Bulker Q&As and CIs on the IACS CSR Knowledge Centre

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **149** | 7/2.2.2.4 | CI | global strength analysis | 2006/10/25 | In FE models for global strength analysis, the number of plate elements on the height of primary supporting members is not clear.<br>In particular, for transverse primary members inside the hopper tank and the upper wing tank. | The general case for all primary supporting members of both double hull or single side bulk carriers shoud be 3 elemnts in height. The case of primary supporting members in hopper tank and top side tank should be a particular case, once again for both double hull and single side bulk carriers. Then side frames in single side bulk carriers are covered in a separate item. Considering that, we suggest to modify the third and fourth bullets in 2.2.4 as follows: "<br>- webs of primary supporting members are to be divided at least three elements height-wise. However, for transverse primary supporting members inside the hopper tank and top wing tank, in case their web height is smaller than the space between longitudinal ordinary stiffeners, two elements on the height of primary supporting members are accepted<br>- side shell frames in single side bulk carriers and their end brackets are to be modeled by using shell elements for web and shell/beam/rod elements for face plate. Webs of side shell frames need not be divided along the direction of the depth" | |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **169** | 7/2.2.5.4&. 6 | Question | horizontal shear force | 2006/9/11 | The formulae in 2.5.4 and 2.5.6 deal with horizontal shear force, but there is no sign convention for horizontal shear force. | In order to have the same relation ship between horizontal shear force and horizontal bending moment as the one between vertical shear force and vertical bending moment, I suggest introducing the following definition:<br>"The horizontal shear force “Qh” is positive in the case of resulting force towards portside preceding the ship transverse section, and resulting forces towards starboard following the ship transverse section, and is negative in the opposite case"<br><br>This definition is not mentioned in CSR. Therefore, we will submit the following modification to Hull Panel.<br><br>(1) Chapter 4 Section 1 Figure 1<br>The symbol “Q” in the figure is amended to “Qs” and “Qwv”..<br>(2) Chapter 7 Section 2 [2.5.4]<br>The definition of symbols of “QV_FEM, QH_FEM, MV_FEM, and MH_FE“ are amended as follows.<br>QV_FEM, QH_FEM, MV_FEM, and MH_FEM: Vertical and horizontal shear forces and bending moments created by the local loads specified on the FE model.<br>Sign of QV_FEM, MV_FEM and MH_FEM are in accordance with sign convention defined in Ch.4 Sec.3. Sign of QH_FEM is positive in the case of resulting force towards portside preceding the ship<br>transverse section, and resulting forces towards starboard following the ship transverse section, and<br>is negative in the opposite case.<br>(3) Chapter 7 Section 2 [2.5.6]<br>The definition of symbols of “QV_T, QH_T, MV_T, and MH_T“ are amended as follows. QV_T, QH_T, MV_T and MH_T:Target vertical and horizontal shear forces and bending moments, defined in Table 3 or Table 4, as the location xeq. Sign of QV_T, MV_T and MH_T are in accordance with sign convention defined in Ch.4 Sec.3. | |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **170** | Ch 7 App 2 2.2.2 & 2.2.3 | CI | PSI Factor | 2007/6/11 | In chapter 7 App2, 2.2.2 and 2.2.3, the formulae to obtain sigma x, sigma y, psi x and psi y are given for "longitudinal compression" and "transverse compression". In case the stress are in tension, psi will become bigger than one, and the associated stress will be the minimum tension stress. According to the definition of psi in Ch6 Sec3 and the schemes and formulae in Ch6 Sec3 Table 2 doe, psi is supposed to be smaller than one.<br>One interpretation is to change the formula for sigma and psi in order that psi is lower than one and sigma is the maximum tension stress.<br>The other interpretation is to keep the formulae as they are in order to get the minimum tension stress. | As the psi factor will not be used with tension stresses, it seems preferable to retain the minimum tension stress (ie the maximum stress with the sign convention for stress in the buckling rules) in order to be conservative. Therefore, the formula for sigma x or sigma y is unchanged, and psi is not calculated (or limited to one) for tension stress. | |
| **197** | 7/4.3.3 | CI | simplified method | 2006/10/31 | We understand that the methodology used in the simplified method is commonly applicable to the intersection of inner bottom plate and sloping plate of lower stool as well as bilge knuckle part. Therefore, Common Interpretation should be prepared as soon as possible so that this method can be applied to the intersection of sloping plate of lower stool and inner bottom plate | Your understanding is right. The simplified method is applicable to the intersection of inner bottom plate and sloping plate of lower stool as well as the intersection of inner bottom plate and hopper slant plate. That's was the original intention of the requirement. In applying the requirement of Ch.7 Sec 4 [3.3], therefore, the following interpretation is prepared in order to be in line with the original intention. Common Interpretations for:<br>Chapter 7/Section 4/3.3Simplified method for the bilge hopper knuckle part [The text of the Rules] The words "bilge hopper knuckle parts" , "bilge knuckle part" and "hopper slope plate" in the title of [3.3], the text of [3.3.1] and [3.3.3], the title of Fig.6 and the text in the top of column of the Table 1. Common Interpretation The requirements of [3.3] are applicable to the knuckle part not only bilge knuckle part but also lower stool knuckle part such as the intersection of the inner bottom plate and sloping plate of lower stool. | |
| **218** | 7/4.3.2.1 | Question | hot spot stress range | 2006/11/28 | The procedure of obtaining hot spot stress brings very pessimistic results and differs from that of JTP.We would like to ask you to reconsider and revise the procedure as soon as possible.In conjunction with the above, 3.3.2 should be also reconsidered. | The existing procedure is not modified. However, possible changes will be subject to the future harmonisation work between CSR for oil tankers and CSR for bulk carriers. | |
| **219** | 7/4.3.3 | Question | connection | 2006/11/8 | Please develop and introduce a simplified method for the connection of lower stool of transverse BHD with inner bottom as soon as possible. | The simplified method is applicable to the intersection of inner bottom plate and sloping plate of lower stool as well as the intersection of inner bottom plate and hopper slant plate. That's was the original intention of the requirement. | |
| **248** | 7/2.2.1.1 | Question | FE model | 2006/11/30 | Extent of model; The extent of FE model is required to be three cargo holds and mid one is the target assessment. In handy bulk carriers, loaded holds(Nos.1 and 5 holds) are not included in the mid part model(Nos.2-4 holds). Please clarify the FE model for handy bulk carriers with 5 cargo holds. | The FEA assessment of cargo holds is restricted to the midship area by the CSR.However, assessment of holds of both ends is left to the responsibility of each Society – this may be an extrapolation schema, a specific FE analysis, a FEA provided by the ship designer,…Furthermore, it should be noticed that this problem is also relevant in the CSR for Oil Tankers. | |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **278** | 7/App.2,Fig2 | Question | FE | 2006/11/22 | My only comment is that the Amendment for Ch7, App 2, [2.2.3], Fig 2 is still not clear to me. | The numbers 1 to 8 in Fig. 2 indicate the diplacement nodes number of the shell element of FE. The numbers 1 to 6 in bold style in Fig.2 indicate the stress calculation points number of panel which is obtained from the transform matrix using the displacement of the node numbers 1 to 8.The figure may be splited into two figures in a next revision of the CSR: one for the displacement points and the other for the stress calculation points. | |
| **287** | 7/4.3.3.3 & Table 7.4.1 | Question | colum plate thickness | 2006/12/18 | Is the column plate thickness, t column, based on the gross inner bottom plate? | The requirement of 1.4.1, Ch 7 Sec 1 mentions as follows. "Direct strength analysis is to be based on the net scantling approach according to Ch 3 Sec 2." According to this requirement, the thickness in Table 1 of Ch.7 Sec 4 [3.3.3] is "Net thickness" in FEA. In order to clarify this, the text modification will be proposed as "Corrigenda". **Also Included in Corrigenda 5** | |
| **288** | 7/4.3.3.3 & Table 7.4.2 | Question | Radius R | 2006/12/20 | a) The radius R is believed measured to the radius on upper surface of hopper knuckle is that correct.<br>b) The thickness t is assumed to be the plate thickness in way of radius knuckle. t is assumed gross thickness. Is that correct?<br>c) K2 in Note 2 should read K3<br>d) Note 2 only applies to radius knuckle, therefore the text "For bend type knuckle ..." should be inserted<br>e) Does it mean that the insert plate in the floor web is to be the same thickness as inner bottom plate? | a) Yes, it is correct.<br>b) No, it is not correct. The thickness t is always the "Net thickness" in FEA.<br>c) Yes. It is typo. The "Corrigenda" will be issued soon.<br>d) Noted. The text of Note (2) should be revised as follows. "In using the correction factor K3 for bend type knuckle, the members should be arranged such that the bending deformation of the radius part is effectively suppressed." This revise will be issued soon as "Corrigenda"<br>e) Yes, it is recommended to be the same thickness as inner bottom plate where the fatigue assessment is carried out by simplified method. However, where the fatigue assessment is carried out by very fine FEA, the thickness of insert plate is to be determined based on the results of fatigue assessment. | |
| **289** | 7/4.3.3.3 & Fig.7.4.7 | Question | longitudinal rib | 2006/12/21 | Is there a maximum distance for the position of the single longitudinal rib required by Table 2 Note (2)? | No, there isn't. This figure is just example. The distance for the position of the single longitudinal rib is determined by case by case basis but the single longitudinal rib is recommended to fit near of knuckle part as far as practicable. | |
| **290** | 7/4.3.3.3 Fig 7.4.8 | Question | longitudinal ribs | 2007/1/8 | The figure shows two longitudinal ribs, and indicates a distance of 500mm from the margin girder to the second rib. Is this correct? | Yes, it is correct that Figure 8 shows two longitudinal ribs, and indicates a distance of 500mm from the margin girder to the second rib.<br>However, in order to clarify the arrangement of transverse rib, longitudinal rib and extent of local reinforcement, we will consider the rule change proposal of Figures 7 and 8 in future. | |
| **291 attc** | 7/4.3.3.3 Table 7.4.2 | Question | intersection | 2007/1/11 | Regarding the simplified method, IACS Q&A (no 11) in the official spreadsheet, indicates that simplified method is applicable to intersection of inner bottom plate and sloping plate of lower stool as well.<br>For this connection with longitudinally framed inner bottom and vertically stiffened lower stool, K2 is understood = 0.9, and K4 =0.9. Is that correct?<br>It is assumed that Note 3 i.e. insert plate in web, is only applicable to hopper knuckle connection. | In our point of view, if the simplified method is applicable to intersection of inner bottom plate and sloping plate of transverse lower stool, the correction coefficients K2 and K4 should be considered in the following way:<br>- K2 equal to 0,9 should be considered when there is a thickness increment of longitudinal girder web, up to the thickness of the inner bottom plating,<br>- K4 equal to 1.0 in general and equal to 0.9 when longitudinal ribs are fitted. | Y |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **292 attc** | 7/4.3.2.2 | Question | Radius R | 2007/1/31 | Please find the attached PDF describes our implementation for Lambda as follows. Could you check it if our interpretation is correct?<br>(a) welded intersection between plane plates apply to;<br>- Bilge Hopper plane part to Hopper Transring.<br>- Side Girder to Hopper Transring and Floor.<br>- Inner Bottom to Floor.<br>- Side Girder to Inner Bottom.<br>b) welded intersection between bent plate and plane plate apply to;<br>- Bilge Hopper bent part (between R.ENDs) to Hopper Transring. | Your interpretation is correct, however, the parts indicated in the question are not required to carry out the fatigue assessment. The fatigue assessment is to be carried out for the members and locations described in Table 1 Ch 8 Sec 1. | Y |
| **293** | 7/4.3.2.1 | Question | geometric stress | 2007/1/23 | The principal stress in the 4th line is a surface stress (at top or bottom of the element? or a membrane stress (at neutral axis of the element? According to [3.1.1], the hot spot stress is defined as the structural geometric stress on the surface at a hot spot. However, in figure 3, it seems a membrane stress. Could you tell us which is correct? | Surface stress is used for hot spot stress evaluation. Figure 3 shows the locations of stress evaluation points to define the hot spot stress. In order to clarify used stresses, we will consider the editorial correction of the second sentence of the first paragraph as follows. “The surface stress located at 0.5 times and 1.5 times the net plate thickness are to be linearly extrapolated at the hot spot location, as described in Fig. 3 and Fig. 4.” | |
| **294** | 7/4.3.3.2 | Question | nominal stress range | 2007/1/31 | The second and third words "nominal stress" is not consistent with terminology used in 3.2.1 is "nominal stress" a principal stress? or normal stress? | The word “normal stress” instead of “nominal stress” is correct. This revision will be issued as “Corrigenda”. | |
| **334** | 7/2.3.4 | Question | Measurements | 2007/3/9 | Would you please confirm which direction is the maxium relative deflection delta_ max between the double bottom and the afterward (forward) transvers bulk head? Z or the reluctant? | The maximum relative deflection has to be measured normal to a line, which connects the adjacent bulkheads at Bottom / CL. | |
| **340 attc** | 7/2.3.2.3 | Question | Stress Levels | 2007/7/2 | According to Ch.7 Sec.2 [3.2.3] “The reference stresses in FE model that does not include orthotropic elements, as specified in [2.2.4] are not to exceed 235/k N/mm2 (..)” We have 3 multiple questions. See the attached. | 1. Your understanding that is the local plate bending is neglected is correct.<br>2. In principle stress levels of all elements should be within the allowable criteria. However, the averaged stress among smaller elements (e.g., quarter size or smaller) can be used when deemed reasonable by the Society.<br>3. All elements over the height of the girder should be within the allowable criteria when the difference of size of all elements in girder is relative small. | Y |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **341 attc** | 7/2.3.2.3 | Question | Stress Assessment | 2007/7/2 | Section 3 Detailed stress assessment.<br>Item [2.1.1] “Where the global cargo hold analysis of Sec.2 is carried out using a model complying with the modelling criteria of [2.2.4], the areas listed in Tab 1 are to be refined at the locations whose calculated stresses exceed 95% of the allowable stress as specified in Sec 2,[3.2.3]. Please review following related questions (see the attached). | 1a. Your understanding is correct.<br>1b. Your understanding is correct.<br><br>2. According to 2.1.1 of Ch 7 Sec 3, as the refined areas are limited to the locations listed in Table 1 of Ch 7, Sec 3 and the stresses thereof obtained by coarse mesh FEA in Ch 7 Sec 2 exceed 95% of the allowable stress, the enlarged area to create the refine mesh is not required to the locations where the stresses obtained by coarse mesh FEA is below 95% of allowable stress. Therefore, The example given in "b" of your questionary document as attached is correct.<br><br>3. The example given in "a" of your questionary document as attached is correct. | Y |
| **343 attc** | 7/2.2.3.1 | Question | Boundary conditions for FE analysis | 2009/9/4 | FE analysis of cargo hold structures - boundary conditions<br>See the attached question | Your comments have been noted and we can advise that the boundary conditions have been changed accordingly in RCN No.1-5 to the July 2008 Rules. | Y |
| **393** | 7/2.2.3.1 | Question | Longitudinal Items | 2007/6/11 | 1. Normally at neutral axis on centreline, there are no longitudinal items present,so to which "independent point" are the nodes on longitudinal members at both end sections to be linked ?<br>2. to which node is the total moment (still water & wave) to be applied ?<br>3. are boundary conditions to be applied only to the master node of coupling equations & not at all end nodes of longitudinal items ? | In general “independent point” does not locate in any members of the FE model but shall be produced additionally near the cross point of centerline and neutral axis. The nodes on the longitudinal members at the end shall be rigidly linked to the “independent point”. It might be common way to use the bulk data card “MPC” (Multi-Point-Constraint) in case of MSC/NASTRAN. The total moments (enforced moment for BM/SF adjustment) and boundary conditions are to be applied to the independent point only. | |
| **411** | 7/2.2.5 | Question | Horizontal Bending Moment | 2007/6/12 | Handling of horizontal moment induced by P1-Loadcase: Loading conditions with load case P1 create horizontal bending moments, which increases from "0" at one model side to a maximum value at the other side. We adjust these horizontal bending moments with counter shear forces and bending moments at the model ends analog to the horizontal bending moment in the R1 load case. The target value for the horizontal bending moment in P1 load case is "0" at mid of cargo hold model.Please confirm. | We confirm that the target value for the horizontal bending moment in P1 load case is “0” at the mid of cargo hold model. | |
| **484** | 7/2.3.3 | Question | Buckling and Ultimate strength assessment | 2007/7/2 | Regarding buckling and ultimate strength assessment in a global strength analysis, an increase in thickness of each panel satisfying requirements will be obtained by iteration. As there is no clear process in the current rules, it is considered appropriate that the stress may be used as it is with no reductions associated with thickness ratios in each iteration step. Is this correct?<br>If not correct, some known approches are considered available, for example,<br>(i) all component stresses are reduced with thickness ratios,<br>(ii) the same as (i) but stresses in the global X direction are not reduced,<br>(iii) only the stress due to local loads is reduced with thickness ratios and the stress due to hull girder loads is not reduced.<br>Please advise a common process to apply proper stresses for required thickness calclations. | CSR only requires that the results of DSA are to comply with the strength criteria in Chapter 7. There is no need to specify the iteration procedure to confirm the reinforcement of structure in CSR because it is considered that the responsibility of reinforcement of structure which does not comply with the strength criteria is up to designers not classification societies. Classification society only confirms that the results of DSA carried out for the given scantlings of structure comply with the strength criteria specified in the Rules. | |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **542** | 7/2.3.3 | RCP | Thickness iteration procedure for buckling strength assessment | 2007/10/24 | Whilst an answer has been given in IACS KC484 to the question on thickness iteration procedure for buckling strength assessment, it is still requested that a common iteration procedure or a Rule stipulation be specified.<br>Question: Regarding buckling and ultimate strength assessment in a global strength analysis, an increase in thickness of each panel satisfying requirements will be obtained by iteration. As there is no clear process in the current rules, it is considered appropriate that the stress may be used as it is with no reductions associated with thickness ratios in each iteration step. Is this correct? If not correct, some known approaches are considered available, for example, (i) all component stresses are reduced with thickness ratios, (ii) the same as (i) but stresses in the global X direction are not reduced, (iii) only the stress due to local loads is reduced with thickness ratios and the stress due to hull girder loads is not reduced. Please advise a common process to apply proper stresses for required thickness calculations.<br><br>Answer: CSR only requires that the results of DSA are to comply with the strength criteria in Chapter 7. There is no need to specify the iteration procedure to confirm the reinforcement of structure in CSR because it is considered that the responsibility of reinforcement of structure which does not comply with the strength criteria is up to designers not classification societies. Classification society only confirms that the results of DSA carried out for the given scantlings of structure comply with the strength criteria specified in the Rules.<br>As in CSR-DHOT 9/2.1.2.1 in respect of submission of results stipulating that '(m) proposed amendments to structure where necessary, including revised assessment of stresses, buckling and fatigue properties showing compliance with design criteria", it is considered necessary for CSR-BC to implement a harmonised iteration process for determining amended scantlings by thickness iteration. | The report of the FE analysis has to demonstrate that the ship structure has been designed according CSR-BC. | |
| **571 attc** | Ch4 App3 and Ch7 sec 4 | Question | fatigue strength assessment | 2008/8/9 | Please answer to the attached question for fatigue of Bulker CSR. | A1. For fatigue strength assessment, the cargo density used is to be as much “realistic” as possible. Therefore, the cargo density according to Ch 4 App.3 should be used for fatigue strength assessment not only by direct analysis specified in Ch 8 Sec 3 but also simplified method specified in Ch 8 Sec 4. We will consider the rule change proposal accordingly<br>A2. We think that Ch 7 Sec 4 3.3.2 referred in the question is Ch 7 Sec 4 3.2.2 correctly. The the definition of lamda for "welded intersection between plane plates" is applicable for intersection of two plates and intersection of plating and bracket.<br>A3 The correction factor of Ch 7 Sec 4 [3.2.2] is applicable to the case where the stress at the 0.5 t from the hot spot is slightly greater than the stress at the 1.5 t from the hot spot. | Y |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **636** | 7/2.2.3.1 | RCP | High Stress of Cross Deck | 2008/3/26 | Regarding the draft answer for "PH7101_: High Stress of Cross Deck obtained by DSA (KC ID No.343)", we would like to offer following suggestions to have a feasible conclusion for this issue before the wording of the draft answer is settled.<br>1. It is noted that the problem has happened in the DSA using a FE cargo hold model under the load cases of R1, R2, P1 and P1, where dynamic pressures induced will be unsymmetrical to the ship centre line. As described in Table 2 of Ch. 7, Sec. 2, Para. 2.3.1 of the CSR for BC, the cargo hold model is simply supported at both ends through the independent point for vertical bending and horizontal bending whilst relevant bending moments are applied at both ends to achieve the target values, however, the rotation around x axis at the fore end is constrained in addition to the warping, i.e., fully fixed at the fore end for torsion, whilst those are free at the aft end. Under such boundary conditions, if there is any local pressure in it unsymmetrical to the centre line, the cargo hold model is naturally twisted without any control.<br><br>Relevant boundary conditions may need to be added to the aft end and will probably be well modified the wave-induced torsional moment and warping.<br><br>2. It is understood that the load cases of R1, R2, P1 and P2 correspond to beam sea since hydrodynamic pressures are independent of x coordinate as shown in Ch. 4, Sec. 5, Paras. 1.4 and 1.5. Wave-induced torsional moments in the load cases may, therefore, be relatively small as compared with those induced in oblique sea which may be given in Ch. 4, Sec. 3, Para. 3.4, however, the torsional moments are not available in any part of the Rules.<br><br>3. Warping may be calculated at any position using the formula in Ch. 8, Sec. 5 if relevant wave induced torsional moment is available, whilst the formula is insufficient from the following points of view;<br>3.1. The rate of twisting is calculated by pure torsion, i.e., St. Venant's torsion only. The secondary torque induced as a result of the constraint of warping is ignored. (Note: Warping is proportional to the rate of twisting.) 3.2. The hull section is treated as closed section and hatch openings is taken into account by introduction of deck opening coefficient without any theoretical background. The hull section is to be an open section and the cross deck is to be treated as a spring resisting the torsion.<br><br>4. The control of the boundary conditions is quite complicated and difficult for torsion, then, the rotation is to be constrained even at the aft end under the load cases of R1, R2, P1 and P2, i.e., Rx is to be fixed at the aft end. This may give a reasonable solution for the cargo hold model apart from the torsion.<br><br>5. The cross deck bending due to torsion is to be examined in oblique sea separately, if necessary. | 1.We will consider the rule change proposal regarding the boundary condition on rotational restriction about x-axis in order to avoid the unreasonable stresses due to unexpected and unreasonable warping of FE model.<br>2. The examination regarding the stress assessment of hatch corner has been carried out by IACS another PT separately. | |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **637 attc** | 7/2.2.1.1 | RCP | The extent of FE Model | 2008/5/12 | Whilst an answer has been given in IACS KC248 to the question for assessment of holds of both ends, the procedure is not clarified but left to the responsibility of each Society.<br>Question ID: 248 Approved: 30/11/06<br>Rule Ref.: Text 7/2.2.1.1 (bulker)<br>Question: Extent of model The extent of FE model is required to be three cargo holds and mid one is the target assessment. In handy bulk carriers, loaded holds(Nos.1 and 5 holds) are not included in the mid part model(Nos.2-4 holds). Please clarify the FE model for handy bulk carriers with 5 cargo holds.<br>Answer: The FEA assessment of cargo holds is restricted to the midship area by the CSR. However, assessment of holds of both ends is left to the responsibility of each Society – this may be an extrapolation schema, a specific FE analysis, a FEA provided by the ship designer,… Furthermore, it should be noticed that this problem is also relevant in the CSR for Oil Tankers.<br><br>However, it is considered necessary to provide a common procedure to decide scantlings subject to Common Structural Rules. Furthermore, the local strength and hull shear strength in way of the foremost and aftermost cargo holds should be assessed by the direct strength analysis using the FE cargo hold models to confirm the structural adequacy and suitability in way.<br>1) Local strength aspect<br>Due to the hull form change, the double bottom shape will become slender toward the fore end of the foremost cargo hold and the aft end of the aftermost cargo hold respectively. Consequently bottom girder/floor arrangements in way will differ from those amidships and transmission of loads on the double bottom to the girders and floors will differ from that amidships. Furthermore, the sectional shape of the hopper tank will become crescent toward the fore and aft ends whilst it is triangular amidships. Application of the outcome of the direct strength<br><br>analysis for the cargo holds amidships is very difficult for such different structural configuration and not relevant. The direct strength analysis should be carried out for the foremost and aftermost cargo holds to assess the load supporting capability of the bottom girders/floors and the transverse webs in the hopper tank.<br>2) Hull shear strength aspect<br>Under alternate loading conditions, very high hull girder shear forces will be induced at the aft transverse bulkhead of the foremost cargo hold and at the fore transverse bulkhead of the aftermost cargo hold and those will be corrected by a factor which is derived taking into account load transmission to the transverse bulkhead through the bottom girders on the assumption that the double bottom shape is rectangular whilst it is not rectangular in way. The hull shear strength is critical at both transverse bulkheads, however, it deeply depends upon accuracy of the factor. To avoid uncertainties in derivation of the factor, the hull shear strength should be assessed by the direct strength analysis. | We appreciate the questioner's effort to provide the disccusion material on this matter.<br>We will ask the Hull Panel to resolve this matter and we will submit this proposal tp the Hull Panel as a support material for discussion. | Y |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **637 attc** | 7/2.2.1.1 | RCP | The extent of FE Model | 2008/5/12 | The procedure of the direct strength analysis is proposed for the foremost and aftermost cargo holds as shown in the attachment which is basically in line with those for the cargo holds amidships.<br>Please specify the procedure for assessment of holds of both ends on the rules and provide the procedure of the direct strength analysis for the foremost and aftermost cargo holds. | (Refer to the former page) | Y |
| **650 attc** | 7/2.3.2.1 | RCP | FE Model | 2008/5/28 | Reference is made to Chapter 7 Section 2 3.2.1<br><br>Quote<br>Where the effects of openings are not considered in the FE model, the reference stresses in way of the openings are to be properly modified with adjusting shear stresses in proportion to the ration of web height and opening height.<br>Unqoute<br><br>There is no clear definition in the rule on how to make this correction. We know this is done differently between different customers. Definitions known to DNV are the "Vertical" and "CSR Tank" procedure as illustrated in attachment.<br><br>Please conclude on a procedure to be used for CSR Bulk and include in Ch. 7 Sec. 2 or in Appendix to Ch. 7 as found appropriate. | We will consider the Rule change considering the proposal. | Y |
| **675** | 7/2.3.2.3 | Question | double bottom girders | 2009/5/27 | 1) Is it suitable to evaluate the equivalent stress of the coarse mesh of a double bottom longitudinal girder (3 elements over the height and loaded with bending), if the element size of the upper and lower element is 1.2 x frame spacing? What is the maximum allowable element size and/or number in relation to the girder height in order to consider the bending stress in the equivalent stress criteria?<br>2) Please confirm that is not necessary to model a dummy truss element at the connection of the double bottom girder to adjacent plating in order to evaluate the bending stress of the girder!<br>3) If a girder is built with a flange instead of connecting two PSM, the axial stress of the flange is to be evaluated and has to be within the design limits (S_axial<=235/R_eH)? | 1. The girders such as the 1/3 of its height are 1.2 time of longitudinal frame spacing should be divided into 4 or more elements height-wise. In general, mesh height of girder is expected less than spacing of longitudinal stiffeners according to Ch.7 Sec.2 2.2.4.<br>2.Such dummy element is not required from CSR requirements.<br>3. The axial stress of the flange should be less than the design limit (235/k). This is the same as the axial stress of flange of trans. rings in bilge hopper tanks and top side tanks should be less than design limit according to Ch.7 Sec.2 3.2.1. | |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **718** | 7/2.3.3 | CI | Change of element thickness & material in EPP buckling check | 2008/7/31 | Chapter7_Sec2_[3.3] Change of element thickness & material in EPP buckling check<br>Regarding the EPP, which consist of elements with different thickness and/or material yielding strength, it would better provide a practicable approach for buckling check based on DSA reults. Currently, there would be three options ,<br>1) The weighted average thickness, along with the minimum material yield strength will be used<br>2) The weighted average thickness, along with the weighted average material yield strength will be used<br>3.1) When the plate thickness changes within the field breadth b, buckling strength may be checked for an equivalent plate field axb' by using the smaller thickness t1, where<br>b' = b1 + b2 * ( t1 / t2) ** 1.5.<br>In this case b1 is the breadth with the smaller thickness t1 and b2 is the breadth with the larger thickness t2 within the total breadth b..<br>3.2) When the plate thickness of an elementary panel varies over the length ""a"", the minimum plate thickness will be used.<br>3.3) Anyway, for elements with different material yield strengths, the minimum material yield strength is generally to be used.<br>Please be kindly request to provide clarification or confirmation. | This issue is still under investigation. An interpretation will be prepared. | |
| **719** | 7/A2 | CI | Displacemen t buckling check based on DSA | 2008/7/31 | Chapter7_Appendix2 Displacement buckling check based on DSA<br>JBP rule provides a displacement method to obtain the reference stress for buckling check of EPP. However, following issues would still need to be clarified,<br><br>1)The conditions, under which the displacements method is to be used compulsively.<br><br>2)Does the displacement method is just optional ? Therefore, we could use stress method only for any EPP buckling check. | A1 The displacement method for evaluating the stresses of panel is not compulsively.<br><br>A2 Yes, the displacement method is optional. | |
| **738** | 7/1.1.2.1 | Question | Strength Assessment of the primary supporting members | 2008/7/2 | In Ch 7, Sec 1, relevant to direct strength assessment of the primary supporting members, the requirement [1.2.1] states that: "Computer programs for FE analysis are to be suitable for the intended analysis. Reliability of unrecognized programs is to be demonstrated to the satisfaction of the Society prior to the commencement of the analysis."<br>The meaning of "unrecognized" programs needs to be clarified. | In this context, a "recognized" program is a FEA program well known and widely used in the shipbuilding industry, which has been proven its reliability. "Recognized " program in this context doesn't mean that such program shoud be recognized by a specific procedure from Class Society or IACS. | |

| KCID No. | Ref. | Type | Topic | Date completed | Question/CI | Answer | Attach ment |
|---|---|---|---|---|---|---|---|
| **822** | 7/3.2.1.1 | Question | ares to be refined | 2009/3/3 | Ch.7 Sec.3 2.1 Areas to be refined : For the end brackets of hatch side coaming and hatch end beam, they are not listed in the Table 1. Thus, could we understand these areas are not required to be refined even if the calculated stresses exceed 95% of the allowable stress as specified in Sec 2,[3.2.3]? We suspect that there should be some technical background for such brackets since the deck plating in way of the most stressed hatch corners is listed in the Table 1. In general, the high stressed elements may be found at the end bracket of hatch side coaming. | Yes, the structural members not listed in Table 1 of Ch 7 Sec 3 are not required to be refined even if the stresses calculated by coarse mesh analysis exceed 95% of the allowable stress. | |
| **846** | 7/2.2 | Question | openings in PSM | 2009/9/28 | Ch.7 Sec.2 [2]<br>Please provide guidelines on how to represent openings in PSM webs in the FE cargo hold model, similar to CSR Tanker rules App. B 2.2.1.15 | The representation of openings in PSM for finite element hold models will be addressed by the harmonisation process. | |
| **892** | 7/3.2.1.1 & Table 7.3.1 | question | corosion deduction | 2009/7/28 | For the current CSR/BC rules and current practice of the class societies, with regard to the fine mesh FEM model of the transverse set of Primary Support Members mentioned in the second figure in 7/3 Tab 1, is the portion of the model representing the single side skin frame to be modeled by deducting 1.0Tc or 0.5Tc? | Regarding the fine mesh FEM model of the transverse set of Primary Support Members mentioned in the second figure in 7/3 Tab 1, the portion of the model representing the single side skin frame to be modeled by deducting 0.5tc. | |
| **919** | 7/4.3.2.2 & 3.3 | Question | Fatigue assessment for welded intersection between bent plate and plane plate | 2010/1/27 | With regard to fatigue assessment for welded intersection between bent plate and plane plate, KC292 said that " the parts indicated in the question are not required to carry out the fatigue assessment".<br>Howerver, CSR in Bulk Carrier says that the correction factor λ at 7.4.3.2.2 and (K2, K3) correction coefficient at 7.4.3.3.3 is considered for bent type. (i.e. bilge hopper to floor)<br>Please clarify the applied spots among structure. relative sentences are to be deleted if intersection for bent type is not required to carry out the fatigue assessment. | Fatigue cracks are found on bilge hopper knuckle part of bend type, accordingly, fatigue strength assessment on bilge hopper knuckle part of bend type should be carried out.<br><br>At the bilge hopper knuckle part of bend type, fatigue crack mainly occurs from weld toe of transverse web welding, and penetrates the knuckled connection between hopper plate and inner bottom plate. Therefore the most important stress in fatigue strength assessment is the longitudinal stress on the knuckled connection between hopper plate and inner bottom plate. It is necessary to assess the stress in fatigue assessment. | |
| **928** | Text 7/1.1.5.1 | question | FEA | 2009/6/26 | According to CH7, Sec1, 1.5.1 the most severe loading regime shall be used in FEA. We noticed during the work in PT3 that several Societies use deck loads according to CH4, Sec5, 2. in FEA. From our point of view the negotiation of deckloads causes a more severe situation, because the upwards directed deformation of the TWT in full load condition is reduced by deck loads. This can be judged comparing the buckling strength of the sloped plate of the TWT with and without deck loads. Another aspect of the definition of deck loads makes the usage in FEA disputable. In hogging and sagging condition and for all drafts are the "dynamic" deck loads the same. We request a clear advise of the application of deck loads in FEA (Yield, buckling and Fatigue check) for different loading conditions and load cases. | This question is now relevant to the harmonisation between CSR BC and CSR OT and will be submitted to the relevant project team. In the meantime, the loads to consider on the deck for FEA calculations are defined in Ch.4 Sec.5 [2]. | |
| **1006 attc** | 7/4.3.2 | Question | Hot spot stress by linear interpolation | 2010/1/18 | Rule Ref.: Text 7/4.3.2 (bulker)<br>How to obtain the hot spot stress by a linear extrapolation method is not specified in the CSR BC. We find that there are several methods, as shown in the attachment. Please confirm which one should be adopted. | The method to obtain hot spot stress by linear interpolation will be considered during the Harmonization process between CSR OT and CSR BC. In the mean time it may be left to the discretion of the individual class society | Y |

KC#291

ClassNK

**Stress Concentration Factor for Knuckle Part**
**(Stool Structure, Bilge Hopper Structure, etc.)**

## 1. Basic SCF

Stress condition around the knuckle part is generally depending on the angle of knuckle part and on the distance from knuckle point. According to the Williams' solution (R.William and Soutas-Little, "Elasticity", Dover publishing, 1998), stress on the plate surface around knuckle part is given by the equation below:

$$\sigma_r = \frac{A'}{r^{\lambda-2}} \tag{1}$$

where $r$ ; Distance from the knuckle point to the evaluated point

$\lambda-2$ ; Parameter which shows the degree of the effect of singular point depending on the angle to the horizontal of sloped plate, $\theta$

$A'$ ; Coefficient

Since the value of $\lambda-2$ is depending on $\theta$, the equation which gives the approximate to a strict solution of $\lambda-2$ was examined. Then the simplified approximate equation is obtained as below. Table 1 shows the comparison between the strict solution and the approximation.

$$\lambda-2 = 0.2 + 0.0028\cdot\theta \tag{2}$$

**Table 1 Comparison between the strict solution and the approximation**

| $\theta$ (deg.) | $\lambda-2$ | $0.2+0.0028\cdot\theta$ |
|---|---|---|
| 90 | 0.4556 | 0.4520 |
| 75 | 0.4261 | 0.4100 |
| 60 | 0.3840 | 0.3680 |
| 45 | 0.3265 | 0.3260 |
| 30 | 0.2480 | 0.2840 |
| 20 | 0.1813 | 0.2560 |

According to the equation (1), the value $\sigma_r$ is asymptotic in a certain value when $r$ becomes around 300mm to 500mm. If an asymptotic value is assumed to be a nominal stress, the stress concentration factor can be defined as below.

$$\sigma_r = \frac{A'}{r^{\lambda-2}} = \frac{A}{r^{\lambda-2}}\cdot\sigma_n = K_0\cdot\sigma_n \qquad \left[ K_0 \equiv \frac{A}{r^{\lambda-2}} \right] \tag{3}$$

When the stress around the knuckle part is evaluated by the FE analysis, coefficient $A$ is expressed as below.

$$A(r) = \frac{\sigma_r}{\sigma_n} r^{\lambda-2} = \frac{\sigma_{FEM(r)}}{\sigma_n} r^{\lambda-2} \tag{4}$$

Although the coefficient $A$ is originally depending on the distance from the knuckle point, the coefficient $A$ is evaluated as the mean value around the knuckle part to generalize the stress concentration factor. In order to evaluate the value of coefficient $A$, FE analyses of stool and bilge hopper structures of bulk carriers and bilge knuckle structures of tankers were made. The obtained results are shown in Fig.1. Since the value of coefficient $A$ shows strong dependency on the angle, the approximated equation of $A$ with the angle is obtained as below.

$$\overline{A} = 0.14\,\theta\cdot(1.15 - 0.0033\,\theta) \tag{5}$$

On the other hand, from an engineering viewpoint, the stress concentration factor is defined as the ratio of the hot spot stress evaluated by the FE analysis to the nominal stress as below.

$$K_0 \equiv \frac{\sigma_{hot\ spot}}{\sigma_n} \tag{6}$$

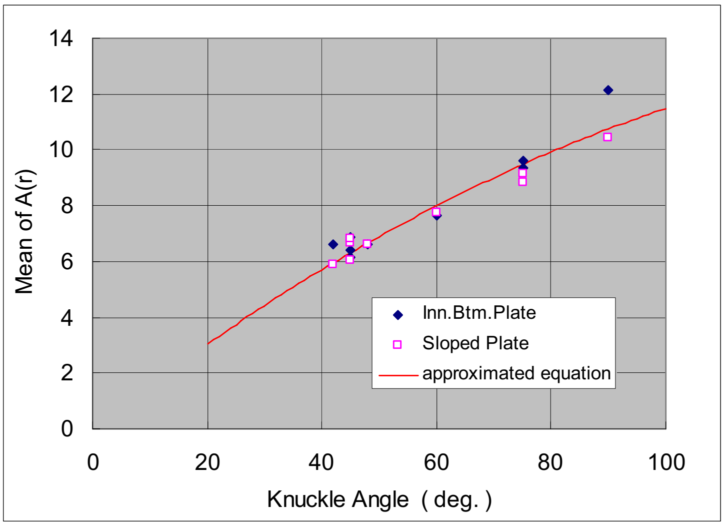



**Fig. 1 Evaluated Value of Coefficient '*A*'**

In general, the hot spot stress is obtained by the linear extrapolation based on the stresses at the points where 0.5t and 1.5t part from the hot spot position. Table 2 shows the evaluated stress at the points 0.5t and 1.5t part from the hot spot position and the extrapolated hot spot stress. According to the results shown in Table 2, the calculated stress according to the approximated equation at a point 0.5t part from the knuckle point is almost same as the extrapolated stress based on the FE analysis.

Therefore, the stress concentration factor for the knuckle part can be defined as the equation below.

$$K_0 \equiv \frac{A}{r^{\lambda-2}} = \frac{0.14\theta \cdot (1.15 - 0.0033\theta)}{(0.5 \cdot t)^{(0.2+0.0028\cdot\theta)}} \qquad [\sigma_{hot} = K_0 \times \sigma_n] \tag{7}$$

**Table 2 Comparison of the hot spot stress**

| $\theta$ (deg.) | *0.5 t* | | *1.5 t* | | hot spot | | (e) / (b) |
|---|---|---|---|---|---|---|---|
| | FEM(a) | formula(b) | FEM(c) | formula(d) | FEM(e) | formula(f) | |
| 45 | 18.6 | 18.9 | 14.3 | 13.2 | 20.8 | 21.8 | 1.10 |
| 45 | 20.6 | 24.7 | 16.8 | 17.6 | 22.5 | 28.2 | 0.91 |
| 45 | 12.4 | 13.4 | 9.5 | 9.4 | 13.9 | 15.4 | 1.03 |
| 45 | 14.4 | 15.2 | 11.9 | 10.6 | 15.7 | 17.5 | 1.03 |
| 60 | 12.0 | 13.8 | 9.1 | 9.2 | 13.5 | 16.1 | 0.97 |
| 60 | 14.6 | 19.3 | 12.2 | 12.9 | 15.8 | 22.5 | 0.82 |
| 75 | 14.0 | 15.4 | 10.3 | 9.8 | 15.9 | 18.2 | 1.03 |
| 75 | 16.8 | 23.2 | 13.4 | 14.8 | 18.5 | 27.4 | 0.80 |
| 75 | 7.9 | 9.1 | 5.8 | 5.8 | 9.0 | 10.8 | 0.98 |
| 75 | 10.2 | 13.6 | 8.3 | 8.7 | 11.2 | 16.1 | 0.82 |
| 90 | 9.7 | 10.1 | 7.0 | 6.2 | 11.1 | 12.1 | 1.09 |
| 90 | 12.1 | 16.5 | 9.4 | 10.0 | 13.5 | 19.8 | 0.82 |
| 45 | 24.2 | 25.7 | 19.9 | 18.0 | 26.4 | 29.6 | 1.03 |
| 45 | 20.7 | 24.2 | 17.8 | 16.9 | 22.2 | 27.9 | 0.92 |
| 48 | 19.6 | 20.9 | 15.4 | 14.5 | 21.7 | 24.1 | 1.04 |
| 48 | 15.9 | 18.0 | 13.9 | 12.5 | 16.9 | 20.8 | 0.94 |
| 42 | 9.9 | 8.0 | 7.5 | 5.6 | 11.1 | 9.2 | 1.39 |
| 42 | 10.7 | 11.7 | 8.8 | 8.3 | 11.7 | 13.4 | 1.00 |

## 2. Correction coefficient for SCF

### 2.1 Influence Factors on Stress Concentration

When the stress concentration factor of an actual structure is evaluated, it is necessary to correct the basic stress concentration factor because this value is the one evaluated based on the solution to two dimensional plane problem. The following correction coefficients will be necessary if the difference between an actual structure and the idealization model, which is the base of $K_0$.

$$K_t = K_0 \times K_1 \times K_2 \times K_3 \times K_4$$

where $K_0$ ; SCF depending on the dimensions of the considered structure (Eqn.(7) & Table 2)

$K_1$ ; Correction factor depending on the plate bending process

$K_2$ ; Correction factor depending on the thickness increment of the web plate

$K_3$ ; Correction factor depending on the insertion of horizontal gusset or longitudinal rib

$K_4$ ; Correction factor depending on the insertion of transverse rib

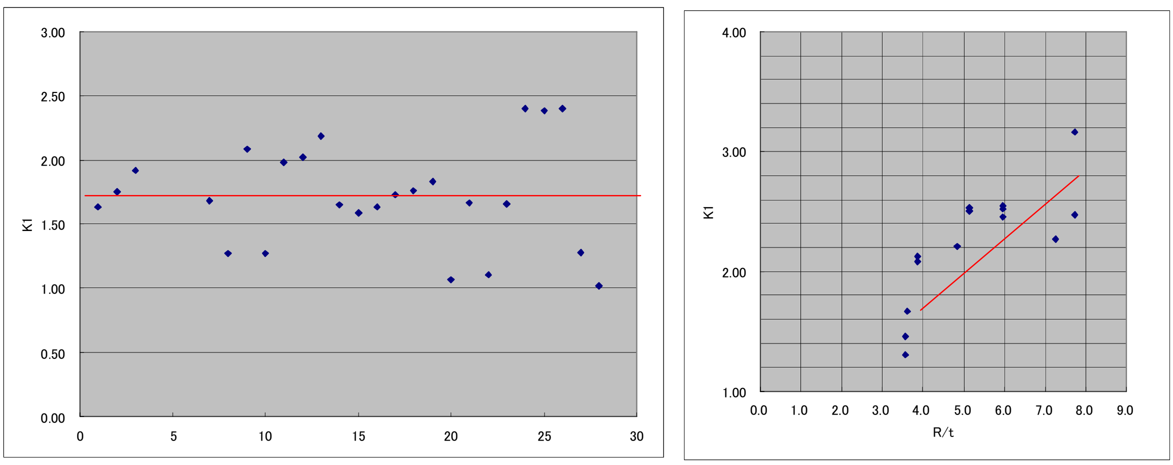
In order to evaluate the above mentioned correction factors, a number of FE analyses were made as shown in Table 3. According to the results of FE analyses, following values were evaluated as the correction factors.

**Table 3 FEM Analyses**

| part of structural | knuckle type | longitudinal rib | transverse rib |
|---|---|---|---|
| VLCC Lower knuckle | R=120 - 800 | none / attached | none / attached |
| | weld type | none / attached | none / attached |
| Bulk Carrier Bilge knuckle | R=60 - 120 | none / attached | none / attached |
| | weld type | none / attached | none / attached |
| VLCC Upper knuckle | R=120 - 800 | none | none |
| | weld type | none | none |

### 2.1 Correction Factor

Figure 2 shows the evaluated value of correction factor $K_1$ according to the FE analyses for weld type structures and bend type structures. The correction factor $K_1$ for weld type structure does not depend on the plate thickness but $K_1$ for bend type structure depends on the radius of bend part and the plate thickness. According to the results, the correction factors $K_1$ for weld type and bend type could be obtained as below:




**(a) weld type** **(b) bend type**

**Fig. 2 Evaluated Value of Correction Factor K1**

$$K_{1,\,weld} = 1.7$$

$$K_{1,\,bend} = \begin{cases} 1.75 & ; \quad R/t < 4 \\ 0.2625 \cdot R/t + 0.7 & ; \quad 4 \le R/t \le 8 \\ 2.80 & ; \quad 8 < R/t \end{cases}$$

The difference of SCF between weld type and bend type is the effect of bending stress due to cross bending occurred in bend type knuckle part. It is noted that the location of hot spot point is different between both structures. If the cross bending is controlled effectively, SCF for bend type becomes almost same as the SCF for weld type. According to the results of FE analyses, $K_3 = 0.9$ was obtained as the average value for weld type, which shows the effect of stress reduction due to the longitudinal rib. And the correction factor $K_3$ was so determined that the $K_1 \times K_3$ for bend type becomes same as one for weld type. Then the correction factors $K_3$ for weld type and bend type could be obtained as below:

$$K_{3,\,weld} = 0.9$$

$$K_{1,\,bend} = \begin{cases} 0.85 & ; \quad R/t < 4 \\ 1.15 - 0.075 \cdot R/t & ; \quad 4 \le R/t \le 8 \\ 0.55 & ; \quad 8 < R/t \end{cases}$$

According to the results of FE analyses, $K_2 = 0.9$ and $K_4 = 0.9$ were obtained as the average values regardless of the difference of knuckle type.

### 3. Summary

The geometrical stress concentration factor for the bilge hopper knuckle is giving by the following equation.

$$K_t = K_0 \times K_1 \times K_2 \times K_3 \times K_4$$

| | | |
|---|---|---|
| $K_0$ | ; | SCF depending on the dimensions of the considered structure |
| $K_1$ | ; | Correction factor depending on the plate bending process |
| $K_2$ | ; | Correction factor depending on the thickness increment of the web plate |
| $K_3$ | ; | Correction factor depending on the insertion of horizontal gusset or longitudinal rib |
| $K_4$ | ; | Correction factor depending on the insertion of transverse rib |

**Table 4 Stress concentration factor $K_0$**

| **Plate thickness (*mm*)** | **Angle of hopper slope plate to the horizontal (*deg.*)** | | | |
|---|---|---|---|---|
| | 40 | 45 | 50 | 90 |
| 16 | 3.0 | 3.2 | 3.4 | 4.2 |
| 18 | 2.9 | 3.1 | 3.3 | 4.0 |
| 20 | 2.8 | 3.0 | 3.2 | 3.8 |
| 22 | 2.7 | 2.9 | 3.1 | 3.6 |
| 24 | 2.6 | 2.8 | 3.0 | 3.5 |
| 26 | 2.6 | 2.7 | 2.9 | 3.4 |
| 28 | 2.5 | 2.7 | 2.8 | 3.3 |
| 30 | 2.4 | 2.6 | 2.7 | 3.2 |

Note: Values for intermediate plate thickness and angle may be interpolated from the values given in the table.

**Table 5 Correction Coefficients**

| **Type of knuckle** | $K_1$ | $K_2$ | $K_3$ | $K_4$ |
|---|---|---|---|---|
| Weld Type | 1.7 | 0.9 | 0.9 | 0.9 |
| Bend Type | 1.75 ; $R/t < 4$<br>2.80 ; $R/t > 8$ | | 0.85 ; $R/t < 4$<br>0.55 ; $R/t > 8$ | |

Notes :

(1) When evaluating $K_1$ and $K_3$ between $4 \le R/t \le 8$ , the linear interpolation is applied
*"R"* denotes the radius of bend part and "*t*" denotes the plate thickness

(2) In using the correction coefficients $K_2$ , the increase in web thickness is taken based on the plate thickness of the inner bottom plating.

(3) In using the correction coefficients $K_3$ and $K_4$ , the members should be arranged such that the bending deformation of the radius part is effectively suppressed.

KC#292



## 3.2 Evaluation of hot spot stress

### 3.2.1

The hot spot stress in a very fine mesh is to be obtained using a linear extrapolation. The stresses located at 0.5 times and 1.5 times the net plate thickness are to be extrapolated at the hot spot location, as described in Fig 3 and Fig.4.

The principal stress at the hot spot location having an angle with the assumed fatigue crack greater than 45° is to be considered as the hot spot stress.

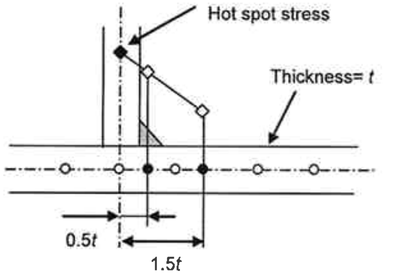



**Figure 3: Definition of hot spot stress at an intersection of two plates**

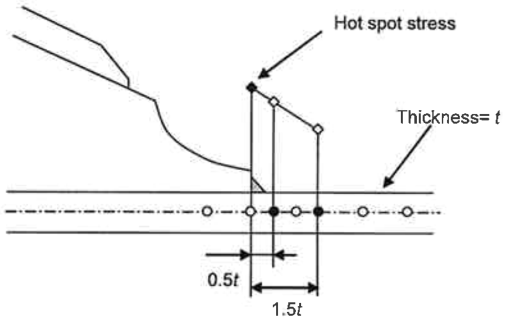



**Figure 4: Definition of hot spot stress at an intersection of plating and bracket**

### 3.2.2

The hot spot stress at the intersection of two plates, as obtained from [3.2.1], is to be multiplied by the correction factor $\lambda$ defined below, considering the difference between the actual hot spot location and assumed location and the difference of stress gradient depending on the angle $\theta$, in deg, between the two plates, to be measured between 0° and 90°.

- welded intersection between plane plates: $\lambda = \begin{cases} 0.8 & : \theta \le 75 \\ 0.8 - \frac{0.2}{15}(\theta - 75) & : 75 < \theta \end{cases}$ —— (1)





- welded intersection between bent plate and plane plate: $\lambda = 0.7$ (i.e. bend type bilge knuckle part) —— (2)

### 3.2.3

The hot spot stress in a non-welded area or along free edge is to be determined by extrapolating the principal stresses of the two adjacent elements, as shown in Fig 5.

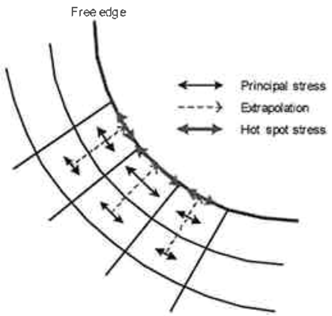



**Figure 5: Definition of the hot spot stress along free edge**

## 3.3 Simplified method for the bilge hopper knuckle part

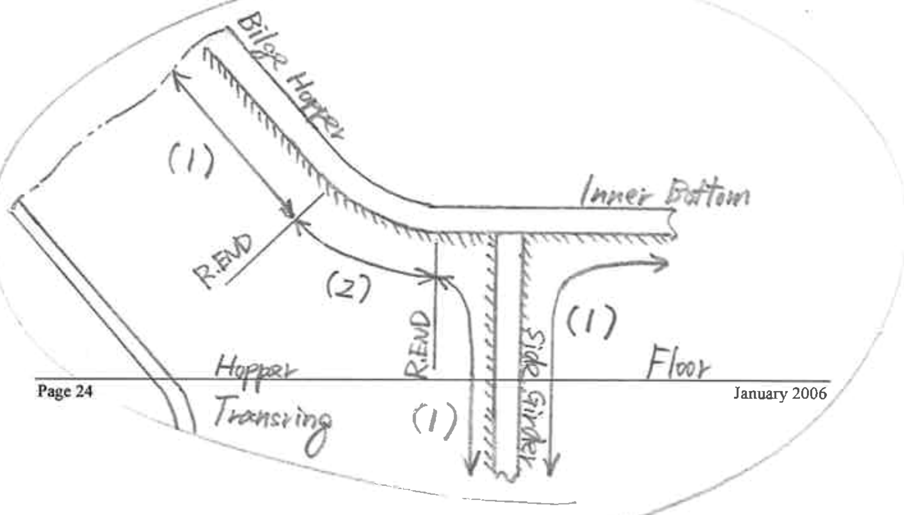
### 3.3.1

At the bilge knuckle part, the hot spot stress $\sigma_{hotspot}$ may be computed by multiplying the nominal stress $\sigma_{nominal}$ with the stress concentration factor $K_{gl}$ defined in [3.3.3].

$$\sigma_{hotspot} = K_{gl}\,\sigma_{nominal}$$

### 3.3.2

The nominal stress at the hot spot location is to be determined by extrapolating the membrane stresses located at 1.5 times and 2.5 times the frame spacing from the hot spot location, as shown in Fig 6.



KC#340

# KC ID #340 Question

**Chapter 7 Direct strength assessment**

**Section 2 Global Strength FE analysis of cargo hold structures.**

According to Ch.7 Sec.2 [3.2.3] "The reference stresses in FE model that does not include orthotropic elements, as specified in [2.2.4] are not to exceed 235/k N/mm2 (..)"

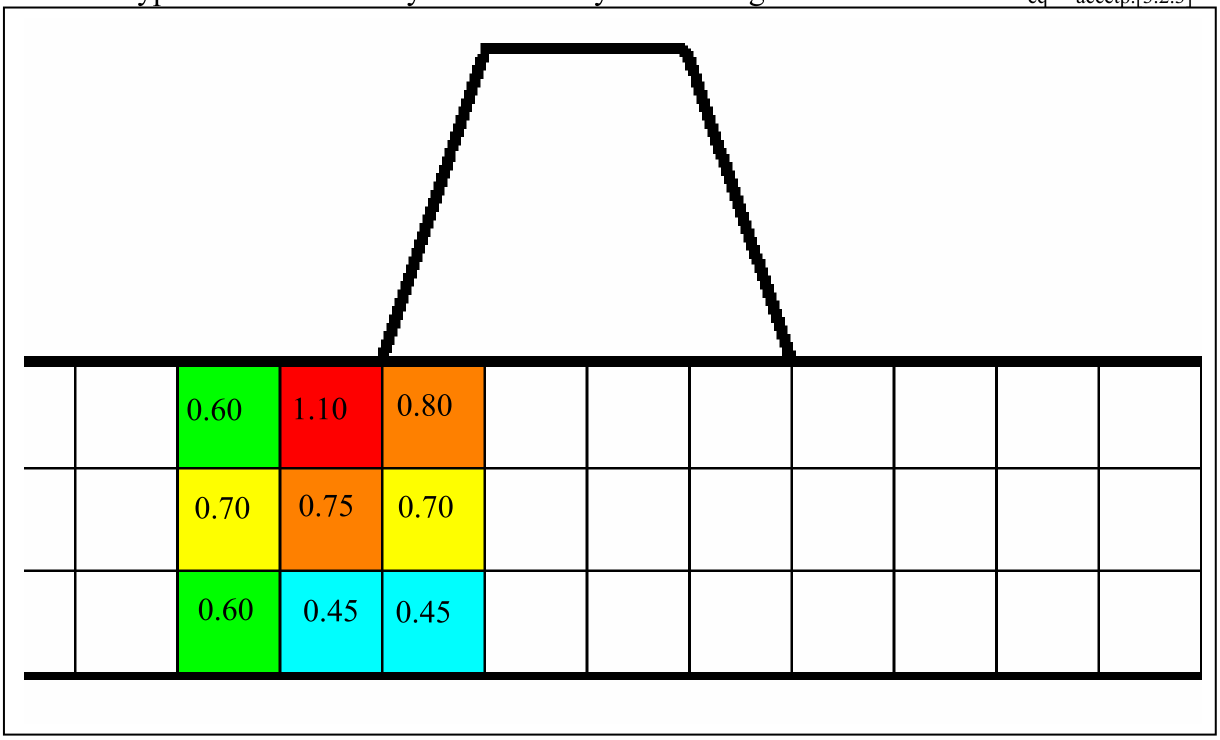
Q1: We assume item [3.2.3] is referring to membrane stress only. That is, local plate bending is neglected. Please confirm.

Q2: We assume the acceptance criteria of Ch. 7 Sec. 2 [3.2.3] is related to an element size of S x S. That is:

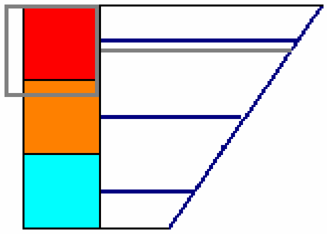
a. all elements with size equal to the representative stiffener spacing S x S (as specified in sec. 2 [2.2.4]) is to be within the limit specified in [3.2.3]
b. smaller elements when averaged over the representative stiffener spacing are to be within the limit specified in 3.2.3

Please advice

Q3: A typical connection of a longitudinal girder to the lower stool is shown in the figure below. A typical utilization for yield in a heavy ballast cargo hold is indicated $\sigma_{eq}/\sigma_{accetp.[3.2.3]}$.

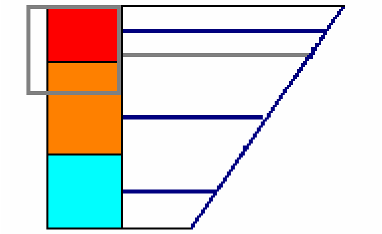


Assuming all 3 elements are equally sized over the height of the double bottom as indicated on the figure. What is the correct application of [3.2.3]?:



a. Each individual element over the height has to be within the requirement of [3.2.3]. That is, the red element has to be reinforced until the utilization is < 1. ?
   or
b. The results may be averaged over a typical stiffener spacing, SxS, in the double bottom as indicated with grey in the below figure. The averaged utilization should be <1?

Assuming the 3 elements are slightly different is size. What is the correct application of [3.2.2]?



c. Each individual element over the height has to be within the requirement of [3.2.3]. That is, the red element has to be reinforced until utilization is < 1.?
   or
d. The results may be averaged over a typical stiffener spacing, SxS, in the double bottom. The averaged utilization should be <1?
   or
e. The results may be averaged based on an element size = $H_{dblBottom}/3$?

KC#341Q

**KC ID# 341 Questions**

Q1: According to Ch.7 Sec.3 [2.1.1] "(..)*the areas listed in Tab 1 are to be refined at the locations whose calculated stresses exceed 95%(..)*"What is the correct interpretation of this item?

a. We assume that only areas covered by Table 1 need to be refined if the utilization according to section 2 (coarse mesh model) is above 95%. Areas not given in table 1 are not subject to refined mesh analysis according to section 3 even if the stress level is above 95%. Please advice.

b. If all areas mentioned in Table 1 have utilization below 95% according to the analysis in section 2 (coarse mesh model), no refined mesh is required. Please advice.

Q2: Example:
A refined mesh analysis is made for one location in table 1 where peak stresses in the global analysis (coarse mesh model) according to section 2 is above 95% of allowable limit.
The refined model will cover an area of the (coarse mesh model) model where stress level according to section 2 (coarse mesh model) range from 80-99% of allowable limits.
In the refined mesh analysis according to chapter 3 the allowable stress levels are above 280/k in a large area. That is, high stressed elements are identified at locations where the global analysis according to section 2 show stresses below 95%. What is the correct application of the CS Rules?

a. Where the stress level according to section 2 (coarse mesh model) is below 95% of acceptable limit no reinforcement will be required by the analysis of section 3.
   or
b. Where stress level according to section 3 is above the acceptable limit of section 3, reinforcements are required. This is regardless of result in coarse mesh analysis in section 2.

Q3: Example: The uppermost element in the web of a double bottom girder at the connection to hopper tank or stool plating has a utilization of 1.1 against yield according to the coarse mesh model of section 2. Ref. situation in Q3 above. The fine mesh model according to section 3 is made of the area and stress levels are found to be within the limits of section 3. What is the correct application of the CS Rules?

a. Coarse mesh analysis according to section 2 has to be satisfied before doing fine mesh analysis according to section 3. Both requirements shall be fulfilled.
   or
b. If the results of the fine mesh analysis of section 3 are within rule limits of section 3, it is acceptable that the coarse mesh analysis according to section 2 is above the limits of section 2.
   or
c. The results may be accepted based on fine mesh analysis if:
   I: The criteria of section 2 [3.2.3] is satisfied for the fine mesh analysis when stresses are averaged over an area, SxS, equal to the representative stiffener spacing.
   and
   II: The criteria of section 3 [3.1.1] is satisfied for the fine mesh analysis.

Please note that alternative c. is in line with the procedure in the CSR for Tankers.

KC#343

| Ch | Sec | Para | Comment |
|---|---|---|---|
| 7 | 2 | 2.3.1 | The required thickness for cross deck shown below is obtained by the buckling analysis of global strength assessment for P'max BC.<br><br>4CH(Ball) 3CH(Ore) 2CH(Emp)<br><br>\| \| 5CH-4CH \| 4CH-3CH \| 3CH-2CH \| 2CH-1CH \|<br>Upper Deck 25.0AH36 23.0AH36 21.0AH36 15.0AH32<br>Cross Deck 16.5AH32 18.0AH32 19.5AH32 22.5AH32<br><br>As a result, it is found that the required thickness for cross deck tends to be thicker than that of upper deck. This phenomenon is more remarkable towards the forward end of the three hold model where the sectional modulus is lesser. In this respect, following reasons are considered.<br>1. The current boundary condition is that the both ends of model are simply supported and Rx at fore end is fixed and Rx at aft end is free which results the model to deform too softly.<br>2. The subjected Load case is Full Load condition and applied design wave is P1, hence torsional moment induces.<br>3. As such, the maximum stress occurs around hatch corners, which may be due to the combination of longitudinal stress due to hull girder bending and twisting under torsional loads, in line with the large local deformation of the elements in the area.<br><br>To obtain the feasible required thickness for cross deck, it is suggested that that Dx for Independent point on aft end of model to be fixed as forward end of the model. |

KC#571

1. Density for fatigue calculation is different between Ch4, App3 and Ch8, Sec4, 2.3.5.
According to Ch8, Sec4, 2.3.5, minimum density is 1.0
According to Ch4, App3, there is no minimum density.

Ch8, Sec4, 2.3.5

$p_{CW,ij(k)}$ : Inertial pressure, in kN/m$^2$, due to dry bulk cargo specified in Ch 4, Sec 6, [1.3], with $f_p$ = 0.5, in load case "*i*1" and "*i*2" for loading condition "(*k*)"

Ch4, Sec6, Table1

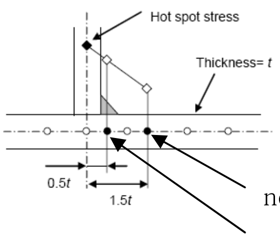
**Table 1: Density of dry bulk cargo**

| Type of loading | Density | |
|---|---|---|
| | BC-A, BC-B | BC-C |
| Cargo hold loaded up to the upper deck | max($M_H/V_H$, 1.0) | 1.0 |
| Cargo hold not loaded up to the upper deck | 3.0 (1) | - |
| (1) Except otherwise specified by the designer. | | |

Ch4, App3, Remarks 1) $M_H$ /$V_H$
MH : The actual cargo mass

2. Is the correction factor of Ch7, Sec4, 3.3.2 to be applied to only the intersection of two plates or both the intersection of tow plates and intersection of plating and bracket?

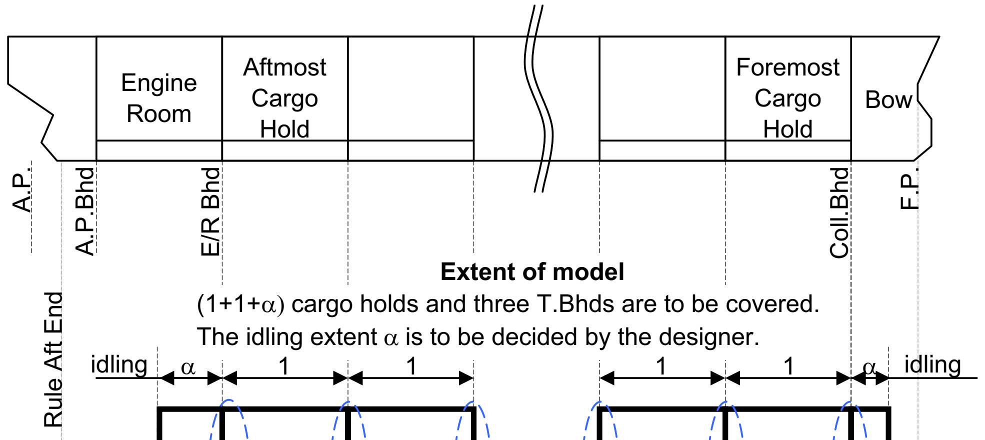
3. If stress of no1 element is slightly greater than no2 element, is the correction factor of Ch7, Sec4, 3.3.2 still to be applied?




no 2 element
no 1 element

KC#637

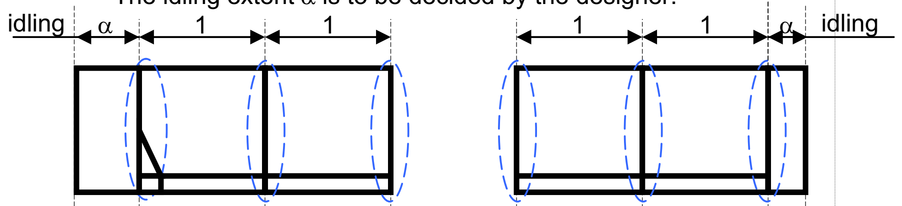
## Procedure of Direct Strength Analysis for Foremost and Aftermost Cargo Holds




### Extent of model

(1+1+α) cargo holds and three T.Bhds are to be covered.

The idling extent α is to be decided by the designer.




### Boundary conditions

Both ends of model are to be simpliy supported according to Tab 1 and Tab 2 in Ch 7 Sec 2.

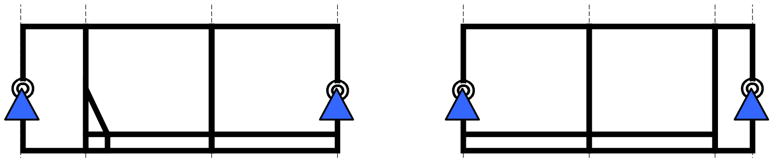


Table 1: Rigid-link of both ends

| 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 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 | **Fix** | - | - |
| Independent point on fore end of model | Fix | Fix | Fix | Fix | - | - |

### Hull Girder loads

Target BM is to be applied at 1/3 cargo hold length in mid-hold.

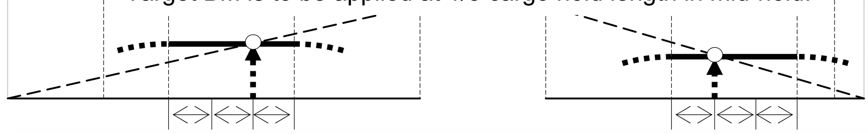


Table 3: Target loads for vertical bending moment analysis

| Hull girder effect | Still water | Wave | Considered Location |
|---|---|---|---|
| Vertical bending moment | $M_{SW}$ | $C_{WV} M_{WV}$ | 1/3 CH length from T.Bhd |
| Vertical shear force | 0 | 0 | 1/3 CH length from T.Bhd |
| Horizontal bending moment | --- | $C_{WH} M_{WH}$ | 1/3 CH length from T.Bhd |
| Horizontal shear force | --- | 0 | 1/3 CH length from T.Bhd |

Table 4: Target loads for vertical shear force analysis

| Hull girder effect | Still water | Wave | Location |
|---|---|---|---|
| Vertical bending moment | $0.8M_{SW}$ | $0.65\ C_{WV} M_{WV}$ | Transverse bulkhead |
| Vertical shear force | $Q_{SW}$ | $Q_{WV}$ | Transverse bulkhead |
| Horizontal bending moment | --- | 0 | Transverse bulkhead |
| Horizontal shear force | --- | 0 | Transverse bulkhead |

# Standard Loading Conditions

**Table 3: Bending moment analysis applicable to loaded hold in alternate condition of BC-A (mid-hold is loaded hold)**

| No. | Description [a] | Draught | Loading Pattern for Aftmost CH | Loading Pattern for Foremost CH | Load Case (Design Wave) / Still water vertical bending moment [b] | | | | Remarks (see below) |
|---|---|---|---|---|---|---|---|---|---|
| 5 | Multi Port -2 ([3.3.2]) | $0.83T_S$ | $M_{full}$ | $M_{full}$ | F2 / $M_{SW,H}$ | P1 / $M_{SW,S}$ | | | 3), 6) |
| 6 | Multi Port -3 ([3.3.3]) | $0.67T_S$ | | $M_{full}$ $M_{full}$ | P1 / $M_{SW,S}$ | | | | 3), 6) |
| 7 | Multi Port -3 ([3.3.3]) | $0.67T_S$ | $M_{full}$ $M_{full}$ | | P1 / $M_{SW,S}$ | | | | 3), 6) |
| 8 | Multi Port -4 ([3.3.4]) | $0.75T_S$ | | $M_{full}$ | F2 / $M_{SW,H}$ | R1 / $M_{SW,H}$ | R1 / $M_{SW,S}$ | P1 / $M_{SW,S}$ | 3), 6) |
| 9 | Multi Port -4 ([3.3.4]) | $0.75T_S$ | $M_{full}$ | | F2 / $M_{SW,H}$ | R1 / $M_{SW,H}$ | R1 / $M_{SW,S}$ | P1 / $M_{SW,S}$ | 3), 6) |
| 10 | Alternate Load ([3.4.2]) | $T_S$ | $M_{HD}$+ $0.1M_H$ | $M_{HD}$+ $0.1M_H$ | F2 / $M_{SW,H}$ | P1 / 0 | | | 2) |
| 15 | Harbour Condition -1 ([3.6.1]) | $0.67T_S$ | $M_{HD}$+ $0.1M_H$ | $M_{HD}$+ $0.1M_H$ | --- / $M_{SW,P,H}$ | --- / $M_{SW,P,S}$ | | | 2), 15) |
| 16 | Harbour Condition -1 ([3.6.1]) | $0.67T_S$ | | $M_{full}$ | --- / $M_{SW,P,H}$ | --- / $M_{SW,P,S}$ | | | 3), 14), 15) |
| 17 | Harbour Condition -1 ([3.6.1]) | $0.67T_S$ | $M_{full}$ | | --- / $M_{SW,P,H}$ | --- / $M_{SW,P,S}$ | | | 3), 14), 15) |
| 18 | Harbour Condition -2 ([3.6.2]) | $0.67T_S$ | | $M_{full}$ $M_{full}$ | --- / $M_{SW,P,H}$ | --- / $M_{SW,P,S}$ | | | 3), 14), 15) |
| 19 | Harbour Condition -2 ([3.6.2]) | $0.67T_S$ | $M_{full}$ $M_{full}$ | | --- / $M_{SW,P,H}$ | --- / $M_{SW,P,S}$ | | | 3), 14), 15) |

**Table 4: Shear force analysis applicable to loaded hold of BC-A (mid-hold is loaded hold)**

| No. | Description | Draught | Loading Pattern for Aftmost CH | Loading Pattern for Foremost CH | Load Case | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 10SF | Alternate Load ([3.4.2]) | $T_S$ | $M_{HD}$+ $0.1M_H$ | $M_{HD}$+ $0.1M_H$ | F2 / $0.8M_{SW,H}$ / $Q_{SW}$ | | | | 2), 7) |

**Table 5: Bending moment analysis applicable to BC-B and BC-C**

| No. | Description [a] | Draught | Loading Pattern for Aftmost CH | Loading Pattern for Foremost CH | Load Case (Design Wave) / Still water vertical bending moment [b] | | | | Remarks (see below) |
|---|---|---|---|---|---|---|---|---|---|
| 5 | Multi Port -2 ([3.3.2]) | $0.83T_S$ | $M_{full}$ | $M_{full}$ | F2 / $M_{SW,H}$ | P1 / $M_{SW,S}$ | | | 4), 7) |
| 6 | Multi Port -3 ([3.3.3]) | $0.67T_S$ | | $M_{full}$ $M_{full}$ | P1 / $M_{SW,S}$ | | | | 4), 7) |
| 7 | Multi Port -3 ([3.3.3]) | $0.67T_S$ | $M_{full}$ $M_{full}$ | | P1 / $M_{SW,S}$ | | | | 4), 7) |
| 8 | Multi Port -4 ([3.3.4]) | $0.75T_S$ | | $M_{full}$ | F2 / $M_{SW,H}$ | R1 / $M_{SW,H}$ | R1 / $M_{SW,S}$ | P1 / $M_{SW,S}$ | 4), 7) |
| 9 | Multi Port -4 ([3.3.4]) | $0.75T_S$ | $M_{full}$ | | F2 / $M_{SW,H}$ | R1 / $M_{SW,H}$ | R1 / $M_{SW,S}$ | P1 / $M_{SW,S}$ | 4), 7) |
| 12 | Harbour Condition -1 ([3.6.1]) | $0.67T_S$ | | $M_{full}$ | --- / $M_{S,P}(+)$ | --- / $M_{S,P}(-)$ | | | 4), 12),13) |
| 13 | Harbour Condition -1 ([3.6.1]) | $0.67T_S$ | $M_{full}$ | | --- / $M_{S,P}(+)$ | --- / $M_{S,P}(-)$ | | | 4), 12), 13) |
| 14 | Harbour Condition -2 ([3.6.2]) | $0.67T_S$ | | $M_{full}$ $M_{full}$ | --- / $M_{S,P}(+)$ | --- / $M_{S,P}(-)$ | | | 4), 12), 13) |
| 15 | Harbour Condition -2 ([3.6.2]) | $0.67T_S$ | $M_{full}$ $M_{full}$ | | --- / $M_{S,P}(+)$ | --- / $M_{S,P}(-)$ | | | 4), 12), 13) |

**Table 6: Shear force analysis applicable to BC-B and BC-C**

| No. | Description [a] | Draught | Loading Pattern Aft Mid Fore | | Load Case (Design Wave) / Still water vertical bending moment [b] / Still water shear force | | | | Remarks (see Table 5 above) |
|---|---|---|---|---|---|---|---|---|---|
| 5SF | Multi Port -2 ([3.3.2]) | $0.83T_S$ | $M_{full}$ | $M_{full}$ | F2 / $0.8M_{SW,H}$ / $Q_{SW}$ | | | | 4), 7), 8) |

KC#650

Procedures to correct for effective web area in way of openings

## CSR Tank procedure



### 2.5 Geometrical Properties of Primary Support Members

#### 2.5.1 Effective shear area of primary support members

2.5.1.1 For calculation of the shear area of primary support members the web height, $h_w$, is to be taken as the moulded height of the primary support member.

2.5.1.2 For single and double skin primary support members, the effective net web area, $A_{w\text{-}net50}$, is to be taken as:

$A_{w\text{-}net50} = 0.01\, h_n\, t_{w\text{-}net50}$ cm²

Where:

$h_n$ for a single skin primary support member, *see Figure* 4.2.16, the effective web height, in mm, is to be taken as the lesser of:

(a) $h_w$

(b) $h_{n3} + h_{n4}$

(c) $h_{n1} + h_{n2} + h_{n4}$

for a double skin primary support member, the same principle is to be adopted in determining the effective web height.

$h_w$ web height of primary support member, in mm

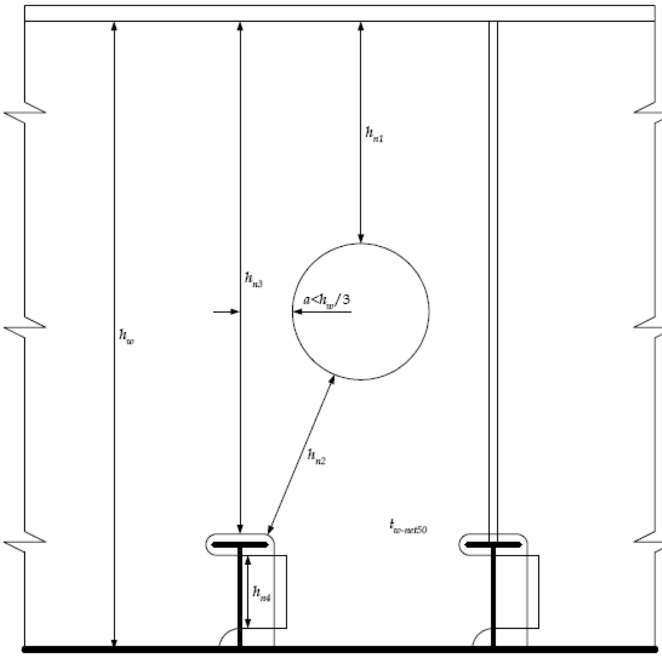
$h_{n1}$, $h_{n2}$, $h_{n3}$, $h_{n4}$ as shown in *Figure 4.2.16*

$t_{w\text{-}net50}$ net web thickness $= t_{w\text{-}grs} - 0.5\, t_{corr}$ mm

$t_{w\text{-}grs}$ gross web thickness, in mm

$t_{corr}$ corrosion addition, as given in *Section 6/3.2*, in mm

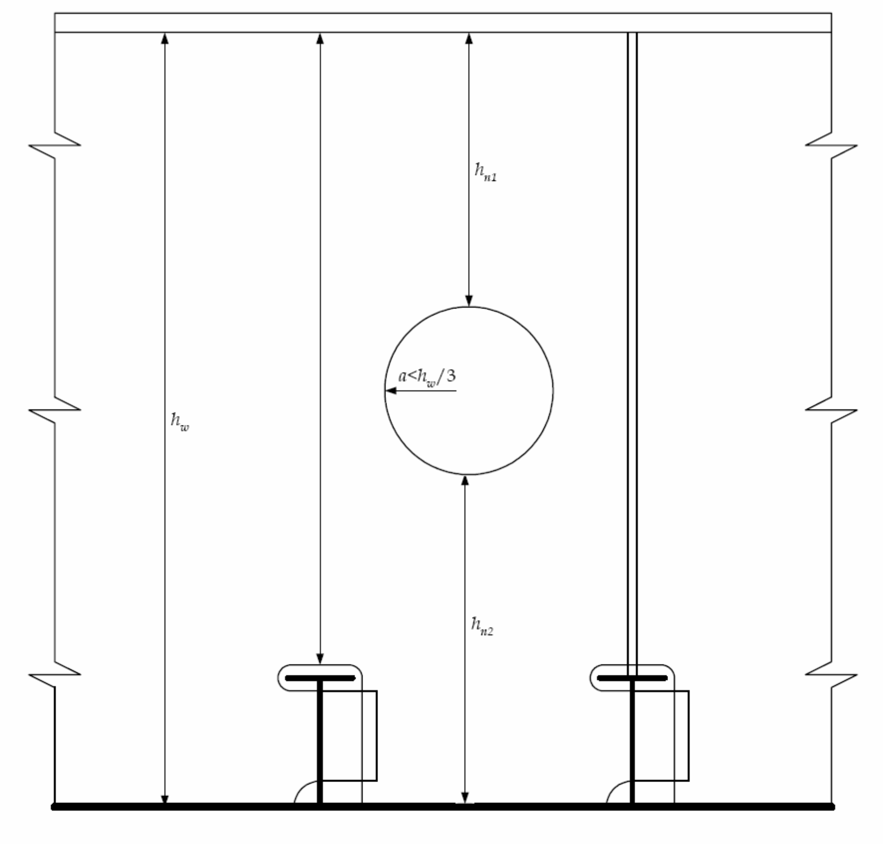
**Figure 4.2.16**
**Effective Web Area in way of Openings**




<u>Note</u>
The figure shows effective web height for a single skin primary support member. The effective web height of a double skin primary support member follows the same principles.

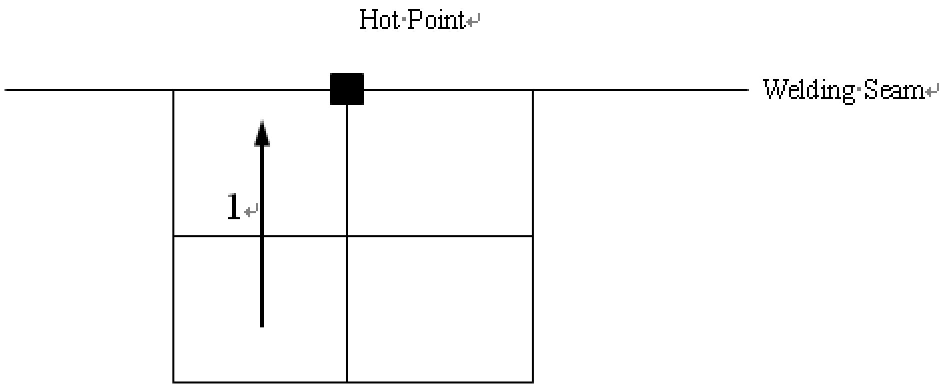
**“Vertical method”**

Shear area is adjusted based on the ratio $h_w/(h_{n1}+h_{n2})$ measured vertically.

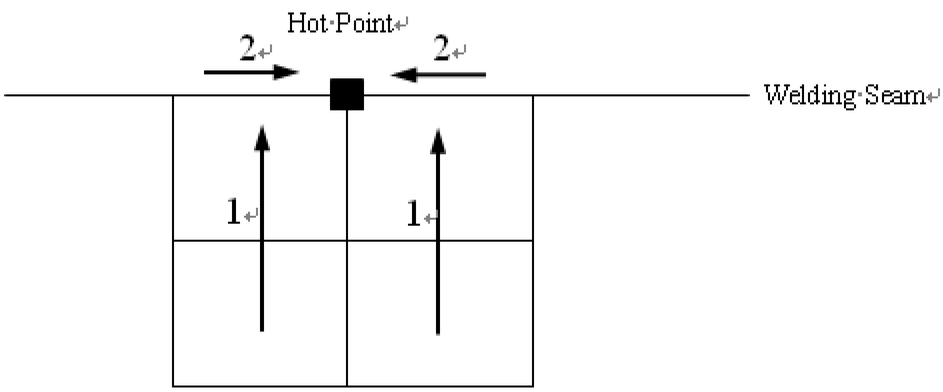


KC#1006

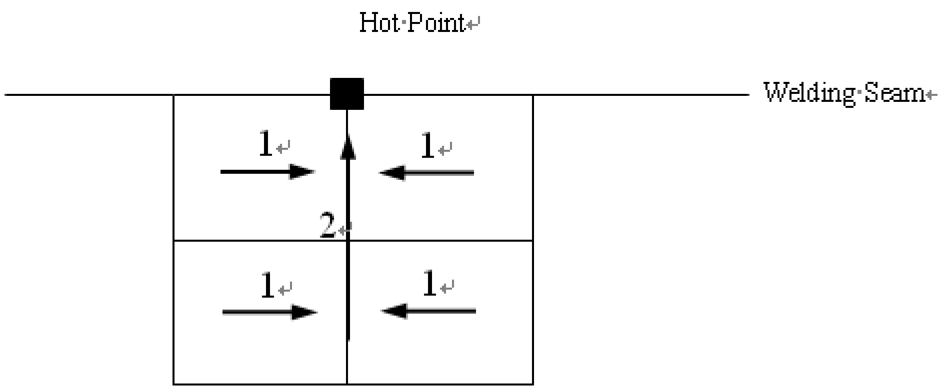
1.


Hot Point
Welding Seam
1

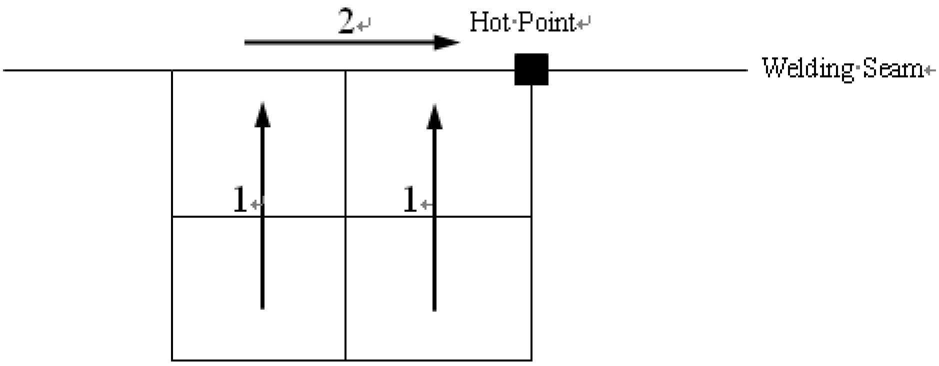
2.


Hot Point
2
2
Welding Seam
1
1

3.


Hot Point
Welding Seam
1
1
2
1
1

4.




5.