IACS CSR on Tankers

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Abstract

At the end of 2005, International Association of Classification Societies (IACS) adopted the Common Structural Rule (CSR) for Tankers and Bulk Carriers, which came into force since April 1, 2006.

In this paper, based on design experiences of a 105K Aframax tanker, a 165K Suezmax tanker and a 317K VLCC, results of evaluation on structural steel weight and some crucial technical issues are discussed. In addition, some suggestions to CSR are made for practical and reliable application.

1 GENERAL

In 2003, three classification societies of LR, ABS and DNV agreed to constitute a Joint Tanker Project (JTP) team and to develop a Common Structural Rule (CSR) for tankers under the purpose of rule transparency, no competition and construction of robust ships. Eventually at the end of 2005, IACS Council adopted CSR for Tankers, which came into force since April 1, 2006. It seems, however, many items still remain to be modified or changed to enhance reliability and rationality of rule requirements.

In this paper, based on HHI's design experiences of a 105K Aframax tanker, a 165K Suezmax tanker and a 317K VLCC, following technical issues are discussed by comparing CSR with previous rules before CSR (pre-CSR hereinafter).

1) Structural steel weight/corrosion addition/higher tensile steel
2) Minimum/maximum draughts of abreast full/empty conditions
3) Bottom Slamming
4) Shear force correction in way of bulkhead stringers
5) Prescriptive requirement for primary support member (PSM)
6) Effect of toe grinding on fatigue strength

Table 1 below lists principal characteristics of referred tankers in this paper.

Table 1 Principal characteristics

Principals \ Size	Aframax	Suezmax	VLCC
LBP (m)	234	264	324
B (m)	42	50	60
D (m)	21.2	23.2	29.6
Ts (m)	15	17.15	22
DWT (kilo ton)	105	165	317
Classification	KR/ABS	DNV	KR/ABS

2 TECHNICAL ISSUES

2.1 *Structural Steel weight corrosion addition/higher tensile steel*

Table 2 shows result of structural steel weight increase within cargo hold length compared to pre-CSR design. The higher tensile steel portion is 35% for all cases.

Table 2 Steel weight increase within cargo hold length

Unit: Ton

Aframax	Suezmax	VLCC
+1,000 (9.4%)	+1,200 (7.4%)	+2,000 (6.0%)

By CSR being adopted, structural steel weights are increased by 6~10% compared to those by pre-CSR design within cargo hold length. It is worthwhile to note that the increased design corrosion addition is one of the major factors for the steel weight increase by CSR.

Early in 2007, HHI received a letter from an engineering company with regard to the conversion of a VLCC to an FPSO. Parts of contents in the letter are quoted as follows, regarding to corrosion matters.

> "··· preparing a bid for an FPSO to be converted from a 1996 DH VLCC ··· In our search for candidate tankers we looked closely at your hull (1997) and found it in excellent condition. Ballast tank coatings, cargo tank under deck coatings, and tank bottom coatings are still in excellent condition so there is virtually no corrosion. We looked at another shipyard's tanker (1996) which was built with no coating under deck in the cargo tanks, and found general wastage around 2mm on the deck plate; there was little or no wastage on uncoated structure (longs, transverse webs) lower in the cargo tanks."

Under the circumstance of lack of information, with regard to inspection results of corrosion on operating ships, it is hard to judge which value of corrosion addition for new building would be appropriate. It seems, however, that requirements of corrosion addition in present CSR are unnecessarily severe considering that enhanced application of ballast tank coating is already in effect and cargo tank coating will become mandatory in near future or in case that the vessels applied a cargo tank coating already.

Figure 1 illustrates comparison of design corrosion additions between CSR and pre-CSR of ABS (in parenthesis). Although there is some deviation among classification societies of pre-CSR, the required values of design corrosion additions in CSR are double or more, in general, than those of pre-CSR.

In conclusion, it will be most valuable to reinvestigate the accumulated survey reports in view of corrosion. Inclusion of data for "narrow wing type single hull tankers" will help to ensure the reliability of data, since that this type vessel has a quite long lasted experience.

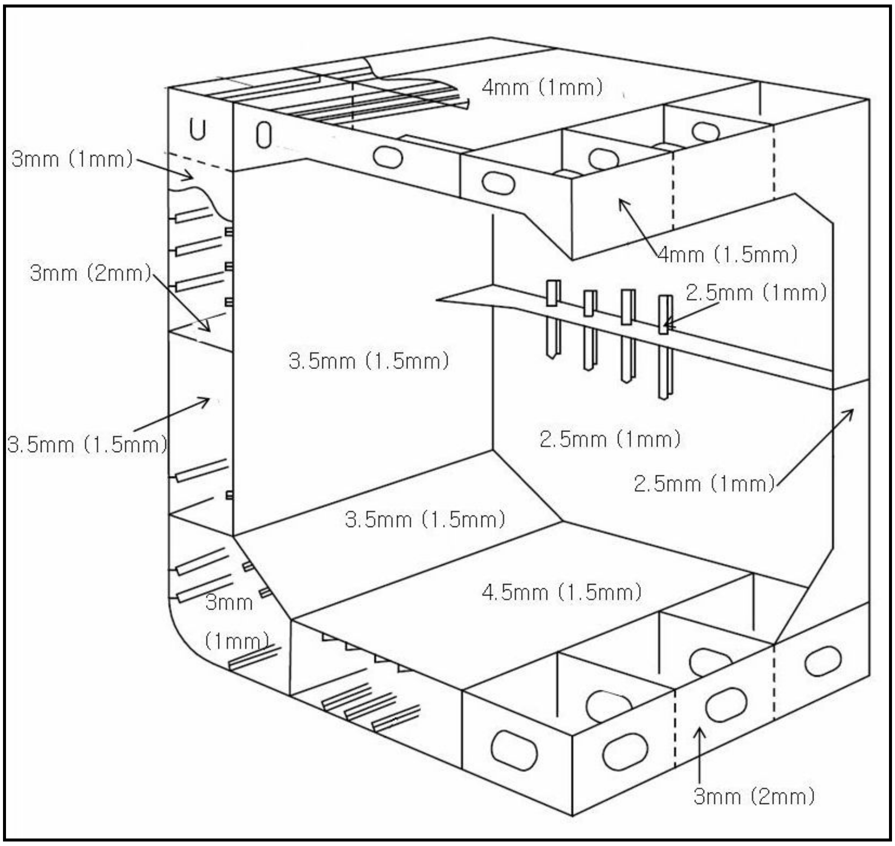

Fig. 1 Corrosion addition of CSR vs. pre-CSR (ABS)

An idea of reducing a new building and operating cost with CSR is more extensive use of higher tensile steel. Traditionally, lower portion of higher tensile steel (30%~35%) is preferred by many ship owners. According to design experience with CSR, it is found out that, although portion of higher tensile steel is increased to 40~45%, scantlings may not be thinner in many areas compared with those thickness by pre-CSR.

2.2 *Min. /Max. draught of abreast full/empty condition*

In CSR, the minimum and maximum draughts of abreast full/empty conditions are stipulated as shown in Table 3, for both prescriptive rule calculation and strength analysis using FEA, without any consideration on length of cargo tanks. The major scantlings of primary members including inner hull/external shell plating are determined in many positions by these two conditions.

Table 3 Min./Max. draught requirements for abreast full/empty

L. BHD Type		Center L.BHD		Two(2) L.BHD		Rule reference
Condition		Full	Empty	Full	Empty	
Prescriptive		0.6 T_{sc}	0.9 T_{sc}	0.6 T_{sc}	0.9 T_{sc}	Table 8.1.6
FEA	Sea	0.6 T_{sc}	0.9 T_{sc}	0.8 T_{sc}	0.55 T_{sc}	Table B.2.3/ B.2.4
	Harbor	1/3 T_{sc}	T_{sc}	0.7 T_{sc}	0.65 T_{sc}	

T_{sc} = Scantling draught.

Basically the minimum and maximum draughts of abreast full/empty conditions are related to the ratio of one hold length over ship length or to the number of holds in the cargo area regardless of hold division of athwartship direction divided by longitudinal bulkheads. For an example, if the number of holds is small and individual hold length is long, the minimum draught of the abreast full condition will be deeper while the maximum draught of the abreast empty condition will be lighter. Reversely, if the vessel has many holds, the situation will be opposite and this is a natural phenomenon. However, in CSR, there is no correlation between the longitudinally 6 holds tanker (Aframax or Suezmax tanker) and 5 holds tanker (VLCC). This requirement results in quite large scantling increment of the bottom plate thickness for an Aframax tanker or a Suezmax tanker comparatively than that for a VLCC. This effect is also found in the longitudinal bulkhead thickness in way of the transverse bulkhead. Hence the requirement of the abreast full/empty draughts is to be reconsidered. In this regard, following formulas of (1) to (2) for abreast full/empty draughts, which are related to the ratio of individual hold length (l_h) over ship's length (L), are proposed for IACS consideration.

- Minimum draught of abreast full condition

$$T_{min} \propto (l_h / L)T_{sc} \quad \text{(but not lesser than heavy ballast arrival condition)} \qquad (1)$$

- Maximum draught of abreast empty condition

$$T_{max} \propto (L / l_h)T_{sc} \quad \text{(but not greater than } T_{sc}\text{)} \qquad (2)$$

2.3 *Bottom Slamming*

With regard to bottom slamming, the prescriptive rule requirement for the thickness of double bottom floor is too severe. It is resulted from the fact that carry-over forces to adjacent floors through bottom longitudinal frames are not properly considered, and shear force distribution along floor is applied too conservatively. In consequence, required scantlings by the prescriptive rule are thicker by 40~50 % than those determined by an FEA, which is permitted as an alternative of the prescriptive requirement in CSR. Hence the prescriptive rule requirement should be modified so as to be practical.

2.4 *Shear force correction in way of bulkhead stringers*

Theoretical background of the stringer correction for hull girder shear forces in the prescriptive rule of CSR is based on pre-CSR requirement of DNV. However, some factors and loadings in CSR are changed from those in DNV. Eventually, this requirement influence unreasonably heavier scantlings to longitudinal bulkhead plating. In CSR, distribution of shear forces is verified correctly through an FEA. According to comparison results, in case of a VLCC, determined scantlings of longitudinal bulkhead plating by the prescriptive rule are thicker by 20~30 % than those by an FEA. Because the prescriptive rule requirement with regard to the shear force correction is mandatory, plating of the longitudinal bulkhead near to the transverse bulkhead position should be reinforced that much unnecessarily. In this regard, the prescriptive rule in CSR should be reconsidered or removed.

2.5 *Prescriptive requirement for primary support member (PSM)*

For scantlings of primary support member (PSM), CSR requires minimum section modulus and/or shear area etc, as below.

> "The section modulus and/or shear area of a primary support member and/or the cross sectional area of a primary support member and a cross tie may be reduced to 85% of the prescriptive requirements provided that the reduced scantlings comply with the FE cargo tank structural analysis"

The formula prescribed in CSR is based on a classical beam theory with some assumptions of boundary effects. Accordingly, it is hard to consider exactly the effect of structural member's interaction in the formula, and hence it requires actually irrational scantlings in some cases.

Figure 2 shows the change of the shape of a deck transverse web frame in a VLCC. The size of the deck transverse web frame is increased due to the above prescriptive requirement, while in this case it becomes worse in accommodating the relative deflection between inboard and outboard longitudinal bulkheads. This can make the structure more vulnerable to damage at toe area, if not designed carefully.

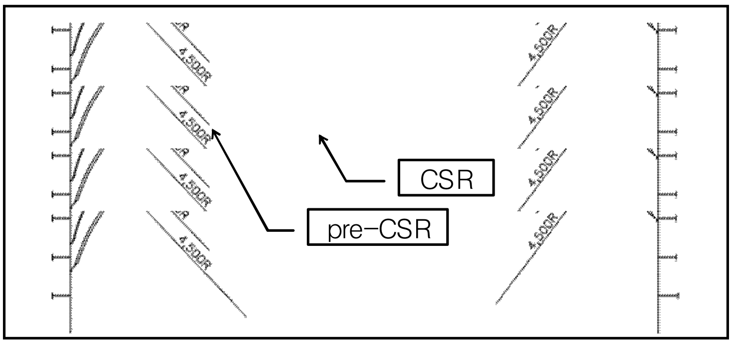

Fig. 2 Changes of deck transverse

2.6 *Effect of toe grinding on fatigue strength*

With regard to the effect of toe grinding on fatigue strength of ship structures, CSR specifies as follows;

> "The benefits of weld toe grinding should not be taken into consideration at the design stage. However, an exception may be made for the weld connection between the hopper plate and inner bottom if the required design fatigue life can not be satisfied by means of practical design options such as increasing local thickness, extending weld leg length and modifying local geometry. The calculated fatigue life is to be greater than 17 years excluding grinding effects."

Above statement, however, seems to be lack of background and has almost same meaning that toe grinding should not be applied in design of ship structures. According to a systematic research work carried out last year, it is obvious that fatigue strength is enhanced greatly, as shown in Figure 3 (Ryu et al., 2007), by toe-grinding. Due consideration of toe-grinding effect is urgently required in CSR for a rational structural design.

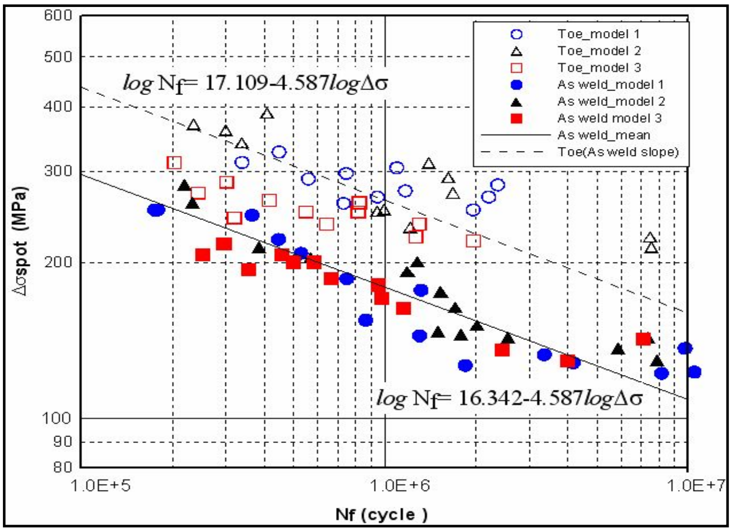

Fig. 3 Comparison of fatigue strength between as-welded joints and toe-ground weld joints

3 CONCLUDING REMARK

Based on the design experience of three series of tankers in accordance with CSR, some critical technical issues are discussed in this paper and summarized as follows.

- Requirements of design corrosion additions in CSR are doubtful and they need to be reinvestigated, considering that this is one of the major factors in steel weight increase. More extensive usage of higher tensile steel will be helpful for saving a new building and operating cost with present CSR, if design experience with pre-CSR is well reflected.
- The draught requirement of abreast full or empty condition needs to be improved in logical way, in consideration that it creates queer scantlings in some areas.
- Prescriptive rule requirement for bottom slamming should be modified to reduce big deviation with FEA results.
- Prescriptive rule requirement in CSR with regard to the stringer correction of hull girder shear forces appears unreasonable and not necessary because distribution of shear forces at abreast full/empty condition could be verified correctly by an FEA. Hence, the prescriptive rule requirement should be reconsidered.
- The prescriptive limitation on scantlings of primary support member (PSM) is believed to be lack of background and may drive the structural design change irrationally. Also it can act as an obstacle to flexibility of advanced design capability.
- Due consideration of toe-grinding effect on fatigue strength of weld joints is required.

From technical point of view, CSR is a much developed structure rule by adopting high technology even it contained lots of technical problems in its earlier versions including above issues and it is now welcomed to unify rule requirements of classification societies to one for the end users. However, there still remain some critical areas to be reinvestigated without delay. IACS presents the main purpose of CSR is “rule transparency, no competition and construction of robust ship”. According to the design experience of tankers, shipbuilders rather feel that the background of CSR is still vague in many areas. No competition among classification societies sounds good; however in some sense, it may act as an obstacle to technical improvement for more robust and reliable structure in efficient way. It is believed hard to expect technical improvement without competition! For the next generation and technical improvement, the rule should allow flexibility of shipbuilder's design, if it is proven safe.

4 REFERENCES

Korean Register of Shipping 2007, Common Structural Rules for Double Hull Oil Tankers

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DNV Classification notes No.72.1 (Oct. 2006) Allowable thickness diminution for hull structure

H. R. Ryu, et al (2007) Effect of Toe Grinding on Fatigue Strength of Ship Structure, Proc. PRADS 2007, Houston.