KC#914

Rule Change Proposal
Requirement to single side frame section modulus due to ballast pressure.

Reference is made to requirements for frames of single side bulk carrier subject to ballast pressure. Ch. 6 Sec. 2 [3.3.1]. IACS KC 457/215/356

Summary of DNV understanding, Ballast hold assumed.

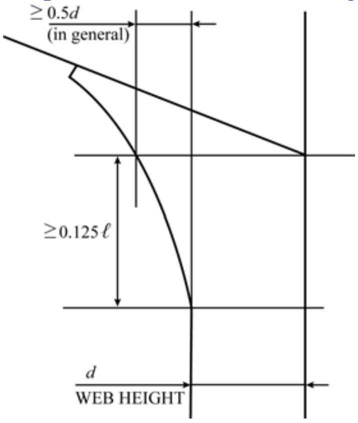
Section modulus at mid span

1. [3.3.1] (All pressures) with length as defined in Ch. 3 Sec. 6 Figure 16
2. [3.2.3] (Ballast pressure only) with length as defined in sketch 4 of Figure 2 in Ch. 3 Sec. 6.

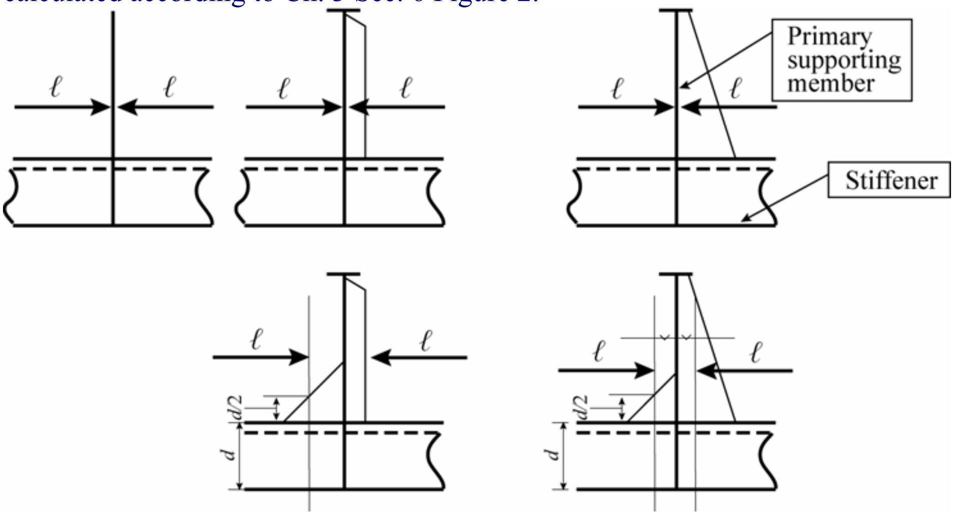
Sectional modulus at ends ref. [3.3.3]/[3.3.4]

1. 2xW[3.3.1] (All pressures) with length as defined in Ch. 3 Sec. 6 Figure 16
2. 2xW[3.2.3] (Ballast pressure only) with length as defined in Ch. 3 Sec. 6 Figure 2

Requirements for bracket length are given in Ch. 3 Sec. 6 Figure 20 (same as UR S12).



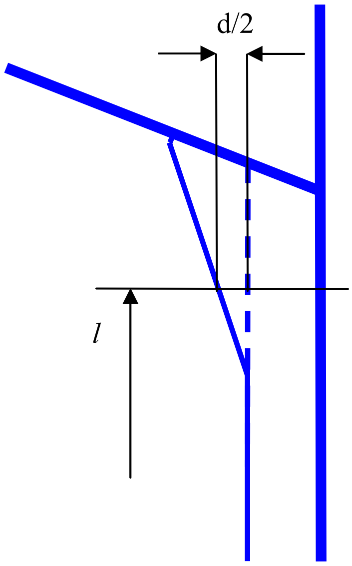
At the connection of top wing tank, the bracket height is 0.5d. The effective length is calculated according to Ch. 3 Sec. 6 Figure 2.



It should be noted, that for the standard UR S12 bracket arrangement, the effective lengths are identical to the length between topwing and hopper knuckle ($l_{eff}=l$). That is, no reduction by effective span as stipulated in KC #215.

In KC#356 it is shown that for $l_{eff}=l$ the sectional modulus for [3.2.3]= 2x [3.3.1]. In practice this correspond to an m-factor of m_{mid}=10 and m_{end}=5, which is very conservative. Note also that m=10 is normally the end moment of a vertical stiffener.

In order to accommodate the equation [3.2.3] we see designs with long and slender brackets for side frame as shown in the figure below.



The brackets give large reduction to effective length. DNV is concerned about this development as the length may be reduced to an extent so that the mid span sectional modulus is below originally required by DNV Rules.
DNV is of the opinion that the requirement of [3.2.3] should be substituted by equations giving a more physically representation of the moment distribution of the frame, removing the possibility to manipulate the requirement by bracket design.

Please note following

1. **The effective span evaluation according to Ch.3Sec.6Figure2 is not valid for side frames.**
   The span of single side frames should be according to Ch.3Sec.6Figure2. In Fig. 2 typical end connections <u>for continuous stiffeners are shown</u>. End connection cases where the stiffener is terminated at the end support have not been shown. Also, no precaution is taken. E.g. stating that the stipulations of Figure 2 only apply provided the end bracket is effectively supported. Hence, Figure 2 should not be used for single side frames.

2. **Bending moment distribution of the side frames is governed by elastic response of the supporting structure in top wing and hopper tank.**
   The side frames in bulk carriers is a typical case where the effectiveness of the end support could be questioned. The end support for side frames in Ch.6 Sec.2 [3.4.1] is formulated as a requirement to the section modulus of the longitudinal stiffeners supporting the upper and lower connecting brackets of the side frame. The requirement ensures that the end supports have <u>bending moment capacities (plastic)</u> that are related to the sea pressure load on the side frame. The actual bending moment by the connecting brackets on a side frame subject to the sea or the ballast pressure load will be determined <u>by the elastic response of the structure.</u>
   It may be noted that the required bending moment capacity of the upper end is only half of that required for the lower end support. Current formulation for section modulus is assuming same bending moment in both ends (m=5).

3. **Increased extent of main frame bracket gives limited effect of the bending moment distribution of the main frame.**
   According to the present CSR, an increase of frame bracket length allow for reduction of span length according to Ch.3 Sec. 6 Figure 2 (sketch 4), and thus the section modulus of the frame. Bearing in mind item 1 and 2 above, it is expected that increase of bracket length have a marginal effect on the bending moment of the frame.

We therefore ask for background documentation for the requirement of the last sentence of 3.3.1 of Ch.6 Sec.2.

If documentation is not available, it is suggested that the requirement formulation is revised such that the same span length is applied for the ballast load as for the sea pressure load. The revised formulation should reflect that the bending moment distribution in the frame is dependent on the elastic response of the supports, which is the internal structure in hopper and topwing tank. As discussed above, the elastic stiffness of the bottom support is larger than the top support. Additionally the pressure distribution on the frame should be taken in to account.

Possible rule formulation

Following rule formula is provided as a basis for discussion. The formula is based on DNV Pt.5 Ch.2 Sec.8 and valid for ballast pressure only:

$$W = \frac{l^2 s(P_s + P_w)}{0.9 m R_Y} 10^3$$

$$m_{UpperEnd} = 12, m_{MidSpan} = 18, m_{LowerEnd} = 9$$

Span length l is as defined in Ch. 3 Sec. 6 Figure 19, same as UR S12.

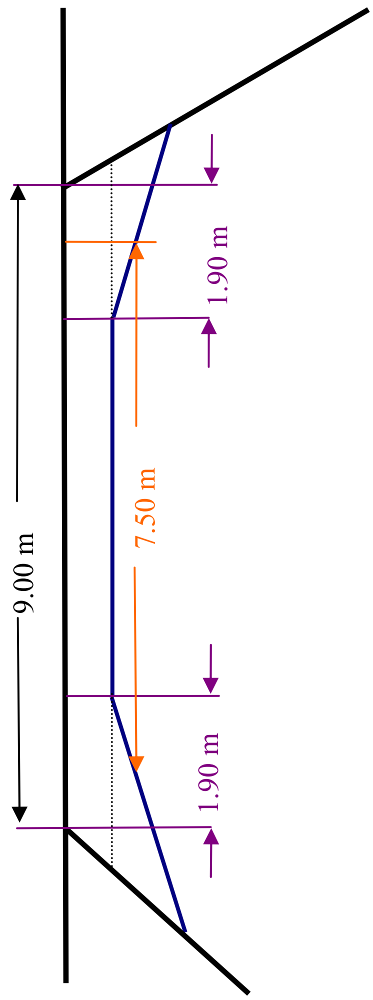
Motivation for change:

1. The proposed equation will give a more physical representation of the bending moment distribution in the frame.
2. For bracket designs as per Ch. 3 Sec. 6 Figure 20, the sectional modulus requirements will be more realistic.
   $m_{UpperEnd}$ change from 5 => 12
   $m_{MidSpan}$ change from 10 => 18
   $m_{LowerEnd}$ change from 5 => 9
3. Section modulus can not be manipulated by large slender brackets in order to bring the requirement of [3.2.3] back to a realistic value.

Comparative calculation

CSR Cape Size Bulk BC-A

$P_{Ballast,Mid\ Span}$	230	kN/m^2
Fr. Sp.	920	mm
Steel	315	N/mm^2



Sectional modulus calculation:

	$CSR_{[3.3.1]}$	$CSR_{[3.2.3]}$ BKT 1.9m	$CSR_{[3.2.3],}$ URS12Bkt	$CSR_{Proposal}$	
Upper (2xMid)	5973	8779	12642	5267	cm^3
Midspan	2987	4390	6321	3512	cm^3
Lower (2xMid)	5973	8779	12642	7023	cm^3