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

KCID No.	Ref.	Type	Topic	Date completed	Question/CI	Answer	Attachment
135	App B/2.2.1.12	Question	Sniped stiffeners	2006/9/11	For sniped stiffeners, how to take into account the reduction to 25% in one element? 1. Take 25% of the average area over one element taking account the actual shape of sniped part, or, 2. Calculate the average area for 2dw part (taking account the actual shape of sniped part) and the rest separately. Reduce 2dw part to 25%. Then take the average of 2dw part and the rest. 3. Apply 25% of intact area to 2dw part with ignoring the actual shape of sniped part. Then take the average of 2dw part and the rest. Does this apply for web stiffeners, which do not take hull girder stress?	Recommend modelling as following: If a stiffener sniped in both sides and three or more elements are applied to such stiffener in the model, two end stiffeners can be modelled with cross section area as 25% An-net50 as in Table B.2.1, the rest of elements can be modelled with cross section area as 100 An-net50.	
157	App B/3.1.2.1	Question	Screening criteria for fine mesh analysis	2006/10/23	(1) According to the requirement of 3.1.2.1, the toe of bracket fitted to lower part of transverse in cargo tank is to be evaluated by fine mesh analysis if the screening criteria given in 3.1.6 are not complied with. Where the hull scantlings of such part is increased based on the results of coarse mesh analysis until such part will become to comply with the screening criteria, we confirmed whether the fine mesh analysis of such part is required or not. (2) If the considered structure complies with the screening criteria but stress obtained by fine mesh analysis does not complied with the criteria specified in Table 9.2.3, is scantling of the structural member required to increase?	(1) If the structural members comply with the screening criteria due to an increase of scantlings based on results of coarse mesh analysis, the fine mesh analysis is not required. (2) If user does fine mesh analysis and see the failure, the fine mesh analysis results should be used for scantling or configuration amendments.	
185	Figure B.3.1 & App. B/3.1.2	CI	Rules for bent type lower hopper knuckle.	2007/10/1	According to the current Rules for bent type lower hopper knuckle, where hot spot fatigue analysis is not carried out (provided that the details as indicated in Figure C.2.4 are complied with), no further calculation than global FE is required. However, at least local fine mesh analysis should be carried out in such case to see the stress level.	It is confirmed that no additional (fine mesh) analysis of bent lower hopper knuckle is required unless required in accordance with 9/2.3.1.3.	
239	B/2.3	Question	FEM	2006/11/7	Appendix B, Number of loading conditions of FEMA large number of loading conditions are still used for FEM. The evaluation of the worst condition can be executed by using the function of CSR software with a relatively few efforts. Although identifying loading conditions which do not satisfy strength criteria is necessary to study countermeasures, a large number of loading conditions will make the study difficult. The number of loading conditions should be decreased.	Your comments are noted. At present there are no plans to carry out further work to simplify the FEM procedure, although this may be considered by IACS in the future.	

KCID No.	Ref.	Type	Topic	Date completed	Question/CI	Answer	Attachment
298	B/2.7.2	Question	FEM	2007/2/20	Appendix B.2.7.2 "FEM Stress Assessment" Appendix B.2.7.2.4 defines the shear stress correction. If the model thickness (tmod-net50) is based on t2-net50 described in Table B.2.2, the calculated value of "τ cor" in 2.7.2.4 will be smaller than "τ elem". From the view point of simple shear correction, it seems to be appropriate and acceptable. Please kindly confirm.	1) Unless the criteria of B/2.7.2.5 are satisfied, in general, the shear stress correction as given in B/2.7.2.4 is to be applied where there are small openings not accounted for in the model (e.g. the case of row 1 in Table B.2.2, cut-outs for local stiffeners, scallops, drain and air holes, etc.) 2) If there are no additional small openings not accounted for in the model and the von-Mises stress calculated based on tau_elem (based on t2 without correction by B/2.7.2.4) is satisfactory, then the correction of shear stress by B/2.7.2.4 is not necessary because tau_elem will be more conservative than the shear stress after applying the correction. However, we suggest to apply the shear stress correction even in this case for consistent application. 3) If there are additional small openings not accounted for in the model or if the von-Mises stress based on tau_elem (based on t2 without correction by B/2.7.2.4) is NOT satisfactory, then the correction of shear stress by B/2.7.2.4 is necessary to accurately calculate the actual shear stress.	
574 attc	Text B/2.7.3.7	CI	Buckling assessments for corrugated bulkheads in the cargo tank	2008/3/28	The requirement of the buckling assessments for corrugated bulkheads in the cargo tank FE analysis are particularly given in 10/3.5.2 and B/2.7.3.7. However the rules does not fully adress the detail procedure of the buckling assessment particularly with regard to the location to be taken and the average procedure of the element stresses. Please clarify.	Please see attached file: 2.8 - (CIP) Common Interpretations April 2008	Y
575 attc	7/4, 8/2, App.B & App.C	CI	Tank approval procedure for cargo tanks	2008/3/28	Please clarify CSR tank approval procedure for cargo tanks design for carriage of high density cargo with partial filling and restriction on max filling height.	Please see attached file: 2.9 - (CIP) Common Interpretations April 2008	Y
576 attc	App.B	CI	Procedures of stress assessment and buckling assessments	2008/3/28	Depending on the actual opening and stiffening arrangement, or whether the openings are modelled or not in cargo tank FE or local fine mesh FE model, procedures of stress assessment and buckling assessments could be different. However, the current Rules do not specifically address these different procedures. Please clarify.	Please see attached file: 3.0 - (CIP) Common Interpretations April 2008	Y

KCID No.	Ref.	Type	Topic	Date completed	Question/CI	Answer	Attachment
691	B/2.2.1.15	Question	Openings in Webs of primary support members	2008/4/4	The requirements for representing openings in webs of primary support members in the cargo tank FE analysis are given in Appendix B / 2.2.1.15 with reference to Table B.2.2. Among the four different possibilities, two of them require to use an equivalent thickness plate instead of modelling the geometry of the opening. In spite of this requirement, our experience reveals that some coarse mesh CSR 3 holds are still modelled using one element deletion in way of opening in webs of primary members. Is this practice still acceptable or should we necessarily prohibit it ?	Modelling of opening geometry can be done in lieu of reduced thickness. However if openings are modelled by deletion of elements, the geometry of the opening should be correctly represented. As minimum the opening in the model should enclose the ENTIRE area of the opening in the structure. NOTE: The screening criteria given in Table B.3.1 are not applicable where the opening is modelled and fine mesh FE analysis is to be carried out to determine the stress level. Screening criteria given in table B.3.1 are only applicable to opening where the modelled thickness in way of the opening is reduced in accordance with Table B.2.2.	
707	Table B.2.4	Question	Emergency Gale ballast condition	2008/6/24	Table B.2.4 load case B7 describe an emergency/gale ballast condition with ballast filled in cargo tanks. - The figure shows full double bottom and side tanks in way of the full cargo tanks. May operational restrictions be applied so that ballast tanks adjacent to ballasted cargo tanks are empty in emergency/gale ballast condition? - load case B7 require strength to be calculated using 100% of SWBM (sag.) which is considered realistic when filling ballast in cargo tanks across. Gale/emergency ballast may also be arranged by unsymmetrical filling of cargo tanks e.g. ballast in Cargo Tank No.2 port and No.4 starboard. Should strength also be calculated with 100% of SWBM for this condition? Are additional strength evaluation needed for unsymmetrical filling?	If ballast tanks adjacent to ballasted cargo tanks are empty in emergency/gale ballast condition, operational restriction is to be added in the loading manual. If the actual loading pattern from the Loading Manual is different to Load Case B7 then the actual is to be used (see Table B.2.4, Note 7). 100% of the SWBM is to be applied when analyzing heavy weather ballast conditions with ballast in cargo tanks including the case with unsymmetrical filling. Additional strength assessment needed for unsymmetrical filling will be evaluated by the individual class societies.	
715	Table B.3.1	RCP	Screening criteria for opening in PSM	2008/6/19	In the screening criteria for openings in PSM, shear stress is to be adjusted according to Note 2 of App.B/Table B.3.1. In order to get the adjusted shear stress, I think that the shear stress is to be adjusted by "t_actual (in FE model according to Table B.2.2)/Actual net thickness (scantling in the drawing deduct the corrosion)".	Note 3 of Table B.3.1 is intended to clarify the point that the criteria given in the table is only valid if the finite element model is according with the Rules, This includes the reduction of area in way of opening is according to Table B.2.2. In another word, if the modelled thickness of the web in way of the opening is NOT reduced in accordance with Table B.2.2, then the criteria cannot be used. To make this clear, we suggest rewriting Notes 1 and 2 as follows. Note 3 remains unchanged. 1. Screening criteria given in this table are only applicable to opening where the modelled thickness of the web in way of the opening is reduced in accordance with Table B.2.2. The element shear stress is to be adjusted using the formula given in B.2.7.2.4 prior to the evaluation of yield utilisation factor for verification against the screening criteria. 2. Where the geometry of the opening is required to be modelled in accordance with Table B.2.2, fine mesh FE analysis is to be carried out to determine the stress level. The screening criteria given in this table are not applicable.	

KCID No.	Ref.	Type	Topic	Date completed	Question/CI	Answer	Attachment
792 attc	Text B/3.1.4.2 & Figure B.3.3	Question	fine mesh analysis	2008/8/29	Appendix B/ 3.1.4.2 specifies that fine mesh analysis is required only for adjoining parts where deck or double bottom longitudinals are connected to transverse bulkhead stiffeners. However, Fig, B.3.3 shows that those areas requiring fine mesh analysis include the first floors next to transverse bulkhead as well as their adjoining parts. Please kindly clarify whether or not floors next to such adjoining parts (see sketch(C)) are also required to be evaluated by fine mesh analysis.	The assessment is only required for the end connections iwo transverse bulkhead and floors next to the transverse bulkhead. See also description of modelling in Appendix B, 3.2.4.	Y
813	Table B.3.1	Question	shear stress connections	2008/8/29	Reference is made to **KC No.715** regarding shear stress corrections for screening criteria. Although the understanding of the questioner is deemed clear and reasonable, the answer given in the KC had caused us further confusion. Please confirm if the following interpretations on this matter are correct. (1)The screening criteria given in Table B.3.1 are applicable to openings in cases where geometry is not required to be represented in the cargo tank FE model. Such criteria are also applicable to web plates whose thickness is not reduced because their openings are too small to reduce the thickness in accordance with Table B.2.2. (h0/h<0.35 and g0<1.2) (2) In cases where thickness is reduced in accordance with Table B.2.2, element shear stress Tau_XY is to be adjusted by multiplying the ratio = tmod_net50 / tw_net50. tmod_net50: reduced web thickness in accordance with Table B2.2. tw_net50 : actual net thickness of web. (Note) The current Note 2 of Table B.3.1 might bring another adjustment by multiplying the ratio = tw_net50 / tmod_net50, which double counts the effect of shear area reduction due to openings and, therefore, should not be applicable.	(1): Yes. The screening criteria is applicable to small openings (h0/h<0.35 and g0<1.2) in the shaded regions, see Figure B.3.1. Fine mesh analysis or evaluation based on screening criteria given in Appendix B/3.1.6 is not required for openings in un-shaded regions if, h0/h < 0.46 and g0 < 1.2, and each end of the opening forms a semi circle arc (i.e. radius of opening equal to b/2). Item (2): See Appendix B/2.7.2.4. Your note: Current Note 2 is proposed re-written in line with KC ID 715.	
898 attc	Table B/2.2	Question	opening geometry	2009/4/29	As per KC ID 691, modelling of opening geometry can be done in lieu of reduced thickness. For buckling assessment of the panel close to the opening as shown on attachment, 'modelling of opening geometry' (considered to simulate more exactly) can be applied in line of the buckling assessment of the 'reduced thickness method'?	1) According to Common Interpretation CI-T3, the geometry of an opening can be included in the cargo tank FE model in lieu of the mean thickness described in App. B/Table B.2.2. Therefore, when an opening in the cargo tank FE model is not large (e.g., h0/h<0.5), it is possible to choose one of two different ways for the representation of the opening. The first one is to apply the mean thickness and the other is to include the geometry of the opening. As a result, two kinds of FE models are available. 2) In order to carry out stress and buckling assessment in Figure PR1 of CI-T3, in general only one of such two FE models would be selected and applied. Furthermore, it is also possible to use both of the FE models, for example one could be applied to stress assessment and the other to buckling assessment, with the provision that all the process of structural assessment are in accordance with the Rule and CI-T3.	Y

KCID No.	Ref.	Type	Topic	Date completed	Question/CI	Answer	Attachment
905	B/2.7.1.1 & Fig B.2.14	Question	cargo tank FE model	2009/4/6	As per the App. B/2.7.1.1, verification of result against acceptance criteria is to be carried out for structural members within longitudinal extent shown in Figure B.2.14, which includes the middle tanks of the three cargo tanks FE model and the region forward and aft of the middle tanks up to the extent of the transverse bulkhead stringer and buttress structure. For the strength assessment of tanks in the midship cargo region, stress level and buckling capability of longitudinal hull girder structural members, primary supporting structural members and transverse bulkheads are to be verified. The Figure B.2.14 explicitly describes the longitudinal extent of FE calculation verification; however, for the transverse members, the extent of FE calculation verification is not clear. Shall the bottom floor structures, as primary supporting structural members, of 1st floor after TBHD and 1st and 2nd floors forward TBHD, which have very little influence of the transverse bulkhead stringer and buttress structure, be verified as well? In some FE Load Cases of loading pattern A5 with Dynamic load case 5a, the bottom floor structures, of 1st floor after TBHD and 1st and 2nd floors forward TBHD, shows higher stress level than those between two mid TBHDs, which is considered to be not a target of this kind of three cargo tank FE analysis.	All elements in the shaded area in Figure B.2.14 are to be assessed.	
953 attc	B/2.5.1.2, B/2.5.3.2	CI	vertical shear force	2009/10/23	Appendix B, 2.5, 2.5.1.2 and 2.5.3.2. In calculating the vertical shear force distribution from the local loads applied to the FE model, it is noted that there is a step in the vertical shear force at a transverse bulkhead position due to the weight of the transverse bulkhead structure. It is not clear which shear force value (i.e. maximum or minimum) should be used as a basis to determine the adjustment required to meet the target value.	The vertical distribution loads are to be applied to produce the required shear force (Qtarg) at both the forward and aft bulkheads of the middle tank of the FE model. It is to be noted that the required adjustment shear forces (ΔQfwd and ΔQaft) are the same at the forward and aft bulkheads if the FE model is symmetrical about mid-position of the middle tank, i.e. fore and aft tanks of the FE model is the same length and arrangement. The adjustment shear forces (ΔQfwd and ΔQaft) should be based on the maximum (absolute) shear force due to local loads at the bulkhead location. The reasons for this choice are as follows: (1)The shear force after adjustment will not exceed the required value. If the minimum (absolute) shear force due to local loads is used as a basis for deriving the adjustment shear force then the final shear force will exceed the required value at certain locations. (2)The areas with high shear stress are the elements located forward and aft of the transverse bulkheads. Among these areas, the area forward of the transverse bulkhead in way of the transverse bulkhead stringers has highest shear stress. (3)The intention is that (a) sagging case (+ve shear force at forward bulkhead) covers the forward region of the forward bulkhead and aft region of the aft bulkhead and (b) hogging case (-ve shear force at forward bulkhead) covers the forward region of the aft bulkhead and aft region of the forward bulkhead. The scantlings in way of the bulkheads are to be based on the maximum from both bulkhead positions. See attached Figures.	Y

KCID No.	Ref.	Type	Topic	Date completed	Question/CI	Answer	Attachment
960	B/2.7.1.1 & Fig B.2.14	Question	strength assessment of middle tanks	2009/10/23	With reference to KC ID 905: As per answer of KC905, all elements in the shaded area in Figure B.2.14 are to be assessed. With regard to this answer, we understand that it is appropriate to assess the structural members of middle tanks including the region forward and aft of such middle tanks up to the extent of the transverse stringers and buttress structures. However, in cases where the strength assessment of tanks, including bottom floor structures in the shaded area, is carried out according to this answer, the transverse members (i.e. 1st floor after TBHD and 1st and 2nd floor forward TBHD) located outside either side of the middle tank of three FE model cargo tanks shows higher stress levels than the transverse members of the middle tank that is located between the two TBHDs in Loading pattern A5_5a, as the original questioner pointed out. Please confirm whether the above result is correct in reference to the calculation result obtained during CSR development.	The draught for loading pattern A5/5a is based on investigation of loading manuals of actual ships. The Rules/Table B.2.3 Note 7 allows the user to use a different draught if it is available from the actual loading manual.	
1013	Table B.3.3	RCP	Yield utilisation factor for heels of transverse bulkhead horizontal stringers	2010/2/12	CSR-T App.B Table B.3.3 specifies the fine mesh analysis screening criteria for heels of transverse bulkhead horizontal stringers. According to the formulae in this table, the λy for heels at longitudinal bulkhead horizontal stringer is obtained by multiplying the axial stress σx in element x direction by a stress concentration factor and the λy for heels at side horizontal girder and transverse bulkhead horizontal stringer is obtained by multiplying the Von Mises stress σvm by a stress concentration factor. However, since σx and σvm determined by FEA represent sums of local stress and hull girder stress, the screening results for the fine mesh elements, which are far from neutral axis and hull girder stress is high, are likely to be severe. For example, even though the local stress of the horizontal girder in way of neutral axis is higher than that in way of upper deck, the screening result for horizontal girder in way of upper deck is more severe than that in way of neutral axis due to the hull girder stress included in σx and σvm. We consider that the stress concentration factor is to be applied taking into account the local stress only. Please confirm above interpretation and reconsider the formulae of λy.	The screening criteria were developed based on correlation studies of the stresses obtained from the coarse mesh cargo tank FE analysis and the fine mesh FE analysis. It is to be noted that the screening formulae given are intended to provide a conservative estimation of the localised stress in way of the structural details, based on the stresses obtained from the cargo tank FE analysis, for the purpose of identifying the necessity for carrying out a further fine mesh analysis. These formulae will not necessarily give accurate prediction of the stress level. Localised stress at the heel of side horizontal girder and transverse bulkhead horizontal stringer was found to be proportional to the Von Mises stress of the element in way of the heel in the cargo tank FE model (see screening formula given in Appendix B/Table B.3.3 of the Rules). A stress concentration factor of 3.0 was derived from correlation between stress result from cargo tank and fine mesh analysis. Localised stress at the heel of longitudinal bulkhead horizontal stringer and transverse bulkhead horizontal stringer was found to be proportional to the longitudinal axial stress of the element in way of the heel in the cargo tank FE model (see screening formula given in Appendix B/Table B.3.3 of the Rules). A stress concentration factor of 5.2 was derived from correlation between result from cargo tank and fine mesh analysis. We will therefore keep the Rules as they are currently, but we will retain your comment for future consideration.	

KCID No.	Ref.	Type	Topic	Date completed	Question/CI	Answer	Attachment
1035 attc	B/2.5.3.2,3,4	Question	Vertical hull girder shear force distribution for frames not arranged in same plane	2010/3/22	Appendix B.2.5.3 of CSR OT specifies the procedure to adjust vertical hull girder shear force distribution. However, it might be only applicable to ships with all structural members of each frame arranged in the same vertical plane. For those ships with structural members of a frame not arranged in the same plane (such as the case shown in the attached figure), i.e. the frame structural members in side, hopper tank and those in double bottom are not in the same plane, how to adjust the hull girder shear force?	For the situation described in the attachment it is acceptable to ignore the special frame and reach the target shear force at the frame before the special frame.	Y
1081 attc	Tanker Table B.3.1	Question	Comment on the CI-T3	2010/11/22	With regard to CI-T3, we would like to make comment as attached. Please consider.	The current procedure in CI –T3 is correct since the reduction factor of opening shall be applied both for capacity of panel and also for working shear stress. It means that in Sec 10.3.4.1.1 C_shear (reduction factor in case 6) to be calculated with corrected buckling factor, K=K x r due to opening and average shear stress in the panel should also be corrected due to opening.	Y
1097	Text 9/2.3.1, App.B/3.1, Sec.9/3.3, App.C/2	Question	Fine mesh analysis on hopper knuckle connection	2011/10/5	Upper hopper knuckle connections are required to be evaluated by fine mesh analysis according to Section 9/2.3.1 and Appendix B/3.1. While lower hopper knuckle connections are required to be by very fine mesh fatigue analysis according to Section9/3.3 and Appendix C/2. We consider that structural assessment of upper hopper knuckle connections similar to lower hopper knuckle connections is possible to be carried out by very fine mesh fatigue analysis that is more advanced calculation than fine mesh analysis. Is it acceptable that very fine mesh fatigue analysis for structural assessment of upper hopper knuckle is carried out?	There is currently no procedure (in CSR OT) to carry out a fatigue assessment of the upper hopper knuckle and individual class requirements should be followed.	

CI-T 1 (Mar. 2008)

Buckling assessment of corrugated bulkheads

Rule Section

9/2.2.5	Acceptance Criteria
Table 9.2.2	Maximum Permissible Utilisation Factor against Buckling
10/3.2	Buckling of plates
Table 10.3.1	Buckling Factor and Reduction Factor for Plane Plate Panels
10/3.5.1	Struts, pillars and cross ties
10/3.5.2	Corrugated bulkheads
B/2.7.3.7	Buckling assessment

Description

Procedure and specific instructions for the buckling assessment of corrugated bulkheads in cargo tank FE analysis.

Common Procedure

1. General

In the absence of suitable advanced buckling method, the following two buckling modes are to be assessed on vertically or horizontally corrugated longitudinal or transverse bulkheads in accordance with 9/2.2.5 (Table 9.2.2) and 10/3.5.2:

A. Corrugation flange panel buckling (refer to 9/2.2.5, 10/3.5.2.1, B/2.7.3.7):

Local buckling of flange panel of corrugated bulkheads is to be checked for uni-axial plate buckling using Case 1 in Table 10.3.1 with applying stress ratio $\psi = 1.0$ (i.e. constant applied stress) and the criteria given in 9/2.2.5 (Table 9.2.2).

B. Corrugation overall column buckling (refer to 9/2.2.5 and 10/3.5.2.2):

Corrugated bulkheads subjected to axial compression is to be checked for overall column buckling failure mode in accordance with 10/3.5.1 and the criteria given in 9/2.2.5 (Table 9.2.2).

Application of buckling assessment to corrugated bulkheads:

	Corrugation orientation	
	Horizontal	Vertical
Longitudinal bulkhead	Required	Required, only if subject to localised vertical forces
Transverse bulkhead	Required	

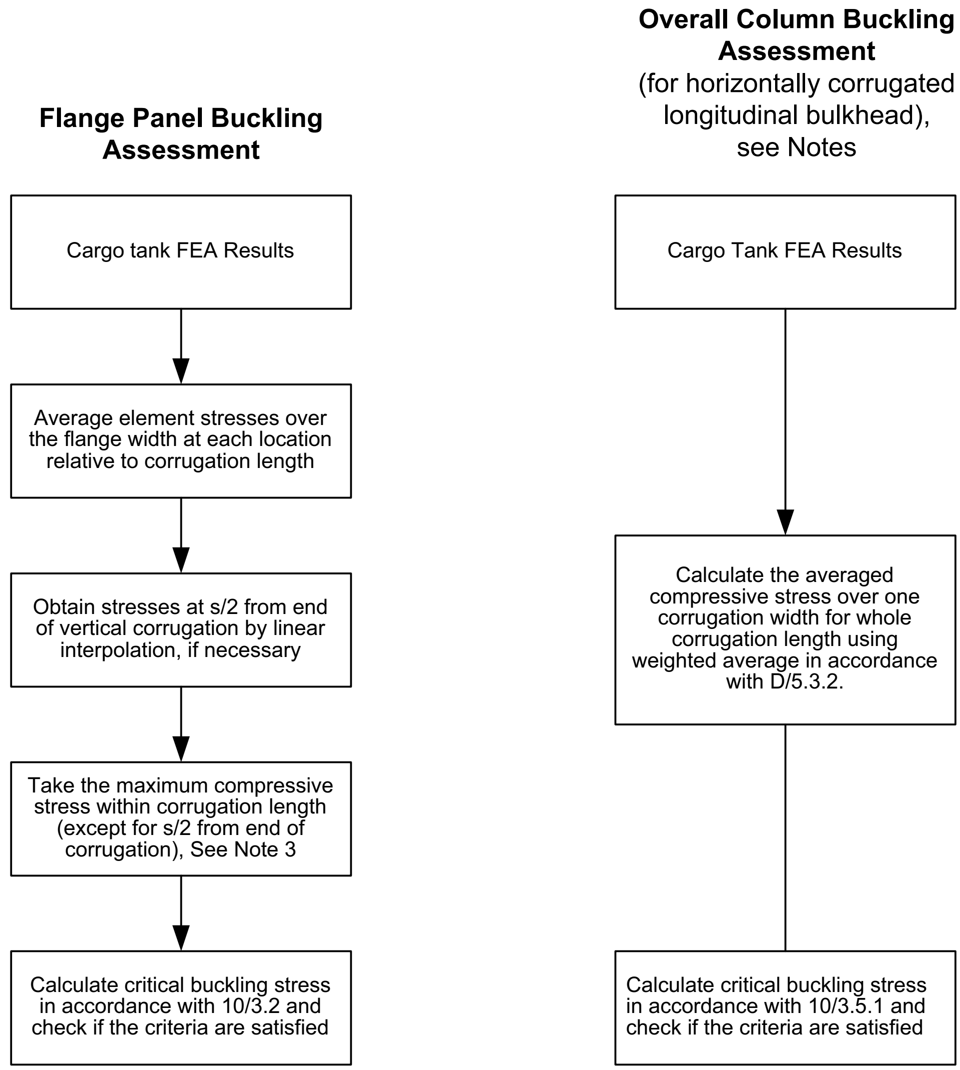
2. Procedure

- Overall procedure of each buckling assessment is indicated in Figure PR1.
- Details of each buckling assessment are summarized in Table PR1.
- Example procedure of averaging and interpolation of element stresses for flange panel buckling on vertically corrugated bulkhead is indicated in Figure PR2.

The buckling assessments are to be done for all corrugation units subjected to compressive forces and for all applicable load cases.

Figure PR1

Flow Chart of Buckling Assessment of Corrugated Bulkheads



Notes:
1. Column buckling assessment is not necessarily required for vertically corrugated bulkheads not subjected to localised vertical forces.
2. For vertically corrugated bulkheads subjected to localised vertical forces (e.g. crane loads), working compressive forces may be obtained by hand calculation and need not be based on FE analysis.
3. Where more than one panel thicknesses are used, each panel thickness is to be checked with the maximum stress within each thickness range.

Table PR1 Summary Details of Buckling Assessments for Corrugated Bulkheads

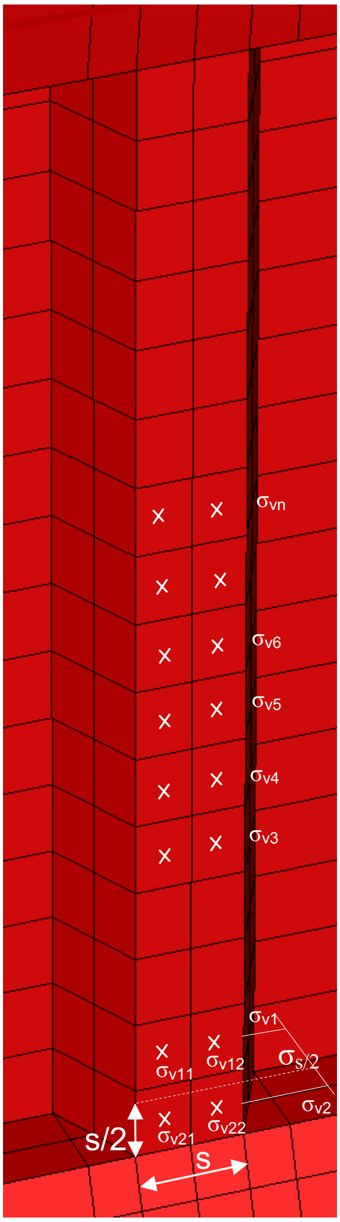
	Failure mode	**Flange Panel Buckling**	**Overall Column Buckling, see Note 1**
1	**Application**	Applicable to all corrugation flanges	See page 1 item B.
2	**Structural model to be assessed**	Each corrugation flange panel. Where more than one plate thicknesses are used for flange panel, maximum stress is to be obtained for each thickness range and to be checked with the buckling criteria for each thickness.	Each corrugation unit (one corrugation space), i.e. half flange + web + half flange
3	**Stress Type**	Membrane stress at element centroid	Membrane stress at element centroid
4	**Direction of stresses**	Stress component parallel to corrugation knuckles Buckling mode for stresses perpendicular to corrugation knuckles is not considered critical, and is not required.	Stress component parallel to corrugation knuckles
5	**Location of stresses to be used**	For corrugation flange inside or at s/2 (s=breadth of the flange) from ends of corrugation, stresses obtained from FE analysis are to be used. For corrugation flange within s/2 from each end of corrugation span, stress can be taken as equal to values at s/2. See Figure PR2	Stresses within one corrugation space: half flange + web + half flange for whole corrugation span (including locations withins/2 from the ends).
6	**Averaging stresses - perpendicular to corrugation knuckles**	Averaging may be done over the flange width. See Figure PR2.	Averaging is to be done over one corrugation space, i.e., half flange + web + half flange for whole corrugation span including for s/2 from the ends (this is a simplification of the process assuming that impact of possible high stresses at ends after the averaging over whole corrugation is negligible) Use weighted average in accordance with D/5.3.2 where element sizes are different and subjected to compressive and tensile stresses.
7	**Averaging stresses - parallel to corrugation knuckles**	Averaging is NOT to be done. See Figure PR2.	

	Failure mode	Flange Panel Buckling	Overall Column Buckling, see Note 1
8	**Final stresses to be used for buckling criteria**	Maximum average compressive stress (average stress calculated as per above 6) except within s/2 from each end of corrugation span (s = breadth of the flange) Where stress at s/2 cannot be obtained directly from a plate element, the stress at s/2 is to be obtained by linear interpolation of centroid stress from neighbour elements. Stress at a location within s/2 is to be taken as the average compressive stress at s/2. Where more than one panel thicknesses are used within a flange panel, maximum stress within each thickness range is to be used.	Averaged compressive stress as per above 6 and 7
9	**Critical buckling stress**	Table 10.3.1, Case 1 with applying stress ratio $\psi = 1.0$ is to be used (uni-axial compression). Where more than one panel thicknesses are used, each panel thickness is to be checked with the maximum stress within each thickness range.	Column buckling in accordance with 10/3.5.1.3 is to be assessed. Torsional buckling as per 10/3.5.1.4 and 10/3.5.1.5 need not be assessed. Effect of bending due to lateral pressure may be ignored. Where web or flange thickness varies along the corrugation length, the section of the least buckling strength is to be used.
10	**Utilisation factors**	Section 9/2.2.5 (Table 9.2.2) "flange buckling", i.e. S+D: 0.9, S: 0.72	Section 9/2.2.5 (Table 9.2.2) "column buckling", i.e. S+D: 0.9, S: 0.72

Note

Working compressive force of localised vertical forces (e.g. crane loads) for overall column buckling assessment of vertically corrugated bulkheads may be obtained by hand calculation and need not be based on FE analysis. For such case, end constraint factor corresponding to pinned end is to be applied except that fixed end may be applied where stool with width exceeding 2 times the depth of corrugation is fitted or where corrugation is directly connected to the inner bottom without lower stool.

Figure PR2
Averaging and Linear Interpolation of Element Stresses for Flange Panel Buckling of Vertically Corrugated Bulkhead



- Averaging element stresses in direction perpendicular to corrugation knuckles is to be done first over the flange width.
- Averaging element stresses in direction parallel to corrugation knuckles is NOT to be done.
- The “interpolation” is to be applied where the stress value at s/2 from lower end cannot be obtained directly from an element.
- After averaging the stresses over the flange width, and after obtaining the stress at s/2 from lower end, the maximum stress is to be used for compliance with the buckling criteria.
- Where more than one plate thicknesses are used for flange panel, maximum stress is to be obtained for each thickness range and to be checked with the buckling criteria for each thickness.

$\sigma_{V11}, \sigma_{V12}, \sigma_{V21}, \sigma_{V22}$: vertical membrane stress evaluated at element centroid;

σ_{V1} : average stress from σ_{V11} and σ_{V12}

σ_{V2} : average stress from σ_{V21} and σ_{V22}

$\sigma_{s/2}$: stress at s/2 obtained by linear interpolation between σ_{V1} and σ_{V2}

$\sigma_{V3}, \sigma_{V4}, \sigma_{V5}, \sigma_{V6}, \ldots , \sigma_{Vn}$: average vertical flange stresses

$\sigma_{final} = \max(\sigma_{s/2}, \sigma_{V3}, \sigma_{V4}, \sigma_{V5}, \sigma_{V6}, \ldots , \sigma_{Vn})$

Implementation date

This CI is effective from 1 April 2008.

Background

The requirements of the buckling assessments for corrugated bulkheads in cargo tank FE analysis are particularly given in 10/3.5.2 and B/2.7.3.7 with the additional explanations in the corresponding background documents. However, the information contained in the rules and the background document does not fully address the detailed procedure of the buckling assessment particularly with regard to the location to be taken and the averaging procedure of the element stresses from the results of the FE analysis for each buckling mode. This procedure is prepared to summarize the procedures and to provide more clarifications of the buckling assessments of corrugated bulkheads.

CI-T 2
(Mar. 2008)

Approval of high density cargo limitation on max filling height

Rule Section

7/4	Sloshing and impact loads
8/2	Cargo Tank Region
App. B	Structural Strength Assessment
App. C	Fatigue Strength Assessment

Description

What calculation procedure applies for approval of high density cargo with restriction on max filling height?

Common Procedure

Filling height of high density liquid cargo, h_{HL}, is not to exceed the following:

$$h_{HL} = h_{tk}\left(\frac{\rho_{appd}}{\rho_{HL}}\right)$$

where,

h_{tk}: tank height
ρ_{appd}: maximum density approved for full filling
ρ_{HL}: density of intended high density cargo

LSM/PSM pres. requirements (Sec.8/2)
no additional checks (assuming ρ_{HL} results in bottom pressures equal to that resulting from density of sea water)

Sloshing(7/4)
- Density of intended high density cargo at maximum filling height and below to be used
- If multiple densities of heavy cargo are intended, it may be necessary to assess sloshing with multiple densities with each corresponding maximum filling height.

Fatigue assessment
Sec.2/3.1.8.2 cargo density of homogeneous fulload condition at full load design draught, T_{full}, minimum 0.9tonnes/m^3.
The cargo density of 0.9 tonnes/m^3 or the cargo density of homogeneous full load design draught, T_{full}, whichever is greater, is to be used. 2. As specified in Section 2/3.1.10.1.(g), higher cargo density for fatigue evaluation for ships intended to carry high density cargo in part load conditions on a regular basis is an owner's extra. Such owner's extra is not covered by the Rules, and need not be considered when evaluating fatigue strength unless specified in the design documentation.

FE assessment
Additional load cases for reduced filling height of a tank are to be based on the standard load cases (full tank) with the density modified as:
$\rho_{appd} = \rho_{HL} \times (h_{HL} / h_{tk})$

Loading Manual
Maximum permissible filling height of high density liquid cargo is to be indicated in the loading manual.

Implementation date

This CI is effective from 1 April 2008.

Background

LSM/PSM pres. requirements (Sec.8/2):
Based on density of sea water, which gives same pressures (within a small margin) as that of reduced filling, hence no additional calculations necessary

Sloshing
HL filling will give increased sloshing pressures, hence need to be checked

Fatigue assessment
Requirement is given in Sec.2/3.1.8.2. Is normally based on cargo density from loading manual, however it is shown that increased density have no effect on fatigue life (dominated by ballast condition below NA) except from uppermost stiffeners in cargo tank, which will not be subject to pressure due to reduced filling.

FE assessment
The principle in CSR is that there are predefined load cases and additional load cases need to be added if the loading manual shows more severe conditions than that assumed in the CSR load cases.

CI-T 3 (Mar. 2008)

Cargo Tank/Local fine mesh FE Analysis Procedure in way of opening

Rule Section

Table 9.2.1	Maximum Permissible Stresses
Table 9.2.2	Maximum Permissible Utilisation Factor Against Buckling
Table 9.2.3	Maximum Permissible Membrane Stresses for Fine Mesh Analysis
10/3.4.1	Buckling of web plate of primary support members in way of openings
Table 10.3.3	Reduction Factors
B/2.2.1.15	Methods representing openings
Table B.2.2	Representation of Openings in Girder Webs
Figure B.2.8	Openings in Web
B/2.7.2.4	Element shear stress correction in way of openings
B/2.7.2.5	Exception for element shear stress correction in way of openings
B/2.7.3.8	Buckling assessment in way of opening
B/3.1.2	Transverse web frame and wash bulkhead
Figure B.3.1	Areas Requiring Consideration for Fine Mesh Analysis on a Typical Transverse Web Frame, Wash Bulkhead and Web Frame adjacent to Transverse Bulkhead
Figure B.3.2	Areas Requiring Consideration for Fine Mesh Analysis on Horizontal Stringer and Transverse Bulkhead to Double Bottom Connections
D/5.4.1.1	Limitations of the advanced buckling assessment method
Table D.5.2	Requirements to structural elements not covered by advanced buckling assessment

Description

Procedure and specific instructions for the panels with openings in modelling, stress assessment and buckling assessment of cargo tank FE and local fine mesh FE analyses.

Common Procedure

A. General

Depending on the actual opening and stiffening arrangement, or whether the openings are modelled or not in cargo tank FE or local fine mesh FE model, procedures of stress assessment and buckling assessments could be different. However, the current Rules do not specifically address these different procedures. This Common Interpretation is intended to outline these different procedures and to provide additional information, particularly on the following aspects:

1. Overall flow of stress and buckling assessments in cargo tank FE and local fine mesh FE analyses (Refer to Figure PR1)
2. Procedure of element shear stress correction for stress and buckling assessments (Refer to Table PR1)
3. Procedure of averaging element shear stress for buckling assessment (Refer to Table PR1)
   Note: Fine mesh analysis screening criteria for openings are not covered in by this Common Interpretation.

B. Notes for element shear stress correction:

1. Element shear stress correction as indicated in B/2.7.2.4, B/2.7.2.5 and Table PR1 are applicable to both stress and buckling assessments.
2. Where minor openings, such as cut-outs for local stiffeners, scallops, drain and air holes, are not included in the cargo tank FE model and local fine mesh FE model, unless exempted by B/2.7.2.5, the element shear stress correction as given in B/2.7.2.4 is to be carried out irrespective of whether the main openings are modelled or not.
3. For application of B/2.7.2.5, all the conditions indicated therein are to be satisfied concurrently.

C. Notes for buckling assessment of the panels with openings:

1. Element shear stress correction is to be carried out in accordance with B/2.7.2.4, B/2.7.2.5 and Table PR1. For axial compression, stress correction is in general not necessary.
2. In accordance with B/2.7.3.8, stresses obtained from either the cargo tank analysis or local fine mesh analysis may be used in the buckling assessment of panels. Buckling assessment is not necessarily required in local fine mesh FE analysis.
3. If openings are not modelled, buckling assessment is to be carried out in accordance with 10/3.4. Advanced buckling assessment cannot be used.
4. If openings are modelled and the opening edges are not stiffened, 10/3.4 should be used for the buckling assessment. Advanced buckling assessment cannot be used. For such case:
   (a) where $d_a/\alpha l_a \leq 0.7$ and $d_b/l_a \leq 0.7$, Case 6 in Table 10.3.1 should be used for shear buckling.
   (b) where $d_a/\alpha l_a > 0.7$ or $d_b/l_a > 0.7$, the reduction factor (r-factor) in Table 10.3.1 for shear buckling is not applicable in principle. In such case, other engineering principles should be used on a case -by-case basis (current CSR do not include specific guidance for such case).
   (c) For buckling assessment against axial compression, Cases 3 and 4 in Table 10.3.1 should be applied.
5. If openings are modelled and the opening edges are stiffened:
   (a) Small openings surrounded by stiffeners outside the opening are to be assessed for buckling using 10/3.4.
   (b) The inside panel with the opening needs not be assessed.
6. Also refer to be following excerpts from "Background document" related to buckling assessment of the panels with openings:

2.2.1.n The intention of introducing the thickness correction procedure in Appendix B/Table B.2.2 of the Rules for modelling web plating in way of an opening is to enable correct representation of the overall stiffness of the three cargo tanks FE model to allow correct load transfer within the structure without modelling of all openings. It is to be noted that the cargo tank analysis is only intended for assessing the overall strength of the structure. Local stresses in way of an opening is in addition assessed using fine mesh finite element analysis, as required by Appendix B/3.1 of the Rules, with accurate modelling of the opening geometry.

2.2.1.o For openings with height, h_o, greater or equal to length, l_o, the deflection across the opening is governed by shear deflection and the thickness correction is proportional to the loss of material in a given cross section.

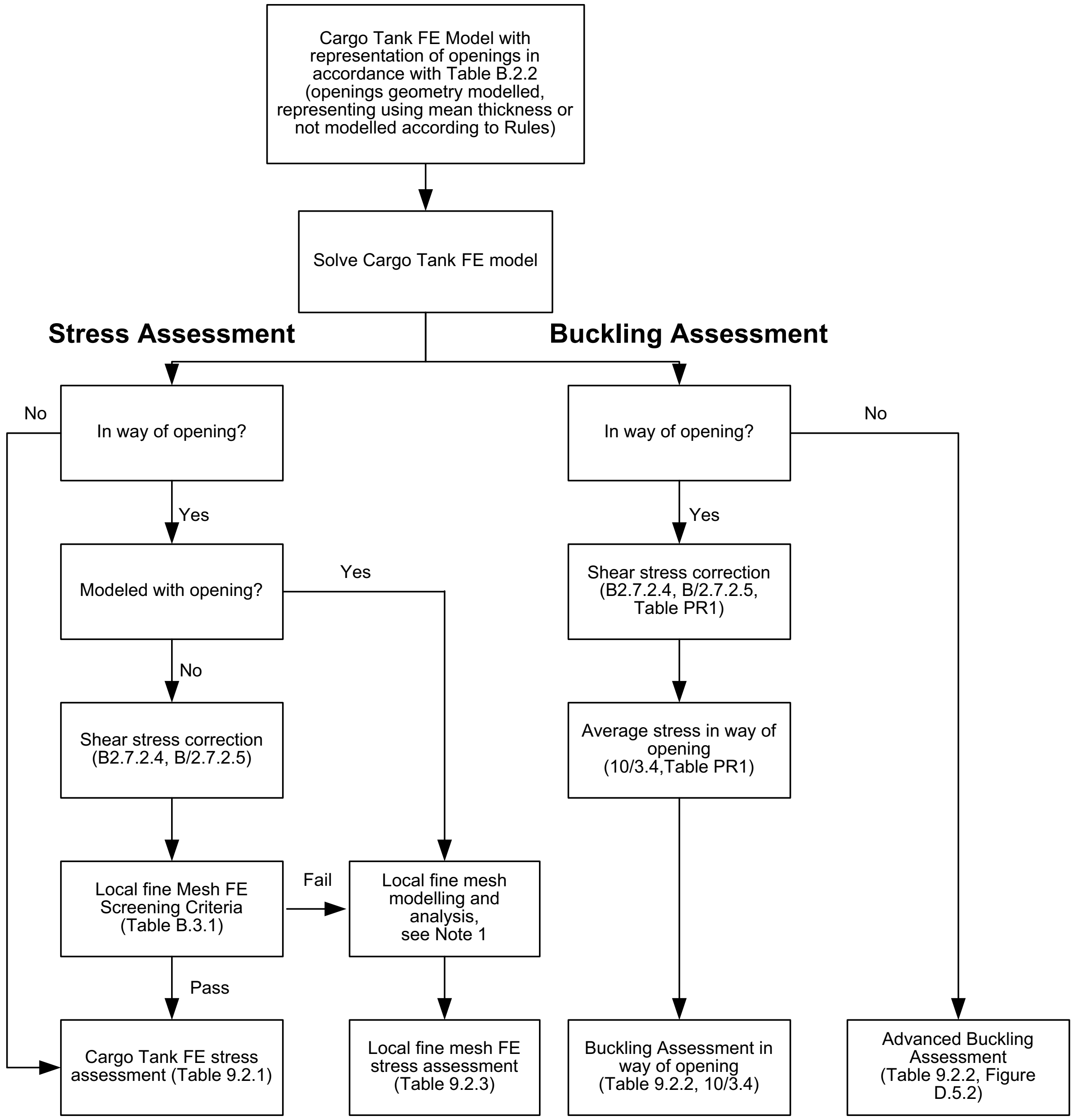
2.2.1.p For longer openings the deflection is a result of combined shear and bending deflection. This effect of bending deflection is taken into account by applying the correction factor, g_o, to the pure shear deflection thickness.

2.2.1.q For large openings, i.e. with $h_o/h \geq 0.5$ or $g_o \geq 2.0$, it is considered necessary to include the geometry of the opening in the cargo tank model in order to obtain an acceptable result, see Appendix B/Table B.2.2 of the Rules for definitions of l_o, h_o and g_o. In this case, fine mesh finite element analysis is mandatory in order to determine the local stress in way of the opening. See B/3.1.6.b.

2.2.1.r In all cases the geometry of an opening can be included in the cargo tank finite element model, even if its size is such that it is acceptable to represent its effect by means of reduced thickness in accordance with Appendix B/Table B.2.2 of the Rules. However, it should be noted that the screening formula, given in Appendix B/3.1.6 of the Rules for determining whether it is necessary to perform a fine mesh analysis of the opening, is only applicable for the cases where the geometry of an opening has not been included in the cargo tank model. If the geometry of an opening is included in the cargo tank model, fine mesh analysis is to be carried out to determine the local stress in way of the opening.

Figure PR1

Flow Chart of Cargo Tank and Local Fine Mesh FE Analyses in way of openings

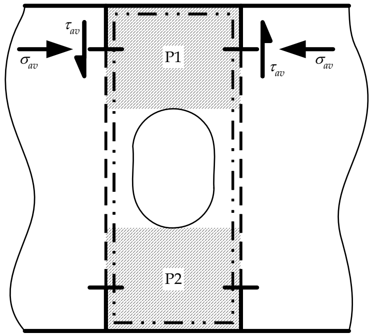
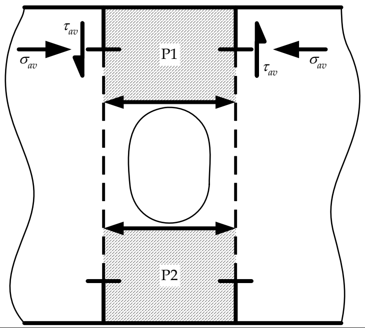


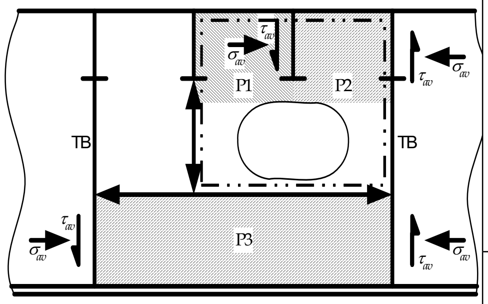
Note:

1. Small openings (e.g. slots for stiffeners, scallops, drain holes, air holes) shall also be included in local fine mesh model to avoid any additional shear correction.

Table PR1

Stress Correction in way of Opening for Buckling Assessment in accordance with Section 10/3.4

Opening Arrangement (These are the same arrangements as Table 10.3.3 for Reduction Factors)	**Major Opening Modelled?**	**Axial Compressive Stress**	**Shear Stress**	
			Shear Stress Correction (B/2.7.2.4, see Note 1)	**Averaging element shear stresses within panel** (calc of working shear stress)
(a) without edge reinforcements 	No	Calculate average stress for each P1 and P2 separately In general, correction of axial compressive stress to account for opening is not necessary.	Shear stress correction, where applicable, is to be done for P1, P2 and in way opening	Average element shear stresses within the area marked with (same area for the reduction factor C_τ in Table 10.3.3.(a)): This includes the elements in way of opening.
	Yes	Same as above	Shear stress correction, where applicable, is to be done for P1, P2 only. Opening part is excluded since there are no elements.	Average element shear stresses within the area marked with (same area for the reduction factor C_τ in Table 10.3.3.(a)): Opening part is excluded since there are no elements.
(b) with edge reinforcements 	No	Same as above	Shear stress correction, where applicable, is to be done for P1, P2 and in way opening	Average element shear stresses within P1 and P2 separately. Opening part needs not be assessed.
	Yes	Same as above	Shear stress correction, where applicable, is to be done for P1, P2 only Opening part is excluded since there are no elements.	Average element shear stress within P1 and P2 separately Opening part needs not be assessed.

(c) example of hole in web 	No	Same as above	Shear stress correction, where applicable, is to be done for P1, P2, P3 and in way opening. For P3, correct only the shear stress of elements in way of cross section at the opening.	For the panel of P1 and P2 with opening, average element shear stress within the area marked with: This includes the elements in way of opening. For P3, average element shear stresses within P3.
	Yes	Same as above	Shear stress correction, where applicable, is to be done for P1, P2, P3 Opening part is excluded since there are no elements. For P3, correct only the shear stress of elements in way of cross section at the opening.	For the panel of P1 and P2 with opening, average element shear stress within the area marked with: Opening part is excluded since there are no elements. For P3, average element shear stresses within P3.
Note: 1. Where modelled shear area and actual shear area are different, including area loss due to minor openings, element shear stresses in way of the cross section of the opening are to be corrected in accordance with B/2.7.2.4.				

Implementation date

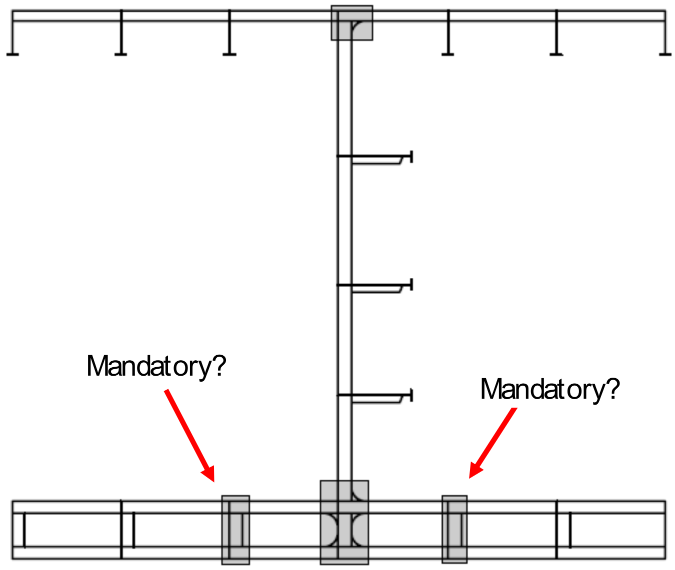
This CI is effective from 1 April 2008.

Background

Depending on the actual opening and stiffening arrangement, or whether the openings are modelled or not in cargo tank FE or local fine mesh FE model, procedures of stress assessment and buckling assessments could be different. However, the current Rules do not specifically address these different procedures. This Common Interpretation has been prepared to provide an outline of these different procedures.

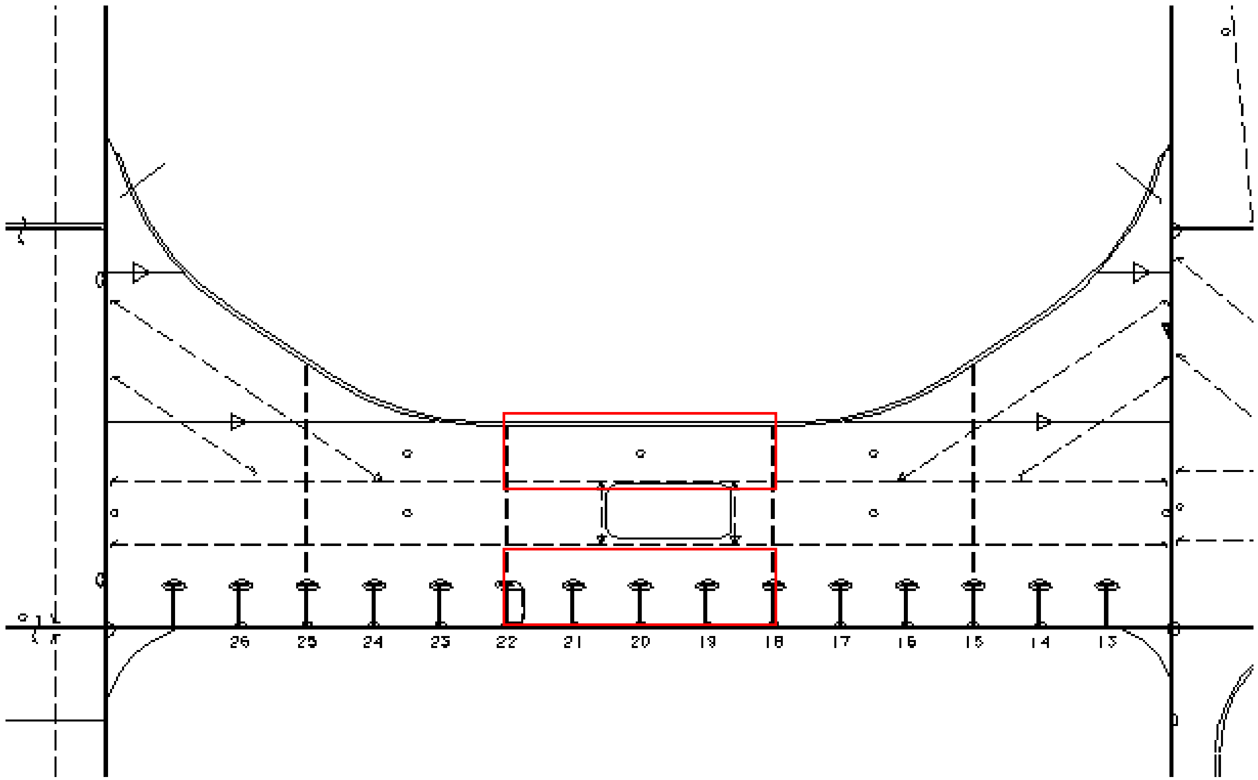
KC#792

Fig. B.3.3 Areas Requiring Fine Mesh Analysis on Deck, Inner and Outer Bottom Longitudinals

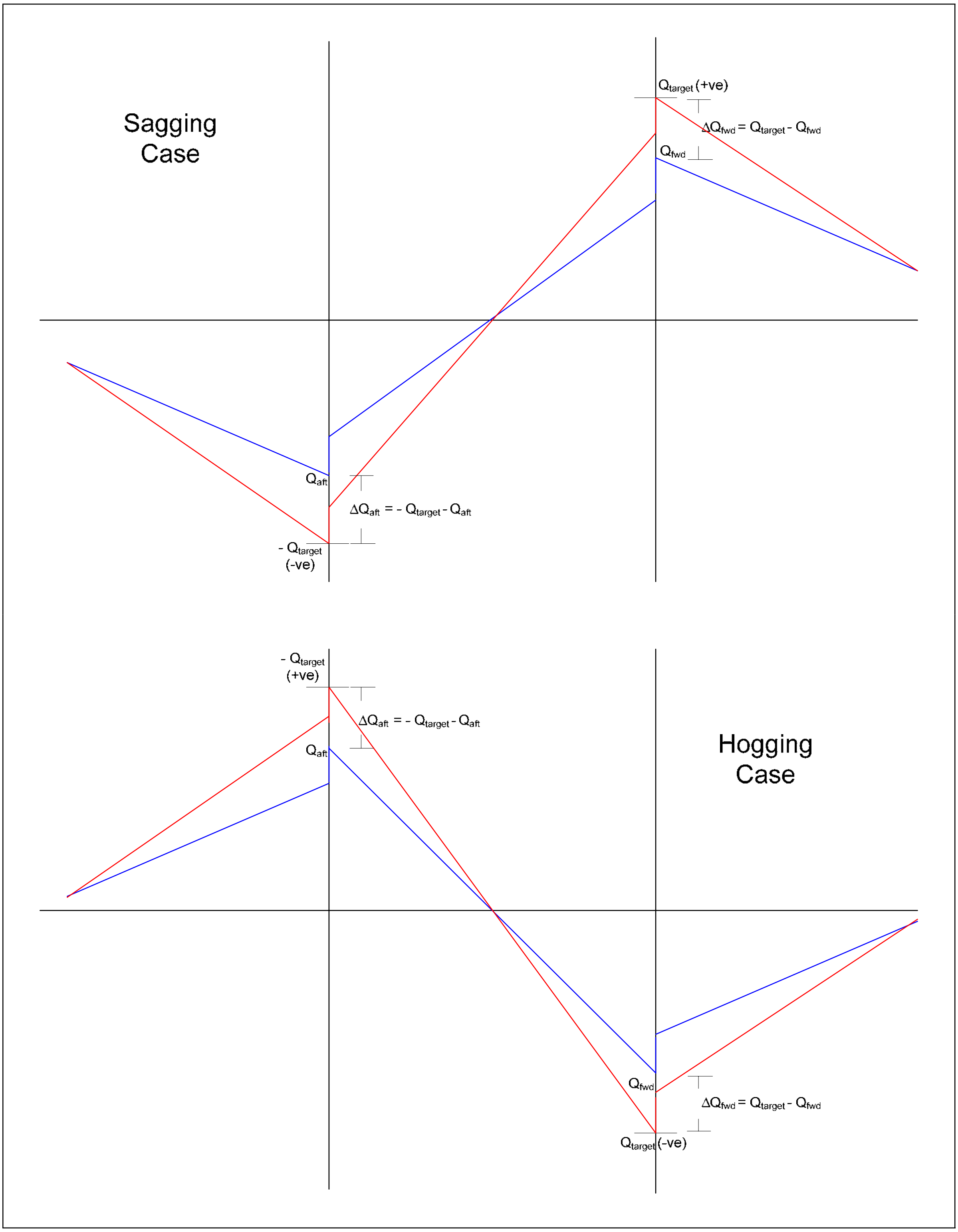


KC#898

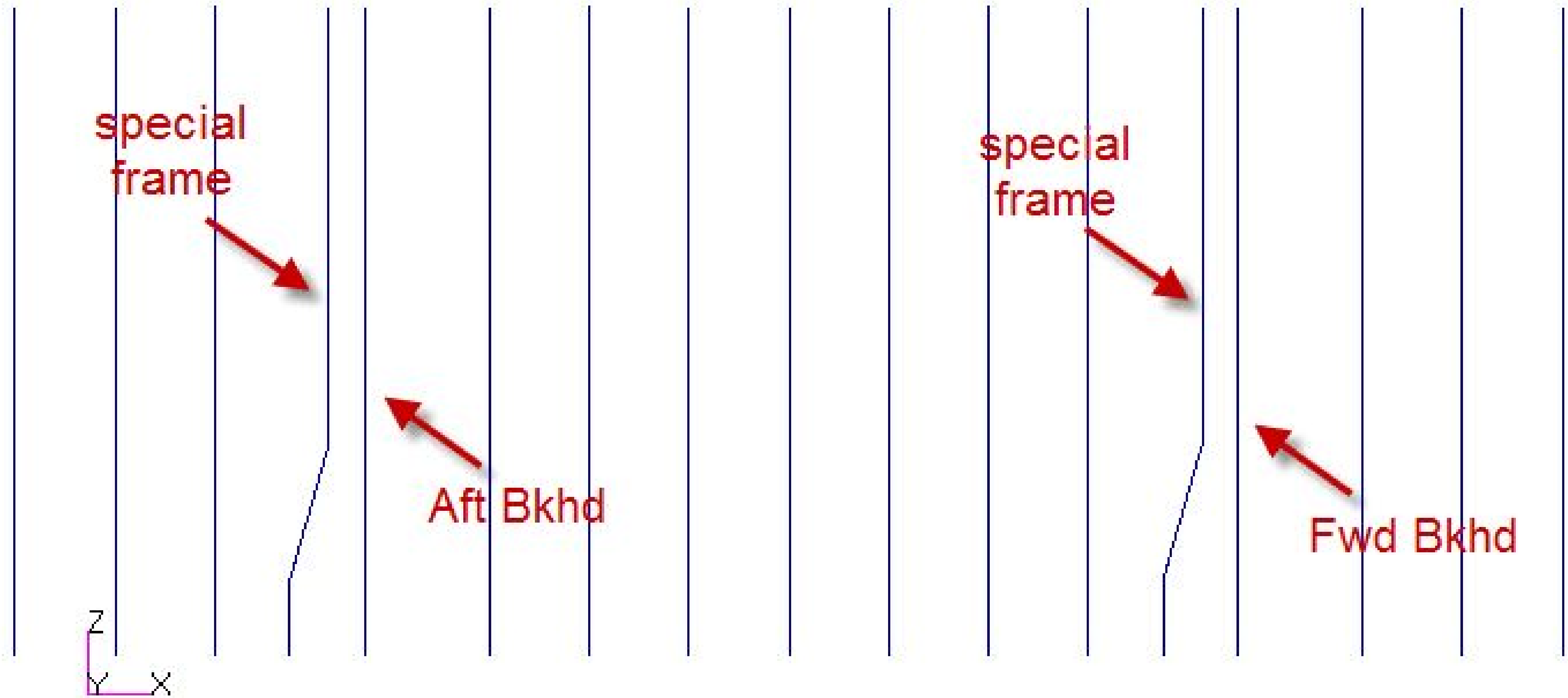
Opening for stringer web plate



KC#953


Sagging Case
Q_{target} (+ve)
$\Delta Q_{fwd} = Q_{target} - Q_{fwd}$
Q_{fwd}
Q_{aft}
$\Delta Q_{aft} = - Q_{target} - Q_{aft}$
$- Q_{target}$ (-ve)
$- Q_{target}$ (+ve)
$\Delta Q_{aft} = - Q_{target} - Q_{aft}$
Q_{aft}
Hogging Case
Q_{fwd}
$\Delta Q_{fwd} = Q_{target} - Q_{fwd}$
Q_{target} (-ve)

KC#1035



KC#1081

1. In CSR for Tankers, the critical shear stress τ_{cr} derived by the following formulas according to Case 6 of Table 10.3.1 takes into account reducing strength due to an effective cross sectional area reduction for shear in addition to the effects of a buckling strength reduction due to an opening.

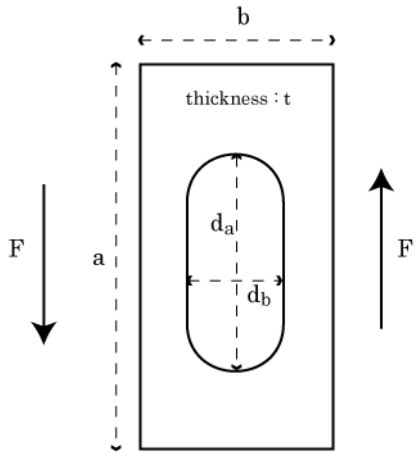
$$\tau_{cr} = C_\tau \frac{\sigma_{yd}}{\sqrt{3}}$$

$$C_\tau = \begin{cases} 1 & \lambda \le 0.84 \\ \dfrac{0.84}{\lambda} & \lambda > 0.84 \end{cases}$$

$$\lambda = \sqrt{\frac{\sigma_{yd}}{K\sigma_E}}$$

$$K = \left[5.34 + \frac{4}{\alpha^2}\right]\left(1 - \frac{d_a}{a}\right)\left(1 - \frac{d_b}{b}\right) \qquad \alpha = \frac{a}{b}$$

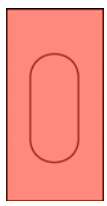
$$\sigma_E = 0.9E\left(\frac{t}{b}\right)^2$$



2. Therefore, if shear force F acts on panels with an opening, a working shear stress τ_{work1} calculated by the following formula should be compared with the critical shear stress τ_{cr}.

$$\tau_{cr} > \tau_{work1}$$

$$\tau_{work1} = \frac{F}{ta}$$

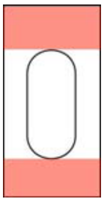


In this case, τ_{work1} is taken as the mean shear stress for the whole panel including the opening (red part).

3. However, in the common interpretation CI-T3, a shear stress correction taking into account the stress increase due to the opening in accordance with Table PR1 is required. This means that if shear force F acts on panels with an opening, the working shear stress τ_{work2} is derived by the following formula and is compared with the critical shear stress τ_{cr} in consideration of an effective cross sectional area reduction due to the opening.

$$\tau_{cr} > \tau_{work2}$$

$$\tau_{work2} = \frac{F}{t(a - d_a)}$$



In this case, τ_{work2} is taken as the mean shear stress for the red part where stress increases due to the opening.

We feel that the effective cross sectional area reduction due to an opening may be considered twice in the assessment procedure according to CI-T3 and this is too strict.

4. Our understanding is that working shear stress should be assessed by the assessment procedure in 2 above.

Please confirm.