UR S21A "Evaluation of Scantlings of Hatch Covers and Hatch Coamings and Closing Arrangements of Cargo Holds of Ships"

Part A. Revision History

Version no.	Approval date	Implementation date when applicable
NEW (May 2011)	23 May 2011	1 July 2012

- **NEW (May 2011)**

.1 Origin for Change:

☑ Other (In order to specify strength criteria for hatch covers on ship types other than bulk carriers, ore carriers and combination carriers, to demonstrate compliance of hatch covers with ILLC 66 Regulation 16)

.2 Main Reasons for Change:

Regulation 16 of the International Load Line Convention (ILLC) 1966 specifies loads on hatch covers that are to be applied to all types of ships. UR S21, Rev. 5 gives strength criteria for hatch covers on bulk carriers, ore carriers and combination carriers as defined in UR Z11. Currently no requirement exists for hatch covers on ship types other than the aforementioned.

This UR is intended to cover that gap by enumerating strength requirements for hatch covers on ship types other than bulk carriers, ore carriers and combination carriers as defined in UR Z11.

.3 List of non-IACS Member classification societies contributing through the TC Forum and/or participating in IACS Working Group:

None

.4 History of Decisions Made:

Action to create task decided at 2nd Hull Panel meeting. Task No. 14 was assigned by the Hull Panel to this undertaking. A dedicated project team was created to execute this task.

Form A was approved by GPG on 5 August 2005. Preliminary versions of the proposed UR and technical background documents were circulated among the Hull Panel members for review.

Final version approved at the 14th Hull Panel meeting in February 2011.

.5 Other Resolutions Changes

None

.6 Dates:

Original proposal: *December 2010 Made by: Hull Panel*
Panel Approval: *February 2011 by: Hull Panel*
GPG Approval: *23 May 2011 (Ref. 11078_IGc)*

Part B. Technical Background

List of Technical Background (TB) documents for UR S21A:

Annex 1. **TB for New (May 2011)**

See separate TB document in Annex 1.

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Technical Background for UR S21A New, May 2011

1. Scope and objectives

To define strength criteria for hatch covers on ship types other than bulk carriers, ore carriers and combination carriers as defined in UR Z11.

2. Engineering background for technical basis and rationale

Reg. 16 of the ICLL 1966 specifies hatch cover loads for all ship types. While a UR (S21) pertaining hatch cover strength exists for bulk carriers, ore carriers and combination carriers, as defined in URZ11, there are no criteria for other ship types. This UR is intended to fill that gap.

3. Source / derivation of the proposed IACS Resolution

The source of the information was obtained through work performed by a dedicated project team and additional input from the Hull Panel.

4. Summary of Changes intended for the revised Resolution:

Not applicable

5. Points of discussions or possible discussions

The UR was developed by the project team (PT) for Task No. 14. Discussions on the draft documents prepared by the PT were reviewed and discussed within the Hull Panel at Panel meetings and via email correspondence.

6. Attachments if any

Detailed technical background document is attached.

Technical Background for UR S21A

Evaluation of Scantlings of Hatch Covers and Hatch Coamings and Closing Arrangements of Cargo Holds of Ships

Technical Background for UR S21a “Evaluation of Scantlings of Hatch Covers and Hatch Coamings and Closing Arrangements of Cargo Holds of Ships”

TB S21a.1 Introduction

UR S21a was developed to supplement UR 21 and applies to all ships except bulk carriers, ore carriers and combination carriers, as defined in UR Z11.

TB S21a.2 Application and definitions (UR S21a.1)

TB S21a.2.1 Definitions – Positions (UR S21a.1.2.2)

The defined positions for hatch covers upon exposed decks are as given by the International Convention on Load Lines (ICLL), 1966 as amended by the 1988 protocol, as amended in 2003, Regulation 13.

TB S21a.2.2 Material (UR S21a.1.3)

The structural integrity of hatch covers is important for the survivability of ships. As a consequence a material class I according to UR S6 (Use of steel grades for various hull members - ships of 90 m in length and above) is to be applied for hatch covers.

TB S21a.2.3 General requirements (UR S21a.1.4)

Hatch cover primary supporting members are required to be continuous to provide sufficient load carrying capacity and an adequate transmission of forces when grillage effects are taken into account.

For similar reason, a maximum spacing of the primary supporting members parallel to the direction of secondary stiffeners is included. It shall not exceed 1/3 of the span of primary supporting members. A ratio of spacing/length limited to 1/3 guarantees a relatively high ratio of effective breadth/spacing. When strength calculation is carried out by FE analysis using plane stress or shell elements, this requirement can be waived because shear lag effects are implicitly considered by this assessment method as long as the mesh density is sufficiently fine.

Hatch cover secondary stiffeners are required to be continuous in order to have the necessary buckling strength against the compressive loads induced by the bending of primary supporting members.

Hatch coaming secondary stiffeners are required to be continuous in order to be able to sustain the bending moment distribution assumed for these elements.

TB S21a.3 Hatch cover and coaming load model (UR S21a.2)

TB S21a.3.1 Vertical weather design load (UR S21a.2.1)

The vertical weather design loads adopted in UR S21a are identical with the loads given by ICLL in Regulation 16 (2), (3), and (4) except for exposed superstructure decks of ships with a length L > 100 m located at least one superstructure standard height above the lowest Position 2 deck. For these decks a reduced design load of 2.1 t/m^2 is required as given by UI LL 70.

The provision that, under the given conditions, the design load for hatch covers on the actual freeboard deck may be as required for a superstructure deck originates from UI LL 70 and is based on an assumed freeboard deck as defined in IACS UI LL64.

The height of the hatch coaming above deck less 600 mm may be considered for the definition of the assumed freeboard deck with respect to the determination of the vertical weather design load on hatch covers.

TB S21a.3.2 Horizontal weather design load (UR S21a.2.2)

As the load model adopted by S21 is very much specific to bulk carries and does not consider the height of a structure above the load line of the assessed ship, the project team decided to adopt the horizontal weather design load from UR S3 (Strength of end bulkheads of superstructures and deckhouses) except for the definition of factor *f* and c_L. Factor *f* is a wave coefficient and was adopted from UR S11 (Longitudinal strength standard). For ships of less than 90 m in length factor *f* was newly defined as it is not given by UR S11. Factor c_L is less than one for ships of less than 90 m in length and reduces the effect of wave coefficient *f*.

TB S21a.3.3 Calculation of container loads (UR S21a.2.4)

Formulas for the support forces A_z, B_z and B_y acting on the hatch cover are based on the assumption that the full vertical static and dynamic acceleration $g \cdot (1+a_v)$ is acting in combination with an acceleration of $0,5 \cdot g$ in transverse direction . The dynamic acceleration factor a_v depends on the position of the considered hatch cover in longitudinal direction. The typical distribution of a_v over the ship length is shown in Fig. 1. The transverse acceleration of $0,5 \cdot g$ corresponds to a static heel of 30°.

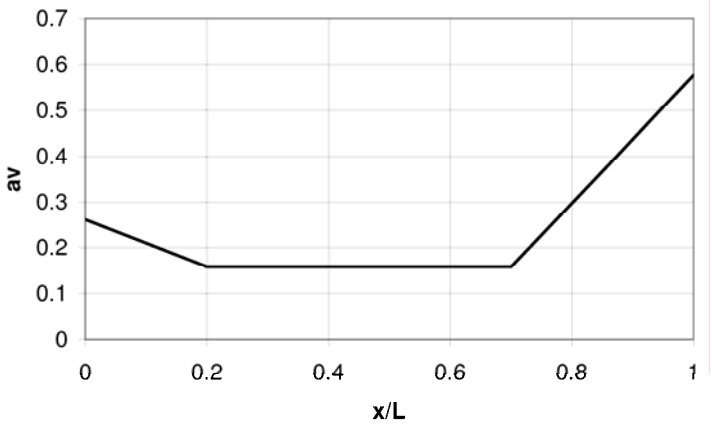


Fig. 1 Distribution of factor a_v

In case of container stacks secured to lashing bridges or carried in cell guides the forces acting on the hatch cover may be specially considered. Fig. 2 gives an example for container secured to the hatch cover (a) and secured to a lashing bridge (b). In the latter case the forces due to the ship's roll motion are transmitted partially to the lashing bridge so that the formulas for the forces acting on the hatch cover given by UR S21a.2.3 may not be applicable. However, as the torsional stiffness of container stacks is limited, support forces at corners of 20' container stacks away from lashing bridge or cell guides, respectively, may not be influenced considerably. These support forces at half length of the hatch cover are definitive for the structural design of the cover. Thus, A_z, B_z and B_y acting on the hatch cover at those stack corners may be assumed according to the given formulae in a conservative manner.

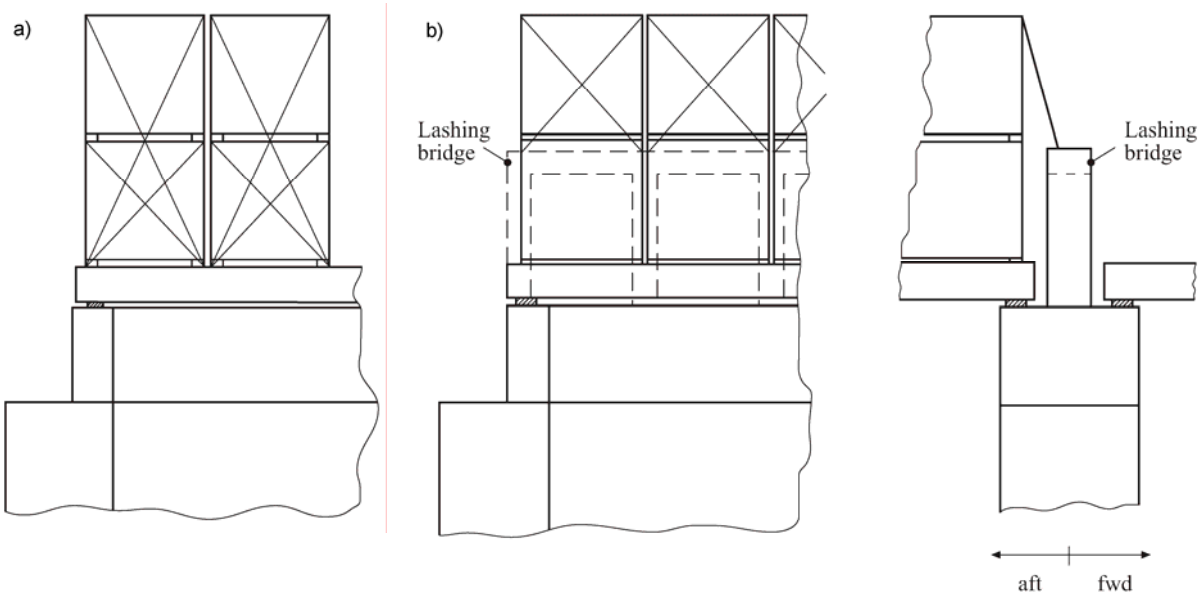


Fig. 2 Container secured to the hatch cover (a) and to a lashing bridge (b)

As an alternative to the given container loads, UR S21a allows applying container loads based on accelerations calculated by an individual acceleration analysis for the used lashing system. The individual acceleration analysis shall be carried out by the individual classification society.

This alternative assessment method allows designing hatch covers more individually with respect to the applied lashing system and according to the acceleration calculation of the individual class society. However, a load model independent from the lashing system provides more flexibility to the owner in choosing different lashing systems or modifying the lashing system without to be limited by the hatch cover design.

TB S21a.3.3.1 Load cases with partial loading (UR S21a.2.4.1)

Point loads and container loads acting on the hatch cover are also to be considered for partial non homogeneous loading which may occur in practice, e.g. where specified container stack places are empty.

UR S21a gives a simplified approach for assessing the partial loading of container hatch covers where the hatch cover is loaded without the outermost stacks, as can be seen in Fig. 3. It

may be necessary to also consider partial load cases where more or different container stacks are left empty.

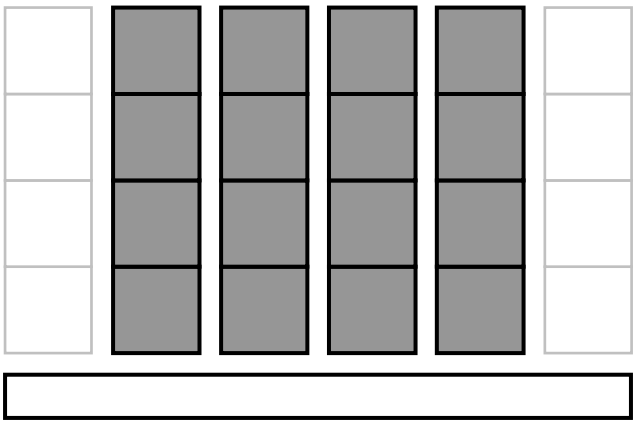


Fig. 3 Partial loading of a container hatch cover

The need for these considerations arise from the occurrence of increased loads due to the unbalanced vertical support forces at the supports of container stacks next to the empty stack places caused by the ship's roll motion.

Fig. 4 schematically illustrates resulting shear force distributions in a transverse primary supporting member of a hatch cover loaded with 20' containers. Distributions are shown for the hatch cover fully loaded and for the partial load case shown in Fig. 3 with horizontal acceleration acting. As can be seen, for the partial container load case in some areas increased shear forces occur.

For further illustration, Fig. 5 shows the equivalent stress distributions of a hatch cover loaded with stacks of 20' container and exposed to vertical and horizontal accelerations. On the left hand side, the hatch cover is fully loaded and on the right hand side the stress distribution is shown for a partial load case similar to the one shown in Fig. 3. It can be seen that increased stresses occur in the center transverse primary supporting members.

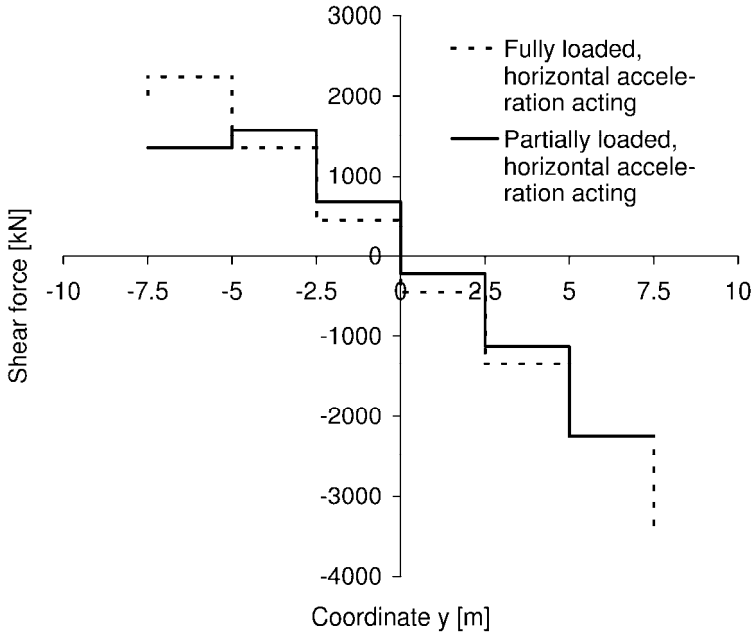


Fig. 4 Shear forces acting in a transverse primary supporting member of a hatch cover due to different load cases

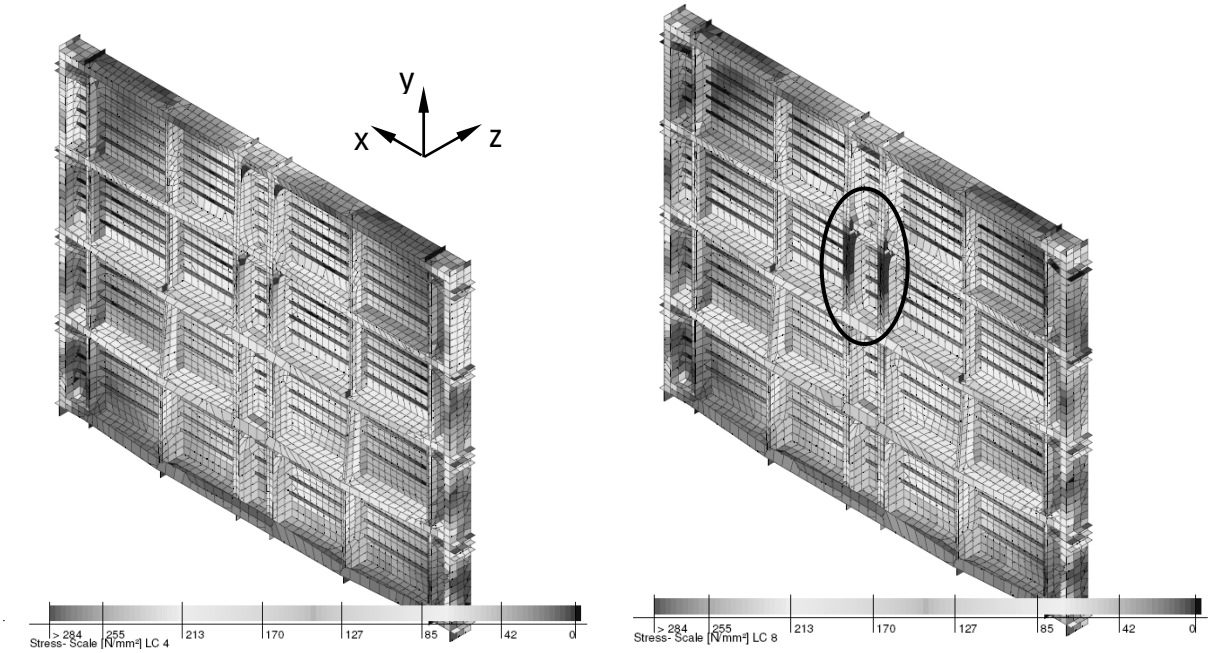


Fig. 5 Stress distribution in a hatch cover, fully loaded (left) and with partial loading (right)

TB S21a.4 Hatch cover strength criteria (UR S21a.3)

TB S21a.4.1 Permissible stresses and deflections - Stresses (UR S21a.3.1.1)

The equivalent stress according to v. Mises is to be assessed. In general, the permissible equivalent stress is 80% of the minimum yield point of the material as required by ICLL Regulation 16 (5).

When loads other than the vertical weather design load are assessed using FEM with plane stress or shell elements the permissible equivalent stress is 90% of the minimum yield point of the material. This is reasonable because due to Poisson effects FEM may calculate increased stresses compared to a grillage analysis. Furthermore, this is justified by the use of FEM as a more sophisticated assessment tool. However, the increased permissible stress is only to be applied for loads other than the vertical weather design load to not contradict ICLL regulations.

TB S21a.4.2 Permissible stresses and deflections - Deflection (UR S21a.3.1.2)

The deflection limit as given by ICLL Regulation 16 (5) is included for the vertical weather design load case.

Where hatch covers are arranged for carrying containers and mixed stowage is allowed, i.e., a 40'-container stowed on top of two 20'-containers, particular attention should be paid to the deflections of hatch covers. Fig. 6 gives an example for a mixed stowage situation and the resulting hatch cover and container stack deflection.

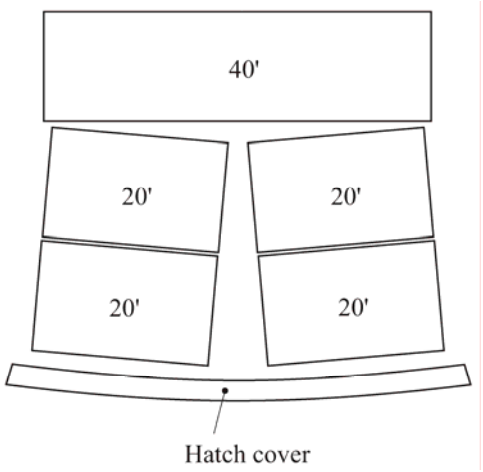


Fig. 6 Example for mixed stowage and resulting hatch cover and container stack deflection

TB S21a.4.3 Local net plate thickness (UR S21a.3.2)

The requirement for the minimum net plate thickness of hatch cover top plating subjected to the vertical weather design load and distributed cargo loads is the same as used in UR S21.

The coefficient 15,8 used in the expression applies for plates under pressure with clamped edges that are free to pull in and with plastic hinges at the edges and at mid-span.

An additional factor $F_P \geq 1{,}5$ is introduced to account for co-existing compressive membrane stress in the hatch cover top plate as well as the possibility that the lateral pressure loading may locally exceed the assumed value. Factor F_P is increased linearly to 1,90 for the attached plate flange of primary supporting members stressed above 80% of the allowable stress limit.

The normal stress of the hatch cover plating may be determined in a distance equal to the stiffener spacing s from webs of adjacent primary supporting members perpendicular to secondary stiffeners and in a distance equal to half of the stiffener spacing s from the web of an adjacent primary supporting member parallel to secondary stiffeners. This accounts for the shear lag effect leading to reduced membrane stresses at the assessed locations. As an example, Fig. 7 shows locations for determination of σ_x and σ_y for the plate field marked in grey. The greater of both stresses is to be taken for the normal stress of the hatch cover plating in the requirement for the local net plate thickness. At assessment point 1 an intermediate stress σ_x over the plate breadth s is determined which is reasonable for the assumed three-hinge-collapse failure mode. The assessment of σ_y at point 2, located in a distance equal to the stiffener spacing from the web of the adjacent primary supporting member, accounts for reduced local bending stresses close to the short edge of the plate field.

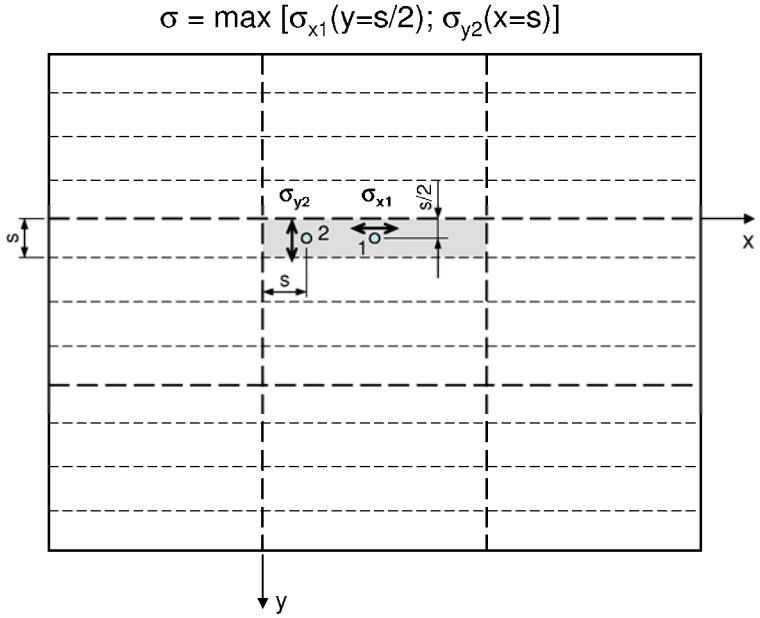


Fig. 7 Determination of normal stress of hatch cover plating

TB S21a.4.4 Net scantling of secondary stiffeners (UR S21a.3.3)

For secondary stiffeners, the minimum elastic section modulus is derived from the elastic bending moment at the fixed end under consideration of the permissible stress as required by ICLL Regulation 16 (5). Only the lateral pressure is considered, while the second order bending moment caused by the combined effect of stiffener deflection (by the lateral pressure load) and the membrane stress in the plate (from the bending of the primary supporting member) is disregarded.

If secondary stiffeners parallel to primary supporting members are regarded for calculating the cross sectional properties of these primary supporting members, it is to be verified that the combined stress of those stiffeners induced by the bending of primary supporting members and lateral pressures does not exceed the permissible stresses.

For hatch cover stiffeners under compression sufficient safety against lateral and torsional buckling is to be verified.

For flat bar secondary stiffeners, a limit on the web depth to net thickness ratio is introduced to prevent their local buckling. This requirement is adopted from UR S21.

TB S21a.4.5 Net scantling of primary supporting members - Primary supporting members (UR S21a.3.4.1)

For all components of primary supporting members sufficient safety against buckling must be verified. For biaxial compressed flange plates this is to be verified within the effective widths. For illustration, Fig. 8 shows a crossing of two primary supporting members with their effective widths. The area where a buckling proof must be carried out for biaxial compression is marked in grey. The buckling proof for parts of the hatch cover plating located in this area is to be done as a combined proof for cases 1 and 2 according to Tab. 5 of UR S21a.

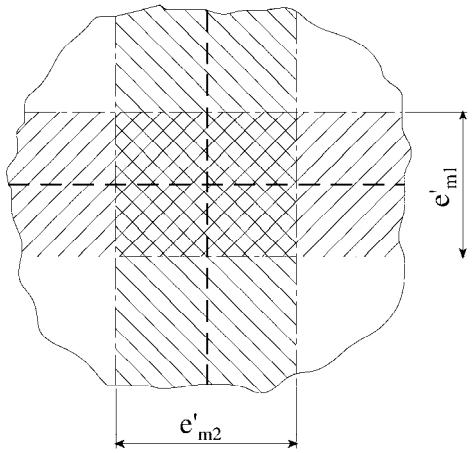


Fig. 8 Crossing of two primary supporting members and their effective widths

TB S21a.4.6 Edge girders (Skirt plates) (UR S21a.3.4.2)

For edge girders the same requirement for minimum net plate thickness is adopted as for the hatch cover top plating except for minimum thickness values that do not depend on the pressure load.

Furthermore, a stiffness requirement for edge girders similar to the requirement as given by IACS Rec. 14 is incorporated to maintain an adequate sealing pressure between securing devices.

TB S21a.4.7 Strength calculations (UR S21a.3.5)

Strength calculation for hatch covers may be carried out by either, using beam theory, grillage analysis or FEM. However, simple beam models shall be adopted only for hatch covers that are not designed as a grillage of longitudinal and transverse primary supporting members. In other cases a grillage analysis using beam elements or an FEM analysis using plane stress or shell elements is appropriate.

TB S21a.4.7.1 Strength calculations - Effective cross-sectional properties for calculation by beam theory or grillage analysis (UR S21a.3.5.1)

When determining cross-sectional properties of a primary supporting member, cross sectional areas of secondary stiffeners parallel to the primary supporting member under consideration and within the effective breadth can be included. In this case it is to be verified that the combined stress of those stiffeners induced by the bending of primary supporting members and lateral pressures does not exceed the permissible stresses.

Special calculations may be required for determining the effective breadth of one-sided or non-symmetrical flanges. This can be done by special engineering formulas or, if available, according to the individual class society's rules. In more complex cases an FEM calculation is recommended.

The cross-sectional area of flange plates under compression may be reduced by buckling of the plating. Flange plates with secondary stiffeners perpendicular to the web of primary supporting members are in particular prone to buckling failure. Thus, the effective width is to be considered for the determination of cross-sectional properties of such primary supporting members for grillage analysis or beam theory calculations. However, the effective width of plating is not to be taken greater than the value obtained for the effective breadth.

TB S21a.4.8 Buckling strength of hatch cover structures (UR S21a.3.6)

For further information regarding the buckling strength criteria refer to the technical background documents of Common Structural Rules for Bulk Carrier (CSR/BC), Chapter 6 – Hull Scantlings, Section 3 – Buckling & Ultimate Strength of Ordinary Stiffeners and Stiffened Panels.

Safety factors for the buckling strength assessment are based on the net scantling approach. To be in compliance with ICLL Regulation 16 (5) the safety factor for assessing the hatch cover when subjected to the vertical weather design load is to be taken equal to1,25. For loads other than the vertical weather design load, a safety factor equal to 1,1 is to be applied. This is justified by the more sophisticated buckling strength approach compared to the approach in UR S21. The chosen safety factor of 1,1 matches that of CSR/BC to be used with this kind of buckling strength approach.

The given correction factors F_1 for boundary conditions at the longitudinal stiffeners correspond to the values given by CSR/BC.

TB S21a.4.8.1 Buckling strength of hatch cover structures - Proof of partial and total fields of hatch covers - Lateral buckling of secondary stiffeners (UR S21a.3.6.3.3)

The factor c_s accounts for the boundary conditions of transverse secondary stiffeners. It is to be 1,0 for simply supported and 2,0 for partially constraint stiffeners. Fig. 9 gives examples for the factor c_s. For a stiffener, the supports of which are equally spaced, a factor $c_s = 1,0$ is to be chosen (a). If a stiffener spacing changes from a wide spacing to a much more narrow spacing, a partial constraint exists and $c_s = 2,0$ is to be chosen (b). Also when brackets are fitted at the supports of the stiffener, it is to be assumed as partially constraint.

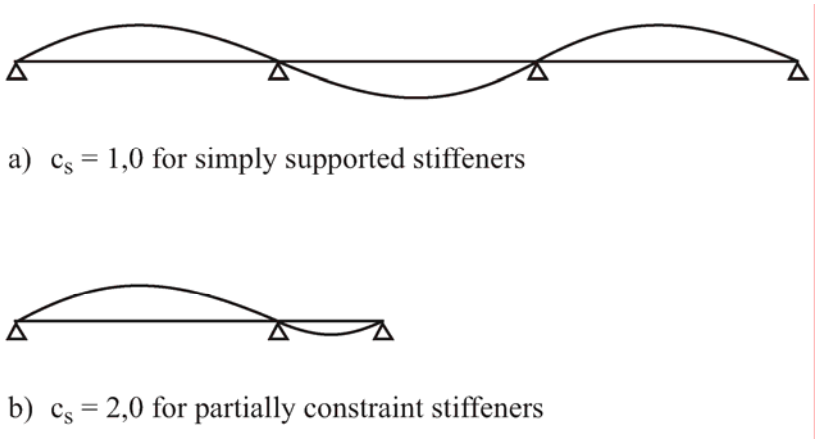


Fig. 9 Examples for the factor c_s accounting for the boundary conditions of transverse secondary stiffeners

TB S21a.5 Details of hatch covers (UR S21a.4)

TB S21a.5.1 Container foundations on hatch covers (UR S21a.4.1)

UR S21a requires designing substructures of container foundations for cargo and container loads applying the given permissible stresses.

Substructures are required to effectively distribute the localized support forces at the container stack corners. An example for container foundations and their substructures is given in Fig. 10. The figure shows a section through a primary supporting member with supporting structural elements like brackets beneath two container foundations. The detail drawing shows a typical container foundation more closely.

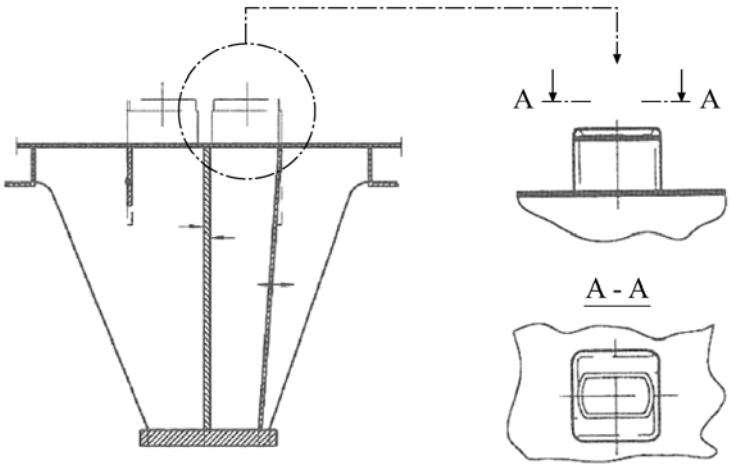


Fig. 10 Example for container foundations and their substructures

TB S21a.5.2 Weather tightness (UR S21a.4.2)

Further to the requirements as given by UR S21a the contents of IACS Rec. 14 are to be observed.

TB S21a.5.2.1 Weather tightness - Dispensation of weather tight gaskets (UR S21a.4.2.2)

For hatch covers of cargo holds solely for the transport of containers, the fitting of weather tight gaskets may be dispensed with upon request by the owners and subject to compliance with the given conditions that correspond to UI LL64.

Among others, it is to be complied with the condition that the exposed deck on which the hatch covers are located is situated above a depth H(x). H(x) is measured from the base line. The definition of H(x) is illustrated by Fig. 11 for a position forward of x/L = 0,75.

Further to the requirements as given by UR S21a, Chapter 3 of IMO MSC/Circ. 1087 is to be referred to concerning the stowage and segregation of containers containing dangerous goods.

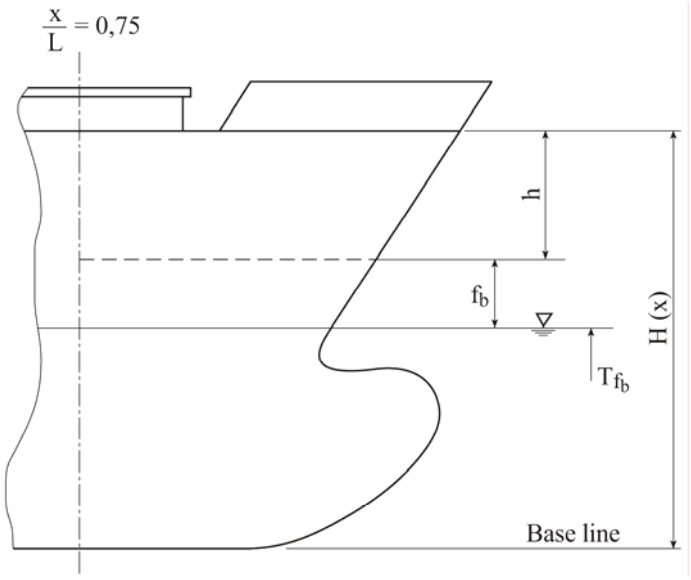


Fig. 11 Definition of H(x)

TB S21a.6 Hatch coaming strength criteria (UR S21a.5)

TB S21a.6.1 Local net plate thickness of coamings (UR S21a.5.1)

The horizontal weather design load model was adopted from UR S3. Thus, the prescriptive local net plate thickness of hatch coamings corresponds to that given in UR S3. The plate thickness required by UR S3 was assumed as a net plate thickness for UR S21a. Additionally, a minimum net plate thickness depending on the ship length was added which is not given by UR S3. Longitudinal strength aspects are to be observed as the given plate thickness formula merely covers local pressure loads.

TB S21a.6.2 Net scantlings of secondary stiffeners of coamings (UR S21a.5.3)

Similar to the prescriptive local net plate thickness, the prescriptive net scantlings for secondary stiffeners of hatch coamings correspond to those given in UR S3. Again, the stiffener section modulus required by UR S3 was assumed as a net section modulus for UR S21a. In addition, a minimum net cross sectional area of secondary stiffeners is required. The latter is based on the elastic shear force of a continuous beam under a uniformly distributed load.

TB S21a.6.3 Coaming stays (UR S21a.5.3)

Coaming stays in general are to be designed for the loads transmitted through them and permissible stresses as defined for hatch cover structures.

For stays of coamings with a height of less than 1,6 m and subjected to the horizontal design weather load, a prescriptive minimum section modulus and web thickness of the stay at the root point are given equal to the requirements of UR S21. Formulae were derived for the elastic shear force and bending moment appropriate to a cantilever under a uniformly distributed pressure. For coaming stays having a height of 1,6 m or more, prescriptive scantlings have not been formulated as a cantilever design can not be assumed.

TB S21a.7 Closing arrangements (UR S21a.6)

TB S21a.7.1 Securing devices - Cross-sectional area of the securing devices (UR S21a.6.1.4)

The requirements, UR S21a gives for the minimum cross-sectional area of securing devices used to maintain an adequate sealing pressure, correspond to the requirement as given by IACS Rec. 14.

For small hatch covers where the packing line pressure needs to be maintained by securing devices, typically rod type securing devices are used. For this type of securing device the given minimum cross-sectional area is applicable.

For large hatch covers securing devices may not be necessary to maintain packing line pressure as the covers are heavy enough. Securing devices then may be needed only as anti-lifting devices. These often exhibit designs which can not be sufficiently assessed only by a required cross-sectional area. They are to be designed according to the requirements for anti-lifting devices (UR S21a.6.1.5).

Where securing devices of special design are used to maintain the packing line pressure and in which significant bending or shear stresses occur, these may be designed as anti-lifting devices. As load the packing line pressure multiplied by the spacing between securing devices is to be applied.

TB S21a.8 Corrosion addition and steel renewal (UR S21a.8)

The requirements for corrosion additions of hatch cover structures are consistent with UI LL70. The requirements for corrosion additions of hatch coamings are consistent with UR S21.

The requirements for steel renewal of hatch cover structures are consistent with the requirements as given by UR S21. Steel renewal requirements for hatch coamings are to be according to the individual class society’s rules.