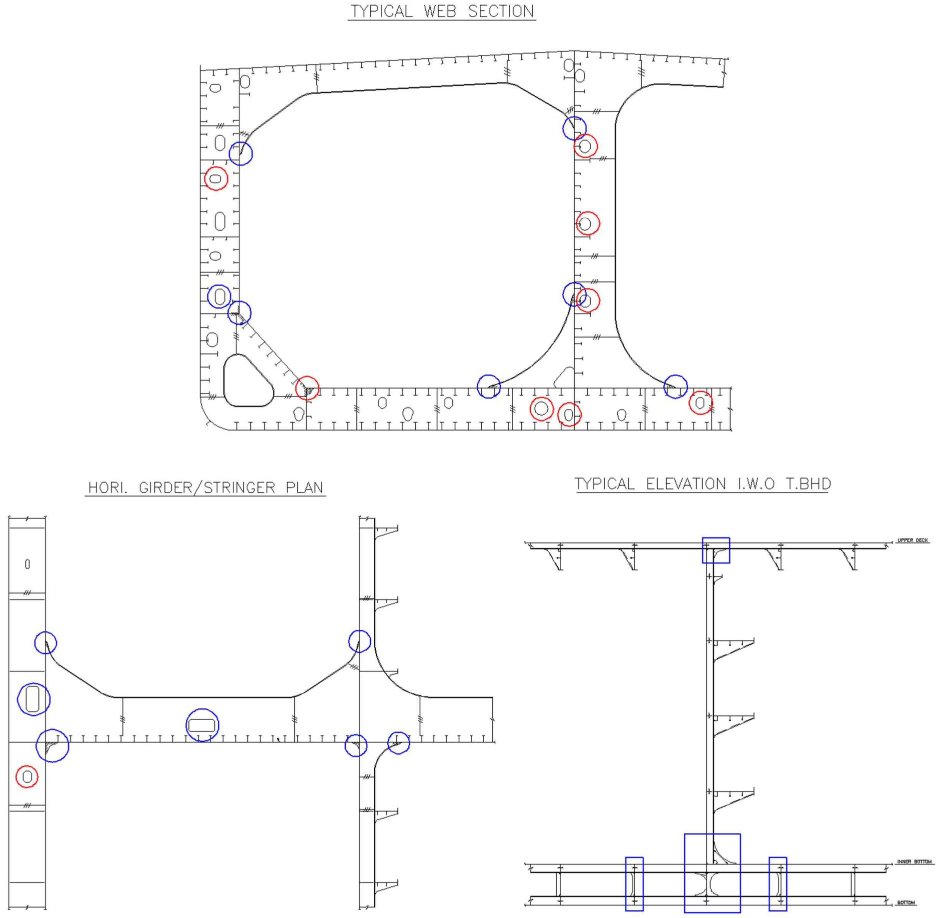

Fig. 6 Areas for Fine Mesh Analysis after Screening

3.3 Fatigue Analysis

The number of hot spots to be assessed by fatigue analysis is increased as shown in Table 9. Positions required to be assessed for CSR are shown in blue circles and the additional positions in CSR-H are shown in red circles in Figure 7. The reinforcements are shown in Table 10. In heel of no.1 stringer, toe grinding is applied because detail design standard does not satisfy fatigue life at toe end. In heel of no.2 stringer, toe grinding and face plate are applied because detail design standard does not satisfy fatigue life at toe end and fine mesh criteria at free edge. The Design of stringer toe end for fatigue strength is shown in figure 8.

Table 9 Difference in Extent of Fatigue Analysis

Position	CSR	CSR-H
Lower hopper knuckle	Mandatory	Mandatory
Toe of PSM or large bracket	-	Screening
Upper hopper knuckle	-	Detail design standard
Heel of stringer iwo double side	-	Detail design standard

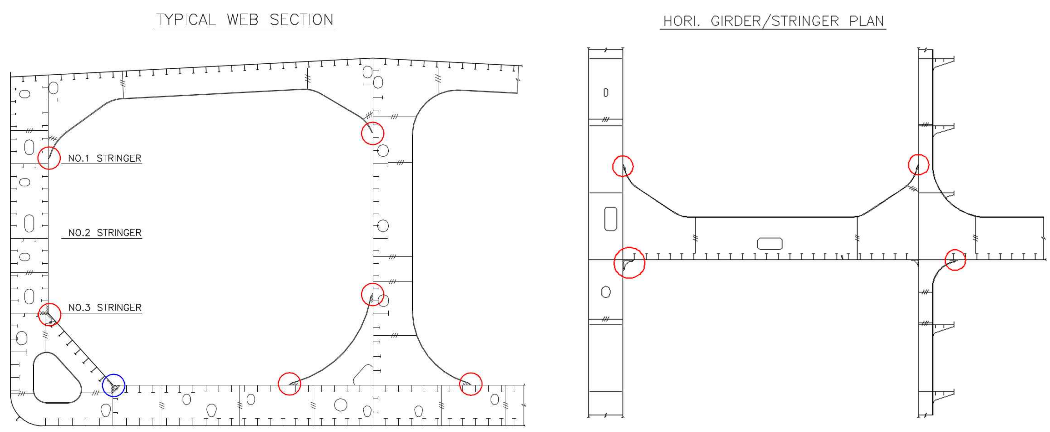

Fig. 7 Hot Spots for Fatigue Analysis

Table 10 Reinforcement due to Fatigue Analysis

Position		Reinforcement
Lower hopper knuckle	Inner bottom plating	+ 2 mm
Toe of PSM or large bracket	Toes at typical web section	No reinforcement
	Toe at no.1 stringer iwo double side	+ more than 10 mm with insert plate at inner hull BHD and thinner face plate (e.g. 350x30 FB → 450x24 FB)
	Toes at other position of stringer	+ 5 ~10 mm with thinner face plate
Upper Hopper Knuckle	Upper Hopper Knuckle	Detail design standard
Heel of stringer iwo double side	Heel at no.1 stringer	Detail design standard (800x800x25AH/600R) with toe grinding
	Heel at no.2 stringer	Smooth bracket with face plate with toe grinding
	Heel at no.3 stringer	No reinforcement

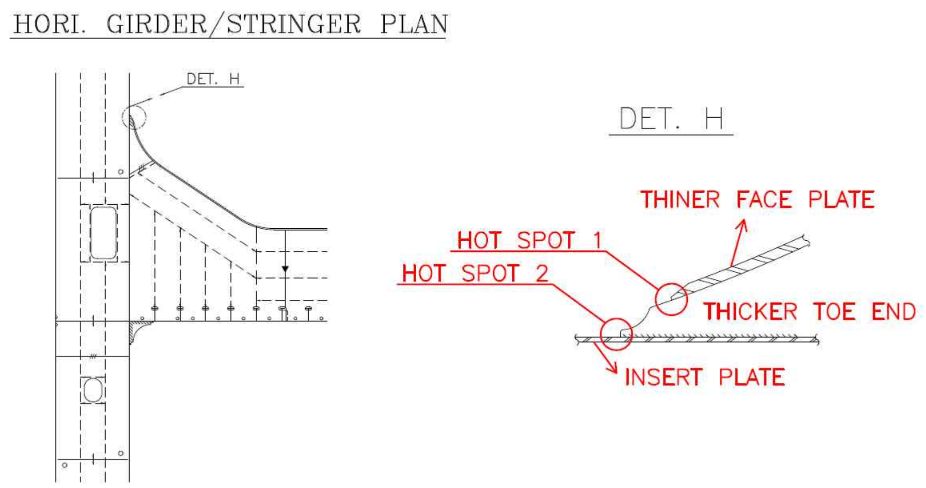

Fig. 8 Design of Stringer Toe End for Fatigue Strength

4 Conclusion

In this paper, the impacts of CSR-H on the design of a Suezmax tanker are reviewed. The main changes of design are caused by items below.

- Internal tank pressure → thickness increase at cargo tank boundary
- Minimum thickness → thickness increase at shell plating iwo ER and stringer plating
- Aft most cargo hold analysis → thickness increase at Bottom Shell forward of E/R BHD
- Fatigue analysis → stringer design change

The impacts of CSR-H are summarized in Table 11. It could be generally commented that the introduction of the CSR-H has resulted in the hull structure being strengthened due to yielding and fatigue in cargo hold region and that approximately 2 month more time is required for the structural design of the vessel when compared with the CSR.

Table 11 Impacts of CSR-H

Item		Impacts
Prescriptive rule change	Corrosion addition in shell plate	- Increased weight(around 1% of hull weight)
	Green sea load	
	Internal tank pressure	
	Bottom slamming region	
	Minimum thickness	
Extended scope of FE analysis	Mid hold analysis	- Increased analysis time and manpower - Increased time of class approval
	Aft most cargo hold analysis	
	Forward cargo hold analysis	
	Forward most cargo hold analysis	
	Fine mesh analysis	
	Fatigue analysis	